THE JEPSON GLOBE

A Newsletter from the *Friends of The Jepson Herbarium*

VOLUME 31 NUMBER 2, Fall 2021

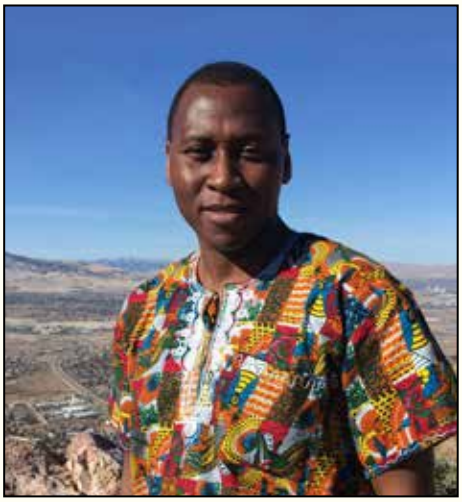
Director's Column: *What, if Anything, are Species?*

By Brent D. Mishler

I've been interested in the topic of species my whole professional life. The biological species concept (BSC; where species are defined by ability to interbreed) that I was exposed to as an undergrad always struck me as a poor fit, at least to plants. As a graduate student working in the exciting early days of cladistics (a.k.a. phylogenetics) I began thinking seriously about how we could develop a concept of species that would fit the new DNA data, analysis methods, and theory coming from Hennigian phylogenetic systematics (although, ironically, Hennig himself botched up species, being too wedded to the BSC). A grad student colleague (Michael Donoghue) and I came up with the phylogenetic species concept (PSC) where species are defined as minimal clades (i.e., monophyletic groups).

After pursuing and elaborating the PSC with Michael and several other colleagues over nearly two decades, I came to the realization that the PSC was fatally flawed in a manner that was common to all species concepts. No matter how you group organisms, whether based on ability to interbreed (under the BSC), morphological or ecological similarity (under several other common species concepts), or phylogenetic relatedness (under the PSC), you still need a separate criterion to rank them as species (rather than some other taxonomic rank). This

(Director's Column continued on page 3)



Israel Borokini in the Virginia Range southeast of Reno, Nevada – Photo by Israel Borokini

New Postdoctoral Fellow Joins the Herbaria

Israel Borokini joined Dr. Brent Mishler's lab as a postdoctoral fellow in August 2021. Israel was born and grew up in Nigeria. His father worked for a government-owned research institute that focuses on cocoa breeding. As a result, he lived most of his teen years in a forest estate with direct encounters with nature: waking up to the sounds of birds chirping in the trees, hiking through dense tropical jungles with friends in search of wild fruits, seeing packs of monkeys hopping in the trees in broad daylight, and going to bed to the barking of wild dogs. Therefore, it is not surprising that Israel pursued a career in biological sciences, getting his Bachelor's and Master's degrees in Botany. Israel recently completed his Ph.D. in

(Continued on page 2)

Fire Recovery at Hastings Reserve

By Jennifer Hunter, Resident Director, Hastings Natural History Reservation

The third week of August, 2020, was a big week for fire in California. Between August 16 and 19, an incredible 367 fires started throughout the state, touched off by a series of lightning storms generated by the remnants of Tropical Storm Fausto in the eastern Pacific. At UC Berkeley's Hastings Reserve in Monterey County, we are well aware that we are vulnerable to wildfire and on the morning of August 16, an ominous column of smoke from the River Fire began rising to the northwest of the Reserve.

On Wednesday, August 20, the River Fire jumped the Sierra de Salinas range and onto the ranch that is our western neighbor. By the early hours of August 21, the fire reached Hastings. After much wringing of hands and gnashing of teeth the smoke cleared. Approximately 600 acres of the reserve burned; all of the buildings were saved.

