Module 7: Mammal Responses to Climate Change in the Past and the Future with Neotoma Explorer

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As discussed in the previous modules, climate has changed repeatedly from colder to warmer conditions. The major changes to cold are called glacials and the warm intervals are interglacials. Animal and plant distributions are frequently controlled by climate extremes, especially seasonal ones. Therefore, if the climate changes from cold to warm or vice versa (i. e.,16O/18O ratios), then using modern mammal distributions and modern climate conditions (Figs. 1 and 2 in Module 3) it is possible to make predictions about how the mammal will respond to the climate change whether it is past or future. These exercises use the Neotoma Paleoecological Database to test predictions, or establish hypotheses, about how certain species of mammals (plants, insects, invertebrates, etc. could also be used but the limiting variables may be differ).

**Exercises: Making and *Testing Hypotheses* about Quaternary Mammal Distributions**

1. Here you will *develop and test hypotheses* about North American mammal responses to climate change during various periods from 9.5-40 ka yrs BP **(ka = 1000s of years – 9.5 ka = 9500 years**). First you will be using [Neotoma Explorer](http://apps.neotomadb.org/explorer/) to examine the modern distribution of each taxa listed in the box. You will then refer to the species’ description pages to gain an understanding of their habitat preferences. You will be asked to select warm and cold periods as reflected in deep sea and ice cores. Then, for the selected cold and warm periods, you will formulate and state your hypothesis about how their geographic range at colder or warmer times in the past may have differed from their modern range. Each hypothesis should be based on your knowledge of modern North American climate (see the North American temperature and precipitation maps given in Module 3), the global climate for each period in question (see 16O/18O curves in Module 4), and the habitat requirements and preferences of each animal.
	1. For each of the species on the right, go to [Neotoma Explorer](http://apps.neotomadb.org/explorer/) to display a map of their modern distribution (To do this, you click on the red “Display modern vertebrate species range on map” and in the “Modern Ranges” box type in the species name and click display).
		* + Northern Pocket Gopher (*Thomomys talpoides*)
			+ Red-Backed Vole (*Myodes gapperi*)
			+ Least Shrew (*Cryptotis parva*)
			+ Heather Vole (*Phenacomys intermedius*)
			+ Black-tailed Praire Dog (*Cynomys ludovicianus*)
			+ Yellow-cheeked Vole (*Microtus xanthognathus*)
			+ Eastern Woodrat (*Neotoma floridana*)
			+ Nine-Banded Armadillo (*Dasypus novemcinctus*)
			+ Lemming (*Dicrostonyx torquatus & D. hudsonius*)
			+ Opossum (*Didelphis* sp.)
	2. Examine Fig. 5 in the Global Records of Climate Change **(**Module 4**)** and determine the global climate relative to today (colder or warmer) at Marine Isotope Stage 2 through ~12,000 BP. State a hypothesis for how the ranges for each of the 10 species during this period may have differed from their modern geographic ranges. At a minimum, each hypothesis should have the following structure: “The geographic range of *species name* *was the same as today* OR *extended further* *north/south/east/west* when global climate between *age range* yrs BP was *much colder/much warmer* than today.” The geographic ranges of some species may suggest auxiliary hypotheses.
	3. Produce a map showing each species’ fossil distribution for the time period with its modern geographic range map to test your hypothesis.
		* In the Neotoma Explorer search box select Advanced; in the pull down Dataset type menu select vertebrate fauna; click on the “Taxa Bar” triangle and enter the species to search for (you may want to select multiple taxa by clicking the “Open advanced taxa form” (gears) icon; click on the “Time Bar” triangle icon and enter the appropriate age range and select the “completely contains result age range” button; type in your Search name (e.g., Species Name: Age Range), and click the “Search” button.
	4. Were your hypotheses correct? If not, check to determine the global climate for the selected time. If your assessment of global climate for the period was correct, then review the species description pages to see what aspects of the animal’s habitat preferences might help explain the fossil distribution.
	5. Which species’ geographic distribution appear to be strongly influenced by temperature? Precipitation? Both? Neither?

**Exercises: Using Quaternary Mammal Distribution to Learn About Past Climate and Ecosystems**

1. Here we will use the New Paris #4, PA fossil assemblage to interpret the climate and ecosystem present in the area when this cave deposit accumulated.
	1. Examine the New Paris #4 data. (To do this, click “Advanced” in the Search Box, in the Dataset type pulldown menu select “vertebrate fauna”, click the “Metadata” bar, enter “New Paris #4” in the “Site name field, and click search.)
	2. Save the New Paris #4 Dataset into an Excel worksheet. (To do this, click the dot representing the site on the map, in the “Site ID” box click on the dataset, and in the “Dataset” box that appears, click on the Disc icon “Save dataset as csv file”. This will open the dataset in an Excel file. Now save the file in the excel file format, .xlsx)
	3. Make a graph in which the species MNIs (minimum number of individuals) are ordered from least to most common. How many mammal species are present? What are the 4 most numerous taxa?
	4. Now you will create a table summarizing the general habitat requirements and the biome each species currently occupies. Make an Excel table that lists the species, minimum number of individuals, critical habitat requirements, and biome they are found in today. You will be filling in the habitat and biome cells for each taxa. (It would be best to copy the data from the first sheet to another sheet and create this table in this second sheet.)
	5. Using the habitat and biome table you created, describe the climate indicated by the animals found here.
	6. Describe in general terms the Late Pleistocene vegetation near New Paris #4 indicated by the mammals found in the deposits.
	7. Do the mammals found here indicate environmental homogeneity or heterogeneity? What aspects of the mammals habitat preferences and where they are found today indicate habitat homogeneity or heterogeneity?
	8. Make a graph that summarizes the MNI of taxa found in and outside of the area today.
	9. Do all of the mammals recovered from New Paris #4 live in the same habitats or biomes today?
	10. What percentage of the total MNI in the New Paris #4 assemblage are found in the area today? What percentage of the total MNI in the New Paris #4 assemblage are not found in the area today?
	11. What does the New Paris #4 fossil assemblage tell you about how organisms respond to changing environments?

