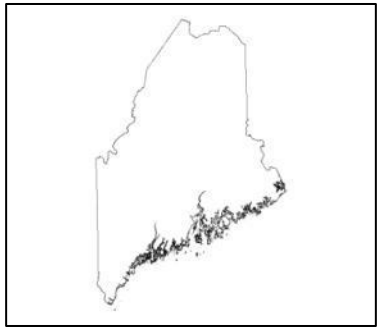
Geologic Site of the Month

December, 2011

Lidar Imagery Reveals Maine's Land Surface in Unprecedented Detail



Text by
Woodrow Thompson

Introduction

"Lidar" is short for Light Detection and Ranging. This remote sensing technique is similar to radar but uses light pulses instead of radio waves. Lidar produces detailed data about objects by bombarding them with laser pulses and recording the reflections of the laser beams from their surfaces. There are many types and applications of lidar. Further details regarding this technology are available from various websites such as Wikipedia - Lidar and LIDAR 101: An Introduction to LIDAR Technology, Data, and Applications.

Lidar

Lidar data can be processed to create a view of the bare earth as it would appear without vegetation cover (Figure 1 and Figure 2). Bedrock ledges, all sorts of landforms produced by rivers and glaciers, and cultural features such as old stone walls and excavations are revealed in unprecedented detail. The Maine Office of GIS website shows an example of the high resolution of lidar imagery in contrast to digital elevation models (DEM's).

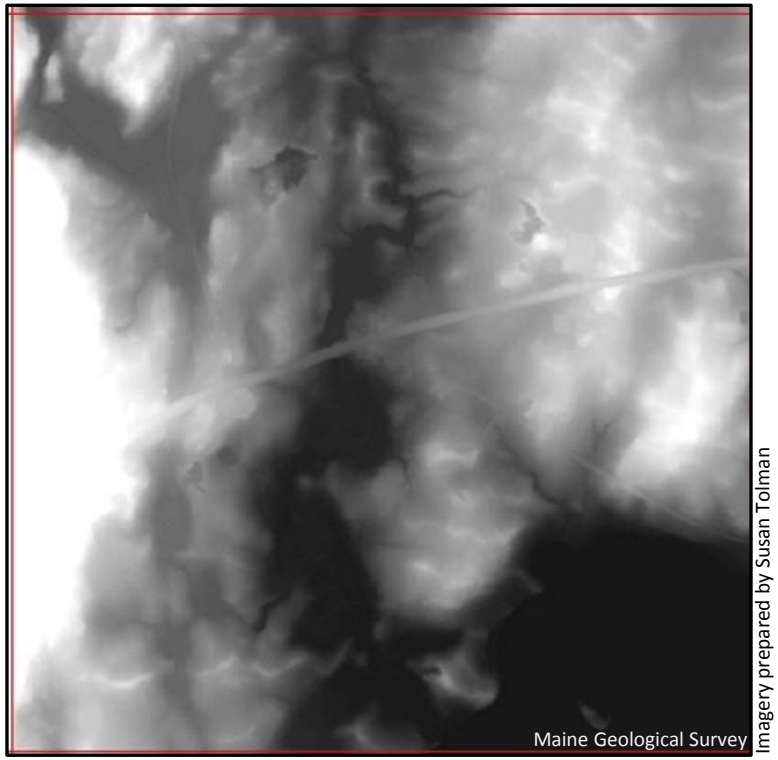


Figure 1. Unprocessed lidar data image. See Figure 2 for same image processed to show a "bare earth" image.

Lidar

Coastal geologists from the Maine Geological Survey currently use lidar to monitor beach changes along the Maine coast. This month we'll look at examples of how lidar reveals glacial and marine features dating back to the Ice Age.