As we caught our breath and began the cleanup effort, it became clear that we were presented with a unique opportunity to observe, firsthand, the impact of fire on our landscape. Indig-

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ALSO IN THIS ISSUE

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Ecology, Evolution, and Conservation Biology at the University of Nevada, Reno, where he worked on several integrated research studies to increase the scientific understanding of *Ivesia webberi*, a federally threatened forb in the Great Basin Desert. His dissertation research included landscape genetics, ecological niche modeling, genome size estimation, and relationship between the soil seed bank and above- ground plant communities. These are in addition to a side project on population abundance estimation and modeling, for eventual statistical comparison with the ecological niche modeling. As a lesser-known species and genus at large, Israel's research generated novel data and tested several hypotheses that led to findings about the eco-evolutionary dynamics of persistence of this neo-endemic and range-restricted plant species, with the potential for knowledge transfer to other species in the genus with similar functional traits. For example, ground-truthing of the ecological niche models resulted in the discovery of eight new locations of *I. webberi*.

Prior to the start of his Ph.D. program, Israel was employed by the National Center for Genetic Resources and Biotechnology in Ibadan, Nigeria. His research at this Center included the conservation of native plant diversity in the entire country, nationwide plant surveys, and the management of gene banks, among others. This wide-ranging research mandate allowed him to conduct several research studies and he has published about 60 research papers, especially on ethnobotany and traditional knowledge diffusion, invasive species management, and the distributions of endemic flora in Nigeria. These papers have been cited almost 700 times, including in the Nigeria's National Biodiversity and Strategic Action Plan, an important biodiversity policy document submitted to the Convention on Biological Diversity (CBD). Additionally, Dr. Borokini represented Nigeria in the CBD's ad-hoc technical expert group on invasive species, developed the country's first invasive species living database to the GBIF, and also listed two species in the IUCN red list of threatened species. Furthermore, Israel currently represents Nigeria (and the United States) in the United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) on the Sustainable Use of Wild Species assessment. To keep him busier, Israel also works as an adjunct faculty member in the Department of Biology at Truckee Meadows Community College, Reno, Nevada, teaching classes and labs on General Biology and Cell and Molecular Biology.

Israel met Dr. Mishler during the 2019 Northern California Botanists (NCB) annual meeting, where Dr. Mishler gave a talk on the Spatial Phylogenetics of California flora. Israel had previously attempted to apply the phylodiversity metrics in a personal-funded project prior to starting his Ph.D. and had been in talks with Dr. Shawn Laffan. Meeting Dr. Mishler was a perfect match that reignited his passion in biogeography – understanding species distributions and coexistence in time and space. Israel will be joining Dr. Mishler's lab as a David H. Smith Conservation Research Postdoctoral Fellow, to build on existing research work on the spatial phylogenetics of the North American flora. Israel is excited for this 2-year fellowship and can't wait to immerse himself into this amazing group of brilliant researchers! Dr. Samuel Cushman of the U.S. Forest Service will also provide mentoring from the government conservation perspective.

Israel is a member of about 10 professional societies and he holds leadership positions in two of them, including being the President of the Africa Section of the Society for Conservation Biology (SCB), and a Director-at-Large for the Northern California Botanists. In addition to reviewing many manuscripts for several journals, Israel also serves as an Associate Editor for the journals *Conservation Science and Practice* and *Economic Botany*. In his very few leisure times, he enjoys a good hike up the mountains of the Sierra Nevada, overnight camping in serene nature, and soaking in hot springs across Nevada and California. And, yes, he has a book of all hot springs from Texas to California. He also loves traveling and he has been to all human-inhabited continents (Antarctica does not count!). He enjoys playing soccer or watching tennis. To learn more about Dr. Israel Borokini's work, please visit his personal website (*tbisrael.wixsite.com/website*), google scholar profile (*scholar.google.com/citations?user=zvXrKpUAAAAJ&hl=en*), or ResearchGate page (*www.researchgate.net/profile/Israel-Borokini*).

