

# Development of a Strategic Spatial Sampling Design for the State of Florida

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Bruland**

# Need for Landscape Scale Studies

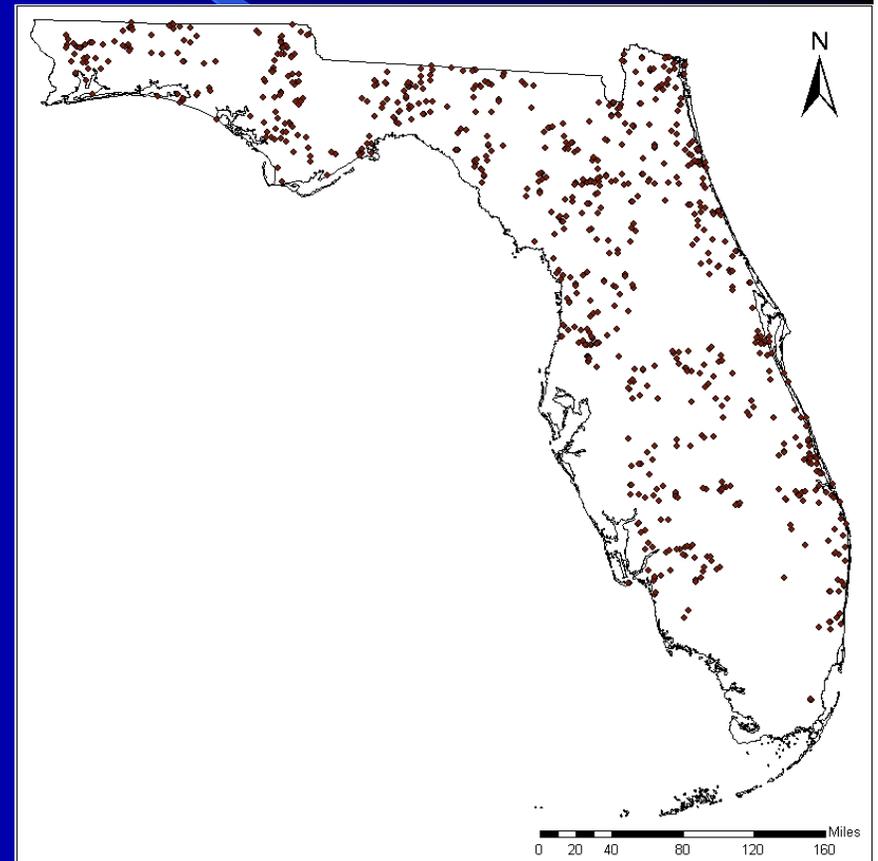
- Development of landscape scale estimates of soil properties
  - Describe the spatial variability across landscapes
  - Decision making
  - Exploiting economical opportunities such as carbon trading
- Development of maps for research, extension and educational purposes

# Need for Appropriate Sampling Design

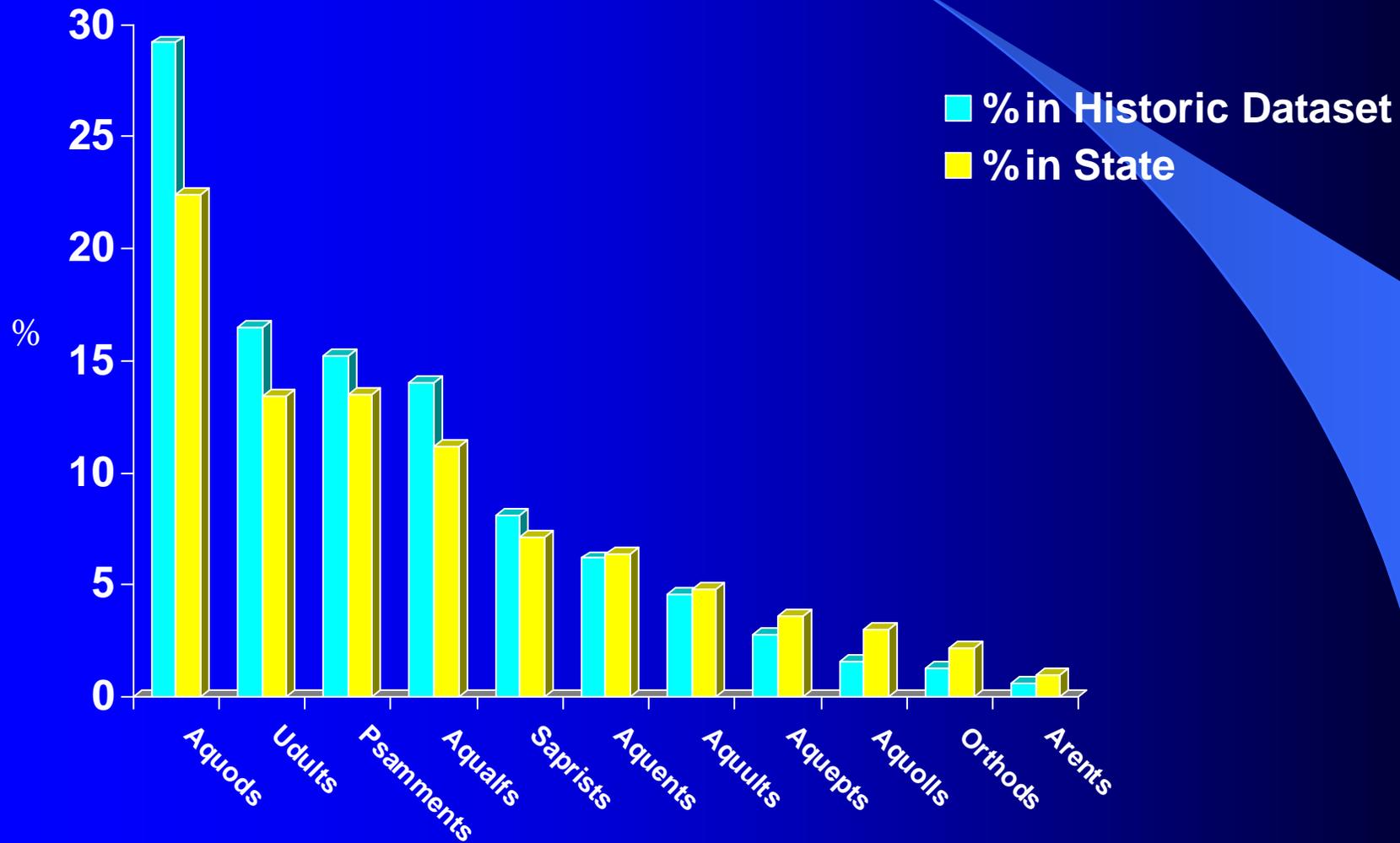
- To build on existing soil knowledge base e.g. NRCS Soil Data Mart
- To ensure adequate coverage of environmental landscape factors e.g. Land Use, Soil Type
- To ensure even geographical distribution

