

Botanizing California

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This study examines the history of botanical collections in California using data from the California Consortium of Herbaria. The data includes nearly a million specimens, each with information about the species collected and the specimen's location. Aggregated and analyzed in GIS, the specimens pose interesting questions about the comprehensiveness and thoroughness of our understanding of the natural world around us. For example, analysis shows that a disproportionate amount of the specimens were collected near highways, suggesting that infrastructure has played a significant role in determining which areas of California and which plants have received the careful attention of botanists. This project is still a work in progress.

Thousands of botanists have surveyed, documented, and classified the plants in all regions of this state -- from the Central Valley to the Mojave Desert, from the Sierra Nevada to the Channel Islands -- for over 150 years. Collectively, they are the bridge between us and the plant kingdom, and their efforts have been our most consistent attempt to understand the natural world. But just how scientific and thorough has this process of understanding the world around us been?

Especially now, as we attempt to quantify and counteract changes in our natural world due to climate change, it is important to understand our baseline. Our current understanding of the natural world is the result of a rich history of biological and environmental sciences, shaped and molded along the way by human decisions, judgments, and errors; it would be error to assume it is complete or accurate.

This project analyzes the spatial and temporal patterns of Californian botanical collections in specific and the history of our attempts to understand our natural world in general. Our research began with data from the California Consortium of Herbaria, which houses digitized records of 1.03 million specimens. Each specimen includes attribute information such as the genus and species, the collector, and the date of collection. Roughly half include latitude and longitude information as well as elevation figures.

Although it is tempting to take the size and extent of the database for comprehensiveness and reliability, it is important to remember the humans involved in building it. On March 11, 1925, it was Rimo Bacigalupi's decision to document the existence of the bristlecone fir (*Abies bracteata*) he found rather than, say, the Santa Clara thorn mint (*Acanthomintha lanceolata*) or any of a hundred other plants growing nearby. The database is a direct result of this decision and thousands like it. Although our study is far from complete, early analysis has already raised provocative questions.

The animation above tracks all herbaria specimen with precise geographic information from 1880 to 2008, superimposed on a