Botany 2021 Annual Meeting

The annual North American botanical meeting Botany 2021 was held virtually July 18-23, 2021. Bruce Baldwin, Brent Mishler, and Klara Scharnagl all presented talks. Their presentations are available on the YouTube channel of the University and Jepson Herbaria:
www.youtube.com/channel/UC-OH10pj_71K6SI73aaz_GA

Bruce G. Baldwin
Facilitating plant conservation through the Jepson Flora Project.
Brent D. Mishler
Application of the PhyloCode at the level formerly known as species, with examples from mosses.
Klara Scharnagl
Symbiotic forms and the lichenized phenotype.

A Message to our *Friends* About the Jepson Workshop Program

Many of us are ready to get back in the field and we have good news – we will be offering in-person workshops in 2022! The program will be announced shortly after Thanksgiving – keep your eye on your email and be sure your membership is up-to-date because members will receive one week of priority registration.

This Fall, we will be offering four virtual events for our members. These OPEN MICroscope Nights will give participants a chance to talk with the instructors and ask in-depth questions. Each session will begin with a short lecture or keying session and then transition to questions and discussion. Details and registration information are available on our website. There is no cost for these events – we hope you can join us!

September 22, 2021

Bruce Baldwin will lead a virtual keying session of one of the Bay Area's tarweeds. Members will learn some of the important characters needed for identification and how to evaluate them. Ever wonder what "phyllaries ½ enclosing a ray ovary" means? Or, "how do tarweeds survive and flower in the hottest, driest time of the year?" This will be your chance to find out!

October 20, 2021

Klara Scharnagl will give a brief introduction to one of the more common California lichens and how to recognize it. She will discuss its morphology and ecology and review some basic terminology. Have lichen questions? Klara has answers!

November 3, 2021

Carl Rothfels will discuss some of the recent changes in fern taxonomy and why the changes were made in the *Jepson eFlora*. He will then dissect a fern and show some of the features needed for identification. What is a false indusium and how do you tell how many times pinnate a fern frond is? Tune in to find out!

December 1, 2021

Brent Mishler will talk about bryophytes and their biology and share new information resulting from his integrative project on the moss clade *Syntrichia* that ranges from genomes through systematics and physiology, to the important ecological role these mosses play in fragile biotic soil crust environments in drylands around the world. All questions are welcome, anything from basic biology to species concepts are all fair game!

Left: *Blepharizonia laxa*, photo by Neal Kramer
Right: *Adiantum shastense*, photo by Len Linstrand

(Director's Column, cont. from page 1)

is because all of those grouping criteria produce nested sets of entities; there is no unique cutoff criterion to tell which level should be species.

Finally, I realized that the solution needed was even more radical than getting rid of the BSC in favor of the PSC. Instead, we need to get rid of the species rank itself, following the arguments being pursued by many in favor of rankless classification that eventually led to the development of the PhyloCode (*phylonames.org/code/*). The species rank was not included in the general discussions about rankless classification, but it is clear now that it must be. My most recent papers on the topic address how we can do classification without any ranks (including species) and how we can use such classifications to pursue academic topics like ecology and evolution, as well as applied topics like conservation.

My new book (*What, if Anything, are Species?)* explores this controversial topic in detail, following my 40 year intellectual odyssey outlined above. Nine previously published papers are reprinted, and newly written material is added to the beginning of each chapter to explain how the reprinted papers in that chapter connect. The final chapter, exploring implications, is entirely new material. The general conclusion is that species are nothing special; entities currently given that rank are simply clades like taxa at all other levels on the tree of life, smaller or larger than the traditional species level. There are a number of advantages of fully rankless classification and of a multi-level approach to ecology, evolution, and conservation (e.g., see the recent paper by Bruce Baldwin and me for practical considerations: "Beyond Species: Cryptic Diversity and its Importance" in *Artemisia: Journal of the California Native Plant Society* 48(2): 43-47, 2021).

