

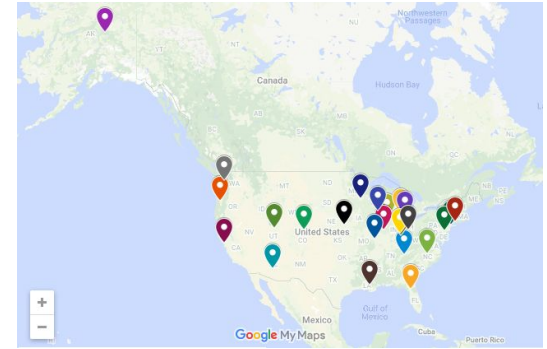
Building a Global Consortium of Bryophytes and Lichens: Keystones of Cryptobiotic Communities (GLOBAL)



Jessica Budke & Matt von Konrat



- Collaborators: 25 US Herbaria
- Project Start Date: 15 September 2021
- Project Duration: 3 years



BROWN




Yale
University
Herbarium



GLOBAL Goals


- I. Establish a novel cryptobiotic consortium integrating 6M records.

Consortium of
NORTH AMERICAN BRYOPHYTE HERBARIA



Home Search Images Species Checklists Crowdsourcing Associated Projects More Information Sitemap Help [Log In](#) [New Account](#)

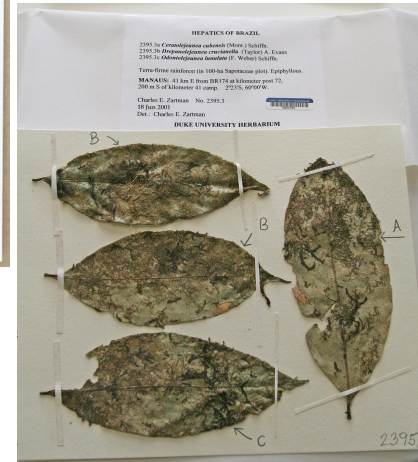
Consortium of
NORTH AMERICAN LICHEN HERBARIA



Home Search Images Species Checklists Crowdsourcing Associated Projects More Information Sitemap Help & Resources [Login](#) [New Account](#) English ▾

GLOBAL Goals

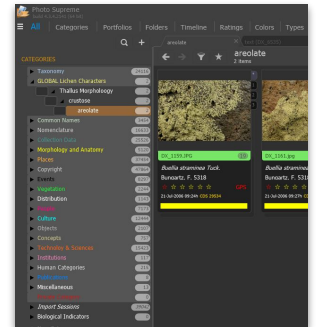
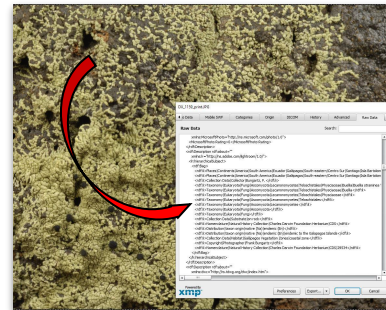
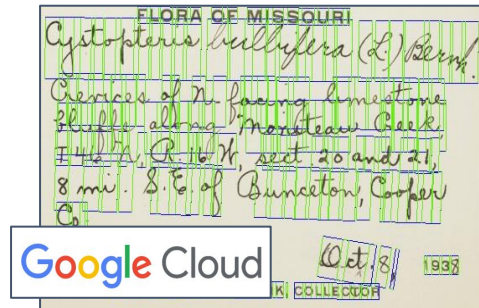
- I. Establish a novel cryptobiotic consortium integrating 6M records.
- II. Digitize label data and specimens for 1.2M bryophytes/lichens focusing on non-North American specimens from 25 US herbaria.



GLOBAL Goals

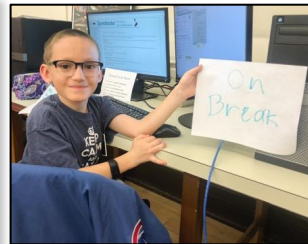
- I. Establish a novel cryptobiotic consortium integrating 6M records.
- II. Digitize label data and specimens for 1.2M bryophytes/lichens focusing on non-North American specimens from 25 US herbaria.
- III. Create a connected world: Innovative automation, integration, image tagging, and machine learning.

