ESRI Mid-Atlantic User Group Conference

December 6–7, 2011

Hunt Valley, MD

Four Iterations (1986 '95 2002 '07) of Statewide, Detailed, Land Use Land Cover Mapping for New Jersey, With Comments

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FRAMEWORK and Land Use Land Cover

Organizations are currently concentrating on identifying and using existing information with Intranet and Internet geo-applications.

Many layers nationwide do not contain detailed data required for regulatory agencies or to leverage other Internet applications.

Strained budgets are requiring more coordination just to fund GIS data development projects.

The current national framework model does not include Land Use Land Cover as a layer. Most of the US does not have detailed LULC from which to make critical environmental decision making (as well as many others) in a timely manner.

Since LULC is critical for so many environmental analyses and models.. **A national discussion needs to begin on how states (including counties and muns) can work with federal agencies to build a consistent more detailed LULC framework.**
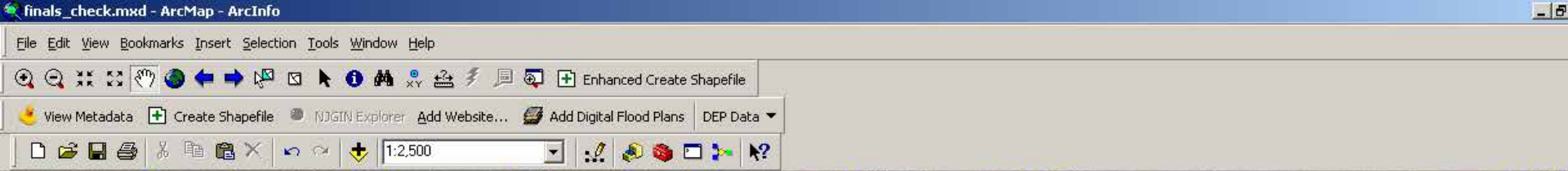
Land Use/Land Cover is the categorization
of human activities and natural elements
on the landscape

2007 Land Use/Land Cover Update

All LU/LC data sets produced using the same basic technique:

Photo-interpretation of aerial imagery.

Modifications due to advances in technology, image resolution and image capture result in more accurate and more detailed delineations:

1986 done using an analog method; 1:24000 scale basemaps; 2.5 acre minimum mapping unit (mmu); 40 categories

1995, 2002 and 2007 done in a digital environment using interactive editing

1995 from 1:12000 scale digital images, 1 meter pixels, scanned aerial photos; 1 acre mmu; added Impervious surface estimates: ~60 categories

2002 from 1:2400 scale digital images; 1 foot pixels, scanned aerial photos; 1 acre mmu; ~75 categories

2007 from 1:2400 scale digital images; 1 foot pixels; direct digital image capture; 1 acre mmu; ~80 categories

Where we started

Photo-basemap: 1:24000 scale original; analog process; positional accuracies +/-60 feet

Where We Are

2007 Color Infrared Digital Image: 1:2400 scale;1 ft. pixels; direct digital image; positional accuracies +/- 4 ft. (95% accuracy)

Classification System: Anderson et al. 1976
Edited for Each Iteration

Classification system used in all LU/LC data sets is a modified *Anderson (1976)* system developed by USGS:

7 major categories: Urban (1000)

Agriculture (2000)

Rangeland (3000)*

Forest (4000)

Water (5000)

Wetlands (6000)

Barren Land (7000)

*No true rangeland in New Jersey

2007 Land Use/Land Cover Update

The classification system is hierarchical so each general category can be further divided into more detailed categories

For example;

1000 Urban (level I)

1100 Residential: (level II)

1110 Multiple Unit, High Den.   (level III)

1120 Single Unit, Medium Den.   "

1130 Single Unit, Low Den.   "

1140 Single Unit, Rural   "

	A	B	C	D	E	F
1	LU/LC 86	LU/LC 95	LU/LC 02	LU/LC	LU/LC NAME	Lu/Lc Name
2						
3				1000	**URBAN OR BUILT-UP LAND**	Urban Or Built-Up Land
4						
5				1100	RESIDENTIAL	Residential
6	**1110**	**1110**	**1110**	**1110**	**Residential (High Density or Multiple dwelling)**	Residential (High Density Or Multiple Dwelling)
7				1111	Single Unit, High Density	Single Unit, High Density
8				1112	Multiple Dwelling, Low Rise (3 stories or less)	Multiple Dwelling, Low Rise (3 Stories Or Less)
9				1113	Multiple Dwelling, High Rise (4 stories or more)	Multiple Dwelling, High Rise (4 Stories Or More)
10	**1120**	**1120**	**1120**	**1120**	**Residential (Single Unit, Medium Density)**	Residential (Single Unit, Medium Density)
11	**1130**	**1130**	**1130**	**1130**	**Residential (Single Unit, Low Density)**	Residential (Single Unit, Low Density)
12	**1140**	**1140**	**1140**	**1140**	**Residential (Rural, Single Unit)**	Residential (Rural, Single Unit)
13	**1150**	**1150**	**1150**	**1150**	**Mixed Residential**	Mixed Residential
14						
15	**1200**	**1200**	**1200**	**1200**	**COMMERCIAL & SERVICES**	Commercial & Services
16				1201	Central Business District (CBD)	Central Business District (Cbd)
17				1202	Commercial Strip Development	Commercial Strip Development
18				1203	Isolated Commercial Establishments for Goods and/or Services	Isolated Commercial Establishments For Goods And/Or Services
19				1204	Isolated Commercial Office Buildings	Isolated Commercial Office Buildings
20				1205	Shopping Centers	Shopping Centers
21				1206	Resorts, Hotels, Motels & Related facilities	Resorts, Hotels, Motels & Related Facilities
22				1207	Educational Institutions	Educational Institutions
23				1208	Health Institutions	Health Institutions
24				1209	Correctional Institutions	Correctional Institutions
25				1210	Government Centers	Government Centers
26	**1211**	**1211**	**1211**	**1211**	**Military Installations**	Military Installations
27				1212	Other Institutional	Other Institutional
28				1213	Mixed Commercial & Services	Mixed Commercial & Services
29	**1214**	**1214**	**1214**	**1214**	**Former Military; Indeterminate Use**	Former Military; Indeterminate Use
30						
31	**1300**	**1300**	**1300**	**1300**	**INDUSTRIAL**	Industrial
32				1310	Light Industrial	Light Industrial
33				1320	Heavy Industrial	Heavy Industrial
34				1330	Power Generation	Power Generation
35						
36	**1400**	**1400**	**1400**	**1400**	**TRANSPORTATION, COMMUNICATION & UTILITIES**	Transportation, Communication & Utilities
37			**1410**	**1410**	**Major Roadway**	Major Roadway
38			**1419**	**1419**	**Bridge Over Water**	Bridge Over Water
39				1420	Railroad Facilities	Railroad Facilities
40				1430	Bus and Truck Terminals	Bus And Truck Terminals