The book is open access thanks to a grant from the Berkeley Research Impact Initiative (BRII), sponsored by the UC Berkeley Library; it is freely downloadable or readable online at: *www.taylorfrancis.com/books/oa-mono/10.1201/9781315119687/anything-species-brent-mishler*.

Big Data and Biodiversity: UC/JEPS Researchers Play a Key Role in a State-wide Initiative

The California Conservation Genomics Project (CCGP) is a state-funded initiative with a single goal: to produce the most comprehensive, multispecies, genomic dataset ever assembled. Why is investigating and protecting regional biodiversity important? California is currently home to the most diverse plant and animal life in the U.S. and genetic variation will play an important role in the long-term survival of all species. Scientists participating in the CCGP have selected over 200 threatened, endangered, or otherwise valuable species to study. Using HiFi sequencing and assembly, the researchers will capture the genetic variation that exists across the range of each species and those data will reveal regional biodiversity and inform conservation decisions in the face of rapidly accelerating species declines.

Faculty and Research Associates from the University and Jepson Herbaria are involved in this work. Below are descriptions of their projects. More information may be found online (www.ccgproject.org/).

Layia glandulosa in Canyon Gato Montes, Tehachapi Mountains – Photo by Neal Kramer.

Bruce Baldwin, Isaac Marck, and Ryan O'Dell (Hollister BLM)

Layia glandulosa (white layia) and close relatives *Layia discoidea* (rayless layia) and *Layia pentachaeta* (Sierra layia)

Layia glandulosa has been shown to include a diversity of evolutionary lineages that are eco-geographically and morphologically distinct. Although this complex occurs almost exclusively in sandy or gravelly soils, one particularly distinctive lineage, treated as *L. discoidea*, is an excellent example of recent evolutionary divergence onto serpentine soils. Complete interfertility of these lineages has made this species complex especially valuable for studying the evolution of adaptations in the California flora.

Mimulus guttatus – Photo by Benjamin Blackman

Benjamin Blackman and Jason Sexton (UC Merced)

*Mimulus guttatus** (common monkeyflower) and *Mimulus laciniatus** (cutleaf monkeyflower)

Populations of common monkeyflower are often locally adapted to environments that vary substantially in their annual temperature and precipitation cycles and some populations are even found in acutely stressful habitats like serpentine soils, coastal dunes, or copper mine tailings. Consequently, this species possesses exceptional genomic diversity, study of which will highlight what variants may be most important to conserve for adaptation to current and future climates.

Cutleaf monkeyflower is an endemic plant with a limited distribution. Even within its limited latitudinal range, populations of this species have adapted to a wide range of climate conditions from chaparral habitats in the foothills to sub-alpine areas at >8000 ft above sea level. Thus, studying its genomic diversity can inform how populations have adapted to diverse environments.

* The *Jepson eFlora* treats these taxa in the genus *Erythranthe*.

Susan Fawcett and Lucas C. Majure (University of Florida)
Opuntia basilaris (beavertail)

The *Opuntia basilaris* complex includes the widespread and ecologically important *Opuntia basilaris* var. *basilaris* (beavertail), as well as the threatened *Opuntia basilaris* var. *brachyclada* (short-joint beavertail), and the endangered *Opuntia basilaris* var. *treleasei* (Bakersfield cactus).

This study will help to disentangle the complex evolutionary histories of these iconic desert plants and better describe and recognize the diversity of these cacti across the landscape. Understanding genetic variation in wild populations will also inform ongoing restoration and management, especially for the threatened and endangered taxa.

Opuntia basilaris – Photo by Susan Fawcett

Brent Mishler and Ixchel González-Ramírez
Asterella californica (California asterella)

Asterella californica is a thalloid liverwort that occurs along the west coast of North America and in almost all the ecoregions of California. It is part of the soil biocrust community and one of the first colonizers of bare soil. To the best of our knowledge, this will be the first study attempting to understand genetic and morphological diversity within a liverwort species. There are important implications for conservation to understand this haploid dominant and spore-dispersed plant.