MORPHOBANK
HOMOLOGY OF PHENOTYPES OVER THE WEB &
A database of peer-reviewed morphological matrices

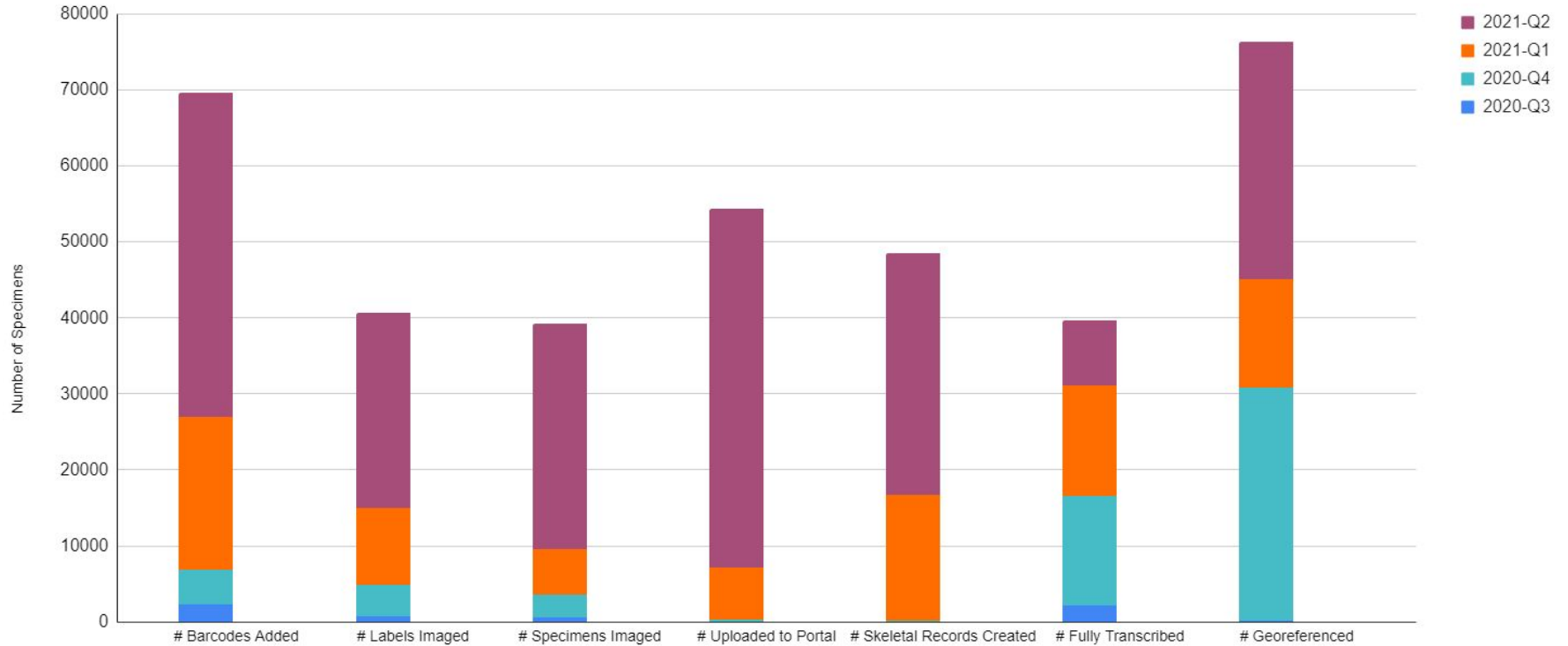


GLOBAL Goals

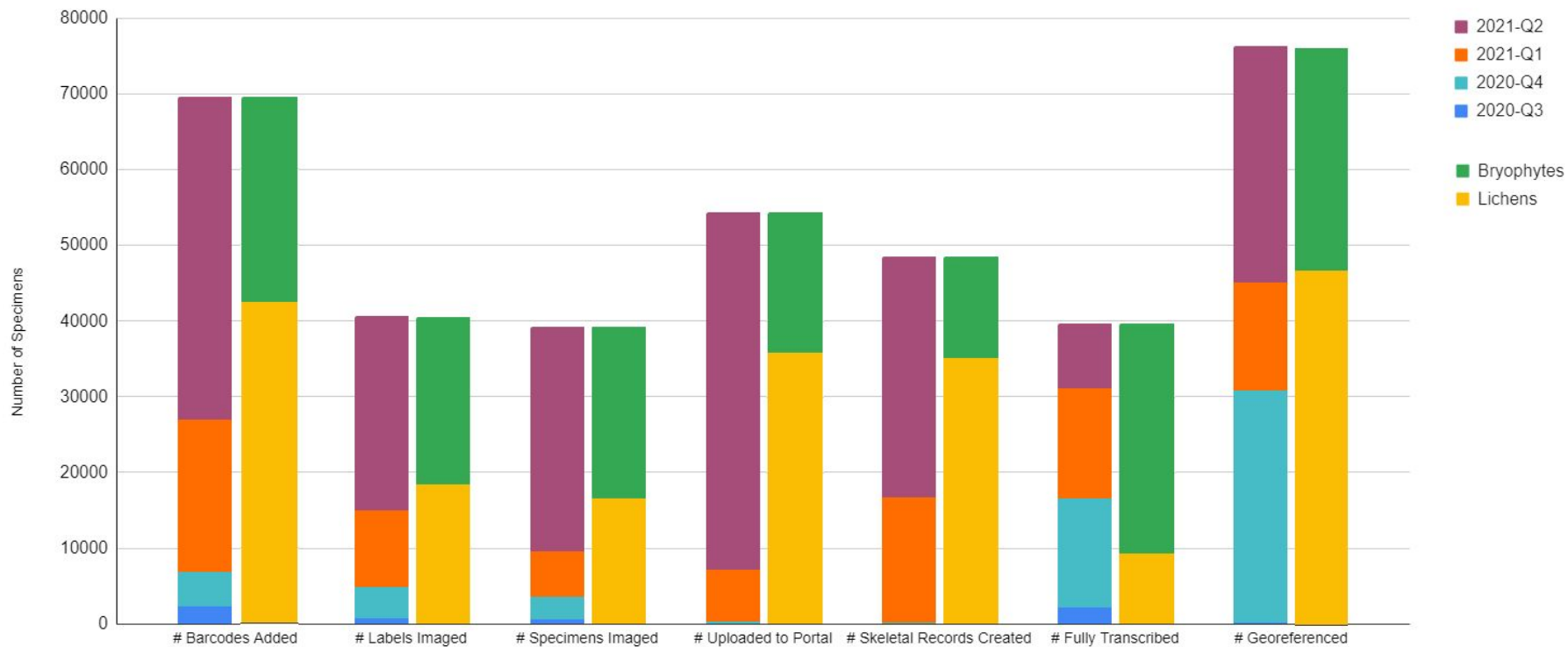
- I. Establish a novel cryptobiotic consortium integrating 6M records.
- II. Digitize label data and specimens for 1.2M bryophytes/lichens focusing on non-North American specimens from 25 US herbaria.
- III. Create a connected world: Innovative automation, integration, image tagging, and machine learning.
- IV. Focus on public engagement and education.



