Geography 144 Midterm
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1. How do the physical dynamics of the ocean environment influence the distribution of terrestrial life? Provide examples that illustrate the points you make. In your answer, include discussion of at least two distinctly different scales.

Heat transfer from ocean water to land or vice versa. Modifies coastal climate over large scales with longitudinal gradients.

Global scale with latitudinal gradient: Evaporation of the oceans occurs at different rates depending on latitude. Near the equator, more evaporation takes place because of more direct sunlight, and the air can hold more moisture because it is warmer. Near the poles, less evaporation takes place because of the less indirect solar heating, and the colder air cannot hold as much moisture. Thus there is a global evaporation gradient. When water goes up, it must eventually come down, and we find there is also a global precipitation gradient determined by latitude (trade winds, westerlies, polar easterlies determine where precipitation will fall)

Water has a moderating effect on temperature extremes, so areas near the oceans tend to have less variable temperatures than areas in the middle of continents.

http://www.physicalgeography.net/fundamentals/8g.html :
Mid-continental regions tend to be drier than coastal regions because of their distance from sources of moisture, and polar regions are drier because cold air cannot hold as much moisture as warm air.

Landscape scale with altitudinal gradient: Fog off CA shore is a small scale with an altitudinal gradient.

"This circulation transports enormous amounts of heat, resulting in more moderate climates on land areas that are near the ocean. For example, London is warmer in winter than Toronto, even though London is closer to the North Pole." - http://terra.nasa.gov/FactSheets/Oceans/

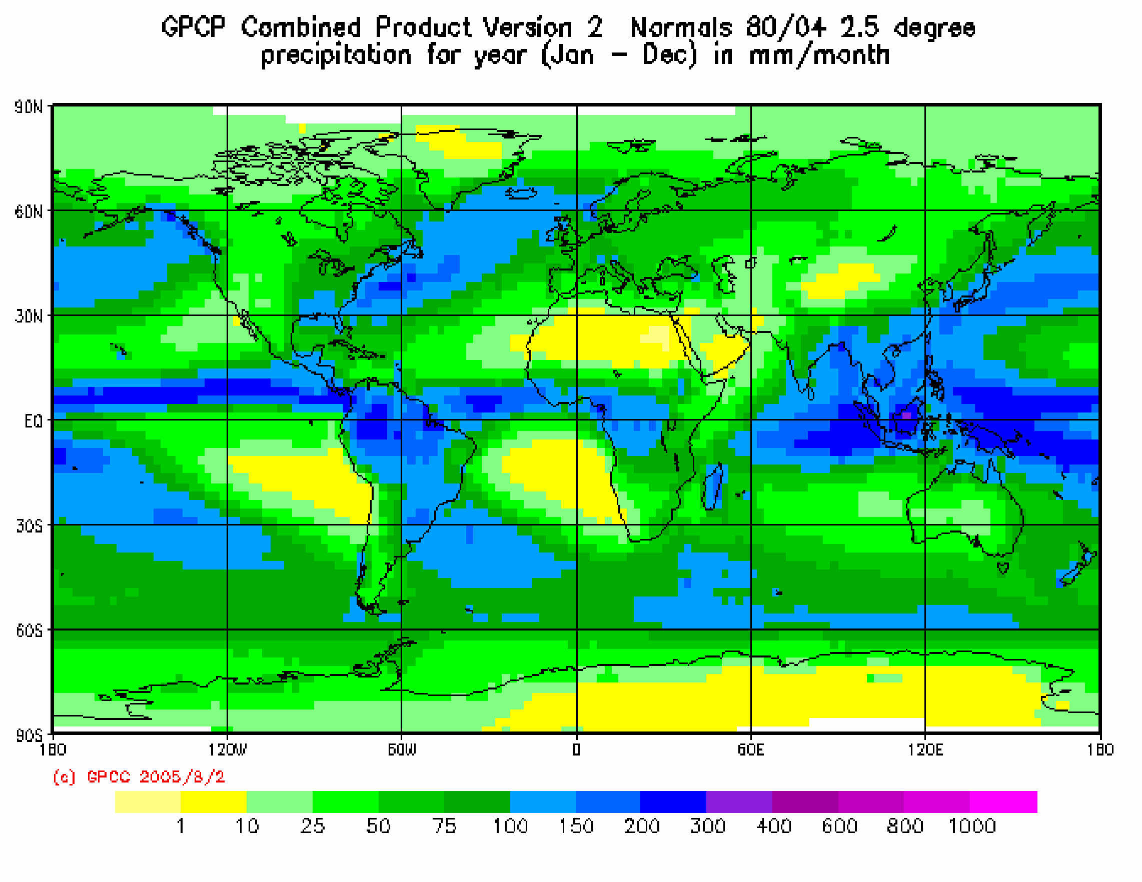
Upwelling zones (where cold, deep, nutrient-rich water comes up to the surface) are often very productive areas for marine life, which increases the abundance of terrestrial animals that eat marine life. Examples are penguins, seals, and maritime birds that catch fish.