# Florida Soil Characterization Database

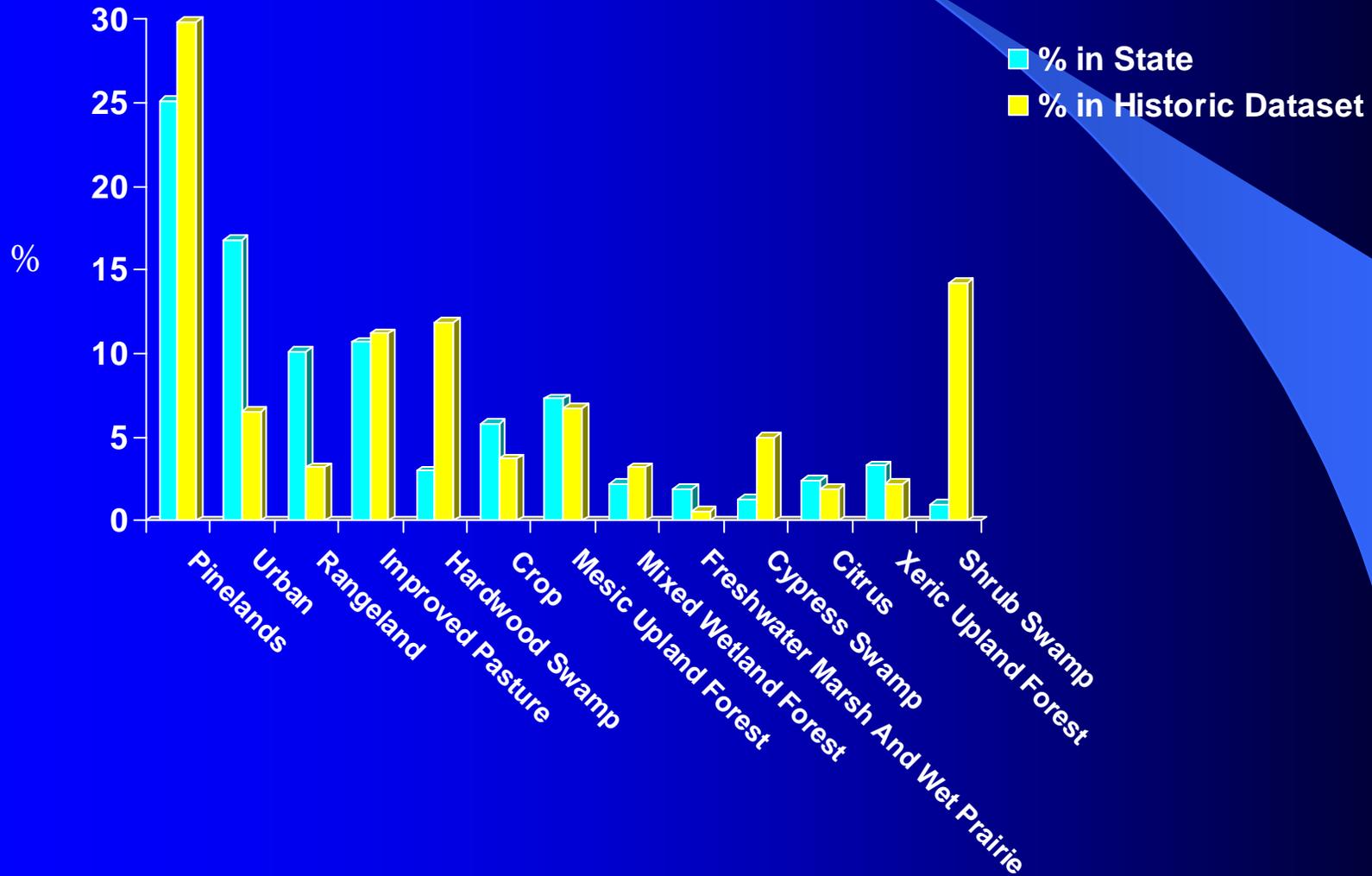
- Funded by “Accelerated Soil Survey Program”
- Database collected from 1965 to 1996
- Covering 58 counties
- 1288 profiles
- 8272 horizons
- 144 different physical and chemical soil properties (incl. soil C)



# Distribution of Historic Samples across Suborders



# Distribution of Historic Samples across Land uses



# Role of GIS in Soil Survey

- Analyzing and integrating different data layers
- Useful for upscaling the measured soil properties

# SCORPAN Model

$$S_a = f(s, c, o, r, p, a, n)$$

Where  $S_a$  = soil attribute to be predicted,

s = soil properties, c = climate, o = organisms, r = relief, p = parent material, a = age, n = space

**McBratney et al., 2003**

# Objectives

- **Measure and map soil carbon storage for the state of Florida**
- **Identify representative sampling locations that capture the underlying soil C variability**
- **Understand the effects of various environmental factors**
- **To include 50% of the sites from the historic Florida Soil Characterization Database**
- **Compare the present soil C with historic measurements (~1990).**

# Stratified Random Sampling

## Advantages:

- **Captures the underlying variability of landscape factors**
- **Represents important subpopulations**
- **Efficient**
- **Strategic sampling across a landscape**
- **Greater accuracy of estimation due to lower sampling error**

# Stratified Random Sampling

## Disadvantages:

- **Necessary to identify “right” strata**
- **More knowledge of the population is needed.**
- **More complex to develop and analyze the results**
- **Depends on the accuracy of the data used for identifying the strata**

# SCORPAN Model

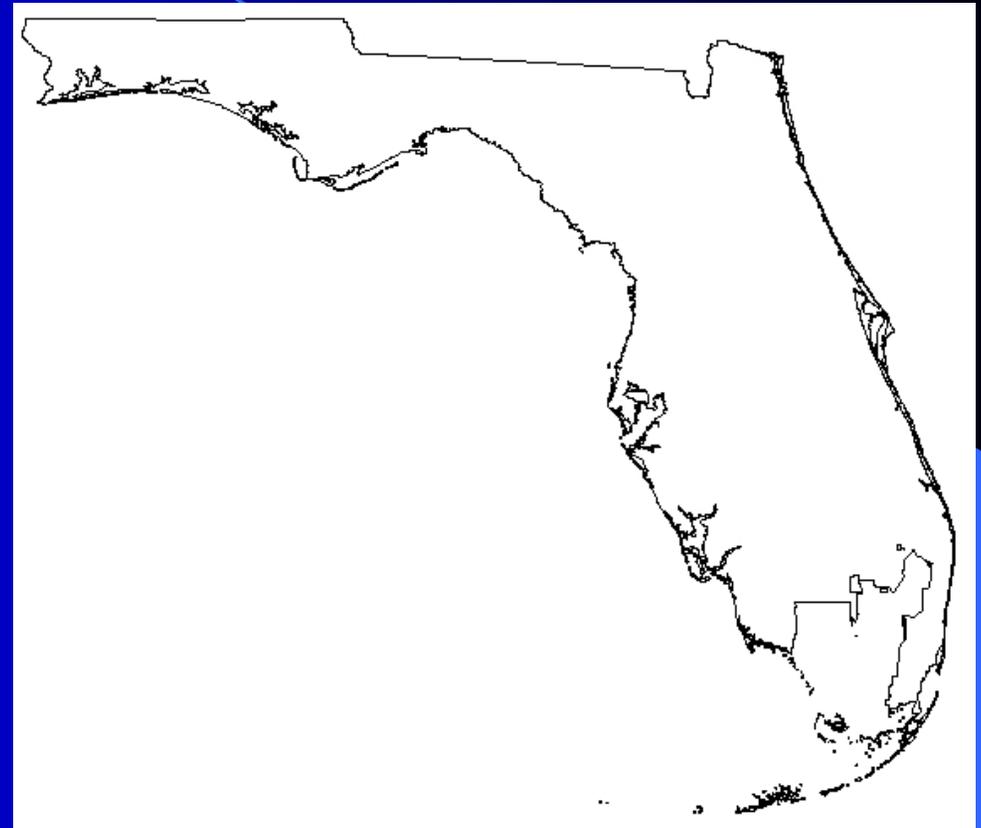
- **S = Soil properties** → Suborder
- C = Climate
- **O = Organisms** → Land Use
- R = Relief
- P = Parent material
- A = Age
- N = Space

Parton, 1987; Schulze and Freibauer, 2005

# Delineation of the Study Area

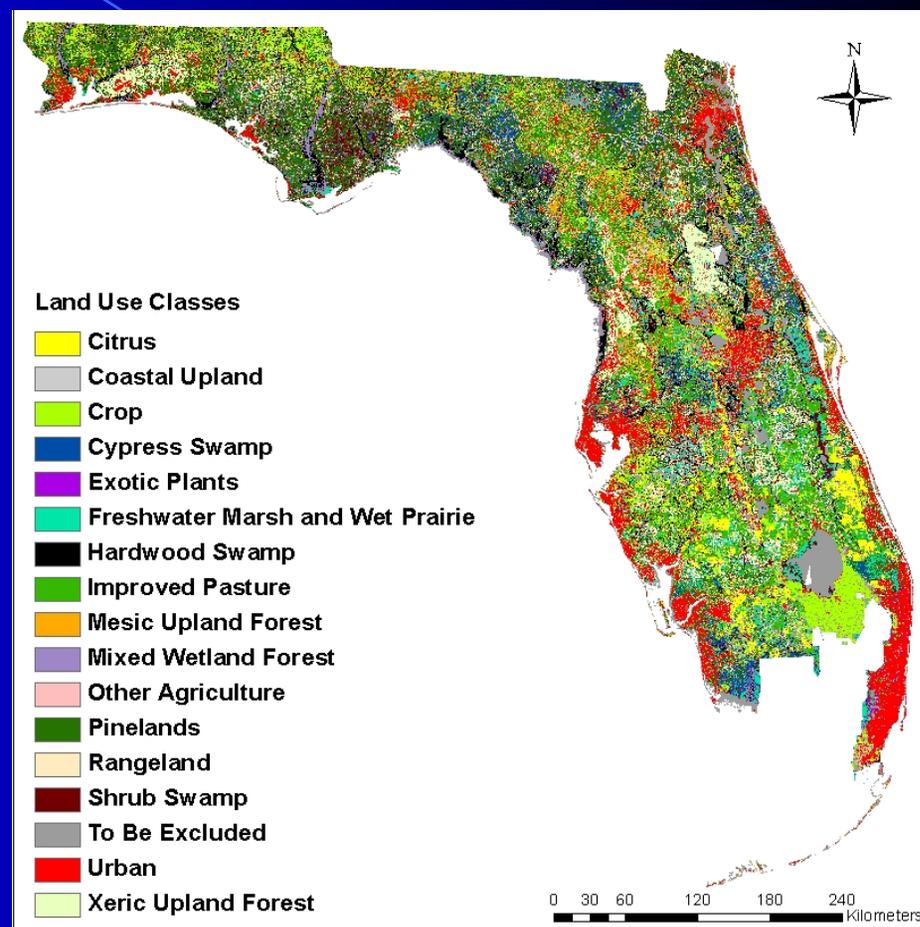
## Areas excluded

- The Greater Everglades area
- Specialty layers
  - Army sites
  - Interstate and state highways
  - Railways
  - Airports
  - Cemeteries



