Species Ranges, Natural History, and iNaturalist Citizen Science

Learning Outcomes: Students will be able to…

- describe factors that may cause a species range to shift or expand,
- explain what natural history is and how its study applies to questions or range shifts,
- upload occurrence records to iNaturalist,
- and identify observed specimens using the iNaturalist or similar app.

Introduction: Species ranges

Species are found within a geographic range, or distribution, determined by a combination of physical tolerances and biological interactions. For example, the red mangrove tree *Rhizophora mangle* is commonly found along intertidal coastlines in the tropics and subtropics. It is restricted to areas with temperatures above 20℃. This limits their distribution further north or further south due to intolerance to freezing and near freezing temperatures. At a more local level, red mangrove is restricted to a thin band of trees immediately adjacent to the sea, and this landward distribution is limited by biotic interactions such as competition with other tree species and herbivory by numerous invertebrate species. It is also limited by the abiotic factor of water-saturated soils. You can see how a combination of factors restrict this species within geographic ranges. So it is with other species.

The geographic range for a species may change over time as local conditions change. Red mangroves are expanding northward in the Gulf of Mexico and along the east coast of Florida as climate change increases temperatures. This is known as a range expansion - when a species moves into an area where it did not exist previously. Expansions have been demonstrated across multiple terrestrial and marine species, where species have been shifting poleward or higher in latitude in response to changes in global climate. Birds, reef-building corals, butterflies, other insects, and more, all have species with documented range expansions northward. The rate of expansion tends to be highest in areas where more rapid warming is occurring.

Range expansions may occur via natural dispersal in response to changing environments, but may also occur through accidental or intentional introductions of species to new areas by human activities. These species may be termed non-indigenous, introduced, exotic or invasive, usually depending on the impact to local communities and ecosystems. The brown marmorated stinkbug, *Halyomorpha halys,* is an insect that was introduced to North America from Asia only about 20 years ago and has spread throughout much of the eastern United States. Another example of an invasive species with an expanding range is kudzu *Pueraria montana*. Introduced from Japan to prevent topsoil erosion on croplands, it quickly spread throughout the southeastern United States. Rapid expansion of the geographic ranges of invasive species is facilitated by high dispersal and reproduction, allowing them to quickly colonize areas with favorable abiotic conditions and limited natural competitors and predators. As these species spread into new regions, which will also occur as a result of climate change,

they can wreak havoc on native species in these new regions. Both of these species are common on Davidson College's campus.

Human activities associated with urbanization can also affect geographic ranges. Land use changes increasingly fragment habitats, altering species interactions and leading to local extinctions. Reducing habitat available constricts geographic ranges, limits dispersal, and prevents gene flow. In some instances, species may extend their ranges into urban areas. Food resources may actually attract fauna to urban areas.

In sum, many anthropogenic activities can interact to impact organisms and lead to distributional shifts in species. Understanding which species distributions are changing in relation to human influences is critical to exploring mechanisms for change, and ultimately, conservation and management. We will use the immense amount of data available online to investigate potential range shifts in species that you select, with my guidance.

Natural History

Natural history, as a field of study, should be thought of as a practice of intentional, focused observation and attentiveness in the natural world. Natural historians' objects of study ranged from meteorology to geology to zoology to botany. Early natural historians paid great attention to surveys of the natural world, taxonomy, and the classification of variation. Taxonomy, the science of naming species, is much more important to biology than you might expect given how little attention we pay to it in our biology courses. You will learn more about taxonomy in the next protocol, where we begin to use online data portals to investigate some of the species you find while carrying out this protocol.

Natural historians are sometimes thought of as old-fashioned in style and out of touch with modern methodologies. Ecologists tend to perform hypothesis-driven studies with one organismal model system and then move on, rather than take the time to develop a comprehensive natural history of a study species. This leads to a loss of natural history expertise, as ecologists are not teaching natural history to their students. Even here at Davidson, students spend more time indoors, conducting lab experiments and simulations, rather than observing actual organisms in an uncontrolled context.

The process of patient observation is essential to natural history, and unsurprisingly, to the scientific method. Observations from the study of nature often lead to the questions that lead to hypotheses that lead to experiments that lead to new scientific discoveries. Natural history began as a descriptive practice, and is often still thought of as descriptive, but all those descriptions and observation can be integrated and used to formulate patterns used to make predictions. These observations, from museum collections and citizen observations, can now be digitized and made available to anyone with an internet connection. You will use such observations to draw conclusions about the effects of human activities on a few species.