The liverwort *Asteralla californica.* Both male (M) and female (F) plants can be seen. The fertilized female gametangia become raised up inside the familar "umbrellas" often seen in the spring. Photo by Ixchel González-Ramírez

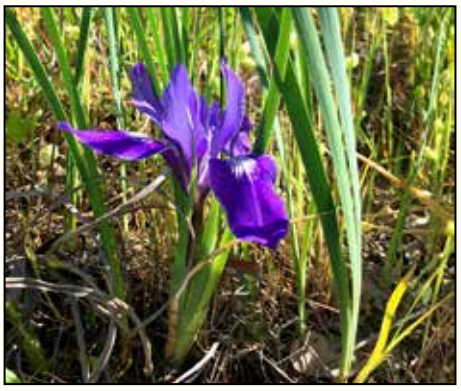
Carl Rothfels, Fay-Wei Li, and Forrest Freund
Azolla filiculoides (common mosquito fern) and *Azolla microphylla* (Mexican mosquito fern)

Azolla filiculoides and *A. microphylla* are small, free-floating aquatic ferns found in relatively still waters, ponds, and lakes. They provide available nitrogen to natural and agricultural systems. They can also act as a substantial carbon sink under the right conditions, sequestering large amounts of carbon due to their rapid annual blooms and bursts.

Azolla microphylla – Photo by Carl Rothfels

Carol Wilson
Iris macrosiphon (bowltube iris)

Iris macrosiphon provides food resources, including nectar, pollen, fleshy appendages on developing seeds, and underground storage organs (rhizomes) that are rich in carbohydrates and oils. Rhizomes can survive fires and drought and also provide renewal shoots for regrowth, where the species can take advantage of short growing seasons through its readily available reserves. The genomics of nutrient and water sequestration in underground organs, renewal growth, nectar production, and development of seed appendages are relatively unknown but likely to provide important information about resistance to climate change and food production within the landscape.



Iris macrosiphon – Photo by Carol Wilson

(Continued from page 1)

enous Californians have been using fire as a tool for land management for thousands of years and we are quite literally surrounded by hundreds of species specially adapted to succeed in an ecosystem punctuated by frequent, and often intense, fires.

When the River Fire arrived at our doorstep, it did not burn uniformly. Subtle differences in microclimate can mean slightly more ambient humidity or slightly more water stored in plant tissues and therefore a reduced risk of burning. Areas with dense vegetation often burn with greater intensity as understory plants serve as ladder fuels, allowing fire to quickly move into tree canopies. Windswept hillsides and ridgelines are often drier due to increased evaporation and fire moves faster as it feeds on the oxygen in each gust. This is all to say that vegetation in different areas of the landscape was affected differently and the net effect was a matrix of fire intensity and burn severity.

At Hastings this heterogeneity manifested in several ways. The fire first crossed into the reserve in the oak woodlands at our northwestern boundary. The grasses burned quickly. The fire's impact on the oaks was less predictable. For example, in one area a small stand of live oaks and valley oaks appeared almost untouched, while mere feet away another oak was so thoroughly torched that the only evidence it ever existed is a hole in the ground where the root ball burned out.