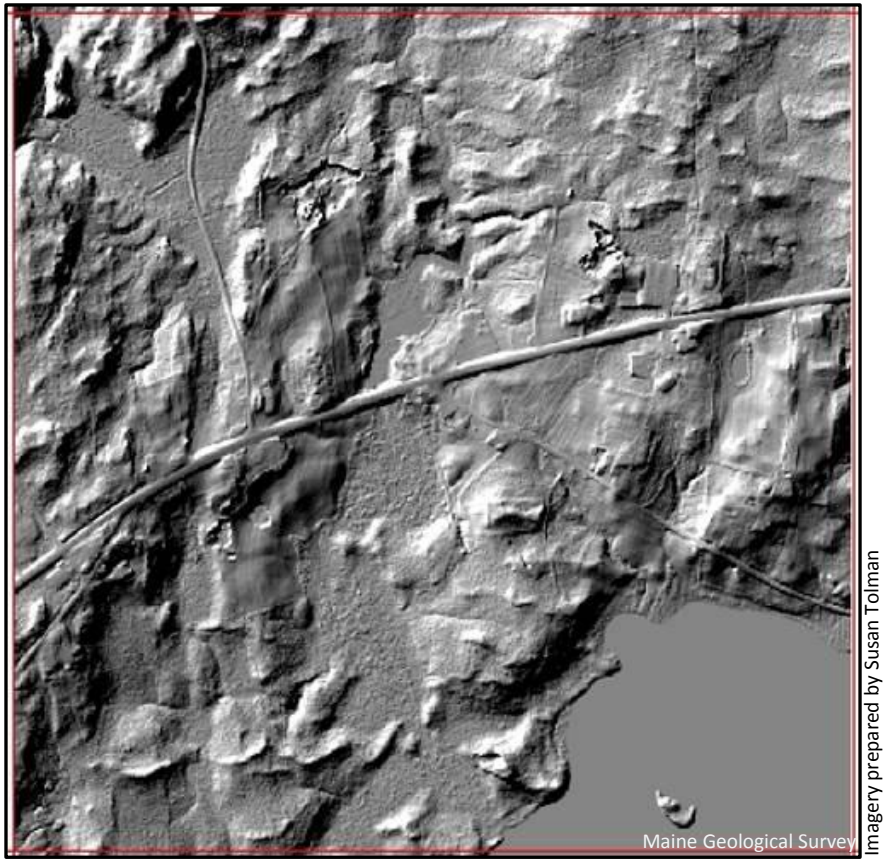


Figure 2. Lidar data processed to show a "bare earth" image. See Figure 1 for unprocessed lidar image.

Moraines and More Moraines

Maine's coastal lowland was submerged by the ocean during retreat of the last glacial ice sheet, and ridges of glacial sediments (till, sand, gravel) were deposited along the margin of the glacier as it receded. These low ridges are called "moraines." The moraines are most abundant in the formerly submerged areas, where they formed in shallow marine waters. Today it is common to see houses and small cemeteries on the moraine crests because they are higher, better drained, and easier to excavate than the marine clay in the low ground between moraines.

Figure 3. Moraine ridge (center) in blueberry field, Cherryfield, Maine.

Moraines and More Moraines

It has long been known that moraines exist in great numbers in southern Maine, but in some areas their distribution and continuity are difficult to determine. The large bouldery moraines in the blueberry fields of eastern Maine are the easiest to see (Figure 3), but elsewhere the moraines are more subtle. Topographic map contours don't always reveal them, and they are often concealed by forest cover or located in areas of difficult or restricted access (Figure 4).

Figure 4. Bouldery moraine in densely forested area of Dresden, Maine.

Moraines and More Moraines

Figure 5 is a lidar image of the area between the villages of Waldoboro and Warren. Topographic details have been enhanced by an artificial "sun" illumination from the north. U. S. Route 1 crosses the northern part of the image, and the Maine Eastern Railroad track is also visible. Most startling are the swarms of narrow moraine ridges that trend east to northeast across the area. The close and regular spacing of these moraines suggests annual deposition, with each one marking where the position of the ice margin stabilized during the winter months. Figure 5 also shows a few places where north-south ridges were sculpted by glacial ice flow.