# Land Use 2003

- Florida Vegetation and Land Cover Data (2003)
- Resolution: 30m
- Treatment (GIS):
  - Reclassification
  - Delineation
  - Area calculation

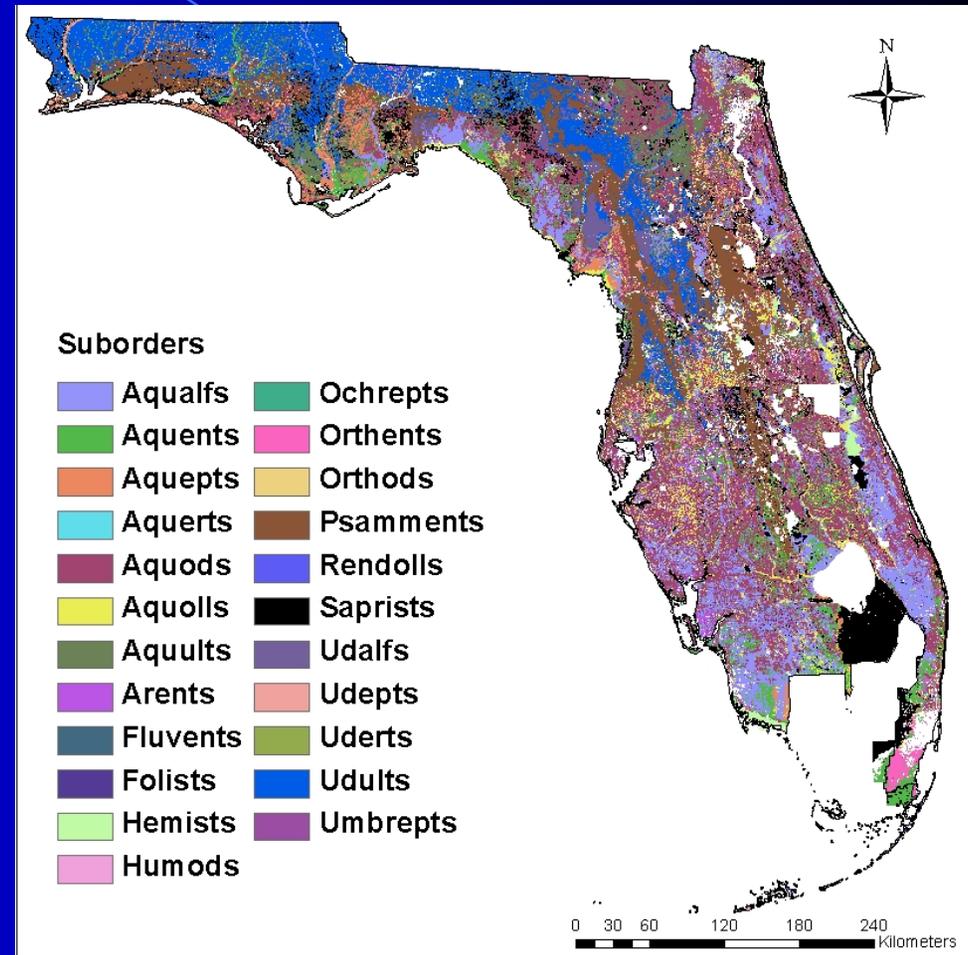


Data Source: Florida Fish and Wildlife Conservation Commission, Tallahassee, FL

| Land Use Classes                    | Area (km <sup>2</sup> ) | %           |
|-------------------------------------|-------------------------|-------------|
| <b>Pinelands</b>                    | <b>25,998</b>           | <b>19.3</b> |
| Urban                               | 16,073                  | 11.9        |
| Rangeland                           | 12,516                  | 9.3         |
| Improved Pasture                    | 11,992                  | 8.9         |
| Hardwood Swamp                      | 7,993                   | 5.9         |
| Crop                                | 7,734                   | 5.7         |
| Mesic Upland Forest                 | 7,512                   | 5.6         |
| Mixed Wetland Forest                | 6,087                   | 4.5         |
| Freshwater Marsh and<br>Wet Prairie | 5,730                   | 4.2         |
| Cypress Swamp                       | 5,330                   | 4.0         |
| Xeric Upland Forest                 | 4,435                   | 3.3         |
| Shrub Swamp                         | 3,955                   | 2.9         |
| Citrus                              | 3,851                   | 2.9         |
| Other Agriculture                   | 879                     | 0.7         |
| Exotic Plants                       | 178                     | 0.1         |
| Coastal Upland                      | 62                      | 0.0         |
| <b>Total</b>                        | <b>134,830</b>          | <b>100</b>  |

# Soil Suborders

- Suborder data from NRCS Soil Data Mart (2006)
- Scale 1:24,000
- Treatment (GIS)
  - Extraction of county data and merging
  - Delineation
  - Area calculation

