Late Holocene History of Dune Activity Along the Elkhorn River in Northeastern Nebraska

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Presentation Outline

- Master’s Thesis project, presented July 2011
- Project Goals
- Background
- Study Site and Methods
- Results and Discussion
- Conclusions

Goals

- Develop a chronological framework of eolian activity through optical dating
  - Determine when eolian activity/dune formation occurred and the potential causes.

- Determine if the Stanton dune field, along the eastern margins of the Great Plains, was as sensitive to prehistoric drought episodes that activated the Nebraska Sand Hills OR if it was more stable and thus a climatic threshold location.
  - Compare dune activity to that of other regional dune fields to identify patterns.

Background

- Eolian features are important for climatic studies
- Understanding how sensitive these landscapes are to drought and the magnitude of past activations important for the future
  - Dust Bowl had devastating effects but pales in comparison to prehistoric activations on the Great Plains

Background

- Nebraska Sand Hills is currently stabilized by steppe and grassland vegetation but was active for several distinct periods over the last 10,000 years

- Major eolian activity is linked to SEVERE drought THUS pre-historic climatic conditions are important to understand

Citations: Bleed and Flowerday, 1998; Miao et al., 2007

http://eas.unl.edu/~tfrank/History%20on%20the%20Rocks/News/2008%20TRIP.html

http://www.travel-destination-pictures.com/picture/te-paki-sand-dunes-87.htm

Background

- Megadroughts identified by extensive sections of eolian sand in soil/sediment profiles and through dating of eolian sands, buried soils and peats, and pollen records

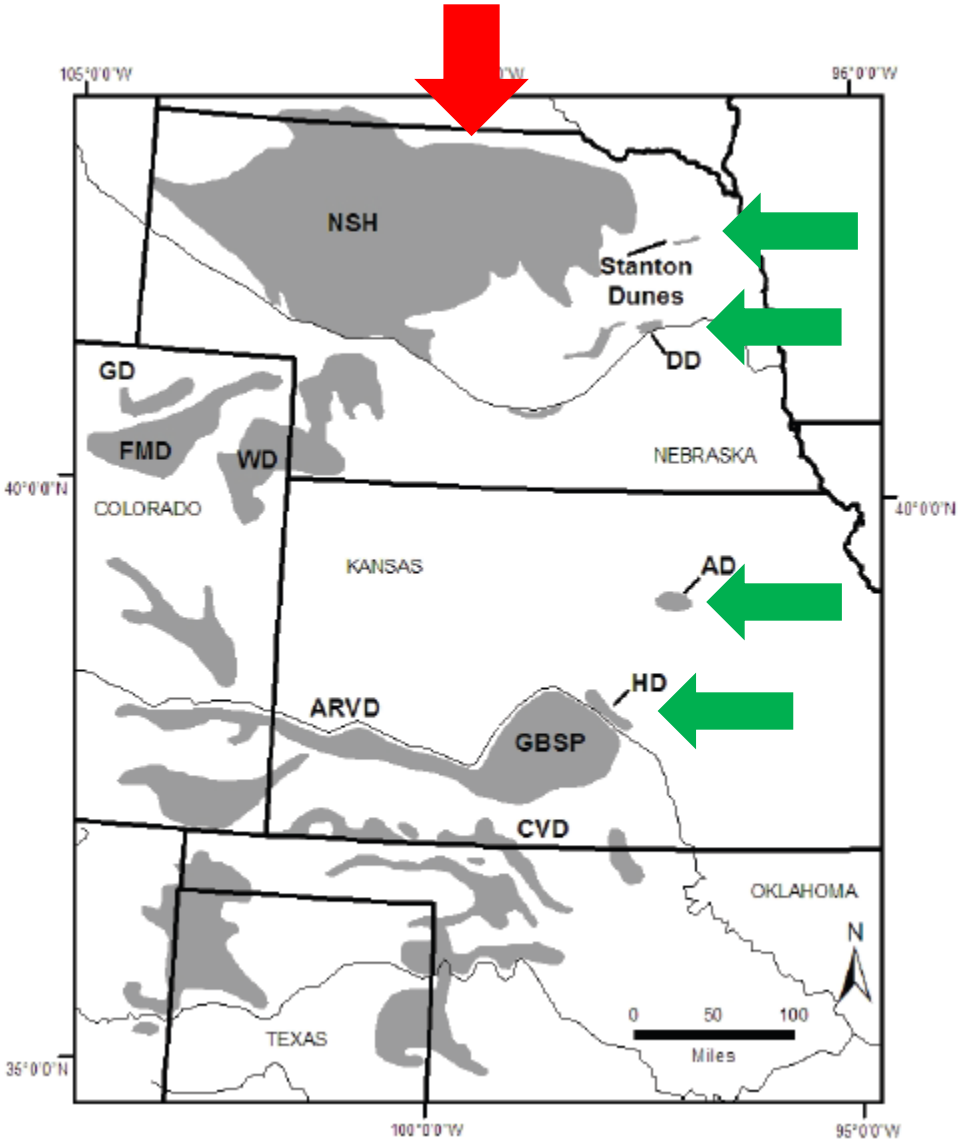
- Early studies focused on radiocarbon dating and pollen records which is not ideal for dating eolian activity

- Optically stimulated luminescence (OSL) dating is a much better method for dating activity