Final

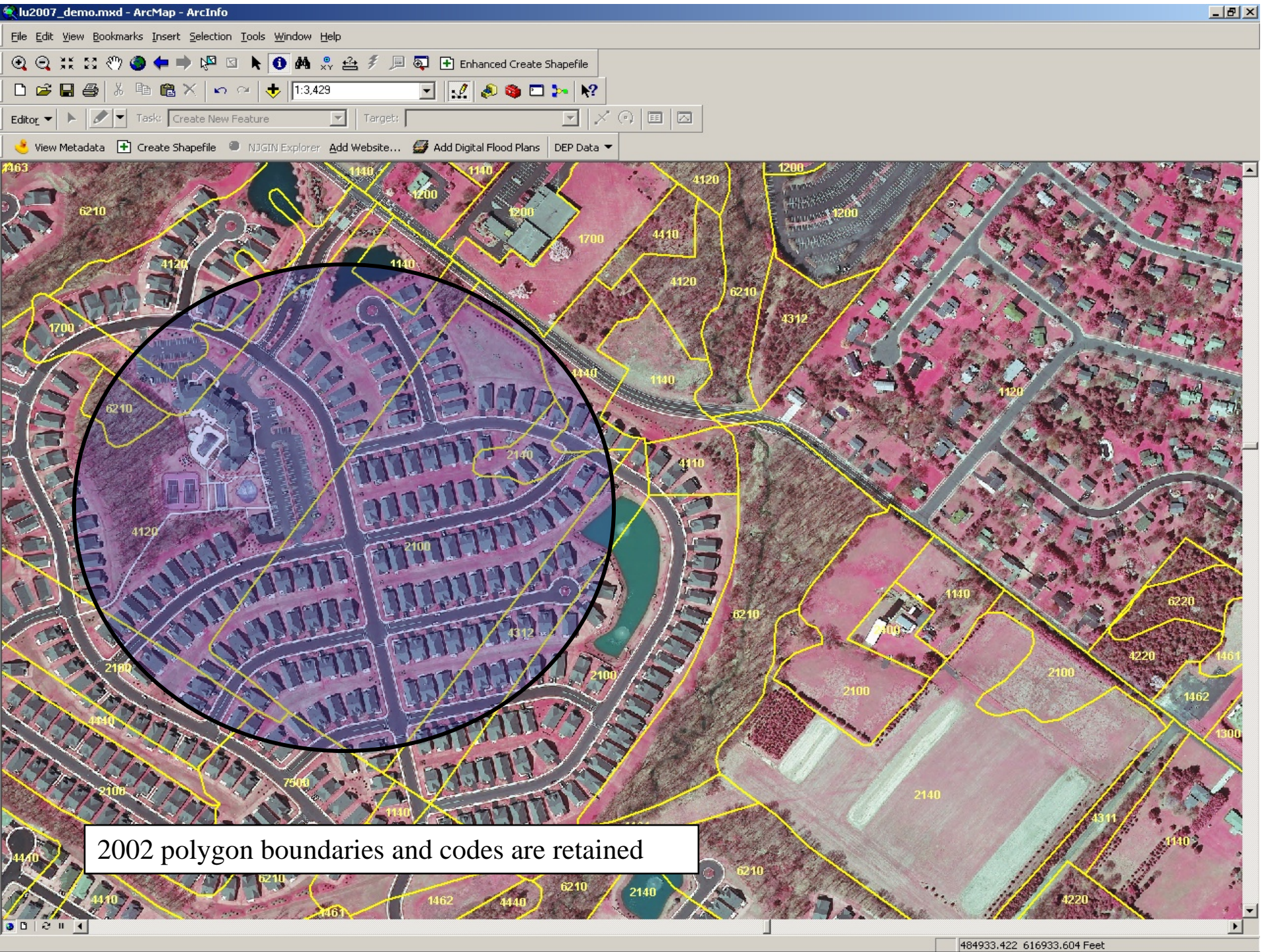|	A	B	C	D	E	F
117				**4000**	**FORESTLAND**	Forestland
118						
119				4100	DECIDUOUS	Deciduous
120	**4110**	**4110**	**4110**	**4110**	**Deciduous, 10-15% Crown Closure**	Deciduous, 10-15% Crown Closure
121	**4120**	**4120**	**4120**	**4120**	**Deciduous, >50% Crown Closure**	Deciduous, >50% Crown Closure
122						
123				4200	CONIFEROUS	Coniferous
124	**4210**	**4210**	**4210**	**4210**	**Coniferous, 10-50% Crown Closure**	Coniferous, 10-50% Crown Closure
125	**4220**	**4220**	**4220**	**4220**	**Coniferous, >50% Crown Closure**	Coniferous, >50% Crown Closure
126	**4230**	**4230**	**4230**	**4230**	**Plantation**	Plantation
127						
128				4300	MIXED DECIDUOUS/CONIFEROUS	Mixed Deciduous/Coniferous
129	4310			4310	Mixed with Coniferous Prevalent (>50% Coniferous)	Mixed With Coniferous Prevalent (>50% Coniferous)
130	**4311**	**4311**	**4311**	**4311**	**Mixed with Coniferous Prevalent (10%-50% Crown Closure)**	Mixed With Coniferous Prevalent (10%-50% Crown Closure)
131	**4312**	**4312**	**4312**	**4312**	**Mixed with Coniferous Prevalent (>50% Crown Closure)**	Mixed With Coniferous Prevalent (>50% Crown Closure)
132	4320			4320	Mixed with Deciduous Prevalent (>50% Deciduous)	Mixed With Deciduous Prevalent (>50% Deciduous)
133	**4321**	**4321**	**4321**	**4321**	**Mixed with Deciduous Prevalent (10%-50% Crown Closure)**	Mixed With Deciduous Prevalent (10%-50% Crown Closure)
134	**4322**	**4322**	**4322**	**4322**	**Mixed with Deciduous Prevalent (>50% Crown Closure)**	Mixed With Deciduous Prevalent (>50% Crown Closure)
135						
136	4400			4400	BRUSHLAND/SHRUBLAND (Height<20 feet)	Brushland/Shrubland (Height<20 Feet)
137	**4410**	**4410**	**4410**	**4410**	**Old Field (<25% Brush Covered)**	Old Field (<25% Brush Covered)
138		**4411**	**4411**		**Phragmites Dominate Old Field**	Phragmites Dominate Old Field
139	**4420**	**4420**	**4420**	**4420**	**Deciduous Brush/Shrubland**	Deciduous Brush/Shrubland
140	**4430**	**4430**	**4430**	**4430**	**Coniferous Brush/Shrubland**	Coniferous Brush/Shrubland
141	**4440**	**4440**	**4440**	**4440**	**Mixed Deciduous/Coniferous Brush/Shrubland**	Mixed Deciduous/Coniferous Brush/Shrubland
142						
143	**4500**	**4500**	**4500**	**4500**	**SEVERE BURNED UPLAND VEGETATION**	Severe Burned Upland Vegetation
144						
145				**5000**	**WATER**	Water
146						
147	**5100**	**5100**	**5100**	**5100**	**STREAMS & CANALS**	Streams & Canals
148				5110	Streams	Streams
149				5120	Canals	Canals
150						
151	**5200**	**5200**	**5200**	**5200**	**NATURAL LAKES**	Natural Lakes
152				5210	Small Lakes	Small Lakes
153				5220	Medium Lakes	Medium Lakes
154				5230	Large Lakes	Large Lakes
155						
156	**5300**	**5300**	**5300**	**5300**	**ARTIFICIAL LAKES & RESERVOIRS**	Artificial Lakes & Reservoirs

