LiDAR Use in Soil Survey

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Project Description

Since 2005, NRCS soil scientists in Vermont have been collaborating with Dr. Xun Shi of Dartmouth College to develop and implement an automated, knowledge-based approach to soil mapping. The major focus of this effort is software called Soil Inference Engine (now known as ArcSIE). Essex County, Vermont will be the first initial survey area in the country to be completed utilizing this type of automated technology, and one of the first steps in the process was the acquisition of LiDAR (Light Detection and Ranging) elevation data.

What goes into Inference?

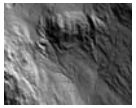
What about LiDAR?

Multiple laser returns are classified into feature types. For soil survey, we use a bare earth model from last return data.

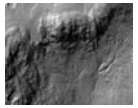

Image source: University of Montana

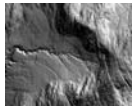
LiDAR Processing

Starting with bare earth quarter-quarter-quad sized ASCII GRID files, the soil survey staff processes the LiDAR data to make it suitable for soil survey work, including inference. This includes reprojecting, mosaicing, and clipping the data to specific work areas.

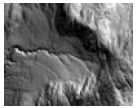


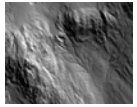
Hillshades are made of each quarter-quad for visualization purposes, using four different azimuths.



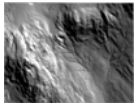


Using ArcSIE, artifacts are removed from the 1m data



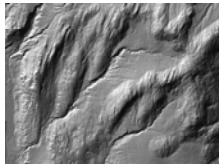


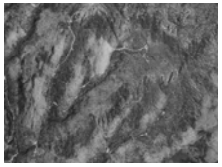
The data are further smoothed by filtering and resampling to a 5m pixel size, which is used for inference work.



Mapping Process

The first step in the digital soil mapping process is the delineation of parent materials and landforms. High resolution LiDAR data are essential for this process.



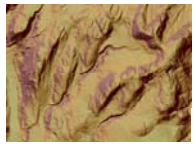


1m LiDAR Hillshade vs. Black and White Ortho Photo; same area; 1:18,000

Signatures in the LiDAR data make it possible to recognize and delineate bedrock controlled landforms vs. deep, dense till areas, for example. Appropriate digital soil mapping techniques are used within each type of delineation.

Terrain Derivatives

In Essex County, the knowledge for soil inference is represented by a set of rules about environmental values; more specifically rules about slope and smoothed wetness index. These environmental layers are derived from the processed (5m) LiDAR DEM using ArcSIE.

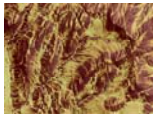

Slope – 30m Neighborhood

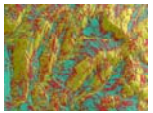

Smoothed Wetness Index

Inference Process

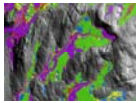
Using ArcSIE, inference is performed in appropriate areas. Inference results are in the form of fuzzy raster maps. The fuzzy membership value at each pixel represents the similarity of that pixel location to the typical soil formative environment.

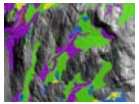

Soil Inference Engine Results for Cabot Soil


Soil Inference Engine Results for Dixfield Soil


Hardened (Defuzzified) Map

Slope is integrated with the hardened SIE map. Slivers are removed using ArcSIE in order to achieve a standard minimum size delineation.





Raster results are further processed and then vectorized using ArcSIE in order to achieve a SSURGO ready product. Map unit composition is determined by traditional transects as well as some high intensity sampling.

ArcSIE

ArcSIE supports knowledge-based raster soil mapping, and is the main tool used in the digital soil mapping process in Essex County, Vermont.

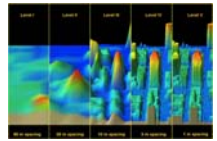
What are some ArcSIE Functions?

- Terrain Derivatives
  - Slope Gradient
  - Wetness Index
  - Aspect
  - Curvature
- Soil Inference
- Post Processing
  - Hardening
  - Sliver Removal
  - Diversity
- Vectorizing

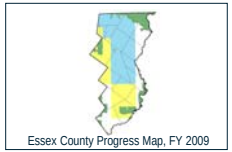
Raster soil maps are created based on the soil environment model **S = f (E),** where **S** is Soil, **E** is the formative Environment, and **f** is the soil-environment relationship.

Conclusions

DEM source and resolution affect our ability to model reality. In landscapes similar to Essex County, VT, as well as in areas with little relief, 1m LiDAR is necessary for accurate modeling.


Source: Geographic Sciences Branch, National Cartography and Geospatial Center

Utilizing LiDAR and ArcSIE, over 230,000 acres in Essex County, Vermont have been mapped since 2007 at an order two level of detail.


Essex County Progress Map, FY 2009


Typical Essex County Landscape