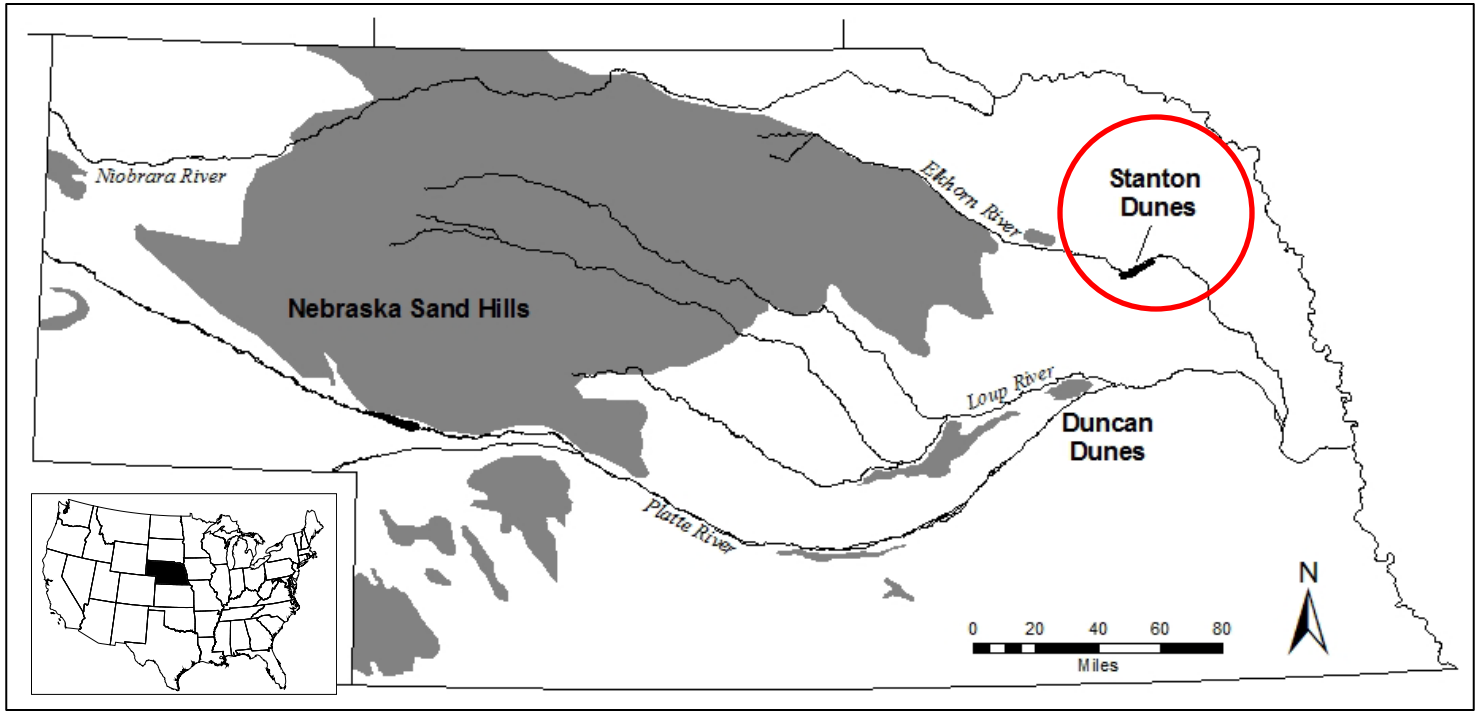
Citations: Arbogast, 1996; Stokes, 1999

Background

- Eolian Age Chronology of the Great Plains
  - Wide-spread eolian activity across the Great Plains
  - 99th Meridian
- Nebraska Sand Hills (Miao et al., 2007)
  - 9.6 to 6.5 ka, and around 3.8, 2.5, and 0.7 ka
- Duncan Dunes (Hanson et al., 2009)
  - 4.3 to 3.5 ka and 0.9 to 0.5 ka
- Abilene Dunes (Hanson et al., 2011)
  - 1.1 to 0.5 ka
- Hutchinson Dunes (Halfen et al., 2012)
  - 2.1 to 1.8 ka, 1.0 to 0.8 ka, and 0.6 to 0.07 ka



Study Site



- About 42° N, 97° W, and 145 km (90 mi.) east of NE Sand Hills and 113 km (70 mi.) northeast of Duncan Dunes

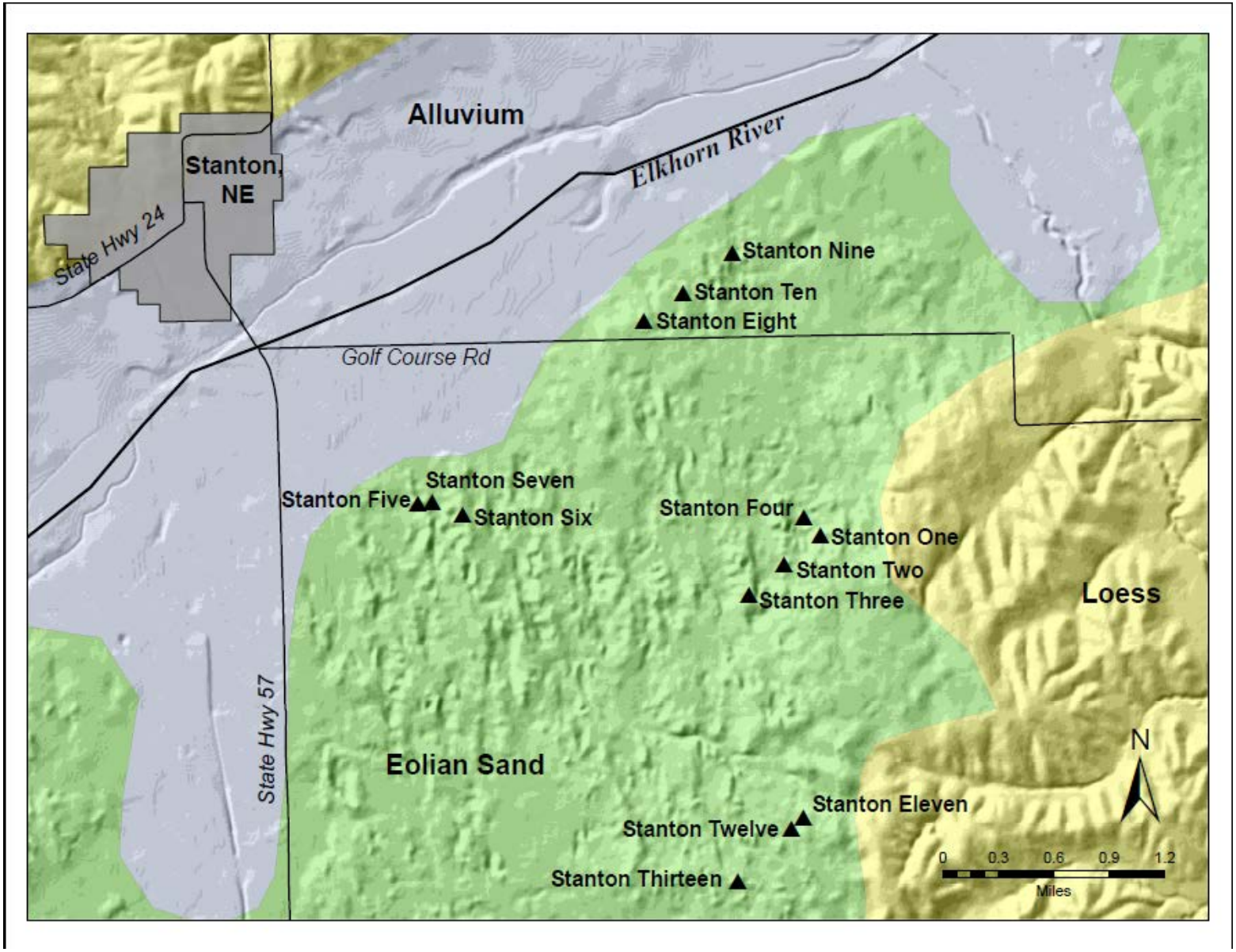
Study Site

- Climate
  - Humid continental
  - 25-35 in. avg. annual precip.
  - NNW winds fall-winter, S winds spring-summer, avg. annual S wind
- Currently stabilized by grassland vegetation like the Nebraska Sand Hills
- Land use
  - Agriculture (rangeland, pasture, cropland)
- Geology
  - Barchan dune forms
  - Loess capped uplands of Peoria Loess about 12-16 meters thick

View of Stanton dune field from Stanton 13.
November 19, 2010

Citations: Hammond et al., 1982; NDNR, 2011; Mason et al., 2001

Study Site


Alluvium
Elkhorn River
Stanton, NE
State Hwy 24
Stanton Nine
Stanton Ten
Stanton Eight
Golf Course Rd
Stanton Seven
Stanton Five
Stanton Six
Stanton Four
Stanton One
Stanton Two
Stanton Three
Loess
State Hwy 57
Eolian Sand
N
Stanton Eleven
Stanton Twelve
Stanton Thirteen
0 0.3 0.6 0.9 1.2
Miles

Methods

- Sediment Cores
  - Giddings probe
- Particle size analysis
  - Malvern Mastersizer 2000E
- Optically stimulated luminescence (OSL) dating
  - Risø TL/OSL Readers

Stanton Thirteen; Stanton Dune Field, Stanton, NE.
November 19, 2010

Results

- Lamellae-like Features
  - Present in 11 of 13 cores with very little to no clay accumulation
- Geochemical Analysis
  - No difference between eolian and alluvial sediments; Similar to Nebraska Sand Hills eolian sand
- Eolian Ages
  - Modern (n=2)
  - 0.41 to 0.63 ka (n=7)
  - 0.82 to 0.96 ka (n=2)
  - 3.8 to 5.8 ka (n=6)
  - 9.8 ka (n=1)
- Alluvial Ages
  - 15.8 to 23.7 ka (n=6)

Lamellae; Stanton Eight Core.