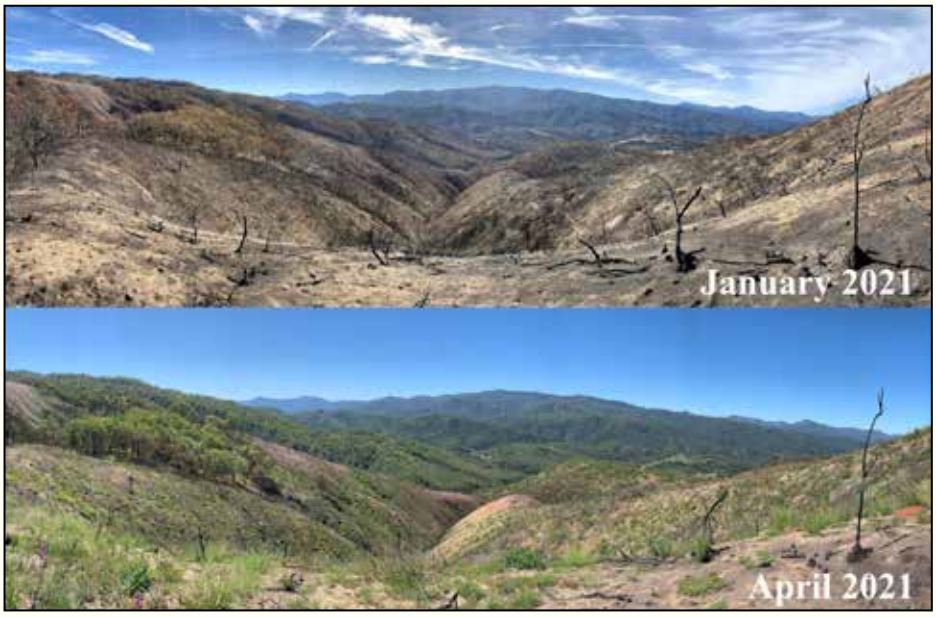
In contrast, acres upon acres of chaparral were completely obliterated. Chaparral species like chamise, manzanita, and ceanothus tend to grow in drier areas and their architecture, with lots of surface area, a near continuous canopy, standing dead branches, and exfoliating bark make these species particularly flammable. Resins in the tissues of chaparral species further amplify the speed and intensity with which this ecosystem burns.

In the first weeks after the fire it was striking to look into the hills above Hastings. From a distance it appeared the oak woodland canopy was only minimally impacted, but there were enormous bare spots where the chaparral was simply gone. The first signs of recovery appeared quickly. In oak woodlands, the burning of the understory, including years of accumulated thatch, increases nutrient availability to grasses and allows for greater water infiltration (and faster green up). In some areas, we had bunch grasses re-sprouting a scant 12 days after the fire. While most of the oaks did have some crown damage, few trees burned completely, and there is now a flush of new green leaves growing at the ends of otherwise charred branches.

When chaparral plants are killed in a fire (like many ceanothus and manzanita species) they rely on a dormant seed bank that is stimulated to germinate from the heat of the fire or from chemicals released by the burning wood. Other species, like chamise and toyon, readily re-sprout from underground burls. At Hastings, we saw our first sprouting of burned chamise in early November, approximately 11 weeks after the fire and as we approach the one-year anniversary of the River Fire our formerly bare chaparral slopes have a distinct green tinge.

We have had about half our usual precipitation this year. Between the drought and the fire, we weren't quite sure what to expect from our wildflowers. This spring we had our usual fields of lupine and poppies with the spectacular addition of hillsides filled with yellow fiddlenecks. Geophytes like blue dicks and golden brodiaea erupted in late April and May. By virtue of propagating via underground corms and bulbs these species were both safe from the fire and suddenly released from competition with other annual and perennial forbs.

We are already firmly in the 2021 fire season and it remains to be seen how this year's drought will impact the recovery of areas that burned in the River Fire. The atmospheric conditions that gave rise to the lightning storm that sparked all of those fires throughout the state last August are likely to occur again, given the impacts of a changing climate and increased sea surface temperatures around the world. We expect that fire will play a larger part in the future of Hastings than it did in our past; for the moment, we are enjoying watching the continued recovery of our ecosystems and are hoping for a quiet summer.



Entire hillsides of chaparral were completely burned but began to come back to life this spring. Photo by Jen Hunter.

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Jepson Herbarium Resources & Projects related to the California flora

The Jepson Herbarium includes approximately 400,000 plant specimens from California.

Director: Brent D. Mishler
California Phylodiversity Project
Systematics and ecology of *Syntrichia*

Jepson Curator: Bruce G. Baldwin
Jepson eFlora
Systematics and evolution of Calif. tarweeds and relatives (tribe Madieae, Compositae), *Chaenactis* (Chaenactidieae, Compositae), and *Collinsia* (Plantaginaceae).