Final
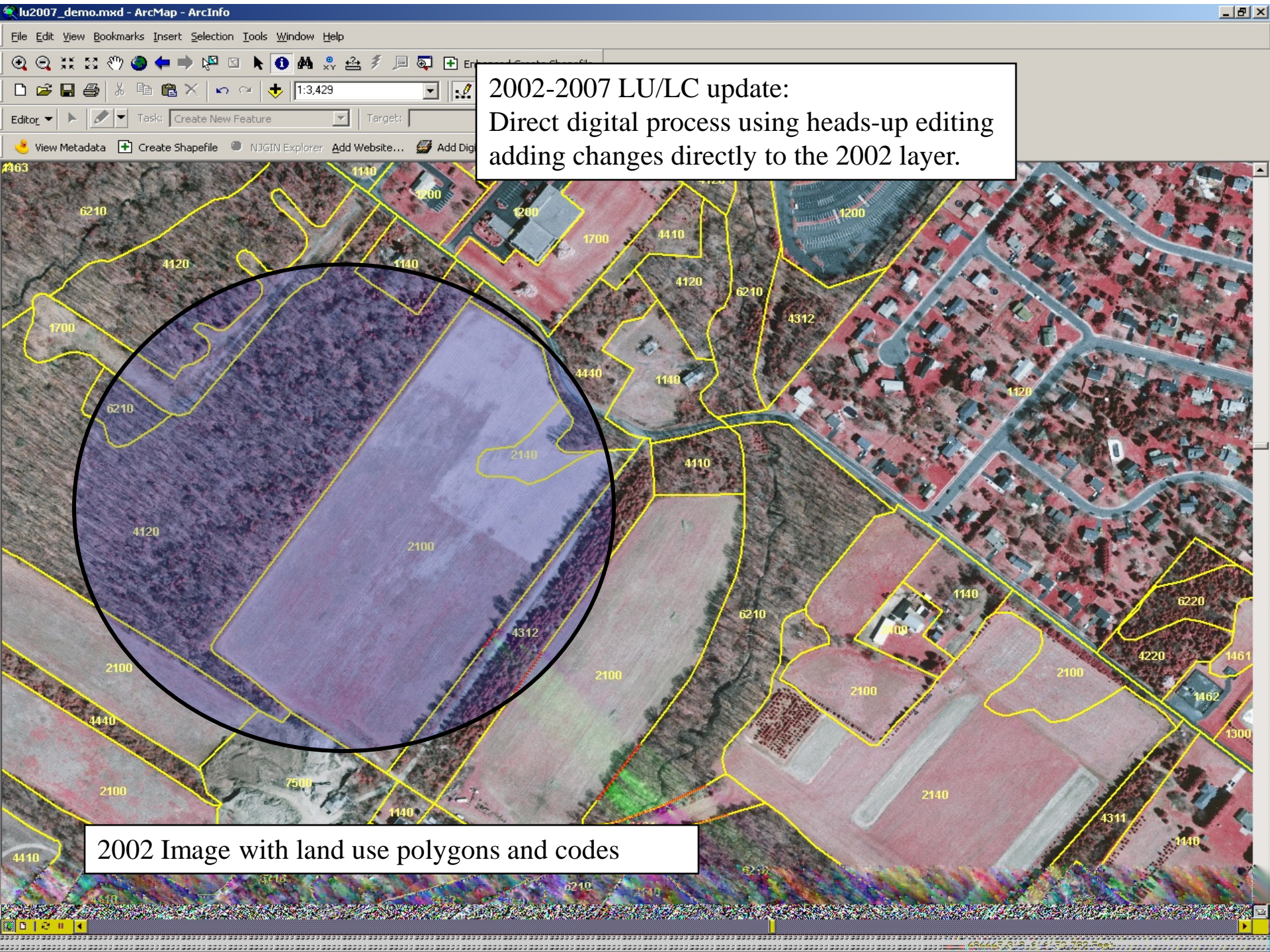
2002-2007 LU/LC update:
Direct digital process using heads-up editing adding changes directly to the 2002 layer.
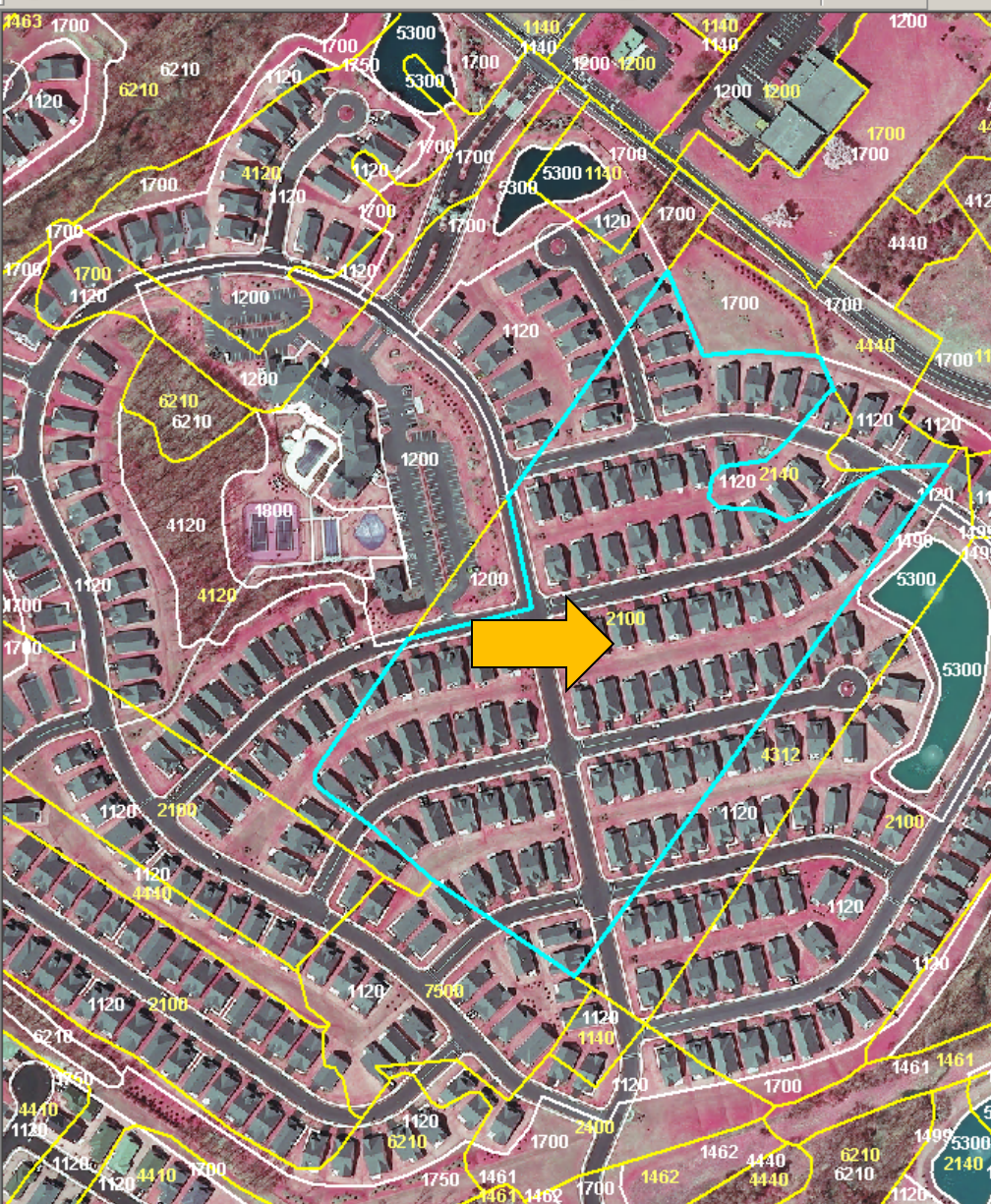
2002 Image with land use polygons and codes

