Project: What are the ecological consequences of trophic downgrading in mixed/short grass prairies in North America?

Premise: North American ecosystems have fundamentally changed over the late Pleistocene and Holocene; from a system dominated by mammoths, to bison, to domestic livestock. Given the very different body size and herd formation of these 'ecosystem engineers', it is likely that animals influence soil structure, water tables, vegetation and other animals in the ecosystems. What has been the ecological influence of the continued 'downsizing' of the largest animals in the ecosystem?

Learning Goals:

1. Students will understand
    a. that earth's systems are dynamic and change is continual.
    b. significant patterns in and impacts of climate change during the late Pleistocene and Holocene in North America.
    c. how climate change, human action, and alterations in species distribution have collectively influenced the distribution and abundance of grassland ecosystems in North America.
2. Students will be able to use the Neotoma database to create a map of the distribution of fossil remains of species.
3. Students will investigate the role that "ecosystem engineers" play in driving ecosystem change. In particular, they will evaluate the ecological consequences of trophic downgrading of top herbivores (mammoth to bison to domestic livestock) during the late Quaternary.
4. Students will develop hypotheses about the role played by top consumers in shaping observed variations over time in grassland ecosystems.

Part 1. Creating Distribution Maps – Mammoths & Mastodons in Pleistocene North America

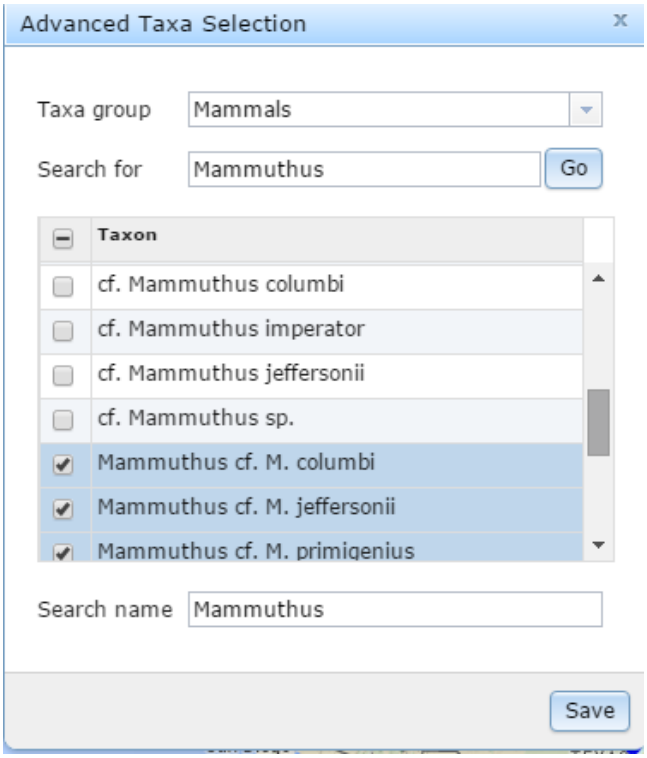
1. Log onto http://www.neotomadb.org/. Click on the Explorer icon to open the online tool that will allow you experiment with the data available using this took.

2. Click on the Binoculars icon on the top left. This will open a search box that will allow you to find and display data.

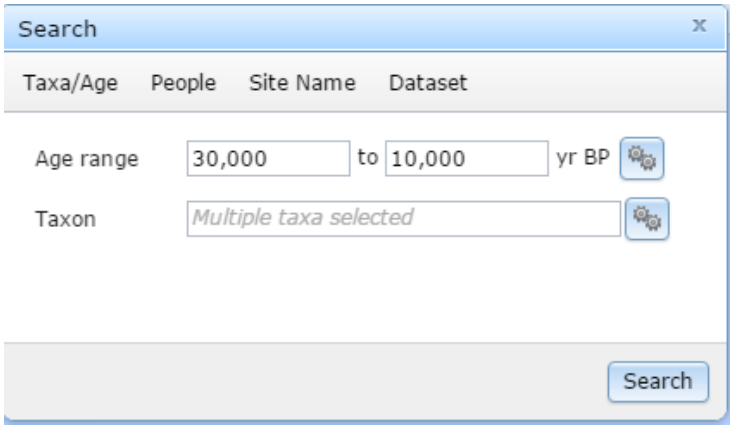
3. In the search box, set the Age Range to 30,000 to 10,000. [We are choosing a large age range because the dates associated with the data are often very broad, and the search tool will only catch the sites that have dates that fall *entirely* within this range. This keeps us from eliminating relevant data.]