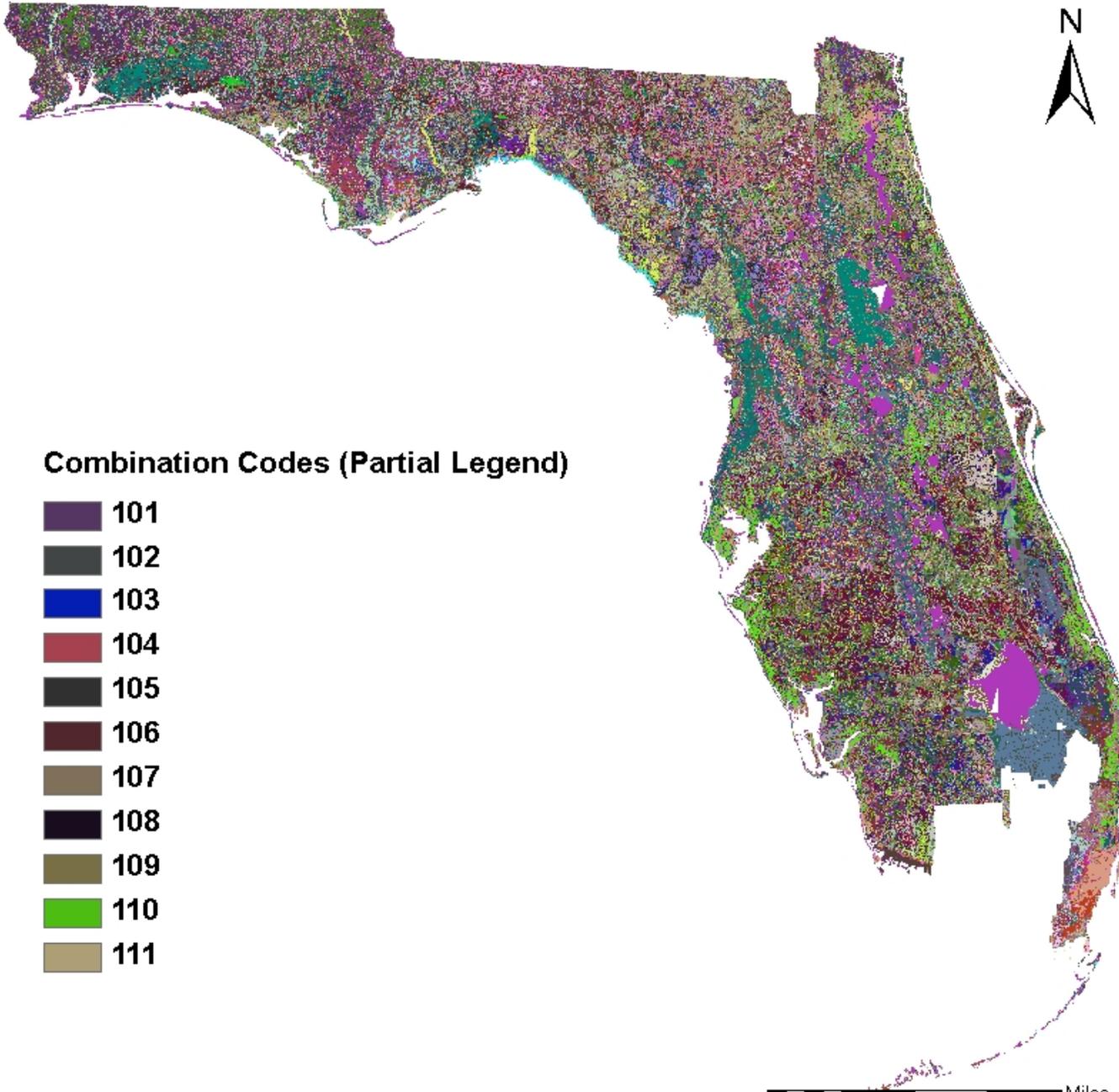


Data Source: Natural Resources Conservation Service - Soil Data Mart

| Suborder      | Area(km <sup>2</sup> ) | %            |
|---------------|------------------------|--------------|
| <b>Aquods</b> | <b>30,157</b>          | <b>22.41</b> |
| Psammments    | 18,104                 | 13.45        |
| Udulfs        | 18,007                 | 13.38        |
| Aqualfs       | 15,105                 | 11.22        |
| Sapristis     | 9,555                  | 7.10         |
| Aquents       | 8,624                  | 6.41         |
| Aquults       | 6,440                  | 4.79         |
| Aquepts       | 4,886                  | 3.63         |
| Aquolls       | 4,099                  | 3.05         |
| Orthods       | 3,001                  | 2.23         |
| Udalfs        | 2,035                  | 1.51         |
| Arents        | 1,329                  | 0.99         |
| Hemists       | 1,046                  | 0.78         |
| Orthents      | 888                    | 0.66         |
| Humods        | 391                    | 0.29         |
| Udepts        | 376                    | 0.28         |
| Fluvents      | 143                    | 0.11         |
| Water         | 10,244                 | 7.61         |
| <b>Total</b>  | <b>13,4577</b>         | <b>100</b>   |

# Combination of Suborder and Land Use Strata

- **Assigning numbers to different land uses and suborders**
  - **Values from 100 to 1700 were assigned to the land use classes and**
  - **Values from 1 to 24 were assigned to the suborders.**
- **Addition of the two layers in the Spatial analyst (ArcGIS)**
- **E.g.  $1700 + 1 = 1701$ , where the first two digits indicate the land use and the last two digits denote the suborder**



**Combination Codes (Partial Legend)**

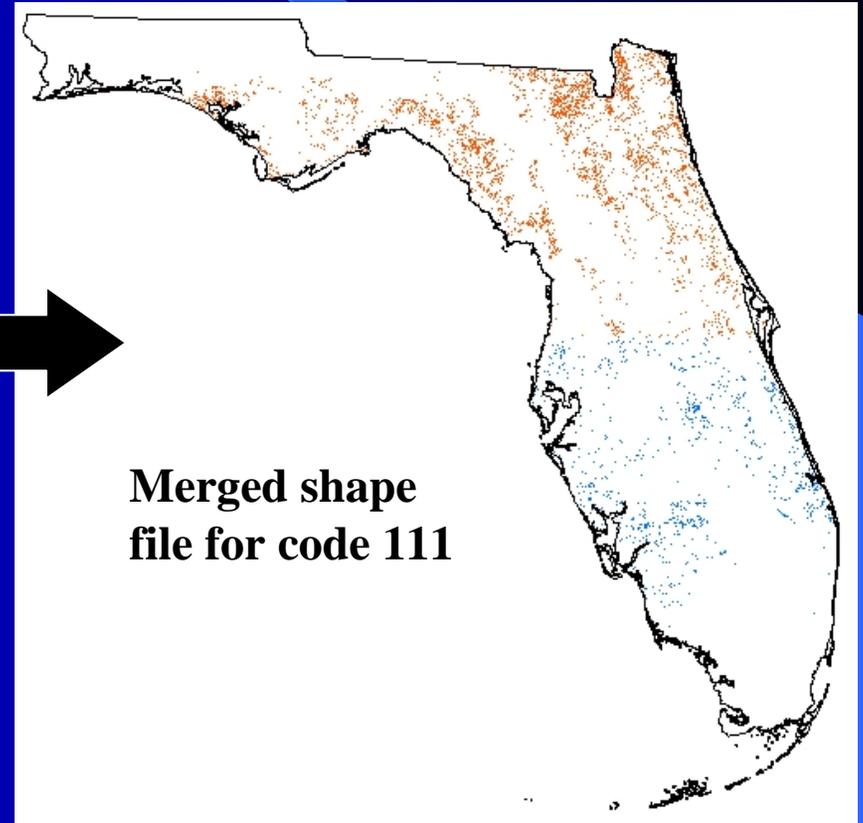
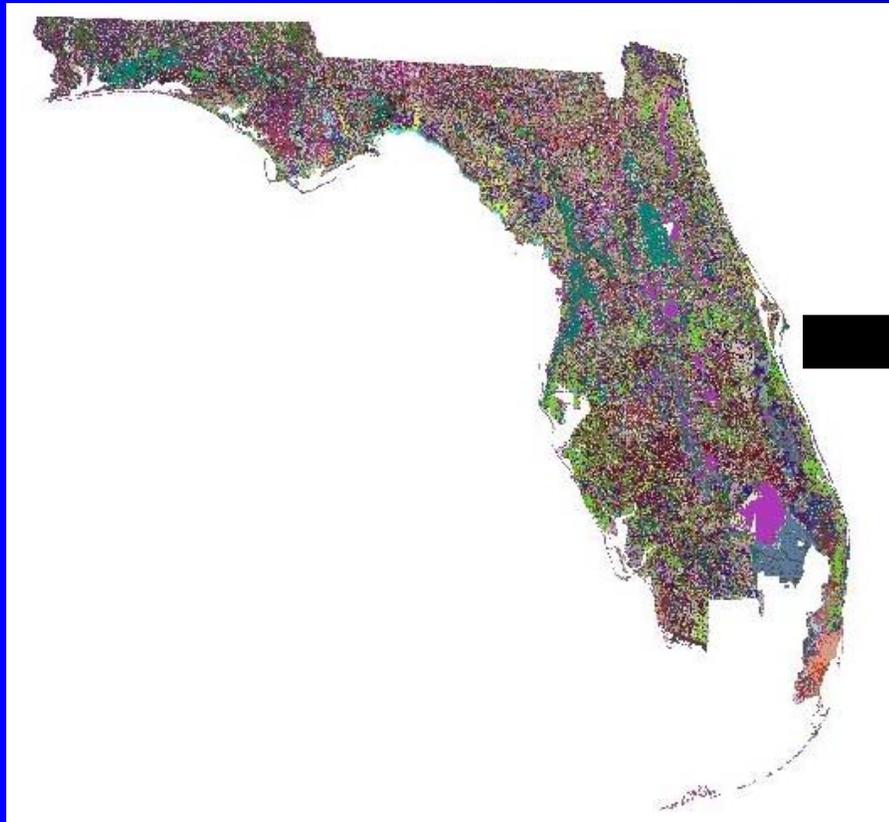
- 101
- 102
- 103
- 104
- 105
- 106
- 107
- 108
- 109
- 110
- 111

0 15 30 60 90 120 Miles

| Land use +<br>suborder code | Land_Use               | Suborder      | Area (sq.km.) | %          |
|-----------------------------|------------------------|---------------|---------------|------------|
| <b>111</b>                  | <b>Pinelands</b>       | <b>Aquods</b> | <b>7267</b>   | <b>7.8</b> |
| 101                         | Pinelands              | Udults        | 5967          | 6.4        |
| 511                         | Rangeland              | Aquods        | 4746          | 5.1        |
| 411                         | Improved<br>Pasture    | Aquods        | 4451          | 4.7        |
| 1611                        | Urban                  | Aquods        | 3653          | 3.9        |
| 1606                        | Urban                  | Psamments     | 3270          | 3.5        |
| 706                         | Xeric Upland<br>Forest | Psamments     | 2800          | 3          |
| 106                         | Pinelands              | Psamments     | 2765          | 2.9        |
| 201                         | Crop                   | Udults        | 2532          | 2.7        |
| 104                         | Pinelands              | Aquults       | 2402          | 2.6        |
| 114                         | Pinelands              | Aqualfs       | 2451          | 2.6        |
| 801                         | Mesic Upland<br>Forest | Udults        | 2243          | 2.4        |
| 202                         | Crop                   | Saprists      | 1857          | 2          |