2002 polygon boundaries and codes are retained

Summary of Classification Type (Label07) and Count and Sum_Acres for a Watershed

Attributes (top table):

SHAPE			
Polygon			
Polygon			
Polygon			
Polygon			
Polygon			
Polygon	1.313394	1200	COMMERCIAL/SERVICES
Polygon	0.010073	1200	COMMERCIAL/SERVICES
Polygon	0.100295	1200	COMMERCIAL/SERVICES
Polygon	2.652512	1120	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY
Polygon	0.431403	7430	DISTURBED WETLANDS (MODIFIED)
Polygon	0.053442	1200	COMMERCIAL/SERVICES
Polygon	3.22775	1400	TRANSPORTATION/COMMUNICATION/UTILITIES
Polygon	0.027931	1200	COMMERCIAL/SERVICES
Polygon	0.023316	1200	COMMERCIAL/SERVICES

Context menu:
Σ Statistics…
Field Calculator…
Calculate Geometry…
Turn Field Off
Freeze/Unfreeze Column
✕ Delete Field
Properties…

Right table:

				URBAN
1.182055	1200	COMMERCIAL/SERVICES		URBAN
0.009066	1200	COMMERCIAL/SERVICES		URBAN
0.090266	1300	INDUSTRIAL		URBAN
0.663128	1120	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY		URBAN
0.04314	6210	DECIDUOUS WOODED WETLANDS		WETLAN
0.045426	1700	OTHER URBAN OR BUILT-UP LAND		URBAN
1.93665	1400	TRANSPORTATION/COMMUNICATION/UTILITIES		URBAN
0.020948	6210	DECIDUOUS WOODED WETLANDS		WETLAN
0.019819	6210	DECIDUOUS WOODED WETLANDS		WETLAN

Record: 0 Show: All Selected Records: (0 out...

Attributes of type07:

OID	TYPE07	Count_TYPE07	Sum_ACRES
0	AGRICULTURE	1522	10471.1184
1	BARREN LAND	1239	3722.1643
2	FOREST	8119	34688.5226
3	URBAN	24369	129906.3707
4	WATER	2482	5986.8073
5	WETLANDS	12520	40268.9391

Record: 1 Show: All ect

Attributes of label07:

OID	LABEL07	Count_LABE	Sum_ACRES
0	AGRICULTURAL WETLANDS (MODIFIED)	754	2410.6374
1	AIRPORT FACILITIES	10	45.5422
2	ALTERED LANDS	165	1277.3695
3	ARTIFICIAL LAKES	1419	2162.1488
4	ATHLETIC FIELDS (SCHOOLS)	272	1439.3023
5	BARE EXPOSED ROCK, ROCK SLIDES, ETC	1	1.4778
6	BEACHES	6	10.5827
7	BRIDGE OVER WATER	245	48.2678
8	CEMETERY	111	1089.9782
9	CEMETERY ON WETLAND	16	58.0506
10	COMMERCIAL/SERVICES	3877	13549.8952
11	CONFINED FEEDING OPERATIONS	1	2.1468
12	CONIFEROUS BRUSH/SHRUBLAND	216	466.4048
13	CONIFEROUS FOREST (10-50% CROWN CLOSURE)	65	126.1273
14	CONIFEROUS FOREST (>50% CROWN CLOSURE)	379	1821.6161
15	CONIFEROUS SCRUB/SHRUB WETLANDS	77	73.7984
16	CONIFEROUS WOODED WETLANDS	153	537.1092
17	CROPLAND AND PASTURELAND	709	7844.8352
18	DECIDUOUS BRUSH/SHRUBLAND	1016	2193.5517
19	DECIDUOUS FOREST (10-50% CROWN CLOSURE)	982	2005.1285
20	DECIDUOUS FOREST (>50% CROWN CLOSURE)	3332	22274.072
21	DECIDUOUS SCRUB/SHRUB WETLANDS	1265	2215.1895
22	DECIDUOUS WOODED WETLANDS	5710	25738.4369
23	DISTURBED WETLANDS (MODIFIED)	776	850.3661
24	EXTRACTIVE MINING	58	614.878
25	FORMER AGRICULTURAL WETLAND (BECOMING SHRUBBY, NOT BUILT-UP)	55	141.0018
26	FRESHWATER TIDAL MARSHES	33	70.8963
27	HERBACEOUS WETLANDS	956	1593.9527
28	INDUSTRIAL	1728	9618.68
29	INDUSTRIAL AND COMMERCIAL COMPLEXES	14	59.1072
30	MAJOR ROADWAY	562	3205.2433
31	MANAGED WETLAND IN BUILT-UP MAINTAINED REC AREA	324	657.4135
32	MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	532	561.2788
33	MILITARY INSTALLATIONS	5	57.4936
34	MIXED DECIDUOUS/CONIFEROUS BRUSH/SHRUBLAND	716	1706.7774
35	MIXED FOREST (>50% CONIFEROUS WITH 10-50% CROWN CLOSURE)	54	159.3087

File
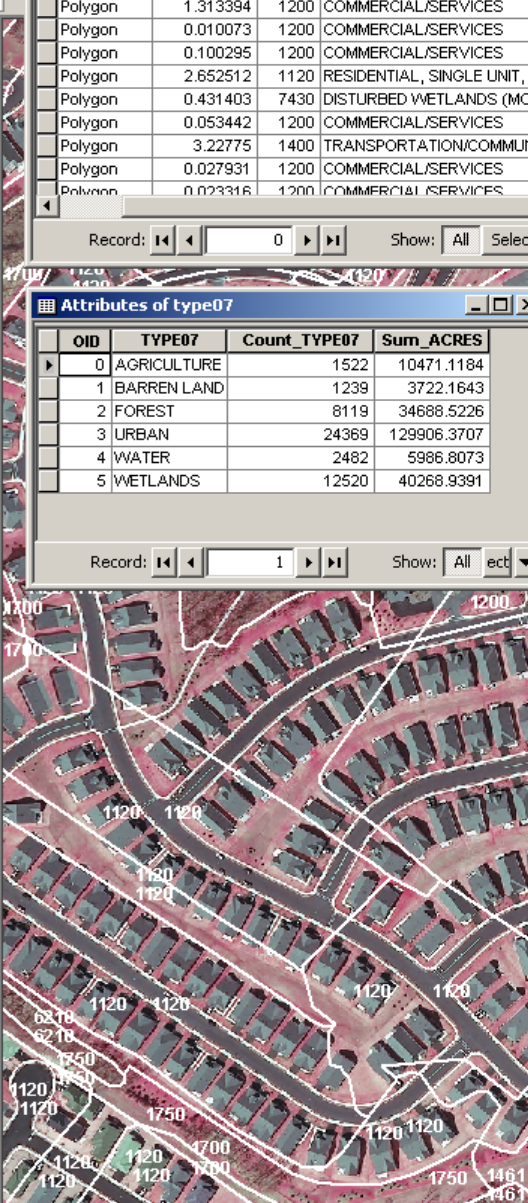
This Selection Shows Forest Lost From 2002 to 2007 by Class