Results

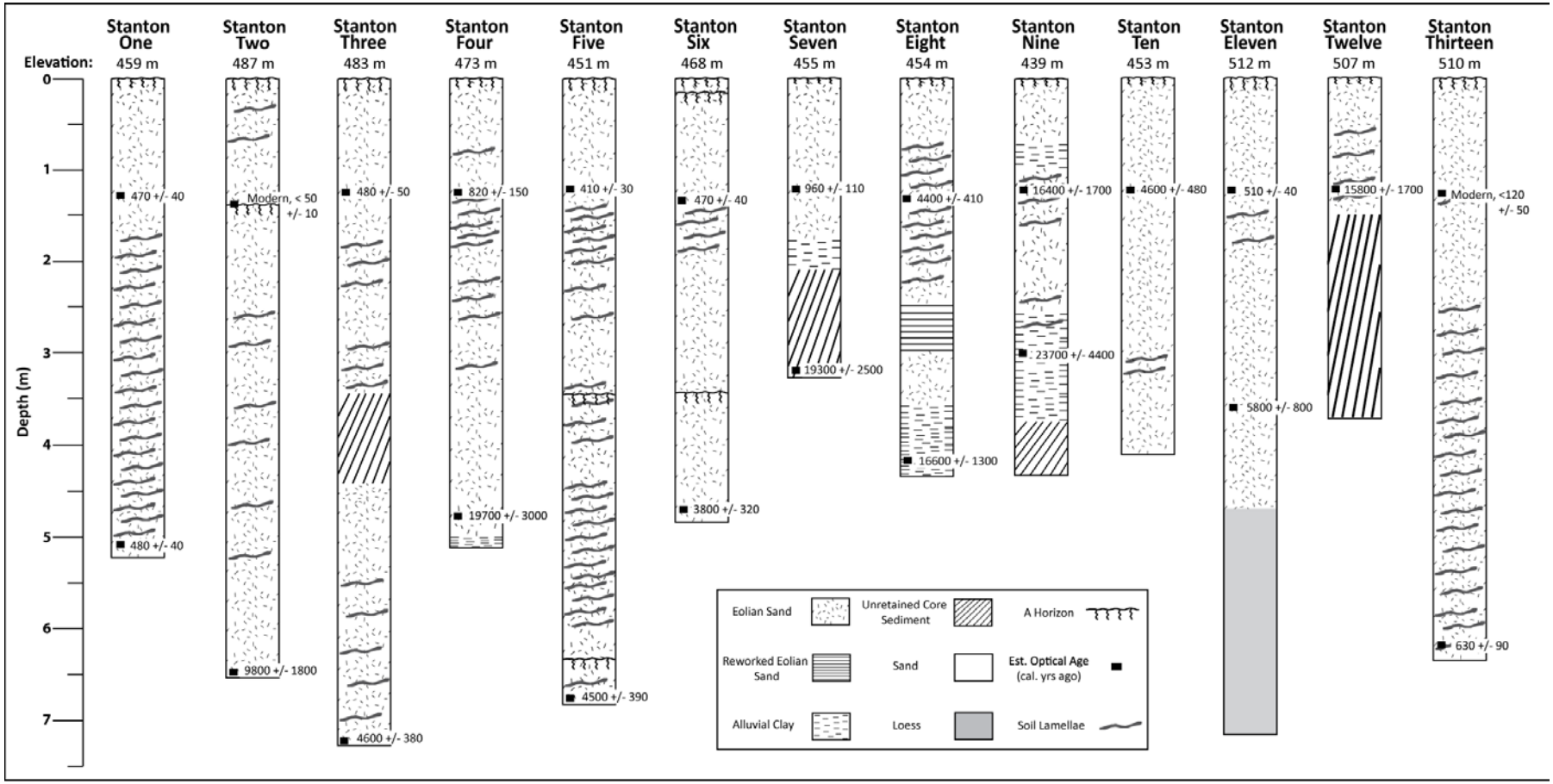
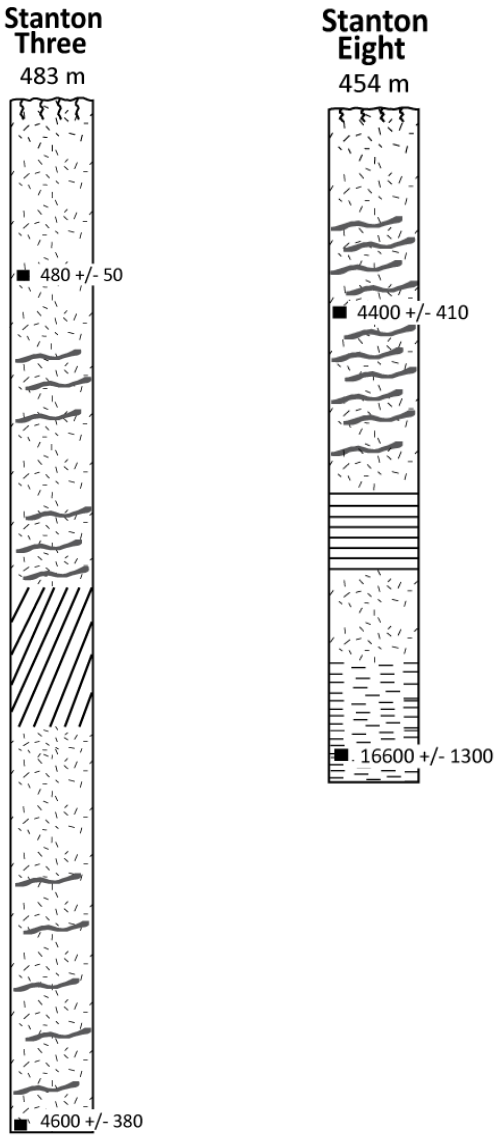
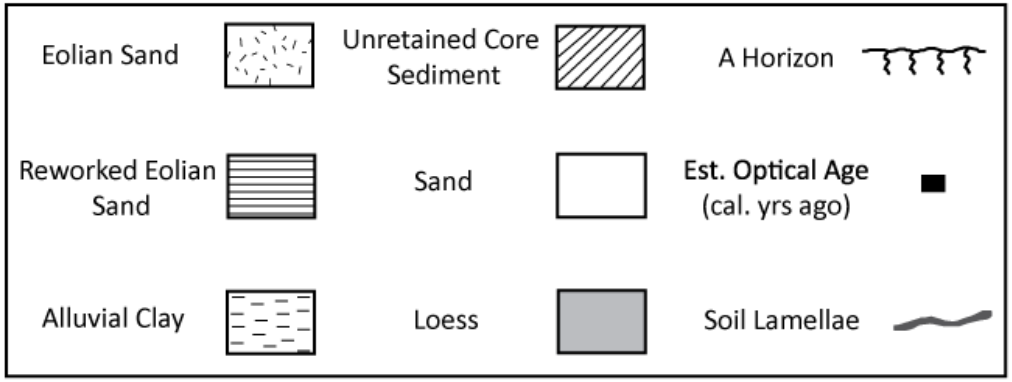


Figure 3. Sediment core stratigraphy and optical age chronology of the Stanton Dunes, Nebraska. Sediment core locations are noted in Figure 2B.

