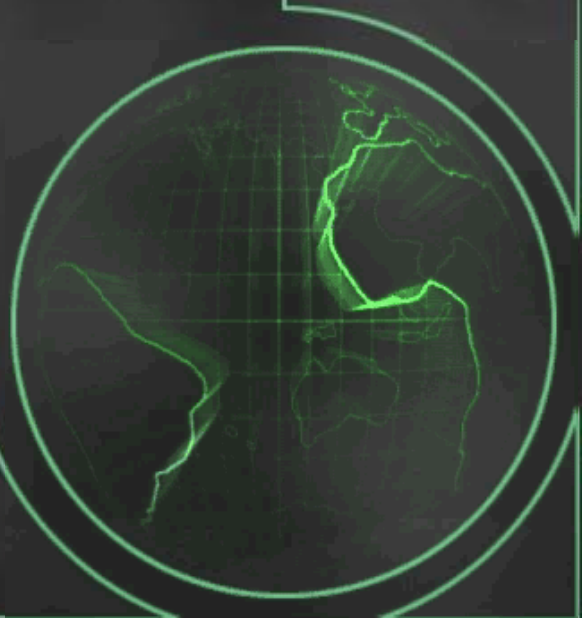
Land Cover and Land Use Change in Amazonia

LCLUC Science Team Meeting
University of Maryland
November 19-21

David Skole
Michigan State University



Deforestation, regrowth, fragmentation, and degradation in Amazonia: carbon dynamics

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Walter Chomentowski
Eraldo Matricardi
Robert Walker
Marcellus Caldas
Marcos Pedlowski
Andrea Silva
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Mark Cochrane
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Luis Guilherme
Richard Houghton
Bill Laurance

BSRSI
Basic Science and Remote Sensing Initiative
MICHIGAN STATE UNIVERSITY

Objectives

- Are the inter-annual dynamics and rates of deforestation and abandonment to secondary forest significantly different than the decadal mean values in Amazonia, and can this account for a dampening of the biogenic source of carbon apparent in annual observations of atmospheric carbon dioxide?

  Through the integration of socioeconomic and satellite data and the development of dynamic deforestation models, can we improve our understanding of the dynamics of deforestation and the various controls on rates of deforestation and regrowth

Objectives

- **Research Objective 1:** To measure inter-decadal rates of deforestation and regrowth and its spatial pattern at less than 100 m resolution over the whole using Landsat data from Landsat Pathfinder;

- **Research Objective 2:** To measure inter-annual rates of deforestation and regrowth for the whole basin using stratified sampling methods with Landsat data between the inter-decadal inventories from Objective 1;

- **Research Objective 3:** Amazônia-wide coupling of sociodemographic, agricultural, and econometric data at the municipio level for a suite of specific variables in order to develop land-use change variable sets;

- **Research Objective 4:** Establish intensive case studies using multi-temporal (annual) satellite data at specific sites to estimate transition dynamics and transition probabilities for secondary growth turnover in simple LUCC models;

- **Research Objective 5:** Conduct field-based case study analyses of the decision-making processes for farmers and other land-managers, using key informant surveys and models;

- **Research Objective 6:** Couple empirical results and models of LUCC at the basin and site level to biogeochemical models through collaboration with other teams and utilization of an existing terrestrial carbon model.

Publications

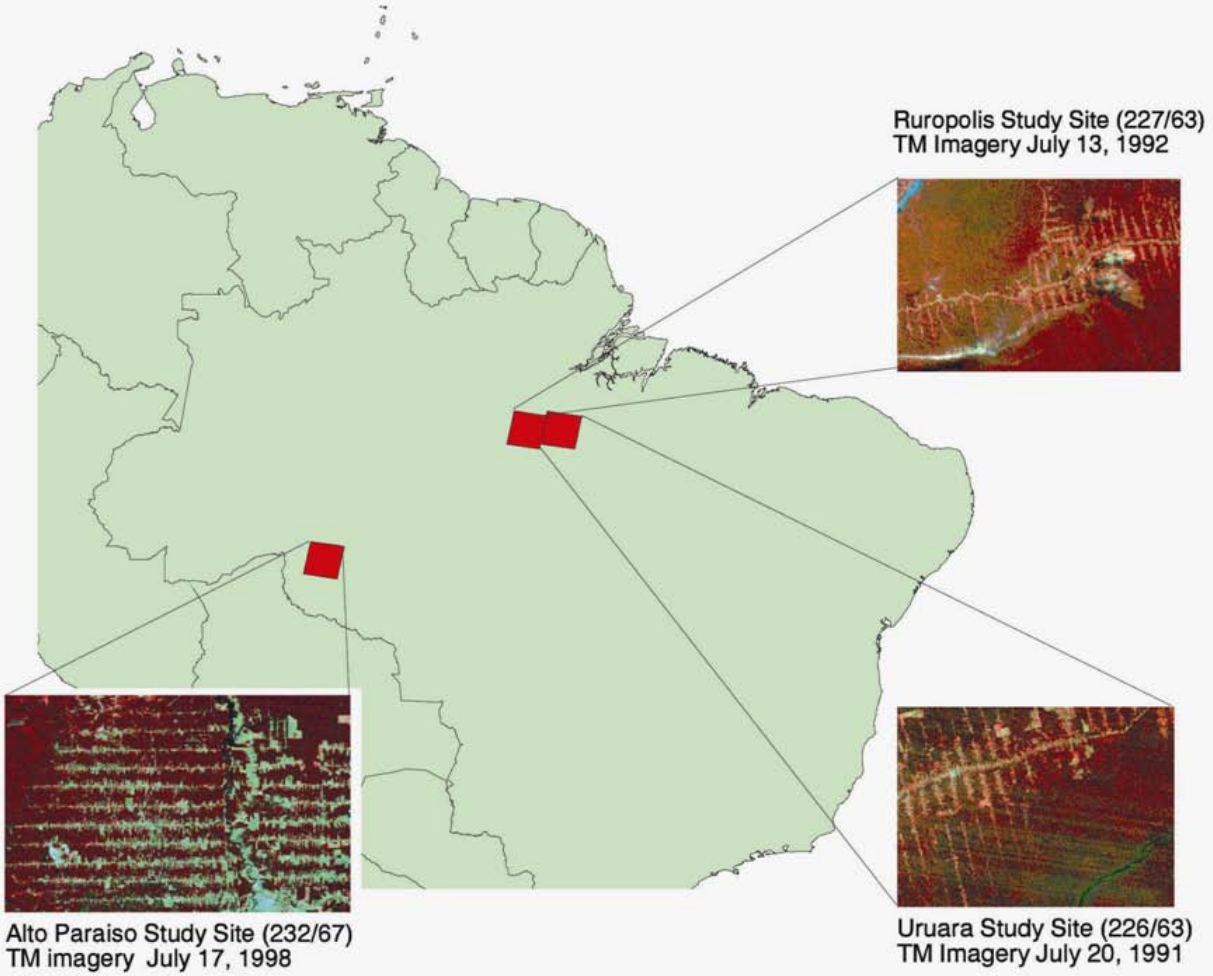
- 16 peer review papers in print, in press, or in review:

- e.g. Science, Nature, Int. J. Remote Sensing, Conservation Biology, Journal of Tropical Ecology

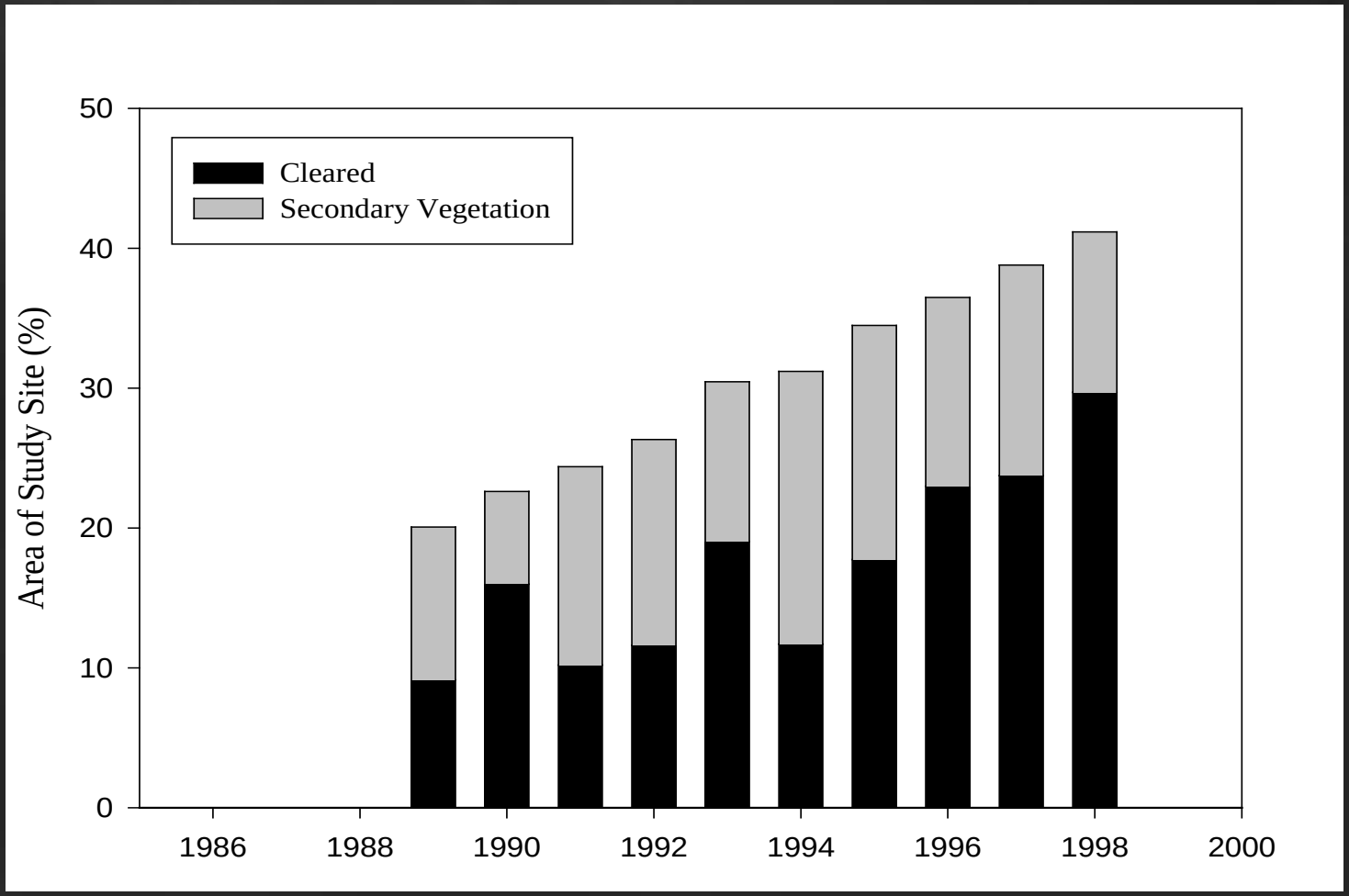
Activities

- Focus has been on documenting and understanding the full suite of land cover disturbances by humans:
  - Deforestation, regeneration, and degradation through selective logging and fire
  - Synergies between forms of disturbance, such as fire and logging, logging and deforestation
  - Spatial attributes, such as fragmentation and changes in size class distribution of clearings
- And building diagnostic and prognostic models.
- Use two case studies at field sites (Para and Rondonia) for understanding fine scale issue, and basin-wide analysis for comprehensive perspective