50445	Polygon	0.008863	1200	COMMERCIAL/SERVICES	URBAN	95	0.00842	4110	DECIDUOUS FOREST (10-50% CROWN CLOSURE)
3	Polygon	0.083107	1110	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	URBAN	20	0.016621	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)
4	Polygon	1.222704	1110	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	URBAN	20	0.244541	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)
6	Polygon	2.634093	1110	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	URBAN	25	0.658523	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)
					URBAN	30	0.060663	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)
					URBAN	30	0.144843	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)
					URBAN	35	0.019245	4110	DECIDUOUS FOREST (10-50% CROWN CLOSURE)
					URBAN	35	0.068508	4110	DECIDUOUS FOREST (10-50% CROWN CLOSURE)
					URBAN	35	0.48568	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)
					URBAN	35	0.002683	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)
					URBAN	35	0.013315	4312	MIXED FOREST (>50% CONIFEROUS WITH >50% CROWN CLOSURE)
					WATER	0	0	4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)

Selection Statistics of LandUseUpdate_WS09

Field
ACRES

Statistics:

Count: 4156
Minimum: 0.000007
Maximum: 69.888433
Sum: 3177.870965
Mean: 0.764647
Standard Deviation: 2.229737

Frequency Distribution

4,000
3,000
2,000
1,000
0

0.0 7.3 14.6 21.9 29.2 36.6 43.9 51.2 58.5 65.8

Options ▼

Attributes of forest_lost

ID	LABEL07	Count_LABEL07	Sum_ACRES
30	RESIDENTIAL, SINGLE UNIT, LOW DENSITY	703	533.2619
37	TRANSITIONAL AREAS	302	514.2944
23	OTHER URBAN OR BUILT-UP LAND	545	502.0018
31	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	558	358.0208
29	RESIDENTIAL, RURAL, SINGLE UNIT	612	324.688
5	COMMERCIAL/SERVICES	260	181.0216
14	INDUSTRIAL	162	158.4861
27	RECREATIONAL LAND	106	124.4113
34	STORMWATER BASIN	217	120.5143
28	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	77	84.8056
8	CROPLAND AND PASTURELAND	47	38.8615
12	EXTRACTIVE MINING	21	37.9469
2	ARTIFICIAL LAKES	101	32.2845
15	MAJOR ROADWAY	71	30.7381
1	ALTERED LANDS	36	26.1879
38	TRANSPORTATION/COMMUNICATION/UTILITIES	66	25.6968
22	OTHER AGRICULTURE	35	20.3841
10	DECIDUOUS WOODED WETLANDS	83	13.4775
3	ATHLETIC FIELDS (SCHOOLS)	19	11.2756
41	UPLAND RIGHTS-OF-WAY UNDEVELOPED	16	8.3198
21	ORCHARDS/VINEYARDS/NURSERIES/HORTICULTURAL AREAS	19	7.438
4	CEMETERY	11	5.7692
20	NATURAL LAKES	8	2.7886
13	HERBACEOUS WETLANDS	2	2.2653
32	SALINE MARSH (HIGH MARSH)	1	1.9401
		15	1.8981
		9	1.8967
		2	1.1425
		12	1.0444
		2	1.0182
		4	0.9616
		6	0.7409
		6	0.5299
24	PHRAGMITES DOMINATE COASTAL WETLANDS	3	0.4975
17	MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	7	0.3734

Select by Attributes

Enter a WHERE clause to select records in the table window.

Method: Create a new selection

[LABEL07]
[TYPE07]
[IS07]
[ISACRES07]
[LU02]
[LABEL02]

=	<>	Like	'AGRICULTURE'
>	>=	And	'BARREN LAND'
<	<=	Or	'FOREST'
?	*	()	'URBAN'
		Not	'WATER'
			'WETLANDS'

Is   Get Unique Values   Go To:

SELECT * FROM LandUseUpdate_WS09 WHERE:

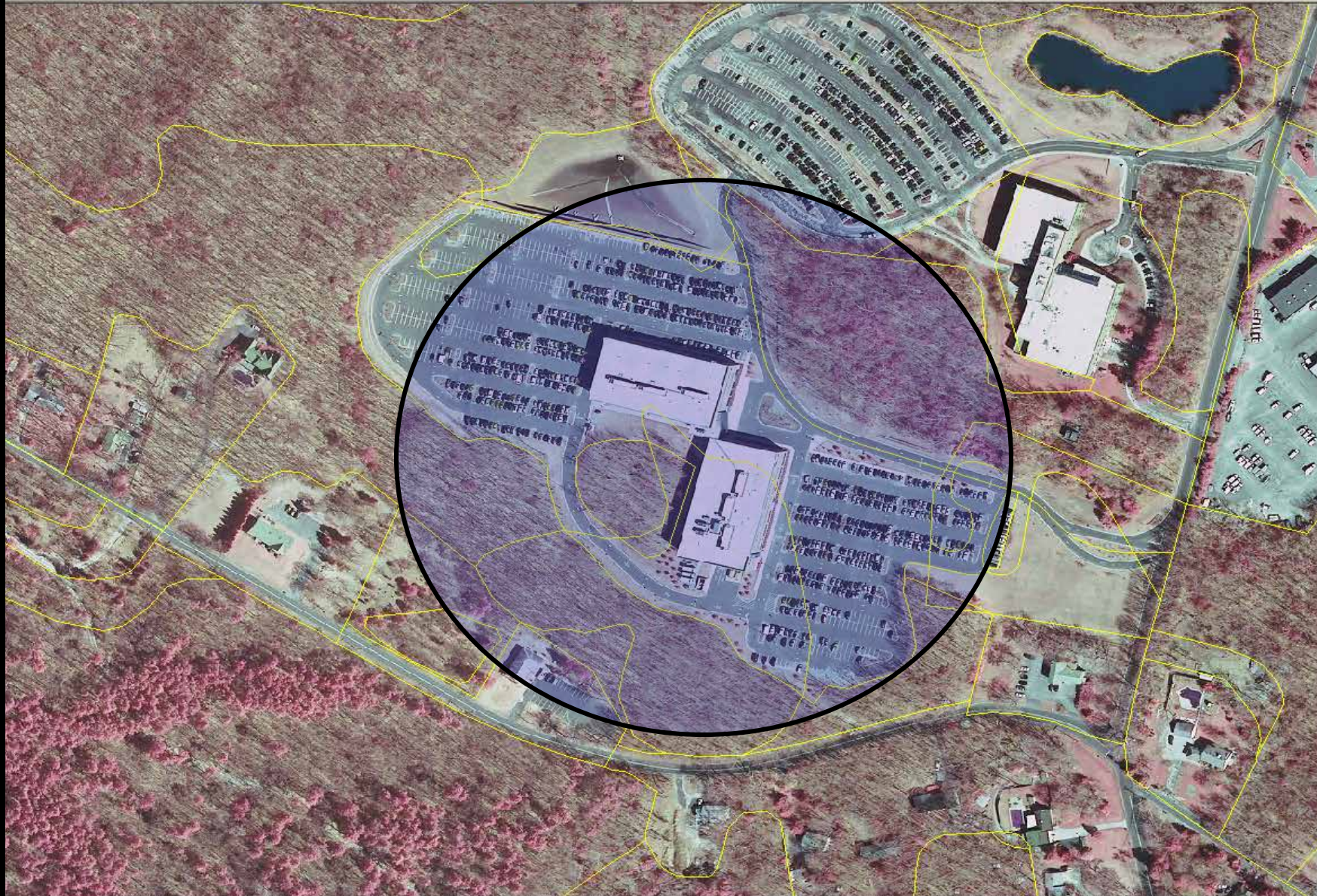[TYPE02] = 'FOREST' AND [TYPE07] <> 'FOREST'

