GSA Southeastern Section
60th Annual Meeting 23–25 March 2011
ID# 184903

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LIDAR DIGITAL ELEVATION MAPS OF NEBRASKA'S RAINWATER BASINS

VISUALIZING THE PLANFORMS OF THE CAROLINA BAYS' WESTERN COUSINS

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The Rainwater basins are the surface expression of elliptical depressions developed in fluvial sands and gravels buried by a blanket of several meter-thick loess. These basins are palimpsest landforms created by the draping of a younger loess blanket over these underlying depressions. -(Zanner and Kuzila 2001)

Are the Rainwater Basins Related to The Carolina Bays?

While there has been a great deal effort expended in researching the "Carolina bays" on the eastern seaboard of the United States, little attention has been paid to the significant quantity of elliptical-shaped landforms in Nebraska, United States. William Zanner (2001) proposed a relationship between the Rainwater Basins of Nebraska and the Carolina bays, based on core sampling through overburden loess layers, and suggested the ancestral depressions were created sometime prior to 27 ka. Since that time a significant blanket of late Wisconsin glacial loess have been deposited, rounding off the originally sharp edges of the bay rims he discovered. In 2010, the Nebraska Department of Natural Resources released high-resolution 2-meter Ground Sample Distance (GSD) LiDAR data with 0.39 m vertical accuracy for much of the southeastern region of their state.

We present digital elevation maps (DEMs) generated with this data. These clearly exhibit the presence of significant quantities of elliptical planform depressions with many facets in common with those in the East. The use of these LiDAR maps has enabled this identification with their sub-meter relief fidelity, as the characteristic planforms are rarely seen or identified on the ground or in satellite imagery. Their distinct closed elliptical circumpheral rims, variety of sizes, and common alignments in any one area are considered by us to be as enigmatic as the Carolina bays' planforms. In some areas, local dunes visible in the LiDAR maps have breached the landforms, but the underling ancestral basin structure continues to show through.

While not found in quantities as extensive as those in the East, we hold the geospatial mapping of the surviving basins to be critical to our triangulation attempt, when correlated to their Eastern brethren.

Elevation Profiles

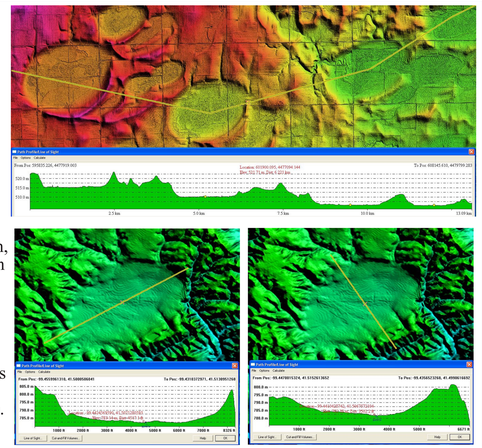
Our use of elevation data includes the generation of "elevation profiles" using Global Mapper. These demonstrate the disparate altitudes of adjacent bays. We speculate this to be an effect of the ejecta blanket draping over the gently eastward-sloping plains landscapes.

As on the East coast, these oval aligned basins are present on a continuum, without regard to altitude.

The Rainwater Basins are spatially large, correlating well with the larger Carolina bays. Such large bay formation, both East and West, seems dependent on terrain with gentle relief. We speculate that - if ever existent - smaller basins have been inundated with overburden and no longer map through.

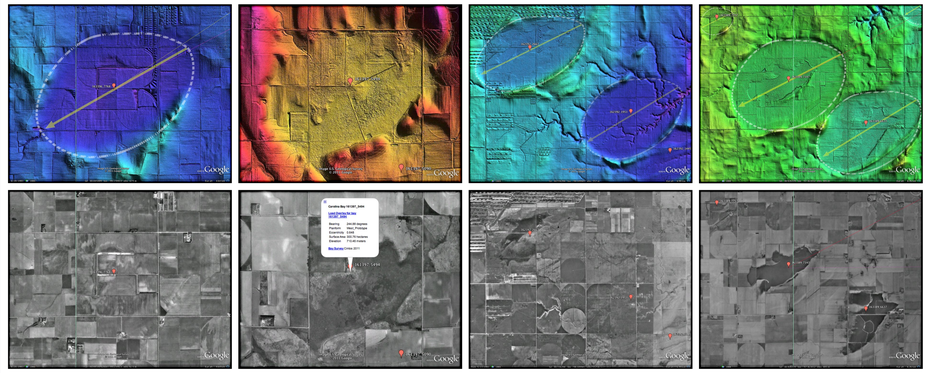
Right upper: an example from the Genera, NE region. Bay floor elevations range from 535 m AMSL to 495 m AMSL (40 m) over a distance of 14 km.