According to our textbook, a map of global productivity shows us that ocean upwelling tends to occur along the west coasts of continents and at higher southern latitudes (p. 133).

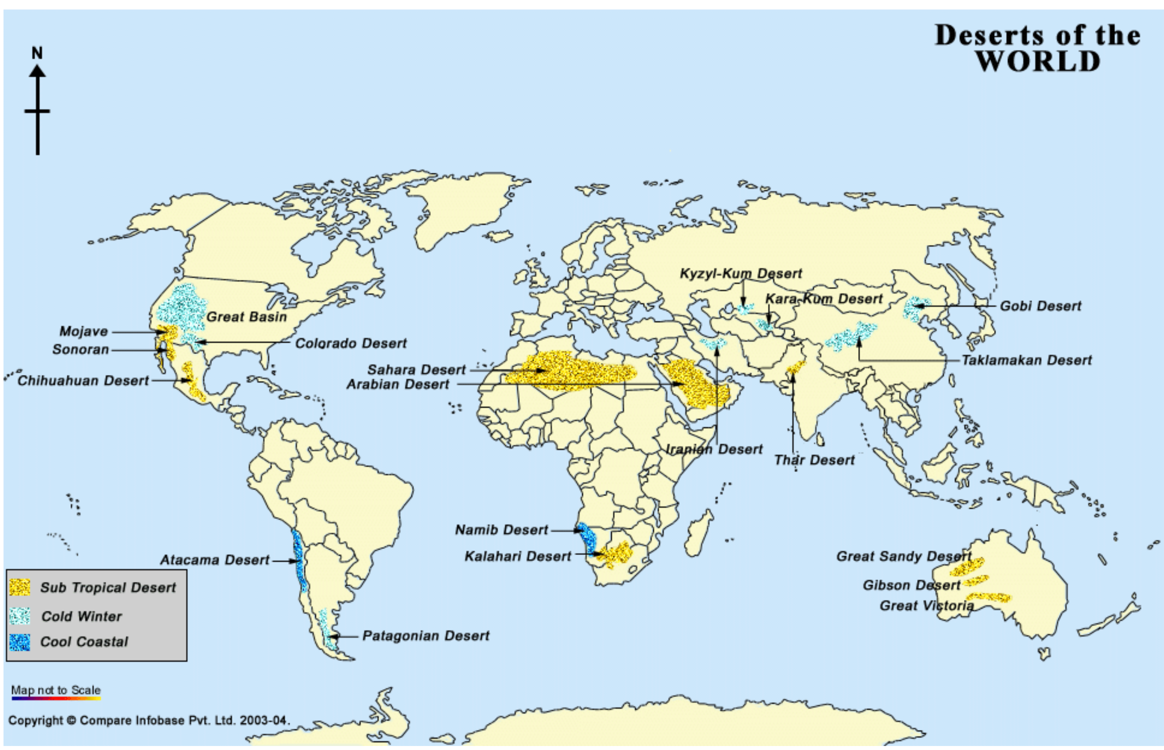
The temperature of the water off the coast is important for influencing the nearby terrestrial climate. Also, ocean currents and winds are important for dispersal.

Precipitation largely evaporates from the oceans since the oceans cover most of Earth's surface. More evaporation takes place near the equator and rains back to earth depending on wind patterns, affecting the distribution of plants adapted to different levels of precipitation, and forming the latitudinally different distribution of the world's biomes. All biomes of the world fall somewhere along a graph of temperature and precipitation.

Mediterranean-type ecosystems such as that in southern California form near cool water and hot, dry land. These ecosystems can be found not only in SW California, but also SW Australia, southern Europe, western South Africa, and western South America in Chile.



