

Abstract

- Herbarium specimens provide permanently curated, verifiable baseline data about plant biodiversity
- Digitization is revealing the value of specimens as “big data” for addressing ecological questions
- Digitization has also revealed spatial and temporal biases in specimen data
- The Eastern Plains of Colorado are an example of an under-botanized region
- Collectors should design inventories to address Eastern Plains collections biases; this requires partnering with private landowners
- Collection data is most valuable when data rich and useful for diverse future researchers
- Botanists and ecologists should strive to link their data sets, which have complementary strengths



Figure 1. Example of a curated, data-rich herbarium specimen

Increasing the value of botanical collections for understanding grasslands I. Strategically sampling Colorado’s under-botanized Eastern Plains

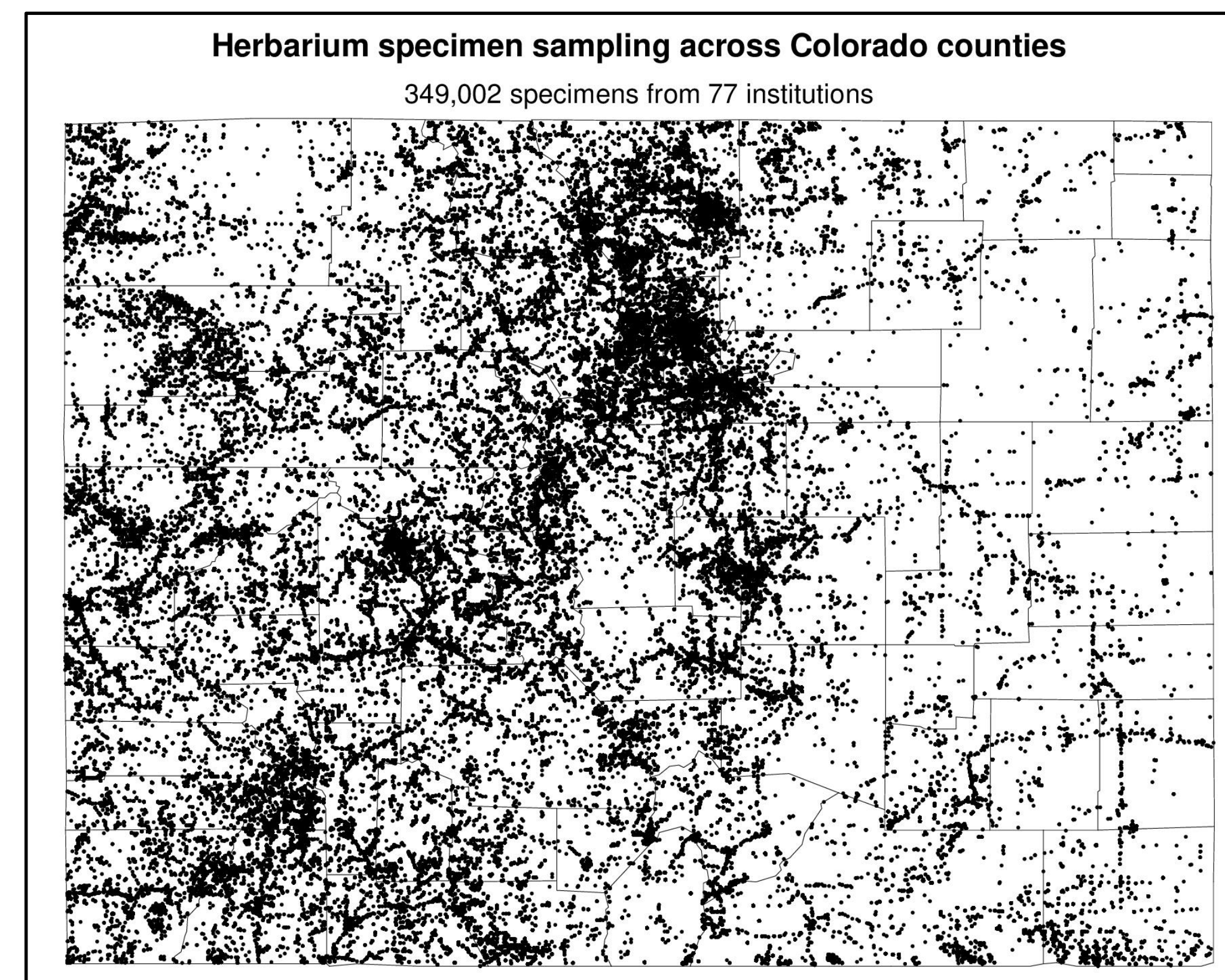


Figure 4. Specimen collection locations show the Eastern Plains are under-botanized. This lessens the value of specimen data for exploring macro-ecological patterns. Correcting this bias is important, as herbarium specimens are the only permanent physical record of site conditions. They are extremely valuable in a rapidly changing world.