4. Below the Age Range box, there is a box labeled Taxon. Click the wheel icon next to this box. This will open a new menu that will allow you to select the taxa that interest you. In the box next to Taxa Group, type Mammals. In the Search for box, type Mammuthus. [This is the Genus for mammoth species in prehistoric North America.] Click Go.

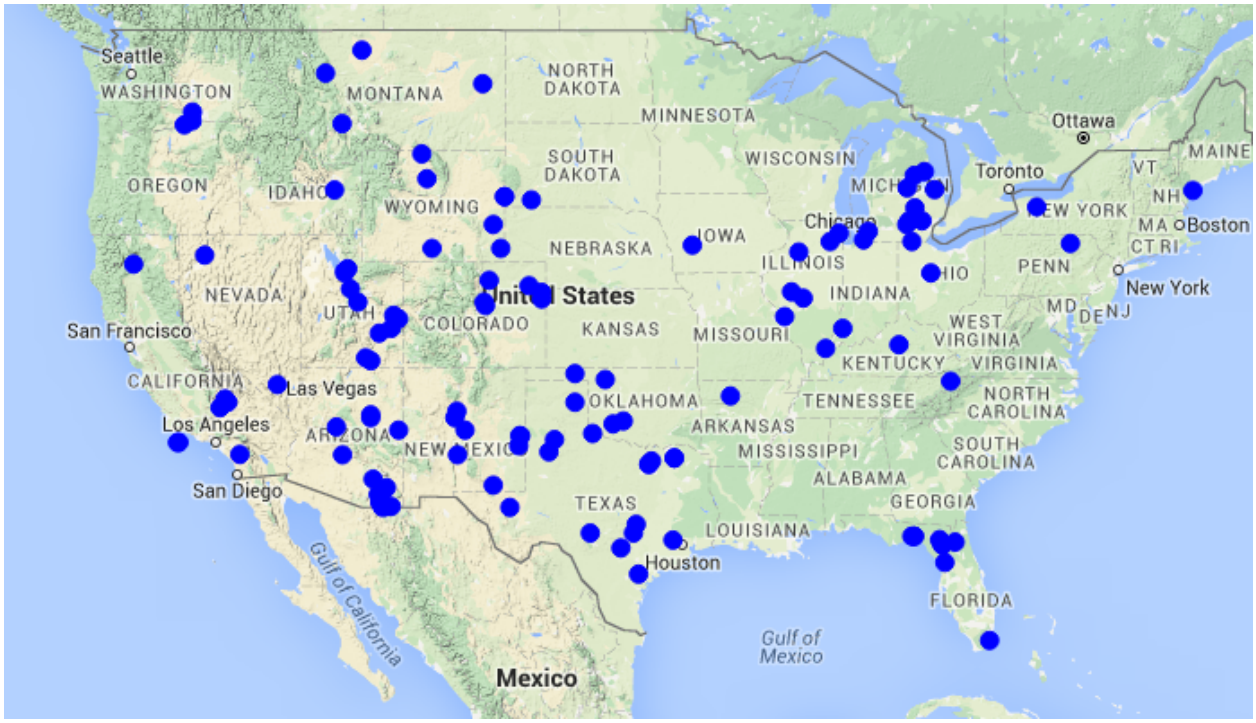
5. You should see a number of *Mammuthus* species names listed in the box. Select all of these, *except for* the samples that have not been firmly identified to species. These are marked c.f. or have a question mark before the genus designation. You can choose the samples that are marked *Mammuthus* c.f. because these are identified to genus, but not to species.



6. Click Save. The window with the taxa list will close, and you will see your original search box again. Click Search.



7. A series of dots should appear on your map of North America. These are the 126 sites with *Mammuthus* remains that date to the age range that you specified.

