Geomorphic Investigations of Newly Identified Linear Dunes in Western Wisconsin, USA

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Abstract

The purpose of this poster is to present results of research conducted in western Wisconsin (Buffalo, Chippewa, Southern Dunn, Eau Claire, Pepin, Pierce and St. Croix Counties). Our analysis of high resolution LiDAR-derived DEMs and soil texture data (sandy, gravel-free soil parent materials) revealed ~375 linear dunes (interpreted based on morphology), one of many sandy eolian (wind-deposited) landforms previously unknown in the study area we are investigating (sand sheets, deflation hollows, parabolic dunes, sand ramps, and eolian dammed drainages). Linear dunes were identified and mapped independently by three team members. The dunes are 40 to 2,600 m long, up to ~100 m wide, and ~1.5 to 3 m high. They also exhibit a preferred WNW to ESE orientation suggesting formation under a WNW paleowind. Preliminary age control indicates they formed from ~13 ka to 11 ka during the terminal late-Pleistocene. Their age and orientation is consistent with paleowind reconstructions based on loess distributions across the study area. Further investigations to better constrain their age, describe their internal stratigraphy (to confirm our paleowind reconstruction), and their relationship to sand stringers, similar landforms widely observed in similar landscape settings in southeastern Minnesota and elsewhere in the western Great Lakes region, are ongoing.

Introduction

Purpose:
- Identify and map linear dunes, contribute to the reconstruction of post-glacial paleoenvironmental and paleoclimatic and landscape evolution of the modern landscape of the Western Great Lakes region of North America.
- Paleowind direction, inferred from orientation of linear dunes (NW-SE), can be used to explain observed locations of loess (east-facing slopes of bedrock ridges).

Research Question:
- Are linear dunes located in the study area and if so, can they be used to reconstruct paleoenvironmental conditions?
- It is hypothesized that the sources for much of the loess observed on the modern-day Lower Chippewa River Valley (LCRV) and adjacent parts of western Wisconsin are directly linked to the formation of sandy eolian deposits.

Previous Research:
- Schaetzl et al. (2017) is more detailed study of the sandy eolian landforms, based on sand textures of landforms with dune-shaped morphologies using the soil survey data.
- They used LiDAR data with a range in resolution from 3 ft. to 15 ft. cell sizes.
- Dune morphologies were also used to infer paleowind directions. Dunes formed on westerly winds between 14,000 and 10,000 BP. They conclude that, LCRV:
  - Dune morphology indicates NW to SE paleowind direction
- Linear dunes they describe are:
  - 1.5 to 3.0 meters high and 100 meters wide
  - >1 km in length
  - Symmetrical in cross-section
  - Western ends of dunes are sometimes more sharply defined than eastern ends
- In the summer of 2017, an ORSP, SREU grant from the University of Wisconsin-Eau Claire (UWEC) and funding from Minnesota State University, Mankato (MNSU) supported field work in Dunn County and parts of Eau Claire County to ground-truth some linear dunes.
  - Samples were collected from several linear dunes. These samples will be used to determine the age of those individual dunes using a technique called optically-stimulated luminescence (OSL) dating.

Study Area

- Schaetzl et al. (2017) identified a rich array of sandy eolian landforms including parabolic sand dunes, linear sand dunes, sand ramps, deflation hollows, sand sheets, and eolian dammed drainage systems in the LCRV.
- Our expanded study area includes Buffalo, Eau Claire, Chippewa, the south part of Dunn County, Pepin, Pierce, and St. Croix counties in western Wisconsin (south of the last glacial maximum terminal moraine) (Refer to Figure 1 below).