Increasing the value of botanical collections for understanding grasslands II. Combining specimen collections with plot-based ecological data

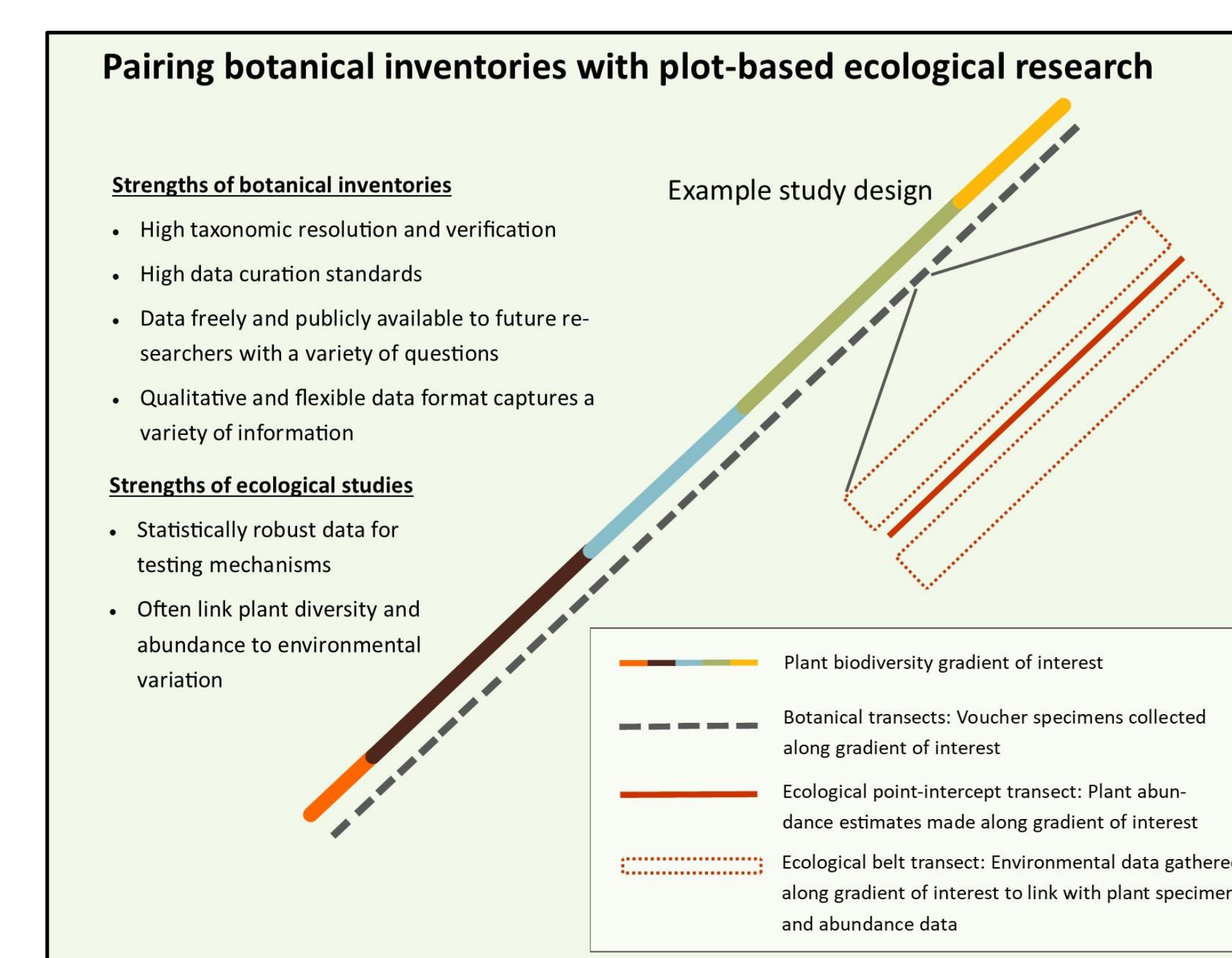


Figure 7. When possible, botanists and ecologists should collaborate to mesh the strengths of collecting and plot-based research. For example, most specimens can only be identified when in flower or fruit. Botanists can build accurate species lists for ecologists by collecting plants as they mature over a season. Ecologists can then link abundance data to botanical species lists and curated collections.