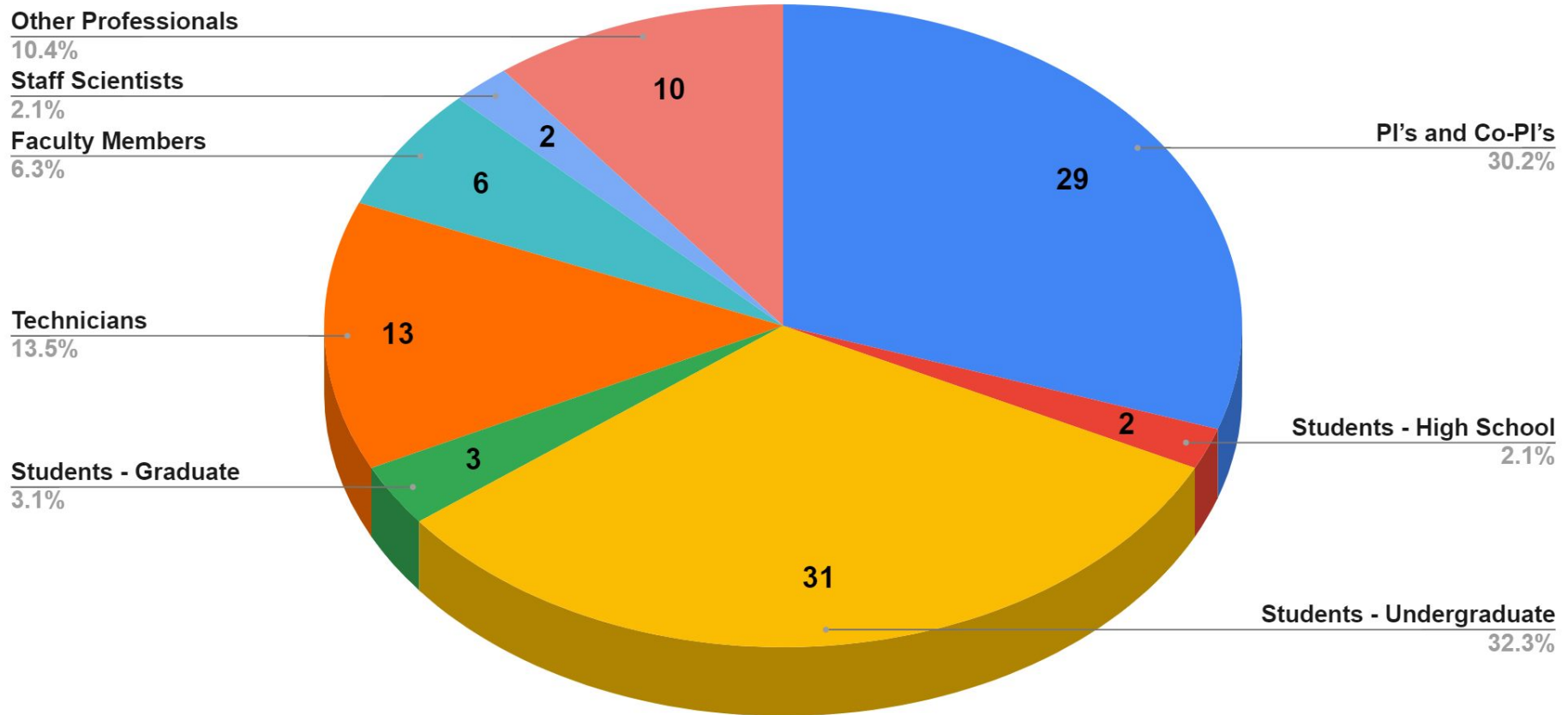
GLOBAL Digitization Progress



GLOBAL Digitization Progress



GLOBAL Participants



Acknowledge the Traditional Custodians of the land on which we virtually gather today, and pay my respects to their Elders, past and present. I extend that respect to Indigenous and First Nation people all around the world that are joining us today.

Building a Global Consortium of Bryophytes and Lichens: keystones of cryptobiotic communities

- I. Establish a novel cryptobiotic consortium integrating 6M records.
- II. Digitize label data and specimens for 1.2M bryophytes/lichens focusing on non-North American specimens from 25 US herbaria.
- III. Create a connected world: Innovative automation, integration, image tagging, and machine learning.**