Citizen Science and Contributions to Online Species Occurrence Records

Citizen science (AKA crowd-sourced science or volunteer monitoring) is scientific research conducted, in whole or in part, by amateur (or nonprofessional) scientists. Citizen science is sometimes described as "public participation in scientific research," participatory

monitoring, and participatory action research whose outcomes are often advancements in scientific research, as well as an increase in the public's understanding of science.

iNaturalist is currently the most popular citizen science website, followed by eBird and Zooniverse, in second and third place, respectively. iNaturalist is a community (citizen) science platform that is maintained by the California Academy of Sciences and the National Geographic Society. It is also an online social network of naturalists, citizen scientists, and biologists built on the concept of mapping and sharing observations of biodiversity across the globe.

iNaturalist is both a website and a smart phone/tablet application for people to upload nature observations. It is also a repository of data that can be freely accessed. Observations recorded with iNaturalist provide valuable open data to scientific research projects, conservation agencies, other organizations, and the public. High-quality "research grade" observations are added to the Global Biodiversity Information Facility (GBIF) where they can be accessed along with other digitized natural history data. The project is considered a model natural history mobile application.

Individuals contributing to iNaturalist make observations, often by taking a photograph or recording a sound (videos are not currently supported). They upload the observation to the application and include additional information (e.g., location, date and time, notes, etc.) and it gets added to either a project of interest or just to the global collection. You will add your contributions to a group project that I will set up. iNaturalist utilizes a computer-generated image matching algorithm to help in the identification of the organism. Once an observation has been uploaded, the community can access the observation and help to identify the species. In addition, there are forums for discussion and user-generated guides about different organisms or regional flora and fauna.

Materials

- Macrolens camera attachment for a smartphone (optional)
- iNaturalist app on your phone
- Internet or cellular connection
- See your instructor if you do not have a smartphone

Methods

You will become a contributor to iNaturalist. Perhaps not all of you will be able to contribute due to your current situation. However, my goal is for most of you to contribute to and for all of you to explore iNaturalist. To get an introduction to the site/app, go to https://www.inaturalist.org/pages/getting+started (Links to an external site).

Your goal is to submit at least 25 records to iNaturalist. If you foresee any issues with collecting even that number of observations, please let me know, especially if you're not on campus this semester. The records may be of any species (plant, animal, fungus, protozoan).

First, create an account. We will then link that account name to the project that I create. That allows me to view all students' observations in one place. For each observation, upload your photographs. You can enter multiple photos of the same organism in one record, but do not create separate records of the same individual. Enter all the relevant information, including species identification, if known. If your image is taken on a phone and the location information is on, then the image should be tagged with the location information and it will be entered automatically when the image is uploaded.

The basic process from a smartphone is to tap "observe" and then you can either take a picture or use one you've already taken. You can then enter date and location if it is not automatically entered (if the picture was tagged with that information). If you tap "What did you see?" iNaturalist will use its image matching algorithm to take a guess what it is. It usually does a pretty good job, assuming your image is of good quality. If you're not sure, pick the highest taxonomic resolution and other users may narrow it down for you. That is, use order or family if you are not sure of the genus or species. You can also add notes, these are the natural history observations that are mentioned above. Finally, all the way to the bottom is an option to add to a project. Select our project once you are added to it, although it will also add the observation automatically.

So, to summarize, upload at least 25 observations of organisms to the Davidson College Biodiversity Spring 2022 project on iNaturalist by 6 or 7 April, depending upon your laboratory section. Be sure to submit your iNaturalist username to your instructor to be added to the project!

25 observations must include:

- At least 15 Research Grade observations
- At least 10 animals
- At least 10 plants
- Try to get at least one organism that is neither plant nor animal (e.g., fungus)
- No more than 2 observations of any one species
- No observations of cultivated/domesticated organisms – my dog doesn't count!
- No duplicate observations (same individual organism submitted by multiple people)
- Dead (but identifiable) organisms are fine

Tips:

- Take multiple photos of animals as you approach them, so if they flee, you have some documentation.
- Take multiple photos of different organismal characters (leaves, bark, buds, trunk for plants; top, side, front, back for animals) and add them to the same observation to help with identification.

- Make your best educated guess as to the identification when uploading including using the image matching algorithm of iNaturalist. However, **do not uncritically accept** whatever is the top match of iNaturalist!
- Make sure that location and time are accurate if uploading via the web.
- Be prepared and careful: appropriate attire, water, sun protection, etc.
- Take a buddy/phone if venturing into new areas of campus.
- Start early; it can take time for observations to be identified by others in the iNaturalist community.
- Check in on your observations from time to time to respond to comments.
- Don't agree to others' identifications of your observation without your own reason. Your identifications should reflect your own knowledge.

Other rules:

Harassment of Vertebrates Prohibited: Vertebrates are protected by law during research activity. During our iNaturalist survey, harassment of vertebrates is prohibited. This means that you should not approach a vertebrate animal closely enough that you force it to change its behavior. If a vertebrate seems to become alert to or threatened by your presence, move away slowly. If vertebrates move away from you, do not pursue them to continue taking pictures. There will be plenty of opportunities to make observations!

No duplicate observations (including from other classmates). For example, if you and a partner are making observations together, and find an organism, only one of you can submit that observation for credit.

Analysis and Considerations for the Next Phase of the Research Project

As a class we will compile the results and we will examine some descriptive statistics to describe biodiversity of our project. We will then discuss how best to select species for range expansion analysis. Download and read the introduction to GBIF document, which contains the protocol that you and your team will conduct and which will form the basis of your research report.