**Exercises: The Odd Distribution of the Opossum**

1. Here you will compare the modern and Pleistocene distribution of the opossum (*Didelphis virginiana*, *D. marsupialis*, *Didelphis sp*., and *Didelphis*) using modern environmental data to explain its past and present geographic range and barriers to dispersal. Specifically, you will develop hypotheses that might explain its modern disjunct geographic distribution in southeastern North America and the west coast.
	1. Open explorer, click on the “Display modern vertebrate specie range on map” icon, then in the “Modern Ranges” box type *Didelphis virginianus*, and click Display to view its modern range. Describe the opossum’s geographic distribution. Where is it found today? What areas of North America is it not found?
	2. Develop an explanation (hypothesis to be tested) for the opossum’s disjunct west coast and southeast range.
		* What might be the barriers to opossum dispersal out of the southeast?
		* Use information presented elsewhere in the Neotoma Education Portal, e.g., a terrestrial biome map (either the Google Earth Terrestrial Biomes by Olson et al. 2001, the biome map given in Module 2, or another you may find doing an internet search), and a map of North American climate (either the precipitation gradient map in Module 1, the Google Earth Koeppen-Geiger map, or another you may find doing an internet search), to support your argument.
	3. Now, use Neotoma Explorer to search for all opossum dating to the Pleistocene, i.e., 40-20ka yrs BP) and then for Holocene opossum, i.e., 10ka-.001yrs BP (exclude cf. *D. virginiana* from both searches because the cf. designation indicates the analyst was not 100% sure of the species identification). How do the Pleistocene and Holocene distributions of opossum compare to its modern geographic range?

**Cautionary Note: The Black Tailed Prairie Dog Distribution**

In most of our exercises we have made simplistic assumptions that climate is the dominant limiting variable. However, for some species, there are other limiting variables and many times they can be numerous, so it can be hard to determine what has caused a range change. Also, these other variables may be directly or indirectly related to climate or may even be independent of climate. For instance, the distribution of the black tailed prairie dog – *Cynomys ludovicianus* – appears to be primarily limited by moisture (E-W distribution highly correlated with latitude); whereas, it appears to have a broad tolerance limit for temperature (wide latitudinal range in distribution). Other factors may include but not limited to:

Precipitation (dry climate)

Soil Moisture (dry but some moisture)

Soil type (not sand)

Soil thickness (1-2 m)

Short grass (no tall grass or forest –diet & predator avoidance)

Moderately “large” area (colonial)

In these cases, other independent evidence may be needed to confirm the change in distribution of the species.

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Fig. 1 Distribution map and illustration of the black tailed prairie dog (*Cynomys ludovicianus*). Both images from: https://naturalhistory.si.edu/mna/

Exercises: Making Predictions about Future Mammal Distributions

1. The modern distribution and habitat requirements of many mammals allow reasonable hypothesis about how many may respond as continued global warming impacts species tolerance limits, resources, and habitats.

a. For each of the species on the right, go to Neotoma Explorer to display a map

of their modern distribution (To do this, you click on the red “Display modern

vertebrate species range on map” and in the “Modern Ranges” box type in the species,name then click display). If a distribution map is not available there, do a web search for that species’ distribution map. Print out each species’ modern range map. (You may do this by either clicking the “Printer” icon, or using a screen capture tool like snipping tool (Windows) or Grab (Mac).

* 1. Now, compare each animal’s geographic distribution to the North America temperature and precipitation gradient maps given in Module 3, Figs. 1 & 2. Describe the species’ modern range and state if temperature or precipitation or both or neither seem to greatly influence its range.
	2. or each species above, state a hypothesis (make a prediction) about how their range might shift if global climate continues to warm (e.g., “If global warming continues, species name will begin move out of areas and disperse to the east/west/south/north). Which of the animals listed in the box would likely have to disperse to other areas? In which direction would each probably move (north, south, east, or west)?

It may be useful to write or type your hypothesis on each range map and indicate the predicted changes in distribution with arrows and, if necessary (for those who live at high elevations, for example) indicate areas where the species might become extirpated.

* 1. Write a short paragraph explaining the reasoning for your hypothesis.

You should reference both the temperature and precipitation gradient maps as well as your knowledge of each species (see Module 4: Descriptions of Select Mammal Species or data gathered in a web search for that species.)