Curator of Ferns and Lycophytes: Carl Rothfels
Divergence and hybridization in Californian ferns and lycophytes (especially *Notholaena*, *Cystopteris*, *Isoëtes*).

Curator of W. N. American Flora: Barbara Ertter, *Flora of Mount Diablo* and flora of the East Bay, North American Potentilleae

Asst. Director for Development & Outreach, and *Globe* editor: Staci Markos

Biodiversity Informatics Manager: Jason Alexander

Collections Staff: Ana Penny

Archivist and Librarian: Amy Kasameyer

Public Programs: Staci Markos, Roxanne Andersen

Membership, workshop enrollment, and *Globe* design: Roxanne Andersen

Staff Research Associate: Bridget Wessa

Jepson Videos: Staci Markos, Amy Kasameyer

Trustees:
Vice Chancellor Emeritus Beth Burnside; Professor Emeritus Russell Jones; Professor Emeritus John Taylor and Professor Brent D. Mishler (ex officio)

Constancea: UC Publications in Botany (online)

The Jepson Globe, Vol. 31 No. 2

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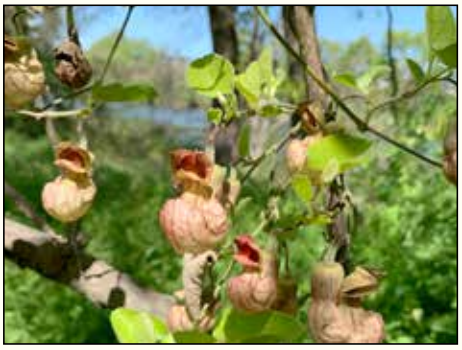
New Jepson Videos on YouTube

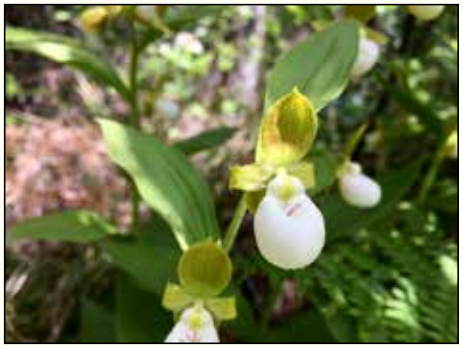
https://www.youtube.com/c/Jepsonherbarium



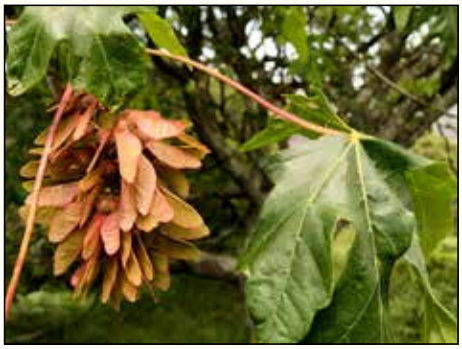
Aristolochia californica (California pipevine)

We've organized the Jepson Videos into playlists! Viewers can now find videos in a particular family, region, or habitat. For example, check out our playlist for Coast Range species.

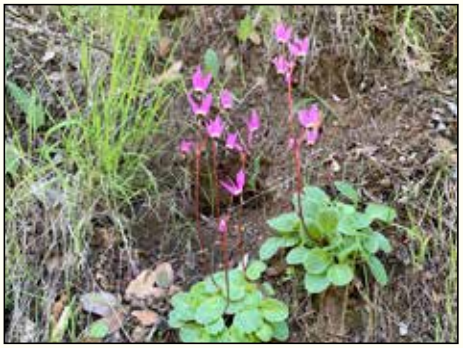
Chrysolepis chrysophylla (giant chinquapin)



Cypripedium californicum (California lady's slipper)



Acer macrophyllum (big-leaf maple)



Two videos about *Primula*, produced in collaboration with Bob Allen