Botanical collections have unique value

Herbarium specimens:

- Are the only physical record of species occurrences on the landscape
- Have excellent spatial and temporal breadth (~350 million specimens have been collected over more than three centuries)
- Are critical for taxonomic verification and as records of long-term trends



Figure 2. Locations of worldwide herbaria (from Index Herbariorum)



Figure 3. The United States Herbarium has more than 5 million specimens

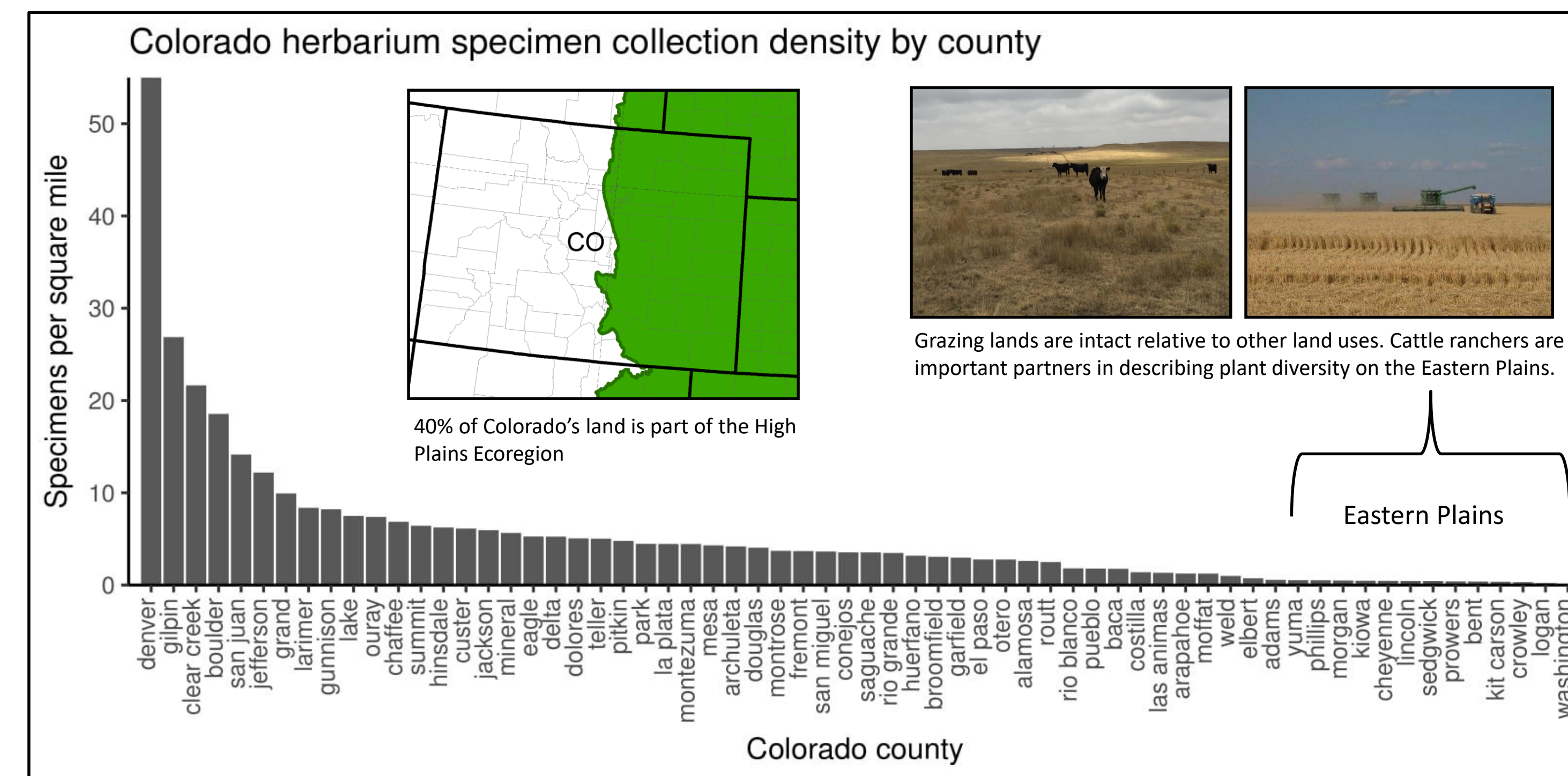


Figure 5. Although the Eastern Plains comprise 40% of Colorado’s land (inset, left) and contain high-quality grazing land (insets, right), botanists have not spent much time characterizing this ecosystem relative to the Southern Rocky Mountains and Western Slope. This is partly because much of the land is privately owned and difficult to access.