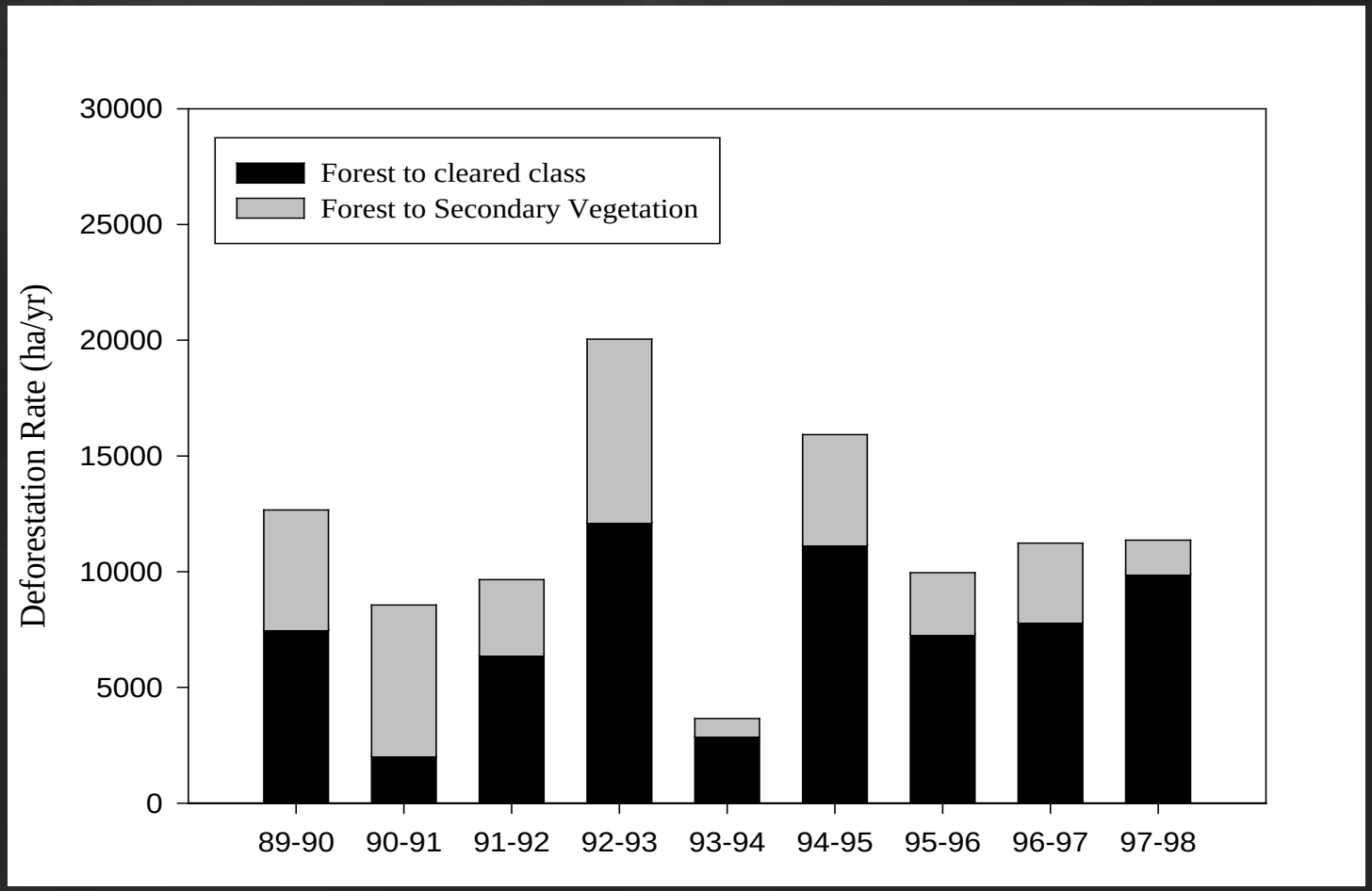
Sites for analysis



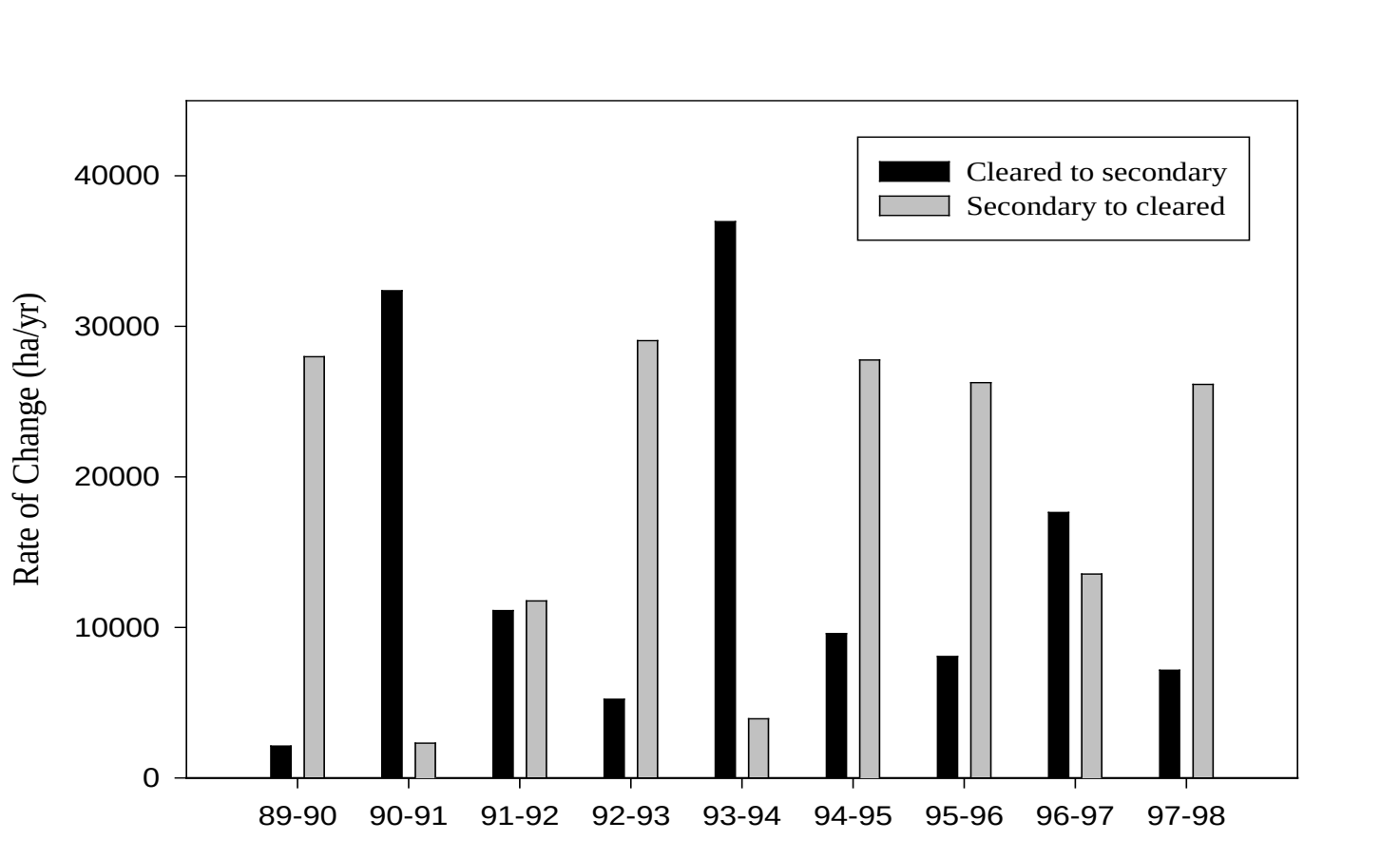
Area Changes at Amazon 1 site



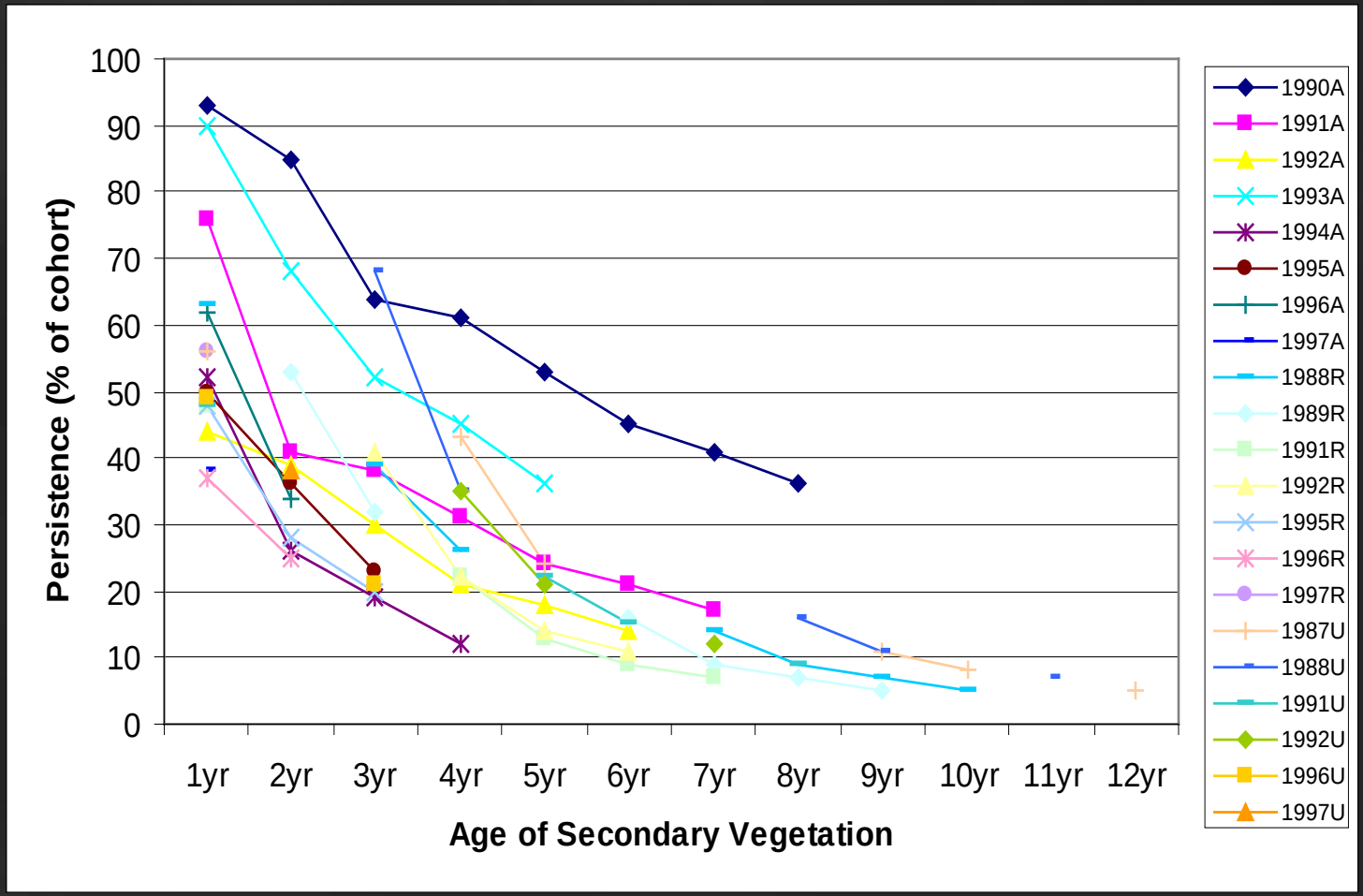
Rates of change at Amazon 1



Transitions at Amazon 1

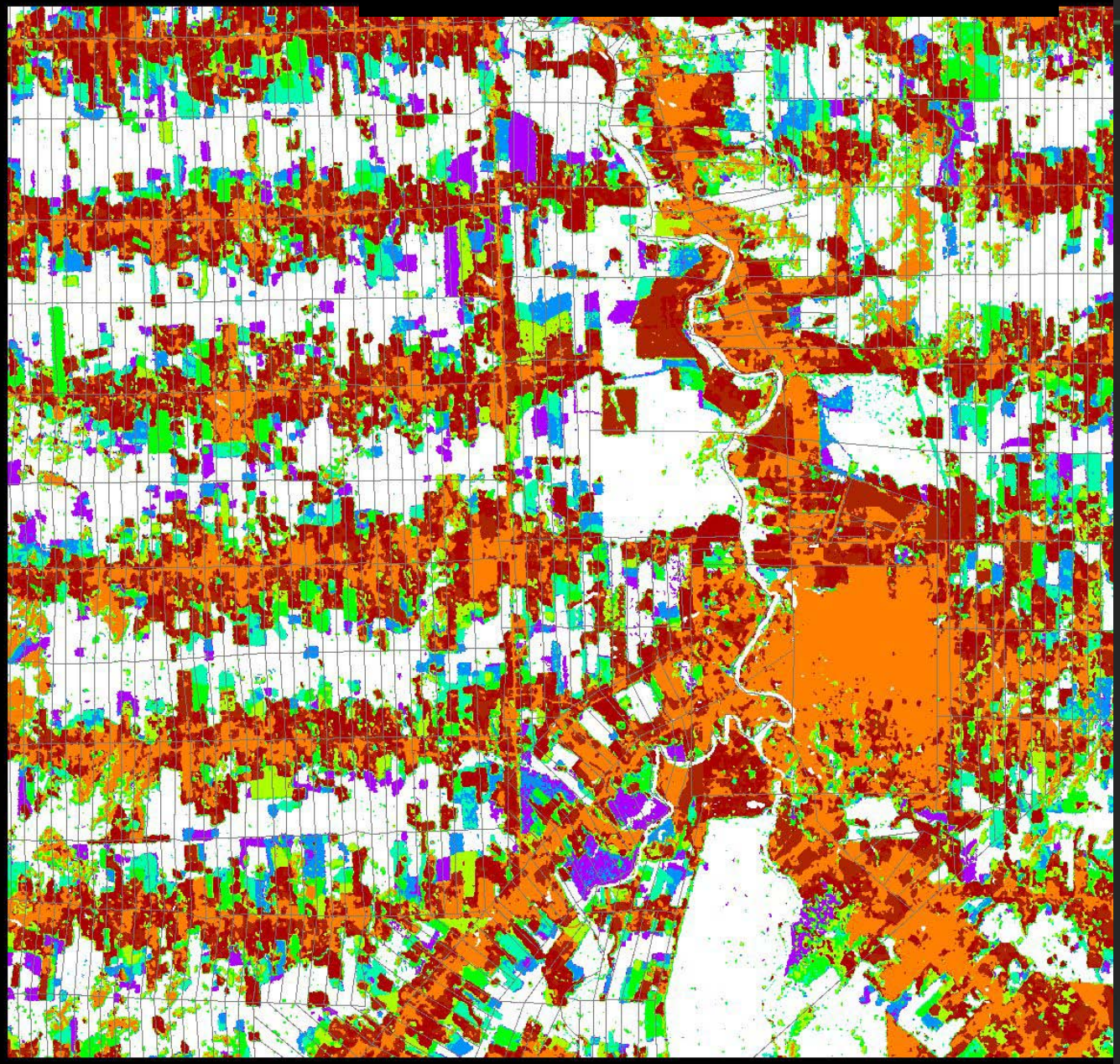


Survivorship: Life cycle dynamics

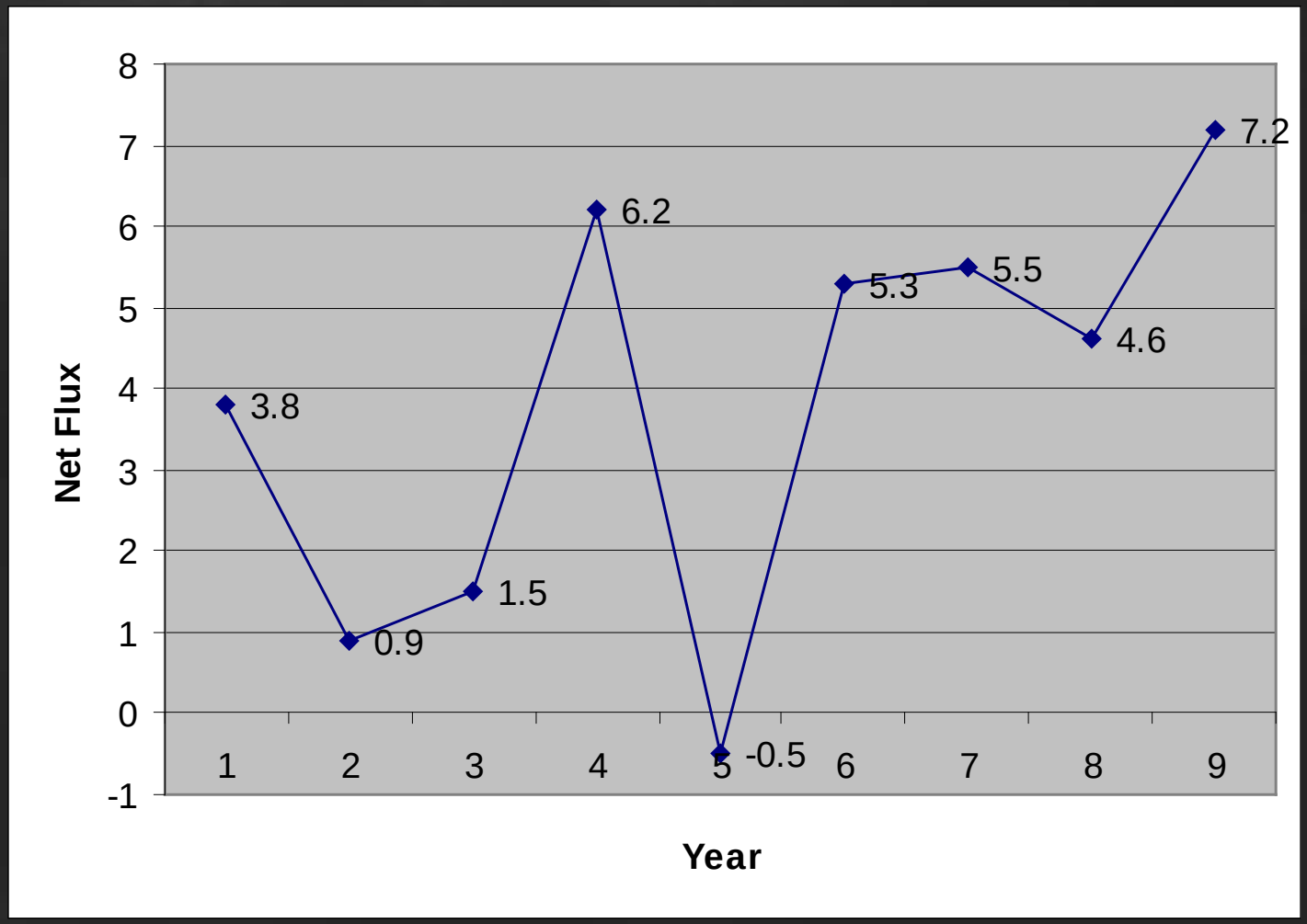


Survivorship of second growth

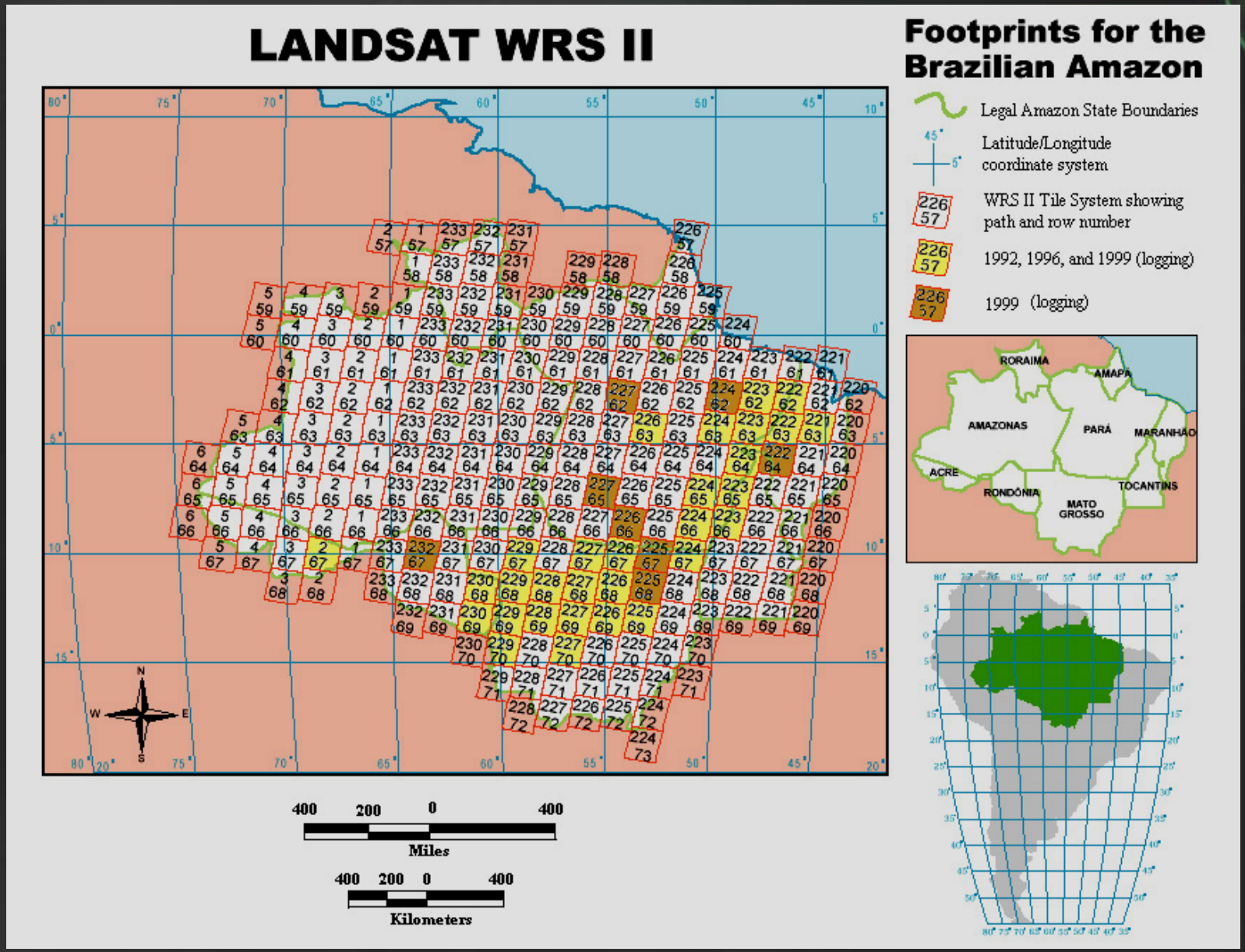
	1yr	*2yr*	*3yr*	*4yr*	*5yr*	*6yr*	*7yr*	*8yr*
1990	**93**	**85**	**64**	**61**	**53**	**45**	**41**	**36**
1991	**76**	**41**	**38**	**31**	**24**	**21**	**17**	**---**
1992	**44**	**39**	**30**	**21**	**18**	**14**	**---**	**---**
1993	**90**	**68**	**52**	**45**	**36**	**---**	**---**	**---**
1994	**52**	**26**	**19**	**12**	**---**	**---**	**---**	**---**
1995	**50**	**36**	**23**	**---**	**---**	**---**	**---**	**---**
1996	**62**	**34**	**---**	**---**	**---**	**---**	**---**	**---**
1997	**38**	**---**	**---**	**---**	**---**	**---**	**---**	**---**



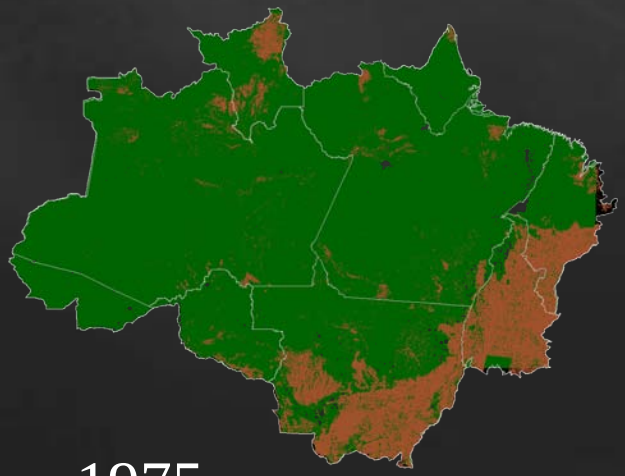
Carbon flux over time



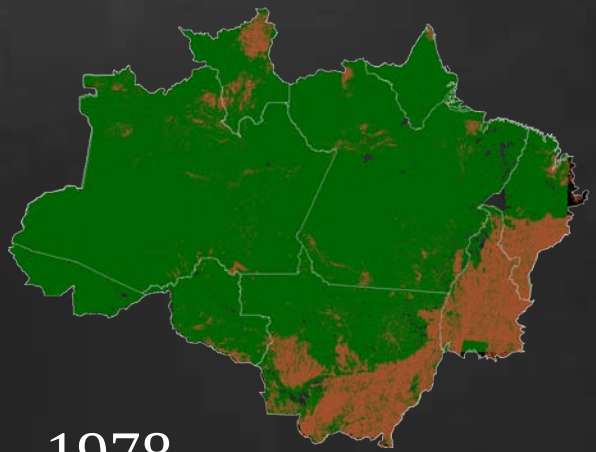
Basin scale deforestation



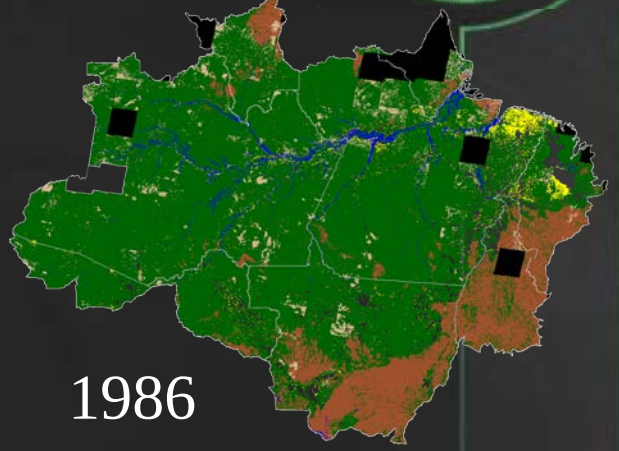
Basin wide deforestation and regrowth data (www.trfic.msu.edu)



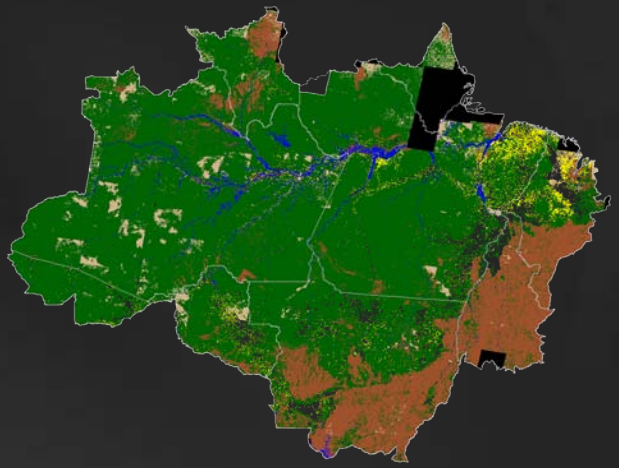
1975



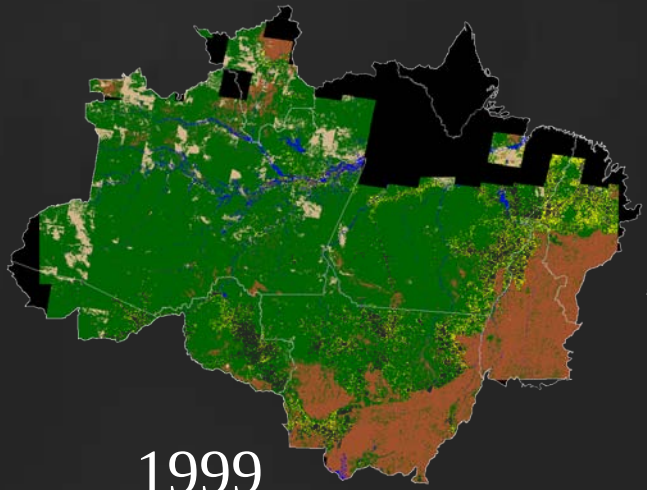
1978



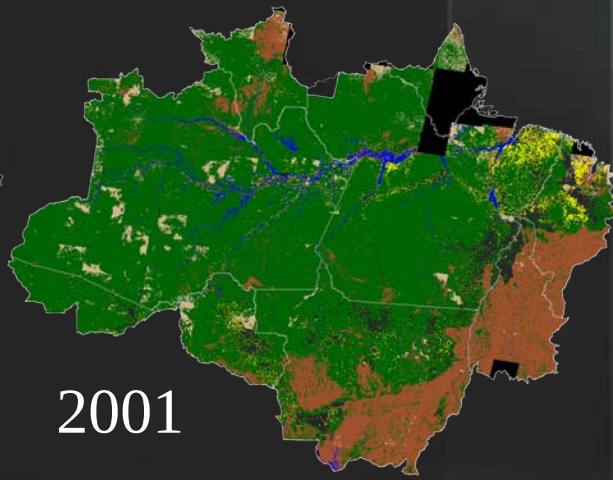
1986



1992

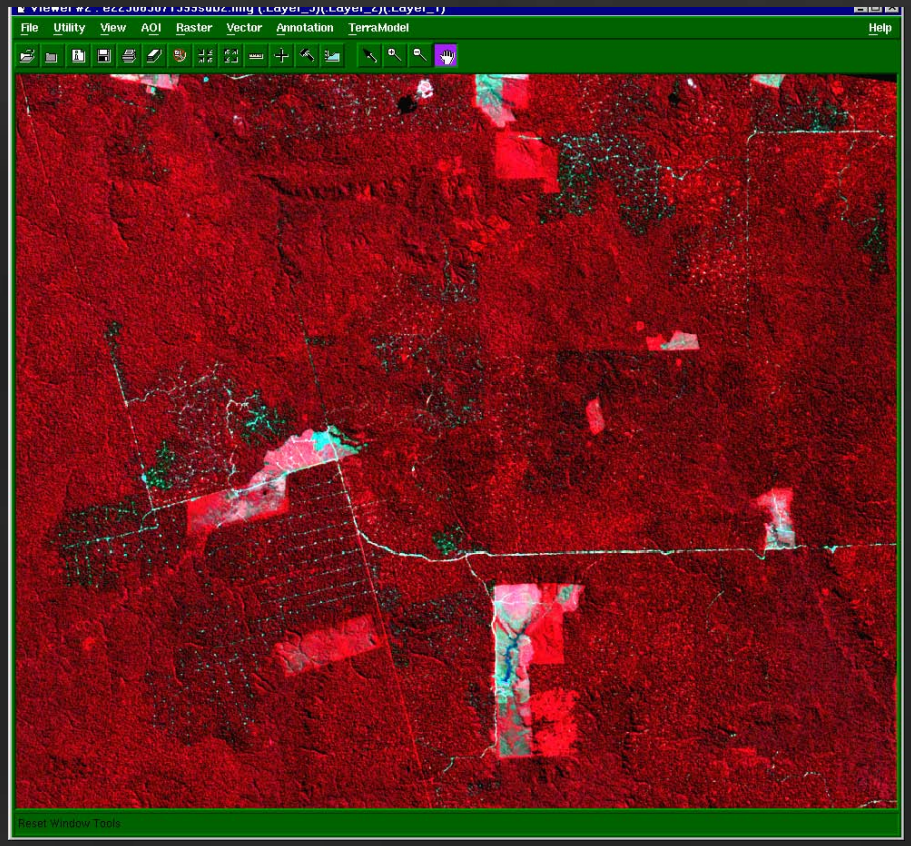


1999

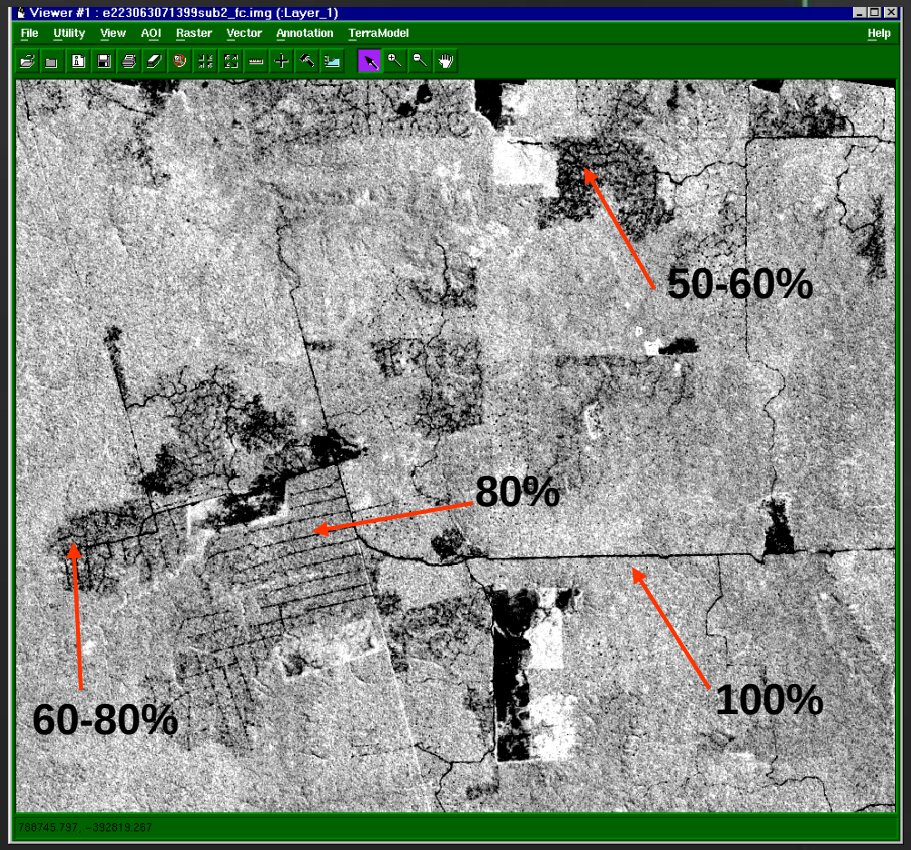


2001

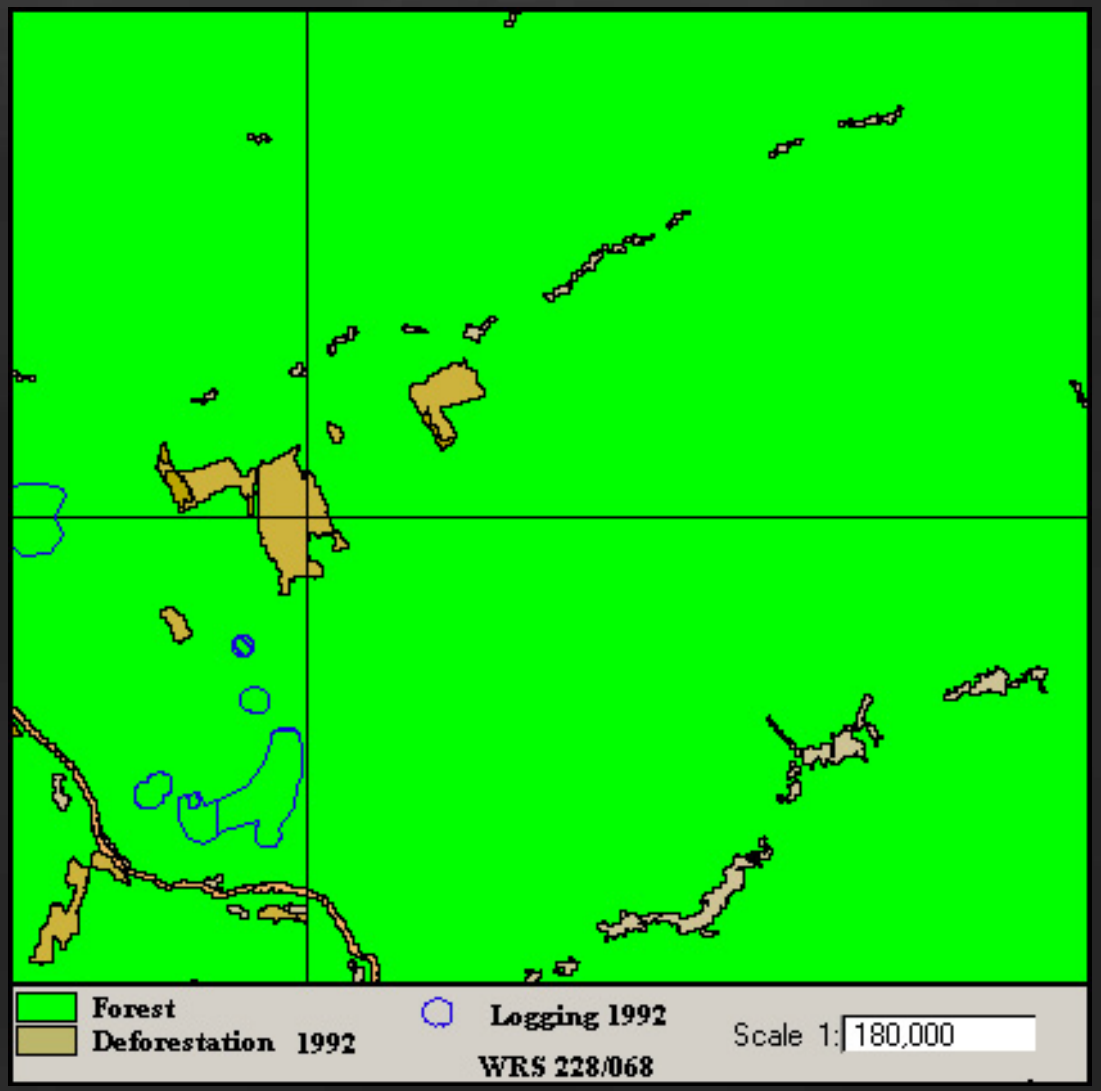
High resolution fractional cover assessment