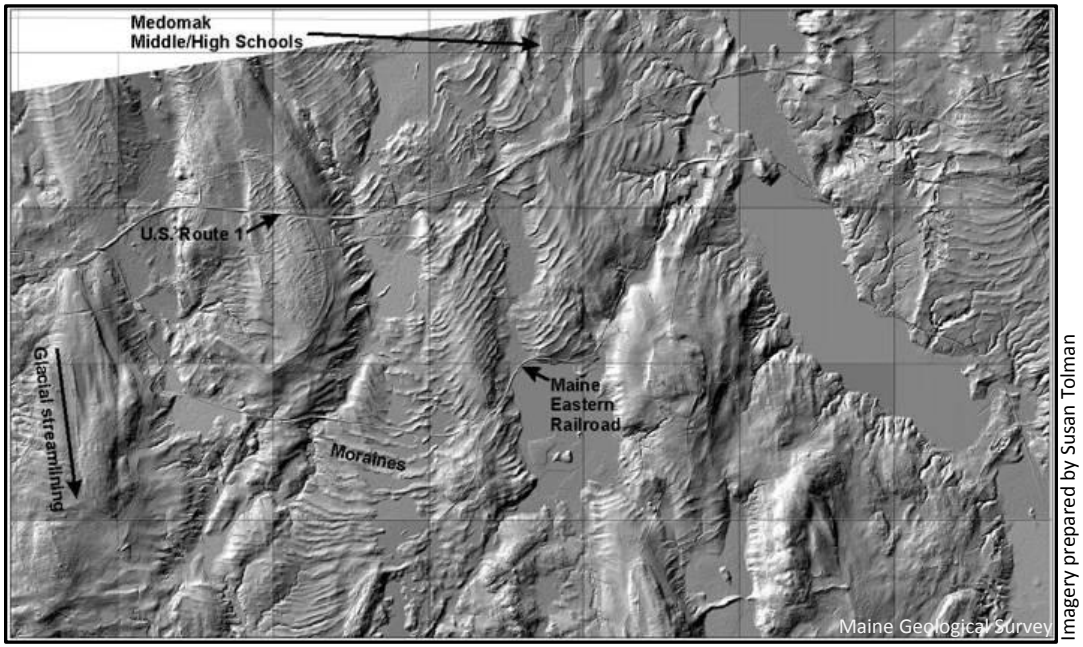
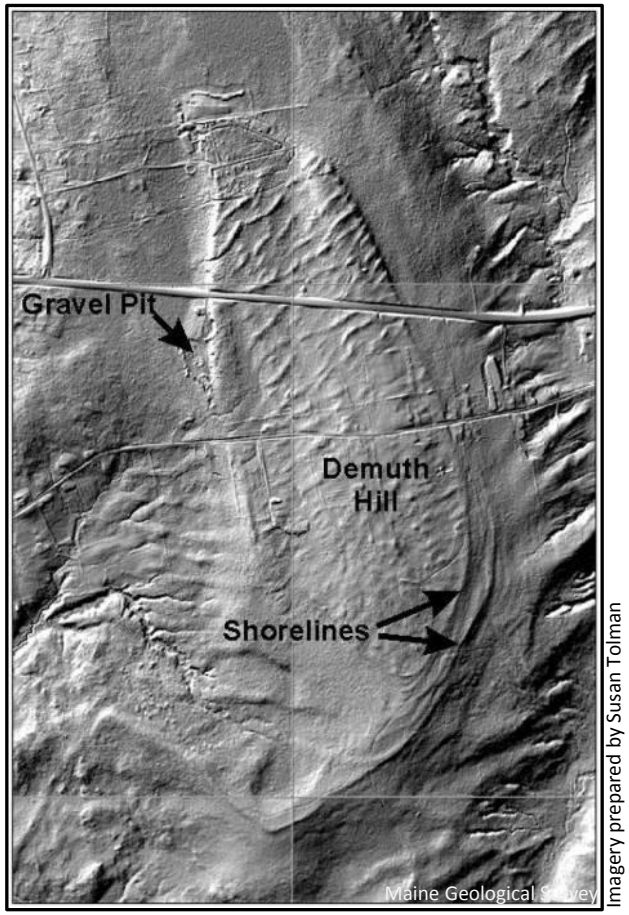