Increasing the value of botanical collections for understanding grasslands III. Integration and distribution of botanical and ecological data

- Darwin Core is an accepted set of standards for describing biodiversity data
- Provides definitions, examples, and commentaries to ensure consistent application of standards across users
- Can be used to link multiple data sets, including physical specimens and plot-based data, as well as all associated meta-data

Structure of the Data Archive

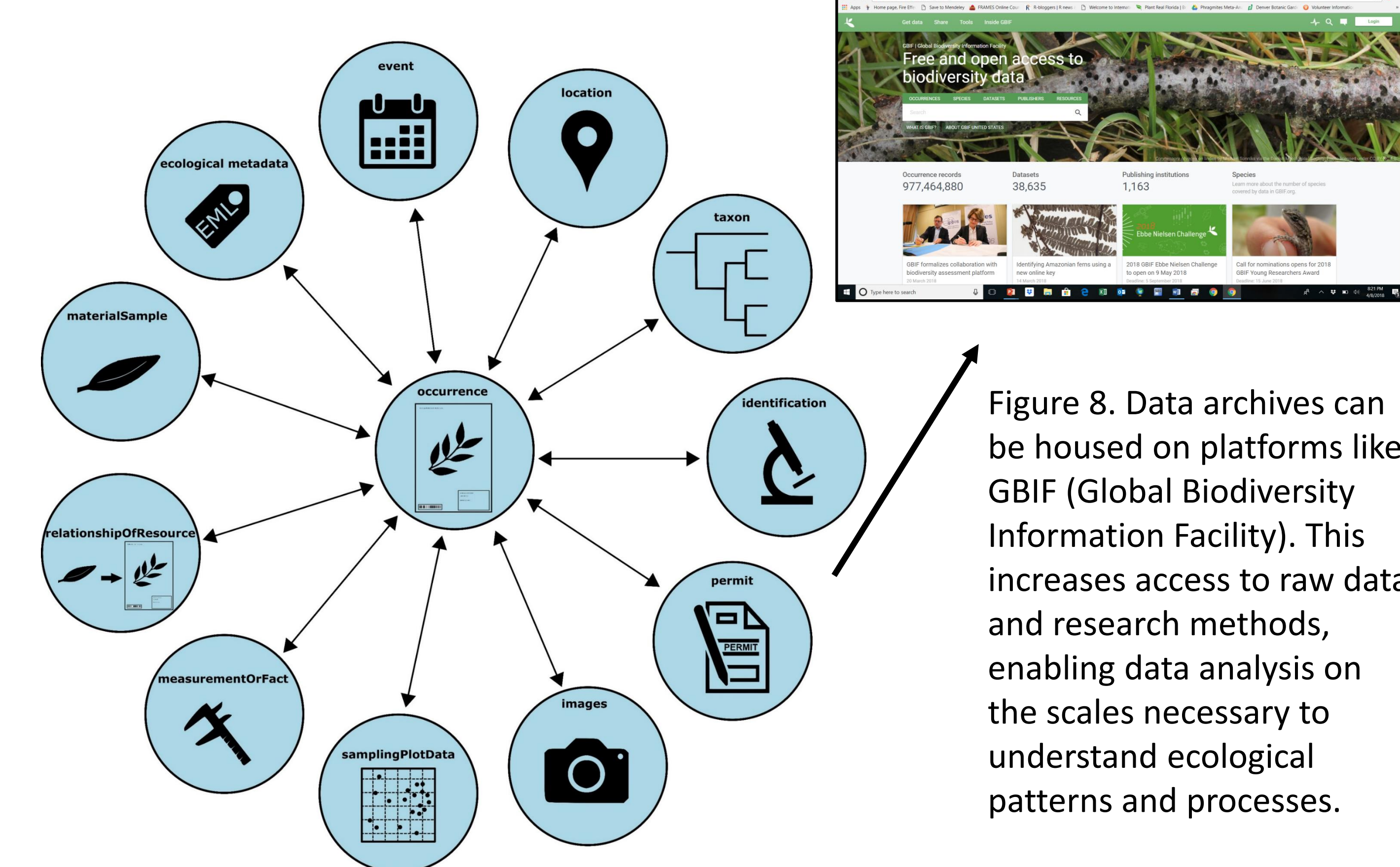


Figure 8. Data archives can be housed on platforms like GBIF (Global Biodiversity Information Facility). This increases access to raw data and research methods, enabling data analysis on the scales necessary to understand ecological patterns and processes.