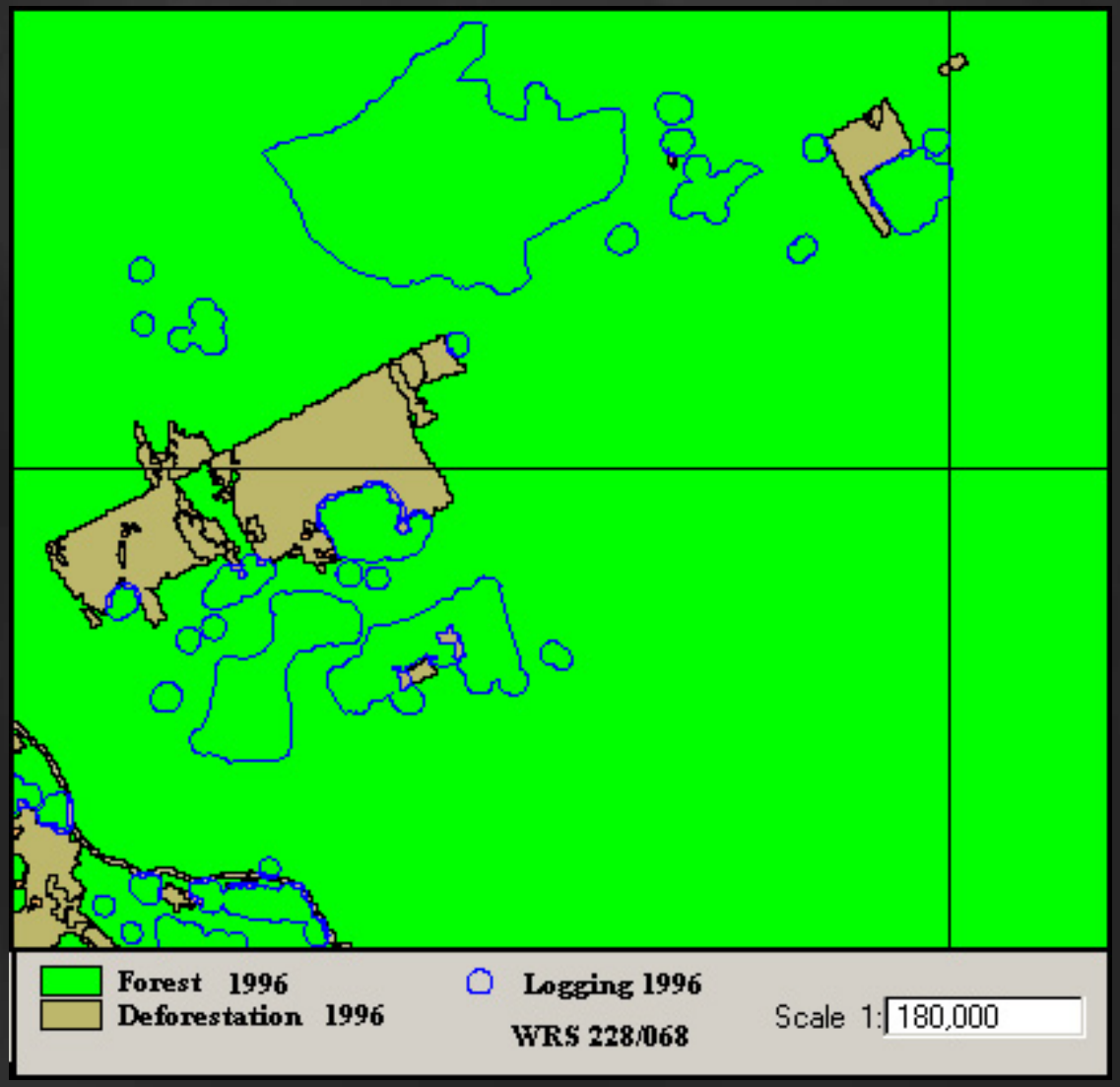


Site 2 – Color composite

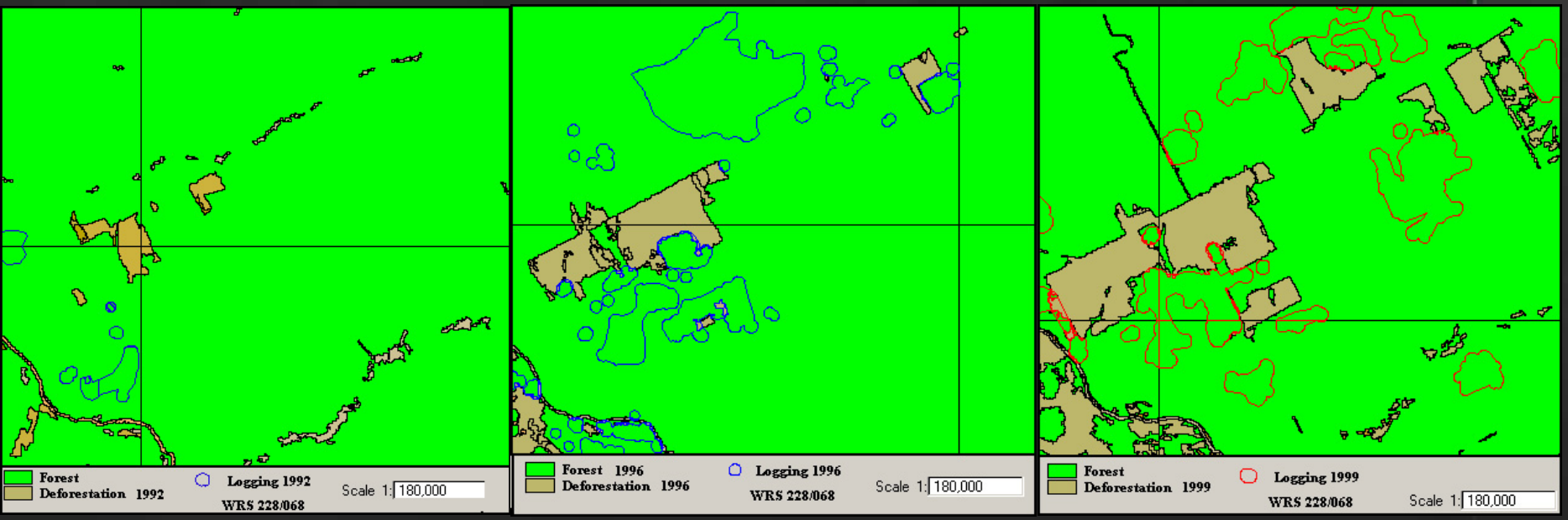


Site 2 – Fractional Cover

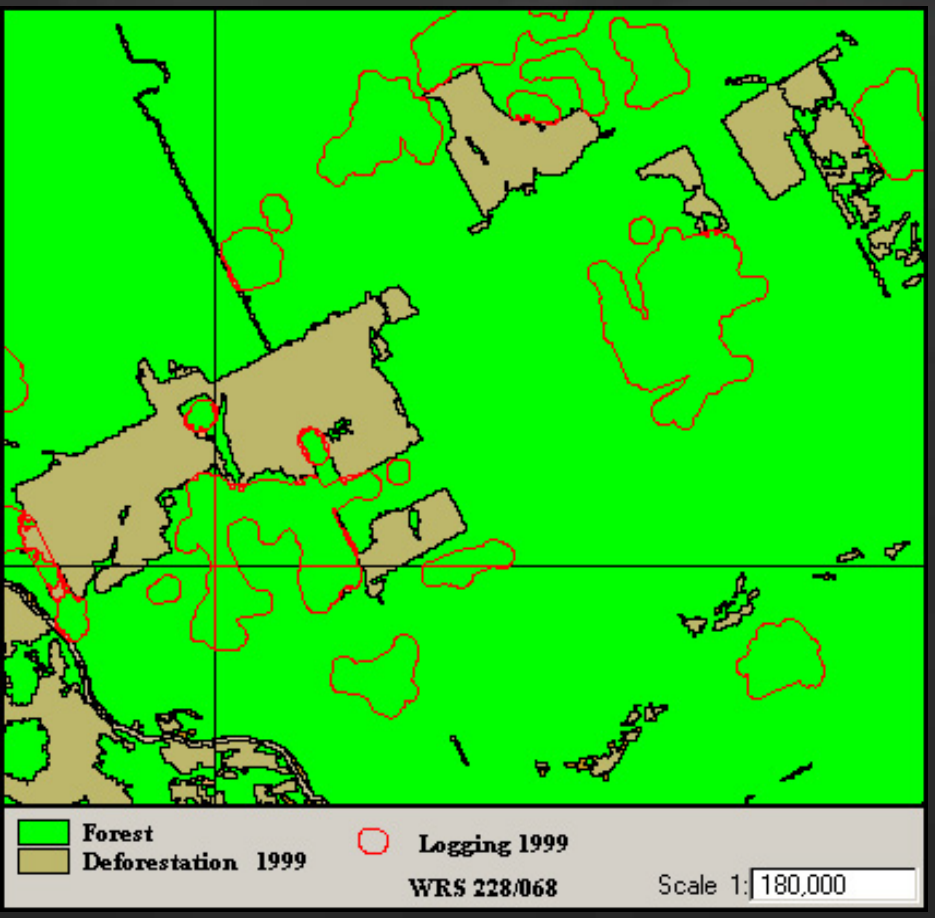

Forest
Deforestation 1992
Logging 1992
WRS 228/068
Scale 1: 180,000

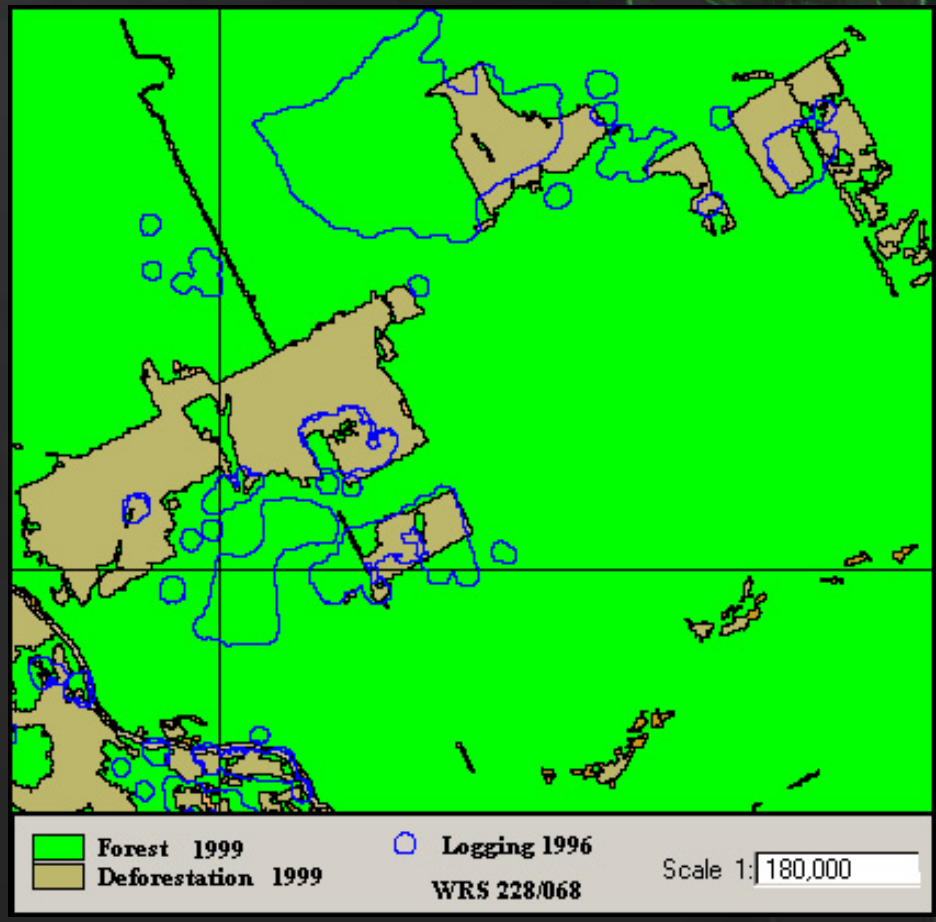

Forest 1996
Deforestation 1996
Logging 1996
WRS 228/068
Scale 1: 180,000

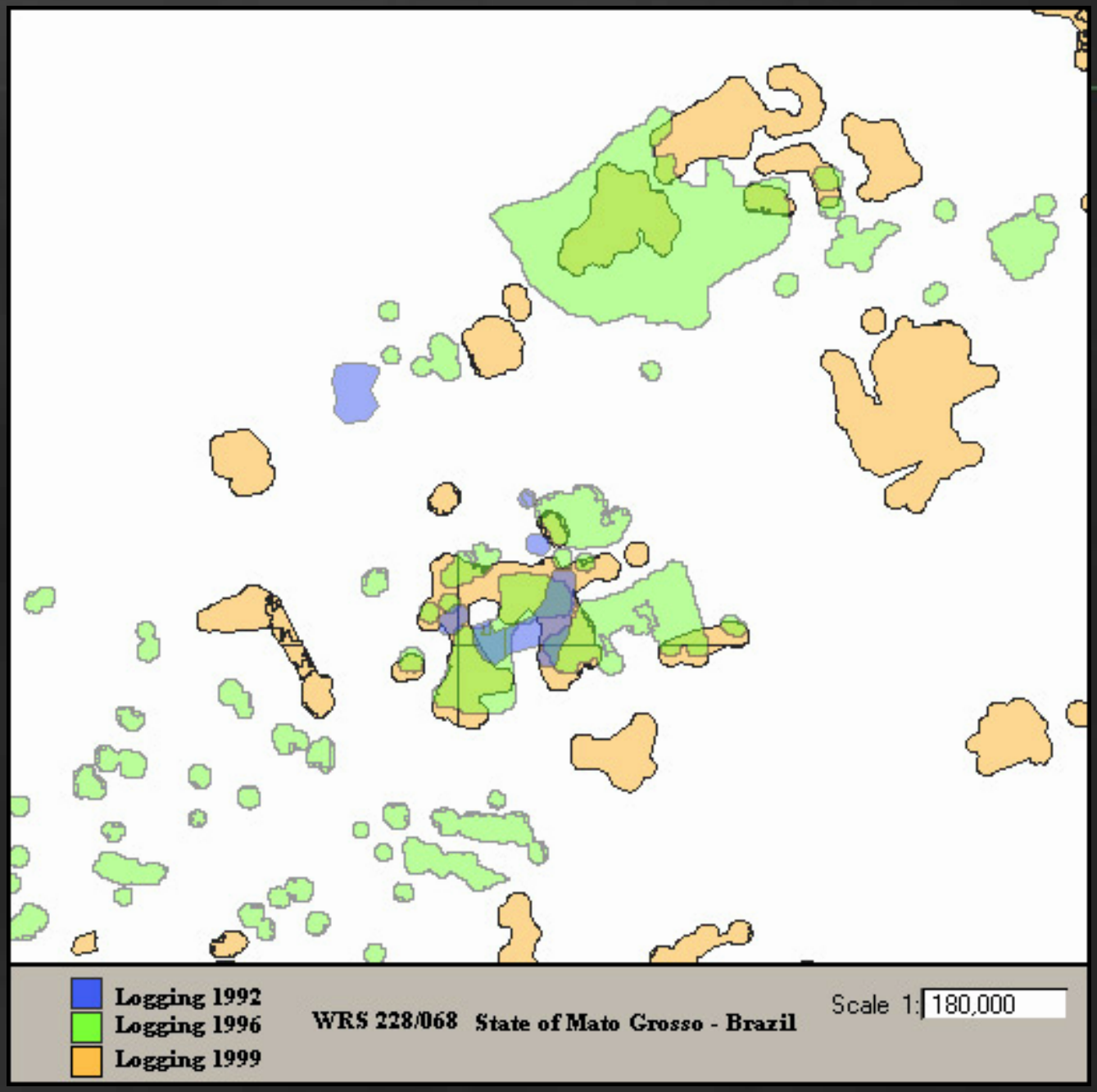
Evolution of the landscape



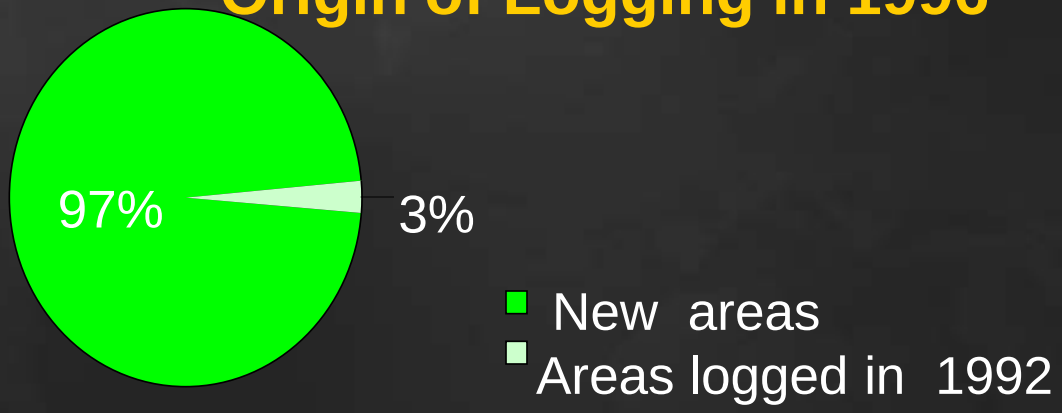
Synergy between agents



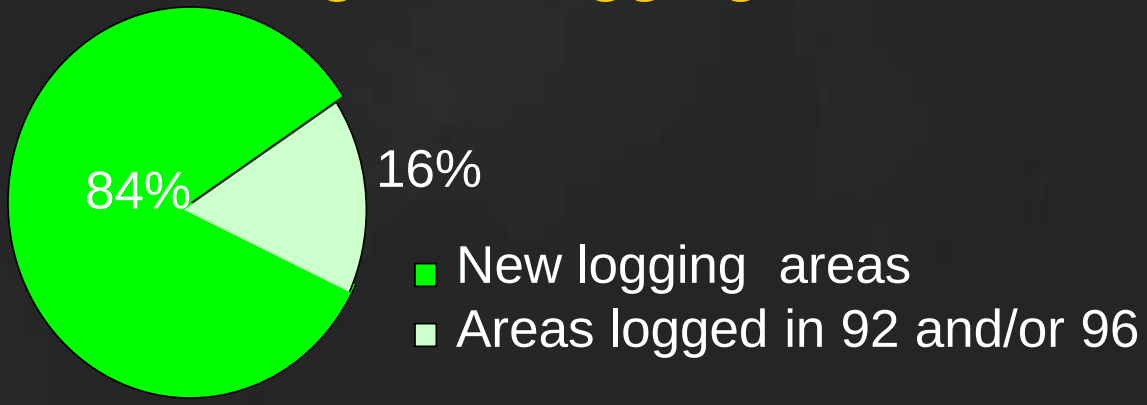



Logging 1992
Logging 1996
Logging 1999
WRS 228/068 State of Mato Grosso - Brazil
Scale 1: 180,000