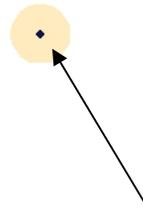
| Land use + suborder code | Land_Use            | Suborder      | No of samples from historic dataset | No of samples from reconnaissance dataset | Total     |
|--------------------------|---------------------|---------------|-------------------------------------|---|-----------|
| <b>111</b>               | <b>Pinelands</b>    | <b>Aquods</b> | <b>51</b>                           | <b>27</b>                                 | <b>78</b> |
| 101                      | Pinelands           | Udults        | 42                                  | 22  | 64        |
| 511                      | Rangeland           | Aquods        | 24                                  | 27  | 51        |
| 411                      | Improved Pasture    | Aquods        | 24                                  | 23  | 47        |
| 1611                     | Urban               | Aquods        | 25                                  | 14  | 39        |
| 1606                     | Urban               | Psamments     | 23                                  | 12  | 35        |
| 706                      | Xeric Upland Forest | Psamments     | 20                                  | 10  | 30        |
| 106                      | Pinelands           | Psamments     | 19                                  | 10  | 29        |
| 201                      | Crop                | Udults        | 18                                  | 9   | 27        |
| 104                      | Pinelands           | Aquults       | 17                                  | 9   | 26        |
| 114                      | Pinelands           | Aqualfs       | 17                                  | 9   | 26        |
| 801                      | Mesic Upland Forest | Udults        | 16                                  | 8   | 24        |
| 202                      | Crop                | Saprists      | 8                                   | 12  | 20        |