Results


Stanton Three
483 m
480 +/- 50
4600 +/- 380
Stanton Eight
454 m
4400 +/- 410
16600 +/- 1300

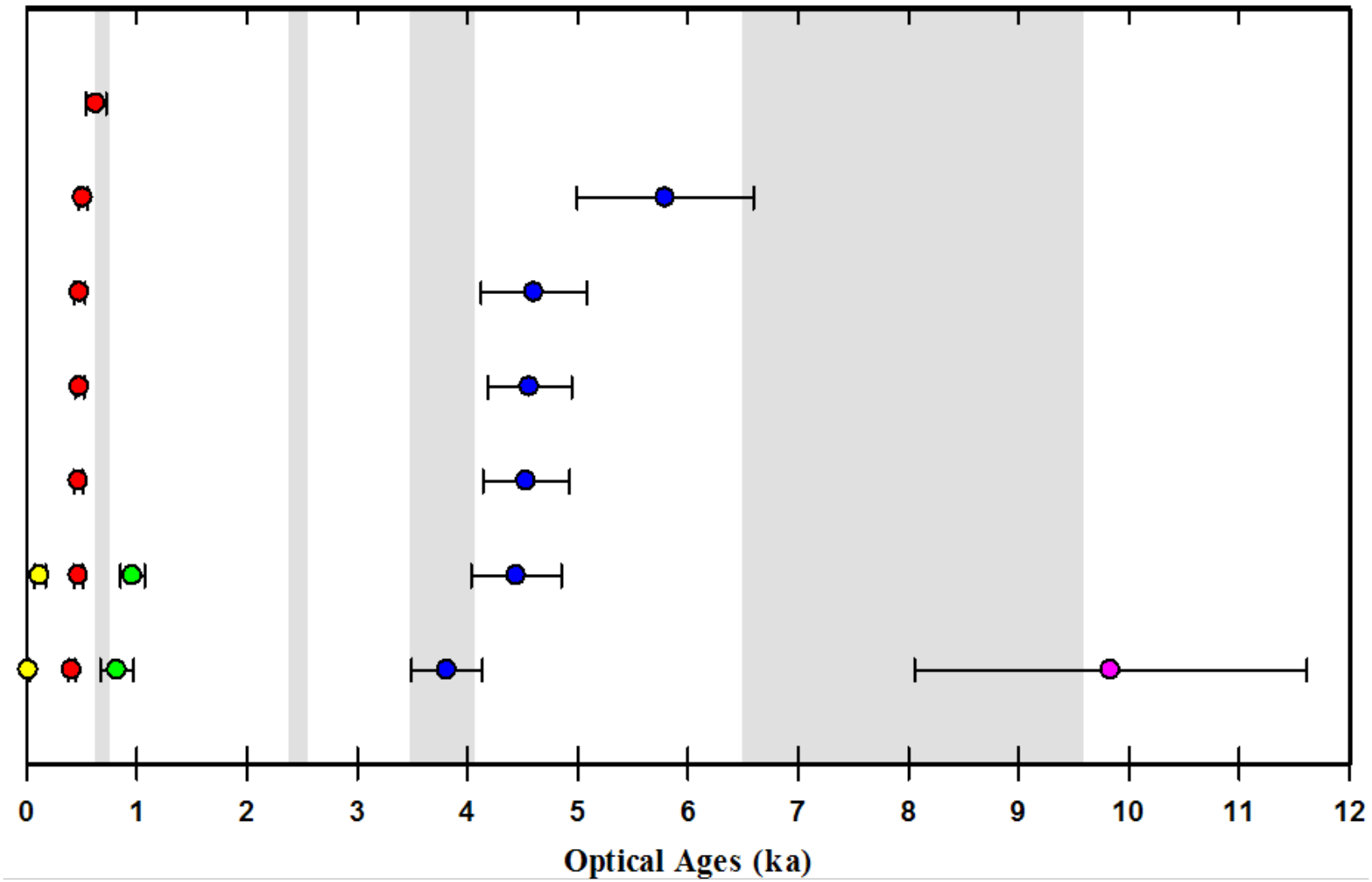

Eolian Sand
Unretained Core Sediment
A Horizon
Reworked Eolian Sand
Sand
Est. Optical Age (cal. yrs ago)
Alluvial Clay
Loess
Soil Lamellae

Discussion

- Lamellae-like Features
  - Not actual lamellae; inadequate clay accumulation
  - Loess-capped uplands likely source of aerosolic dust
  - Cannot assume formation without further investigation

- Alluvium
  - Lack of partial bleaching of OSL samples, dating successful
  - Optical ages (23.7-15.8 ka) indicate sediments were deposited during Marine Isotope Stage 2