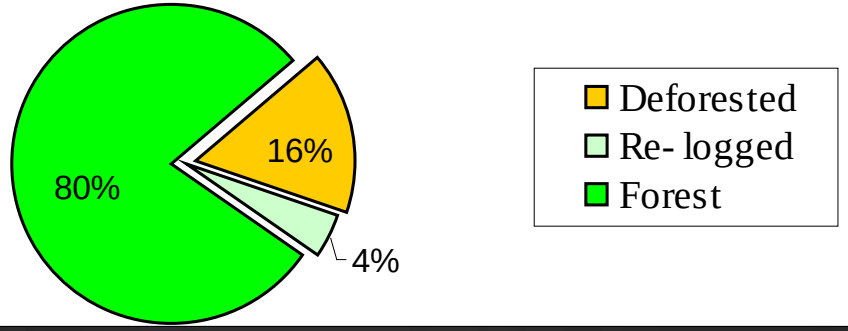
Origin of Logging in 1996



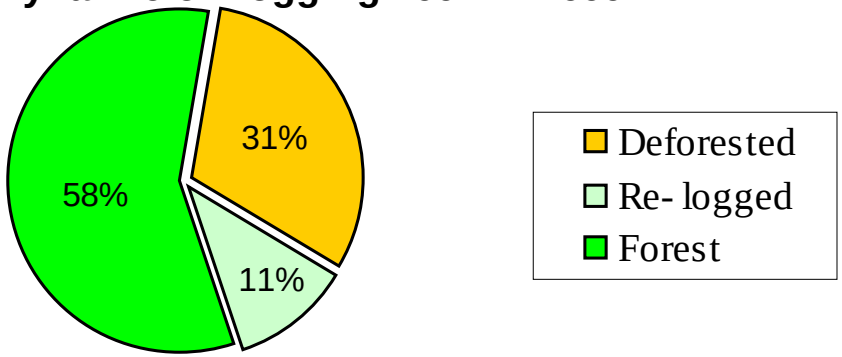
Origin of Logging in 1999



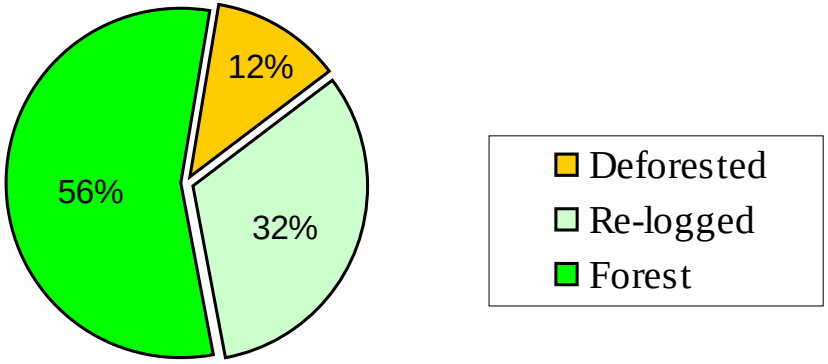
Dynamic of Logging 1992 in 1996



Dynamic of Logging 1992 in 1999



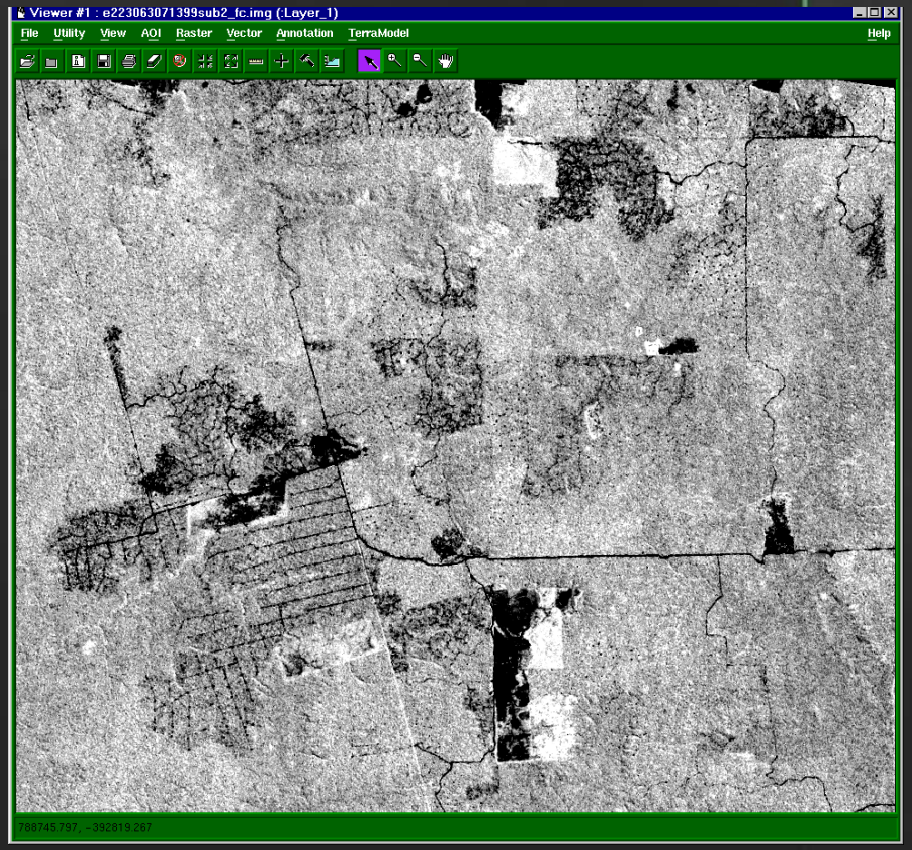
Dynamic of Logging 1996 in 1999



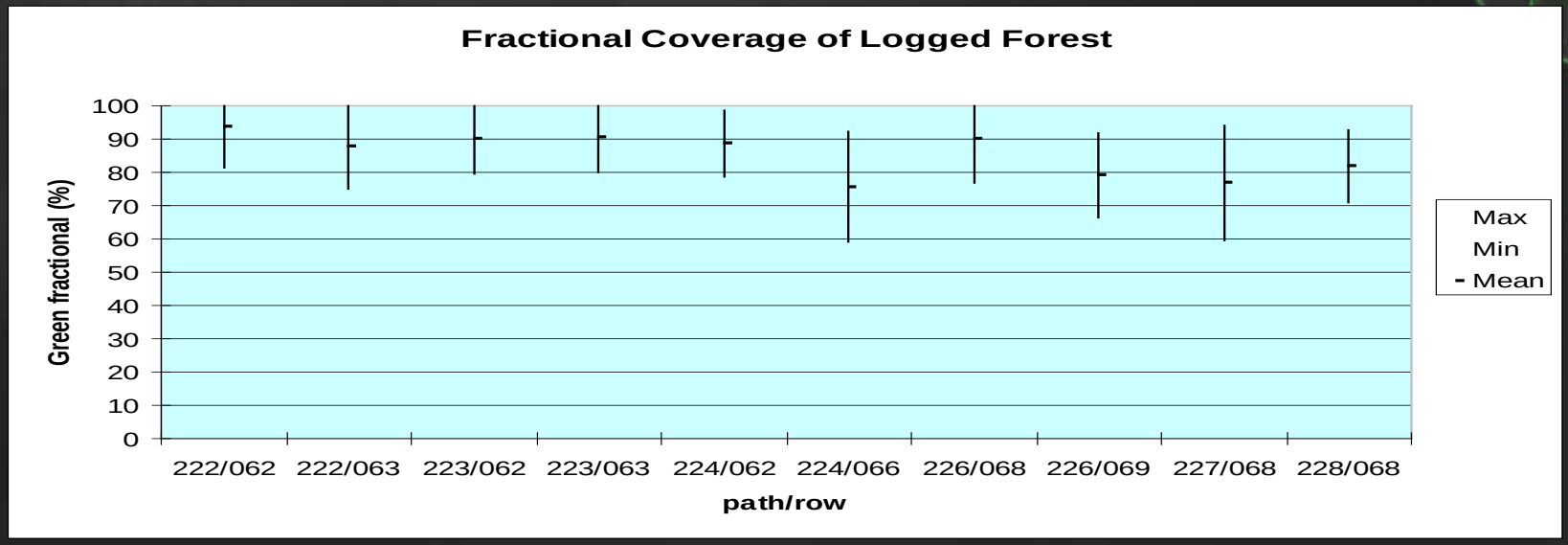
State	1992		1996		1999	
	Area (Km2)	%	Area (Km2)	%	Area (Km2)	%
Acre	8.00	0.14	30.00	0.32	26.00	0.11
Amapá	-	-	-	-	-	-
Amazonas	-	-	-	-	-	
Maranhão	512.00	9.10	578.00	12	1,941.00	8.30
MatoGrosso	2,667.00	47.40	3,797.00	.18	11,646.00	.81
Pará	2,405.00	.74	,856.00	.39	9,449.00	40.42
Rondonia	30.00	0.53	176.00	1.86	304.00	1.30
Roraima	-	-	-	-	-	-
Tocantins	5.00	0.09	12.00	0.13	13.00	0.06
Total	**5,627.00**	100	**9,449.00**	100	**23,379.00**	100

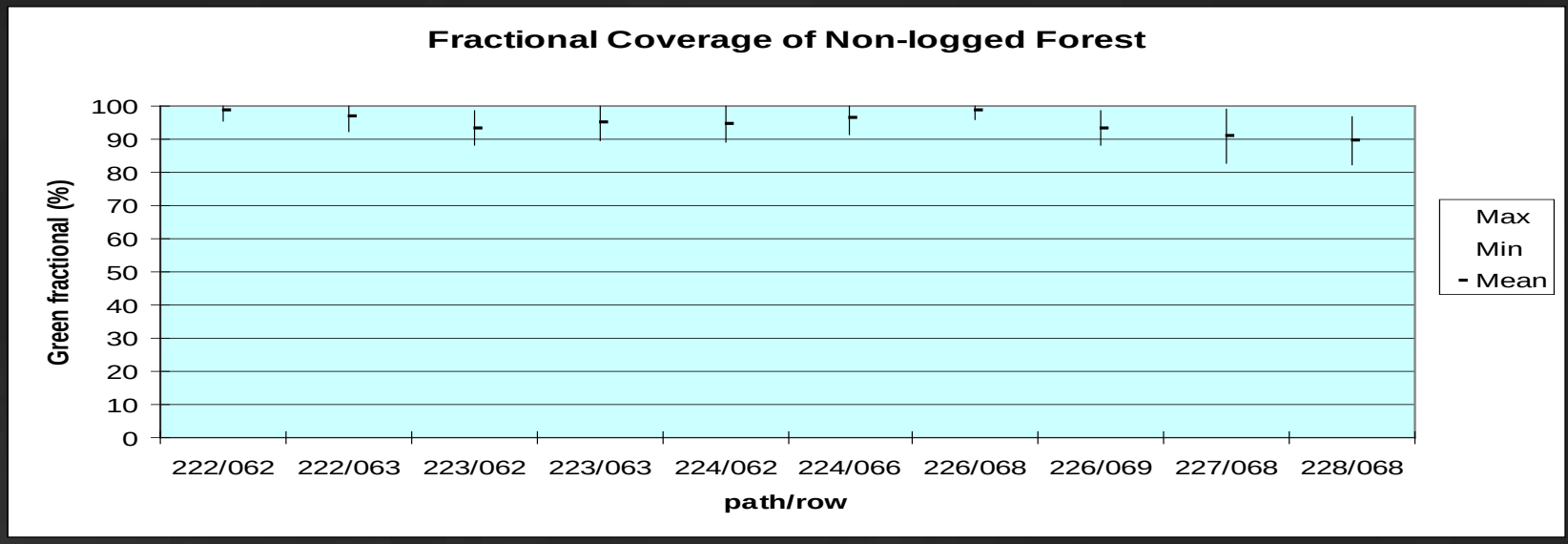
Continuous fields for detection of logging

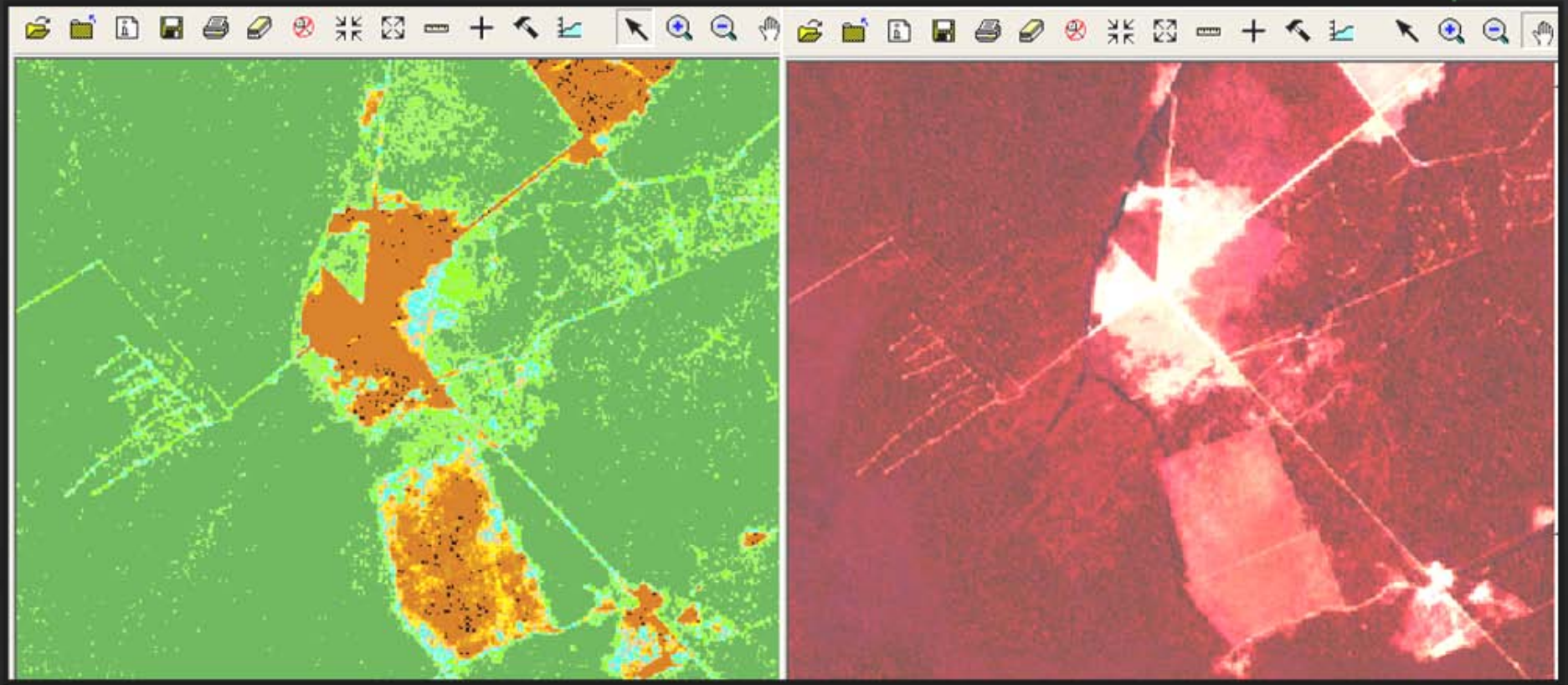
Site 2 – Color composite

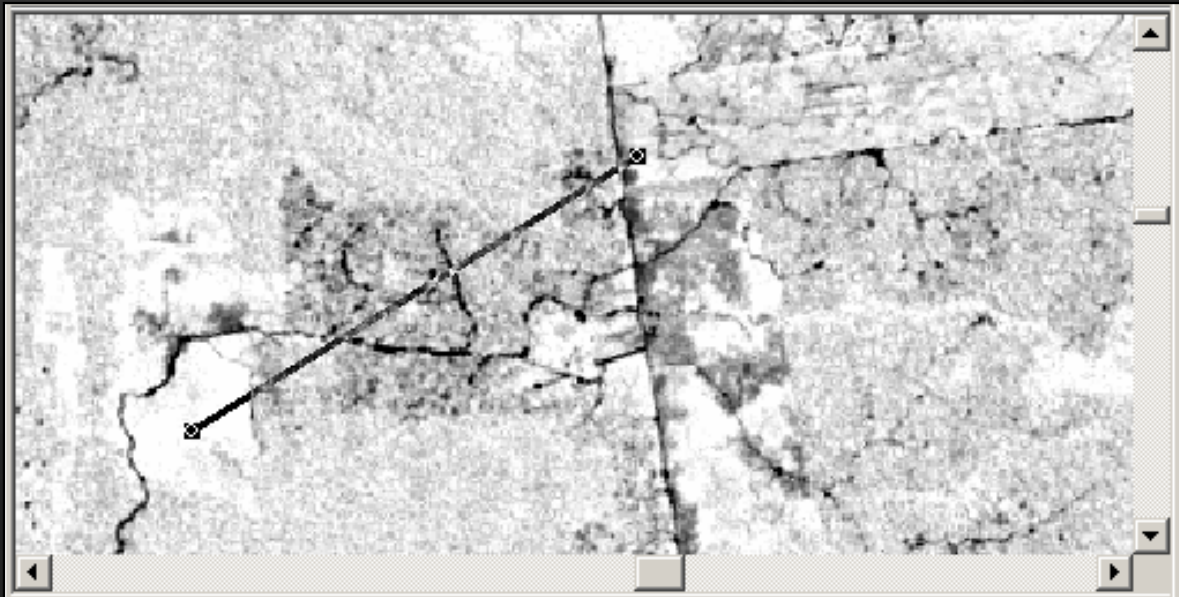


Site 2 – Fractional Cover


Fractional Coverage of Logged Forest
Green fractional (%)
100
90
80
70
60
50
40
30
20
10
0
222/062
222/063
223/062
223/063
224/062
224/066
226/068
226/069
227/068
228/068
path/row
Max
Min
Mean


Fractional Coverage of Non-logged Forest
Green fractional (%)
100
90
80
70
60
50
40
30
20
10
0
222/062
222/063
223/062
223/063
224/062
224/066
226/068
226/069
227/068
228/068
path/row
Max
Min
Mean

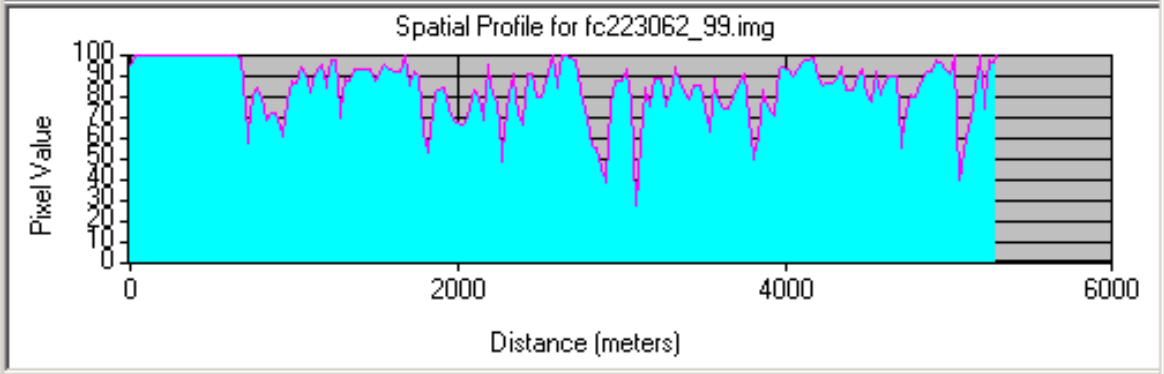




SPATIAL PROFILE #1 --> Viewer #1

File Edit View Help

Plot Layer: 1



Point #	(:Layer 1)
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12	100
13	100
14	100
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17	100
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22	100
23	100
24	98.7415
25	61.7898
26	79.038
27	83.6492
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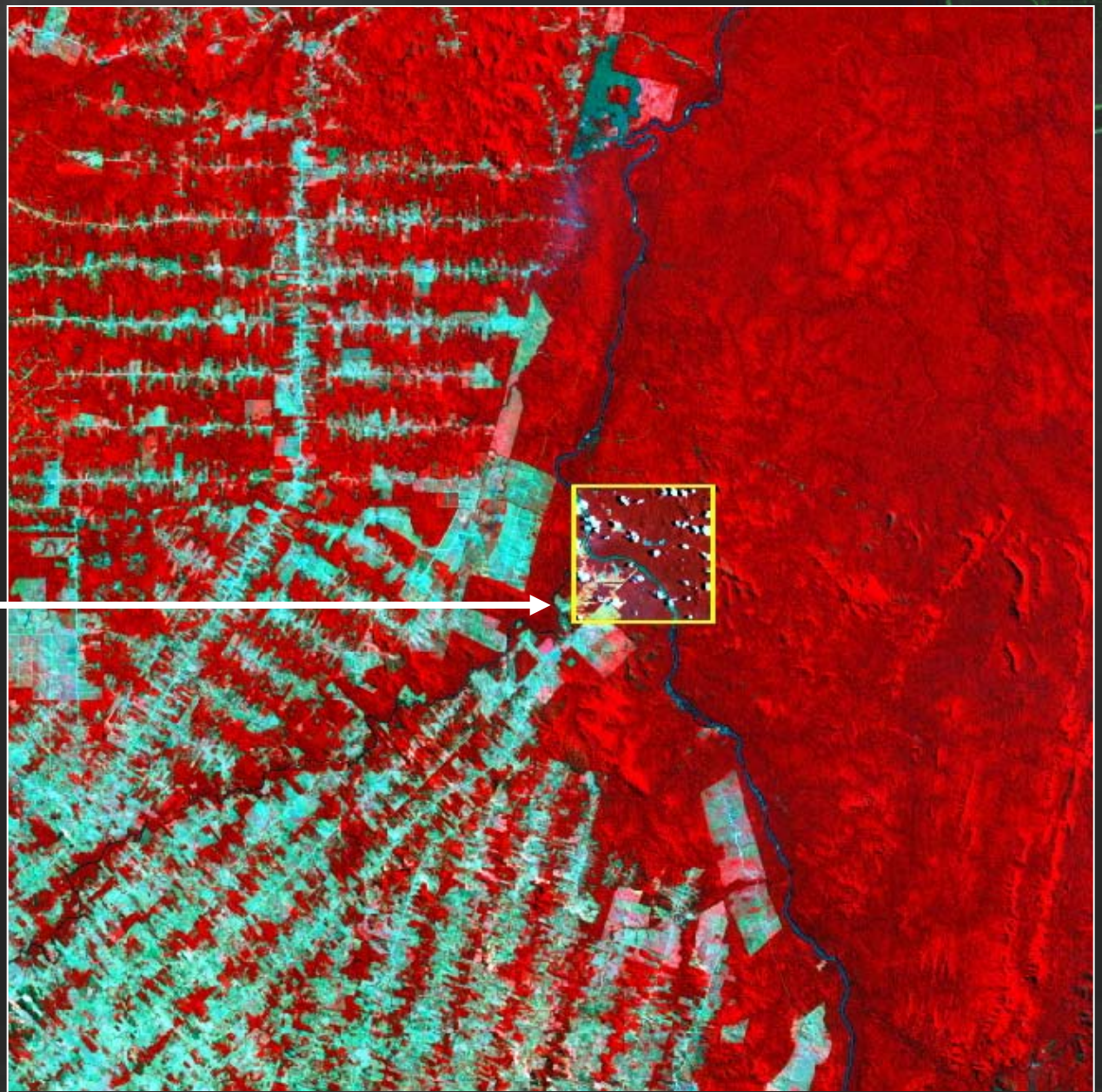
29	68.254
30	71.2821
31	71.1803