(from physicalgeography.net)



2. Why have islands been such a major focus of biogeographic study?

According to our textbook, islands are ideal subjects for natural experiments due to their being "well-defined, relatively simple, isolated, and numerous." Islands can vary in area, level of isolation, and presence of predators and competitors. This allows for an observational assessment of each of these abiotic and biotic factors on community structure, given that we can select a group of islands where variation in all factors except those of interest to our hypothesis is minimized or controlled for. Islands give us the limitation of not being able to perform artificial experiments on them due to their size, but this is offset by the fact that these natural experiments have been running for thousands and even millions of years. Most islands were created and populated sufficiently long ago that their communities have responded evolutionarily to the abiotic and biotic forces that act to shape communities.

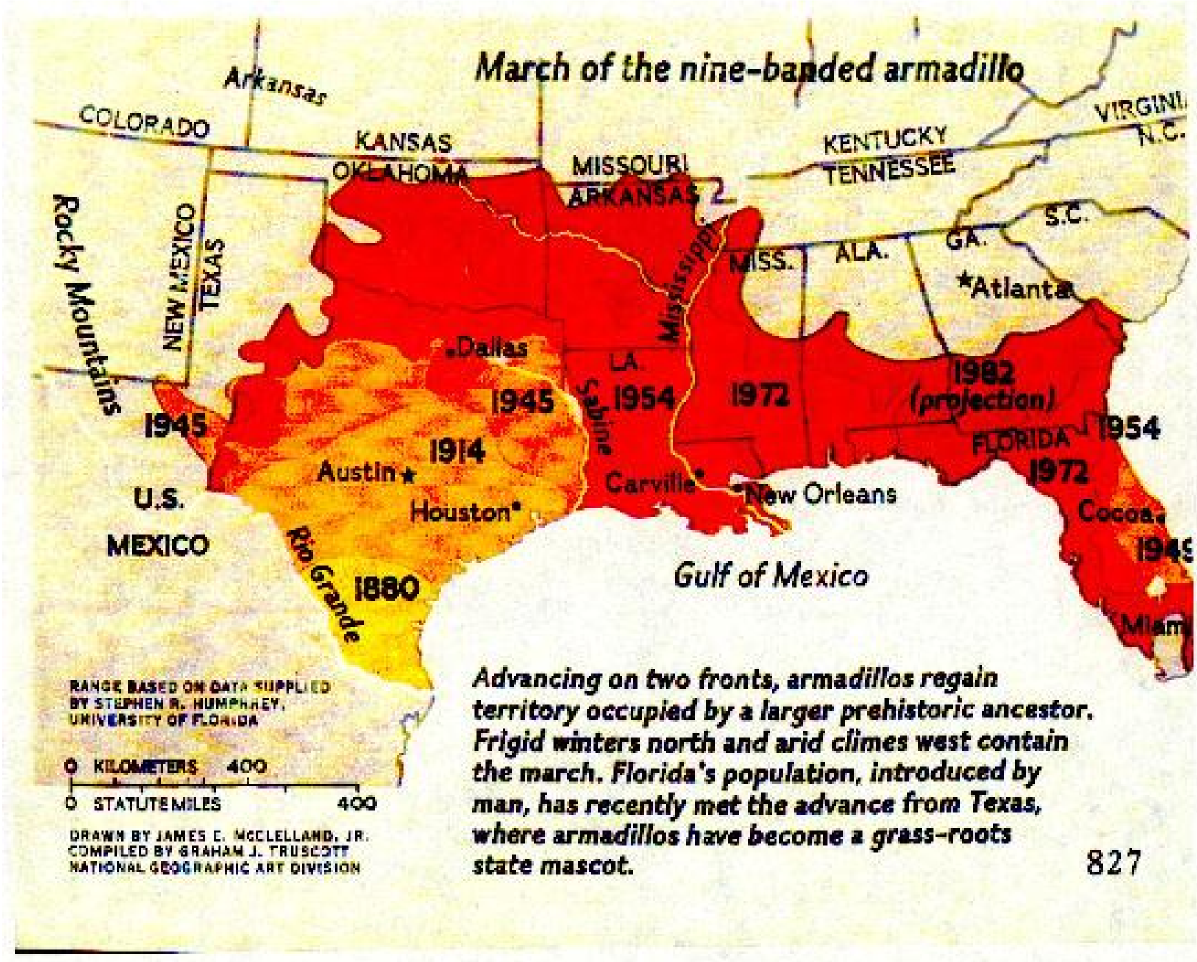
Islands are easy to manipulate (removing all insects and watching recolonization – find this example),

Islands have obvious, strong barriers/boundaries that can be used to define areas within and outside the island study area.

Small islands are easy to travel around on

Islands often have unique species that attract biogeographic interest as to how they got there (and evolved).