Apply   Close

Most of the Forest Lost Is to Residential Single Family Low Density

2002 Image with Edits from 2007 Already Made

The Ex-urbanization of America

2007

State wide Land Use/Land Cover Statistics 1986-2007 (In Acres)

| Land Use Type	1986	1995	Net Change	Per/Year
Agriculture	744,382	659,017	-85,365	-9,485
Barren Land	57,223	57,971	+748	+83
Forest	1,641,279	1,602,578	-38,701	-4,300
Urban Land	1,208,553	1,342,525	133,972	+14,868
Water	783,334	788,479	+5,145	+572
Wetlands*	1,049,269	1,033,471	-15,798*	-1,755*

Land Use Type	1995	2002	Net Change	Per/Year
Agriculture	652,334	596,804	-55,530	-7,933
Barren Land	57,562	61,352	+3,789	+542
Forest	1,616,683	1,575,220	-41,463	-5,923
Urban Land	1,334,476	1,440,464	+105,988	+15,141
Water	800,610	800,572	-38	-6
Wetlands*	1,022,291	1,009,544	-12,747*	-1,821*

Land Use Type	2002	2007	Net Change	Per/Year
Agriculture	594,599	566,045	-28,554	-5,711
Barren Land	59,138	51,678	-7,460	-1,492
Forest	1,568,809	1,526,367	-42,442	-8,488
Urban Land	1,452,077	1,532,364	+80,287	+16,057
Water	803,611	810,541	+6,930	+1,386
Wetlands*	1,005,735	996,975	-8,760*	-1,752*

*includes all wetlands changes, both natural and artificial, and to both natural and disturbed wetlands

Net Level I Acreage Values, 1986-2007
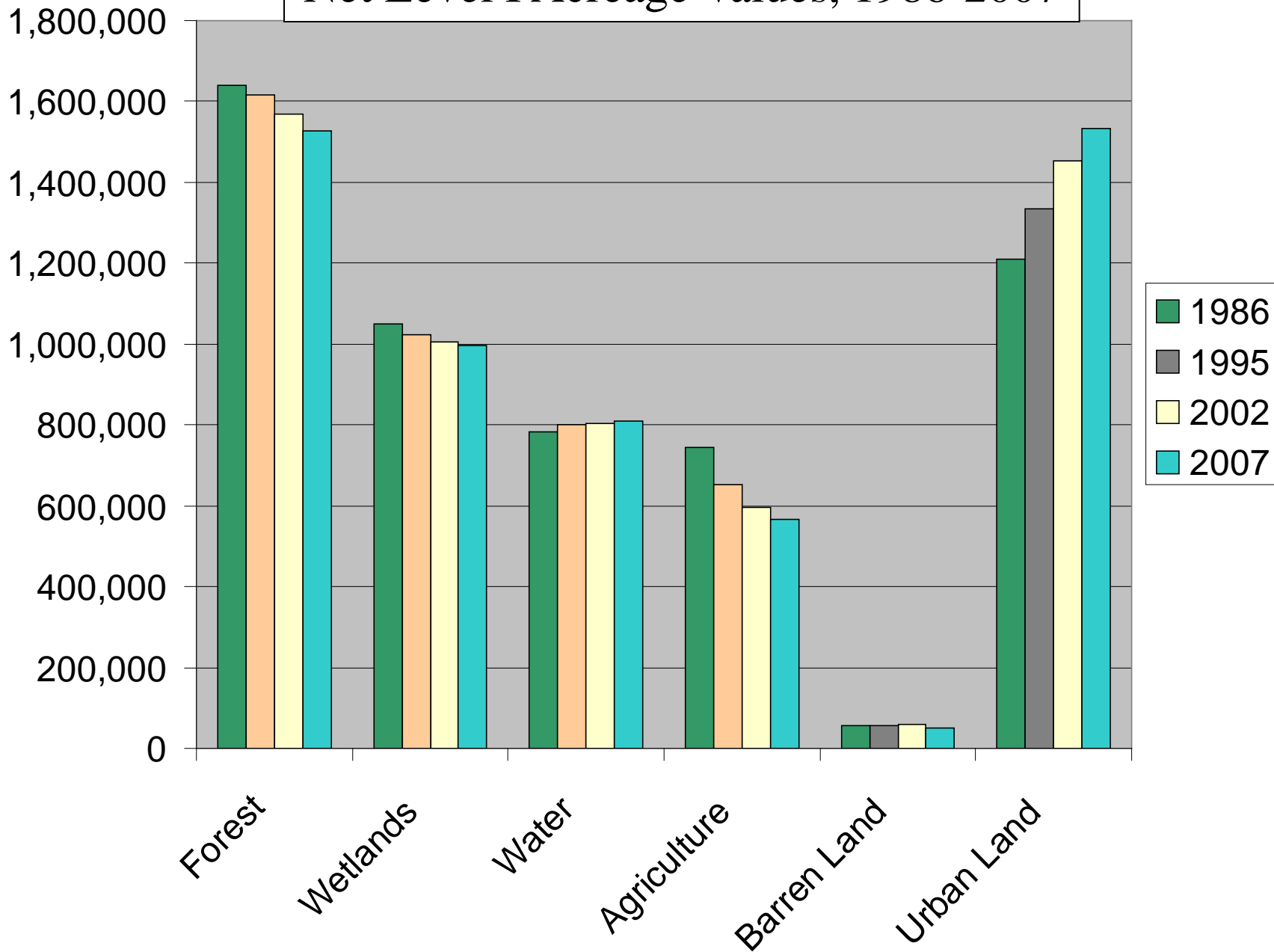
Major Urban Category Increases: 2002-2007 (Acres)*

