



March 6, 2021

Dr. Carl Rothfels
University & Jepson Herbaria
University of California, Berkeley
5406 Boyce Hall
Riverside, CA 92521

Dear Dr. Rothfels:

Enclosed is your executed permit to collect plant samples from *Azolla filiculoides* and *A. microphylla*, *Layia glandulosa*, and *Asterella californica* as part of California Conservation Genomics Project within selected units of the California State Park System. It is a policy of this office to issue permits annually, so this permit is valid from March 6, 2021 to March 6, 2022. Each year, you may request a renewal of this permit before it expires; we recommend that permit application be submitted at least 60 days in advance for the planned fieldwork. Please access the website at: http://www.parks.ca.gov/?page_id=21557 for guidance on preparing your renewal application.

Please read all the conditions that apply to this permit very carefully. You are prohibited from conducting any research activities in any park units until you make contact with the appropriate district permit coordinator (see attached list of contacts) and receive their permission to begin your field work in the park units within their districts. This is an opportunity for you to inform the district permit coordinator about the specifics of your work and to gain assistance with getting access to the park units. Please be aware that the district permit coordinator may apply site-specific restrictions to your permit to protect sensitive areas and resources, which could affect the timing or proposed location for some research activities. All research and collecting activities conducted under your California State Park permit must be consistent with the terms and conditions, and local restrictions applied by the district permit coordinator as they retain final approval authority.

As a reminder, you are required to submit to us a summary report of your activities in the California State Park units by March 6, 2022, as well as a final report and any associated data products within one month of their completion. Please keep a copy of this permit with you in the field.

Best wishes for a successful project.

Sincerely,

Nita Barve

Nita Barve
Environmental Scientist
Natural Resources Division
California Department of Parks and Recreation
Nita.Barve@parks.ca.gov
(916) 653-9365

SPECIAL PERMIT CONDITIONS:

Dr. Carl Rothfels, Univ. of California, Berkeley
California Conservation Genomics Project
Permit valid from 03/06/2021 through 03/06/2022

In addition to the Standard Conditions and Restrictions stated on the Application and Permit to Conduct Scientific Research and Collections, the following conditions are applied:

- 1) This permit does not authorize access to park units, facilities, or parking lots during posted closures. California State Parks' response to COVID-19 may result in lack of access to sites identified for Scientific Research or Collection due to park closures, or implementation of other safety measures. Please check for park closures through the COVID-19 Resource Center (https://www.parks.ca.gov/?page_id=30350), AND contact your permit coordinator to determine if there are other reasons that may inhibit access during this time.
- 2) The Permit Holder (and field assistants) will make every effort to minimize off-trail impacts (e.g., erosion, trampling of vegetation, and creation of volunteer trails) by utilizing formal trails and roads whenever possible.
- 3) The Permit Holder (and field assistants) agrees to abide by all park rules and regulations, including, but not limited to, no-dog and dog-leash requirements, backcountry access requirements, no vehicles allowed on beaches, and posted area closures necessary to protect sensitive species, habitats, or resources.
- 4) Following sampling, and no later than March 6, 2022, the Permit Holder must submit a summary report of activities conducted in the California State Park units to:

Attn: Environmental Program Manager
Natural Resources Division
California Department of Parks and Recreation
P.O. Box 942896
Sacramento, CA 94296-0001
nrd.research@parks.ca.gov

A final report and any associated data products must also be submitted to the above address within one month of their completion.

- 5) Prior to conducting field work in coastal areas, the Permit Holder (and field assistants) will review the two attached brochures, *Western Snowy Plover Sharing the Beach* (<http://www.parks.ca.gov/pages/23071/files/ploverpdf.pdf>) and *Rules and Guidelines for Protecting the Snowy Plover* (<http://www.parks.ca.gov/pages/23071/files/flyerploverhr.pdf>). Federally threatened Western Snowy Plovers are small shorebirds that nest and over winter on many Pacific Coast beaches and other coastal areas.
- 6) The Permit Holder will acknowledge the participation of California Department of Parks & Recreation in any reports or presentations from the data collected on Parks lands.
- 7) The Permit Holder is responsible for obtaining any additional permits or approvals required for research and collecting activities conducted beyond the California State Park System boundaries.
- 8) The Permit Holder (and field assistants) must carry a copy of this permit at all times while conducting field work.

- 9) This California State Park Permit does not authorize collection of rare, threatened, or endangered species protected by California law, nor does it authorize targeted collection of federally-listed species.
- 10) This Scientific Collection Permit functions as a landbase access agreement between California State Parks and the Permit Holder, whereby access is only allowed given the acceptance of permit conditions and liability framework.

Special Conditions for Santa Cruz District

- 11) The project includes work in Big Basin Redwoods State Park. Currently, access to burned areas within Big Basin Redwoods SP is restricted, and may require a State Parks staff escort. Contact the Santa Cruz Permit Coordinator for additional information.

Contact List for Parks

You **MUST** notify the District contacts identified below prior to activities in their respective park units. Two weeks' notice is required. Districts may have particular concerns regarding study design and sampling locations, and they retain final approval authority. Failure to contact may result in loss of sampling opportunity.

ANGELES DISTRICT

District Office: (818) 880-0363

Danielle LeFer
Danielle.LeFer@parks.ca.gov
(818) 880 0365
Castaic Lake SRA
Malibu Creek SP
Topanga SP

BAY AREA DISTRICT

District Office: (707) 769-5652

Christina Freeman
Christina.Freeman@parks.ca.gov
(707) 769-5652
Jack London SHP
Sugarloaf Ridge SP
Trione-Annadel SP

CENTRAL VALLEY DISTRICT

District Office: (209) 536-5930

Andrew Collum
Andrew.Collum@parks.ca.gov
(209) 536-2658
Millerton Lake SRA

CHANNEL COAST DISTRICT

District Office: (805) 585-1850

Brooke Sheridan
Brooke.Sheridan@parks.ca.gov
(805) 585-1858
Gaviota SP
La Purisima Mission SHP

COLORADO DESERT DISTRICT

District Office: (760) 767-4037

Danny McCamish
[Danny. McCamish@parks.ca.gov](mailto:Danny.McCamish@parks.ca.gov)
(760) 767-3716
Anza-Borrego Desert SP
Cuyamaca Rancho SP

DIABLO RANGE DISTRICT

District Office: (925) 447-0426

Clinton Elsholz
Clinton.Elsholz@parks.ca.gov
(916) 705-3022
Wes Gray
Wes.Gray@parks.ca.gov
(831) 236-4546 (cell)
Mount Diablo SP

GREAT BASIN DISTRICT

District Office: (661) 724-1206

Christopher Hon
Christopher.Hon@parks.ca.gov
(661) 248-5719 (off)
(661) 753-7482 (cell)
Arthur B. Ripley Desert Woodland SP
Fort Tejon SHP
Red Rock Canyon SP
Saddleback Butte SP

INLAND EMPIRE DISTRICT

District Office: (951) 443-2423

Ken Kietzer
Ken.Kietzer@parks.ca.gov
(951) 453-4250
Chino Hills SP

MONTEREY DISTRICT

District Office: (831) 649-2836

Matthew Allen
Matthew.Allen@parks.ca.gov
(831) 649-2839
Carmel River SB
Julia Pfeiffer Burns SP
Moss Landing SB
Point Lobos SNR

NORTH COAST REDWOODS DISTRICT

District Office: (707) 445-6547

Amber Transou
Amber.Transou@parks.ca.gov
(707) 834-7675
Humboldt Redwoods SP
Jedediah Smith Redwoods SP
Tolowa Dunes SP

NORTHERN BUTTES DISTRICT

District Office: (530) 538-2200

Trish Ladd
Trish.Ladd@parks.ca.gov
(530) 538-2200
Anderson Marsh SHP
Bidwell-Sacramento River SP
Clear Lake SP

OCEANO DUNES DISTRICT

District Office: (805) 773-7170

Ronnie Glick
Ronnie.Glick@parks.ca.gov
(805) 365-5284
Oceano Dunes SVRA
Pismo SB

ORANGE COAST DISTRICT

District Office: (949) 492-0802

Riley Pratt
Riley.Pratt@parks.ca.gov
(949) 366-8532
(949) 324-9130 (cell)
Crystal Cove SP

SAN LUIS OBISPO COAST DISTRICT

District Office: (805) 927-2065

Katie Drexhage
Katie.Drexhage@parks.ca.gov
(805) 772-6322
Morro Bay SP

SANTA CRUZ DISTRICT

District Office: (831) 335-6318

Joanne Kerbavaz
Joanne.Kerbavaz@parks.ca.gov
(831) 335-6395 (off)
(650) 720-5007 (cell)
Big Basin Redwoods SP
Pescadero SB
The Forest of Nisene Marks SP

SONOMA-MENDOCINO COAST DISTRICT

Mendocino Sector Office: (707) 937-5804

Russian River Sector Office: (707) 865-2391

Brendan O'Neil
Brendan.O'Neil@parks.ca.gov
(707) 865-3129

Mendocino Sector
MacKerricher SP
Russian River Sector
Armstrong Redwoods SNR

APPLICATION AND PERMIT TO CONDUCT SCIENTIFIC RESEARCH AND COLLECTIONS

BIOLOGICAL GEOLOGICAL PALEONTOLOGICAL
 NEW RENEWAL

FOR DEPARTMENT USE ONLY	
APPLICATION NO.	DATE RECEIVED
21-820-18	12/11/2020
DISTRICT NAME	CEQA
NRD	N/A
PERMIT TYPE: <input checked="" type="checkbox"/> Biological <input type="checkbox"/> Geological / Soils	
<input type="checkbox"/> Paleontological <input type="checkbox"/> Other: _____	
<input type="checkbox"/> Summary Report Received	
<input type="checkbox"/> Insurance Required <input type="checkbox"/> Liability Waiver Required	

The Principal Investigator hereby applies to the Department of Parks and Recreation for a Permit under Title XIV, California Code of Regulations, Section 4309, and Public Resources Code Section 5097.5/5001.65, to conduct investigations on lands of the State of California.

Instructions: Applications must be TYPED and signed upon submission. If more space is needed, continue on separate sheet(s). Attach to your application: (1) a Curriculum Vitae (CV) or résumé for the Principal Investigator (and for the person(s) overseeing field work, if different from PI); (2) maps, coordinates, and/or GIS files indicating precise locations of proposed work; (3) a full study proposal; and (4) copies of any additional permits required for your research. Complete application packages should be sent to the district office that administers the park unit(s) where the research will take place, or to the Natural Resources Division, Sacramento, for multi-district requests. *At the request of the Department, you may be required to submit proof of insurance and/or obtain participant liability waivers.*

APPLICANT ORGANIZATION University of California, Berkeley, University and Jepson	PHONE NO. (Incl. Area Code) 510-642-3281
ORGANIZATION MAILING ADDRESS / CITY / STATE / ZIP CODE <small>University and Jepson Herbaria, University of California, Berkeley, 1001 Valley Life Sciences Building #2465, Berkeley, CA 94720-2465</small>	E-MAIL ADDRESS

PRINCIPAL INVESTIGATOR (PI) - ATTACH RÉSUMÉ OR CV (NOTE: Faculty advisor/sponsor must sign as PI for student applicants)

NAME Carl Rothfels	TITLE Dr.	CELL PHONE NO. (Incl. Area Code) 919-907-8744
MAILING ADDRESS / CITY / STATE / ZIP CODE <small>Department of Integrative Biology, University of California, Berkeley, University and Jepson Herbaria 1001 Valley Life Sciences Building #2465, Berkeley, CA 94720-2465</small>	E-MAIL ADDRESS crothfels@berkeley.edu	

PERSON IN DIRECT CHARGE OF FIELD WORK - ATTACH RÉSUMÉ OR CV IF DIFFERENT FROM PI

NAME Forrest Freund	TITLE Mr.	CELL PHONE NO. (Incl. Area Code) 415-497-9687
MAILING ADDRESS / CITY / STATE / ZIP CODE <small>Department of Integrative Biology, University of California, Berkeley, 3040 Valley Life Sciences Building #3140, Berkeley, CA 94720-2465</small>	E-MAIL ADDRESS lentic64@berkeley.edu	

ADDITIONAL PARTICIPANTS - ATTACH CONTINUATION SHEETS, IF NECESSARY

1	NAME Ixchel Sarahi González-Ramírez	TITLE Ms.	CELL PHONE NO. (Incl. Area Code) 510-326-3032
	MAILING ADDRESS / CITY / STATE / ZIP CODE same as above	E-MAIL ADDRESS ixchel_gonzalezrmz@berkeley.edu	
2	NAME Isaac Mark	TITLE Mr.	CELL PHONE NO. (Incl. Area Code)
	MAILING ADDRESS / CITY / STATE / ZIP CODE same as above	E-MAIL ADDRESS ilichtermarck@berkeley.edu	
3	NAME	TITLE	CELL PHONE NO. (Incl. Area Code)
	MAILING ADDRESS / CITY / STATE / ZIP CODE	E-MAIL ADDRESS	
4	NAME	TITLE	CELL PHONE NO. (Incl. Area Code)
	MAILING ADDRESS / CITY / STATE / ZIP CODE	E-MAIL ADDRESS	
5	NAME	TITLE	CELL PHONE NO. (Incl. Area Code)
	MAILING ADDRESS / CITY / STATE / ZIP CODE	E-MAIL ADDRESS	
6	NAME	TITLE	CELL PHONE NO. (Incl. Area Code)
	MAILING ADDRESS / CITY / STATE / ZIP CODE	E-MAIL ADDRESS	
7	NAME	TITLE	CELL PHONE NO. (Incl. Area Code)
	MAILING ADDRESS / CITY / STATE / ZIP CODE	E-MAIL ADDRESS	

STATE PARK UNIT(S) TO BE INCLUDED ON PERMIT	COUNTY(IES)
Azolla sp.: Jededia Smith Redwood SP, Tolawa Dunes SP, Humbold Redwoods SP, MacKerricher SP, Anderson Marsh State Historical Park, Bidwell-Sacramento River SP, Annadel SP, Jack London SP, Sugarloaf Ridge SP, Pescadero Marsh NP, Mississippi Bar SP, The Forest of Nisene Marks SP, Moss Island SWA, Carmel River SB, Pismo Dunes NP, La Purisima Mission SP, Gaviota SP, Malibu Creek SP, Chino Hills SP, Otay Open Space Preserve	Azolla sp.: Del Norte, Humboldt, Mendocino, Sonoma, Lake, Butte, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Los Angeles, Orange, San Bernardino, San Diego
Layia glandulosa: Oceano Dunes State Vehicular Recreation Area, Cuyamaca state ranch, Anza Borrego state park, Mt San Jacinto state park, Castaic lake state recreation center, La Purisima mission state park, Red rock state park, Hayden Hill Flat State Game Refuge, Pfeiffer big sur state park, Williams hill recreation area, Morro bay state park, Arthur B. Ripley Desert woodland state park, Saddleback Butte state park, Ft. Tejon state park	Layia glandulosa: San Luis Obispo, San Diego, Riverside, Los Angeles, Santa Barbara, Kern, Lassen, Monterey
Asterella: Anza Borego, Armstrong Redwoods, Boney Mountain, Border Field, Clear Lake, Crystal Cove, Millerton Lake, Mount Diablo, Point Lobos, Big Basin, Topanga	Asterella: San Diego, Imperial, Riverside, Sonoma, Ventura, Lake, Orange, Fresno, Madera, Contra Costa, Monterey, Santa Cruz, Los Angeles

1. PROJECT TITLE

California Conservation Genomics Project

2. PROJECT PURPOSE

This permit is meant to cover multiple projects within the Department of Integrative Biology that are part of the California Conservation Genomics Project. The CCGP aims to produce state-wide datasets for species of California native taxa to help inform conservation efforts and planning.

3. DESCRIPTION OF PROJECT LOCATION(S) (*Also attach maps, coordinates [projection required for the GPS coordinates], and/or GIS files for each distinct location.*)

For Paleontological permits: Provide Geological Formation

See attached documents.

4. METHOD OF ACCESS (*Describe methods [including type of vehicle] to be used for accessing study sites after arrival at the park unit(s).*)

Azolla - Drive along established roads with a Honda Civic. Access to collection sites will be made by parking at designated areas and hiking to the locality.

Layia glandulosa - Drive along established roads with a high clearance Toyota Tacoma or on foot along existing trails.

Asterella californica - Drive along established roads with BMW X3 and hiking to collection sites

5. SUMMARY OF FIELD METHODS AND ACTIVITIES

Azolla sp.: 5-10 small clumps will either be collected from the water or the mud around the water. Azolla tends to grow in large patches or floating colonies, so these collections will have no appreciable effect on the populations as a whole (see attached documents for full collecting protocol).

Layia glandulosa: We will locate seasonally blooming populations of the annual tarweed Layia glandulosa using the approximate locations of previously digitized herbarium specimens. We will search for viable populations along established roads/trails. When we discover a population in flower, we will follow best practices to collect data for molecular phylogenetic and community ecology study. Specifically, we will gather material for two herbarium vouchers of focal plants and associates by removing leaves, stems, and flowers, but not entire individual plants and drying them in a research grade plant press. We will only make specimens if the sampled plants constitute less than 5% of the population present at a given site. Leaf tissue will be preserved on silica dessicant for DNA analysis and herbarium specimens will be deposited in the Jepson herbarium where they will be preserved and digitized for public use in big data research on phenology and climate change in California plants.

Asterella californica: Collect small patches of thalus from the ground. 1-2 patches per site, but no more than 5% of total population

6. TYPES OF SPECIMENS TO BE COLLECTED (*List species, quantity, size, and condition.*)

Azolla filiculoides and A. microphylla - 5-10 small clumps will either be collected from the water or the mud around the water, but no more than 5% of the total population.

Layia glandulosa: 2 whole plants only if sampled plants would consistute less than 5% of the total population.

Asterella californica - 1-2 clumps of thalus will collected with no more than 5% of the total population taken from a given site.

7. EXPECTED DURATION OF THE PROJECT (*Specify overall project start and end dates and start and end dates of field investigations.*)

Feb 2021 - Dec 2022

8. PLACE AT WHICH LABORATORY WORK WILL BE PERFORMED (*Institution, address, and responsible official name, phone number, and e-mail address*)

Shaffer Lab, TLSB 4140

UC Los Angeles

610 Charles E Young Drive East

Los Angeles, CA 90095

310-825-3598

9. FACILITY THAT HAS AGREED TO CURATE SPECIMENS COLLECTED UNDER THIS PERMIT (*Institution, address, and responsible official name, phone number, and email address*)

University and Jepson Herbarium 1001 Valley Life Sciences Building #2465

Berkeley, CA 94720-2465

10. LOCATION OF DATA AND DATA PRODUCTS COLLECTED UNDER THIS PERMIT (*Specify institution name and/or website where data, maps, reports, GIS files, photos, and other data products (not specimens) will be archived after the project is completed.*)

Data will be distributed through the California Conservation Genomes Project.

NOTE: APPLICATION IS INCOMPLETE UNTIL SIGNED.

PERMIT TO CONDUCT SCIENTIFIC RESEARCH AND COLLECTIONS

ALL PARTICIPANTS MUST CARRY THIS PERMIT AT ALL TIMES WHILE CONDUCTING FIELD RESEARCH/COLLECTIONS.