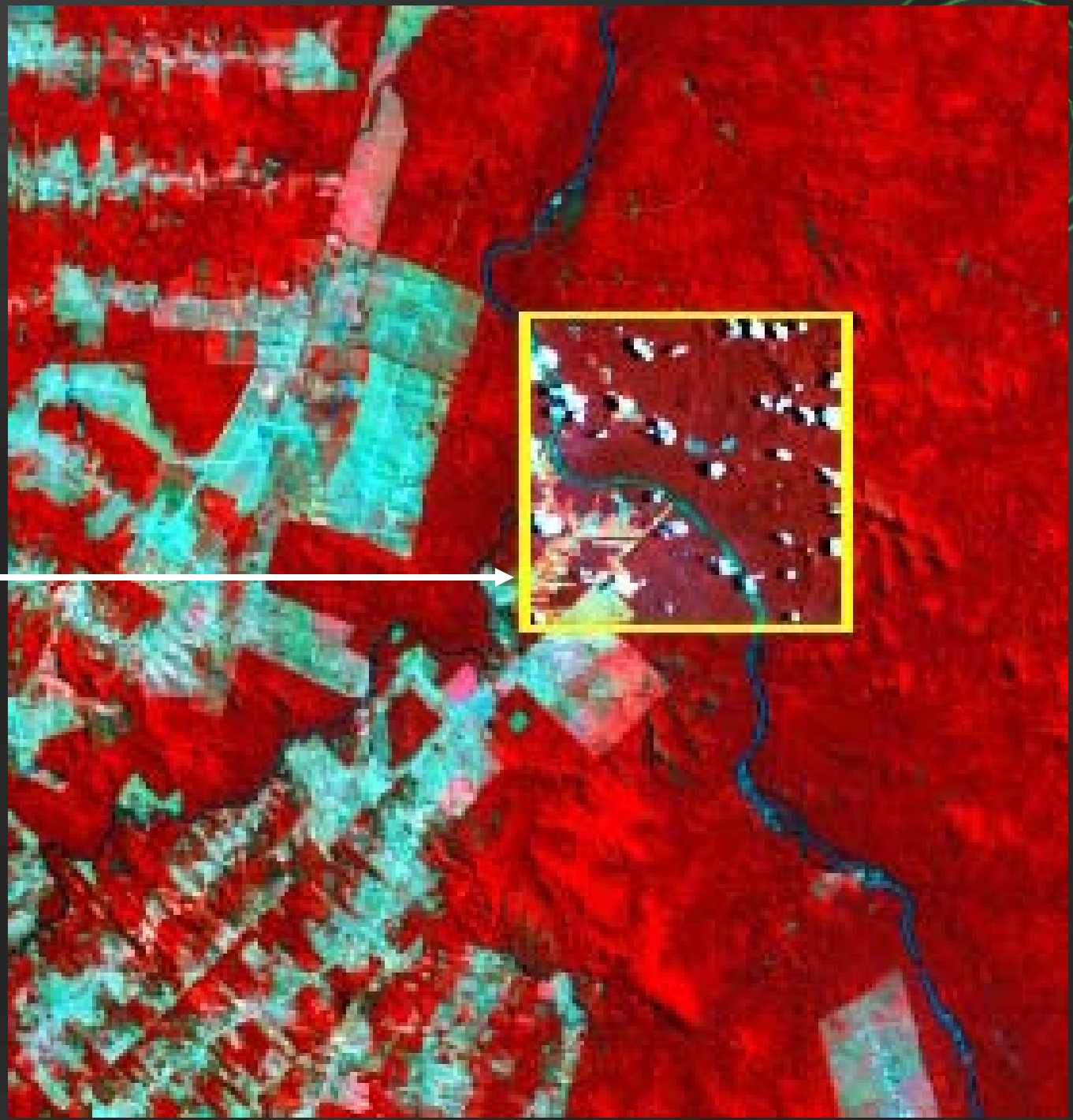
ETM+

IKONOS

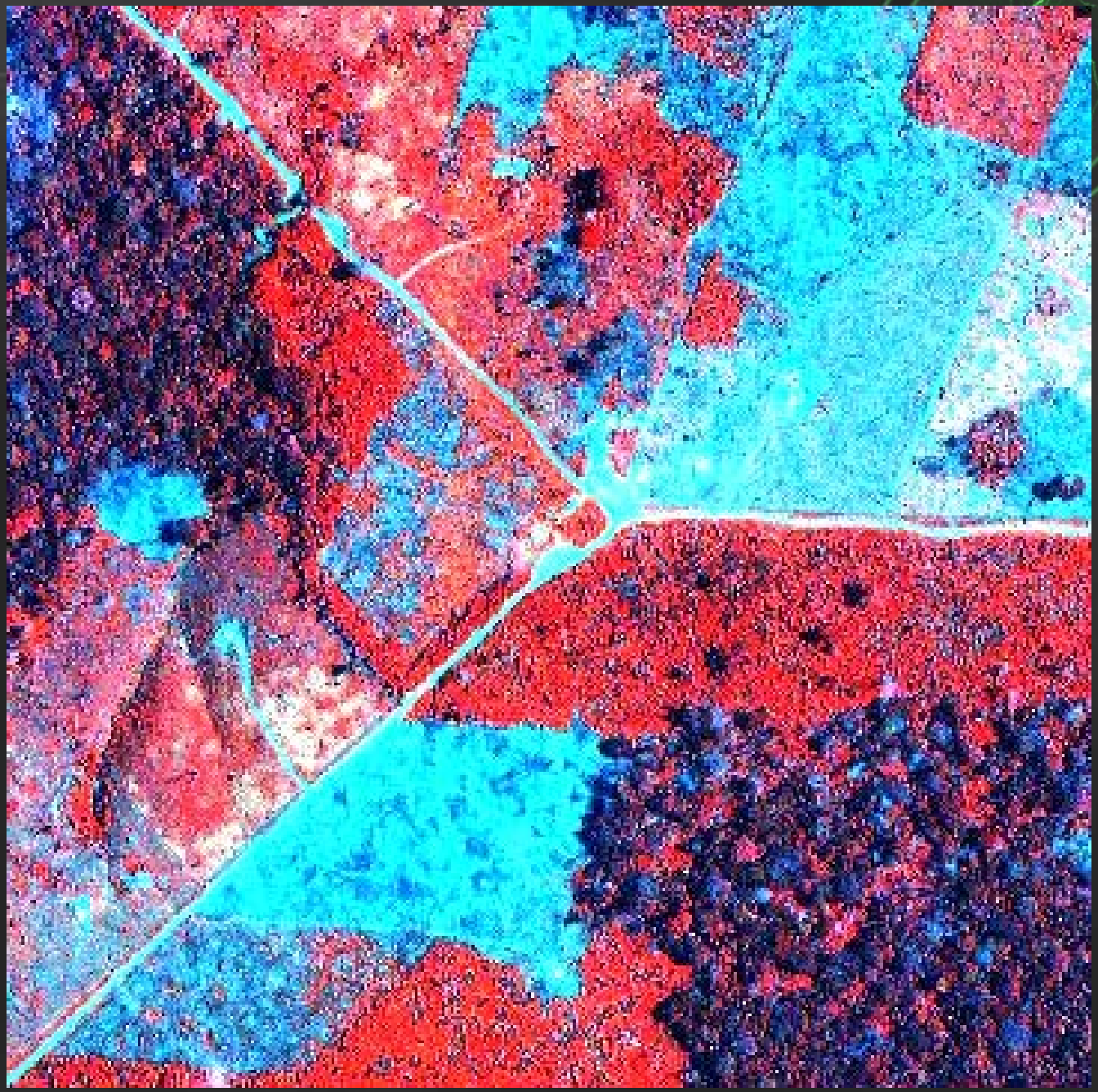


ETM+ →

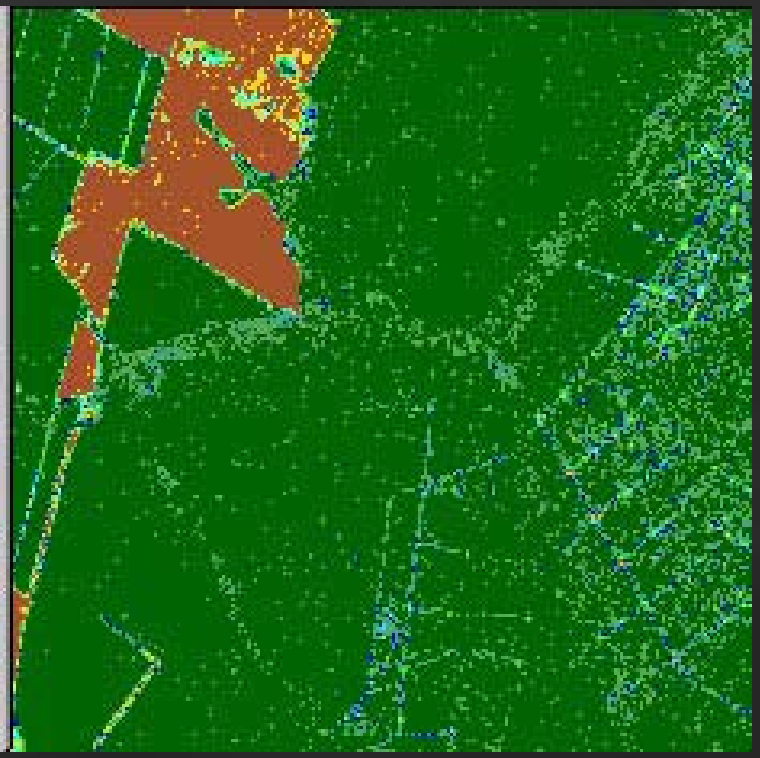
IKONOS →



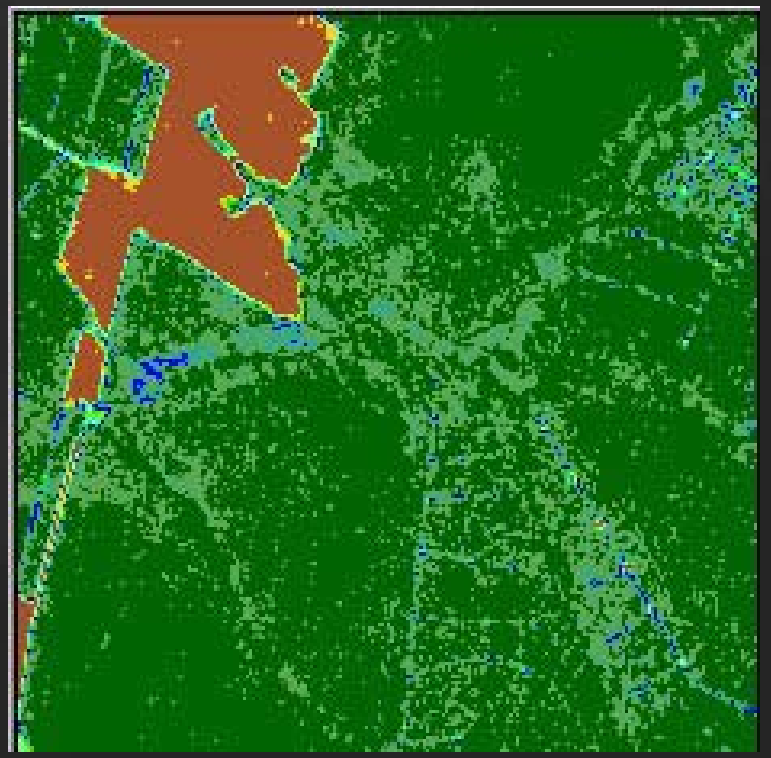
IKONOS



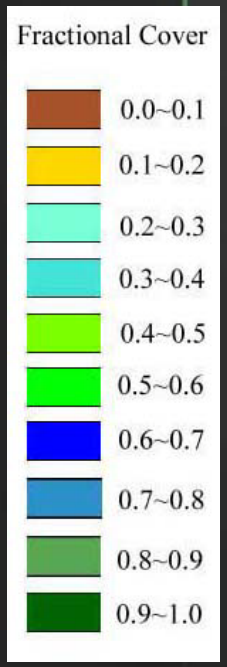
Validation of advanced products



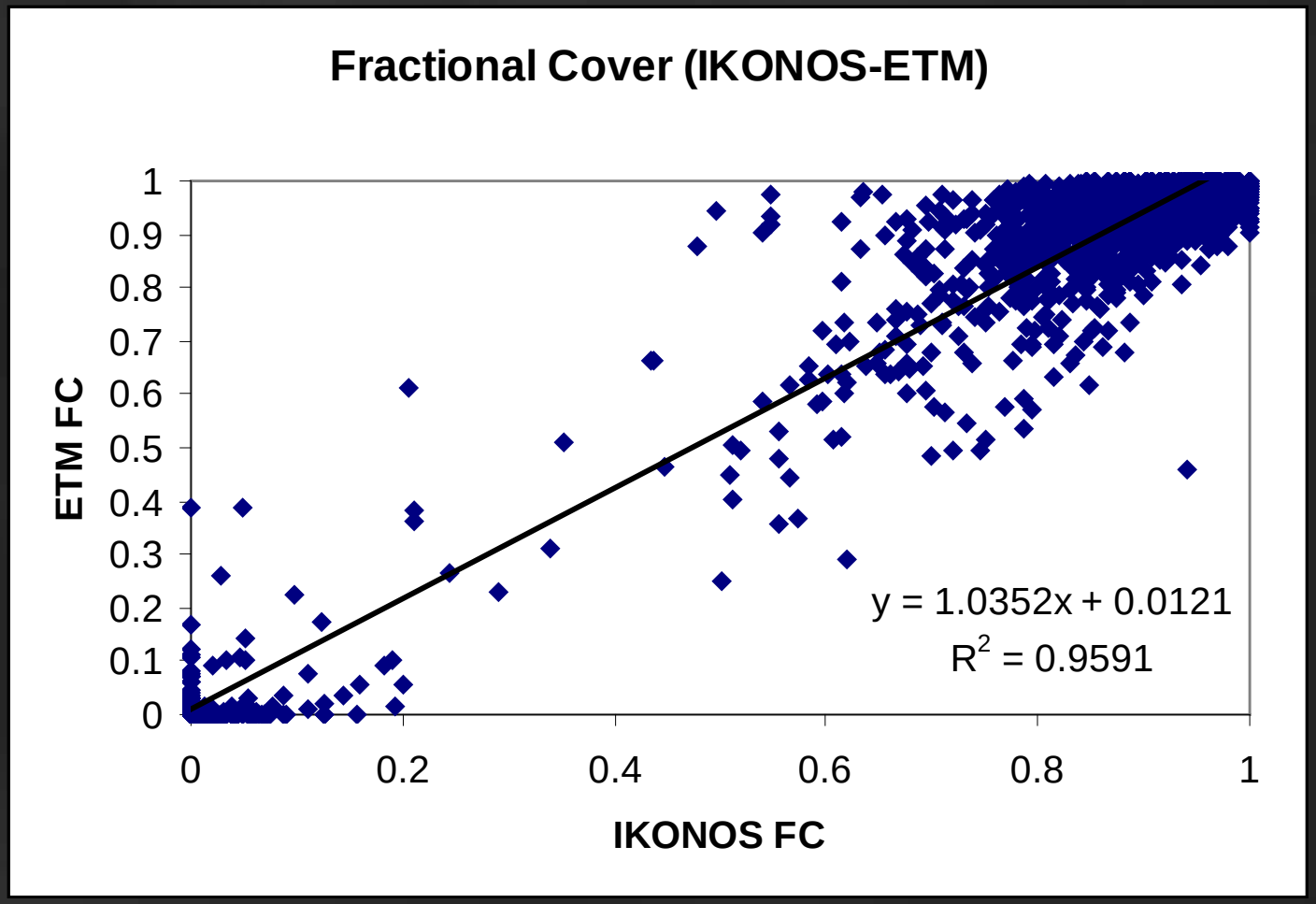
IKONOS fc Map



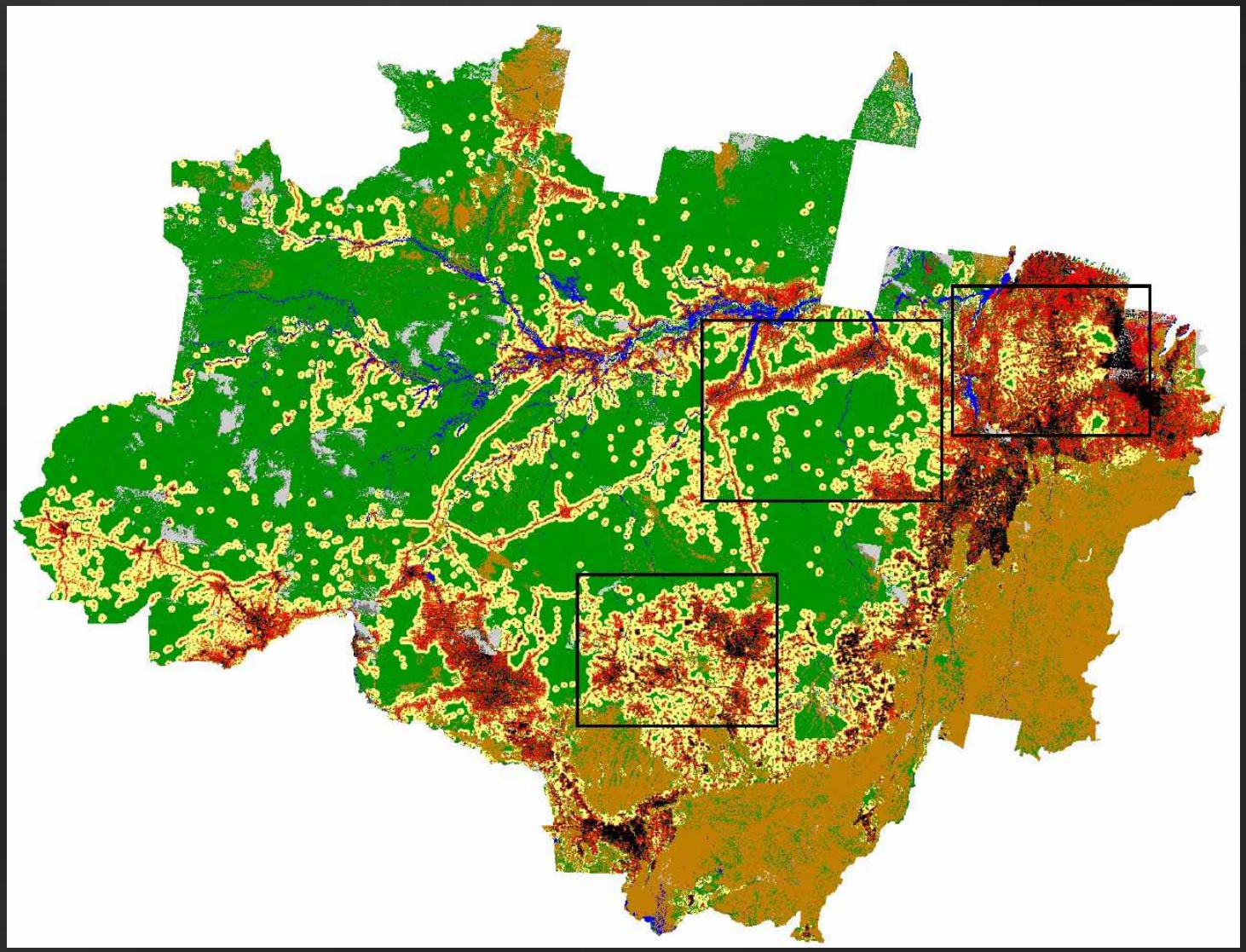
ETM+ fc Map

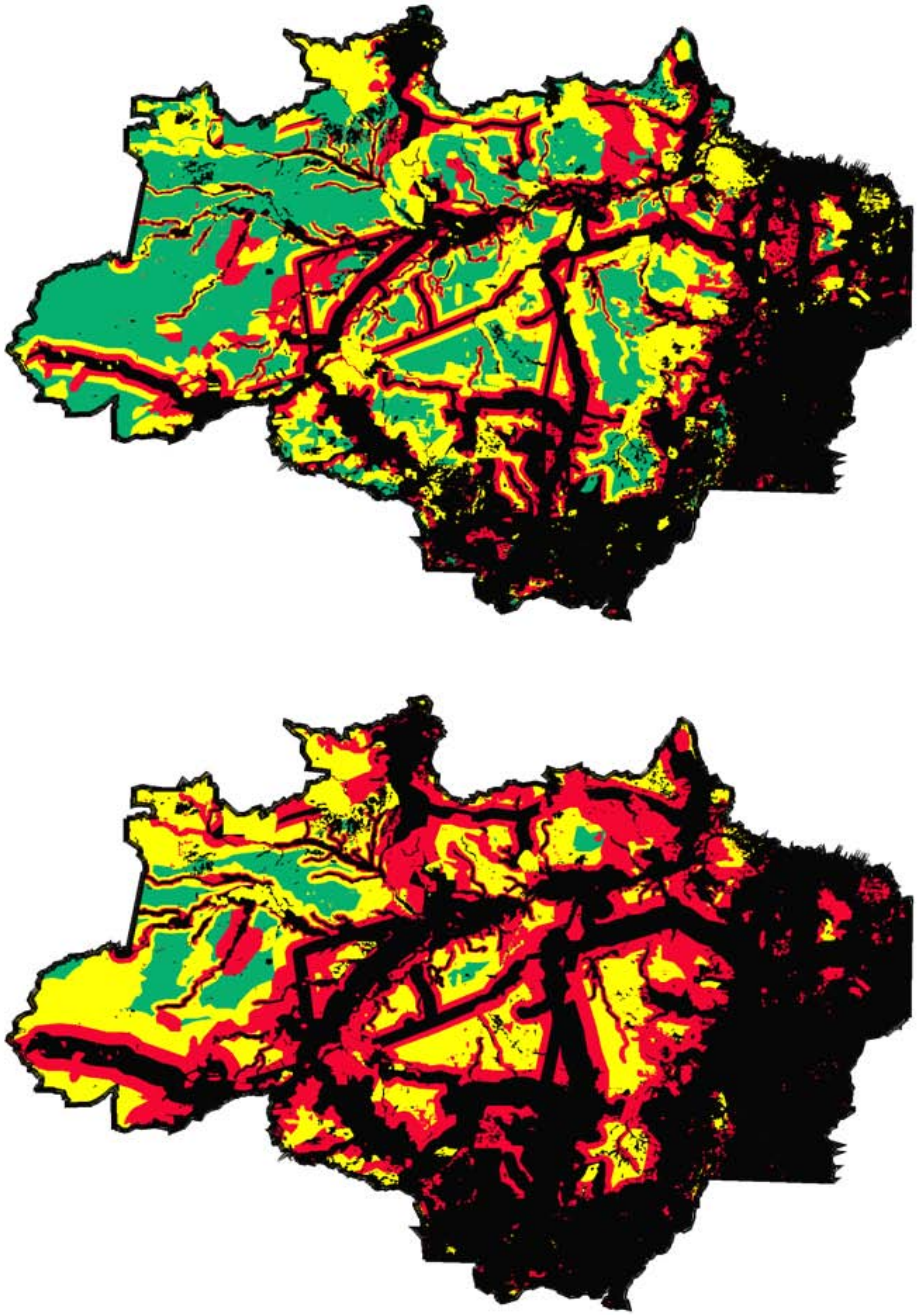


Validation -- Statistical Analysis

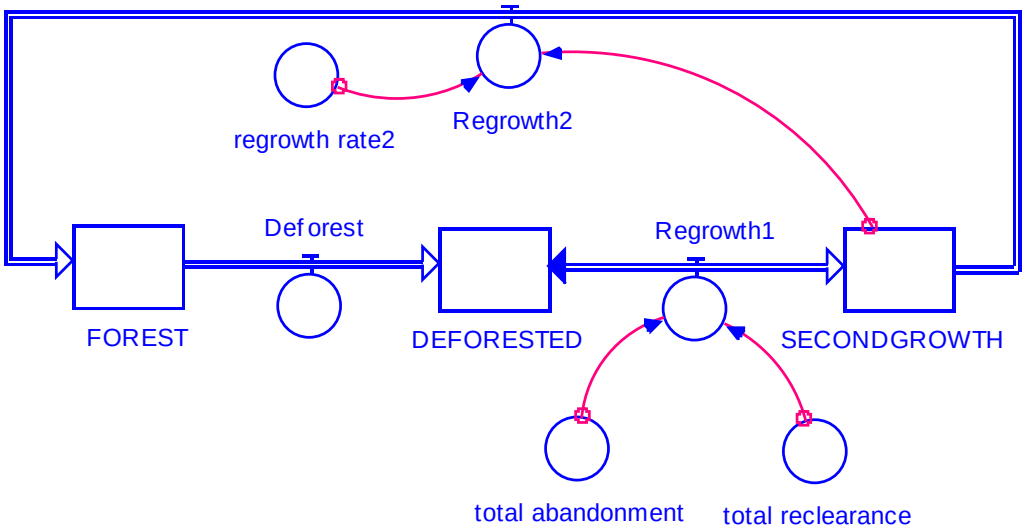


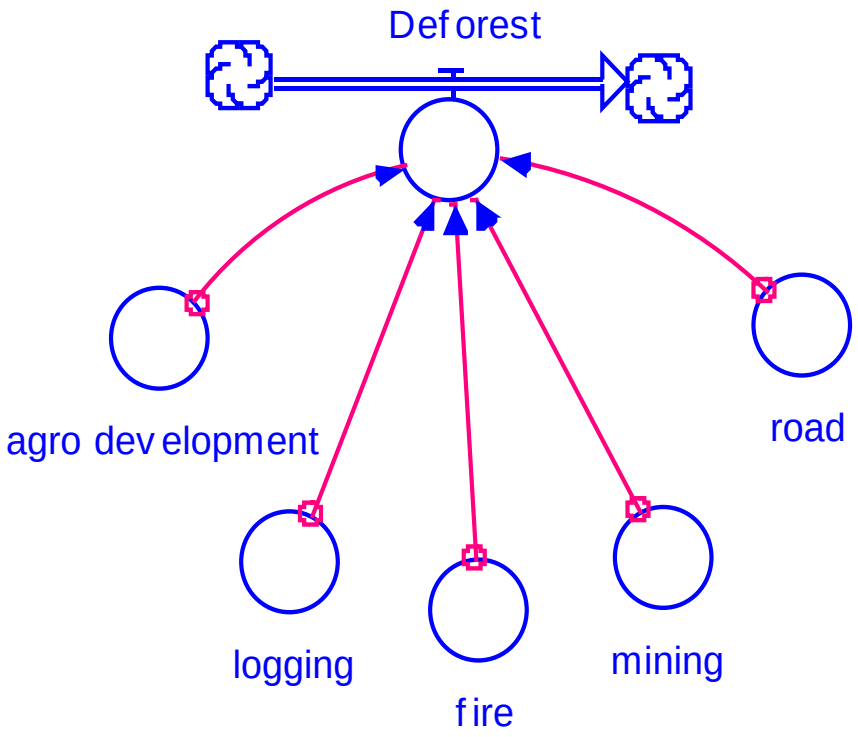
Full Density Range





The basic idea




Deforest
agro development
road
logging
fire
mining

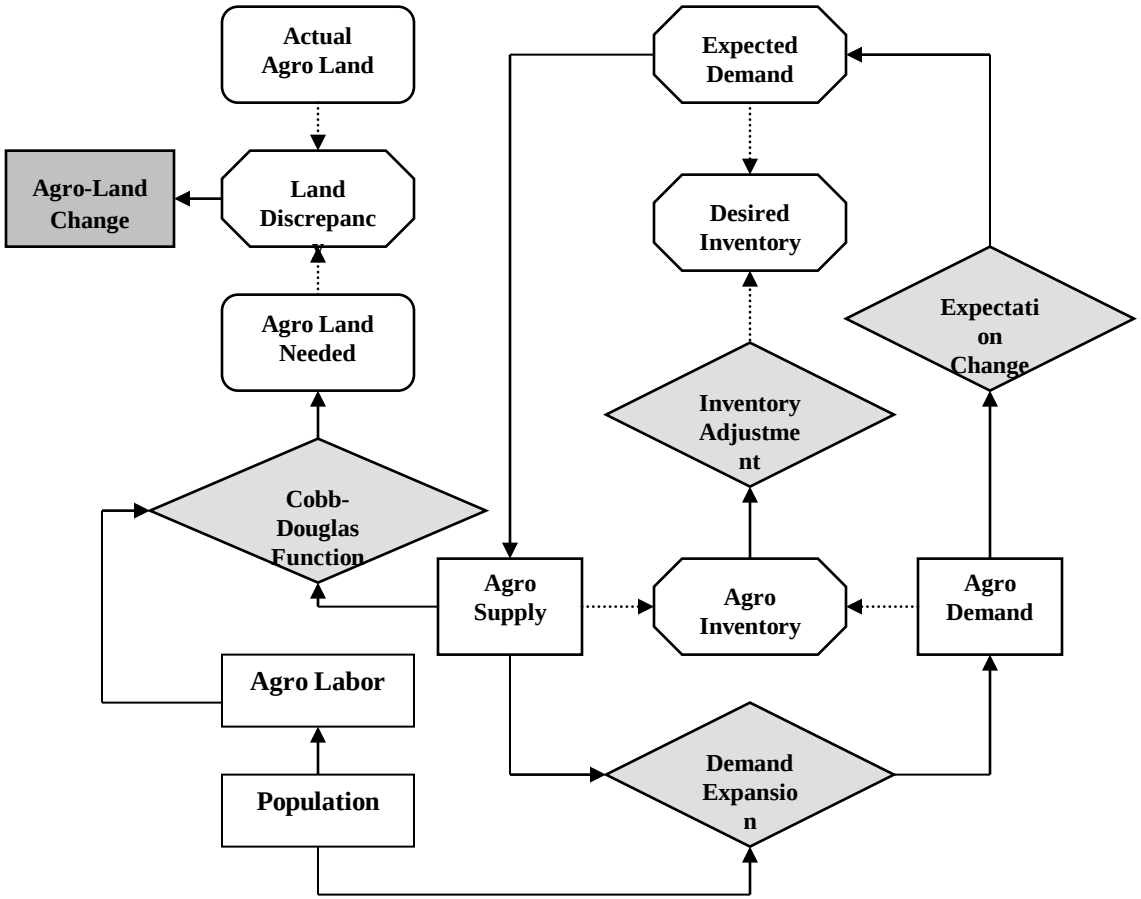
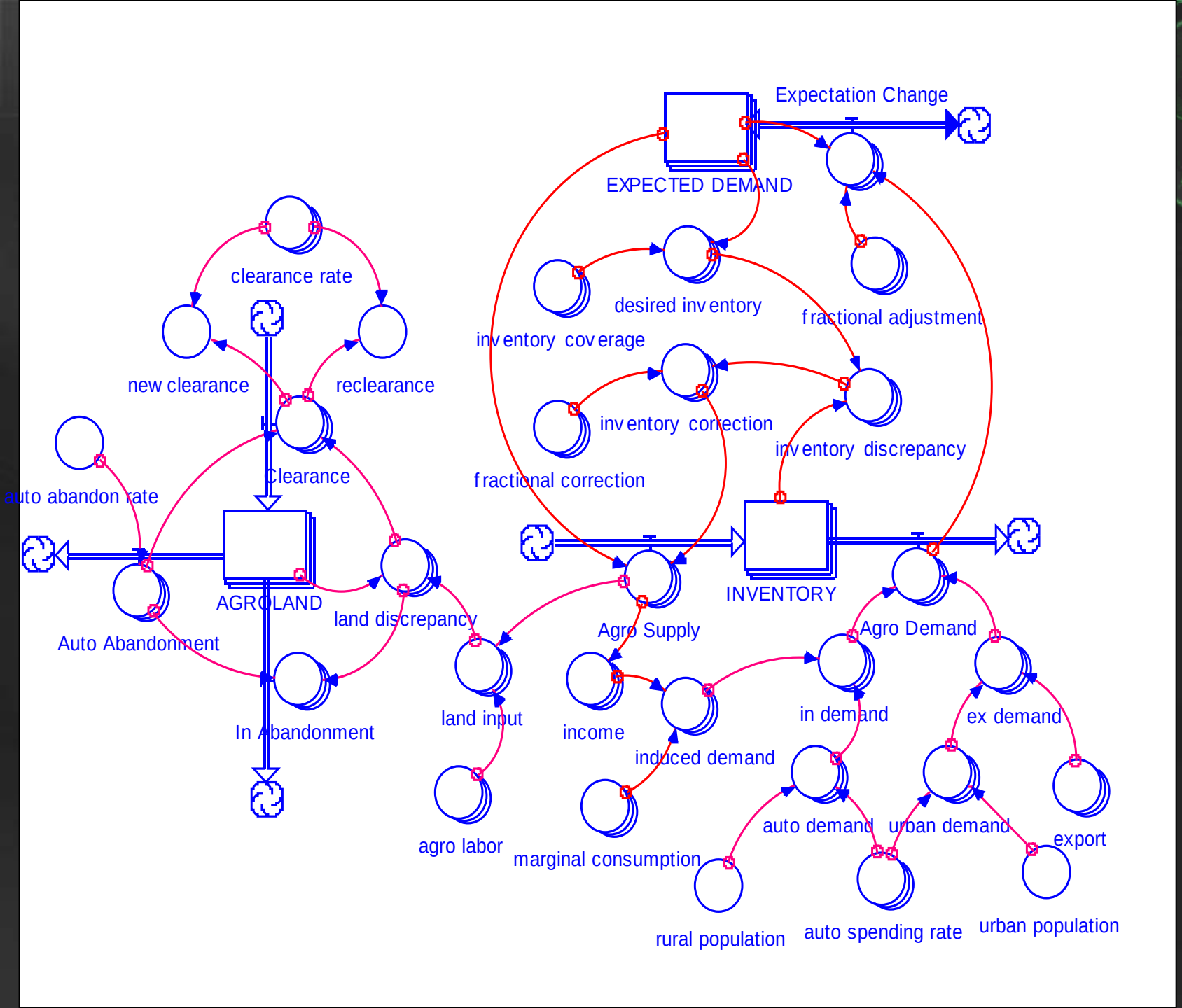
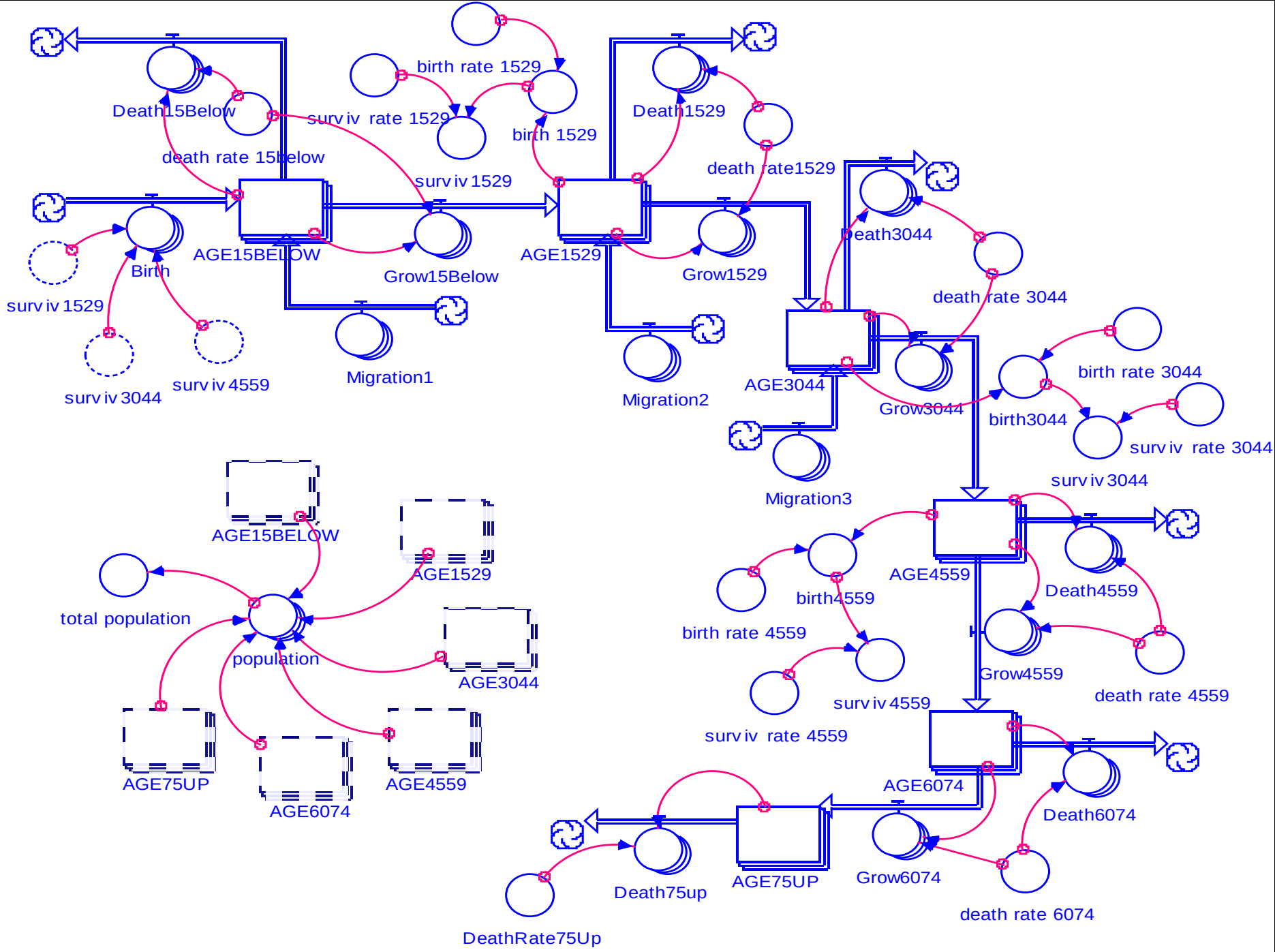