Discussion

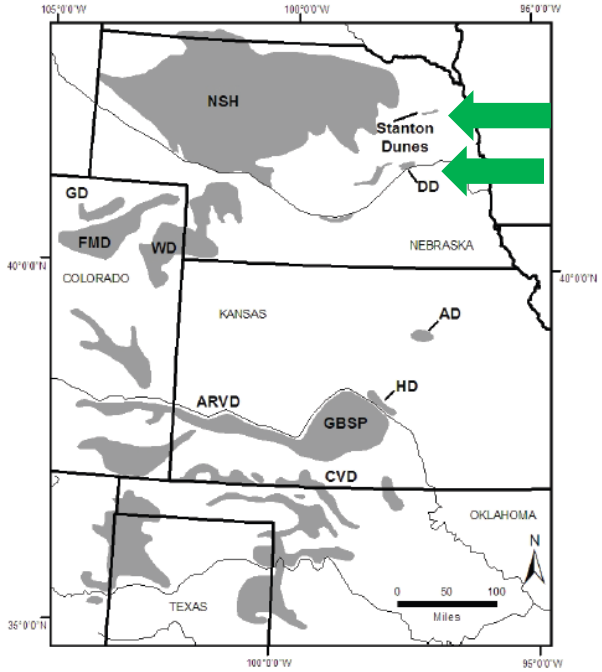


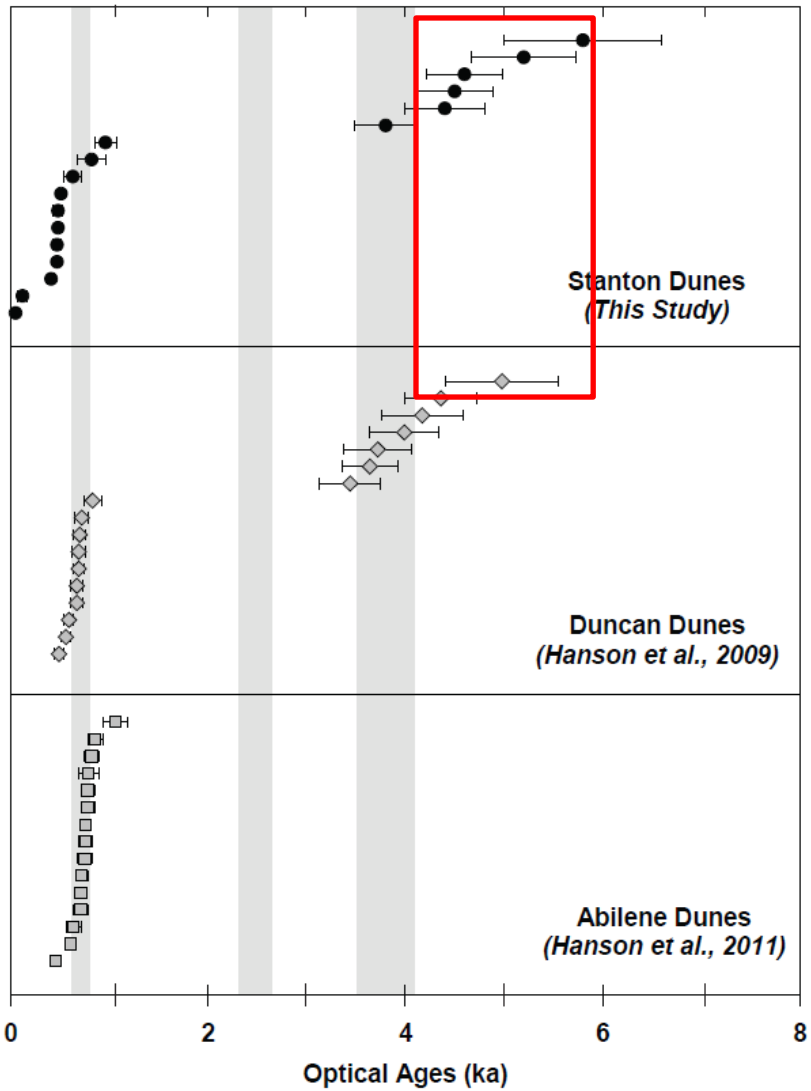
Gray bars indicate Nebraska Sand Hills activations as noted by Miao et al (2007).

Discussion

- Several Stanton ages, and one Duncan age, fall within a notable gap in major dune activation.

- Likely reflects the limited preservation of a large-scale dune activation event.

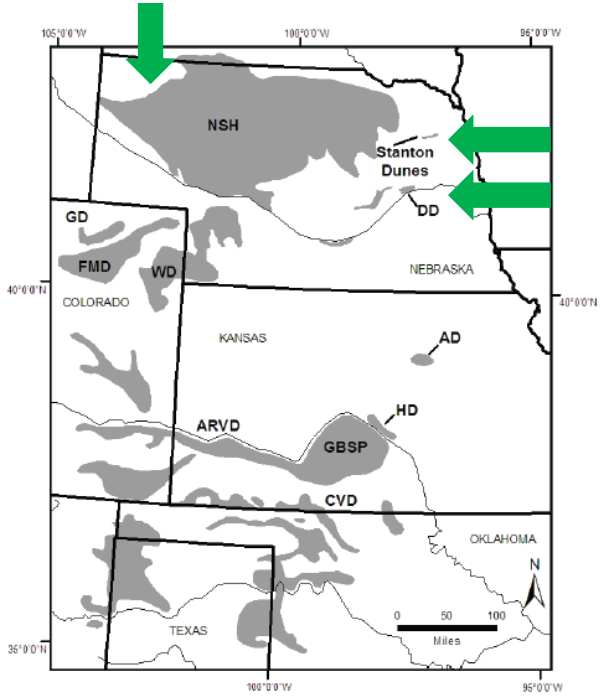


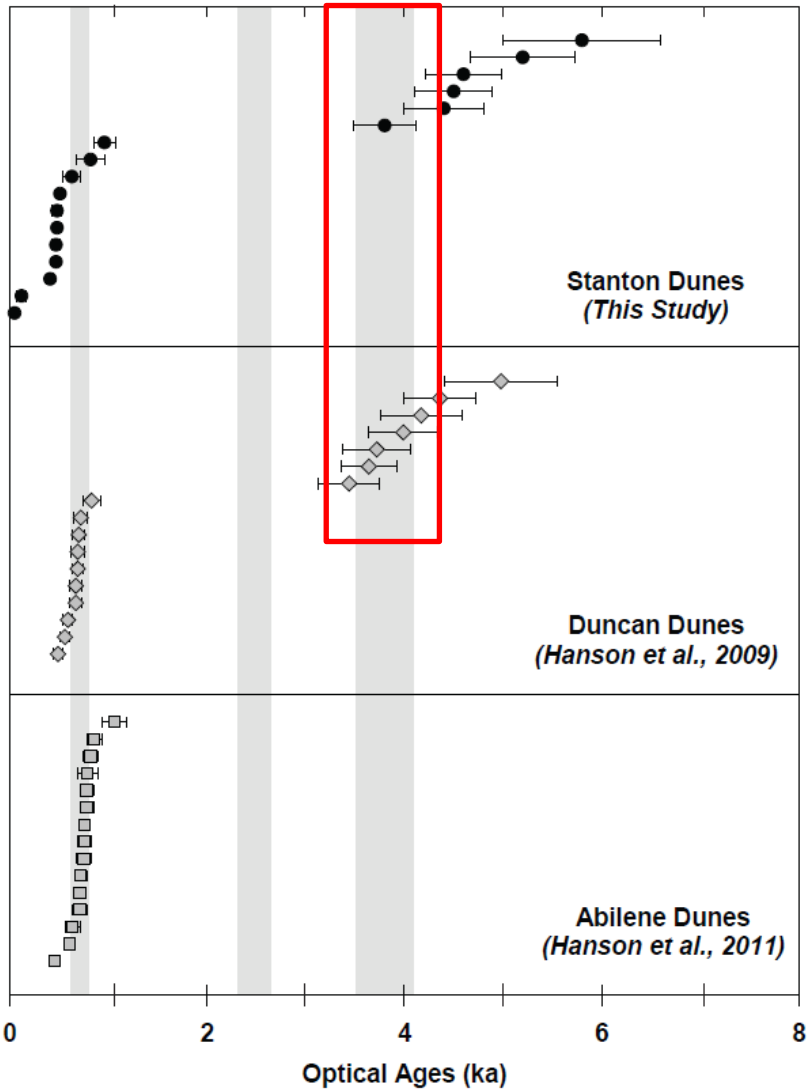


Gray bars indicate Nebraska Sand Hills activations as noted by Miao et al. (2007).

Discussion

- The few ages that fall within error of the major activation period of the Nebraska Sand Hills around 3.8 ka, reflect a far-reaching and distinct period of major activity in Nebraska.