The Department of Parks and Recreation desires to further scientific research within its jurisdiction through cooperation with researchers within the Department's mission to provide long-term protection and management of ecological processes and natural resource elements.

STANDARD CONDITIONS AND RESTRICTIONS

1. General classroom collection is not allowed under this permit.
2. This permit applies only to non-cultural materials, and is limited to the kind, number, and sizes of collections described on this form. Archeological material may NOT be collected under this permit.
3. "Collections" are defined as any material gathered during permitted activity. The collections shall be used for scientific or interpretive purposes only, and shall not be used for commercial purposes. Collections shall remain property of the Department. Curated collections shall be maintained by the Institution listed on page 3, item number 9. Collections should be accomplished by methods that conserve resources. Collections may be transferred to another location with prior written approval from the Department.
4. The collecting must be done away from roads, trails, and developed areas, unless such localities are specified in the permit. Collection shall be done in an inconspicuous manner, and shall not cause damage to the environment. The Department may impose permit-specific conditions (See page 6). Permit-specific conditions shall supersede any conflicting standard conditions and restrictions.
5. Activities conducted in areas designated as sensitive require prior surveys conducted by a State Park resource specialist, and/or a State Park resource specialist may be assigned to the project as a monitor. At the sole discretion of the Department, the Permittee may be required to schedule surveys and/or reserve a project monitor and reimburse the Department for the State Park resource specialist's time and expenses.
6. The Permittee shall submit a summary of information gathered to the applicable District where the investigation(s) took place, and to the Chief of the Natural Resources Division in Sacramento. The Permittee must also make available to the Department any material published as a result of this permit. Upon completion, a copy of such published material shall be submitted to: Natural Resources Division, Department of Parks and Recreation, PO Box 942896, Sacramento, CA 94296-0001.
7. The Permittee shall contact the appropriate District Superintendent (or designee) to receive district approval prior to proceeding with any field activities, and to present a copy of this permit, together with evidence of additional licenses and permits, if required.
8. All participants conducting activities approved by this permit shall inspect their shoes, clothing, vehicles, tools, and equipment for the presence of organic matter and soil, and if present, shall clean these items prior to entering and upon leaving the park to minimize potential spread of invasive species.
9. If permit activities are not carried out to the satisfaction of the Department, this permit may be immediately cancelled.
10. All applicable laws and regulations must be observed by participants in exercising the privileges granted in this permit. It is the responsibility of the Permittee to obtain any additional permits or approvals required for research/collection activities, and to know the boundaries and managing authority of specially designated protected areas or sanctuaries.
11. The Permittee, and all participants, are responsible for knowing and complying with all general rules and regulations for use of Department lands as well as any specific conditions or regulations for this permit and subject property.
12. Applicant Organization agrees to comply with the waiver and indemnity requirements found on page 5, incorporated by reference.
13. For activities presenting greater risk or liability, and at the sole discretion of the Department, Applicant Organization may be required to obtain and present sufficient proof of insurance and/or obtain signed liability waivers from all participants.
14. Questions regarding this permit should be directed to the District Superintendent or the Natural Resources Division's Research Permit Coordinator (multi-district).

I have read the Standard Conditions and Restrictions above and agree to comply with any additional special conditions. I certify under penalty of perjury that all information on this application (including attachments) is true, complete, and correct.

PRINCIPAL INVESTIGATOR'S SIGNATURE <small>(Faculty Sponsor must sign for student applicants)</small> ► 	PRINTED NAME Carl Rothfels	DATE 9-Dec-2020
STUDENT APPLICANT'S SIGNATURE (IF APPLICABLE) ►	PRINTED NAME	DATE

It is the responsibility of the Principal Investigator to ensure that all participants comply with all standard and special conditions. It is the responsibility of the Applicant Organization to meet indemnification and insurance requirements.

PERMIT TO CONDUCT SCIENTIFIC RESEARCH AND COLLECTIONS
WAIVER and INDEMNITY AGREEMENT

Waiver Agreement

Applicant Organization waives all claims and demands against the California Department of Parks and Recreation, its officers, agents, and/or employees for any and all loss, injury, death or damage caused by, arising out of, or in any way connected with this Permit, use of any access route to the Permit activities, or Applicant Organization's exercise of the rights granted by this Permit, except those arising out of the sole negligence or willful misconduct of the California Department of Parks and Recreation or its employees.

Indemnity Agreement

Applicant Organization hereby agrees to comply with the following (initial appropriate section) indemnity agreement:

Standard Applicant (select this section unless a Federal Applicant or University of California Applicant)

Applicant Organization agrees to be responsible for damages to persons or property caused by negligent acts or omissions of its employees acting within their scope of employment. Applicant Organization shall protect, save, hold harmless, indemnify, and defend the State, its officers, agents, and/or employees, from and against any and all loss, damage, claims, demands, liability, costs, recoveries, settlements, penalties, fines and expenses, including, without limitation, all legal fees, attorney fees, accounting fees, expert witness fees, consultant fees, interest and expenses related to the response to, settlement, and/or defense of any claims, legal actions, or liability, which may be suffered or incurred by the State, its officers, agents and/or employees, caused by, arising out of, or in any way connected with this Permit, use of any access route to the Permit activities, or Applicant's exercise of the rights granted by this Permit, except those arising out of the sole negligence or willful misconduct of the State. The obligations contained in this Section, including the waiver and indemnity obligations, shall survive termination of this Permit.

Federal Applicant

Federal Applicant agrees to be responsible for damages to persons or property caused by the negligent acts or omissions of Federal employees acting within the scope of their employment in accordance with the Federal Tort Claims Act, codified at 28 USC 2671 et seq. If found liable in a federal court of competent jurisdiction, the Federal Applicant agrees to pay attorneys' fees to the extent permitted under federal law. To the extent allowable by Federal law, Federal Applicant shall defend the State and its employees from claims arising from the permit activities, except those arising from the sole negligence or willful misconduct of the State or its employees.

X University of California Applicant

University of California Applicant agrees to be responsible for damages to persons or property caused by negligent acts or omissions of its employees acting within their scope of employment. THE REGENTS OF THE UNIVERSITY OF CALIFORNIA shall defend, indemnify and hold THE STATE OF CALIFORNIA AND ITS AGENCIES, their respective officers, employees and agents harmless from and against any and all liability, loss, expense, attorneys' fees, or claims for injury or damages arising out of the performance of this Agreement but only in proportion to and to the extent such liability, loss, expense, attorneys' fees, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions of THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, its officers, agents, or employees.

THE STATE OF CALIFORNIA shall defend, indemnify and hold THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, its officers, employees and agents harmless from and against any and all liability, loss, expense, attorneys' fees, or claims for injury or damages arising out of the performance of this Agreement but only in proportion to and to the extent such liability, loss, expense, attorneys' fees, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions of THE STATE OF CALIFORNIA OR ITS AGENCIES, their respective officers, agents, or employees. (1988 UC/DGS Agreement)

I hereby certify that I am a representative of Applicant Organization authorized to agree to the above indemnification requirements of this permit.

AUTHORIZED REPRESENTATIVE SIGNATURE ► 	PRINTED NAME Carl Rothfels	DATE 9-Dec-2020
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**PERMIT TO CONDUCT SCIENTIFIC RESEARCH AND COLLECTIONS
SPECIAL CONDITIONS**

See attached letter & conditions

FOR DEPARTMENT USE (REVIEW/APPROVAL)

REVIEWED BY	DISTRICT ENVIRONMENTAL SCIENTIST	DATE
► <i>N Rambhia</i>	Nita Barve	03/06/2021
REVIEWED BY	DISTRICT SUPERINTENDENT / MANAGER	DATE
► <i>D Schaub</i>	Dave Schaub	3/6/2021
DPR APPROVAL SIGNATURE*	PRINTED NAME / TITLE	DATE
► 	Senior Env. Scientist	3/6/2021
OTHER DPR APPROVAL SIGNATURE (OPTIONAL)*	PRINTED NAME / TITLE	DATE
► 		

*NOTE: If all park units in single DPR District, Superintendent has approval authority. For more than one DPR District, Natural Resources Division EPM must approve.

PERMIT VALID FROM: 03/06/21 TO: 03/06/22

Azolla:

Tolowa Dunes SP – In slack water of Yontocket Slough
Jedediah Smith Redwood SP – In areas of slow flowing water
Humboldt Redwoods SP – Areas of slow flowing or still water along the Eel River.
MacKerricher SP – Along the edge of Lake Cleone
Anderson Marsh State Historical Park – In still water near Clear Lake Campground
Bidwell-Sacramento River SP – Large pond near junction of River Road and W. Sacramento Ave.
Anadel SP – Ledson marsh and Lake Ilsanjo, as well as creeks
Jack London SP – Plants floating along the edge of Fern lake and pond near junction of Mountain Trail / Upper Lake Trail
Sugarloaf Ridge SP – Ponds along Pierson Road.
Pescadero Marsh NP – Ponds and riparian areas near the nature trails.
Mississippi Bar SP – Marshy area in the south-west corner of the park near the American River bike trail.
The Forest of Nisene Marks SP – In Aptos Creek.
Moss Island SWA – Waterways and ponds off Elkhorn Slough
Carmel River State Beach – waterway and tributaries near the north parkinglot.
Pismo Dunes NP – Oso Falco Lake and adjacent ponds
Gaviota SP – Waterway near the parking lot
Malibu Creek SP – Waterbodies near Crags Rd.
Chino Hills SP – Standing water in creeks
Cuyamaca Rancho SP – Slow portions of the Sweetwater River and standing ponds
Otay Open Space Preserve – Along edge of Otay Reservoir and in slow portions of Otay creek.

Layia glandulosa:

Oceano Dunes State Vehicular Recreation Area - Locality:
1. United States, California, San Luis Obispo, sand-flats at Jack Lake 35.038587 -120.603782 +-490m.

Cuyamaco state ranch - Localities:

1. Near intersection of upper Green Valley Fire Road and Stonewall Grade, Cuyamaca Rancho State Park
32.94054 -116.55333 +-402m. WGS84
2. United States, California, San Diego, West slope of South Peak, Cuyamaca.
32.97959 -116.60912 +-1207m.
3. United States, California, San Diego, Northwest slope of Cuyamaca Peak.
32.96667 -116.61667 +-402m.

Anza Borrego state park

1. Locality: United States, California, San Diego, Anza-Borrego Desert State Park; east of Ranchita; South Fork Hellhole Canyon; 6.05 air miles SW of Borrego Springs; 0.82 air mile NW of intersection of County Highway S-22 and Culp Valley Campground/ Pena Spring Primitive Road.
33.22508 -116.47176
2. United States, California, San Diego, Anza Borrego Desert State Park: vicinity of Whale Peak; south of Pinyon Mountain Valley Road; vicinity of campsite and informal trailhead to top of mountain
33.04689 -116.33308 WGS84

Mt San jacinto state park

1.Locality: United States, California, Riverside, Strawberry valley; San Jacinto River
33.74553 -116.71441 +-8047m. WGS84

Castaic lake state recreation center

1. Locality: United States, California, Los Angeles, Liebre Mountains, slopes between Leona Valley and 'Lost Valley'.
34.6083333 -118.325
2. Locality: United States, California, Los Angeles, Antelope Valley, Munz Canyon Road, near Elizabeth Lake
34.66222 -118.42194
3. Locality: United States, California, Los Angeles, Liebre Mountains region: Knapp Ranch area at upper end of Castaic Creek drainage in broad alluvial valley at head of Cienaga Canyon, south of Liebre Mountain.
34.6871667 -118.6622778
4. Locality: United States, California, Los Angeles, Liebre Mountains, upper West Fork Liebre Gulch along spur leading off along steep ridgeline west of Angeles National Forest Road 8N01, at a point 7.0 road miles from jtn with 8N05.
34.7455556 -118.7633333

la Purisima mission state park

1. Locality: United States, California, Santa Barbara, Purisima Hills: near Mission La Purisima
34.6744 -120.4235 +-2250m.

Red rock state park

1. Locality: United States, California, Kern, Red Rock Cyn
35.364 -117.983 +-2000m.

Hayden hill flat state game refuge

1. Locality: United States, California, Lassen, Dixey Mts.
40.91805 -121.09207 +-5646m.

Williams hill state recreation area

1. Locality: United States, California, Monterey, San Antonio Hills, Lockwood-San Ardo Rd
35.986 -121.003 +-5m. NAD83

Morro bay state park

1. Locality: United States, California, San Luis Obispo, 4 mi s Morro; Cayucos Quad., Coastal Sands
35.304369 -120.873548 +-2000m.

-Arthur B. Ripley Desert woodland state park, along the main trail off lancaster road

-Saddleback Butte state park, in the low joshua tree woodland on the trail to the top of Saddleback butte

-Ft. Tejon state park, Along the fire road above the Tejon ranch building.

California Conservation Genomics of the *Azolla* symbiosis
Rothfels, UC Berkeley

1. Synopsis:

Azolla is a genus of tiny freshwater ferns with obligate, endosymbiotic nitrogen-fixing cyanobacteria, which has extraordinary economic potential in biofertilizer technology, phytoremediation, carbon sequestration, and as a biofuel (Brouwer et al. 2014). In addition, introduced species of *Azolla* rank among the globe's most ecologically noxious weeds, while other species are potentially of conservation concern. *Azolla* is also of great importance for evolutionary biology due the insights it provides into the origins and consequences of heterospory, and its potential as a model system for studying the evolution of symbioses and organelles.

We have a strong interest in the patterns of variation in *Azolla* in California, where up to five described species (*A. caroliniana*, *A.filiculoides*, *A.mexicana*, *A.microphylla*, and *A.rubra*) and at least one additional undescribed species may co-occur (Rothfels and Li, unpublished), some potentially as introductions, and others as rare natives.

We are interested in the spatial variation of this diversity within California at three levels:

1. The species/taxonomic level (which species are present, how can they be distinguished, what are their distributions and abundances);
2. The population genomics level (where are centers of genomic diversity, what are the patterns of connectivity, are particular populations or lineages—of either the natives or the invasives—genomically depauperate);
3. And at the level of the microbiome (do patterns of microbial variation mirror those of the host, do invasive *Azolla* have distinct microbiomes that might explain their ecological success).

For each population sampled for CCGP, we will photo-document a set of plants with a standardized protocol (to capture whole-organism morphology), fix samples for micromorphological characterization (SEM), preserve samples for microbiome isolation and sequencing, and silica-dry material, in addition to taking a herbarium voucher.

We will thus be able to synthesize the CCGP results with comparable morphological and microbiome datasets to produce a broad multi-level picture of *Azolla* diversity within California.

2. Proposed target species:

Azolla has an extremely small genome for a fern, providing an unique opportunity to get deep resequencing data for a broad sample of accessions, an enterprise that would be cost-prohibitive for other fern species. From the perspective of the CCGP it is ecologically complementary to other proposed samples, being a freshwater aquatic that is widely distributed across the state, including in the Central Valley. Furthermore, as a member of the sister lineage to vascular plants *Azolla* helps address a major phylogenetic in the CCGP sample.

Azolla also helps address a functional-ecology gap central to the CCGP. Specifically, the *Azolla* dispersal unit is a haploid spore, and both their fertilization and dispersal are abiotically-

mediated (there are no biotic intermediates, such as animal pollinators or dispersers). In addition to their reliance on abiotically-mediated fertilization and dispersal, free-sporing vascular plants differ from seedplants in fundamental characteristics of their life cycles: in these plants both “generations” (the diploid sporophyte and the haploid gametophyte) are free-living, multicellular, and sessile—they unable to remove themselves from unfavorable environmental and must be able to tolerate those conditions as a fully-functional organism in both the diploid and haploid states. As a result, genetic diversity across the landscape is more closely coupled with climate and microsite in these lineages, making them ideal models for landscape genomics.

Azolla species are important for conservation planning both as potential invasives that need monitoring and control, and as rare natives that warrant conservation attention. More generally, as species of freshwater habitats, they are important as indicators of the health of these ecosystems, which are under particular pressure in water-conscious California. *Azolla* in California are usually treated in *A. filiculoides* and *A. microphylla*, but this treatment is likely inadequate; we will target all *Azolla* in California.

Table 1: Target Species

Class	Order	Family	Species
Polypodiopsida	Salviniales	Salviniaceae	<i>Azolla filiculoides</i>
Polypodiopsida	Salviniales	Salviniaceae	<i>Azolla microphylla</i> s.l.

3. *Sampling design:*

We will sample across the species’ range in California, which spans 11 of the 19 ecoregions (see the Species Page). As a genus of freshwater aquatics, *Azolla* will help fill in geographic gaps in the otherwise predominantly terrestrial sample of CCGP taxa, including strong representation in the Central Valley.

4. *Preferred research approach:*

We will provide high-quality DNA extractions (each documented with a herbarium voucher and linked to other research materials, as described in the Synopsis) of wild-collected samples collected during dedicated CCGP fieldwork. These samples will be submitted to the UCLA core facility, for library prep. under the CCGP protocol.

The primary research goal is for these data to be integrated into the CCGP’s broad synthesis of genomic diversity across California. In addition, Carl Rothfels, Fay-Wei Li, and Michael Song intend to produce a related manuscript characterizing the spatial patterns of microbiome variation, and synthesizing those with the patterns inferred for the host. Depending on preliminary results, we may also characterize *Azolla* morphology (including SEM imaging), and perform morphometric analyses, with the goal of providing end-users (conservation managers, botanical professionals, etc.) with a useable resource for identifying the Californian *Azolla* species in the field.

5. ***Research Team:***

Table 2: Research Team

Member	Current title	Affiliation	Role
Dr. Carl Rothfels	Curator of Ferns and Lycophytes at UC/JEPS, Assistant Prof. Integrative Biology	UC Berkeley	PI
Dr. Fay-Wei Li	Assistant Professor	Boyce Thompson Institute	PI
Michael Song	PhD Candidate	UC Berkeley	team member
Forrest Freund	PhD Candidate	UC Berkeley	team member

Carl Rothfels will coordinate sample acquisition and associated project logistics (including supervising and mentoring the graduate student research assistant). Fay-Wei Li will advise on sampling priorities, and guide subsequent taxon-specific publications resulting from these data. Michael Song will focus on microbiome analysis, and Forrest Freund will be responsible for fieldwork and DNA extractions.

6. ***Budget:***

Table 3: Budget

	Activity	Cost
1. Field work		
Transportation		\$2400
Food		\$900
Camping		\$700
Total requested for field work		\$4000
2. Bench work		
CTAB extractions (x150)		\$200
Library prep. (\$30 x 150)		\$4500
Sequencing (.75Gb x 10x x \$7/Gb x 150 at 70% efficiency)		\$11235
Total requested for bench work		\$15935
3. Personnel		
One semester GSR		\$22086
Total requested for personnel		\$22086
4. Incidentals		
Incidentals for field research		\$400
Incidentals for lab research		\$340
Total requested for incidentals		\$740
 Total requested		\$42,761

Budget justification:

1. Field work

The requested fieldwork budget will cover ~4200 miles of travel to allow sampling throughout the distribution of *Azolla* species at the standard UC mileage rate. We will use personal vehicles for land travel.

2. Bench work and sequencing

Extractions will be conducted in the Rothfels lab in the Department of Integrative Biology at UCB. Library prep. expenses (\$30 each) are based on the UCLA core facility's CCGP rate. The sequencing estimate is based on 10x coverage, a .75 Gb genome size, and a conservative estimate of 70% efficiency (we expect approx. 25% of the reads to be from the microbiome rather than from the *Azolla*; F.-W. Li, pers. comm.).