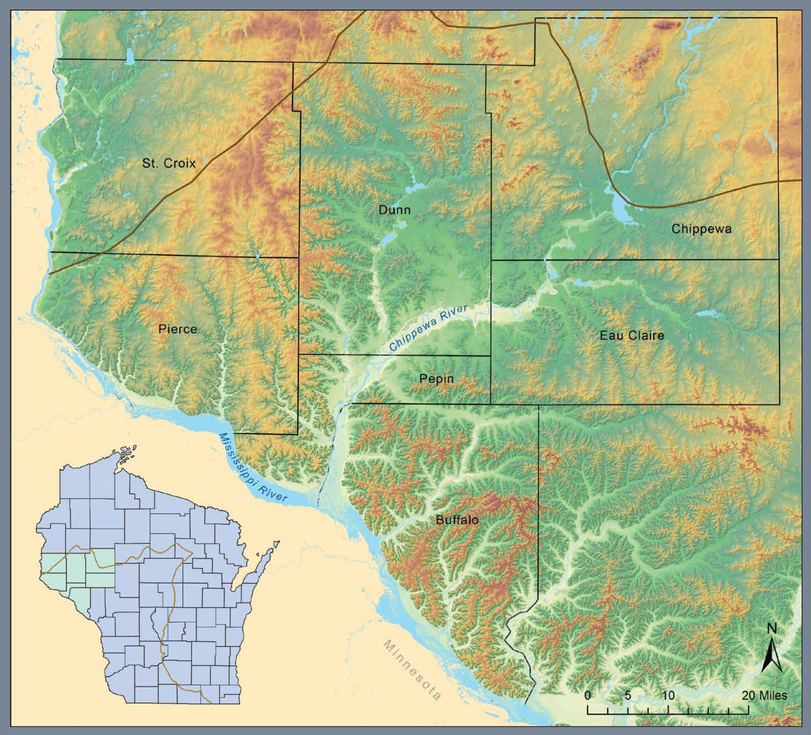

Figure 1. The study area is shown in the seven counties that are located below the last glacial maximum terminal moraine (brown line) in Western Wisconsin. These counties are east of the Mississippi River and connected to the LRCV.

Methods

Step 1:
- Acquire LiDAR data from county geospatial data archives in Wisconsin and import it into an ArcGIS platform.
- Create a High-resolution LiDAR-derived Digital Elevation Models (DEM) and build a 3D model.

Step 2:
- In order to map linear dunes, establish a quantifiable, non-arbitrary criteria for identifying linear dunes based on Schaetzl et al. 2017 (for parts of Eau Claire, Dunn, and Chippewa Counties in Wisconsin).
- Linear ridges were mapped separately by three different people (example shown in Figure 2).

Step 3:
- Linear ridges clearly of non-eolian origin (e.g. eskers, human-made features, point bars) were removed.

Step 4:
- The orientation of linear ridges was determined.

Step 5
- Acquire digital soils data (SURGGO).
- Linear ridges not associated with sandy parent material were removed.

Figure 2. Line shows a Step 2 example. Two linear dunes are shown by arrows without line drawn.

Results

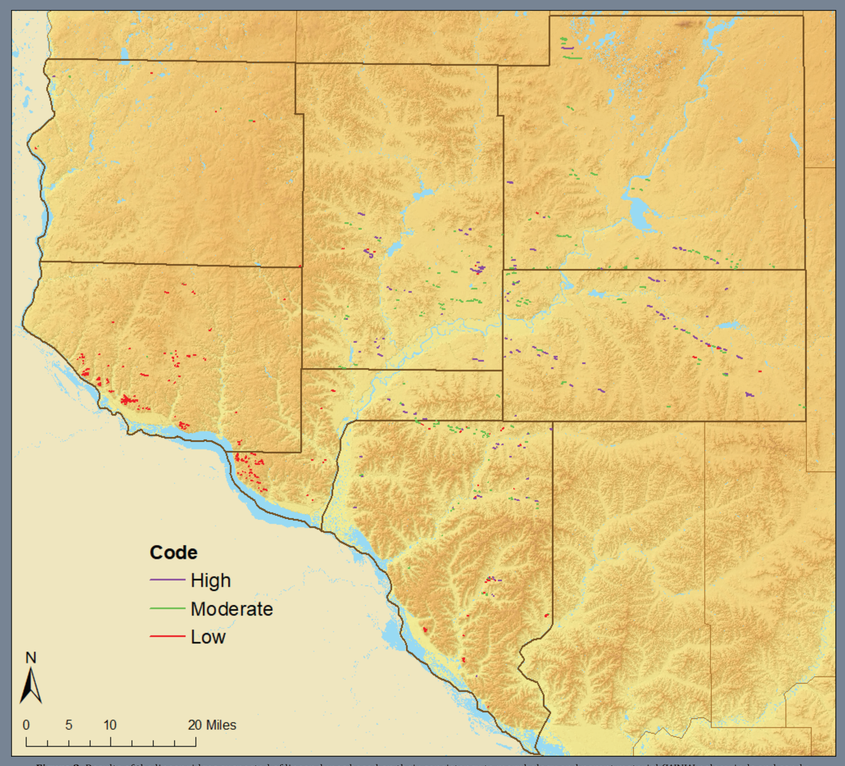

Figure 3. Results of the linear ridges suspected of linear dunes based on their consistency to morphology and parent material (WNW paleowinds and sandy material).