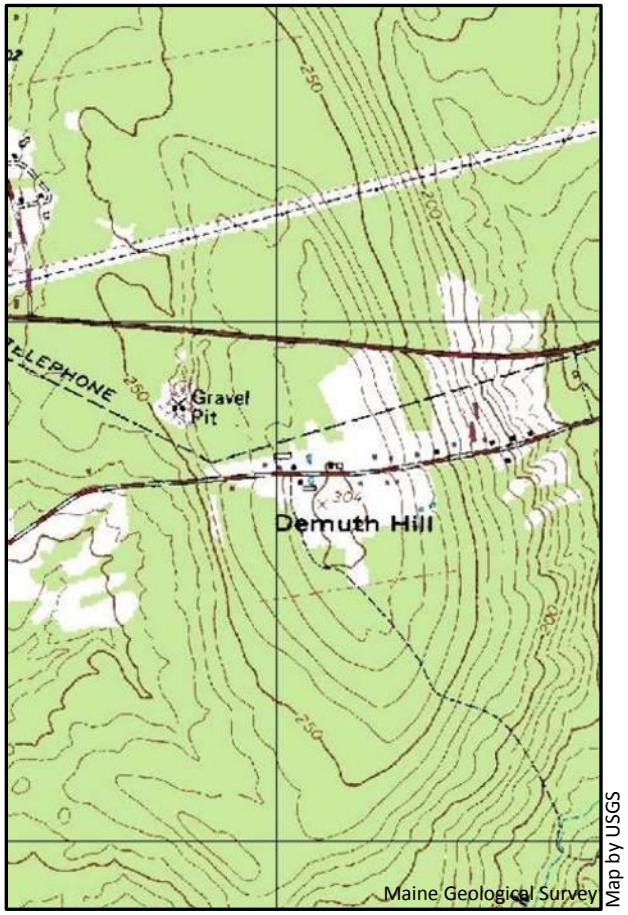
Figure 5. Lidar image showing northern part of the Waldoboro East 7.5-minute quadrangle between Waldoboro and Warren.

Marine raised shorelines

Figure 6 is a close-up of where Route 1 crosses Demuth Hill in Waldoboro, along with a topographic map for comparison.



Imagery prepared by Susan Tolman



Map by USGS

Figure 6. Lidar image and topographic map of northern part of the Waldoboro East 7.5-minute quadrangle.

Marine raised shorelines

The hill is composed mostly of till and has an elongated oval shape due to sculpting by glacial ice flow. The lidar view shows two distinct features. First, there are numerous low-relief moraines trending northeasterly across the hill crest. The moraines occur at elevations of about 300 ft on the highest part of Demuth Hill, which is slightly higher than the 260-270 ft level reached by the ocean during glacial retreat. Figure 7 shows the front (SE) side of one of the moraines just south of Route 1. This ridge is only 3-5 ft high and most boulders that formerly might have littered its surface probably were carried away to make stone walls.

Figure 7. View looking northeast along side of moraine on Demuth Hill.

Marine raised shorelines

The lidar image also reveals marine shorelines resembling bathtub rings that formed around Demuth Hill when it was an island projecting above the late-glacial sea. The uppermost shoreline marks the highest stand of sea level and conforms perfectly to the 260-ft contour on the topographic map (Waldoboro East quadrangle).

Figure 8. Wave-cut bluff (slope on left side of photo) in power line clearing on Demuth Hill.

Marine raised shorelines

This shoreline is most clearly visible where wave attack truncated the moraines north of Route 1 (Figure 6). During a visit to the site, these moraines were not easily seen in the dense forest growth - even in late fall when leaves had fallen - but the shoreline was traced through the woods as a wave-cut bluff about 10 ft high. The latter feature was difficult to photograph (Figure 8) despite its clarity on lidar, and it would have been overlooked without this new imagery. The lidar view also shows what appear to be slightly lower shorelines wrapping around the south end of Demuth Hill.

Numerous pits have been opened along these former marine shorelines in coastal Maine to utilize gravel deposits that resulted from winnowing of glacial sediments in the nearshore zone. One example is seen in Figure 6. Many such pits have been abandoned because the gravels resulting from erosion of till are usually shallow and limited in extent.

The low-relief moraines and shorelines in the forested terrain of Demuth Hill are typical of landscape features that can easily escape detection in aerial photographs and even during ground surveys. The future application of lidar in geologic mapping projects will save time and money during field work and yield maps that are more accurate and detailed

South Pond Readvance

An unusual glacial event occurred in Warren during the recession of the last ice sheet (Figure 9).