3. Personnel

Funds are requested for a one-semester graduate student researcher (GSR). The GSR will perform the field and labwork.

4. Incidentals

Requested funds for incidentals for fieldwork include materials for collecting leaf tissue for DNA analysis, such as vials and silica desiccant, as well as materials for collecting herbarium vouchers. Vouchers will be deposited in UC/JEPS. Requested funds for incidentals for lab work will be used for miscellaneous but essential lab items, such as tips, gloves, tubes, and beads for grinding, as well as additional reagents required for DNA extraction.

Species Page:

1. Species: The *Azolla* diversity that occurs in California is often treated under two species, but this classification likely under-represents the true number of species present (Smith and Murdock 2012).

Common Mosquito Fern. *Azolla filiculoides* Lam.

Mexican Mosquito Fern. *Azolla microphylla* Kaulf.

2. Genome size and brief description of available genomic resources: *Azolla filiculoides* is the first fern to have its genome sequenced (0.75 Gb; Li et al. 2018) with genomic resources available at <https://www.fernbase.org/> including a genome sequence from *Salvinia cucullata*, a member of its sister genus.

3. Known range of *Azolla* in California encompasses 11 Ecoregions: Central California Coast; Central Valley Coast Ranges; Great Valley; Mojave Desert; Mono; Northern California Coast; Northern California Coast Ranges; Sierra Nevada; Sierra Nevada Foothills; Southern California Coast; Southern California Mountains and Valleys.

4. Researchers' experience: Carl Rothfels is the Curator of Ferns and Lycophytes at UC/JEPS, and has extensive experience researching the biology and evolution of ferns and lycophytes. Michael Song is working on microbiome biology for his dissertation and has experience with both field collections and genomics. Forrest Freund has extensive experience with Californian fieldwork and DNA extraction/sequencing. Fay-Wei Li is an expert on fern genomics, and led the project to sequence the *Azolla* genome.

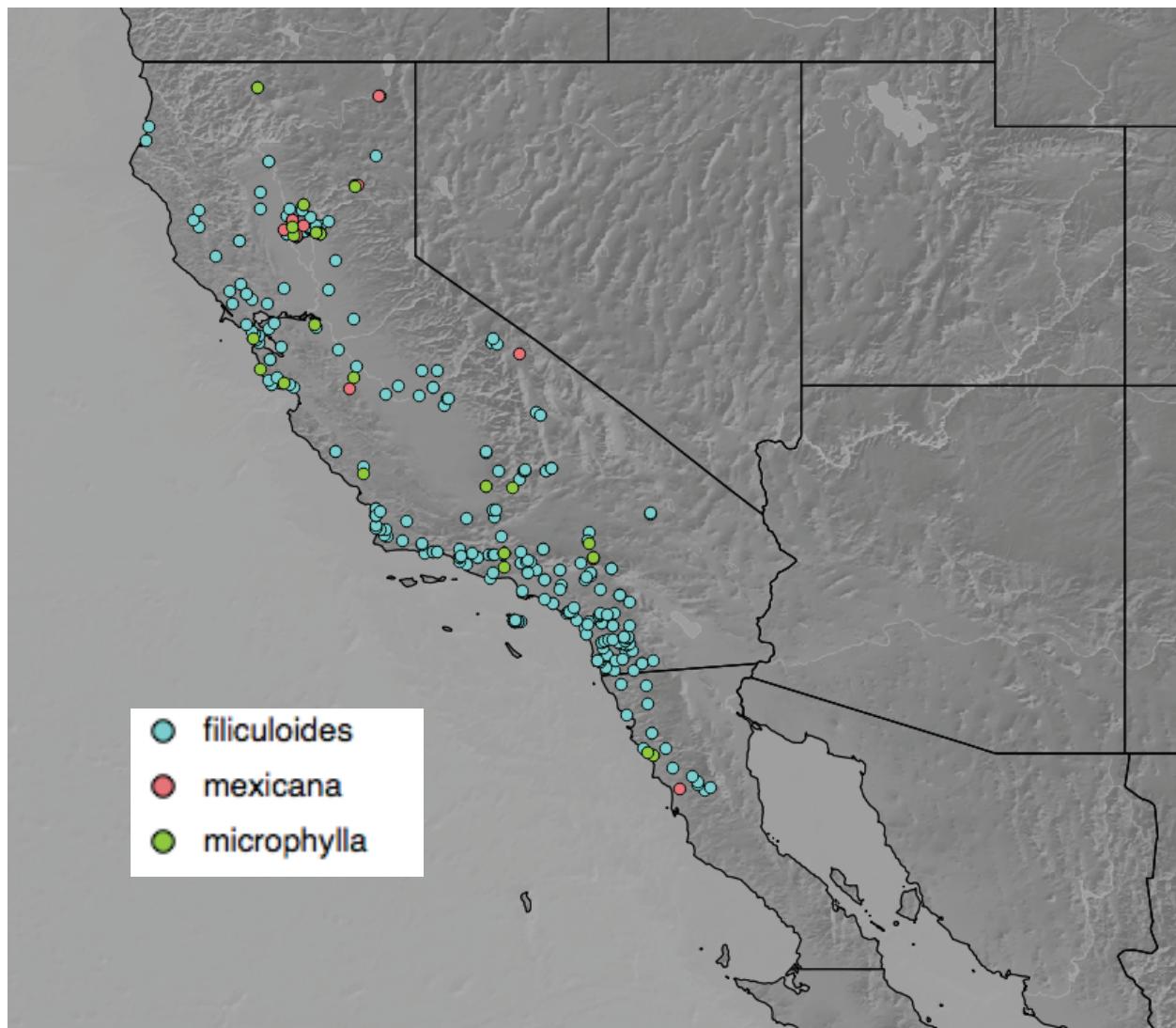
5. Samples in hand and anticipated: See attached template.

6. Anticipated sampling design: Sampling will be approximately uniform across the California range of *Azolla*; see attached Excel file.

7. Timeline for sample acquisition: The sampling will be completed by fall 2021.

8. Special considerations: No special considerations are necessary.

9. Realistic timeline for benchwork and fieldwork: Fieldwork and benchwork (extractions, quantification) will be completed by fall 2021. Fieldwork will be concentrated in the Spring 2021 semester, with the potential for summer fieldwork to fill in any gaps. Extractions will be completed during the summer, too.



Geographic range of *Azolla* species in California. Points indicate collections available through the Consortium of California Herbaria.

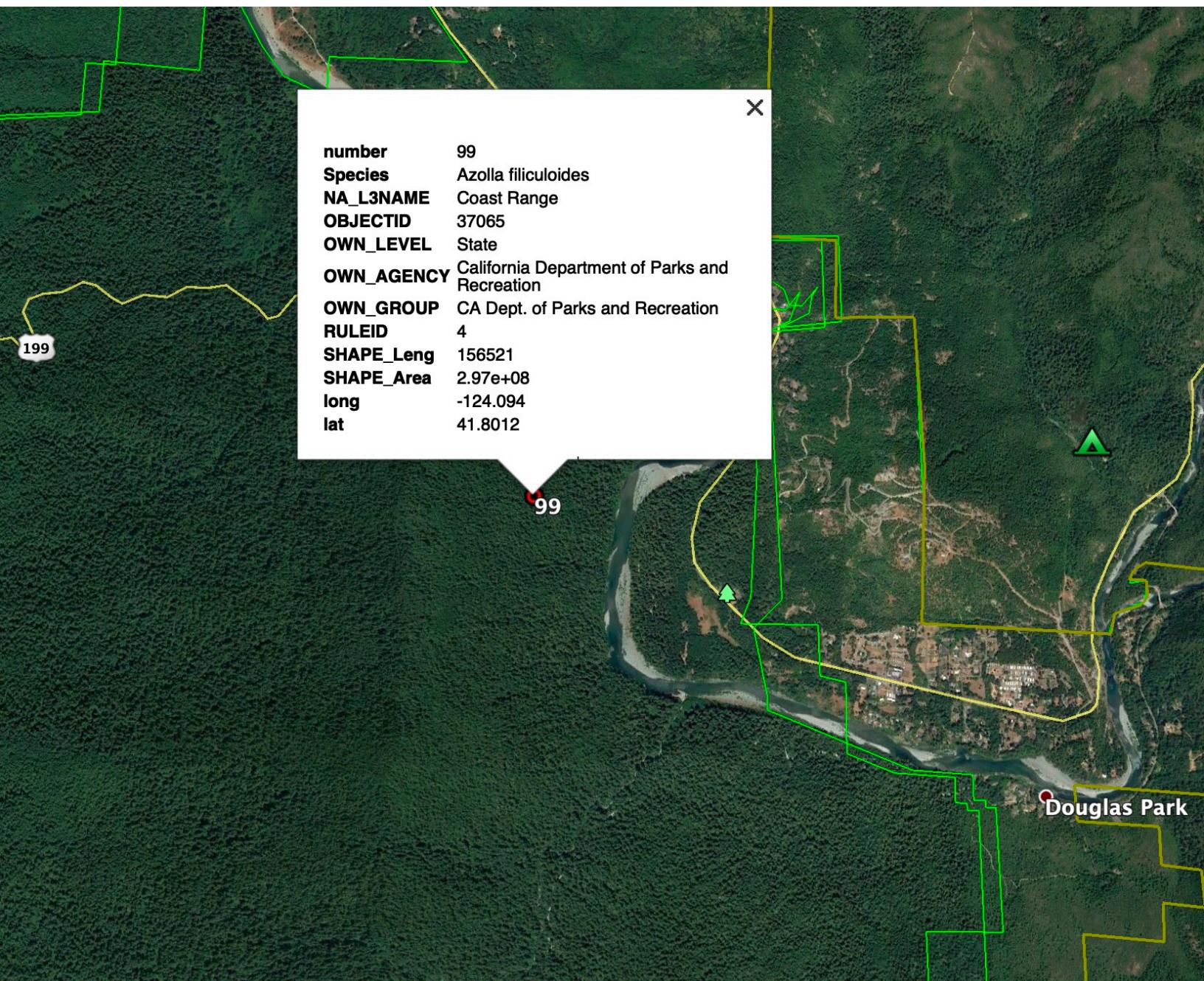
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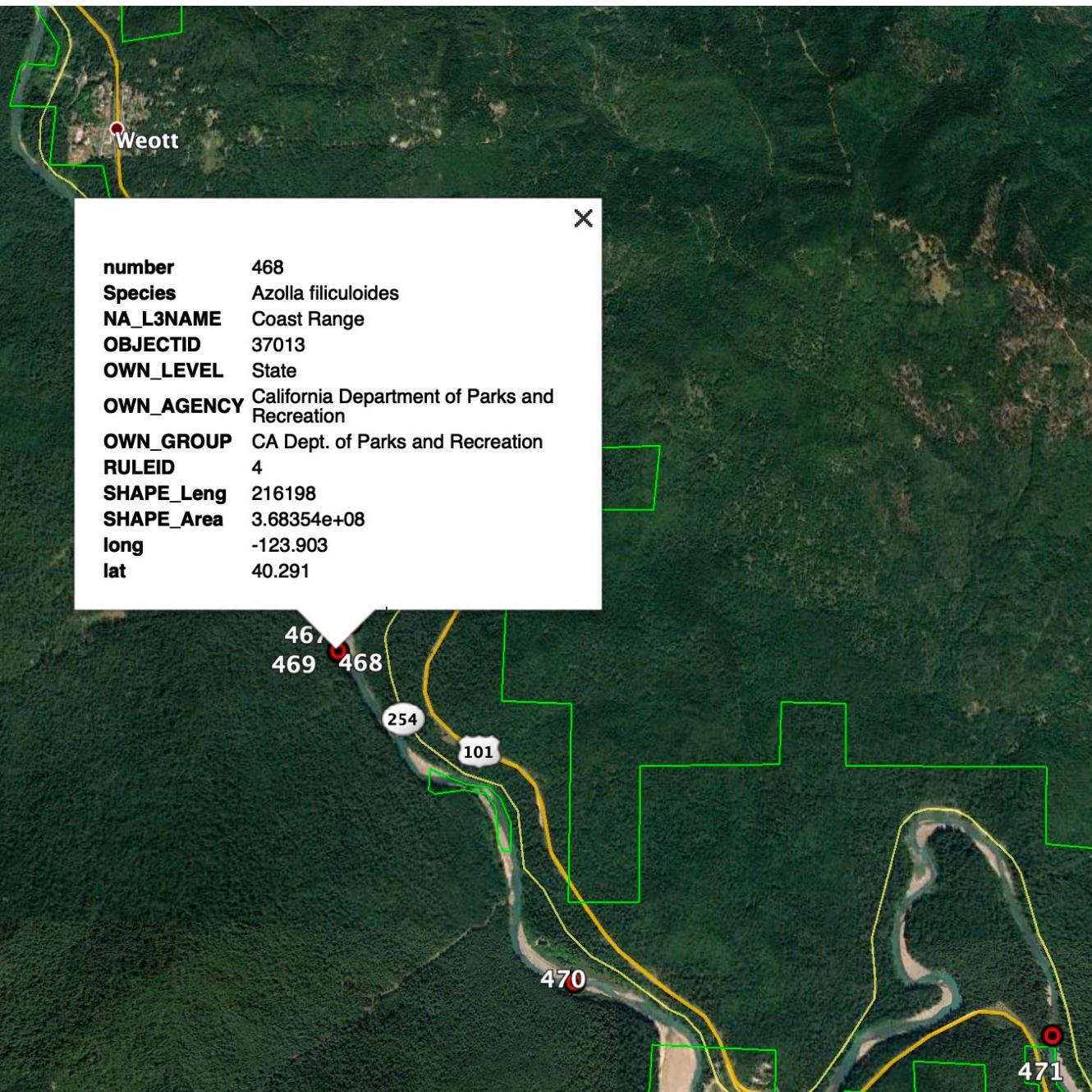
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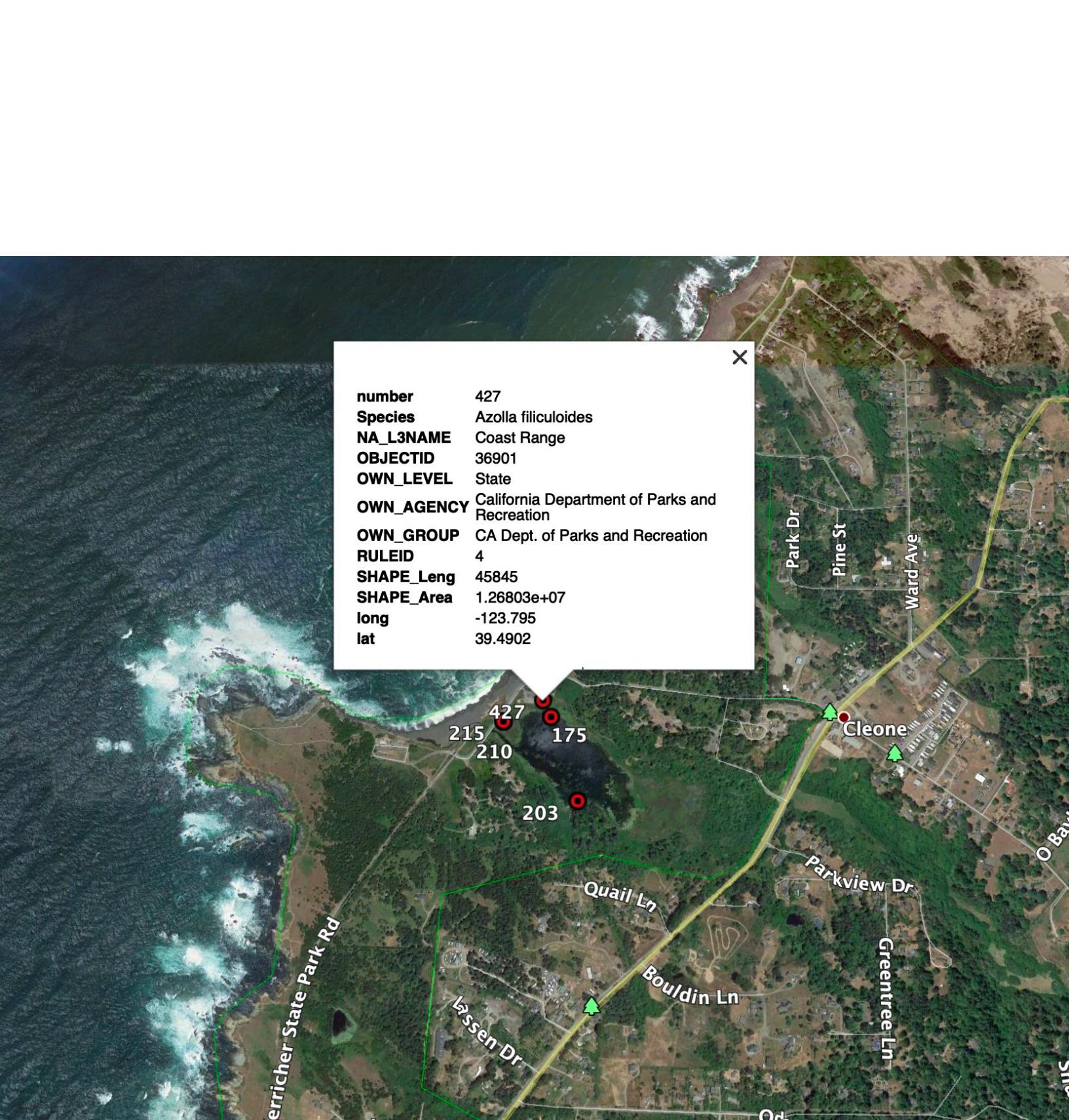


number 109
Species Azolla filiculoides
NA_L3NAME Coast Range
OBJECTID 37071
OWN_LEVEL State
OWN_AGENCY California Department of Parks and Recreation
OWN_GROUP CA Dept. of Parks and Recreation
RULEID 4
SHAPE_Leng 22822.2
SHAPE_Area 1.52568e+07
long -124.197
lat 41.9084