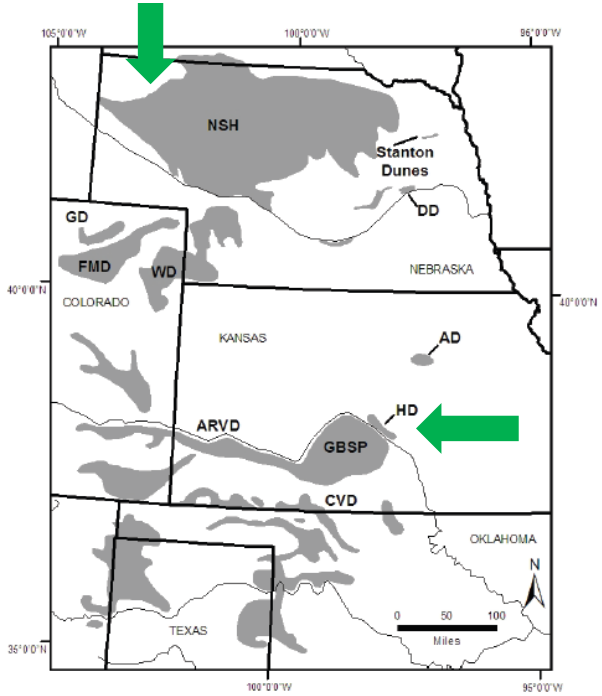


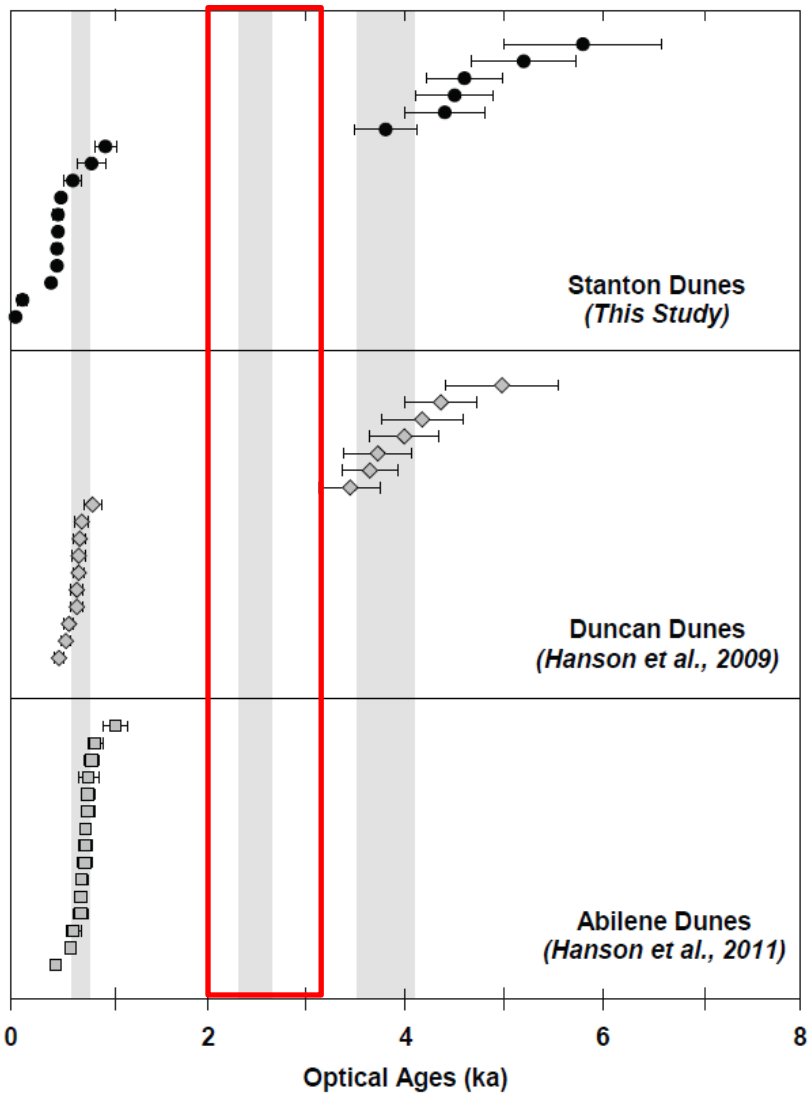


Gray bars indicate Nebraska Sand Hills activations as noted by Miao et al. (2007).

Discussion

- The lack of ages around 2.5 ka in the eastern dune fields could be the result of an extensive and widespread drought that is not well preserved in these three dune fields, as three correlating ages were recently found in the Hutchinson dunes.