3. The Nine-Banded Armadillo



The ecological niche of the nine-banded armadillo

The nine-banded armadillo lives in diverse habitats that range from riparian forests to woodland savannas. Fitch (1952) described their favorite sites as being along cut stream banks or along small stream bottoms in thick woods. A study by Sikes et al (1990) found armadillos in a habitat consisting of bottomland mixed hardwood forests, with pastures comprising 35% of the total area. Taulman and Robbins (1996) noted that armadillos prefer woodlands that grade into open savanna and scrub, as well as bottomland riparian zones to upland forests and brushland. They explain that landscape changes in the northern part of the armadillo's range has produced more suitable woody habitat instead of grassland.

Woodlands and forests are important habitats for armadillos because these omnivorous burrowing mammals forage in 10-12 cm of forest litter for their food (Taulman and Robbins 1996). They mostly eat invertebrates, with beetles and their larvae being the most common food item, but they are also known to eat eggs, small reptiles and amphibians, and some plant material, including cultivated crops (Fitch 1952). Beetles are most important in the summer and fall. Moths, butterflies, and dipterous flies in larval and pupal stages are more important in the spring, and reptiles and grasshoppers are important in the winter. Sikes et al (1990) found that fly larvae were also important in the winter, but concurred with Fitch's earlier finding that beetles and their larvae were eaten in all seasons except winter. Plant food is also important throughout the year, especially in fall. These consist of fleshy fruits, seeds, and mushrooms (Fitch 1952). However, plant material is less important to armadillos living in the northern part of their range compared to those living in the southern part; winter prey selection could reflect adaptations to harsher winter climates in the north, or to winter prey availability. (Sikes et al 1990)

The role of a species is an important component of its ecological niche, and Fitch (1952) provides information on the armadillos' beneficial and damaging roles. They benefit the ecosystem by destroying insect pests and dangerous snakes, digging burrows that are usable by other wildlife as nests and hiding places, and their digging in general mixes the soil and speeds the disintegration of dead wood. They have also benefited humans by becoming food for many rural people in Texas and other states. However, they also destroy crops, quail and domestic poultry eggs, and cause damage to buildings and livestock fences from their burrowing, which tend to make humans perceive them as less valuable.

Armadillos have small home ranges that average 2.5 ha and often overlap (Taulman and Robbins 1996). Layne and Glover (1977) suggest this small home range could reflect the species' specialization for feeding on small invertebrates, which pack a lot of energy and are found in higher biomass per unit area of landscape. Other carnivorous or omnivorous mammals that eat larger, more mobile, and sparsely distributed prey must range more widely to find them.

Reasons for its expansion

There are four main reasons for the rapid expansion of the armadillo's range: 1) climate change, 2) human-induced environmental change, 3) human introduction of armadillos, and 4) omnivory.

Climatic factors

Climate, particularly severe cold and dry weather, has and currently plays an important role in restricting the armadillo's geographic range. Many reports were given of people finding dead armadillos after severe storms who could not find protective cover (Fitch 1952). This is because armadillos don't hibernate or store fat, so they must constantly forage for food (Merriam 2002). The heavy metabolic requirements during winter means a 5kg adult with 14% body fat can survive in a 0 degree C burrow for only 10 days; juveniles fare worse, with 2 kg juveniles having 10% body fat surviving for only 4 days (Humphrey 1974). Thus, he surmised that armadillos would be limited to regions with at least 38 cm annual precipitation and <9 freeze days/year.

However, the expansion was set to continue, due to an apparent regional warming trend in the Great Plains identified by Humphrey (1974). Since the 1970's, armadillos have moved beyond regions with <9 annual freeze days, and have established in areas with 20-24 nonconsecutive annual freeze days and mean January temperatures > -2C (Taulman and Robbins 1996). Interestingly, this warming trend may have began decades before it was identified by Humphrey. Back in 1939, Taber claimed that "the occasional occurrence of cold weather in the vicinity of the 33rd parallel will probably prevent any great number of armadillos from becoming established north of this line." However, armadillos continued to migrate north after 1940, so winter temperatures must have warmed during that time. Thus, we see that a long history of warming in the southern and central US has allowed armadillos to survive farther and farther north. Their temperature boundary has steadily shifted northward, and thus their range has been limited largely by their rate of dispersal.