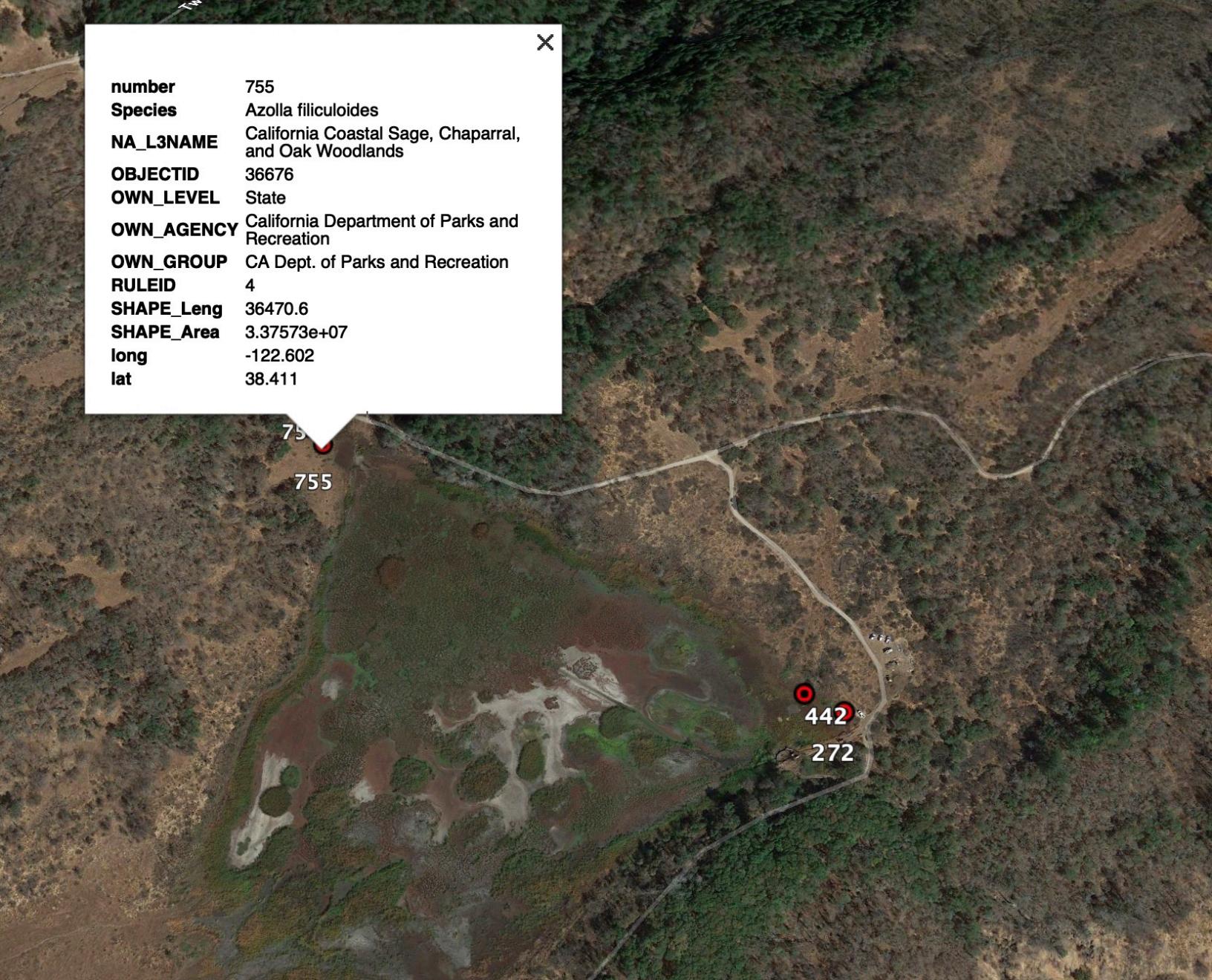
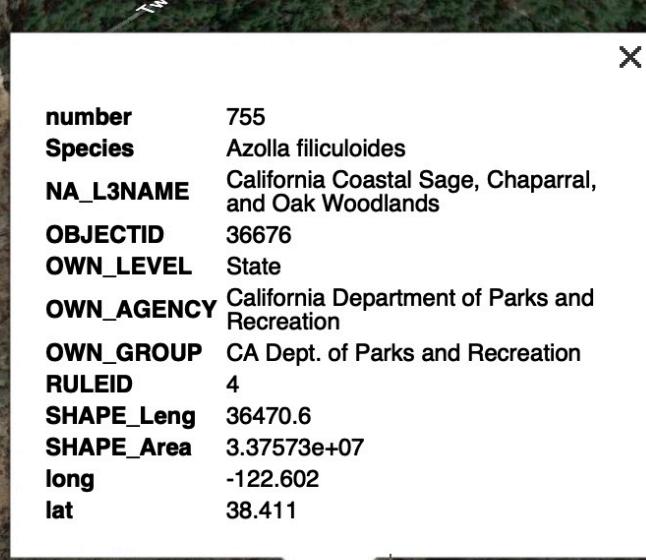
 109
Yontocket













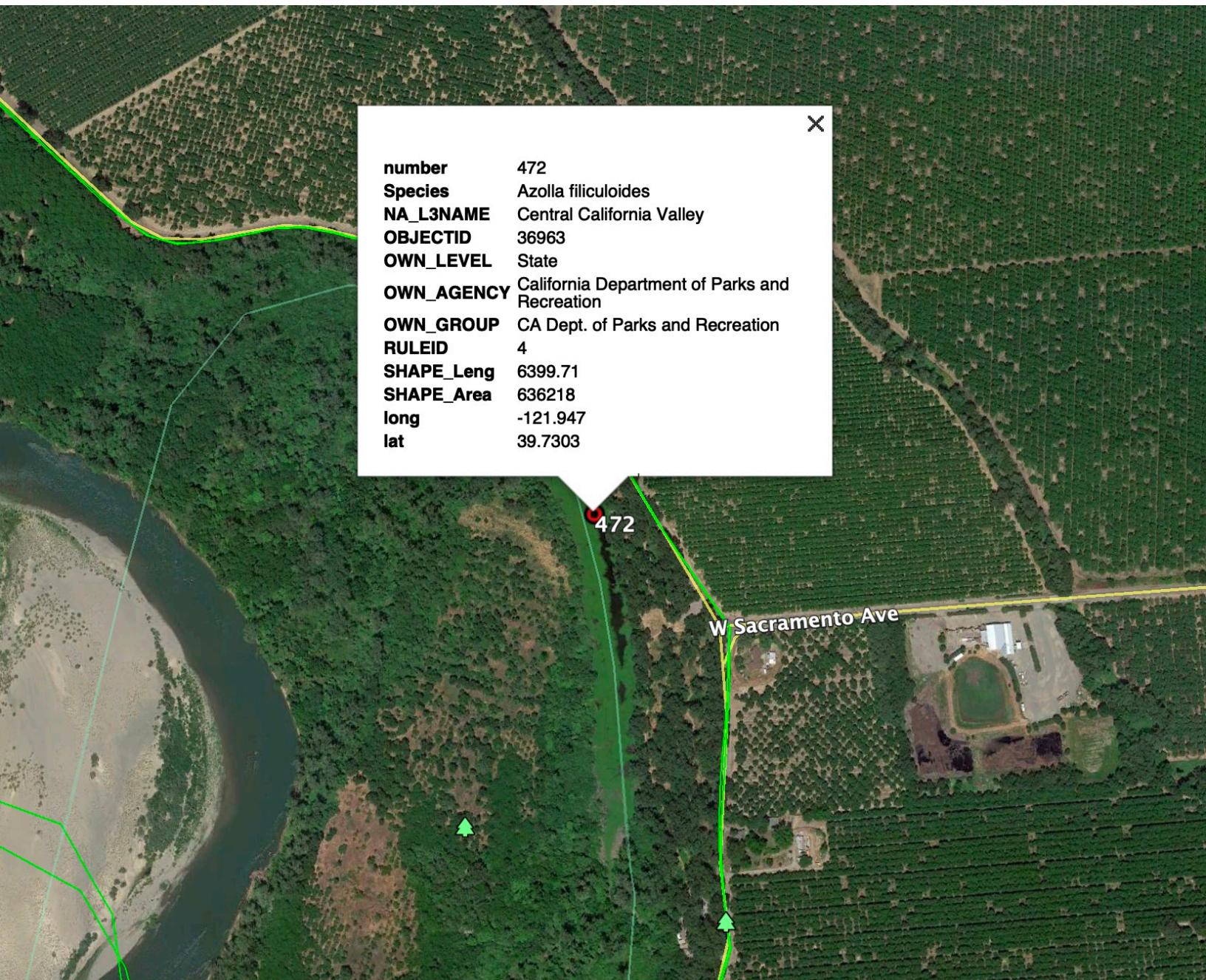
Untitled Placemark

Lat: 38°25'49.70"N
Long: 122°37'49.92"W

Directions: [To here](#) - [From here](#)

Untitled Placemark

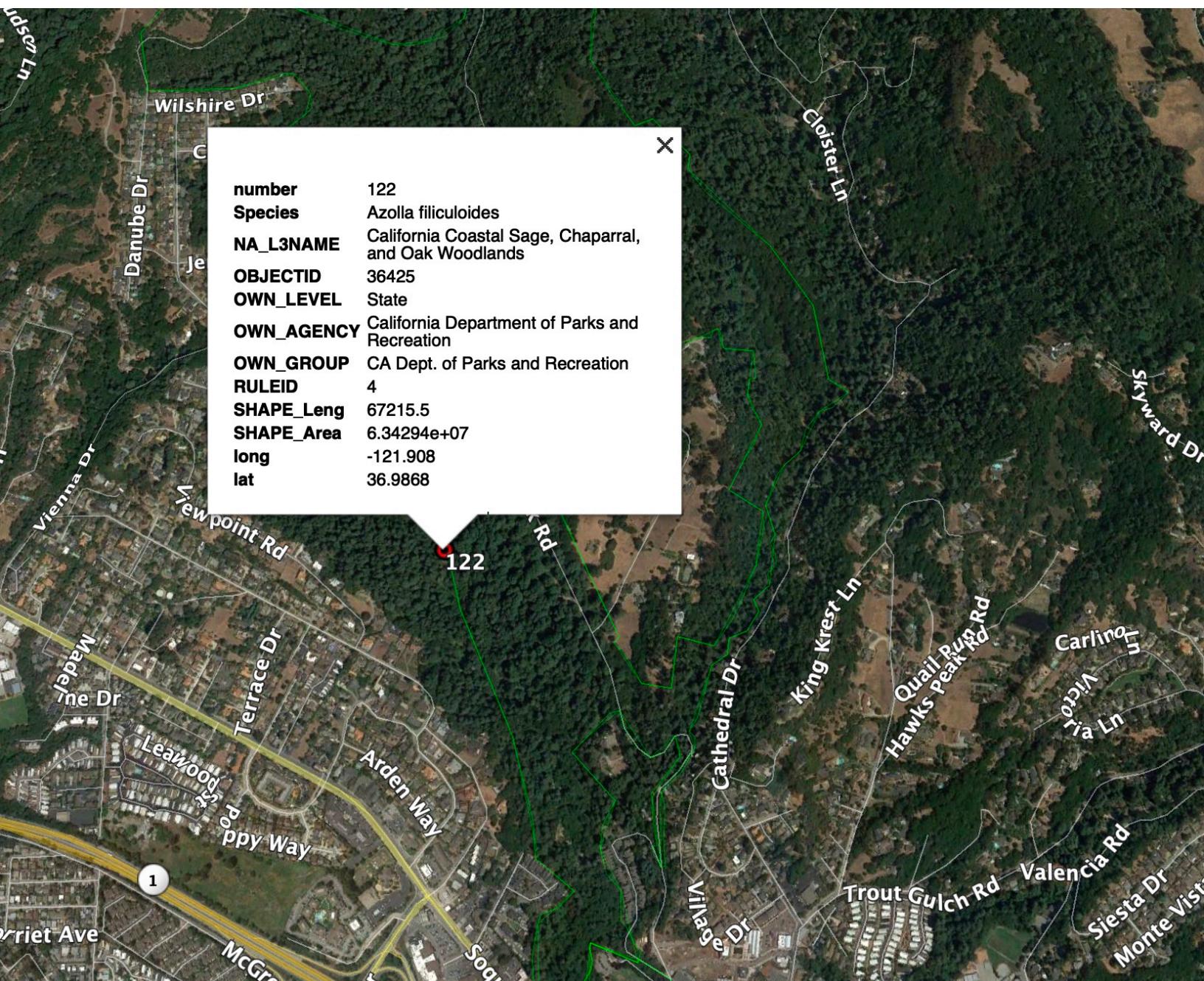






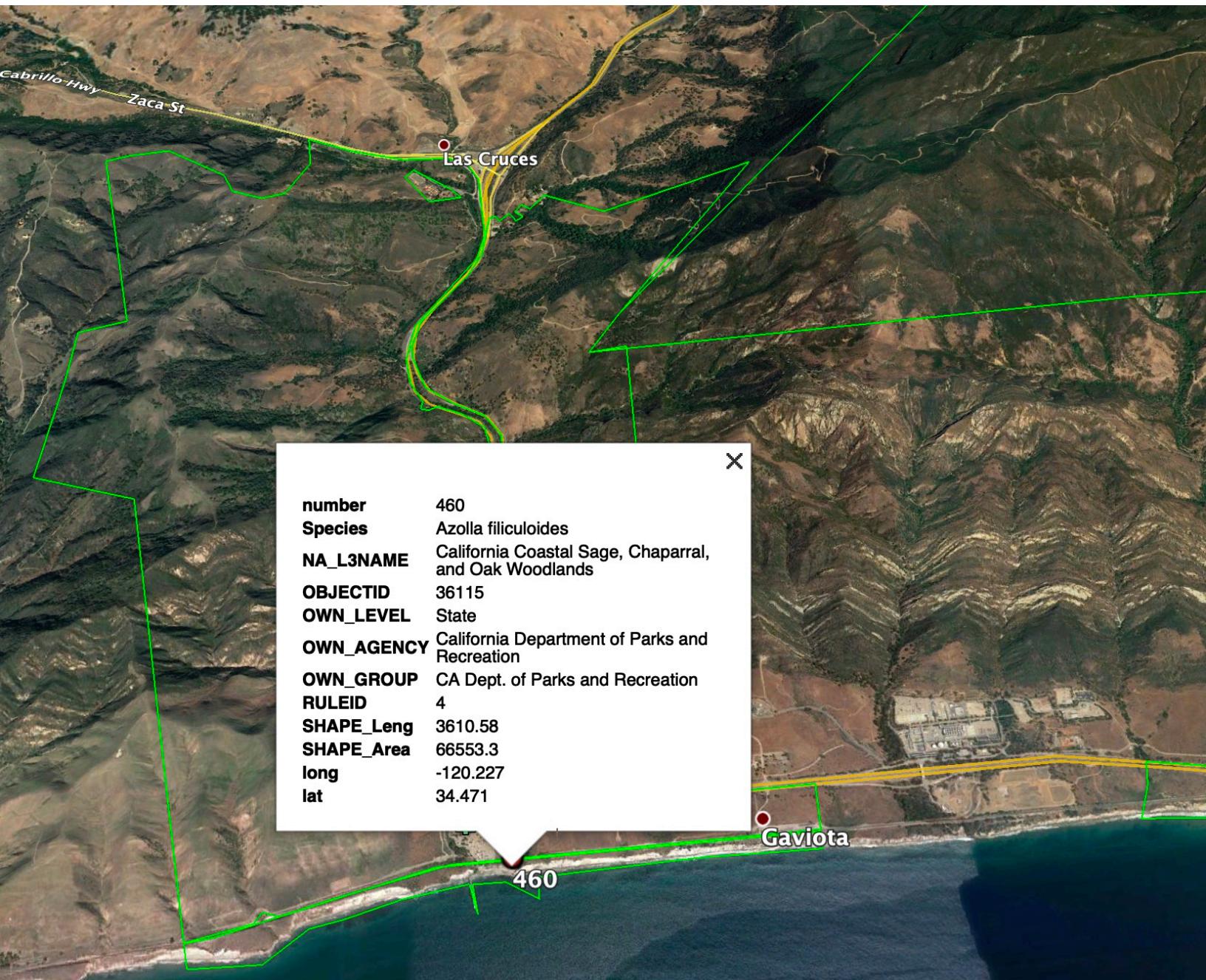
Aerial map showing a green polygon outline and a red dot labeled '5' indicating a specific location. A white callout box displays detailed data for this location.

number	5
Species	Azolla filiculoides
NA_L3NAME	Coast Range
OBJECTID	36456
OWN_LEVEL	State
OWN_AGENCY	California Department of Parks and Recreation
OWN_GROUP	CA Dept. of Parks and Recreation
RULEID	4
SHAPE_Leng	10224.3
SHAPE_Area	3.88088e+06
long	-122.397
lat	37.2581



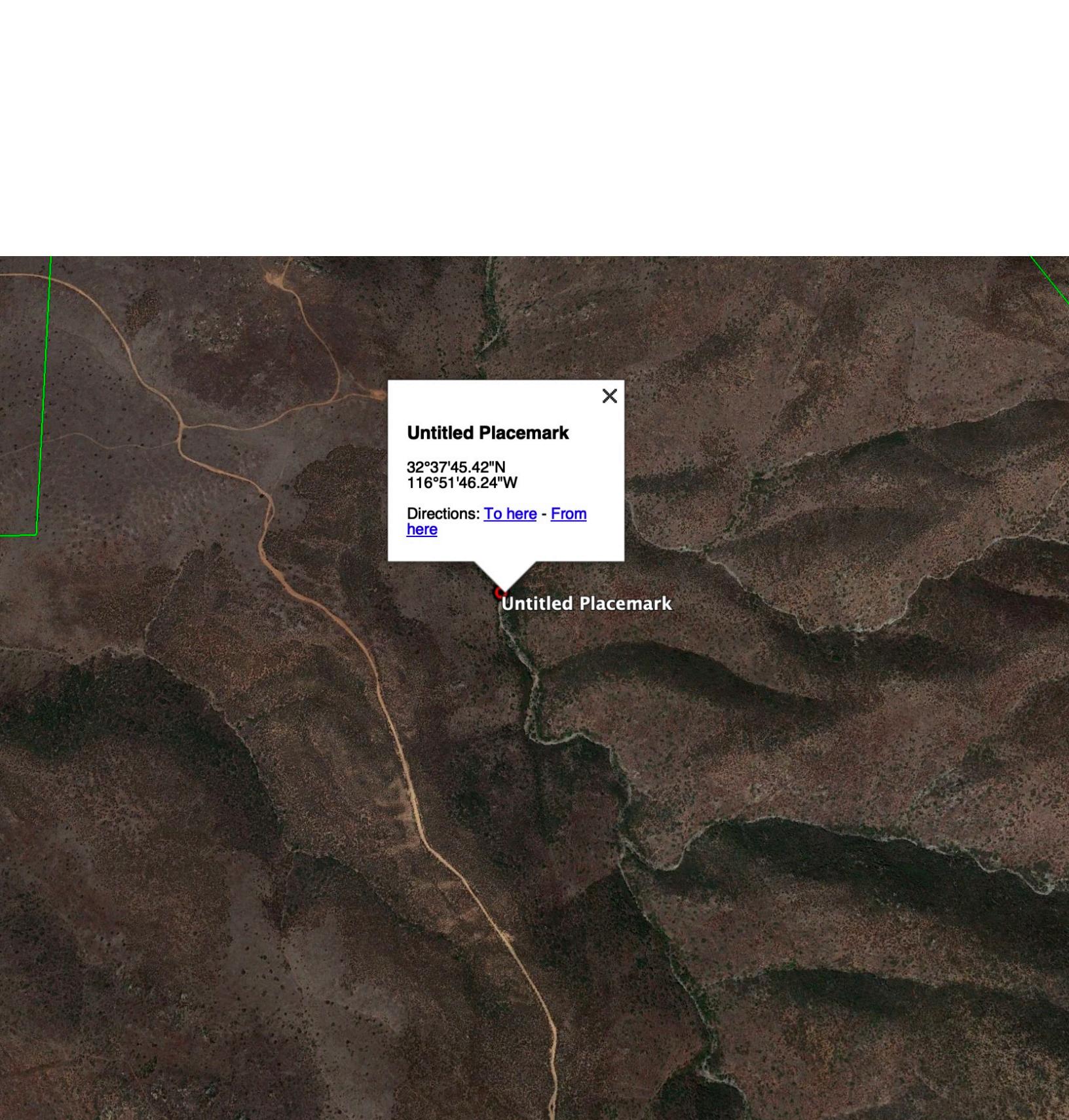












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32°37'45.42"N
116°51'46.24"W

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California Conservation Genomics Project

Genetic diversity patterns of an endemic liverwort: *Asterella californica*

Brent Mishler, University and Jepson Herbaria
Integrative Biology; UC Berkeley

Project Description:

Synopsis:

Liverworts are one of the three lineages of bryophytes. These plants have been understudied in comparison to vascular plants (ferns, lycophytes, and seed plants). Nevertheless, liverworts are a very important component of the flora worldwide, occupying a wide variety of niches, from epiphytes in humid forests, to biocrusts in deserts.¹ They also have a very important role in nutrient and water cycling.² Liverwort biology is different than the biology of the rest of the plants. Their unique physiology and ecology represent a unique evolutionary solution for being a land plant. They have unique morphological characteristics and chemical compounds that are not found in any other lineages³.