# Separating the Land Use + Suborder Combinations



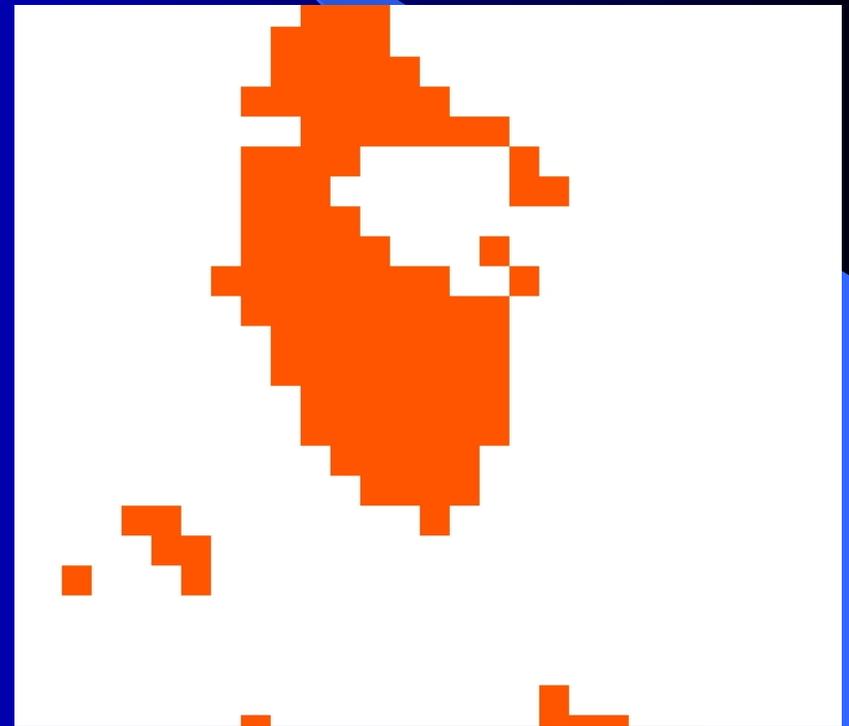
# Excluding Historic Dataset

Shape file with 30m buffer  
around the historic site points

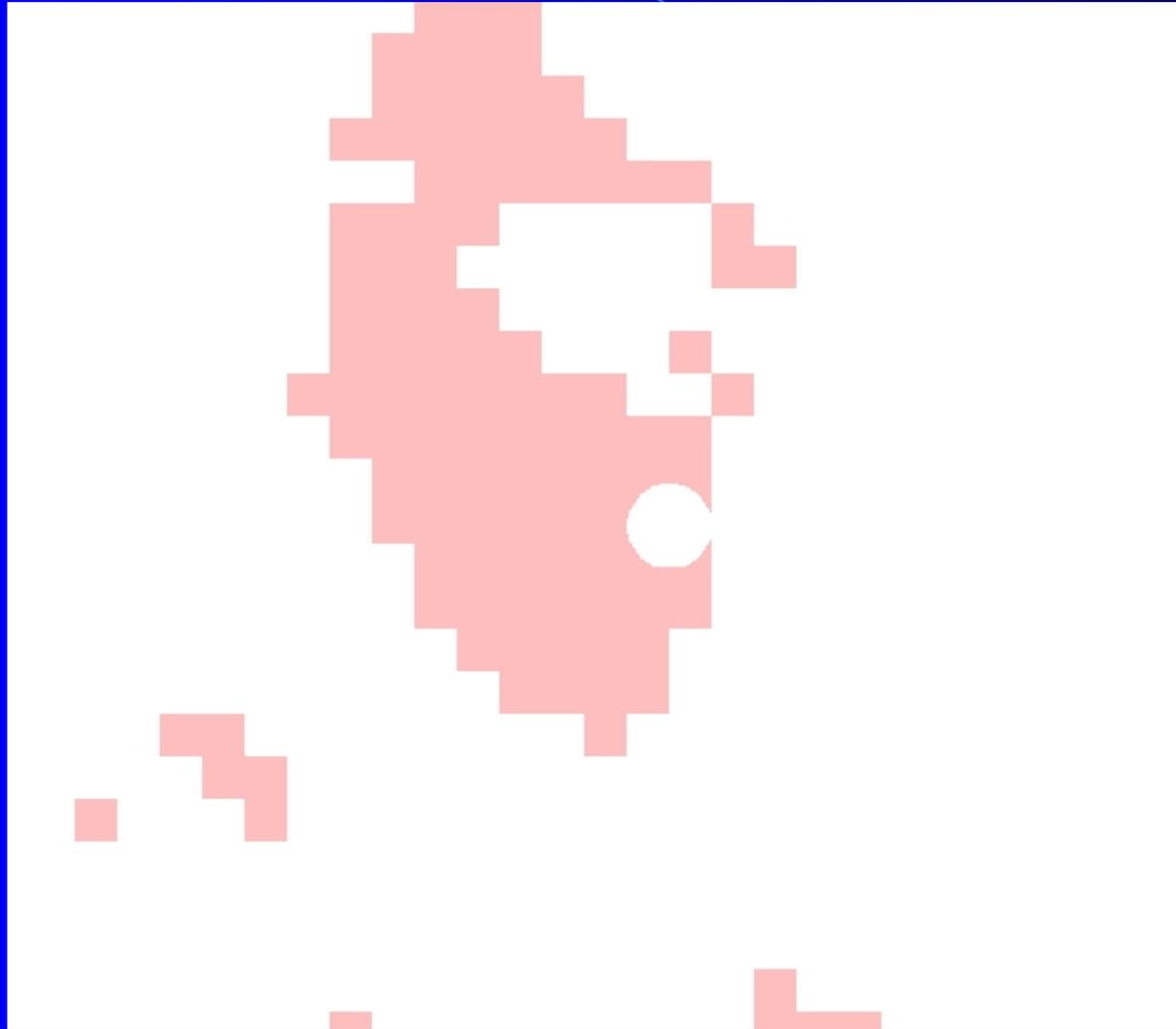


Point file for the  
historic dataset

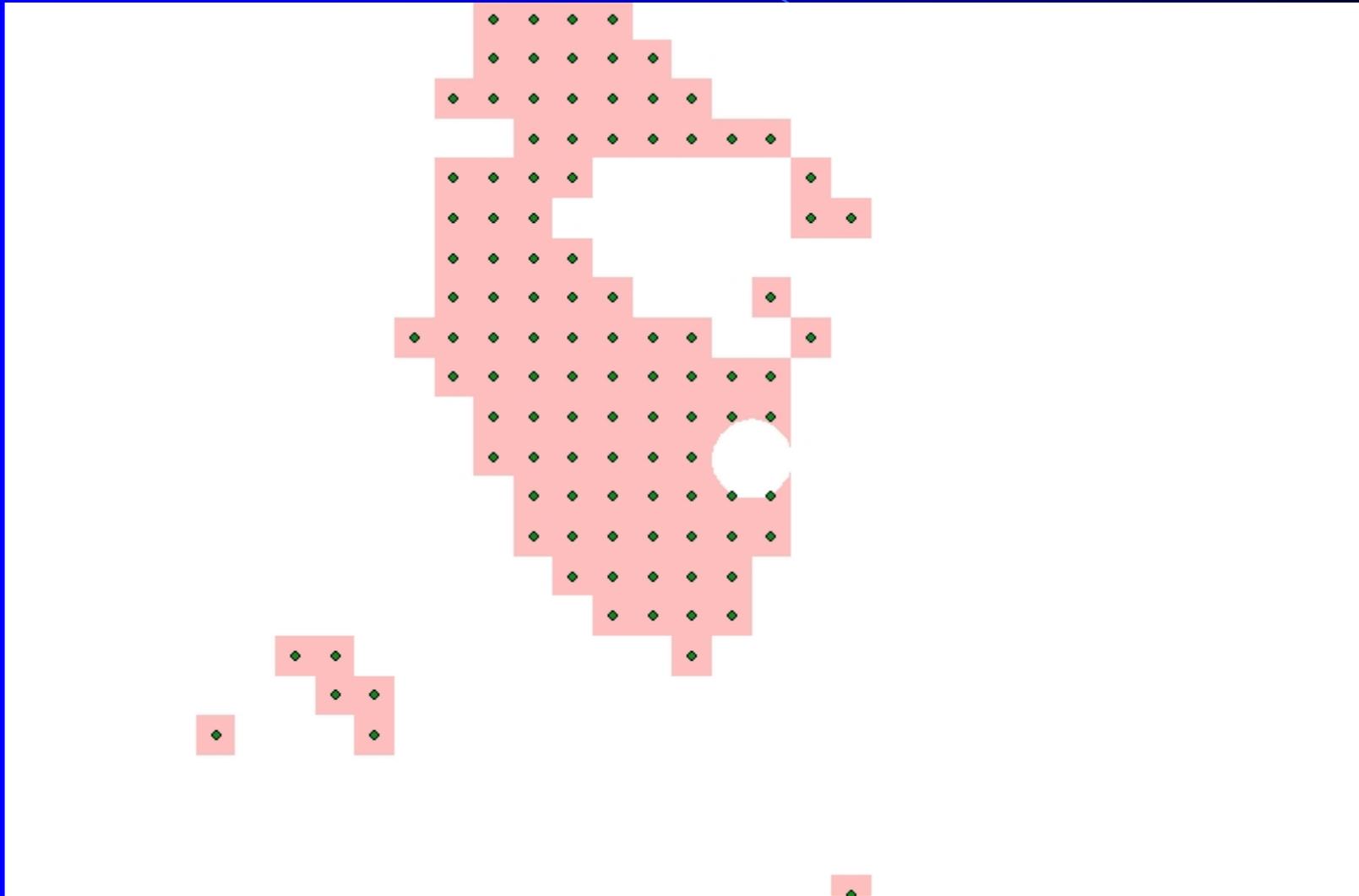
Merged shape file  
for the code 111



# Dataset Without Historic Data



# Constructing Point Files



# Random Selection Using SPSS

Importing data for each code

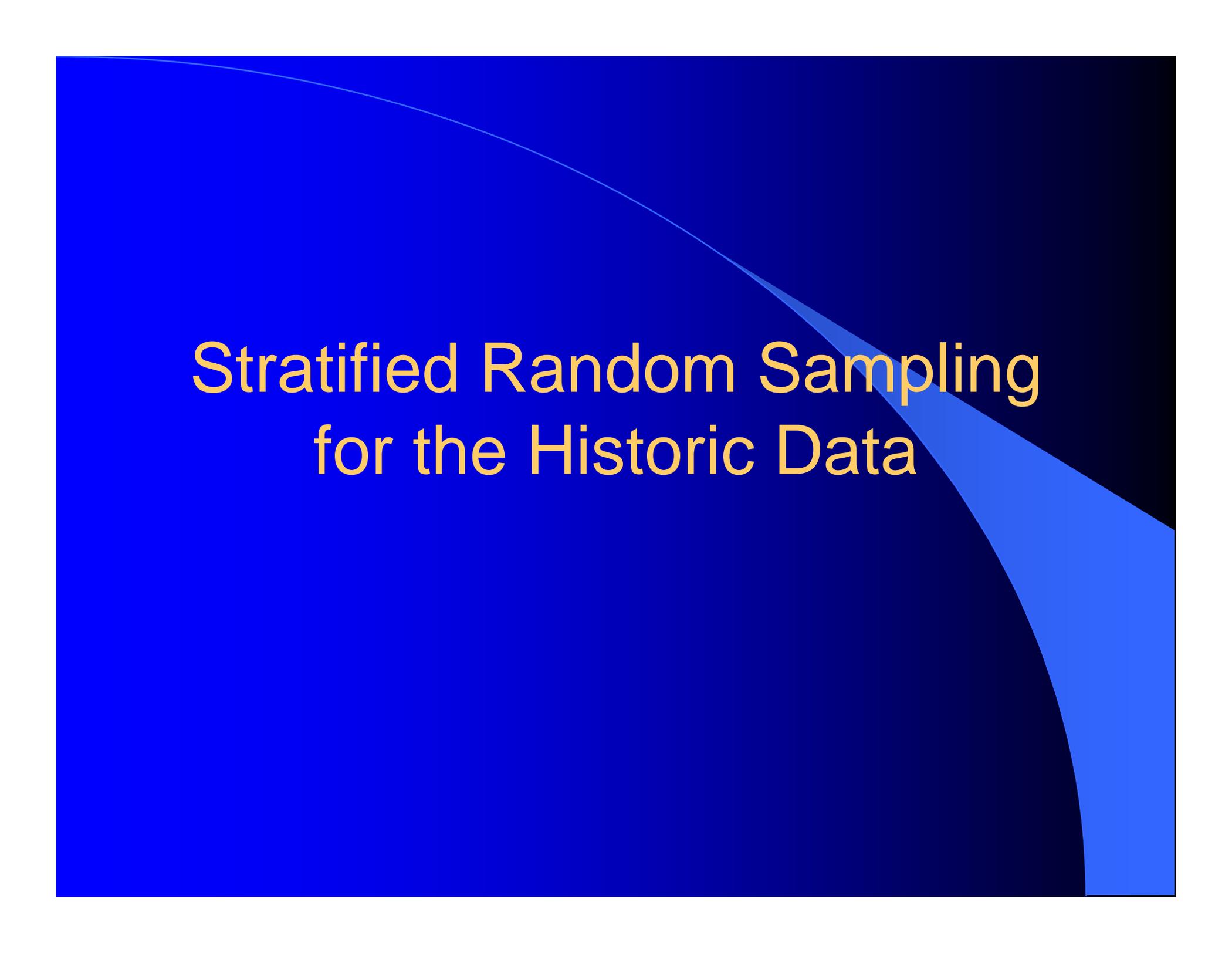
Data

Select Cases

Random sample of cases

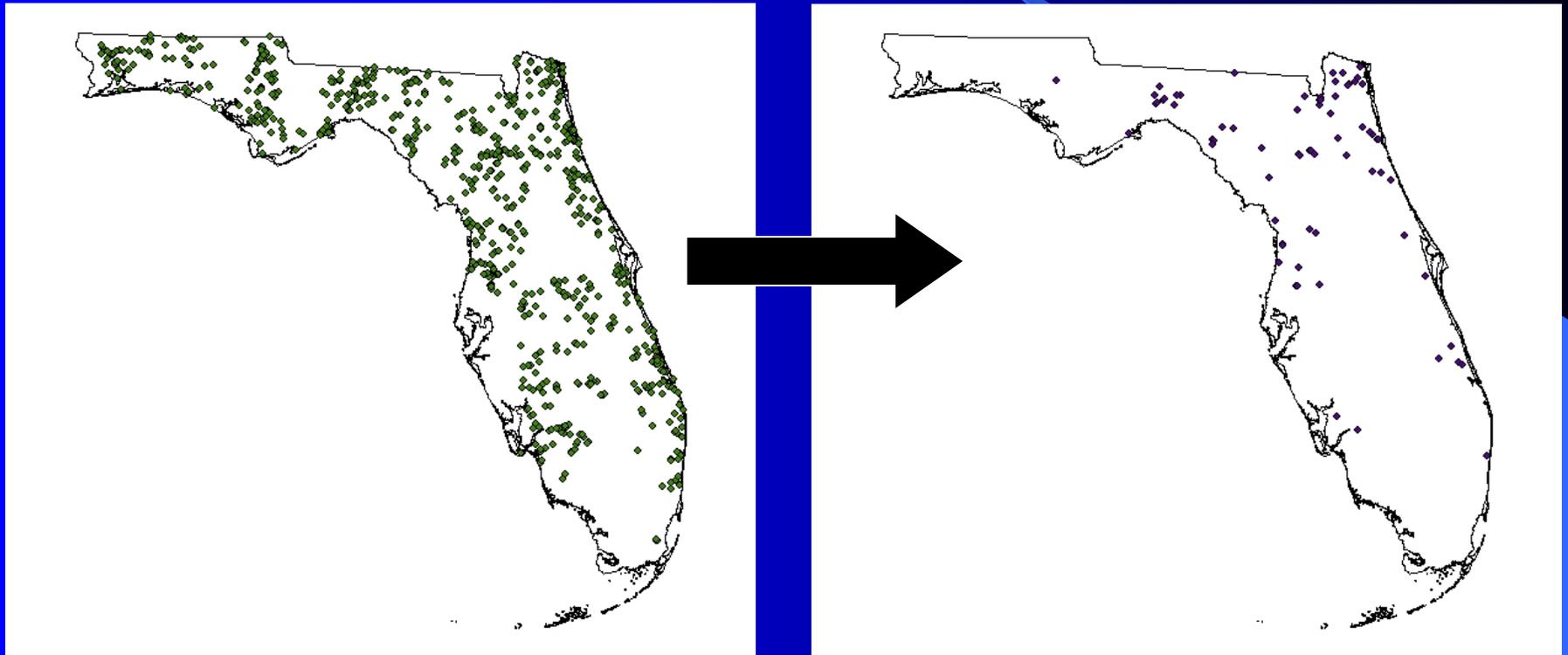
Exactly 'x' cases from the total 'y' cases