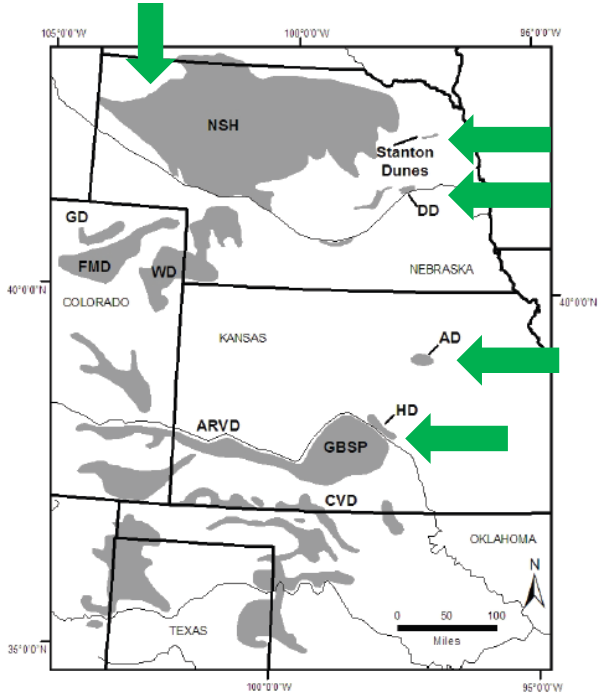


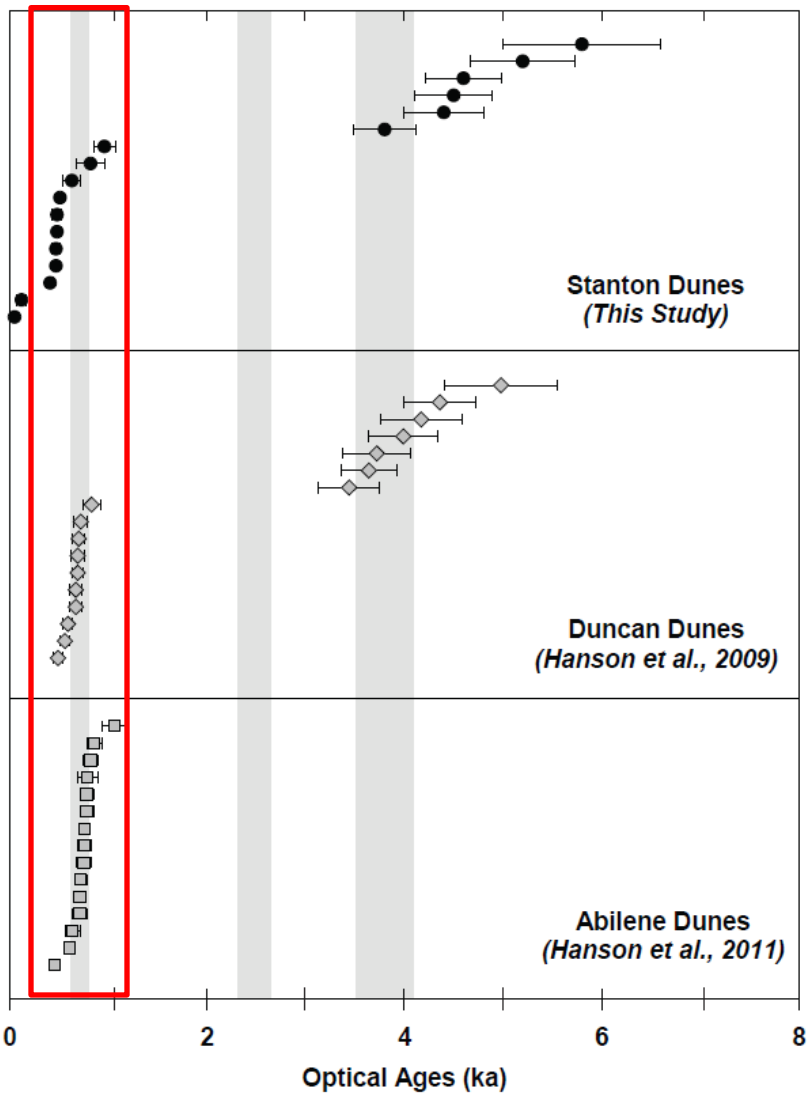


Gray bars indicate Nebraska Sand Hills activations as noted by Miao et al. (2007).

Discussion

- A large cluster of ages fall within error of the most recent activation period in the Nebraska Sand Hills, and is seen in all of the other eastern-lying small dune fields as well.



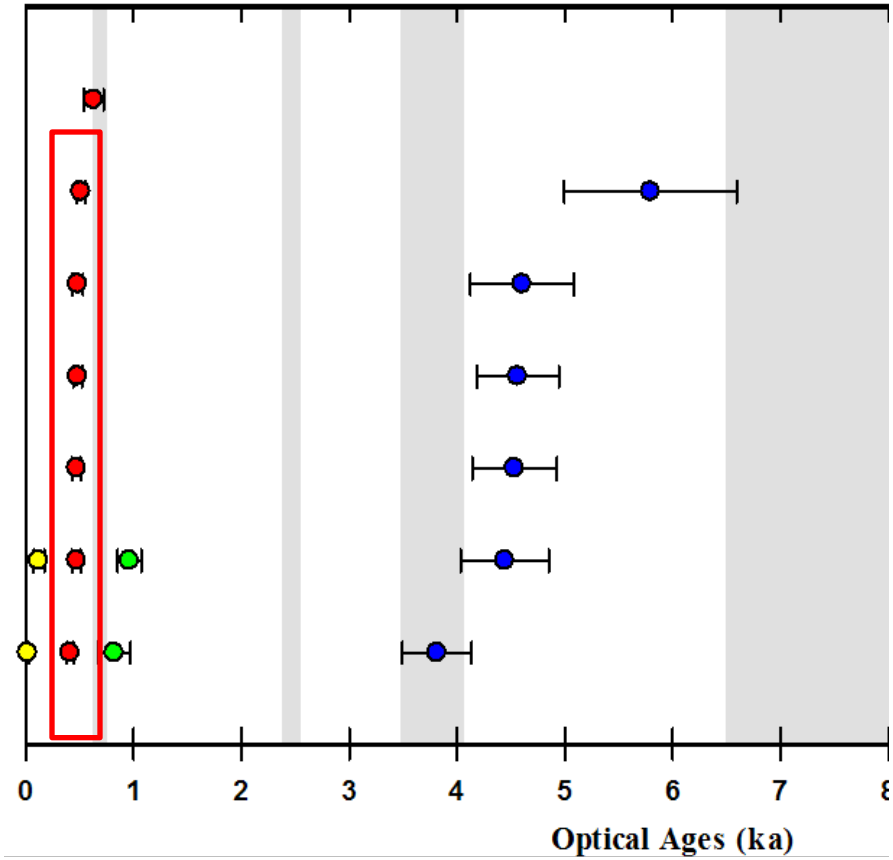


Gray bars indicate Nebraska Sand Hills activations as noted by Miao et al. (2007).

Discussion

- A few Stanton ages fall just after the 0.7 ka activation period – Three possible explanations

1 – These ages are younger due to problems with OSL dating.



Discussion

- A few Stanton ages fall just after the 0.7 ka activation period, but correlate with ages from the western Nebraska Sand Hills by Forman et al. (2005) – Three possible explanations

  1 – These ages are younger due to problems with OSL dating.

  – Not likely. The dose rate values are very consistent throughout the area, even with the wide-range of ages (~24 ka to modern).

Discussion

- A few Stanton ages fall just after the 0.7 ka activation period, but correlate with ages from the western Nebraska Sand Hills by Forman et al. (2005) – Three possible explanations

  2 – These younger ages reflect dunes that formed from an increase in sediment supply from the Elkhorn River, NOT from drought-related causes.

Discussion

- A few Stanton ages fall just after the 0.7 ka activation period, but correlate with ages from the western Nebraska Sand Hills by Forman et al. (2005) – Three possible explanations

  2 – These younger ages reflect dunes that formed from an increase in sediment supply from the Elkhorn River, NOT from drought-related causes.

  - Also not likely. We would expect these younger ages to be concentrated in areas near or adjacent to the floodplain. Instead, they are found at several sites throughout the dune field. None of which were in the area closest to the Elkhorn River.