Bryophytes are highly threatened by both climate change and habitat loss.^{4,5} Compared to other plants, they are more sensitive to increases in temperature and pollutant concentration.^{6,7} Due to the differences in life cycle, physiology, ecology, and geographic distribution pattern between bryophytes and the rest of land plants, it is likely that bryophytes will differ in their response to the current climate crisis. Furthermore, it is unclear if current conservation efforts, primarily based on flowering plants and animals, are effective for bryophyte conservation. Therefore, production of basic knowledge of bryophyte biology is key for improving our understanding about the implications of climate change in this group and the ecosystems they inhabit.

The objective of this study is to produce population-level genetic information for *Asterella californica* (Hampe) Underw. to understand its phylogenetic diversity across its distribution range. By looking for differences across ecosystems we will be able to infer relationships between *A. californica* and the environments it occupies, as well as examine adaptive hypothesis. Furthermore, having a reference genome will promote the study of members of the whole Aytoniaceae.

Proposed target species:

The focal species of this project is *Asterella californica*. This species is restricted to the west coast of North America: almost exclusively to California, with some populations extending to Oregon, Arizona and Baja California. Current phylogenetic evidence suggests that the genus *Asterella* is not monophyletic, and *A. californica* appears to be sister to the other species of *Asterella* plus other genera in the Aytoniaceae family, meaning that it is on a long phylogenetic branch, perhaps a paleoendemic, and that it will be soon moved to its own genus.

It has been hypothesized that liverworts have high dispersal abilities,⁸ allowing wider distributions as compared to vascular plants. However, this pattern is not true for *A. californica*, which is unusual for a liverwort in having its range limited to a narrow geographic region. It thus offers an opportunity to study correlations of environment, functional traits, and genetics across the complete range of a liverwort species. By incorporating *A. californica* in CCGP, the program

will add an account of phylogenetic diversity patterns in an understudied, diverse branch of the tree of life, that is nevertheless important in ecosystem function.

Liverworts have not yet been considered in state and federal conservation plans and management programs. Conservation efforts are incomplete without considering such a distinct and diverse lineage as liverworts. Due to all the biological differences between liverworts and the rest of land plants there are reasons to think that they would respond differently to climate change. Furthermore, little is known about the genetic structure of liverwort populations, thus the study of *A. californica* would be one of the first attempts to understand the genetic structure of a liverwort species across its full geographical range. *Asterella californica* will thus make a great start at adding liverworts to the conservation discussion in California.

Table 1. Species to be sampled

Species
<i>Asterella californica</i>

Sampling design:

The sampling will be focused on representing the overall distribution of the focal species, *Asterella californica*, across its range. Most sampling will be in California, but we will include representative populations from SW Oregon, Arizona, and Baja California. *A. californica* is mainly distributed along the Coastal Ranges (Southern and Northern California Coast and coastal ranges USDA ecoregions) but extends towards the interior in the Great Valley and the Sierra Nevada (Great Valley, Sierra Nevada and Sierra Nevada foothills USDA Ecoregions). The sampling will take into account populations extending to Oregon in the Klamath Mountains ecoregion and South to Baja in the Southern California Mountains ecoregion. By sampling across the range of the species we will be able to assess the correlation of highly variable environmental variables on the genetic diversity of the species, testing for local adaptation patterns and working to gain enough resolution to test for biogeographic history. Understanding the role that macro-environmental variables play in the genetic diversity of this clade of plants is essential to understand the population dynamics of these highly microenvironmental dependent plants.

Preferred research approach:

We would prefer to do the benchwork for extractions in our lab, to be sure we are sampling the right tissues. This is important for bryophytes as they can grow in mixed clumps and an expert needs to be the one to select the plant tissue to use. We would prefer to have the library prep and sequencing done by our local campus genome center. We have a good relationship with them, and easy means for communication about questions or problems.

Research Team:

The team responsible of this project and their role is summarized in Table 2. The principal investigator for this project is Brent Mishler. All the bench work will be conducted in his lab (the Bryolab at UC Berkeley) by the graduate student Ixchel Gonzalez-Ramirez, under the guidance of Sonia Nosratinia, who is the lab manager and has a lot of experience in molecular work. The collection of the specimens will be conducted by Ixchel Gonzalez-Ramirez, and she will be in constant communication with Dr. David Long, the expert of the family Aytoniaceae. The experience of David will be extremely valuable on identification of *A. californica* in the field. Ixchel will also process the data once we have received the sequences. The analysis will consist

on phylogenetic reconstruction of the lineages in *Asterella californica*, phylogenetic relationships of *A. californica* with its closely related groups, as well as genetic structure of the population. All the team will participate in the interpretation of the data.

Table 2. Team members for the project on *A. californica* genetic diversity

Name	Title	Affiliation	Role
Brent Mishler	PI	UC Berkeley	Help with analysis and interpretation
Ixchel González-Ramírez	PhD student	UC Berkeley	PhD student – Sample collection, data processing, and DNA extractions.
Sonia Nosratinia	Lab manager	UC Berkeley	Training and coordinating lab work.
David Long	Professor collaborator	Research Associate, Royal Botanic Garden Edinburgh, Scotland	The world's expert on <i>Asterella</i> taxonomy; will consult on project.

Budget: The budget required for this project is described in Table 3. We anticipate that the total cost of the project is \$49,906 USD. It includes the expenses of fieldwork, bench work, material and human costs.

Table 3. Budget for the *Asterella californica* project

Category	Amount	Justification
Field work	\$5,600	This includes mileage, food, housing, and misc. field expenses and equipment
Bench work	\$1,000	<i>Extractions:</i> Our preferred kit is Qiagen DNeasy Plant Pro Kit. For 150 samples the extraction cost would be \$818 for 3 kits (50 rxns per kit) + \$75 Qubit quantification = \$893. We round this up to \$1000 since some extractions may need to be repeated in trouble-shooting.
	\$3,000	Supplies: This item includes misc. lab expenses (e.g., tips, gloves, tubes, and beads for grinding) @ \$1,000/year.
Sequencing	\$26,250	<i>Library Preparation and Sequencing</i> will be done at the campus genome center, QB3. One cost includes both library prep and sequencing. The charge is \$175 per sample to take the extractions all the way through to the end. For 150 samples, the cost would be \$26,250, covering all library prep kits and reagents, all labor, and all sequencing and QC costs.
Personnel costs	\$13,523	<i>Salary:</i> We are requesting three months summer salary @ 100% time: (2 months in Year 1, and 1 month in Year 2) for a Graduate Student Researcher. This is based on the salary to support Ixchel González, a currently enrolled graduate student in the Mishler Lab who is working on liverworts, including <i>Asterella</i> , for her dissertation.
Other expenses	\$209	<i>GAEL:</i> This General, Automobile, and Employment Liability (GAEL) charge was instituted in 1998 to fund the campus's share of expenses associated with claims and lawsuits defended by the University. For Fiscal Year 2020, the GAEL charge is \$1.55 per \$100 of payroll. GAEL applies to all funds, including gifts and grants, with the exception of direct federal contracts, grants, and flow-throughs.
	\$324	<i>Benefits:</i> The University of California, Berkeley Composite Fringe Benefit Rates (CFBR) have been reviewed and federally approved by the Department of Health and Human Services (DHHS) for use by all fund sources for FY20. Rates beyond June 30, 2020 are estimates and are provided for planning purposes only.
TOTAL	\$49,906	

References

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Asterella californica collection points

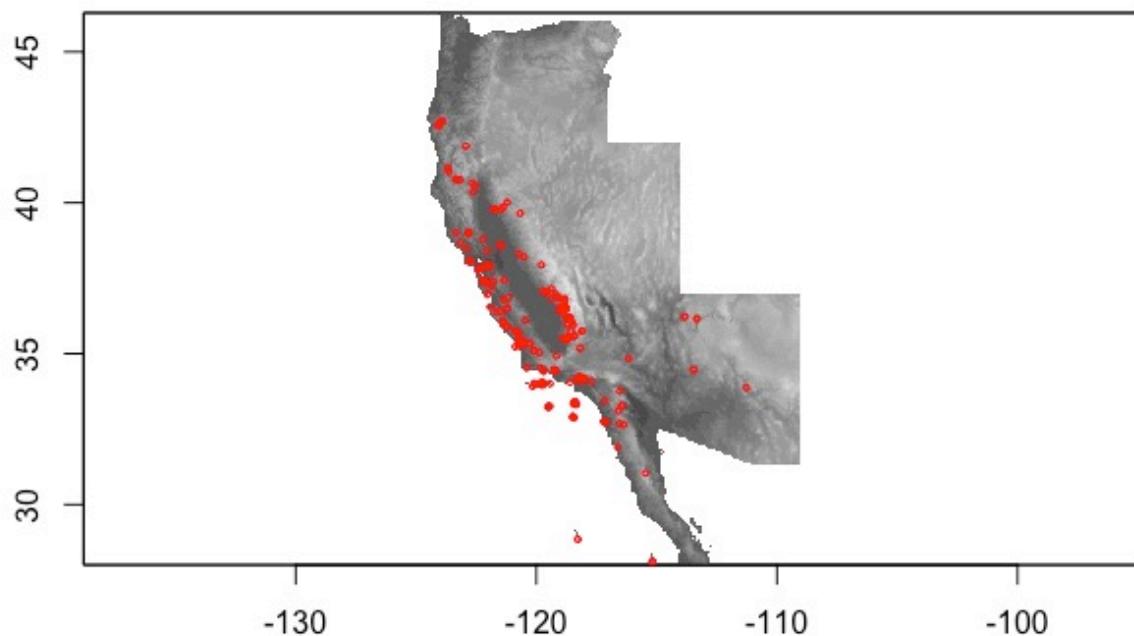


Figure 1. This is the entire world range of the liverwort *Asterella californica*. Data from the Consortium of North American Bryophyte Herbaria.

Species Page - *Asterella californica* (Hampe ex Austin) Underw.

Genome size: Genome size was estimated for *A. californica* as 703 MB (J.D. Bainard et al., 2013, *Mol. Phyl. Evol.* 68: 619-627). The related complex thalloid liverwort *Marchantia polymorpha* has been completely sequenced and there are considerable resources available (Bowman et al. 2017, *Cell* 171: 287-304).

Species range: Throughout California, with a few locations in Arizona, southwestern Oregon, and Baja California. See map on previous page (Fig 1.)

Researcher's experience: Dr. David Long is a well worldwide expert on liverworts, he has a lot of experience in the group *Asterella* belongs to. He has published papers on phylogenetics of the family Aytoniaceae. Ixchel is currently a PhD student specializing on the study of liverworts. The species is easily identifiable on the field.

Samples: The samples will be collected for this project across the full distribution range of the species. The localities we will target are detailed in the attached excel file. The first two rows in this file represent specimens in hand, the remainder are locations (based on specimens in the Consortium of North American Bryophyte Herbaria) to be visited in the fieldwork proposed here.

Sampling design: The sampling will be uniform across the range of the species distribution, prioritizing the representation of all the known populations and ensuring a good representation of the different type of ecosystems where *A. californica* is found.

Timeline for sample acquisition: At least half of the samples will be collected by June 2020.

Special considerations: None

Realistic timeline for benchwork and fieldwork: These plants are much easier to find and collect during the rainy season, thus fieldwork will be split between the remainder of this spring and spring 2021. Most of the fieldwork will be conducted by June 2020. DNA extraction of these samples will be completed during July 2020, while sequencing and assembly will start immediately after the extractions. Collecting will be completed during next winter/spring 2020/2021, and the final bench work by July 2, 2021.

California Conservation Genomics Project: Edaphic evolution and cryptic speciation in the *Layia glandulosa* species complex

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Synopsis. The *Layia glandulosa* complex (including *L. glandulosa* and *L. discoidea*; Table 1 – see p. 6) represents the most widespread obligately outcrossing (i.e., self-incompatible), diploid ($2n = 8_{II}$) species complex in the tarweed subtribe Madiinae of the sunflower family, Compositae (Baldwin 2003a). In a subtribe famous for evolutionary radiations throughout the California Floristic Province (CA-FP), *L. glandulosa* is exceptional for occurring from coastal dunes to montane settings in the CA-FP as well as having a widespread distribution in the Great Basin and Mojave Desert. In addition to its extensive ecogeographic range, allowing for comparison with a wide diversity of other CCGP species, *L. glandulosa* also represents one of the best documented examples of edaphic (soil) specialization among Californian plants. Although *L. glandulosa* is known almost exclusively from sandy or gravelly soils, the clade that exclusively represents the most recent common ancestor of *L. glandulosa* and all of its descendants also includes a nested, serpentine endemic clade that is so different in morphology and ecology that it has been widely recognized as a distinct species, *L. discoidea* (Baldwin 2005).

Proposed Target Species. Classical genetic studies by Clausen, Keck, and Hiesey (Clausen et al. 1947) at Stanford University and by L. D. Gottlieb and colleagues at UC Davis (Gottlieb et al. 1985; Ford and Gottlieb 1989, 1990) demonstrated that *Layia glandulosa* and *L. discoidea* are completely interfertile (and, by extension, share collinear genomes) and that their extreme morphological differences — so great that *L. discoidea* was originally thought to belong to a different tribe of the Compositae — are mostly under the control of a small number of genes of major phenotypic effect. Subsequent molecular phylogenetic studies based on nuclear ribosomal internal and external transcribed spacer (ITS and ETS) sequences that included representatives of 26 populations spanning much of the geographic and ecological distribution of both species demonstrated that *L. discoidea* descended from nearby populations of *L. glandulosa* (Baldwin 2005), most of which are unusual in having yellow rather than white ray flowers; *L. discoidea* lacks ray flowers altogether but has a gene for yellow ray flower color (Ford and Gottlieb 1990). The molecular phylogenetic results corroborated Gottlieb's (2004) hypothesis that *L. discoidea* represents an example of recent peripatric or “progenitor-derivative” speciation, or quantum evolution, rather than evolutionary relictualism, as earlier concluded by Clausen et al. (1947). Unlike most such examples in plants, however, *L. glandulosa* and *L. discoidea* could be compared from a single reference genome, in the absence of any differentiating chromosomal rearrangements.

The above studies demonstrated the value of the *Layia glandulosa* complex as a system for exploring morphological and ecological evolution in plants but did not include enough sampling of populations throughout California or of different nuclear genes to arrive at a solid understanding of evolutionary and biogeographic relationships throughout the complex. As a

result, Baldwin (2005) did not propose any taxonomic changes for *L. glandulosa*, despite evidence that *L. discoidea* is nested within it and that the coastal dune populations of *L. glandulosa* in central California represent a basally divergent lineage that is morphologically intermediate between *L. glandulosa* and *L. pentachaeta*, the (also Californian) sister group of the *L. glandulosa* complex (and our outgroup; see Table 1 on p. 6). The coastal dune populations of *L. glandulosa* are in steep decline as the invasive grass *Ehrharta calycina* continues to take over vast swaths of coastal dune habitat throughout central California (Pickart and Barbour 2007). Other CA-FP and desert lineages were resolved, as well, but without sufficient clade support, gene sampling, and population representation to allow for robust reconstruction of historical biogeography and ecology or to allow for a well-supported revised taxonomy. Most importantly, the precise relationships of the serpentine endemic *L. discoidea* to detected lineages within *L. glandulosa* remained unresolved. Detailed understanding of those relationships is important as a framework for guiding future experimental studies of the evolution of serpentine adaptation in this system. Such studies are urgently needed from a conservation perspective given the floristic importance of serpentine endemism, which accounts for ~12.5% of endemic Californian plant taxa (Safford et al. 2005), and the “seriously endangered” status of *L. discoidea* (California Native Plant Society, Rare Plant Program 2020). These goals align nicely with the CCGP’s goals of detecting areas of high genetic diversity and the conservation of threatened taxa in California.

Sampling design. Sampling will encompass the ecogeographic distribution of the *Layia glandulosa* complex within California, including the 14 USDA Ecoregions of California in which members of this complex occur: Central California Coast, Coast Ranges, Colorado Desert, Great Valley, Modoc Plateau, Mojave Desert, Mono, Northwestern Basin and Range, Sierra Nevada, Sierra Nevada Foothills, Southeastern Great Basin, Southern California Coast, Southern California Mountains and Valleys, and Southern Cascades. Sampling will be guided further by previously published molecular phylogenetic results (Baldwin 2005), to concentrate sampling as warranted to capture lineage diversity previously detected in this species complex. Insofar as practicable, sampling within each USDA Ecoregion will be oriented toward maximizing representation of finer-scale geographic (and ecological) subdivisions of California, as recognized by the Jepson Flora Project (<https://ucjeps.berkeley.edu/eflora/geography.html>). Two samples to represent both subspecies of the sister group (outgroup) of the complex, i.e., *L. pentachaeta* subsp. *albida* and *L. pentachaeta* subsp. *pentachaeta* (both California endemics), will also be included. Specimen vouchers will be deposited in the University and Jepson Herbaria at UC Berkeley. The occurrence of members of the *L. glandulosa* complex in areas that span known phylogeographic boundaries in California, such as the Transverse Ranges and the CA-FP/desert ecotone, and across a coast-to-desert transect make the group a valuable clade for comparison with other CCGP species.

Preferred research approach. As noted in the budget, the current plan is to provide leaf tissue and already-extracted DNAs to the centralized lab where bench work would be conducted, with the provisional assumption that a liquid handling robot operated by a trained research technician would conduct bench work up to the point of DNA sequencing (as per correspondence with Brad Shaffer). In other words, all molecular work would be conducted by the central lab, although we can provide already extracted DNAs of representatives of some populations. The requested one-semester of support for the Graduate Student Researcher (GSR), Isaac Licherter-Marck, would

include field and bioinformatic effort toward obtaining additional samples and achieving evolutionary and biogeographic understanding of the *L. glandulosa* complex beyond the goals of the project-wide analyses. The proposed GSR has considerable experience in the field and with assembly, alignment, and phylogenetic analyses of large genomic datasets. Isaac Lichter-Marck has received training in phylogenomic approaches at UC Berkeley and at the Smithsonian Institution and has been nationally recognized for the quality of his evolutionary and biogeographic work (2019 recipient of the Cooley Award for best paper at *Botany 2019* in Tucson, AZ). The GSR will use both phylogenomic and landscape genetic analyses (including use of F statistics) for the proposed work.