The screenshot displays the SPSS Data Editor interface. The main window shows a data table with columns: HORZINDEX, ID, SOILNAME, SOILORDER, CLASSIFICA, LOCATION, and LATDECDE. The data rows list various soil types such as MYA/KKA SAND, SPARR FINE SAND, and SPARR FINE SAND. Overlaid on the data is the 'Select Cases' dialog box. The 'Select' list contains variables like HORZINDEX, LATDECDE, LONGDECDE, ALBERS\_X, ALBERS\_Y, TOP\_DEP, ROT1\_DEP, DEPTH, SAND\_VC, SAND\_C, SAND\_M, SAND\_F, SAND\_VF, TOT\_SAND, TOT\_SLT, TOT\_CLAY, ORG\_C, BASE\_SAT, and LU095UBORD. The 'Based on time or case range' option is selected, and the 'Range' is set to 'LU095UBORD'. The 'Output' section is set to 'Filter out unselected cases'. The 'Current Status' is 'Do not filter cases'. The 'SPSS Processor is ready' message is visible at the bottom of the window.



# Stratified Random Sampling for the Historic Data

# Selecting Sites from Historic Data



# Random Selection Using SPSS

Importing data for each code

Data

Select Cases

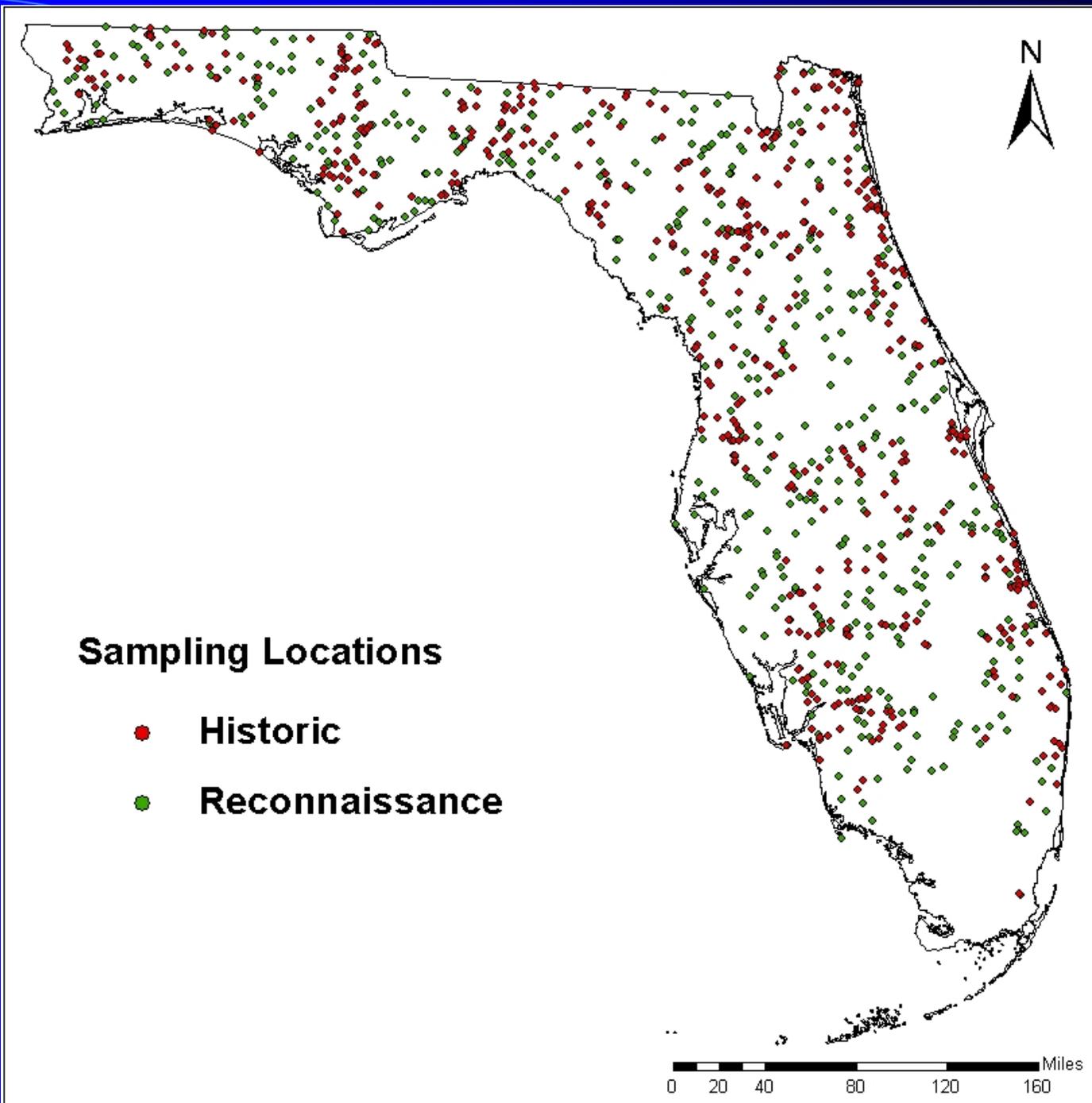
Random sample of cases

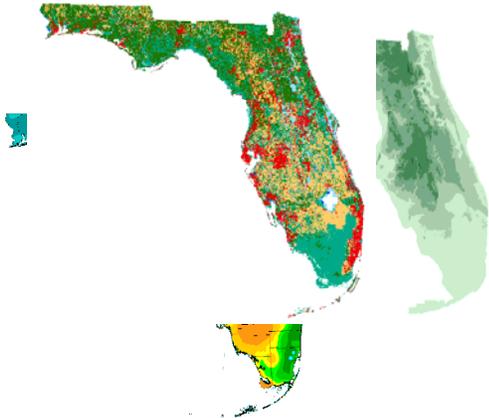
Exactly 'x' cases from the total 'y' cases

The screenshot displays the SPSS Data Editor interface. The main window shows a data table with columns: HORZINDEX, ID, SOILNAME, SOILORDER, CLASSIFICATION, LOCATION, and LATITUDE. The data table contains 44 rows of soil samples. Overlaid on the data table is the 'Select Cases' dialog box. The 'Select Cases' dialog has the following options:

- All cases
- If condition is satisfied
- Random sample of cases
- Based on time or case range
- Use filter variable

The 'Random sample of cases' option is selected. The 'Output' section has  Filter out unselected cases. The 'Functions' list includes LU09SUBORD \* 100. The 'Current Status' at the bottom of the dialog box reads 'Do not filter cases'. The taskbar at the bottom shows the Windows taskbar with various applications open, including Internet Explorer, SPSS, and Microsoft Excel.