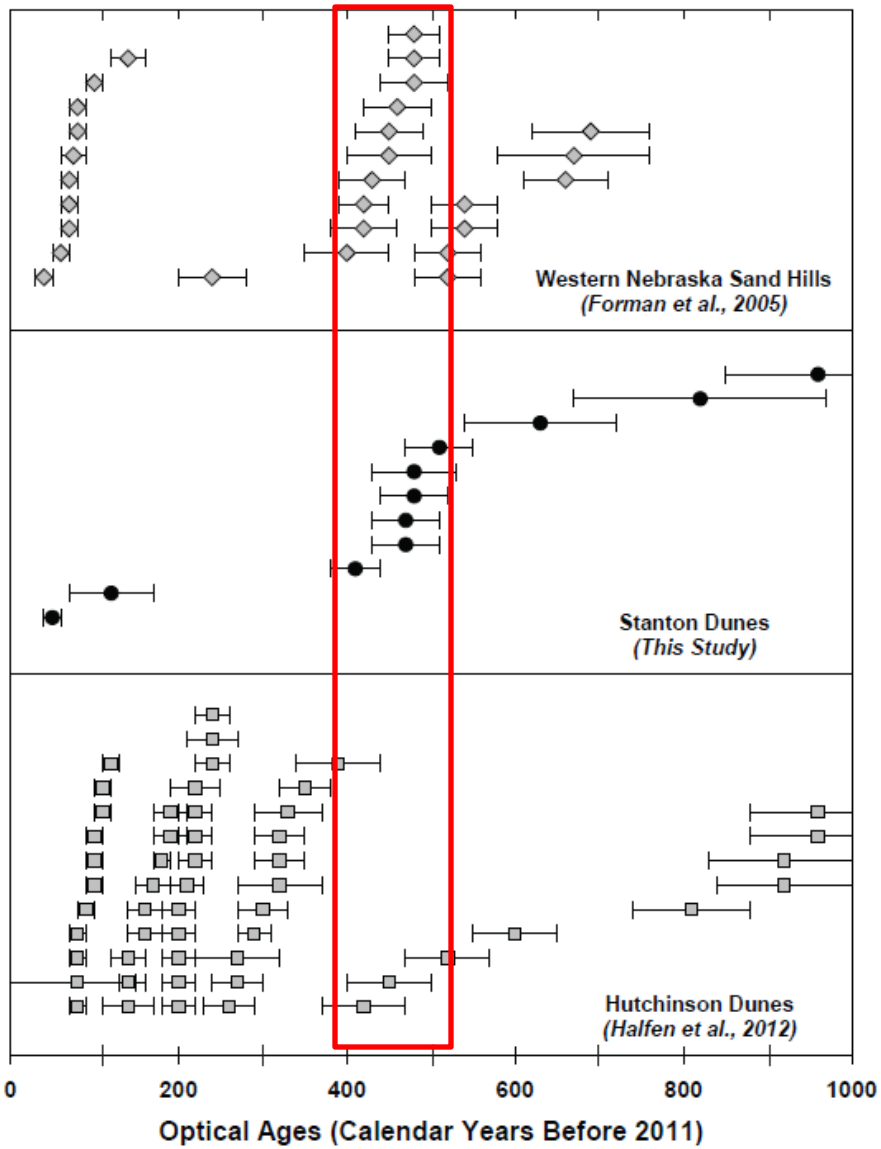
Discussion

- A few Stanton ages fall just after the 0.7 ka activation period, but correlate with ages from the western Nebraska Sand Hills by Forman et al. (2005) – Three possible explanations

3 – These younger ages are the result of regional droughts that impacted areas of the Great Plains differentially in the last 500 years.

Discussion

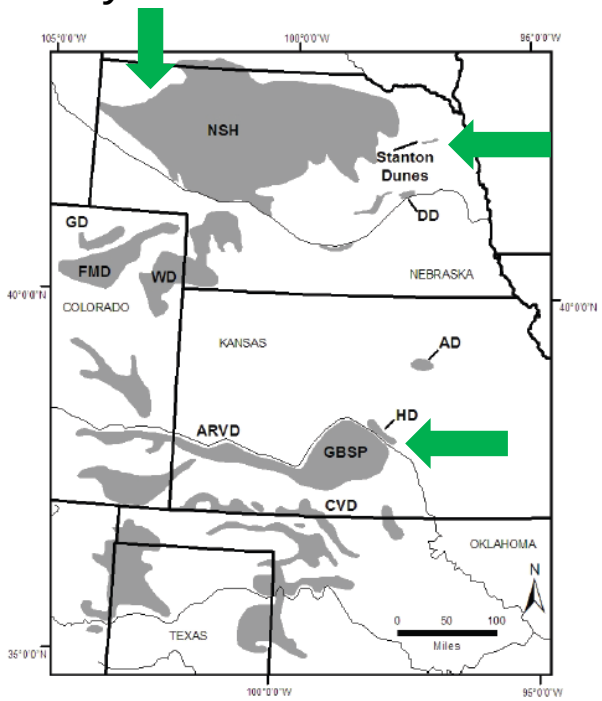
- 3 – These younger ages are the result of regional droughts that impacted areas of the Great Plains differentially in the last 500 years.
  - Several studies have shown eolian activity and drought conditions existed in KS and NE during this time period (Forman et al., 2005; Halfen et al., 2012).
  - A recent study of diatoms from five shallow interdunal lakes in the Sand Hills noted a shift in the diatom community structure ~500 years ago, suggesting a drought period and low lake levels (Schmieder et al., 2011).

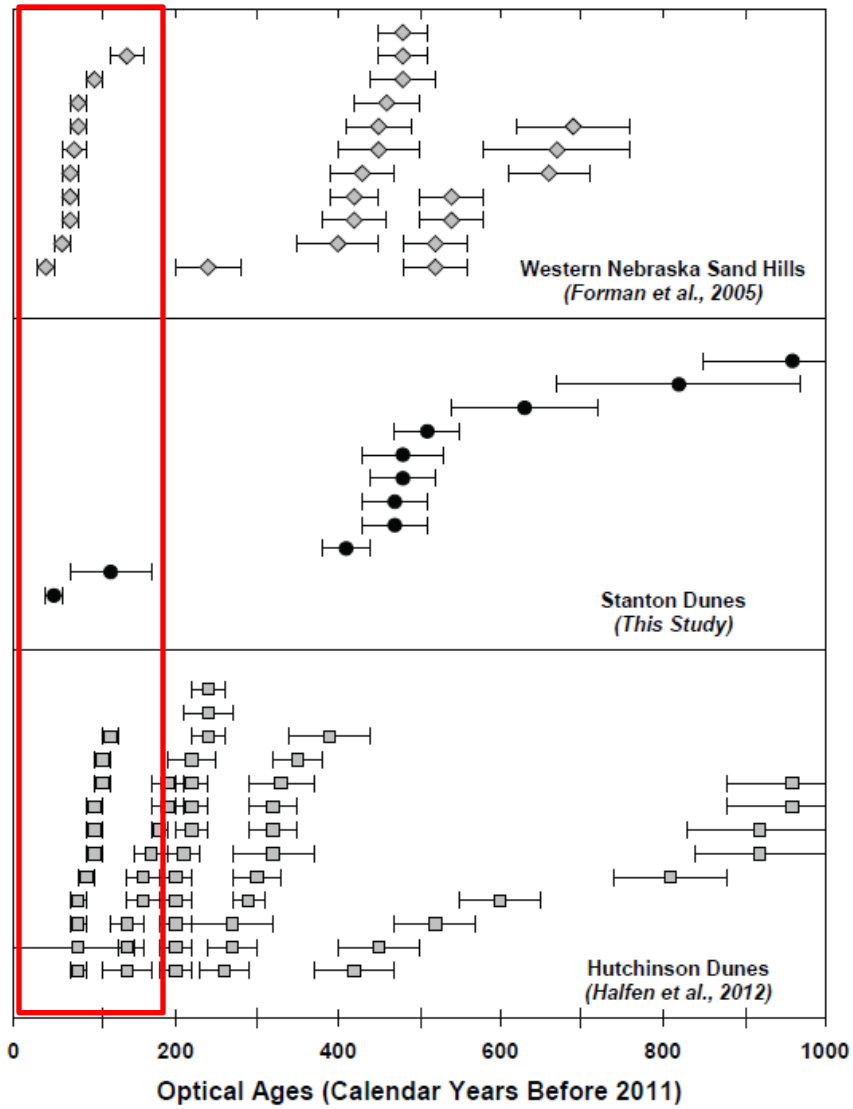


Discussion

- Modern ages from the Stanton dunes correspond with activity in the Sand Hills and Hutchinson dunes.

- Could reflect local eolian deflation related to grazing and agricultural practices, and represent local blowout activity.





Conclusions

- Stanton dune field, though in a cooler, wetter climate than the Nebraska Sand Hills, is highly sensitive to severe drought conditions (megadroughts.)

- Optical dating indicates that this is not a marginal threshold for eastern Great Plains eolian activity, and that wide-spread drought and local deflation have both contributed to Holocene activations of the Stanton dune field.

Acknowledgements

- Nebraska Geological Society for a 2010 Yatkola-Edwards Research Grant and the AAPG for a matching grant
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- Paul Hanson, Matt Joeckel, Dave Loope, Mark Kuzila, and Aaron Young

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Questions?