Right, lower: two elevation profiles across one of the Garfield, NE bays.



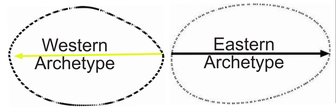
LiDAR vs Satellite Image

Four pairs of images below demonstrate the stunning identifications available using LiDAR visualizations, contrasted with the satellite imagery. The LiDAR is using 10x elevation exaggeration. These features, although stunning in the LiDAR, are often imperceptible to a viewer on the ground. As proof, note that the circular irrigation gantries have no problems traversing these rims. Google Earth screenshots, with LiDAR overlays and hinted with our western archetype planform overlay element.



Data Capture Methodology

Metadata for each proposed bay in our survey is captured using an archetype planform overlay data element in Google Earth, which varies slightly by region. The data is processed and included in an on-line Google Fusion Table, which can be visualized using various tools such as maps, heat maps and graphs. Metadata (surface area, orientation, elevation, eccentricity, location) is available in pop-ups. To date, ~20,000 of an expected 50,000 bays have been measured and processed into the table: `http://cintos.org/Survey`

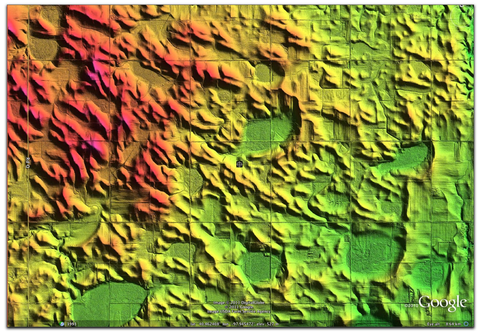


Carolina Bays vs. Sand Dunes

Over the millennia since the emplacement, the majority of the proposed ejecta blanket would have been subjected to wind and water erosion, but the soil within bay rims was stabilized by the presence of moisture captured within the basins. We also suspect that the high heat and pressure of the deposition mechanism created a tightly compacted strata.

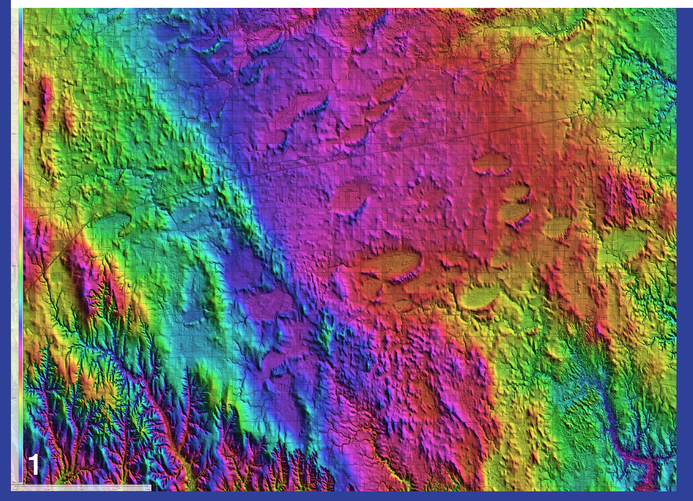
Distorted basins in nearby areas suggest they were at one time elliptical "bays", but have been modified by encroaching sand dunes and ridges. LiDAR of Edgar, NE (right), shows the dune activity.

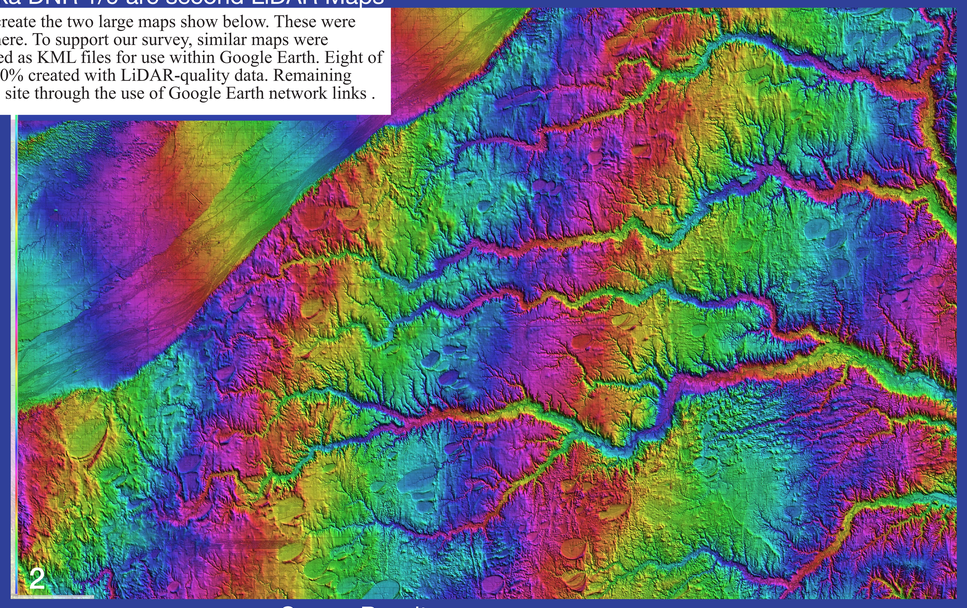
We speculate that much of the sand in the nearby Nebraska Sand Hills was originally deposited as distal ejecta, but that region lacked sufficiently high water table to stabilize the sand. Similar activity might be responsible for the Sand Hills of South Carolina.