1092 linear ridges are identified. 669 are classified as linear dunes (Figure 3).

154 linear dunes are rated at a high confidence (morphology and parent material consistent with linear dune interpretation). 216 are coded as moderate (morphology or parent material ambiguous). 299 are rated low confidence (morphology or parent material inconsistent with linear dune interpretation) (Figure 4).

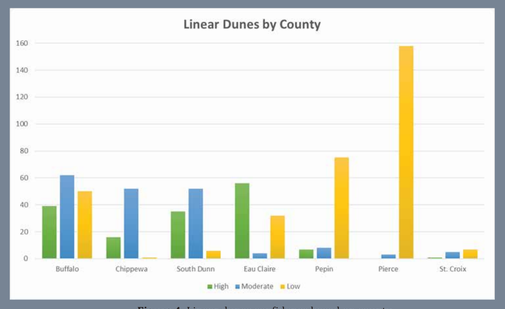

Figure 4. Linear dunes confidence based on county.

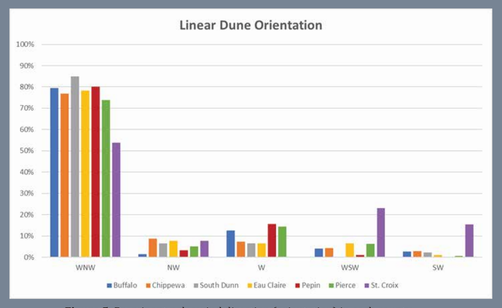

Figure 5. Prominant paleowind direction (orientation) in each county.

Figure 5 shows orientation of linear dunes. 78% of the linear dunes are oriented in the WNW direction, 11% W, 5% NW, 4% WSW and 2% are oriented SW. Which is consistent with paleowind directions during the terminal late-Pleistocene described in the literature.

Discussion

Figure 6. Linear ridges rated a low confidence because they are made of loess. The linear ridges in Pierce and Pepin Counties on the clifftops of the Mississippi River Valley cannot be linear dunes, since they are not eolian.

Linear ridges in Pierce and Pepin counties adjacent to the Mississippi River Valley may be a special case (Figure 6). In those counties, 233 meet the morphological criteria we used to map linear dunes. However, they are associated with loess parent material (not sand), so cannot be linear dunes. However, they are oriented similarly to landforms that meet the morphological and parent material criteria, and their location on uplands to the east of the Mississippi Valley is consistent with the interpretation of a northwesterly paleowind. Therefore, they may be eolian landforms, too.

Conclusions

- 374 linear ridges are consistent with linear dune interpretation.
- About 94 percent of the linear dunes are oriented WNW or NW.
- Linear dune orientation is consistent with the literature that suggest eolian sand transport occurred as a result of winds from the west or northwest.

Future Studies

- We recommend further investigation of the 233 of linear landforms formed in loess, observed in Pierce and Pepin counties to the east of the Mississippi Valley.
- Aquire absolute age control on linear dunes (using optically-stimulated luminescence).
- Investigate internal stratigraphy of linear dunes using ground penetrating radar and methods Mason et al. (1999) used to investigate sand stringers, a landform similar to the linear dunes we describe here.

References

Mason, Joseph, A., Nater, Edward A., William Zanner, C., Bell, James C., 1999. "A new model of topographic effects on the distribution of loess." Geomorphology 223-236.

Schaetzl, Randall J., Phillip H. Larson, Douglas J. Faulkner, Garry L. Running, Harry M. Jol, and Tammy M. Rittenour. 2017. "Eolian sand and loess deposits indicate west-northwest paleowinds during the Late Pleistocene in western Wisconsin, USA." Quaternary Research 1-17.

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