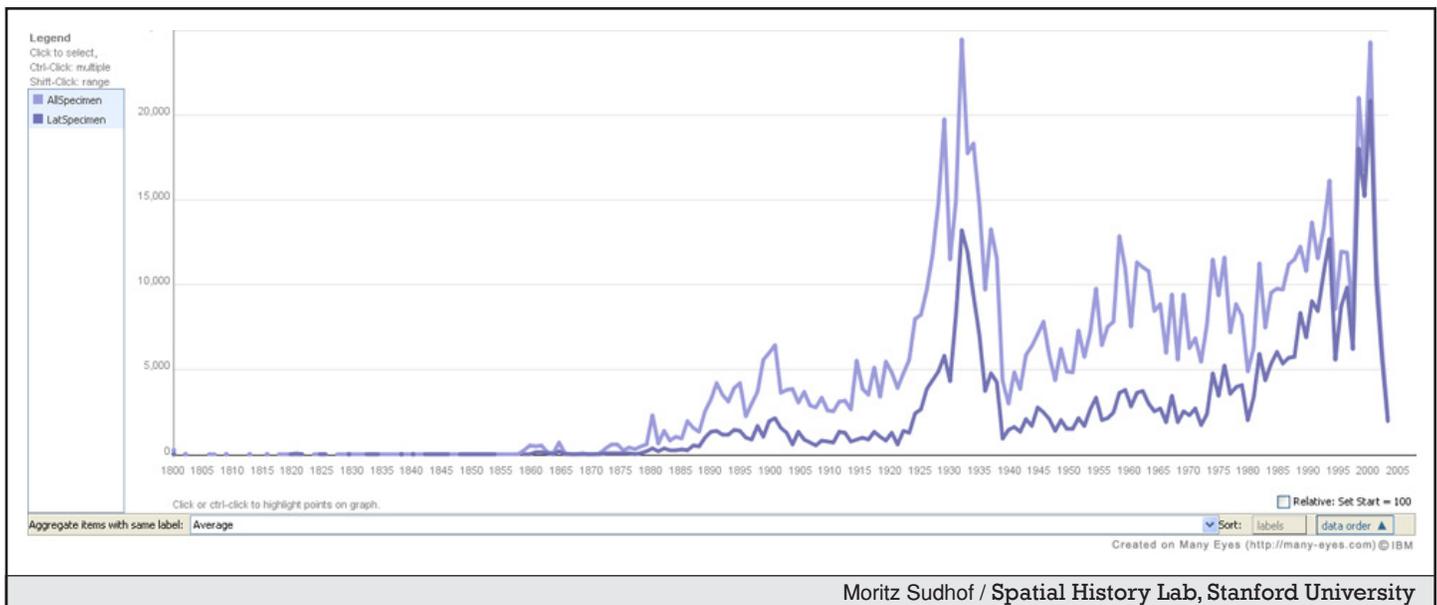


Figure 1 | Herbaria & Infrastructure in 2008

1928 California state highway map. Although road conditions and development have changed since that date, the geographic flow of California's highway system has remained overwhelmingly constant, and the roads on this map still accurately represent the layout of California's highways to this day. The map was chosen not for analytical reasons but rather for its aesthetics and its ability to remind us of the historical nature of our understanding of the world. The animation is in not complete or clean; its purpose is to roughly demonstrate the surprising tendency of specimen to pop up near roads. The area represented by California highways -- even when given a 2 km buffer -- is a small proportion of California's actual geographic extent, yet almost 40% of the specimen can be found within 2 km of California's major roads. This distribution suggests that botanists' decisions of where to collect have been influenced significantly by the existing infrastructure. How can we have a thorough understanding of the natural world if this understanding hinges on our own highway system?

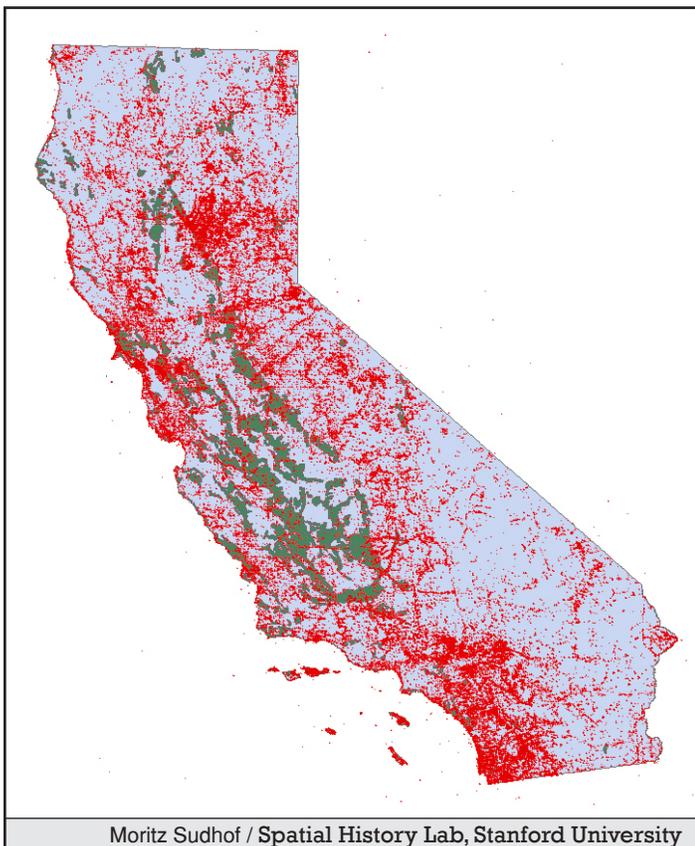
Graphs depicting year by year collection trends of the data

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Moritz Sudhof / Spatial History Lab, Stanford University

Figure 2 | Amount of Specimen Collected Each Year



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Figure 3 | Wieslander Grasslands vs. Graminoid Specimen

also display the variability inherent in the dataset.

Here, the light blue line represents the total quantity of specimen and the darker blue represents the quantity of specimen with specific latitude and longitude information. The graph suggests little in the way long-term organization or consistency

in the collection activity of botanists. Collection intensity seems instead to be influenced by historical considerations. The spike in collections during the 30s, for example, can be attributed to the Wieslander efforts to divide California into ecoregions. The Wieslander ecoregions, themselves a specific attempt to understand California's natural world, provide an interesting contrast to the snapshot of the natural world that the herbaria data presents.

The green regions represent the Wieslander ecoregions considered to be grasslands, and each red dot represents a botanical grass specimen. The two images certainly do not tell the same story of grass growth in California. Wieslander's ecoregions generalize areas by a single kind of plant; botanical collections are interested instead in specific plants and therefore embrace regional diversity. Each is precise in its own way, but neither accurately represents the character of the natural world around us.

Areas of further interest for this project include a more rigorous analysis of the relationship between infrastructure and botanical collections, the style and development of botanical collaboration, and the history of introduced species in California, both in terms of their extent and in terms of our interest in them.

Supplementary Information is linked to the online version of the paper at <http://www.stanford.edu/group/spatialhistory/cgi-bin/site/pub.php?id=17>.

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