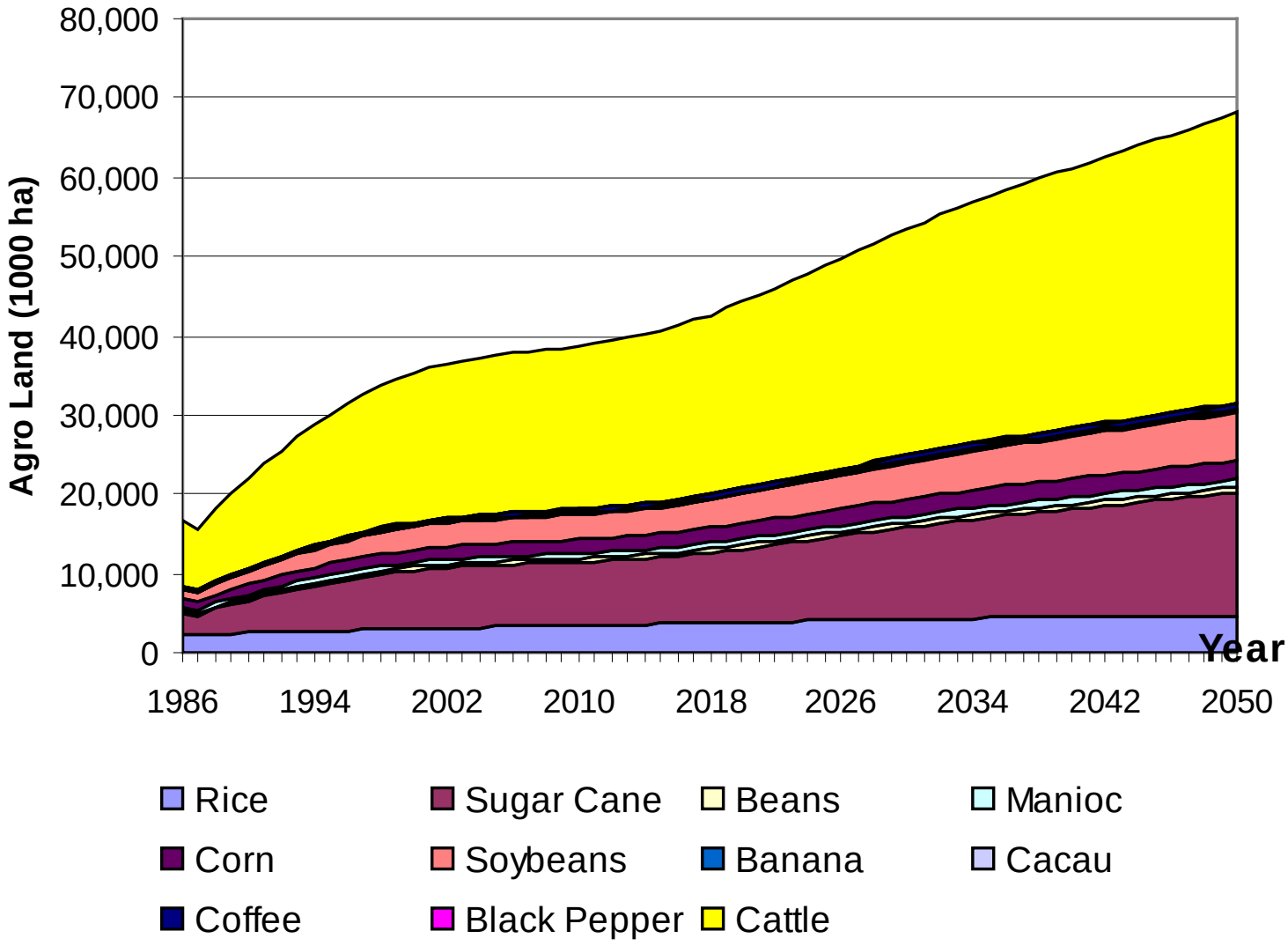
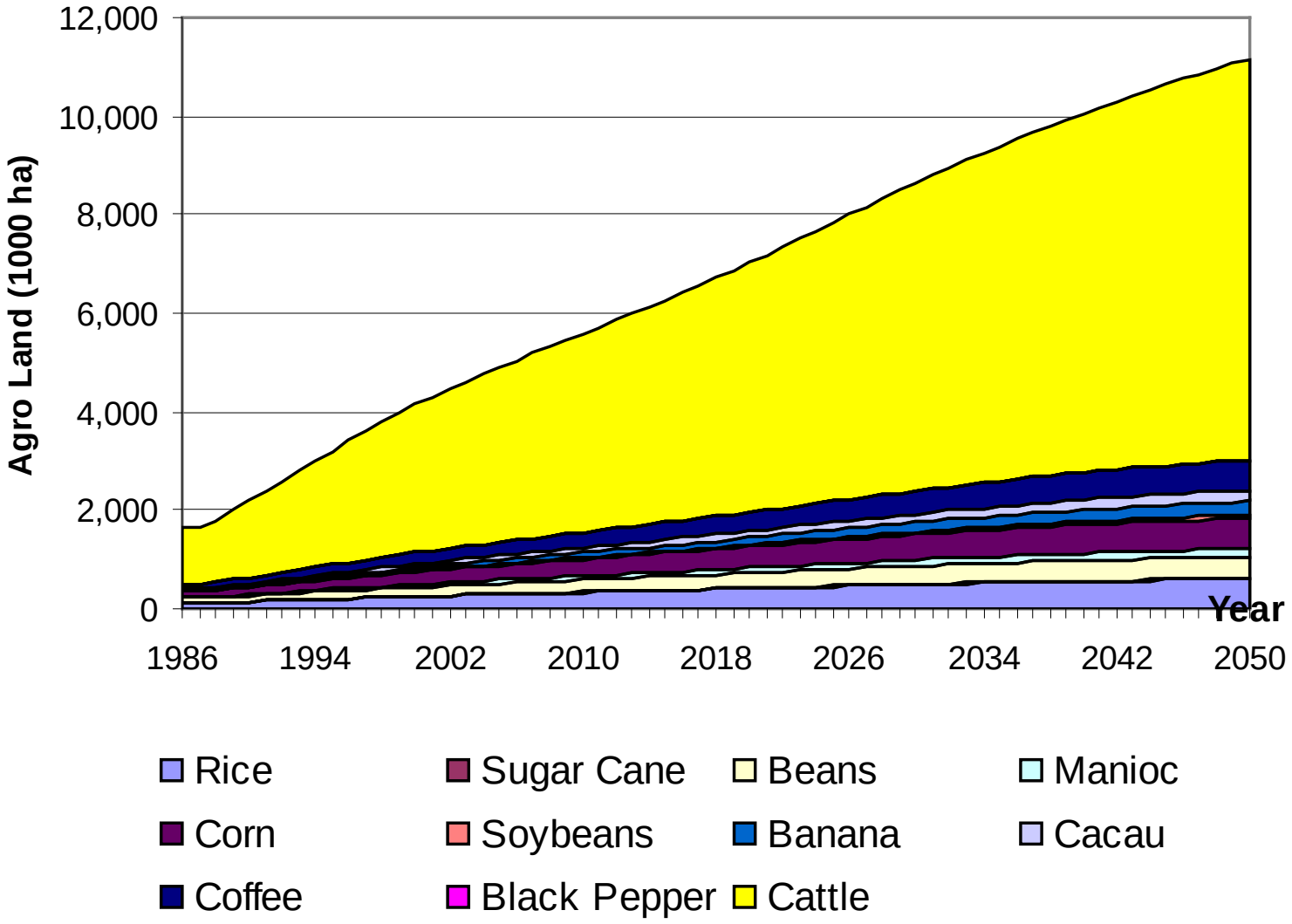


Figure 7: Dynamic agricultural economic growth processes (demand expansion, inventory correction and expectation adjustment) and agricultural land demand through a Cobb-Douglas Production Function


Expectation Change
EXPECTED DEMAND
clearance rate
desired inventory
fractional adjustment
inventory coverage
new clearance
reclearance
inventory correction
inventory discrepancy
Clearance
fractional correction
auto abandon rate
AGRICLAND
INVENTORY
land discrepancy
Agro Supply
Agro Demand
Auto Abandonment
land input
income
in demand
ex demand
In Abandonment
induced demand
agro labor
marginal consumption
auto demand
urban demand
export
rural population
auto spending rate
urban population