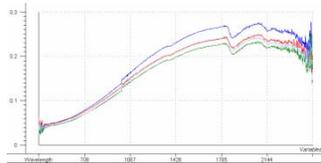
GIS data  
of various  
environmental  
properties

+



**Field  
sampling**

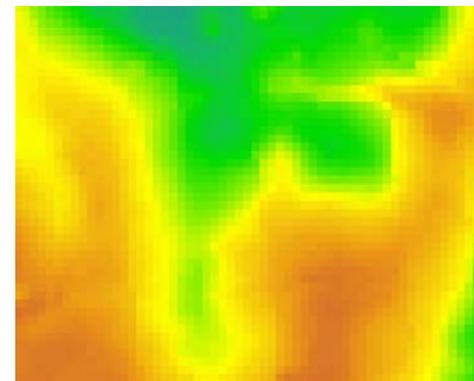
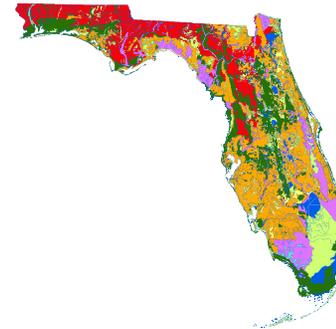
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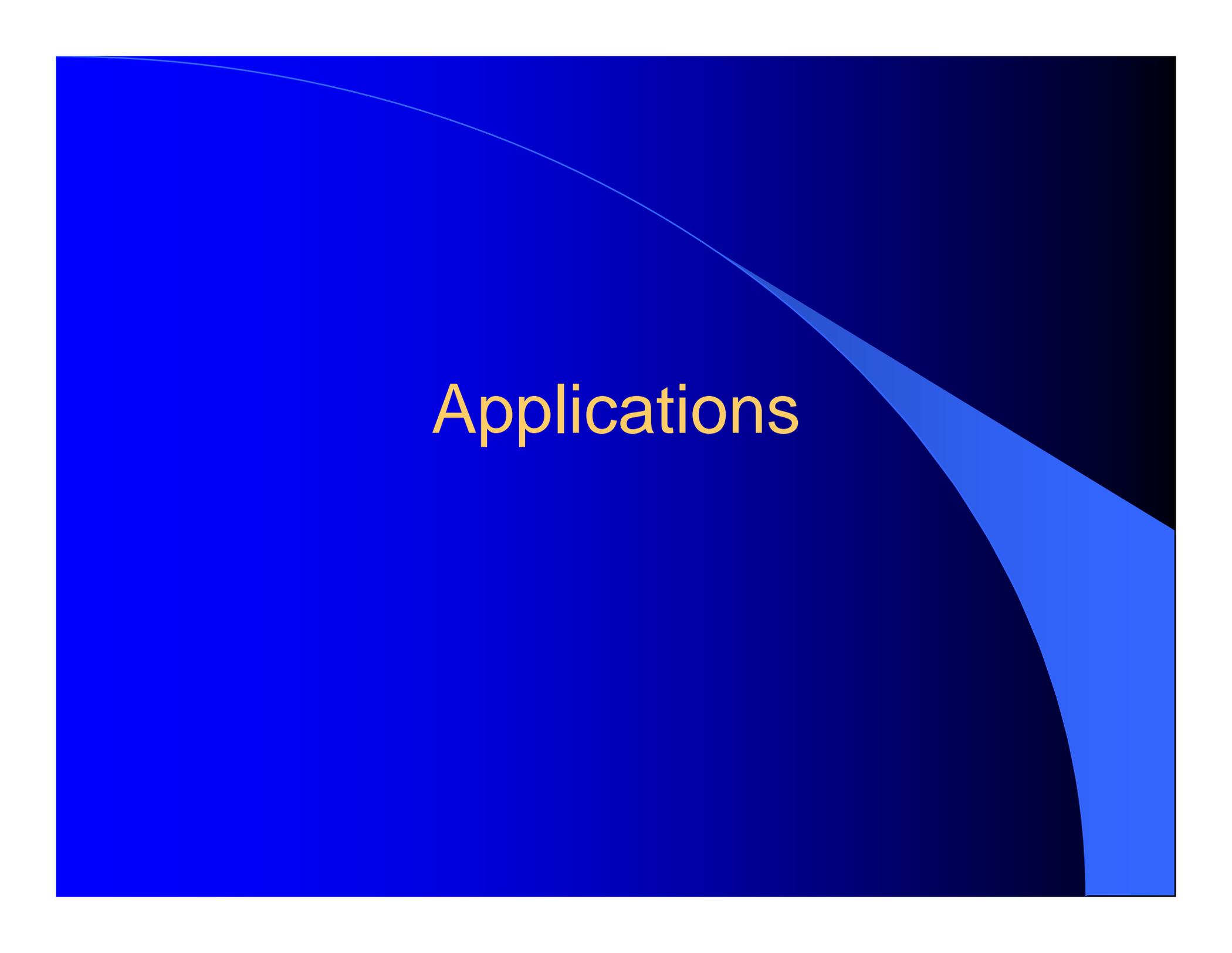


Laboratory  
analysis/  
soil sensing

**Expected  
Results**

**Soil carbon grid  
Florida**



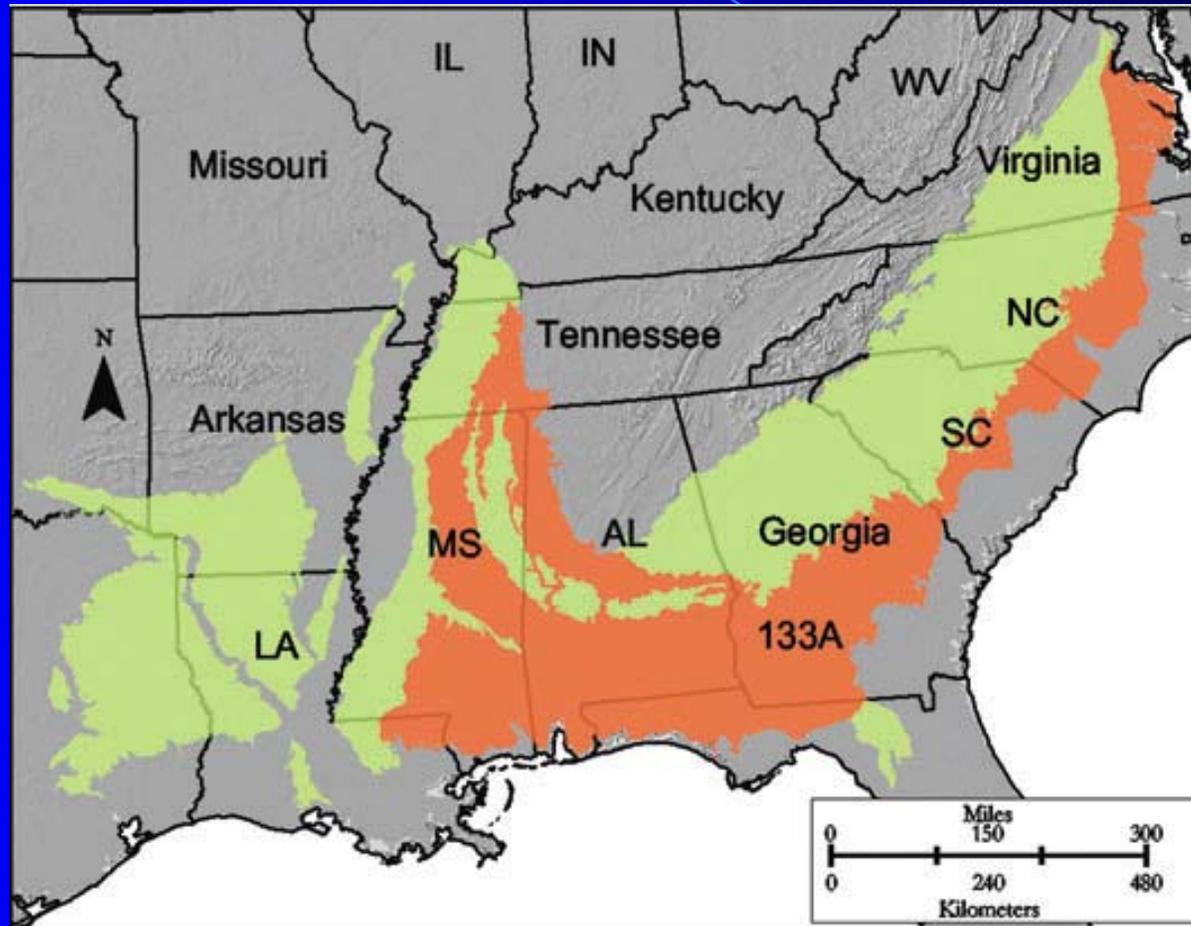
The image features a solid blue background with a subtle gradient. A thin, light blue curved line starts from the top left and arcs towards the right. On the right side, there is a wedge-shaped cutout that tapers towards the top right corner, revealing a darker blue area underneath. The word "Applications" is centered in a bold, yellow, sans-serif font.

**Applications**

# Other large scale projects

- **Strategic soil sampling across Major Land Resource Areas**
- **The USDA NRI topic areas Global Climate Change, Soil Processes etc.**
- **Tool in landscape SOC assessments, supporting the mission of USDA to improve soil quality and reduce the loss of SOC as a result of changing land uses.**

# Use of other input layers



e.g. DEM for MLRA 133A - Southern Coastal Plain

# Other Soil Properties of Significance

- **Land use and geology layers for soil phosphorus**
- **Rainfall and land use for risk of nitrate contamination**

# Other Advantages of the Sampling Technique

- Applicable for large areas by overcoming the 2GB processing limit of ArcGIS
- Any spatial data layer can be used for developing the sampling design
- The method offers precision and flexibility for developing even more complex sampling design
- The layers developed in the process offer valuable information about the population