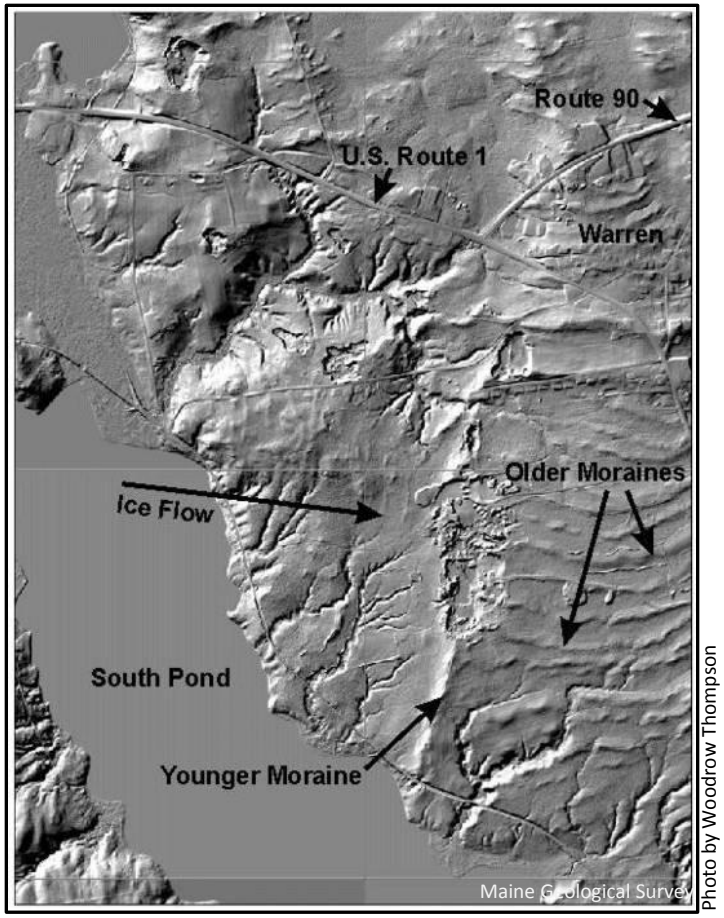
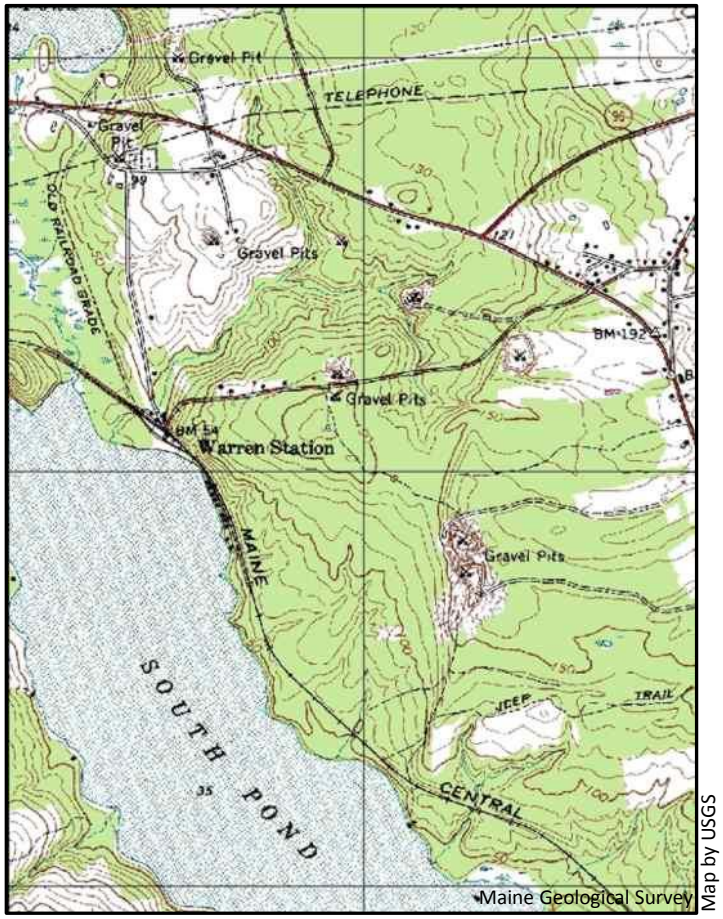


Photo by Woodrow Thompson



Map by USGS

Figure 9. Lidar image and topographic map of South Pond Readvance in Warren. Arrow indicates direction of ice flow during the glacial readvance.

South Pond Readvance

There was a shift from southward to eastward ice-flow in the South Pond area, accompanied by a local readvance of the glacier. A north-south moraine was deposited where the ice margin plowed into and truncated an earlier series of moraines that trend east-west. The South Pond Readvance was already known from geologic mapping, but shows with remarkable clarity on the lidar imagery.

Figure 9 also shows gravel pits that have been opened to extract sand and gravel that washed out of the ice margin along the readvance moraine. The lower-elevation terrain between the moraine and South Pond is covered by fine-grained marine sediments of the Presumpscot Formation. The dendritic drainage pattern seen in this area on the lidar image has developed by erosion of these sediments in postglacial time.