Life cycle of an herbarium specimen: From plant community to digitized data

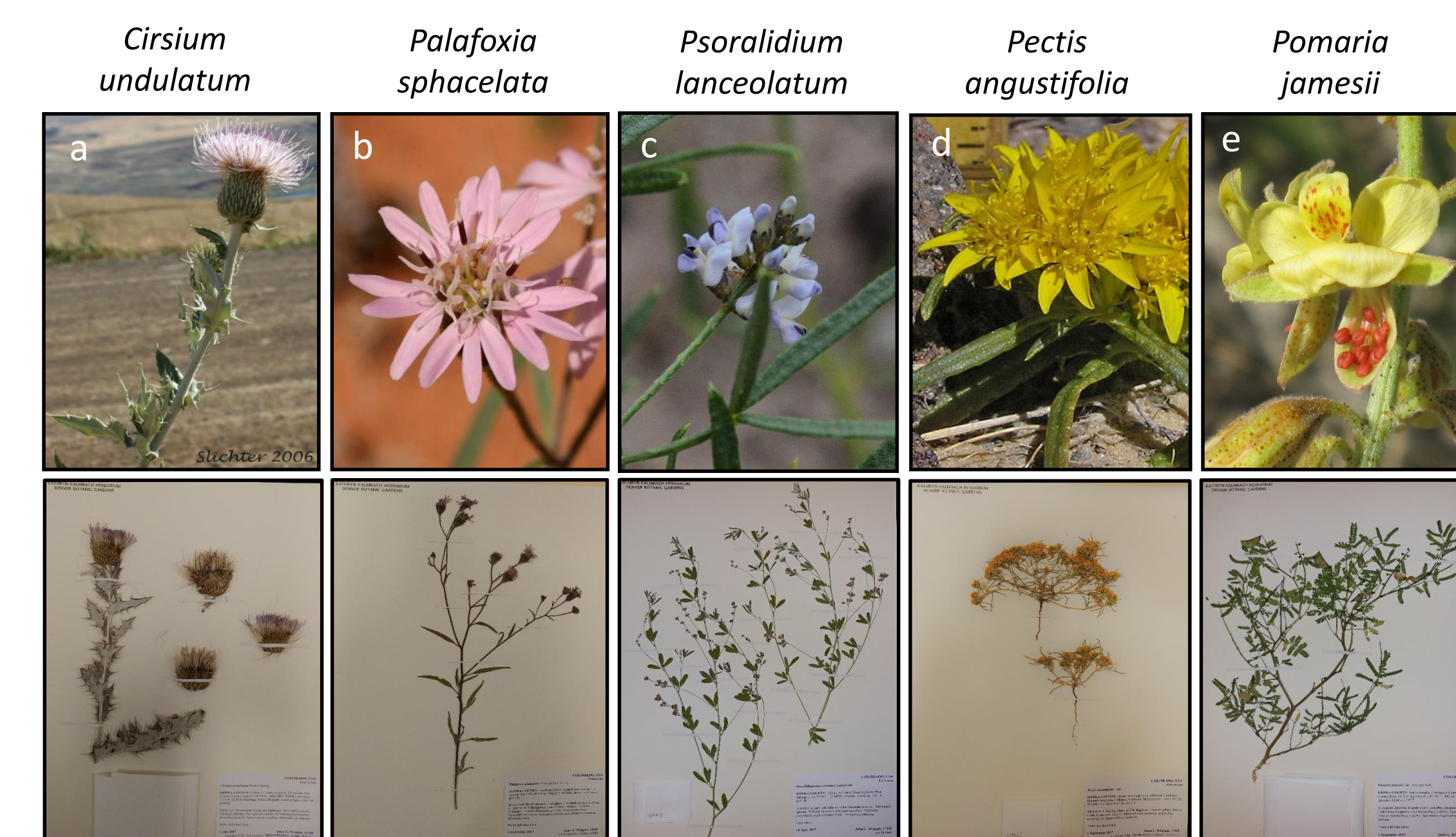


Figure 6. Eastern Plains species that were county records (collected for the first time; plants a, b, c, d) or had only a few collections (plant e) in Kiowa County, CO, in 2017.

Thanks to the private landowners who let us sample their ranches



Figure 9. Botanists from Denver Botanic Gardens speak with landowners Cardon Berry (left) and Cathryn Anderson (right) during visits to their ranches in Kiowa County, Colorado, in 2017.