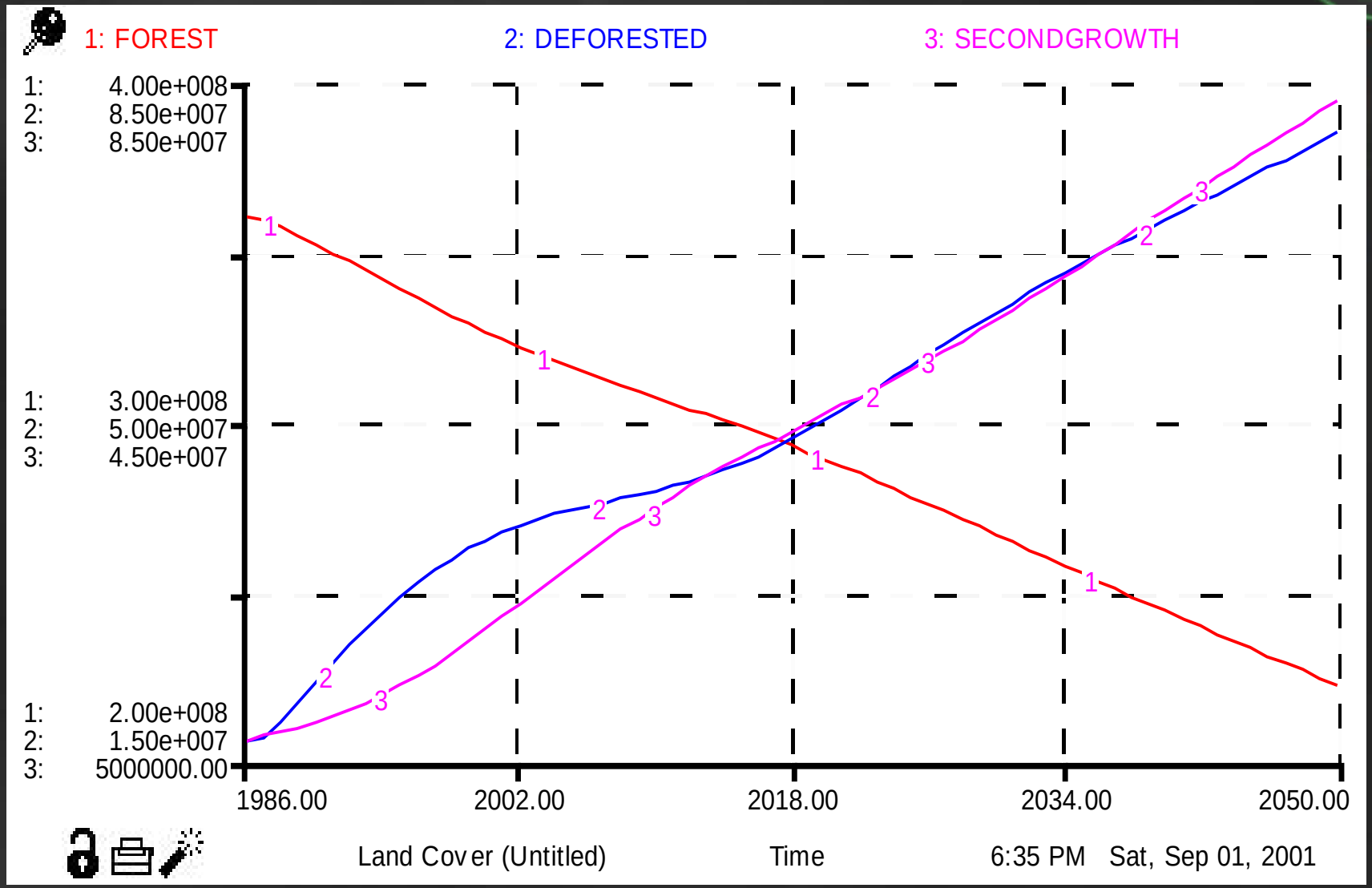

Death15Below
death rate 15below
AGE15BELOW
Birth
surviv 1529
surviv 3044
surviv 4559
Migration1
surviv rate 1529
Grow15Below
birth rate 1529
birth 1529
surviv 1529
AGE1529
Death1529
death rate1529
Grow1529
Migration2
Death3044
death rate 3044
AGE3044
Grow3044
Migration3
birth rate 3044
birth3044
surviv rate 3044
surviv 3044
AGE15BELOW
AGE1529
total population
population
AGE3044
AGE75UP
AGE6074
AGE4559
AGE4559
birth4559
birth rate 4559
surviv 4559
surviv rate 4559
Death4559
Grow4559
death rate 4559
AGE6074
Death6074
Grow6074
death rate 6074
AGE75UP
Death75up
DeathRate75Up

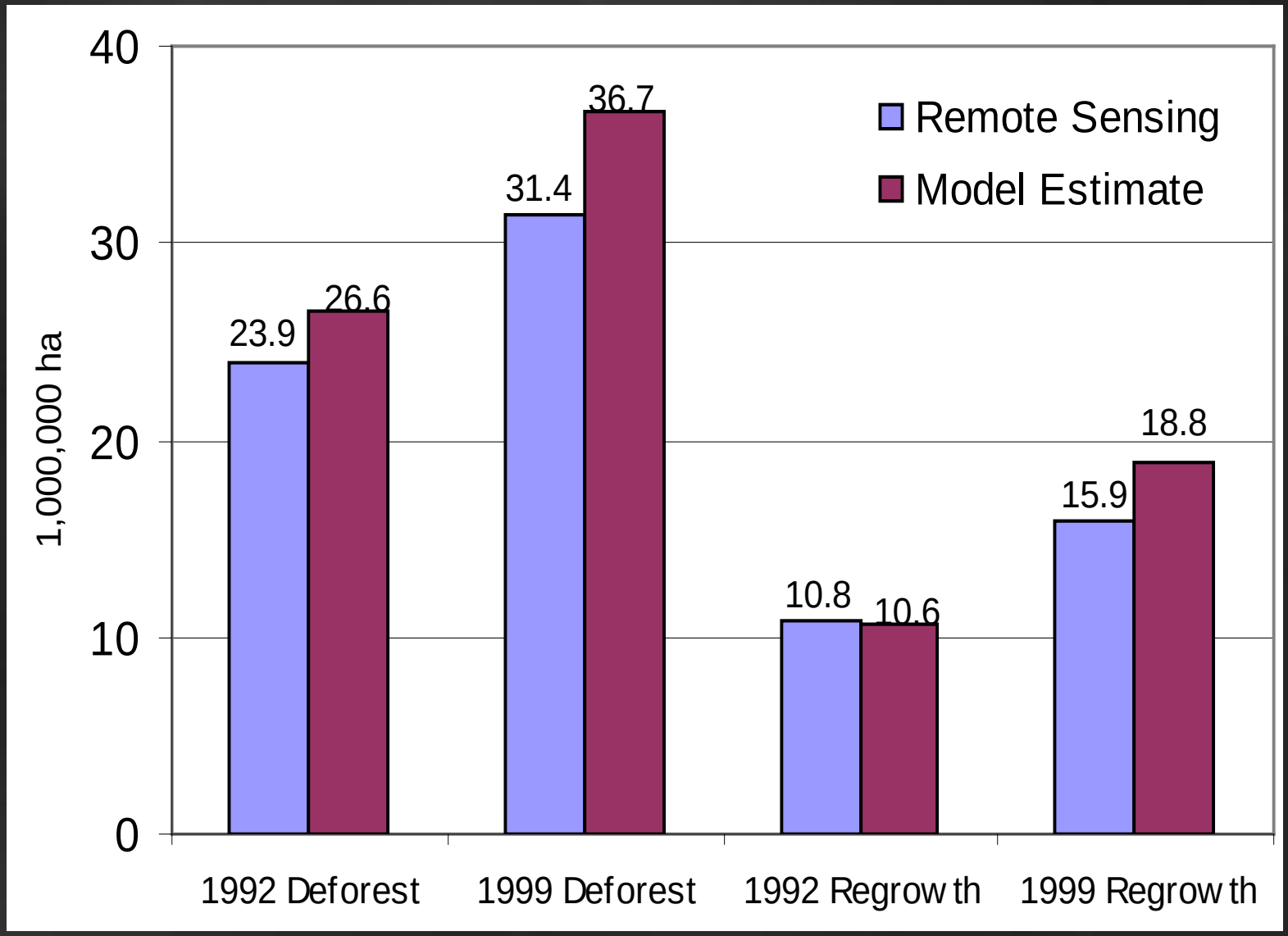

80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Agro Land (1000 ha)
1986
1994
2002
2010
2018
2026
2034
2042
2050
Year
Rice
Sugar Cane
Beans
Manioc
Corn
Soybeans
Banana
Cacau
Coffee
Black Pepper
Cattle


12,000
10,000
8,000
6,000
4,000
2,000
0
Agro Land (1000 ha)
Year
1986
1994
2002
2010
2018
2026
2034
2042
2050
Rice
Sugar Cane
Beans
Manioc
Corn
Soybeans
Banana
Cacau
Coffee
Black Pepper
Cattle

	Brazilian Amazon (1990)			State of Rondonia (1990)		
	Model	Data		Model	Data	
Rice	2,351.0	2,534.6	7.81	149.6	149.6	0.01
Sugarcane	4,565.7	4,521.6	-0.97	0.4	0.4	0.00
Beans	341.3	344.7	0.99	122.1	112.9	-7.56
Manioc	493.4	498.3	1.00	28.6	28.4	-1.00
Corn	1,236.1	1,248.5	1.00	158.0	151.5	-4.11
Soybeans	1,747.0	1,763.2	0.93	9.2	9.1	-1.00
Banana	102.8	103.8	0.94	21.9	21.7	-1.01
Cacau	82.5	82.5	-0.04	38.5	38.3	-0.57
Coffee	247.3	249.4	0.86	138.5	124.2	-10.28
Black Pepper	29.4	30.7	4.25	0.0	0.0	0.00
Cattle	12,699.8	12,703.7	0.03	1,541.0	1554.9	0.91
TOTAL	23,896.3	24,080.9	0.77	2,207.8	2,191.0	-0.76

s E%


1: FOREST
2: DEFORESTED
3: SECONDGROWTH
1: 4.00e+008
2: 8.50e+007
3: 8.50e+007
1: 3.00e+008
2: 5.00e+007
3: 4.50e+007
1: 2.00e+008
2: 1.50e+007
3: 5000000.00
1986.00
2002.00
2018.00
2034.00
2050.00
Land Cover (Untitled)
Time
6:35 PM Sat, Sep 01, 2001


40
30
20
10
0
1,000,000 ha
Remote Sensing
Model Estimate
23.9
26.6
31.4
36.7
10.8
10.6
15.9
18.8
1992 Deforest
1999 Deforest
1992 Regrow th
1999 Regrow th

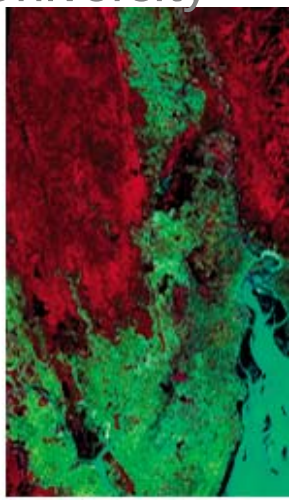
TRFIC

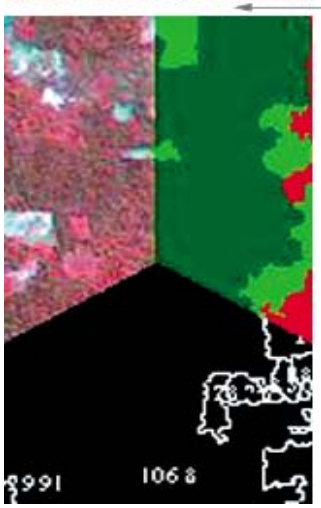
TROPICAL RAIN FOREST INFORMATION CENTER

@ Michigan State University

Collection

Distribution





Processing

Analysis

Earth Science Information Partnership

Tropical Rain Forest Information Center (TRFIC) - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://www.bsrsi.msu.edu/trfic/index.html Go Links

TRFIC

TROPICAL RAIN FOREST INFORMATION CENTER

The Tropical Rain Forest Information Center is a NASA Earth Science Information Partner (ESIP). Our mission is to provide NASA data, products and information services to the science, resource management, and policy and education communities. We provide Landsat and other high resolution satellite remote sensing data as well as digital deforestation maps and databases to a range of users through web-based Geographic Information Systems. We also provide scientific information on the current state of the world's tropical forests, and value-added expert services. *more...*

Data Port
Landsat archive, radar data, on-line ordering...

Data Brokerage
custom acquisitions, data services, co-op...

Products
Maps, Derived Products, Professor's Corner...

Services
Partnering, Consulting...

News & Information
RFRC, events, activities, documents...

Science Program
BSRSI overview, research, facilities...

Contacts
how to reach us...

Notice: we are making changes to this web site on nearly a daily basis. If you have bookmarked specific pages, those bookmarks may need to be updated. Please refresh your browser often and report any broken links to: webmaster@bsrsi.msu.edu -- 6/5/00

NASA

TRFIC has been visited
10649
times since April 5, 2000

ESIP FEDERATION

http://bsrsi.msu.edu/wfw/home.html Internet

MSU TRFIC Map Frame - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://foliage.geo.msu.edu/trficapp/cgi-bin/trfic_cgi.exe?

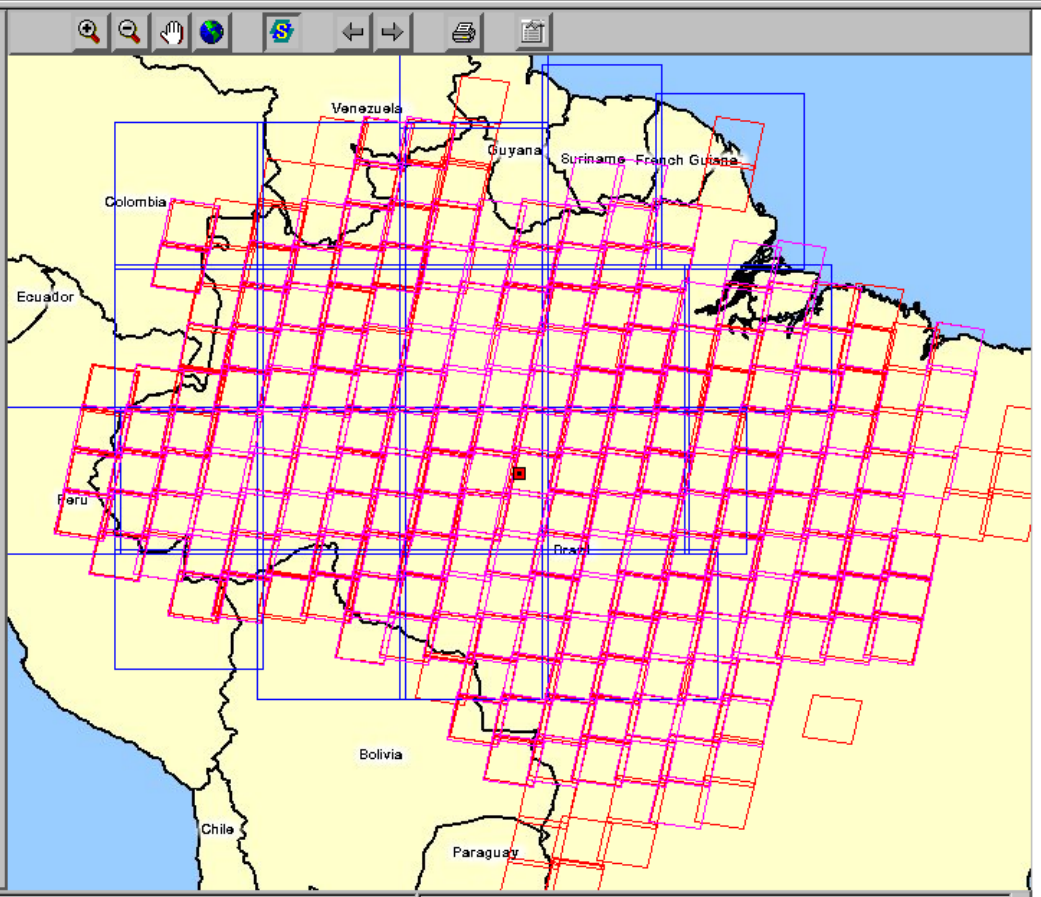
Go Links

Footprints:

- TM - TRFIC (548)
- MSS - TRFIC (0)
- JERS-1 GRFM (21)
- ETM - LS7 (197)
- OTHER (0)

Data Richness:

- No Theme
- All Footprints
- TM - TRFIC
- MSS - TRFIC
- JERS-1 GRFM
- ETM - LS7



Tool: 2210691990062821990/jun/28

Position Long.: -47.3.14 Lat.: -12.22.47

Current Map Extent

-76.51.56 7.25.38
-40.56.24 -21.52.44

Sensor Type

TM,JER,ETM

TM - TRFIC
MSS - TRFIC
JERS-1 GRFM

Year

All

All
1972
1973

Month

All

All
January
February

Cloud Coverage

All

All

Submit

Display	Scene ID	Sensor	Acquired	Path	Row	% Cloud Cover
☐	4066198607032	TM	03/jul/1986	4	66	0
☐	5060199004162	TM	16/apr/1990	5	60	30
☐	5064199008062	TM	06/aug/1990	5	64	0
☐	5067199008062	TM	06/aug/1990	5	67	20
☐	4064199107012	TM	01/jul/1991	4	64	20
☐	5059199201162	TM	16/jan/1992	5	59	10
☐	5063199308302	TM	30/aug/1993	5	63	10
☐	6066199308052	TM	05/aug/1993	6	66	10
☐	6065199308052	TM	05/aug/1993	6	65	10

Complete Order

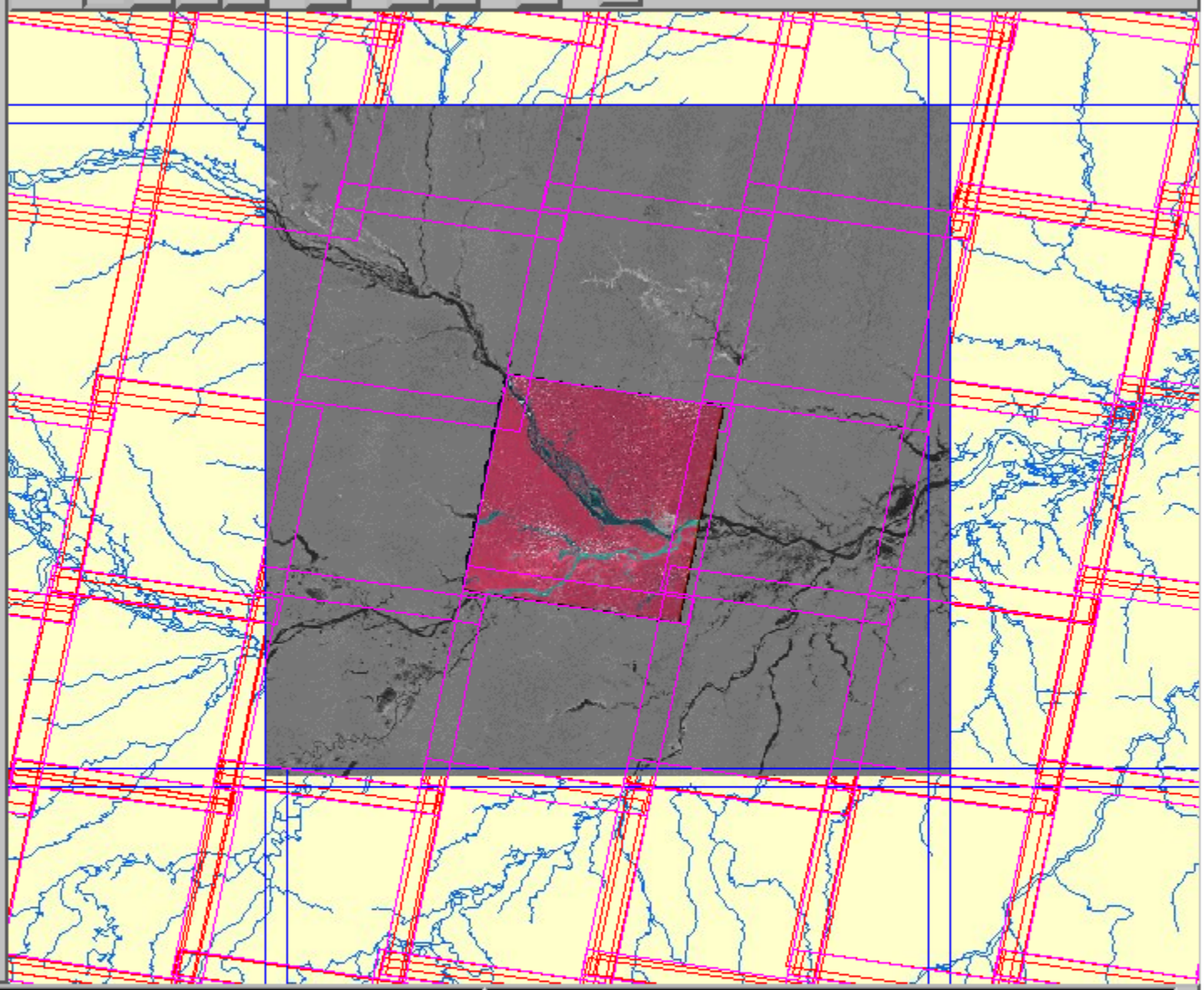
To view a scene in more detail and place an order, click on the 'Scene ID'.

TRFIC Home

Feedback

Done

Internet



M - TRFIC (548)
SS - TRFIC (0)
RS-1 GRFM (21)
TM - LS7 (197)
THER (0)

Richness:
o Theme
Footprints
M - TRFIC
SS - TRFIC
RS-1 GRFM
TM - LS7

Extent
-65.01.23 0.46.58
-56.02.30 -6.32.37

Sensor Type
TM,JER,ETM
TM - TRFIC
MSS - TRFIC
JERS-1 GRFM

Year
All
All
1972
1973

Month
All
All
January
February

Cloud Coverage
All
All

Submit

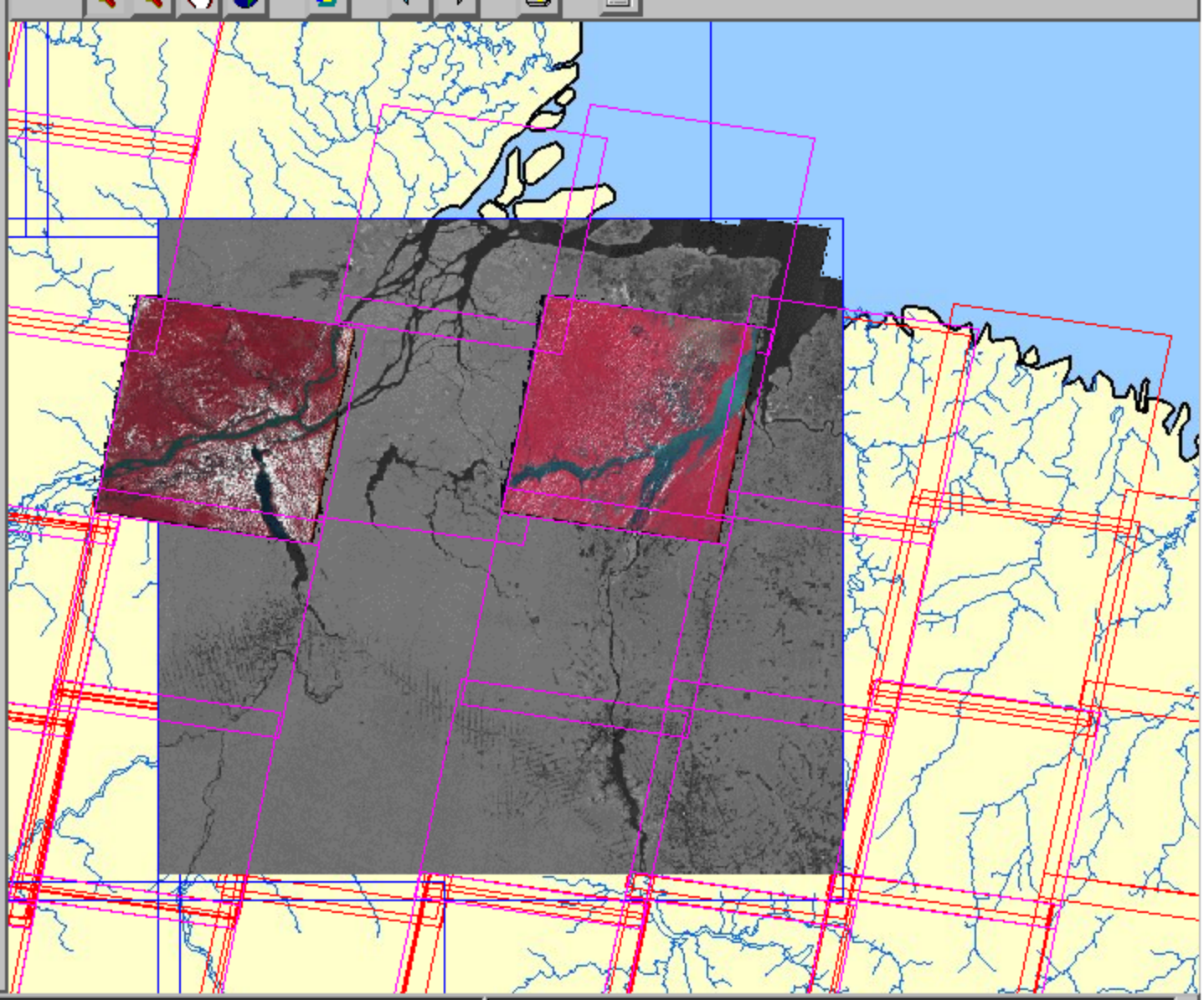
Preferences Dialog

Position Long.: -64.43.57 Lat.: -1.5.11

223061198607172	TM	17/jul/1986	223	61	20
221071198609212	TM	21/sep/1986	221	71	0
221065199006282	TM	28/jun/1990	221	65	0
221066199006282	TM	28/jun/1990	221	66	0
221067199006282	TM	28/jun/1990	221	67	0

Complete Order

To view a scene in more d
and place an order, click o
'Scene ID'.