Research team. See Table 2 (p. 6). Fieldwork will be conducted by the GSR (Isaac Lichter-Marck) and the PI (Baldwin), who will coordinate collecting to maximize efficiency of travel and effort. The GSR will concentrate on obtaining tissue and vouchers in southwestern California and adjacent deserts. Both the GSR and PI will collect in the Coast Ranges, where the highest concentration of lineage diversity was found earlier (Baldwin 2005). The PI has extensive field experience with the *Layia glandulosa* complex and has worked closely with Bureau of Land Management (BLM) botanist Ryan O'Dell, who is willing to help with collection on BLM lands in the South Inner Coast Ranges where *L. discoidea* is endemic and the most closely related lineages of *L. glandulosa* occur, to augment DNAs already in hand. Given the lateness of the spring season and COVID-19 restrictions, all field work will occur in spring semester 2021, when Isaac Marck will be a GSR for the project. For all new collections, we anticipate providing silica-dried leaf tissue; if necessary, seeds of these spring-flowering annuals can be germinated to generate leaf tissue for DNA. The PI has experience germinating and growing these plants, with use of 150 ppm gibberellic acid to break seed dormancy. For older collections, we can provide extracted genomic DNA.

Budget and budget justification. See Table 3 (p. 6).

Species page.

- 1) White layia (*Layia glandulosa*) and rayless layia (*Layia discoidea*) constitute the *L. glandulosa* complex; Sierra layia (*Layia pentachaeta*) is the outgroup (sister group).
- 2) The closest relative for which genome size data are available is annual sunflower (*Helianthus annuus*), with an estimated 3.6 gigabase genome (Badouin et al. 2017). We predict the genome size of the *Layia glandulosa* complex to be somewhat smaller than sunflower ($2n = 17_{II}$) based on dysploidization from a similar base number ($x = 19$) in the tarweed subtribe to $2n = 8_{II}$ in *Layia*.
- 3) Within California, the range of *L. glandulosa* and *L. discoidea* includes the following 14 USDA ecoregions: Central California Coast, Coast Ranges, Colorado Desert, Great Valley, Modoc Plateau, Mojave Desert, Mono, Northwestern Basin and Range, Sierra Nevada, Sierra Nevada Foothills, Southeastern Great Basin, Southern California Coast, Southern California Mountains and Valleys, and Southern Cascades. Although sampling will not occur outside California, *L. glandulosa* extends north to eastern Washington and east to western Utah and northern Arizona in the Intermountain West, and occurs further south in the Sonoran Desert of Arizona and Baja California.
- 4) The PI (Baldwin) has studied this complex and the genus *Layia* more generally in the field, laboratory, and greenhouse for decades (e.g., Baldwin 2003b, 2005, 2006). He has

- annotated thousands of herbarium specimens of *Layia* and published floristic treatments of the genus for *The Jepson Manual* (Baldwin and Bainbridge 1993, 2012), *Flora of North America* (Baldwin et al. 2006), and *Flora of Oregon* (Baldwin and Carr in press).
- 5) See Excel sample sheet for specimens to be studied. Note: 129 rather than 100 samples are included in the sample sheet to provide more context for the geographic distribution (total sampling will be 100 specimens from throughout the range unless actual costs come down sufficiently to include more than 100).
 - 6) Sampling will focus on inclusion of populations across USDA Ecoregions and Jepson Flora Project subdivisions of California, with more concentrated sampling (*a*) in ecoregions and subdivisions underrepresented by existing collections and (*b*) in the Coast Ranges, where the highest density of evolutionary lineages was detected earlier (Baldwin 2005). Sampling outside California will not be conducted, based on the understanding that occurrences outside California probably represent dispersal out of the state (Baldwin 2005).
 - 7) Additional sampling of these spring-flowering annuals is anticipated for March to June 2021, when they are active and expected to be in flower and fruit.
 - 8) We do not anticipate the genome size of these species will exceed that of the sunflower genome and predict genome size will be smaller than sunflower based on dysploidy of *Layia*.
 - 9) Fieldwork in 2021 will conclude by the end of June 2021. If plants must be grown from seed for any population, then tissue can be produced by August 2021 (but we do not anticipate this situation developing).

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Table 1: Species Page

<u>Common name</u>	<u>Scientific name</u>
White layia	<i>Layia glandulosa</i> (Hook.) Hook. & Arn.
Rayless layia	<i>Layia discoidea</i> D.D. Keck
Sierra layia	<i>Layia pentachaeta</i> A. Gray [Note: this species is just the outgroup]

Table 2: Research Team

Principal Investigator (PI)

Bruce G. Baldwin, Professor of Integrative Biology / Curator of the Jepson Herbarium

The PI will oversee all phases of the project and work with the Graduate Student Researcher to obtain samples, analyze sequencing data, and prepare manuscripts for publication.

Graduate Student Researcher (GSR)

Isaac Lichter-Marck, Ph.D. candidate, Department of Integrative Biology

The GSR will undertake most of the fieldwork to obtain samples and will use his bioinformatic skills to participate intensively in phylogenomic and landscape genomic analyses of sequence data. He will also collaborate with the PI in preparation of manuscripts for publication.

Table 3: Budget and Budget Justification

Budget

	Activity	Cost
1. Field work		
Transportation		\$1682
Food		\$300
Lodging		\$340
Total requested for field work		\$2322
2. Bench work		
Cost for standardized project wide bench work at a centralized facility with liquid handling robot and a trained technician as mentioned in correspondence with Brad Schaffer.		\$3500
Total requested for bench work		\$3500
3. Sequencing		
10x coverage for 100 samples with a ~3 Gb genome (@\$7 per Gb sequenced)		\$21000
Total requested for sequencing		\$21000
4. Personnel		
1 semester GSR tuition, fees, and stipend (1/2 time)		\$22585
Total requested for personnel		\$22585
5. Incidentals		
Incidentals for field research		\$400
Total requested for incidentals		\$400
6. Other direct costs		
GAEL		\$193
Project Balance		\$50,000

Total requested	\$50,000
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Budget justification

1. Field work

The requested transportation, food, and lodging budget will cover ~2900 miles of travel to allow sampling of remaining populations throughout the Californian distribution of the *Layia glandulosa* complex (including *L. discoidea* and outgroup) at the standard UCB mileage rate (\$0.58). We will use personal vehicles. This work will be conducted by both the PI and the GSR during the first three months of the project.

2. Bench work

Requested funds will cover DNA extraction and library preparation for 100 samples for sequencing on a Novoseq platform. DNA extractions and library preparation will be conducted at a centralized facility by a liquid handling robot operated by a trained research technician hired by CCGP. Per conversations with CCGP PI Brad Schaffer, the cost of such an approach would come out to \$2,000--3,500 per species if lab work is done at the centralized facility.

3. Sequencing

Requested funds will be used for massively parallel sequencing of 100 samples on a Novoseq 6000 platform. Given an estimated genome size of ~3 Gb and estimated cost of \$7/Gb of sequencing, this cost estimate will yield 10 \times coverage for 100 samples from across the geographic range of the *Layia glandulosa* species complex.

4. Personnel

Requested funds will be used to pay for one semester of a graduate student researcher, including fees, tuition, and stipend at 50% time (Spring Semester 2021). The GSR is essential to this project and will work with the PI to follow standard protocols for collecting high quality leaf tissue for DNA analysis from populations of the *Layia glandulosa* complex (including *L. discoidea* and the outgroup) during the first three months of the funding period. Reference guided assembly of short-read genomic data, alignment of orthologous loci, and phylogeographic and landscape genomic analyses will be carried out by the GSR and PI using a faculty allowance on the SAVIO high performance computing cluster on the UC Berkeley campus during the three months after data is returned from the central laboratory and sequencing facility.

5. Incidentals

Requested funds for incidentals for fieldwork include materials for collecting leaf tissue for DNA analysis, such as vials and silica desiccant, as well as materials for collecting dried herbarium vouchers of all individual plants selected for genomic analysis. Specimen vouchers will be deposited in the University and Jepson Herbaria at UC Berkeley with duplicates deposited at other herbaria.

6. Other direct costs

The General, Automobile, and Employment Liability (GAEL) charge was instituted in 1998 to fund the campus's share of expenses associated with claims and lawsuits defended by the University. For Fiscal Year 2020, the GAEL charge is \$1.55 per \$100 of payroll. GAEL applies to all funds, including gifts and grants, with the exception of direct federal contracts, grants, and flow-throughs.

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EDUCATION/APPOINTMENTS

2015–present	University of California, Berkeley	<i>Assistant Professor and Faculty Curator</i>
2015	National Evolutionary Synthesis Center, Durham NC	<i>Visiting Scholar</i>
2013–2015	University of British Columbia, Vancouver BC	<i>Postdoctoral Fellow</i>
	▪ Advisor: Dr. Sarah Otto	
2006–2012	Duke University, Durham NC	<i>PhD Biology</i>
	▪ Advisor: Dr. Kathleen Pryer	
1996–2001	McMaster University, Hamilton ON	<i>Bachelor of Arts & Science Combined Honours Biology</i>

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45. Li, F-W., L-Y. Kuo, K.M. Pryer, and **C.J. Rothfels**. 2016. Genes translocated into the plastid inverted repeat show decelerated substitution rates and elevated GC content. *Genome Biology and Evolution*. 8(8): 2452–2458
44. Grusz, A.L., **C.J. Rothfels**, and E. Schuettpelz. 2016. Transcriptome sequencing reveals genome-wide variation in molecular evolutionary rate among ferns. *BMC Genomics*. 17(1): 692.
43. Zhou, X.-M., **C.J. Rothfels**, L. Zhang, Z.-R. He, T. Le Péchon, H. He, N.T. Lu, R. Knapp, D. Lorence, X.-J. He, X.-F. Gao, and L.-B. Zhang. 2016. A large-scale phylogeny of the lycophyte genus *Selaginella* (Selaginellaceae: Lycopodiopsida) based on plastid and nuclear loci. *Cladistics*. 32: 360–389.
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39. **Rothfels, C.J.**, and S.P. Otto. 2016. Polyploid speciation. In R. M. Kliman (Ed.), *Encyclopedia of Evolutionary Biology* (pp. 317–326). Oxford: Academic Press. <http://doi.org/10.1016/B978-0-12-800049-6.00073-1>
38. Devos, N., P. Szövényi, D.J. Weston, **C.J. Rothfels**, M.G. Johnson, and A.J. Shaw. 2016. Analyses of transcriptome sequences reveal multiple ancient large-scale duplication events in the ancestor of Sphagnopsida

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 31. **Rothfels**, C.J., F.-W. Li, E.M. Sigel, L. Huiet, A. Larsson, D.O. Burge, M. Ruhsam, M. Deyholos, D.E. Soltis, C.N. Stewart, S.W. Shaw, L. Pokorny, T. Chen, C. dePamphilis, L. DeGironimo, T. Chen, X. Wei, X. Sun, P. Korall, D.W. Stevenson, S.W. Graham, G.K-S. Wong, K.M. Pryer. 2015. The evolutionary history of ferns inferred from 25 single-copy nuclear genes. *American Journal of Botany*. 102(7): 1089–1107. Highlighted article: <http://www.amjbot.org/content/102/7/1009?etoc>
 30. Zhang, L., **C.J. Rothfels**, A. Ebihara, E. Schuettpelz, T.L. Péchon, P. Kamau, H. He, X-M. Zhou, J. Prado, A. Field, G. Yatskievych, X-F. Gao, L-B. Zhang. 2014. A global plastid phylogeny of the brake fern genus *Pteris* (Pteridaceae) and related genera in the Pteridoideae. *Cladistics*. 31: 406–423.
 29. **Rothfels**, C.J., A.K. Johnson*, P.H. Hovenkamp, D.L. Swofford, H.C. Roskam, C.R. Fraser-Jenkins, M.D. Windham, K.M. Pryer. 2015. Natural hybridization between genera that diverged from each other approximately 60 million years ago. *American Naturalist* 185(3): 433–442. *Undergraduate mentee. Press: http://www.eurekalert.org/pub_releases/2015-02/du-dsp021315.php.
 28. Bennett, T., S.F. Brockington, **C.J. Rothfels**, S. Graham, D. Stevenson, T. Kutchan, M. Rolf, P. Thomas, G.K.S. Wong, O. Leyser, B.J. Glover, and C.J. Harrison. 2014. Paralogous radiations of PIN proteins with multiple origins of non-canonical PIN structure. *Molecular Biology and Evolution*. 31(8): 2042–2060.
 27. Itay, M., S. Zhan, **C.J. Rothfels**, N. Arrigo, M. Barker, L. Rieseberg, S. Otto. 2014. Methods for studying polyploid diversification and the dead end hypothesis: A reply to Soltis et al. (2014). *New Phytologist*. doi: 10.1111/nph.13192
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 24. **Rothfels**, C.J., A.K. Johnson*, M.D. Windham, K.M. Pryer. 2014. Low-copy nuclear data confirm rampant allopolyploidy in the Cystopteridaceae (Polypodiales). *Taxon* 63(5): 1026–1036 *Undergraduate mentee.
 23. Floyd, S.K., J.G. Ryan, S.J. Conway, E. Brenner, K.P. Burris, J.N. Burris, T. Chen, P.P. Edger, S.W. Graham, J.H. Leebens-Mack, J.C. Pires, **C.J. Rothfels**, E.M. Sigel, D.W. Stevenson, C.N. Stewart Jr., G.K-S. Wong, J.L.

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22. Sessa, E.B., J.A. Banks, M.S. Barker, J.P. Der, A.M. Duffy, S.W. Graham, M. Hasebe, J. Langdale, F.-W. Li, D.B. Marchant, K.M. Pryer, **C.J. Rothfels**, S.J. Roux, M.L. Salmi, E.M. Sigel, D.E. Soltis, P.S. Soltis, D.W. Stevenson, P.G. Wolf. 2014. Between two fern genomes. *GigaScience* 3(15). doi:10.1186/2047-217X-3-15
 21. Li, F-W., J.C. Villarreal, S. Kelly, **C.J. Rothfels**, M. Melkonian, E. Frangedakis, M. Ruhsam, E.M. Sigel, J.P. Der, J. Pittermann, D.O. Burge, L. Pokorny, A. Larsson, T. Chen, S. Weststrand, P. Thomas, E. Carpenter, Y. Zhang, Z. Tian, L. Chen, Z. Yan, Y. Zhu, X. Sun, J. Wang, D. Stevenson, B Crandall-Stotler, A.J. Shaw, M.K. Deyholos, D.E. Soltis, S. Graham, M.D. Windham, J.A. Langdale, G.K-S. Wong, S. Mathews, K.M. Pryer. 2014. Horizontal transfer of an adaptive chimeric photoreceptor from bryophytes to ferns. *PNAS* 11(18): 6672–6677. doi: 10.1073/pnas.1319929111
 20. **Rothfels, C.J.**, and E. Schuettpelz. 2014. Accelerated rate of molecular evolution for vittarioid ferns is strong and not driven by selection. *Systematic Biology* 63(1): 31–54. doi:10.1093/sysbio/syt058.
 19. Sundue, M.A, and **C.J. Rothfels**. 2014. Stasis and convergence characterize morphological evolution in eupolypod II ferns. *Annals of Botany* 113(1): 35–54. doi:10.1093/aob/mct247.
 18. **Rothfels, C.J.**, A. Larsson, F-W. Li, E.M. Sigel, L.Huiet, D.O. Burge, M. Ruhsam, S.W. Graham, D. Stevenson, G.K.-S. Wong, P. Korall, K.M. Pryer. 2013. Transcriptome-mining for single-copy nuclear markers in ferns. *PLoS ONE* 8(10): e76957. doi:10.1371/journal.pone.0076957.
 17. León, B., **C.J. Rothfels**, M. Arakaki, K.R. Young, K.M. Pryer. 2013. Revealing a cryptic fern distribution through DNA sequencing: *Pityrogramma trifoliata* in the western Andes of Peru. *Amer Fern J* 103(1): 40–48.
 16. **Rothfels, C.J.**, M.D. Windham, and K.M. Pryer. 2013. A plastid phylogeny of the cosmopolitan fern family Cystopteridaceae (Polypodiopsida). *Systematic Botany* 38(2): 295–306.
 15. **Rothfels, C.J.**, E. Gaya, L. Pokorny, Paul Rothfels, Peter Rothfels, and G.R. Feulner. 2012. Five new records for the Arabian Peninsula and other significant fern, lichen and bryophyte collections from the UAE and northern Oman. *Tribulus* 20: 4–20.
 14. **Rothfels, C.J.**, E.M. Sigel, and M.D. Windham. 2012. *Cheilanthes feei* T. Moore (Pteridaceae) and *Dryopteris erythrosora* (D.C. Eaton) Kunze (Drypteridaceae) new for the flora of North Carolina. *American Fern Journal* 102(2): 184–186.
 13. **Rothfels, C.J.***, M.A. Sundue*, L.Y. Kuo, A. Larsson, M. Kato, E. Schuettpelz, and K.M. Pryer. 2012. A revised family-level classification for eupolypod II ferns (Polypodiidae: Polypodiales). *Taxon* 61(3): 515–533.
*Equally contributing.
 12. **Rothfels, C.J.***, A. Larsson*, L.-Y. Kuo*, P. Korall, W.-L. Chiou, and K.M. Pryer. 2012. Overcoming deep roots, fast rates, and short internodes to resolve the ancient rapid radiation of eupolypod II ferns. *Systematic Biology* 61(3): 490–509. COVER ARTICLE. *Equally contributing.
 11. Johnson, A.K.*., **C.J. Rothfels**, M.D. Windham, and K.M. Pryer. 2012. Unique expression of a sporophytic character on the gametophytes of notholaenid ferns (Pteridaceae). *American Journal of Botany* 99: 1118–1124.
*Undergraduate mentee.
 10. Li, F.-W., L.-Y. Kuo, **C.J. Rothfels**, A. Ebihara, W.-L. Chiou, M.D. Windham, and K.M. Pryer. 2011. *rbcL* and *matK* earn two thumbs up as the core DNA barcode for ferns. *PLoS ONE* 6: e26597.
 9. Mayrose, I, S.H. Zhan, **C.J. Rothfels**, K. Magnuson-Ford, L. Rieseberg, M.S. Barker, and S.P. Otto. 2011. Recently formed polyploid plants diversify at lower rates. *Science* 333: 1257.
 8. Galbraith, D.A., N.E. Iwanycki, B.V. McGoey, J. McGregor, J.S. Pringle, **C.J. Rothfels**, and T.W. Smith. 2011. The evolving role of botanical gardens and natural areas: A floristic case study from Royal Botanical Gardens, Canada. *Plant Diversity and Resources* 33(1): 123–131.
 7. Pryer, K.M., E. Schuettpelz, L. Huiet, A.L. Grusz, **C.J. Rothfels**, T. Avent, D. Schwartz, and M.D. Windham. 2010. DNA barcoding exposes a case of mistaken identity in the fern horticultural trade. *Molecular Ecology Resources* 10: 979–985.
 6. Windham, M.D., L. Huiet, E. Schuettpelz, A.L. Grusz, **C.J. Rothfels**, J.B. Beck, G. Yatskievych, K.M. Pryer. 2009. Using plastid DNA sequences to redraw generic boundaries in cheilantheid ferns (Pteridaceae). *American Fern Journal* 99: 128–132.
 5. **Rothfels, C.J.**, M.D. Windham, A.L. Grusz, G.J. Gastony, and K.M. Pryer. 2008. Toward a monophyletic *Notholaena* (Pteridaceae): Resolving patterns of evolutionary convergence in xeric-adapted ferns. *Taxon* 57(3): 712–724.
 4. Jaramillo, A., M.T.J. Johnson, **C.J. Rothfels**, and R.A. Johnson. 2008. The native and exotic avifauna of Easter Island: Then and now. *Boletin Chileno de Ornitologia* 14(1): 8–21.