Residential, Rural, Single Unit: + 26,248

Other Urban or Built-Up Land: + 16,693

Residential, Single Unit, Med. Density: + 12,197

Residential, Single Unit, Low Density: + 11,148

Commercial/Services: + 6,552

Recreational Land: + 4,994

Residential, High Den./Multi-Dwelling: + 4,651

Storm Water Basins: + 3,528

Industrial: + 3,111

Transportation/Comm./Utilities: + 1,063

Impervious Surface Changes:

Total Acres 2002: 485,189

Total Acres 2007: 508,696

Net Change: +23,407

2007 Land Use/Land Cover Update

LU/LC data are key components in many other analyses:

- aquifer recharge

- ground water/surface water flow modeling

- carbon sequestration

- endangered species habitat mapping

- habitat fragmentation

- air quality modeling

- riparian corridor buffer analysis

- smart growth (green growth, sustainability)

- water quality/storm water management studies

- management plan development (Highlands, Pinelands)

SUMMARY: The New Jersey LULC 21 Year Experience

Land Use Land Cover can be delineated to over 80 classes using a classification system like Anderson et al. and photo-interpretation

Local, county, state and federal scientists and regulators require detailed LULC.

Increased detail leads to better and faster decision making either in the office or on mobile devices in the field.

New Jersey DEP and AIS teamed to deliver 4 iterations of LULC over a 21 year period to date to give quality change and trends in LULC for environmental protection.
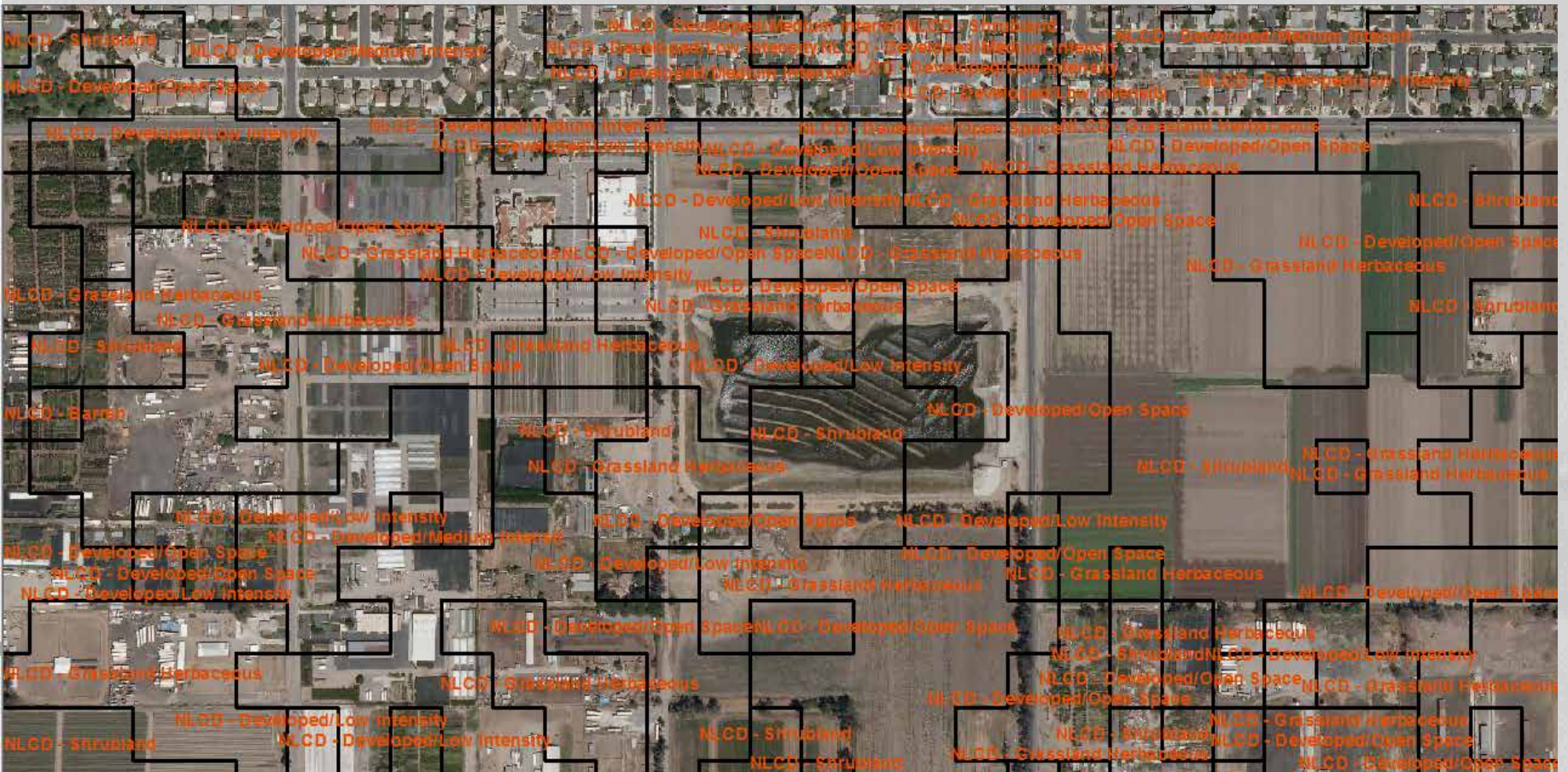
How does this study impact the creation of LULC nationally??

