Just a few degrees can change an ecosystem
Data activity

PAPER DETAILS

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Science and Engineering Practices

Developing and using models (SEP2)
The student can use representations and models to communicate scientific phenomena and solve scientific problems.

Analyzing and interpreting data (SEP4)
The student can perform data analysis and evaluation of evidence.

Disciplinary Core Ideas

ESS3.D: Global Climate Change
Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Crosscutting Concepts

Systems and systems models
When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Stability and Change
Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

DATA SET

The accompanying Data Activity spreadsheet, “How bad can it be DA_datapoints.xlsx,” contains the biome data points for all the maps in Figure 3 (on sheet “Datapoints”). “Datapoints” includes a unique ID for each data point; its location, including latitude, longitude, and altitude; and then the reconstructed or predicted biomes at that location for the past, present, and future. The past biomes (4700BP_R) are from 4700 Before Present (BP) and were reconstructed using pollen core data. Two columns provide present-day biomes for each location—one is based on reconstructions from pollen cores (Present_R), and one is predicted by a simulation from the BIOME4 model (Present_S). Finally, there are four future biomes based on four different models of atmospheric greenhouse gas concentrations. These “Representative Concentration Pathways”
(RCPs) are based on different assumptions of future greenhouse emissions, and result in different predicted temperature increase scenarios: a 1.5°C temperature increase threshold \((RCP2.6L)\); a 2.0°C temperature increase threshold \((RCP2.6)\); a 3.0°C temperature increase threshold \((RCP4.5)\); and a 4.0°C temperature increase \((RCP8.5)\). RCP8.5 is based on a “business as usual” assumption, with a continued increase in greenhouse gas emissions. The other three assume reductions in greenhouse emissions at different points; see the annotations for further details.

**ACTIVITY**

This activity focuses on regional changes in plant ecosystems related to changes in regional climate. First, it is important to specify what “region” refers to in this activity. The modeling research in this paper produced a grid of information, such that there is a data point at each 0.5° x 0.5° coordinate across a map of the Mediterranean. Each of these data points has biome information (either reconstructed or simulated) for every climate scenario defined in the “Data set” section above.

Underlying data for these scenarios—such as pollen samples, weather data, and modeling outputs—were not all available at the same resolution and are not evenly spread out across the Mediterranean region. To allow for more direct comparisons across scenarios, the researchers used information from known data to predict where the missing data points would be. This is called interpolation, and can be used to fill the data gaps or connect different data sources. In this case, it resulted in a 0.5° x 0.5° grid. Comparing single isolated points to one another is less reliably informative than looking at a group of multiple points, so students should look at a group of points.

Imagining a specific point at each location every 0.5° x 0.5° across the map, a region will be a cube containing nine data points:

![Region Grid](image)

It is easiest to use a map to find a longitude and latitude that will serve as the central point, and then use the “Region Calculator” sheet in the “How bad can it be DA_datapoints.xlsx” file to calculate the surrounding coordinates. For example, if the student thinks that Madrid is interesting and wants to explore that region, they may Google “coordinates of Madrid,” which will give her 40.42° N, 3.70° W. The closest central data point would then be 40.25, 3.75.

**Note:** The area covered in the paper straddles the 0° longitude line, and the Excel file uses negative numbers for E longitude coordinates.
Within the data calculator, they would enter in these coordinates to the “Central Point” longitude and latitude cells:

![Region Calculator](image)

The calculator will then produce the coordinates for the region:

![Produced Coordinates](image)

Then, they would use these coordinates to find the nine data points associated with that region, allowing her to investigate the reconstructed or predicted past, present, and future biome types.

Biome data is only available for land coordinates, so a nine-point square may not be possible for locations near a coast. This leaves two options: 1) require students to only pick locations that have a nine-point square region; or 2) for more of a challenge, ask students to define a reasonable alternative—for example, Barcelona is on the coast, at 41.38, 2.17. The closest grid point, 41.25, 2.25 is in the ocean, so there is no data for it. Students could however pick the nine nearest points on land: (42.25, 1.75), (42.25, 2.25), (42.25, 2.75), (41.75, 1.25), (41.75, 1.75), (41.75, 2.25), (41.75, 2.75), (41.25, 1.25), (42.75, 1.75).
Step 1:

Ask each student to pick one region from the maps in Figure 3. Using either the Figure 3 map axes or Google maps, students can determine the longitude and latitude of the central point of a region (described above) that they find interesting. They will be researching and recording the current and future biomes for that location.

Once students have identified the coordinates for all nine points in their region, they can then use the “Data points” sheet to examine past, present, and future biomes for that region. A good start is asking them to compare all nine data points from their region within a single model (ex. Present_R) to see if they are consistent. If they are different, are there patterns in the differences?

Students can then begin to explore changes in the region between the past, present, and the various future scenarios.

Step 2:

Once each student has investigated their own region, have them get into small groups to compare their chosen regions. Suggest that they look at a range of regions – for example, places where two biomes meet, and along the north/south and east/west gradients. If a group has not chosen a variety of regions while working independently, they can investigate one or two additional regions together.

Step 3:

Have groups discuss their regions as a class, with someone taking notes on the board. This provides a way to cover more regions in detail and makes it easier to identify broader patterns.

Depending on your classroom setup and the concepts you’d like to focus on, have students consider any of the following, in small groups or as part of a whole-class discussion:

- What are the past, current, and future biomes of the regions students picked independently? As a group? As a class? How do these changes fit into larger trends in the Mediterranean? Globally?

- The future projections address plant ecosystem changes. How might the changes affect other parts of the ecosystem beyond plants?

- How would the changes affect human land use? How could these changes affect the ecosystem services that are provided in that region?

- What might humans do to address these changes? What policies or action would you propose to help humans adapt to the changes or become more resistant to their impacts?

- Comparing multiple regions, can you identify any common characteristics of areas that are more likely to change in response to climate change? What about areas that are more likely to stay the same?