3. **Rothfels, C.J.** 2004. Significant vascular plant records from the Hamilton area, Ontario. *Canadian Field-Naturalist*. 118(4): 612–615.
2. **Rothfels, C.J.**, L.L. Beaton, and S. Dudley. 2002. The effects of salt, manganese, and density on life history traits in *Hesperis matronalis* L. from oldfield and roadside populations. *Can. Journal of Botany* 80: 131–139.
1. Johnson, M.T. and **C.J. Rothfels**. 2001. The establishment and proliferation of the rare exotic plant, *Lythrum hyssopifolia*, (Hyssop-leaved Loosetrife), at a pond in Guelph, Ontario. *Can. Field-Naturalist* 115(2): 229–233.

PEER-REVIEWED TECHNICAL REPORTS

1. **Rothfels, C.J.** and T.W. Smith. In review. Update COSEWIC report on Green Dragon, *Arisaema dracontium*. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
2. Smith, T.W. and **C.J. Rothfels**. In review. Update COSEWIC report on Broad Beech Fern, *Phegopteris hexagonoptera*. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
3. Waldron, G., **C.J. Rothfels**, J. Bowles, and Environment Canada. 2011. Recovery strategy for the Skinner's Agalinis (*Agalinis skinneriana*) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Environment Canada. v + 16 pp.
4. Smith, T.W. and **C.J. Rothfels**. 2010. Recovery strategy for Few-flowered Club-rush (*Trichophorum planifolium*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. ii + 4 pp. + Appendix vi + 22 pp. + addenda.
5. **Rothfels, C.J.** and S.Y. Gibson. 2007. COSEWIC assessment and update status report on the round-leaved greenbrier (Great Lakes Plains and Atlantic population) *Smilax rotundifolia* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
6. Smith, T.W. and **C.J. Rothfels**. 2007. Recovery strategy for Few-flowered Club-rush/Bashful Bulrush (*Trichophorum planifolium* (Sprengel) Palla) in Canada. Prepared for the Ontario Ministry of Natural Resources by Royal Botanical Gardens. Hamilton. vi + 22 pp.
7. Smith, T.W., **C.J. Rothfels**, and E. Oberndorfer. 2006. COSEWIC assessment and update status report on the American Columbo *Frasera carolinensis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

GRANT SUPPORT

- 2018– **NSF Division of Environmental Biology.** Role: PI.
- 2021 *Collaborative Proposal: The Foundation of Terrestrial Life: Inferring a Total-evidence Timeline of Vascular Plant Evolution.* \$350,000.
- 2018– **NSF Advancing Digitization of Biological Collections.** Role: Lead PI.
- 2021 *Digitization TCN: Collaborative Research: The Pteridological Collections Consortium: An integrative approach to pteridophyte diversity over the last 420 million years.* \$978,117 (total collaboration: \$3,700,000).

SELECT AWARDS

- 2012 **NSERC Postdoctoral Fellowship.** \$40,000/year for two years.
- 2011 **NSF Doctoral Dissertation Improvement Grant.** \$15000.
- 2009 **Lewis and Clark Fund for Exploration and Field Research.** American Philosophical Soc., \$2500.
- 2009 **Dissertation Research Grant.** Duke Center for Latin American and Caribbean Studies. \$900.
- 2009 **Graduate Student Research Grant.** American Society of Plant Taxonomists. \$600.
- 2008 **NSERC PGS D Research Scholarship.** NSERC, doctoral. \$21000/year for up to three years.
- 2007 **Graduate Student Research Award.** Society of Systematic Biologists. \$1700.
- 2007 **Mini-PEET Award.** Society of Systematic Biologists, to enhance the transfer of taxonomic expertise. \$1400.
- 2006 **Julie Payette-NSERC Research Scholarship.** \$25000 for one year.
- 2006 **University Scholars Fellowship.** Duke University's most prestigious award offered for graduate study.
- 2006 **James B. Duke Fellowship.** Duke University. \$4000 per year for four years.

PROFESSIONAL ACTIVITIES

2017– present	Annals of the Missouri Botanical Garden	<i>Associate Editor</i>
	▪ Manage and review manuscripts.	
2010– present	American Fern Journal	<i>Associate Editor</i>
	▪ Manage and review manuscripts.	
2009– present	Misc. Journals	<i>Reviewer</i>
	▪ For <i>American Fern Journal</i> , <i>American Journal of Botany</i> , <i>Annales Botanici Fennici</i> , <i>Annals of Botany</i> , <i>Annals of the Missouri Botanical Garden</i> , <i>AoB PLANTS</i> , <i>Australian Systematic Botany</i> , <i>Biodiversity and Conservation</i> , <i>BMC Evolutionary Biology</i> , <i>BMC Genomics</i> , <i>Botanical Studies</i> , <i>Brittonia</i> , <i>Cladistics</i> , <i>Genome</i> , <i>Genome Biology and Evolution</i> , <i>Grana</i> , <i>International Journal of Plant Sciences</i> , <i>Journal of Biogeography</i> , <i>Journal of Plant Research</i> , <i>Molecular Biology and Evolution</i> , <i>Molecular Ecology Resources</i> , <i>Molecular Phylogenetics and Evolution</i> , <i>New Phytologist</i> , <i>Organisms Diversity & Evolution</i> , <i>PeerJ</i> , <i>Phytokeys</i> , <i>Phytotaxa</i> , <i>Plant Systematics and Evolution</i> , <i>PLoS ONE</i> , <i>Proceedings B</i> , <i>Scientific Reports</i> , <i>Systematic Botany</i> , <i>Systematic Biology</i> , and <i>Taxon</i> .	
2010– present	Misc. Societies	<i>Member</i>
	▪ I am a member of the following professional societies: American Fern Society, American Society of Naturalists, American Society of Plant Taxonomists, International Association for Plant Taxonomy, Society for the Study of Evolution, and the Society of Systematic Biologists.	
2007–2010	Duke University Biology Department	<i>Seminar Coordinator</i>
	▪ Coordinator of the weekly Systematics Discussion Group and Seminar.	

CONFERENCE, SEMINAR, AND POSTER PRESENTATIONS

- Tribble, C., A.C. Jackson-Gain, C. Specht, and **C.J. Rothfels**. 2018. Characterizing the evolution of underground morphology and climatic nich in the order Liliales. *Botany 2018*: Rochester Minnesota
- Song, M., **C.J. Rothfels**, and B. Igic. 2018. Difficulties in the inference of ancient whole-genome duplications. Poster: *Botany 2018*: Rochester Minnesota.
- Freund, F. and **C.J. Rothfels**. 2018. Isoëtes of the west coast state: Undescribed diversity in a biodiversity hotspot. *Botany 2018*: Rochester Minnesota.
- Jackson-Gain, A.C., C. Tribble, and **C.J. Rothfels**. 2018. Species distribution modelling in the order Liliales. Poster: *Botany 2018*: Rochester Minnesota.
- Schuettpelz, E., G. Rouhan, K.M. Pryer, **C.J. Rothfels**, J. Prado, M.A. Sundue, M.D. Windham, R.C. Moran, and A.R. Smith. 2018. Are there too many fern genera? *Botany 2018*: Rochester Minnesota.
- Windham, M.D., T.-T. Kao, N.M. Hay, **C.J. Rothfels**, E. Schuettpelz, and K.M. Pryer. 2018. Rapid biodiversity assessment of ferns using low-tech spore observations on herbarium collections: an example from *Notholaena* (Pteridaceae). *Botany 2018*: Rochester Minnesota.
- Beck, J.B., I.E. Jordon-Thaden, C.R. Rushworth, M.D. Windham, N. Diaz, J.T. Cantley, C.T. Martine, and **C.J. Rothfels**. 2018. I fall to pieces: RADseq techniques can be applied to herbarium-derived DNAs of varying quality. *Botany 2018*: Rochester Minnesota.
- Lockwood, E., G. Burleigh, S. Carey, L. Endara, M. Lehnert, K.M. Pryer, and **C.J. Rothfels**. 2018. A species-level phylogeny of the genus *Equisetum*. Poster: *Botany 2018*: Rochester Minnesota.
- **Rothfels, C.J.** 2018. Next generation polyploid phylogenetics. Invited seminar: San Francisco State University. San Francisco, California.
- **Rothfels, C.J.** 2018. Prospects and pitfalls of polyploid phylogenetics. Invited seminar: Florida Museum of Natural History. Gainesville, Florida.
- **Rothfels, C.J.** 2017. Ancient but still evolving: The ferns among us. Invited lecture: California Native Plants Society, North Coast Chapter. Arcata, California.
- **Rothfels, C.J.** 2017. Next generation polyploid phylogenetics. Invited seminar: Institut für Systematische Botanik. Zurich, Switzerland.
- **Rothfels, C.J.** 2017. Nuclear phylogenetics of ferns and its implications for taxonomy. *International Botanical Congress XIX*: Shenzhen China.
- **Rothfels, C.J.** 2017. Next generation polyploid phylogenetics. Invited seminar: Chinese Academy of Science. Chengdu, China.

- **Rothfels, C.J.** 2017. Next generation polyploid phylogenetics. Invited seminar: University of San Francisco. San Francisco, California.
- **Rothfels, C.J.** 2017. Next generation polyploid phylogenetics. Invited seminar: Ohio State University. Columbus, Ohio.
- **Rothfels, C.J.** 2017. Next generation polyploid phylogenetics. Invited seminar: University of Idaho. Moscow, Idaho.
- **Rothfels, C.J.**, M.A. Sundue, W.L. Testo, and P.G. Wolf. 2017. A sequence-capture approach to multi-locus nuclear phylogenetics of ferns. Botany 2017: Ft. Worth TX.
- Freund, F.D., W. Freyman, and **C.J. Rothfels**. 2017. Inferring the evolution of corm lobation in *Isoëtes* using Bayesian model-averaged ancestral state reconstruction. Botany 2017: Ft. Worth TX.
- Kao, T.-T., F.D. Freund, **C.J. Rothfels**, M.D. Windham, and K.M. Pryer. 2017. Low-copy nuclear data for notholaenid ferns (Pteridaceae) corroborate plastid phylogeny over traditional morphological groupings. Botany 2017: Ft. Worth TX.
- **Rothfels, C.J.** 2016. Next generation polyploid phylogenetics. Invited seminar: UC Davis. Davis, California.
- Zhang, L.-B., L. Zhang, E. Schuettpelz, **C.J. Rothfels**, X. Zhou, and X.-F. Gao. 2016. Circumscription and phylogeny of the fern family Tectariaceae based on plastid and nuclear markers, with the description of two new genera: *Draconopteris* and *Malaifilix* (Tectariaceae). Botany 2016: Savannah GA.
- Pryer, K.M., M.D. Windham, and **C.J. Rothfels**. 2016. A small new genus that unites surprisingly disparate cheilanthonid ferns (Pteridaceae). Botany 2016: Savannah GA.
- **Rothfels, C.J.**, K.M. Pryer, and F.-W. Li. 2016. Next-generation polyploid phylogenetics: Low-cost, high-throughput resolution of hybrid polyploid complexes using PacBio and PURC. Botany 2016: Savannah, GA.
- Graham, S.W, **C.J. Rothfels**, Q. Lin, and S. Zhan. 2016. *Equisetum* and its place in vascular-plant phylogeny. Symposium presentation, Botany 2016: Savannah GA.
- **Rothfels, C.J.** 2016. Deep thoughts: Musings on speciation and the fern hybrid *xCystocarpium rosakianum*. Plant Speciation 2016: Austin TX.
- Li, F.-W., L.-Y. Kuo, M. Simenc, S. Cheng, G.K.-S. Wong,, M.D. Windham, J.P. Der, Y.-M. Huang, **C.J. Rothfels**, K.M. Pryer. 2016. *Salvinia*—a plant without roots—has the smallest known fern genome, and its “root-like” submerged leaves have recruited functional root genes. Poster: Plant & Animal Genome XXIV: San Diego, California.
- **Rothfels, C.J.** 2016. Next generation polyploid phylogenetics (and some of the ferns that love them). Invited seminar: Rancho Santa Ana Botanic Garden. Claremont, California.
- **Rothfels, C.J.**, F.-W. Li, E.M. Sigel, L. Huiet, A. Larsson, S.W. Graham, G.K.-S. Wong, K.M. Pryer. 2015. Curated phylogenomics and the first single-copy nuclear phylogeny of the ferns. Botany 2015: Edmonton.
- **Rothfels, C.J.**, K.M. Pryer, F.-W. Li. 2015. Utilizing the PacBio next-generation sequencing platform to unravel hybrid polyploid complexes. Next Generation Pteridology: Washington, DC.
- Wolf, P.G., E.B. Sessa, D.B. Marchant, F.-W. Li, **C.J. Rothfels**, E.M. Sigel, M.A. Gitzendanner, C.J. Visger, J.A. Banks, D.E. Soltis, P.S. Soltis, K.M. Pryer, J.P. Der. 2015. Skimming the surface of fern nuclear genomes. Next Generation Pteridology: Washington, DC.
- Zhan, S.H., **C.J. Rothfels**, A. Larsson, S. Weststrand, D.O. Burge, M. Ruhsam, F.-W. Li, E.M. Sigel, S. Ellis, S. Shaw, A. Calcedo, T. Chen, L. DiGironomo, E. Sessa, J.P. Der, M. Barker, J. Leebens-Mack, M. Deyholos, G.K.-S. Wong, D. Stevenson, S.W. Graham. 2015. Phylotranscriptomics of the seed-free vascular plants. Next Generation Pteridology: Washington, DC.
- F.-W. Li, S. Cheng, J.P. Der, B. Song, X. Liu, X. Xu, A. Bräutigam, **C.J. Rothfels**, E.M. Sigel, P.G. Wolf, Y. Kato, H. Schlupmann, G.K.-S. Wong, K.M. Pryer. 2015. The Azolla genome and the metagenomes of its obligate endosymbionts: unlocking the massive green potential of a little fern. Next Generation Pteridology: Washington, DC.
- Der, J.P., E. Sessa, B. Marchant, F.-W. Li, **C.J. Rothfels**, E.M. Sigel, J.A. Banks, M.A. Gitzendanner, C.J. Visger, D.E. Soltis, P.S. Soltis, K.M. Pryer, P.G. Wolf. 2015. Comparative exploration of fern genome space. Poster: Plant & Animal Genome XXIII: San Diego, California.
- Li, F.-W., S. Cheng, J. Der, B. Song, X. Xu, X. Liu, A. Bräutigam, **C.J. Rothfels**, E.M. Sigel, P.G. Wolf, Y. Kato, H. Schlupmann, G.K.-S. Wong, K.M. Pryer. 2015. The Azolla genome and the metagenomes of its obligate endosymbionts: Unlocking the massive green potential of a little fern. Poster: Plant & Animal Genome XXIII: San Diego, California.

- Zhan, S.H., **C.J. Rothfels**, Z. Xi, F.-W. Li, E. Sessa, M.S. Barker, J.P. Der, M. Ruhsam, A. Larsson, D.O. Burge, L. DeGironimo, S. Ellis, C.C. Davis, P.G. Wolf, J. Leebens-Mack, M. Deyholos, G.K.-S. Wong, D.W. Stevenson. 2015. *Phylogenomics of ferns and lycophytes, two key lineages in land-plant evolution*. Poster: Plant & Animal Genome XXIII: San Diego, California.
- **Rothfels, C.J.**, A.K. Johnson, P.H. Hovenkamp, D.L. Swofford, H.C. Roskam, C.R. Fraser-Jenkins, M.D. Windham, K.M. Pryer. 2014. *Natural hybridization between lineages that diverged from each other over 50 million years ago*. Oral Paper: Evolution 2014: Raleigh, North Carolina.
- Zhang, L., **C.J. Rothfels**, A. Ebihara, E. Schuettpelz, T. Le Péchon, P. Kamau, H. He, X. Zhou, J. Prado, A. Field, G. Yatskievych, X-F. Gao, L. Zhang. 2014. *A global plastid phylogeny of the bracken fern genus Pteris (Pteridaceae) and related genera in the Pteridoideae*. Oral Paper: Botany 2014: Boise, Idaho.
- Wolf, P.G., J. Der, F-W. Li, **C.J. Rothfels**, M.A. Gitzendanner, C.J. Visger, D.E. Soltis, P.S. Soltis. 2014. *An exploration of fern genome space*. Oral Paper: Botany 2014: Boise, Idaho.
- **Rothfels, C.J.**, E. Schuettpelz. 2013. *Selection at the protein level does not drive the elevated substitution rates of vittarioid ferns*. Oral Paper: Evolution 2013, Snowbird, Utah.
- Li, F-W., **C. Rothfels**, A. Larsson, E. Sigel, L. Huiet, P. Korall, M. Ruhsam, D. Stevenson, S. Graham, G.K.S. Wong, K. Pryer. 2013. *Mining fern transcriptome data for low-copy nuclear markers*. Oral Paper: Botany 2013, New Orleans, Louisiana.
- **Rothfels, C.J.** 2012. *Polyploids are evolutionary failures*. Seminar: Systematics Discussion Group, Duke U.
- **Rothfels, C.J.**, A. Larsson, L-Y. Kuo, P. Korall, W-L. Chiou, K.M. Pryer. 2011. *Ancient, rapid, yet resolvable: The backbone phylogeny of the eupolypod II radiation*. Oral Paper: Botany 2011, St. Louis.
- Johnson, A.K., **C.J. Rothfels**, A.L. Grusz, E. Sigel, M.D. Windham, K.M. Pryer. 2011. *Sporophytes and gametophytes of notholaenid ferns (Pteridaceae) show correlated presence/absence of farina*. Poster: Botany 2011, St. Louis.
- Li, F-W., L-Y Kuo, **C.J. Rothfels**, A. Ebihara, W-L. Chiou, M.D. Windham, K.M. Pryer. 2011. *rbcL and matK earn a thumbs up as the core DNA barcode for ferns*. Oral Paper: Botany 2011, St. Louis.
- **Rothfels, C.J.** 2010. *Fast ferns: An accelerated rate of molecular evolution spans all three genomes in vittarioid ferns*. Seminar: Systematics Discussion Group, Duke University.
- **Rothfels, C.J.** 2010. *Ferns get some spine: Resolving the backbone of the eupolypods II phylogeny*. Seminar: Systematics Discussion Group, Duke University.
- **Rothfels, C.J.**, E. Schuettpelz, K.M. Pryer. 2010. *An accelerated rate of molecular evolution spans all three genomes in vittarioid ferns*. Oral Paper: Evolution 2010, Portland, Oregon.
- **Rothfels, C.J.**, M.D. Windham, K.M. Pryer. 2009. *New insights into the relationships of Cystopteris, Acystopteris, and Gymnocarpium*. Oral Paper: Botany 2009, Snowbird, Utah.
- **Rothfels, C.J.** 2008. *Diversification and Polyploidy in a Cosmopolitan Fern Genus*. Seminar: Systematics Discussion Group, Duke University.
- Windham, M.D., J. Beck, A.L. Grusz, L. Huiet, **C.J. Rothfels**, E. Schuettpelz, G. Yatskievych, and K.M. Pryer. 2008. *Using plastid and nuclear DNA sequences to redraw generic boundaries and demystify species complexes in cheilanthesoid ferns*. Oral Paper: Botany 2008, Vancouver.
- **Rothfels, C.J.**, M.D. Windham, K.M. Pryer, Jordan Metzgar, and Amanda Grusz. 2007. *Making Fronds in the Desert: Phylogenetics of Farinose Ferns (Notholaena: Pteridaceae)*. Oral Paper: Botany 2007, Chicago.
- **Rothfels, C.J.** 2005. *Odonata of Vernal Pools*. Oral Paper: Ontario Vernal Pool Association AGM, ON.
- **Rothfels, C.J.** 2004. *Research at Royal Botanical Gardens*. Seminar: McMaster University Evolution and Ecology Seminar, Hamilton ON.
- **Rothfels, C.J.**, and M.T. Johnson. 2003. *Botanists abroad*. Keynote Address: Field Botanists of Ontario AGM.