M - TRFIC (548)
SS - TRFIC (0)
RS-1 GRFM (21)
TM - LS7 (197)
THER (0)

Richness:
o Theme
Footprints
M - TRFIC
SS - TRFIC
RS-1 GRFM
TM - LS7

Zoom out centering map on point clicked

Position Long.: -52.20.26 Lat.: -2.6.35

Extent
-54.12.36 1.33.57
-45.13.43 -5.45.37

Sensor Type
TM,JER,ETM
TM - TRFIC
MSS - TRFIC
JERS-1 GRFM

Year
All
All
1972
1973

Month
All
All
January
February

Cloud Coverage
All
All

Submit

223061198607172	TM	17/jul/1986	223	61	20
221071198609212	TM	21/sep/1986	221	71	0
221065199006282	TM	28/jun/1990	221	65	0
221066199006282	TM	28/jun/1990	221	66	0

Complete Order

To view a scene in more d
and place an order, click o
'Scene ID'.

MSU TRFIC Search - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address ION=&TITLE=&ADDRESS_1=&ADDRESS_2=&CITY=&ZIP=&COUNTRY=&PHONE=&FAX=&REGION_OF_INTEREST=Brazilian+Amazon&AREA=&PRIME_USE_FOR_DATA= Go Links

Search the TRFIC™ Archive

Step 1: Select Sensor Types

Sensor Type: TM - TRFIC | MSS - TRFIC | JERS-1 GRFM

Step 2: Select Date Range(s) (use shift and control keys to select multiple years)

Year: All | 1972 | 1973 | 1974

Month: All | January | February | March

Step 3: Select Cloud Coverage (Select from one of the options below)

Cloud Coverage: All

Step 4: Select the Maximum Number of Scenes Returned:

Return Max. # of Scenes: 1500

Step 5: Select Region / Area of Interest (first choose type, then area)

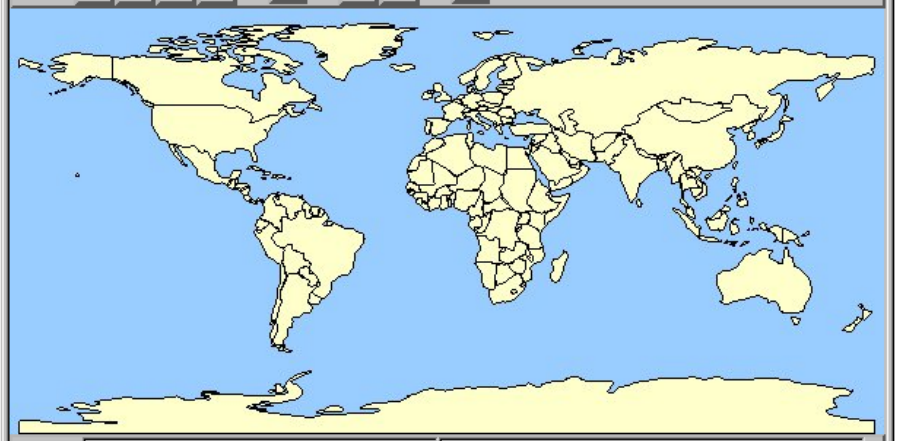
Select Area Type: Country

Upload Shape | Digitize your query area

Country: Brazil

Submit

Map - Microsoft Internet Explorer



Done

Internet

1974 | February | March

Step 3: Select Cloud Coverage (Select from one of the options below)

Cloud Coverage: All

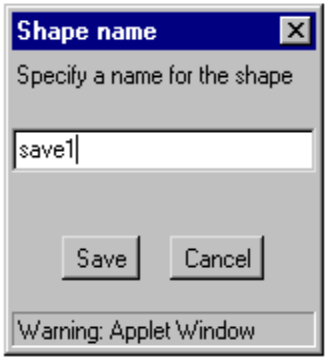
Step 4: Select the Maximum Number of Scenes Returned:

Return Max. # of Scenes: 1500

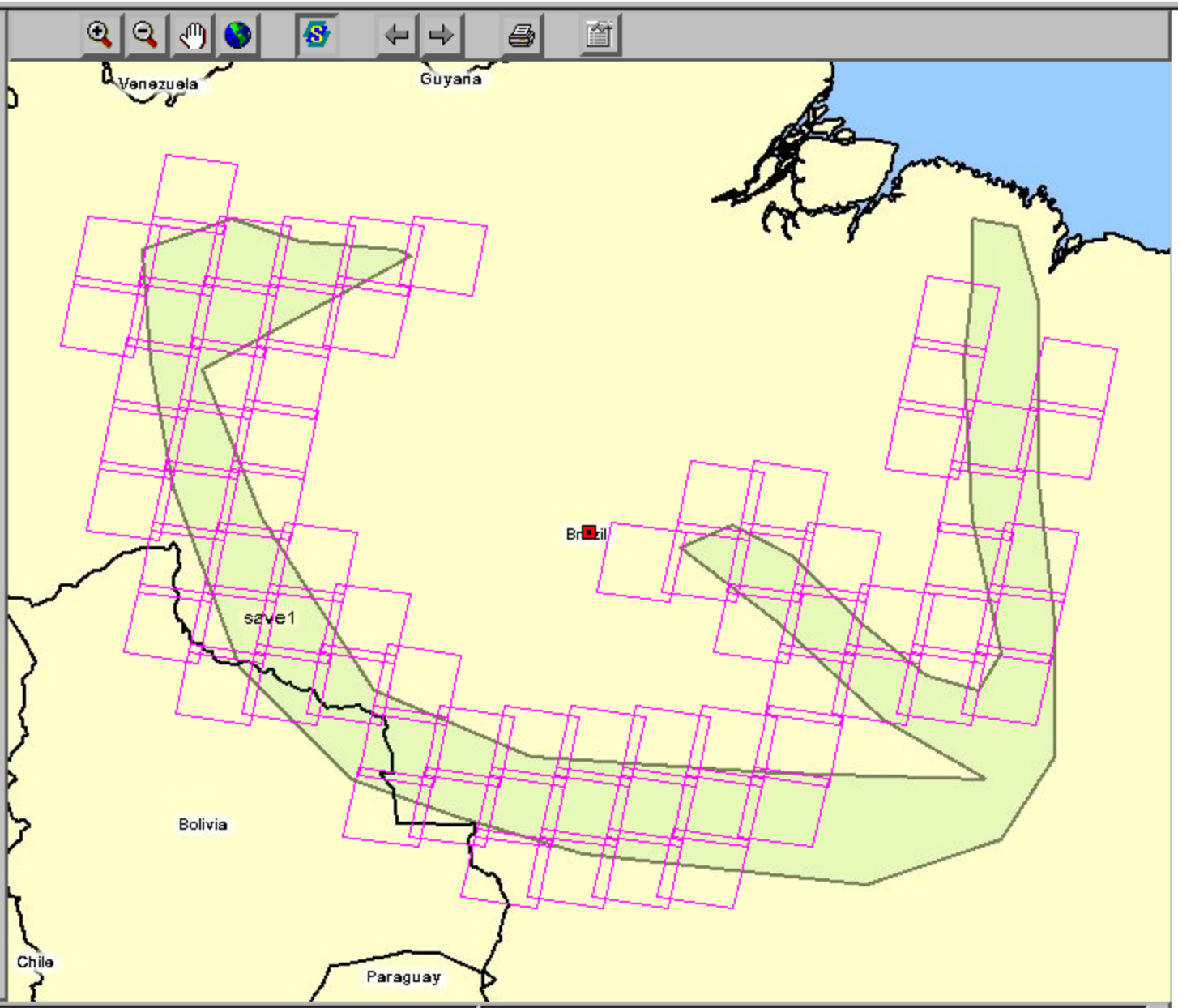
Step 5: Select Region / Area of Interest (first choose type, then area)

Select Area Type: Country | Upload Shape | Digitize your query area

Country: Brazil | Submit



Internet



Position Long.: -50.48.12 Lat.: 1.31.41

Current Map Extent

-69.19.48 1.40.51
-41.56.28 -20.28.29

Sensor Type

ETM

TM - TRFIC
MSS - TRFIC
JERS-1 GRFM

Year

All

All
1972
1973

Month

All

All
January
February

Cloud Coverage

All

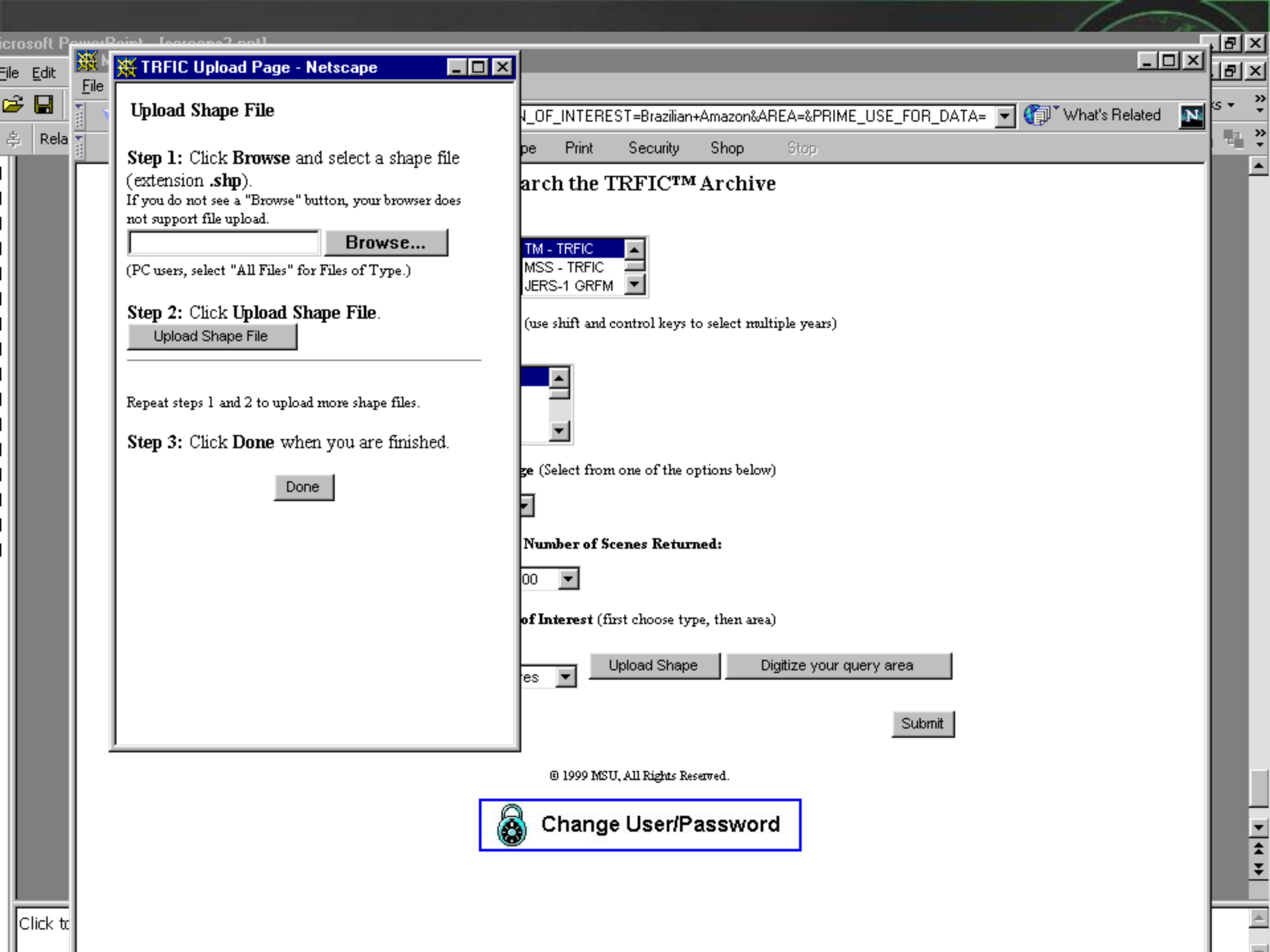
All

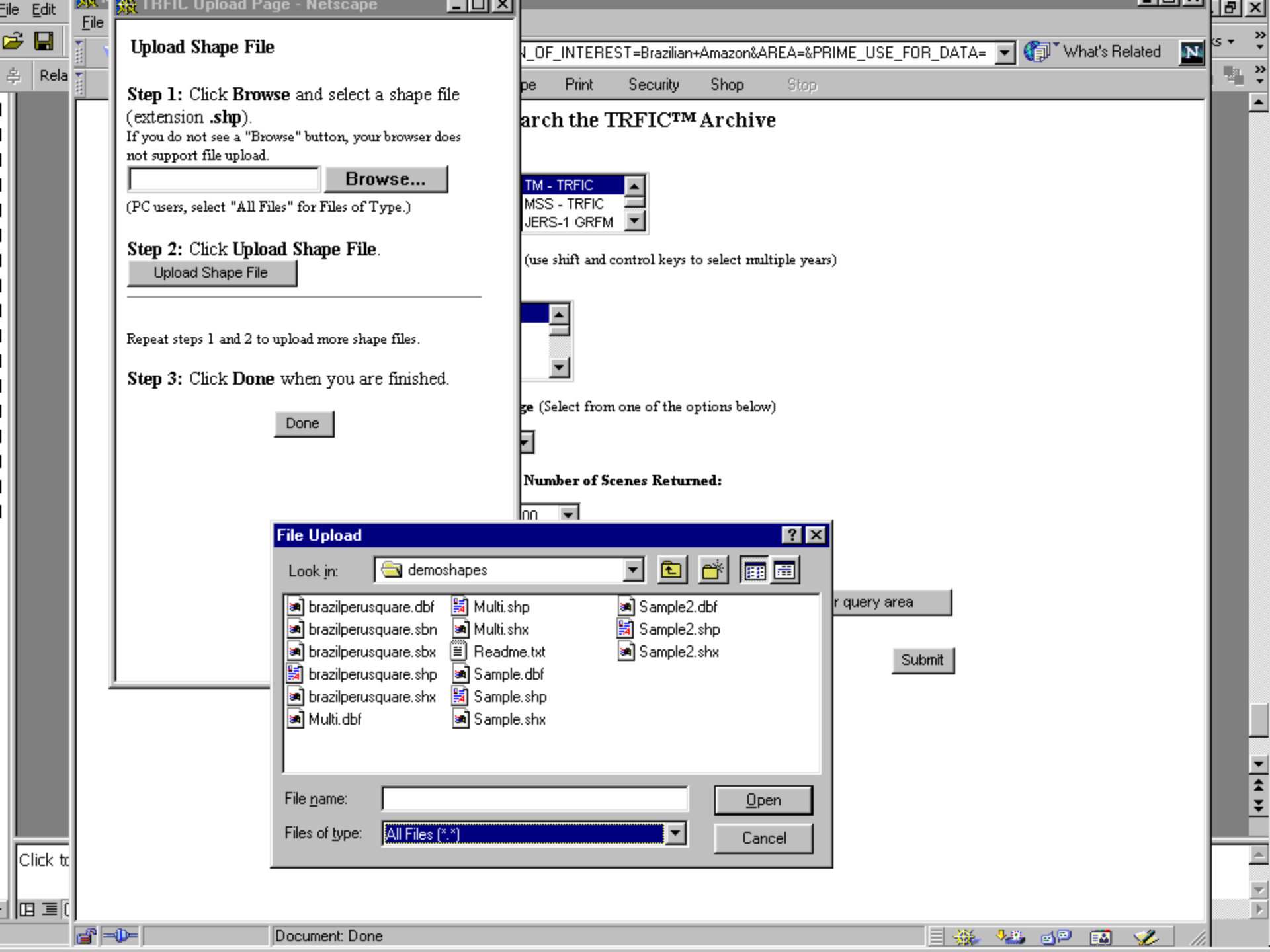
Submit

Scene ID	Sensor	Acquired	Path	Row	% Cloud Cover
1061199910142	ETM	14/oct/99	1	61	19
1062199908272	ETM	27/aug/99	1	62	11
1063200002192	ETM	19/feb/100	1	63	18

Complete Order

To view a scene in more d


TRFIC Upload Page - Netscape
Upload Shape File
Step 1: Click Browse and select a shape file (extension .shp).
If you do not see a "Browse" button, your browser does not support file upload.
Browse...
(PC users, select "All Files" for Files of Type.)
Step 2: Click Upload Shape File.
Upload Shape File
Repeat steps 1 and 2 to upload more shape files.
Step 3: Click Done when you are finished.
Done
What's Related
Print
Security
Shop
Stop
arch the TRFIC™ Archive
TM - TRFIC
MSS - TRFIC
JERS-1 GRFM
(use shift and control keys to select multiple years)
Number of Scenes Returned:
of Interest (first choose type, then area)
Upload Shape
Digitize your query area
Submit
© 1999 MSU, All Rights Reserved.
Change User/Password


TRFIC Upload Page - Netscape
Upload Shape File
Step 1: Click Browse and select a shape file (extension .shp).
If you do not see a "Browse" button, your browser does not support file upload.
Browse...
(PC users, select "All Files" for Files of Type.)
Step 2: Click Upload Shape File.
Upload Shape File
Repeat steps 1 and 2 to upload more shape files.
Step 3: Click Done when you are finished.
Done
N_OF_INTEREST=Brazilian+Amazon&AREA=&PRIME_USE_FOR_DATA=
What's Related
Print
Security
Shop
Stop
arch the TRFIC™ Archive
TM - TRFIC
MSS - TRFIC
JERS-1 GRFM
(use shift and control keys to select multiple years)
ge (Select from one of the options below)
Number of Scenes Returned:
r query area
Submit
File Upload
Look in:
demoshapes
brazilperusquare.dbf
brazilperusquare.sbn
brazilperusquare.sbx
brazilperusquare.shp
brazilperusquare.shx
Multi.dbf
Multi.shp
Multi.shx
Readme.txt
Sample.dbf
Sample.shp
Sample.shx
Sample2.dbf
Sample2.shp
Sample2.shx
File name:
Files of type:
All Files (*.*)
Open
Cancel
Document: Done

File Edit View Go Communicator Help

Bookmarks Location: http://foliage.geo.msu.edu/trficapp/cgi-bin/trfic_cgi.exe? What's Related

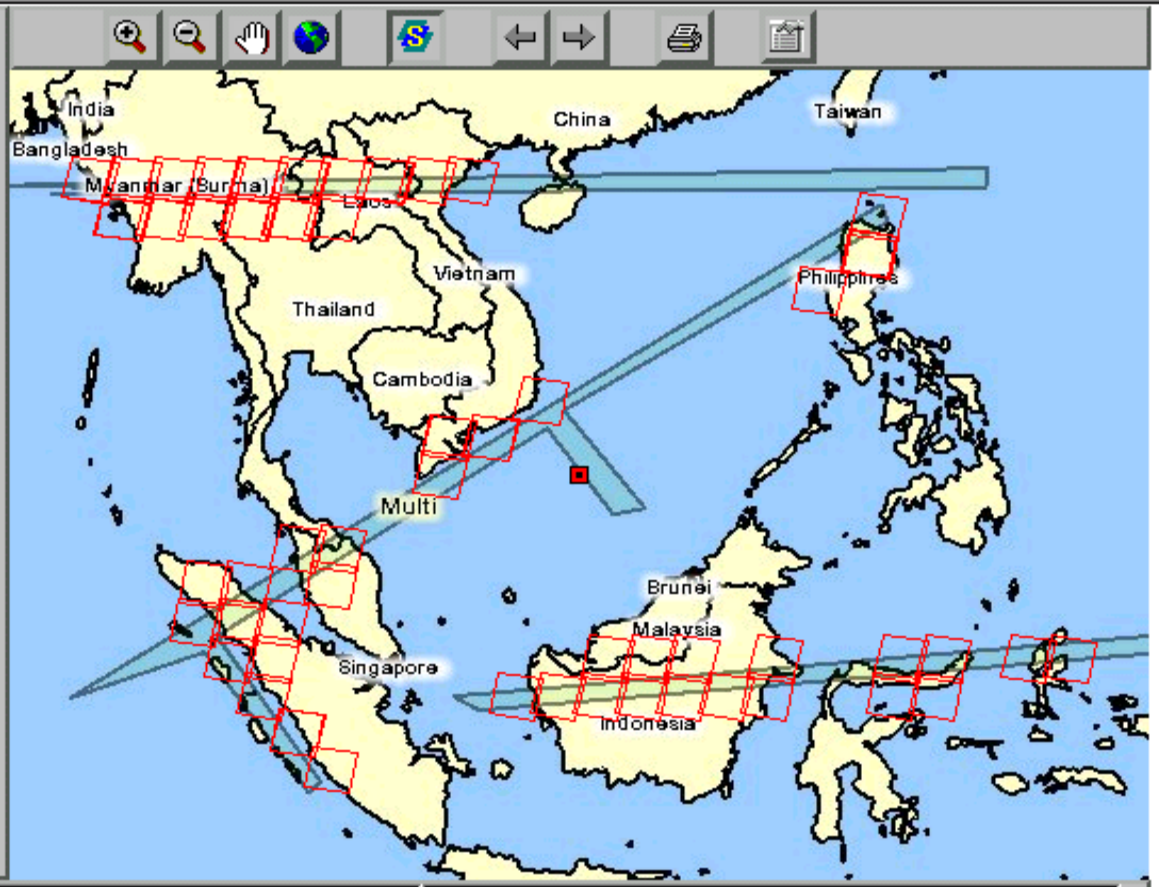
Back Forward Reload Home Search Netscape Print Security Shop Stop

Footprints:

- [x] TM - TRFIC (94)
- [x] MSS - TRFIC (0)
- [x] JERS-1 GRFM (0)
- [x] ETM - LS7 (0)
- [x] OTHER (0)

Data Richness:

- [x] No Theme
- [ ] All Footprints
- [ ] TM - TRFIC
- [ ] MSS - TRFIC
- [ ] JERS-1 GRFM
- [ ] ETM - LS7



Current Map Extent

89.47.59 24.32.46
131.44.10 -7.12.00

Sensor Type

TM

TM - TRFIC
MSS - TRFIC
JERS-1 GRFM

Year

All

All
1972
1973

Month

All

All
January
February

Cloud Coverage

All

All

Submit

Tool:

Display	Scene ID	Sensor	Acquired	Path	Row	% Cloud Cover
☐	127061199005252	TM	25/may/1990	127	61	10
☐	130057199001062	TM	06/jan/1990	130	57	0
☐	127057199102212	TM	21/feb/1991	127	57	10
☐	130058199101092	TM	09/jan/1991	130	58	10
☐	126062199204052	TM	05/apr/1992	126	62	20
☐	128046199211292	TM	29/nov/1992	128	46	0

Complete Order

To view a scene in more detail and place an order, click on the 'Scene ID'.

TRFIC Home

Feedback

Document: Done