Besides temperature, precipitation is also an important limiting climatic factor. Humphrey (1974) noticed a contraction of the armadillo's range at its western boundary, coincident with a decline in precipitation. Taulman and Robbins (1996) describes the limiting annual precipitation value as 38 cm; anything lower than that precludes the species' successful establishment or persistence in an area. They state that armadillos may have already approached a precipitation-defined boundary in the west. In the east, since the species' precipitation and temperature boundaries lie far to the north, Taulman and Robbins claim that armadillos may continue to spread to 39 degrees N latitude in the Midwest, and 41 degrees N along the East Coast.

Human-induced Environmental Change

Since the climate warmed after the last glacial retreat, why didn't the armadillo invade the US long ago? There must have been non-climatic factors that limited its range (Taulman and Robbins 1996). The reason presented by Fitch in 1952 is still widely shared today: the rapid migration of armadillos into the US had been "favored by environmental changes, probably those caused by the advance of civilization during the last century. Otherwise it might have been expected to have spread long ago into the areas which it is only now invading."

Before the mid 1850s, armadillo dispersal could have been hindered by native subsistence hunters, the Rio Grande, and fire-maintained grassland barriers. However, when south TX was settled by Europeans after 1850, these barriers were removed (Taulman and Robbins 1996). The reduction or extermination of large carnivores in the Southwest by cattle ranchers has been cited as an important factor allowing the spread of armadillos northward, since their numbers were no longer kept in check by predation (Taber 1939, Sikes et al 1990). These predators would have included the red wolf, coyote, black bear, puma, jaguar, ocelot, and bobcat. Native Americans also hunted armadillos north of the Rio Grande, but their populations, along with the large predators, also declined upon European settlement (Taulman and Robbins 1996).

Also cited have been changing land-use patterns such as timber cutting, crop establishment, and livestock grazing (Fitch 1952, Sikes et al 1990). These changes altered the ecosystem by decreasing the extent of less suitable dry, fire-maintained grasslands, and increasing the extent of more suitable armadillo habitat.

Human Introduction of Armadillos

Layne and Glover (1977) argue that the armadillo's spatial activity hasn't made a strong contribution to its range expansion, since they have small home ranges, low dispersal tendencies, and sedentary habits. Though armadillos have spread across vast distances, they demonstrated that their actual invasion rate has been slow, and attributed their spread to the accidental or deliberate introduction by humans.

Fitch (1952) mentioned the accidental and deliberate transportation of armadillos into new areas, such as from Texas to Louisiana, Mississippi, and Florida. Taulman and Robbins (1996) explain that accidental and intentional human introductions of armadillos have occurred hundreds of times across the south, and that dispersal rate accelerated due to human travel and commerce. Indeed, the steady growth of transportation routes coincides with the known beginnings of the armadillo's expansion. Taulman and Robbins go on to explain that the rapidity of range expansion seen in the nine-banded armadillo is due to a combination of two dispersal processes – *neighborhood diffusion*, which is the dispersal of pioneer animals along a migration front, and *hierarchical diffusion*, which is the dispersal of pioneer offspring from introduced animals. Thus, interestingly, humans in their own expansion across the United States were largely responsible for the hierarchical diffusion of armadillos, which aided their expansion.

Omnivory

Merriam (2002), in describing the successful northward migration of armadillos into Kansas, cites not only the warming climate and few natural predators as important reasons, but also the armadillo's omnivory. Omnivory is a quality that makes the armadillo a highly adaptable species. They have expanded their range into new, diverse types of habitat, and have had to alter their diet because of varying food availability. They will easily eat whatever is available during the season, and armadillos in the northern part of their range will consume a greater quantity of high-energy insects and less plant material during the winter than those in more southern portions of the range (Sikes et al 1990).

Biogeographic History

The nine-banded armadillo was historically found south of the Rio Grande, its range limit being the lower Rio Grande Valley, near the Mexican border (Taber 1939, Fitch 1952). Several archaeological records show that they occupied Central America in prehistoric times, and today, this species has an extensive distribution in the American tropics (Humphrey 1974). However, Humphrey (1974) identifies Baird as having described a geographic range for the armadillo in extreme southern TX as early as 1859. Since its successful establishment on the US side of the Rio Grande, the armadillo has been gradually spreading northward and eastward. Humphrey predicted that armadillos would overtake their northern barrier in N. OK and AR or southern KS and MO. As of 1982, they occurred in limited numbers as far north as SW Missouri, southern KS, and extreme SE Colorado (Sikes et al 1990). In 2002, Merriam reported that armadillos have been found in almost 25% of KS counties, and are as far north as the Platte River in southern NE. Overall, their average invasion rate has been an extremely rapid 4-10 km/yr owing to human introductions (Merriam 2002).

References

Question 3

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