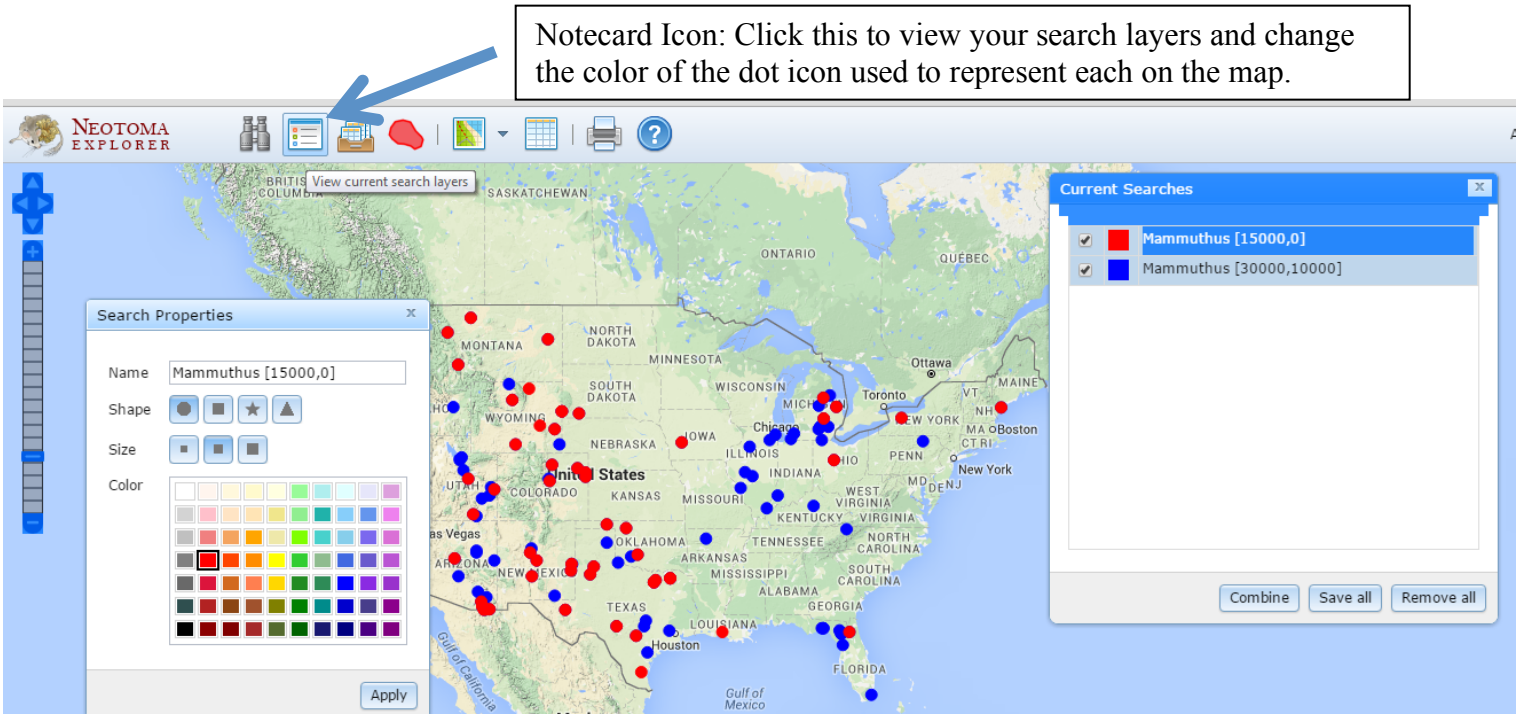


8. Follow the same steps to display the *Mammuthus* sites that date from 15,000-500 on this same map. This will allow you to see whether/how the distribution of mammoths changes over time. Click on the Binoculars icon. Set the search parameters as follows:

Age Range: 15000 to 500
Taxa Group (remember: click on the wheel icon to set this): Mammals

Taxon: Mammuthus (all species, except those marked as c.f. before the genus)

9. This should generate a map that looks like the screen shot below. You can change the color of the dot icons associated with a data series by clicking on the Note Card icon (next to the Binoculars icon). This is demonstrated in the screenshot below:



10. Now add layers that will display the distribution of mastodon (*Mammut americanum*) in North America during the same time frames. Click on the Binoculars icon and set the search parameters as follows:

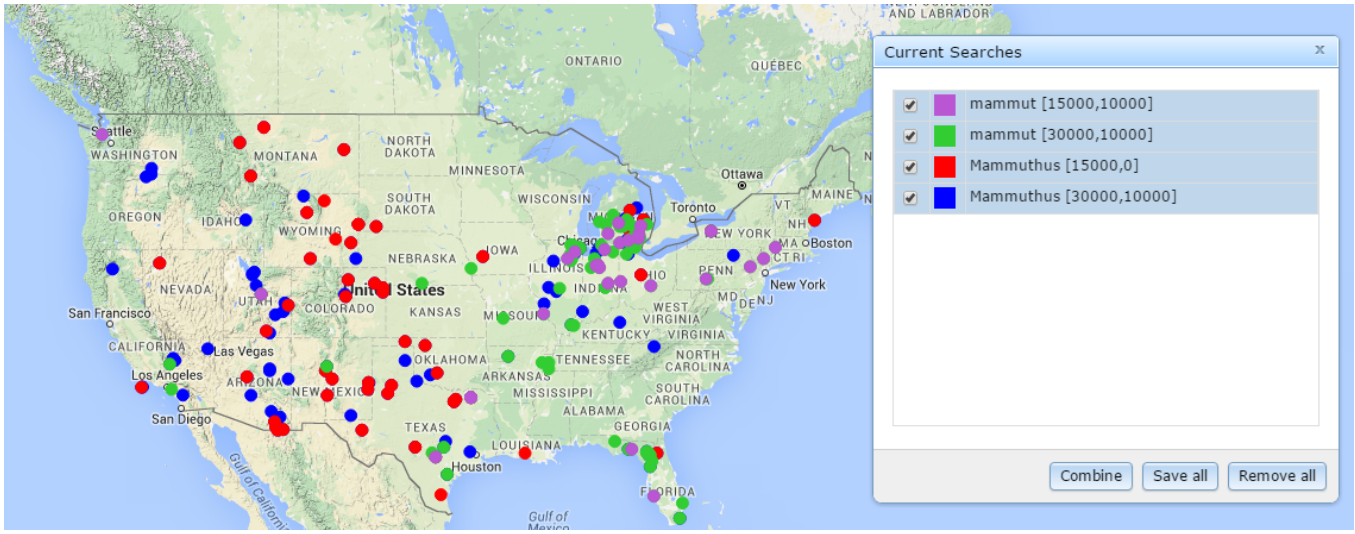
Age Range: 30,000-10,000
Taxa Group (remember: click on the wheel icon to set this): Mammals
Taxon: Mammutus (click Go; among the species that display, select ONLY Mammut americanum and Mammut sp. The other options are mammoths.)

11. Now add the layer displaying mastodons between 15,000 and 500. Click on the Binoculars icon and set the search parameters as follows:

Age Range: 15,000-500
Taxa Group (remember: click on the wheel icon to set this): Mammals
Taxon: Mammutus (click Go; among the species that display, select ONLY Mammut americanum and Mammut sp. The other options are mammoths.)

12. When you run the search described in step 11, the database will probably display the data using the same color icon as the results from your first search. Click on the Notecard Icon to

view your layers and change the colors so that each layer displays in a different shade. Your final map should look like this:



Part 2. Toward A Quantitative Understanding of the Data

In Part A, you generated maps that allowed you to describe some basic patterns in the ways that the geographic distribution of mastodons and mammoths changed over time. You also investigate possible relationships between these and other species and proposed hypotheses about the causes of observed patterns and changes in distribution over time. In this portion of the exercise, you will download a dataset generated using the Neotoma Explorer and investigate ways of quantifying changes in geographic distribution. Specifically, you will calculate the change in geographic range for each species over time (in kilometers, based on the *centroid* – the midpoint of each range calculated using the mean latitude and longitude for the samples).

1. Click on the Notecard tab and toggle off the data layers that you have created thus far. You will need these data layers later.