POPULAR AND OTHER PUBLICATIONS

- **Rothfels, Carl J.** 2017. *Selaginella kraussiana*, in Jepson Flora Project (eds.) Jepson eFlora, http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=44093
- **Rothfels, Carl J.**, Paul Wilson, and Thomas J. Rosatti 2017. *Selaginella*, in Jepson Flora Project (eds.) Jepson eFlora, http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=8877

- **Rothfels, Carl J.**, Ruth E.B. Kirkpatrick, Alan R. Smith & Thomas Lemieux 2017. *Pentagramma*, in Jepson Flora Project (eds.) *Jepson eFlora*, http://ucjeps.berkeley.edu/cgi-bin/get_IJM.pl?tid=77464, accessed on January 14, 2017. [And nested species pages.]
- **Rothfels, Carl J.** and Alan R. Smith 2017. Athyriaceae, Revision 4, in Jepson Flora Project (eds.) *Jepson eFlora*, http://ucjeps.berkeley.edu/cgi-bin/get_IJM.pl?tid=79419, accessed on January 14, 2017.
- **Rothfels, Carl J.** and Alan R. Smith 2017. Cystopteridaceae, Revision 4, in Jepson Flora Project (eds.) *Jepson eFlora*, http://ucjeps.berkeley.edu/cgi-bin/get_IJM.pl?tid=101729, accessed on January 14, 2017.
- **Rothfels, Carl J.** and Alan R. Smith 2017. *Cystopteris*, in Jepson Flora Project (eds.) *Jepson eFlora*, http://ucjeps.berkeley.edu/cgi-bin/get_IJM.pl?tid=10766, accessed on January 14, 2017.
- **Rothfels, Carl J.**, and Alan R. Smith. 2017. Woodsiaceae, Revision 4, in Jepson Flora Project (eds.) *Jepson eFlora*, http://ucjeps.berkeley.edu/cgi-bin/get_IJM.pl?tid=93775, accessed on January 14, 2017.
- Pryer, Kathleen M., Alan R. Smith, and **Carl Rothfels**. 2009. Polypodiopsida Cronquist, Takht. & Zimmerm. 1966. Ferns. Version 14. <http://tolweb.org/Polypodiopsida/20615/2009.01> in The [Tree of Life Web Project](#).
- **Rothfels, Carl**. 2008. Notholaenids. Cloakferns and allies. Version 23. <http://tolweb.org/notholaenids/133570/2008.12.23> [And approximately 30 nested pages] in The [Tree of Life Web Project](#).
- **Rothfels, Carl**. 2008. Pteridaceae E.D.M. Kirchn. 1831. Brake Ferns, Maidenhair Ferns, and allies. Version 23. <http://tolweb.org/Pteridaceae/29352/2008.12.23> in The [Tree of Life Web Project](#).
- Pryer, Kathleen M., Alan R. Smith, and **Carl Rothfels**. 2008. Polypodiidae Cronquist, Takht. & Zimmerm. 1966. Leptosporangiate Ferns. Version 23. <http://tolweb.org/Polypodiidae/21666/2008.12.23> in The [Tree of Life Web Project](#).
- **Rothfels, C.** 2007. The Comet Darner (*Anax longipes*: Aeshnidae): Possibly breeding in Canada. [Ontario Odonata](#) 7:38-41.
- **Rothfels, Carl**. 2007. Three years of the Hamilton odonate count. [Ontario Odonata](#) 7: 36-37.
- **Rothfels, Carl**. 2007. Odonata of Halton Region. [Ontario Odonata](#) 7: 33-35.
- **Rothfels, C.** 2007. Dense darner swarm in Algonquin Provincial Park: Observations and questions. [Ontario Odonata](#) 7:43-48.
- **Rothfels, C.J.** 2007. Significant Hamilton Study Area plant records from the herbarium of Royal Botanical Gardens (HAM): 2005 (part 3). [Wood Duck](#) 60(5): 106-111.
- **Rothfels, C.J.** 2006. The dragonflies and damselflies (Odonata) of Halton Region, Ontario. Pages 135-158 in: [Halton Natural Areas Inventory 2006: Volume 2 Species Checklists](#). Hamilton Naturalists' Club, Halton-North Peel Naturalists' Club, and South Peel Naturalists' Club. Hamilton, Ontario.
- **Rothfels, C.J.** 2006. Significant Hamilton Study Area plant records from the herbarium of Royal Botanical Gardens (HAM): 2005 (part 2). [Wood Duck](#) 60(4): 83-84.
- **Rothfels, C.J.** 2006. Significant Hamilton Study Area plant records from the herbarium of Royal Botanical Gardens (HAM): 2005 (part 1). [Wood Duck](#) 60(3): 60-62.
- **Rothfels, C.J.** 2006. Hamilton odonate count III: Zebras and spatterdocks. [Wood Duck](#) 60(1): 13-15.
- **Rothfels, C.J.** 2006. Significant Hamilton Study Area (HSA) odonate records from 2005. [Wood Duck](#) 59(9): 222-225.
- Van Ryswyk, B. and **C. Rothfels**. 2006. Significant 2005 odonate records from Halton Region. [Wood Duck](#) 59(8): 183-186.
- **Rothfels, C.J.** and W. Muma. 2006. Goldfinch killed by burdock. [Wood Duck](#) 59(7):151-152.
- **Rothfels, C.J.** 2006. One specimen, many stories. [Now @ The Gardens](#). 3(1): 4-5.
- **Rothfels, C.J.** 2006. Heating up the sanctuaries: Gardens' prescribed burns 2006. [Now @ The Gardens](#). 3(2): 7.
- **Rothfels, C.J.** 2005. Significant plant records from the herbarium of Royal Botanical Gardens (HAM): 2003. [Field Botanists of Ontario Newsletter](#). 17(2): 7-12.
- **Rothfels, C.J.** 2005. Botanical diversions: The Latin name game. [Field Bot. of Ontario Newsletter](#). 17(4): 12.
- **Rothfels, C.J.** 2005. A Brown Widow (*Lactrodetus geometricus*) arrives in Burlington. [Wood Duck](#). 59(4): 98.
- **Rothfels, C.J.** 2005. The second annual Hamilton odonate count. [Wood Duck](#). 59(3): 53-55.
- **Rothfels, C.** 2005. American Columbo (*Frasera carolinensis*) in the Cartwright Nature Sanctuary. [Wood Duck](#). 59(1): 3-4.
- **Rothfels, C.J.** 2005. Significant 2004 Hamilton Study Area plant records from the Royal Botanical Gardens herbarium (HAM). Part II: Alphabetical families Lardizabalaceae to Vitaceae. [Wood Duck](#). 58(9): 219-223.
- **Rothfels, C.J.** 2005. Significant 2004 Hamilton Study Area plant records from the Royal Botanical Gardens herbarium (HAM). Part I: Alphabetical families Aceraceae to Lamiaceae. [Wood Duck](#). 58(8): 187-192.

- Welch, T. and **C.J. Rothfels**. 2005. Trumpeter swans (*Cygnus buccinator*) fledge young at The Gardens. Now @ The Gardens. 2(4).
- Scott, E. and **C. Rothfels**. 2005. Getting muddy for the marsh—marsh volunteer plantings 2005. Now @ The Gardens. 2(4).
- Rivet, R. and **C.J. Rothfels**. 2005. York Boulevard Prairie prescribed burn 2005. Now @ The Gardens. 2(3).
- **Rothfels, C.J.**, T.Theysmeyer, and B.McKean. 2005. Rare fish found at the Fishway. Now @T he Gardens.
- **Rothfels, C.J.** 2005. Princess Point Earth Day planting. Now @ The Gardens. 2(2).
- **Rothfels, C.J.** and P.M. Catling. 2005. Major dragonfly migration at Hamilton. Ontario Odonata. 6: 40.
- **Rothfels, C.J.** 2004. Unicorn Clubtail (*Arigomphus villosipes*: Gomphidae): New records and summary of status in Ontario. Ontario Odonata. 5: 5-11.
- **Rothfels, C.J.** 2004. Significant plant records from the herbarium of Royal Botanical Gardens (HAM): 2002. Field Botanists of Ontario Newsletter. 16(3): 7-12.
- **Rothfels, C.J.** 2004. The First Annual Hamilton Odonate Count. Wood Duck. 58(2): 27-29.
- **Rothfels, C.J.**, S. Spisani and J. Sylvester. 2004. Significant 2003 Hamilton Study Area plant records from the Royal Botanical Gardens herbarium (HAM). Wood Duck. 57(9): 213-219.
- **Rothfels, C.J.** 2004. Stoneflies' Great-great-great-great Grandparents. Wood Duck. 57(8): 179.
- **Rothfels, C.J.** 2004. Intrepid insects: Capniids in Cootes. Wood Duck. 57(7): 153-154.
- **Rothfels, C.J.** 2004. The beetle, the oak, the fire, and the future of our nature sanctuaries. Now @ The Gardens.
- **Rothfels, C.J.** 2003. Royal Botanical Gardens Odonate Count 2003. Ontario Insects. 9(1): 11-13
- **Rothfels, C.J.** 2003. Synopsis of Ontario herbaria. Field Botanists of Ontario Newsletter. 16(1): 7-19.
- **Rothfels, C.J.** 2003. Field trip report: Yarmouth Natural Heritage Area. FBO Newsletter. 15(4): 7-9.
- **Rothfels, C.J.** 2003. Royal Botanical Gardens odonate count 2003. Wood Duck. 57(1): 5-7.
- **Rothfels, C.J.** 2003. Significant 2002 Hamilton Study Area plant records from the Royal Botanical Gardens herbarium (HAM). Wood Duck. 56(7): 155-161.
- **Rothfels, C.J.** 2002. Botanical Diversions: Salad taxonomy. Field Botanists of Ontario Newsletter. 15(1): 8-10.
- **Rothfels, C.J.** 2002. Review: Lichen guides. Wood Duck. 56: 68.
- **Rothfels, C.J.** 2002. Learning lichens from Ernie Brodo. Wood Duck. 56: 51-54.
- **Rothfels, C.J.** 2002. Listening to whipbird duets in Australia. Wood Duck. 56: 21-22.
- **Rothfels, C.J.** 2002. Synthesis and Summary of the Historic Fire Regime of Ecodistricts 5E-9 and 5E-10. Ontario Ministry of Natural Resources, Ontario Parks. Unpublished report. 37pp.
- **Rothfels, C.J.** 2001. Doi Inthanon – A Hamilton Naturalist Abroad. Wood Duck. 55(3): 57-58.
- **Rothfels, C.J.** and M.T. Johnson. 2000. Botany Excursions: Massassauga Point and Point Petre Wildlife Area, Prince Edward County. Field Botanists of Ontario Newsletter. 13(3): 6-10.
- **Rothfels, C.J.** 1998. Birds of the Feather Band Together. Wood Duck. 51(7): 131-136.

Forrest D Freund

CURRICULUM VITAE

Forrest D. Freund

University of California Berkeley, Integrative Biology Dept.

e-mail: lentic64@berkeley.edu

EDUCATION

Aug 2014: MS Botany, Claremont Graduate University, Claremont, Ca: Master's thesis: Characterizing Quantitative Variation in the Glossopodia of Three Western North American *Isoëtes* Species; Committee: Dr. James Mark Porter, Dr. James Travis Columbus, Dr. Lucinda McDade

Dec 2007: BS Botany, Humboldt State University, Arcata, Ca: Senior thesis: Proxy Based Digestion: Bacterial Symbiosis of *Darlingtonia californica*; Advisor: Dr. Michael Messler

May 2005: AS Biology, College of Marin, Kentfield Ca.

PRESENTATIONS

Freund, F., W. Freyman, C. Rothfels. 2017. *Inferring the evolution of corm lobation in Isoëtes using Bayesian model-averaged ancestral state reconstruction.* Ft. Worth, Texas, United States of America

Kao, T., **F. Freund**, C. Rothfels, M. Windham, and K. Pryer. 2017 *Low-copy nuclear data for notholaenid ferns (Pteridaceae) corroborate plastid phylogeny over traditional morphological groupings.* Ft. Worth, Texas, United States of America

Columbus, J. T., A. Fisher, **F. Freund**, A. Ingram. 2014. *Origin of the Centropodia clade (Poaceae).* *Botanical Society of America Botany Conference.* Boise, Idaho, United States of America

PAPERS PUBLISHED

Freund, F.D., W.A. Freyman, and C.J. Rothfels. 2018. Inferring the evolutionary reduction of corm lobation in *Isoëtes* using Bayesian model-averaged ancestral state reconstruction. *American Journal of Botany* 105: 275–286.

Freund, F.D. 2016. Characterizing quantitative variation in the glossopodia of three Western North American *Isoëtes* species. *American Fern Journal* 106: 87–115.

Kao, T. T., Pryer, K. M., **Freund, F. D.**, Windham, M. D., & Rothfels, C. J. 2019. Low-copy nuclear sequence data confirm complex patterns of farina evolution in notholaenid ferns (Pteridaceae). *Molecular phylogenetics and evolution*, 138, 139-155.

RELAVANT COURSE WORK

College of Marin

BIOL 116 – Animal and Plant Diversity

SPCH 120 – Interpersonal Communication

SPCH 128 – Intercultural Communication

Humboldt State

Bot 350 – Plant Taxonomy

Bot 353 – Phycology

Bot 359 – Ascomycetes and Bacidiomycetes

Forrest D Freund

Bot 372 – Vascular Plant Morphology

Claremont Graduate University

Bot 305 – Plant Morphology & Anatomy

Bot 370 – Quantitative Phylogenetics

Bot 371 – Morphometrics

Bot 372 – Practicum in Botany: Agristology

Bot 411 – Special Topics in Plant Systematics: Botanical Nomenclature

University of California, Berkeley

INTEGBI 160 – Evolution

INGEBI 200 – Principles of Phylogenetics

TEACHING EXPERIENCE

Spring 2018, Spring 2020 – Introduction to California Plants (INTEG 102L), University of California, Berkeley – taught a lab section of Intro to California Plants. Duties included presenting material to students, developing presentations, exams and quizzes, leading fieldtrips and co-managing the lab section with a second GSI.

Spring 2016, Spring 2017, Spring 2019 – Vascular Plant Systematics (INTEG 168L), University of California, Berkeley – taught a lab section of vascular plant systematics. Duties included presenting materials to students, setting up labs, preparing and grading quizzes, proctoring exams and attending weekly planning meetings.

Fall 2015, Fall 2016, Fall 2017, Fall 2018, Fall 2019, Fall 2020 – General Biology (Bio 1B), University of California, Berkeley – co-taught a lab section of general biology. Duties included presenting the labs to students and answering their questions on the materials, preparing and grading quizzes, holding office hours, and proctoring exams.

PROFESSIONAL EXPERIENCE

2014-2015 Curatorial Assistant, Rancho Santa Ana Botanic Garden – digitization of Marcus E. Jones herbarium collection; specimen entry into the RSA herbarium database; Herbarium seed collection curation; duties include sorting and filing the seed collections for the RSA herbarium.

2009-2010 Field Biology Intern, Bureau of Land Management (BLM) – worked in the field office; duties included management and curation of the field office herbarium, monitoring and surveying for rare, endangered and special status plants on BLM lands. Other duties include managing the Seeds of Success program for the field office, monitoring of mine shafts for bat activity, fieldtrip guide to 3rd grade classes and noxious weed removal from BLM lands.

2006-2007 Greenhouse Assistant, Humboldt State University – worked in the teaching greenhouse; duties included watering, transplanting and caretaking for the extensive teaching collection in the greenhouse.

1999-2005 Lab Manager's Assistant, College of Marin – helped maintain the biological labs at College of Marin; duties included preparation of labs, making cultures and media for microbiology, maintaining lab equipment and museum specimens.

Forrest D Freund

RESEARCH ASSISTANTSHIPS

Lab Manager's Assistant (Fall 2011) – Assisted lab manager at Rancho Santa Anna Botanic Garden with running the Molecular and Anatomy lab facilities at the school. Duties included chemical inventory, preparation of communal reagents, maintaining lab equipment, and monthly billing of research accounts.

***Loesellia* L. (Polemoniaceae) Morphometric and Molecular study (Spring 2012)** – Extensive survey of the seed coat and internal structure of the seeds of various *Loesellia* species, using both light and scanning electron microscopy. Additionally, performed DNA extractions and Sanger sequencing of several *Loesellia* species provided by the project's PI.

Molecular Phylogenetics of *Barleria* L. (Acanthaceae Juss.) (Fall 2012) – Contributed to an ongoing project in the molecular systematics of the *Barleria* genus in Acanthaceae. Major duties were extraction of DNA from silica dried & herbarium materials using both CTAB and extraction kit protocols, amplification of regions as assigned by the PI, and conducting cycle sequencing of amplification products using Sanger sequencing methods.

FELLOWSHIPS

Smithsonian Institution Summer Research Fellowship (May-Aug 2013) – A paid fellowship at the Smithsonian Natural History Museum working with Dr. Elizabeth Zimmer and Dr. W. C. Taylor on the phylogeny of *Isoëtes* in the new world. This fellowship included training at the NMNH, sequencing of the ITS, LFY, AT103 nuclear genes, and the *atpF*, *matK*, *psbK*, *rpoC1* and the *psbA-trnH* and *atpB-rbcL* intergenic spacers from the chloroplast. Additionally, images of the megasporangia from all described species of *Isoëtes* from the continental USA were captured using the scanning electron microscope facilities at the institute.

GRANTS

The Heckard Fund, Jepson Herbarium (2017)

Myrtle Wolfe Grant, California Native Plant Society (2018-2019)

HONORS & AWARDS

Honorable Mention, NSF Graduate Research Fellowship (2012)

Honor roll at Humboldt State University (2006)

Graduated Cum Laude from Humboldt State University (2007)

Lifetime member of Alpha-Gamma-Sigma honor society (2004)

PROFESSIONAL ASSOCIATIONS

American Fern Society (Lifetime member)

American Society of Plant Taxonomists (Lifetime Member)

Botanical Society of America