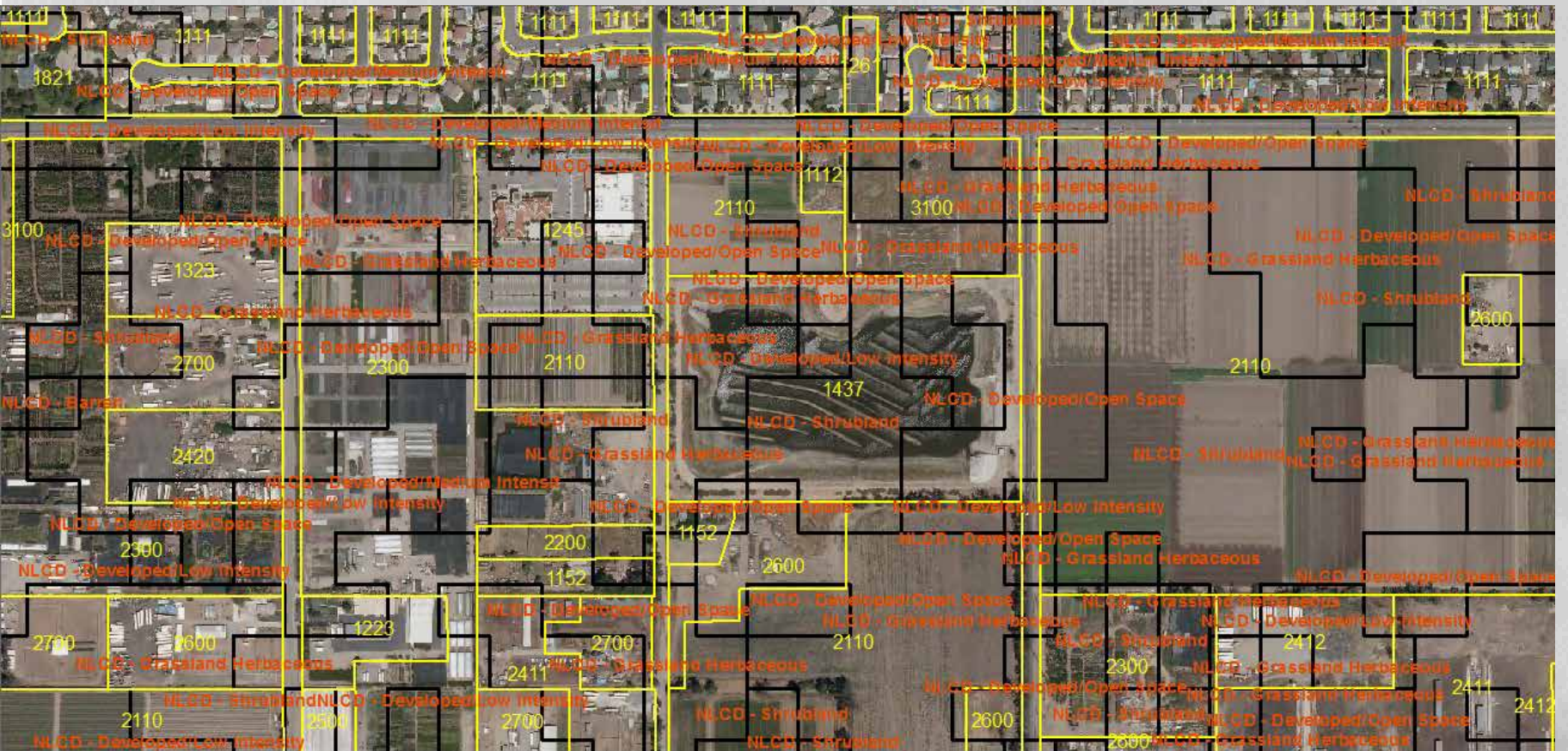# Delineation of LULC Using Aerial Imagery and Classic Photo Interpretations and Delineation.
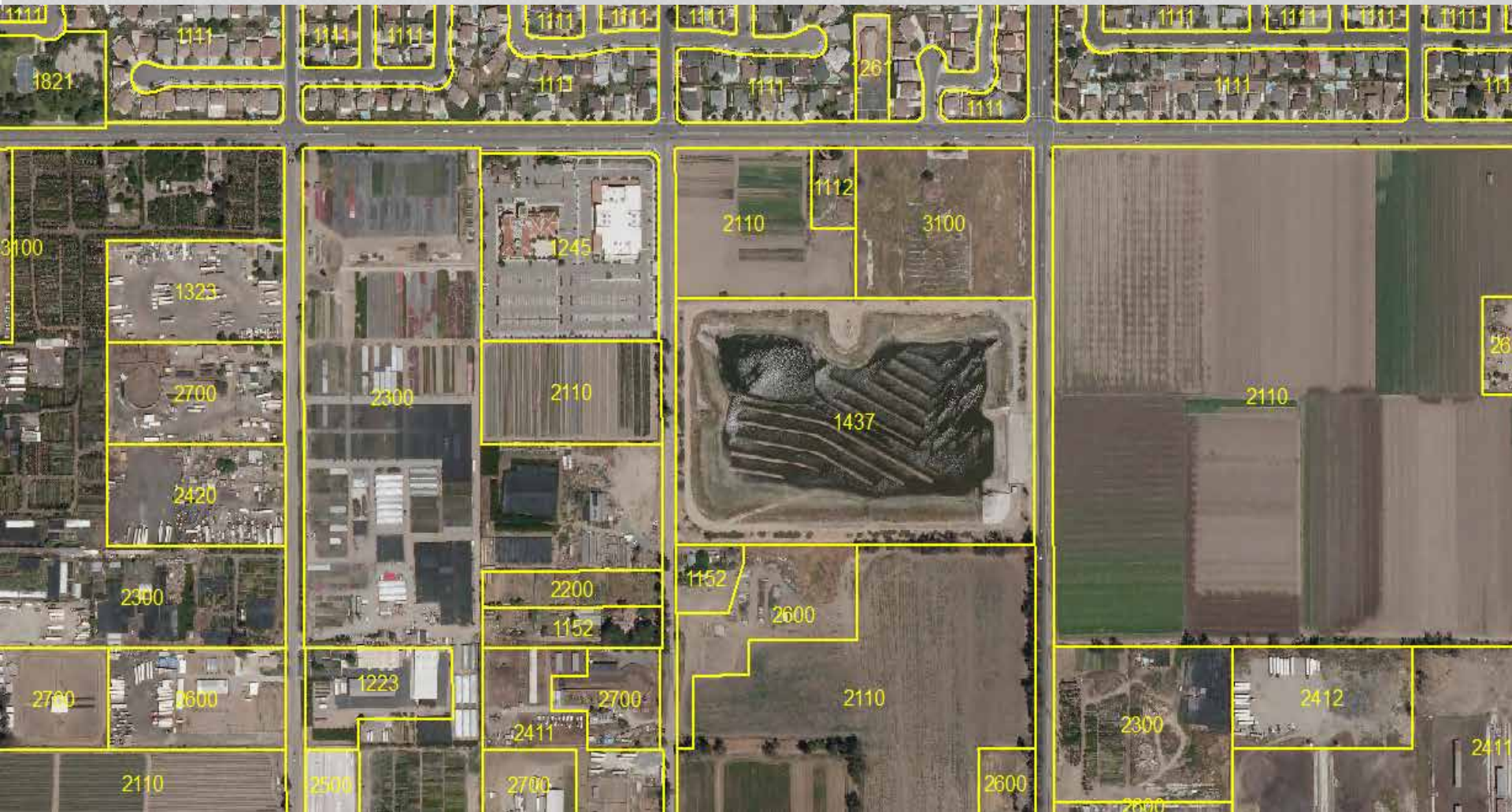
National Land Cover Dataset LULC
For the Same Area

Problem: Many clients will search and find only this
data to try and solve site specific issues.

NLCD Linework (black) with Classification Codes (orange) Over Traditional Delieation Linework and Codes (yellow)

FRAMEWORK and Land Use Land Cover

Land Use Land Cover is the #1 download from NJDEP.

Since LULC is critical for so many environmental analyses and models.. **A national discussion needs to begin on how states (including counties and municipalities) can work with federal agencies to build a consistent more detailed LULC framework.**

To view this data: Search on NJ-GeoWeb* or NJGIN
Or visit\www.nj.gov/dep/gis

Larry Thornton:

larrythornton@SolutionsGIS.com
lthornto@aisgis.com
larry_thornton@verizon.net

QUESTIONS?

Mapping Criteria for LULC

- **Know your clients needs (intra, Internet)**
- In the 1980's**: use the best photo-basemaps available or make a set that meets National Map Accuracy Standards**
- Use a simple **hierarchical classification system** developed for photo-interpretation.
- In the 1990s**: use high quality digital imagery CIR, leaf off.** If not available …fly it.
- **Test leading image processing software v. photo-interpretation**.
- **Follow Best Practices and Standards for the project but maintain consistency.**
- Try **to use the same contractor**, if possible. Steep learning curve.