2. Click on the Binoculars icon and set the search parameters as follows:

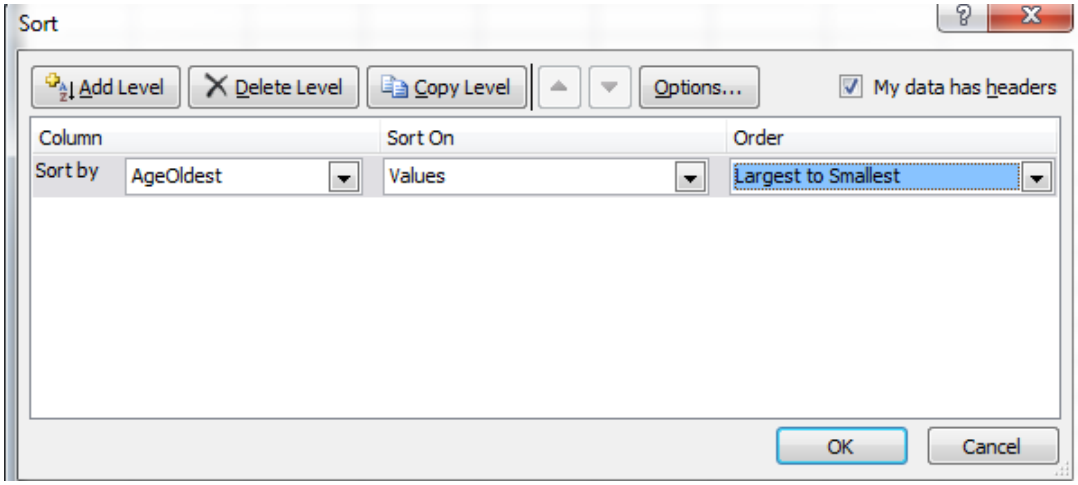
Age Range: 100,000 to 500 [This will allow you to capture all of the samples in the database.]
Taxa Group: Mammals
Taxa: Search for Mammut. This time choose Mammut americanum, Mammut sp, and all of the Mammuthus entries (except for those marked c.f. before the genus). [You are choosing all of the mammoth and mastodon samples in the dataset.]

3. To download this dataset as a csv file, click on the Tray icon (see the screenshot below). This will display your datasets in table form. Choose the tab associated with your most recent search (for all Mammut and Mammuthus spp between 100,000 and 500). Click the Save icon (the blue

diskette picture) in the upper right hand corner of the screen to download the dataset. The data will be saved as a csv file (likely in your Download folder).

4. Open the dataset in MS Excel.

5. Sort the data so that the samples display from oldest to youngest (based on the oldest date in the possible age range). Highlight the AgeOldest column. Using the Data tab, Sort the data from oldest to youngest. [When you are asked if you want to Expand the Selection, click OK.]