Nebraska DNR 1/9 arc second LiDAR Maps

Nebraska Department of Natural Resources (DNR) provided the base LiDAR data used to create the two large maps show below. These were created in the Global Mapper commercial GIS program and exported as geo tiffs for display here. To support our survey, similar maps were created with extents of 0.25º latitude x 0.25º longitude (our self-described Octant) and exported as KML files for use within Google Earth. Eight of these Octants comprise a full USGS 100K Quadrant; the survey covers ~700 Octants, about 40% created with LiDAR-quality data. Remaining Octants are in 1/3 arc second USGS data. All kml-encoded imagery is available from our web site through the use of Google Earth network links .



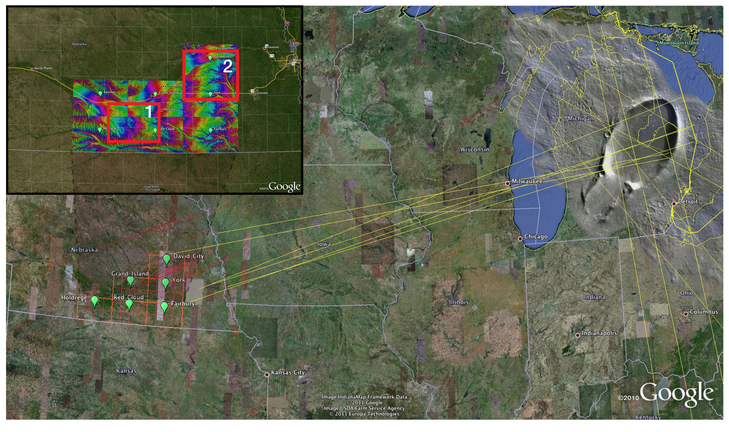


Correlating Carolina bay Orientation

Attempts by others to correlate bays' orientations have failed to resolve a focus, as they were accomplished by drawing straight lines on flat-earth maps. We propose that satisfactory correlation can be obtained by applying several physical aspects of planetary-scale ejecta trajectories, a process not considered as relevant by previous workers. First, the impact may have generated ejecta from a broad geographic extent. Secondly, a planetary body rotates during any realistic ejecta flight-time. Third, the west-to-east ground-velocity between the ejection site and the landing site differs, and the difference will be resolved as the ejecta re-enters the atmosphere and strikes the Earth.

We developed a model for an ejecta curtain wall radiating outward from an impact site. The model addresses ballistic trajectories over a sphere rotating 1/4 degree every minute of loft. A Java calculator was developed specifically to interface with the Google Earth virtual globe. Using the Google Earth "Placemark" metadata element, a given location's latitude and longitude are captured. The calculator processes the placemark and returns a set of Google Earth graphical elements which represents the analytical model's predicted ejecta arrival vector.

Our survey includes ~ 20,000 Carolina bay basins, including ~500 in Nebraska. We maintain that the calculator successfully predicts all orientations (in the East and in Nebraska) when the source impact site is centered over the Saginaw Bay area of central Michigan. The crater visualized is an actual oblique impact crater located north of Acheron Fossae on Mars (NASA/JPL/ASU/ mosaic E. Lakdawalla).



Survey Results

Our bay survey is capturing several mectrics: location, surface area, eccentricity, elevation and orientation. Bay sizes are seen to represent the log-normal distribution, although the western bays's histogram, with their lower quantities and limited small landforms, is not as smooth. Bays are seen rounder further north and further south on the East coast, but the Nebraska bays have similar "Carolina bay" stylistic eccentricity to the central Carolina bays. We expect the arrival bearing to pivot around the impact site. Graph of bearings for ~ 600 0.25º Octants displays a "ratchet", as first latitude (most significant part of Octant value) and then longitude (least significant part of Octant value) vary.