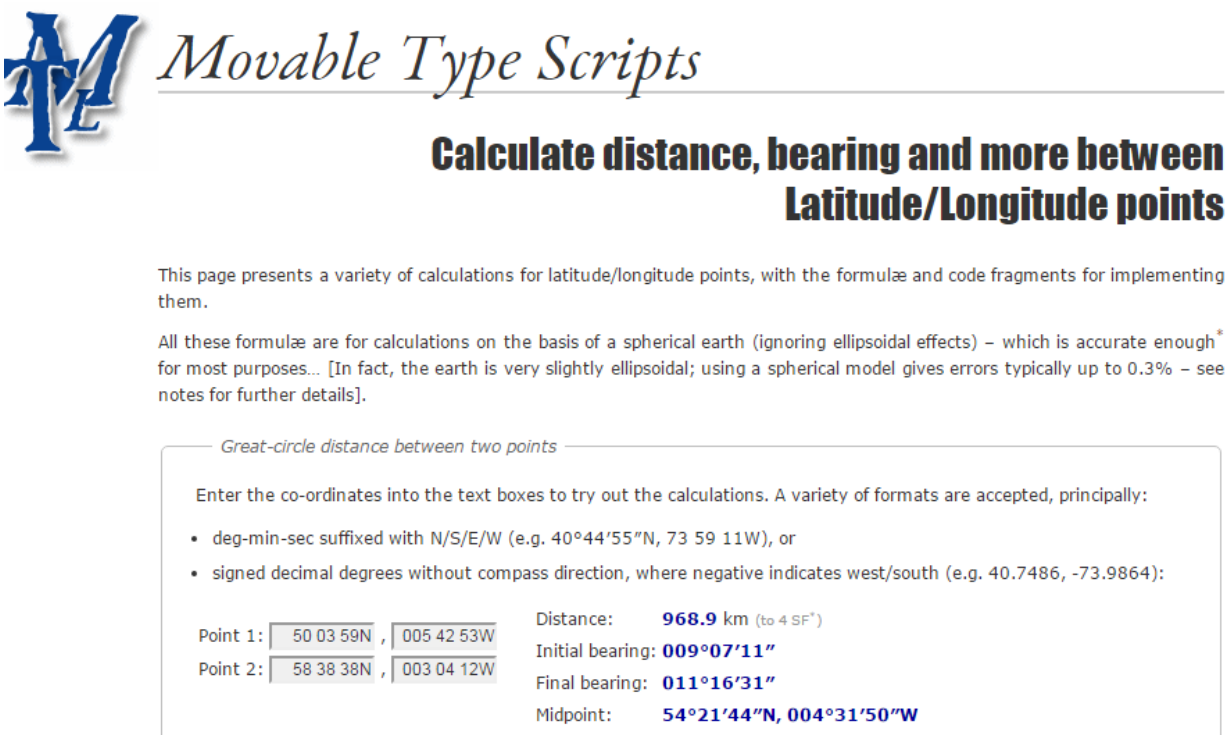


6. In order to quantify changes in geographic distribution over time, you will need to calculate the median latitude and longitude for samples dated to specific time periods. For our purposes, group the samples by time as follows (based on the **OLDEST date** in the associated range):

Older than 45,000 years
44,999-40,000
39,999-35,000
34,999-30,000
29,999-25,000
24,999-24,000
23,999-23,000
Etc.

7. Using Excel, calculate the **mean** latitude and longitude value for each of the time intervals suggested in the previous step. This is the *centroid* (or the midpoint of the animal's geographic distribution) during each of these 5,000 year time intervals. [The mean values work better than median values for the purposes of this exercise.]

8. In order to calculate the distance and directionality of the shifts in geographic range over time (and to view these on a map), you can enter your mean latitude and longitude values into a tool available on this website: http://www.movable-type.co.uk/scripts/latlong.html



This website only allows you to enter two points at a time. Using the tool, calculate the distance and change in bearing for each 5,000 year time interval using the mean latitude and longitude values calculated in the previous steps. You can also click the link to Google Maps to view the change in distribution for each interval.

Enter the data returned by the tool in your spreadsheet so that you can calculate the total distance in distribution range over additional time intervals of interest to you (e.g. the 30,000 to 15,000 and 15,000 to 500 intervals used in Part A).

Note: If you want to map the change in geographic distribution over longer time intervals, you can enter the **midpoint** latitude and longitude values (returned by the webtool for each 5,000 year interval) into Google Earth or ArcGIS online.

9. Now you have a quantitative understanding of how the geographic distribution of these two megafauna species changed over time in Pleistocene North America. Now you will add vegetation layers to your original distribution map in Neotoma to generate hypotheses about why these changes occurred.

10. Return to Neotoma Explorer. You should still have your original layers toggled off (but waiting to be toggled back on). Use the Binoculars icon to search for an add layers representing the distribution of two key vascular plant genera over the same time intervals used in Part A (30,000-10,000 AND 15,000-500): Ambrosia (indicative of long-grass prairie) and Artemisia (indicative of mixed and short-grass prairie).

Use the following search parameters to add these layers:

Age Range: Do TWO searches – 30,000-10,000 AND 15,000 to 500
Taxa Group: (click gear to access this) and type Vascular Plants
Taxa: Artemisia (sage), select all spp. (uncheck the c.f – these are the unidentified spp.)
Set the abundance to greater than 20%
Explanation: indicative of short and mixed grass prairie

Age Range: Do TWO searches – 30,000-10,000 AND 15,000 to 500
Taxa Group: (click gear to access this) and type Vascular Plants
Taxa: Ambrosia, select all spp. (uncheck the c.f. – these are the unidentified spp.)
Set the abundance to greater than 20%
Explanation: indicative of long-grass prairie

11. Toggle your data layers on and off to visualize relationships between mastodon, mammoth, Artemisia, and Ambrosia and changes in the distribution ranges of these species over time. **Drawing on the background material presented in lecture, pose hypotheses related to the observed relationships and changes.**