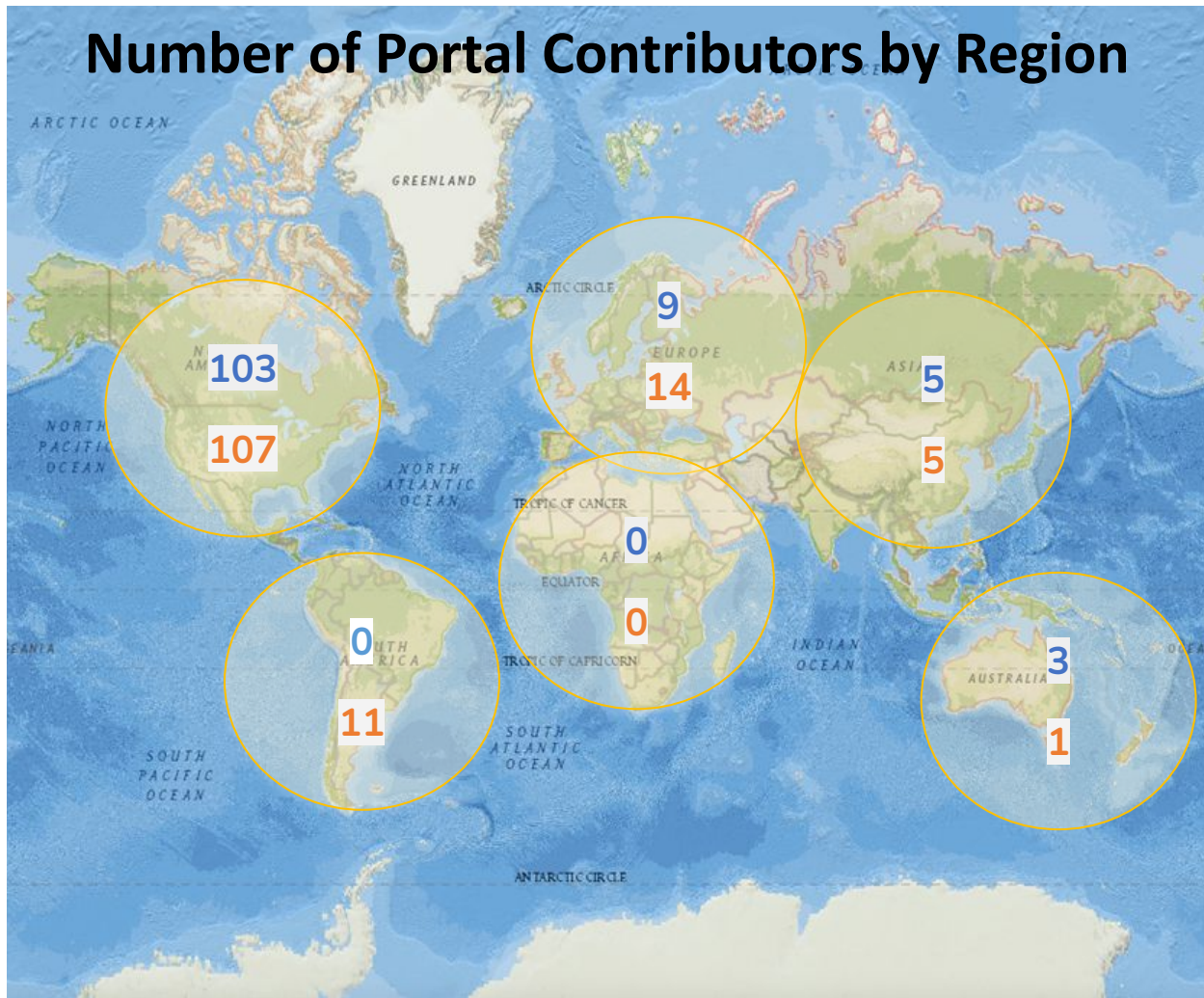
Number of Portal Contributors by Region

Added to CNABH or CNALH

- 21 new international herbaria
- 9 new countries
- 972,743 new bryophyte specimen records
- 998,083 new lichen specimen records

Bryophyte
Herbaria

Lichen
Herbaria





LUND UNIVERSITY

NATURAL HISTORY MUSEUM

富山市科学博物館
TOYAMA SCIENCE MUSEUM



Manaaki Whenua
Landcare Research



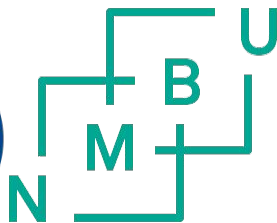
Saitama Museum of Natural History



Naturhistoriska
riksmuseet



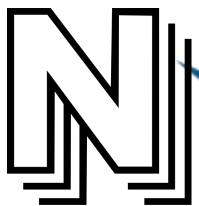
LOMONOSOV MOSCOW
STATE UNIVERSITY



Norwegian University
of Life Sciences

国立科学博物館

National Museum of Nature and Science



Nationalmuseet

IBARAKI
NATURE MUSEUM

UNIVERSITY OF
GOTHENBURG



BERGIANSKA
TRÄDGÅRDEN
Bergius Botanic Garden



Tāmaki
Paenga Hira
Auckland
War Memorial
Museum

Duplicate Matching

Duplicate Coordinate R Script

- Run for 13 collections
- Julie and Katie cleaned up lists of possible duplicates
- 8,000 imported to portals (30,000+ additional awaiting review)

International Collections Data

- 4 more international collections added to the portals in 2021-Q2
- 21 total collections, 970,000+ Bryophyte and 980,000+ Lichen records

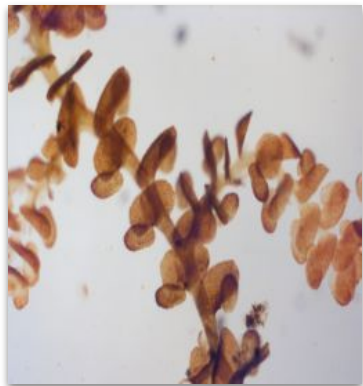
Exsiccatae List and Field Updates

- ASU working on protocols to add exsiccati identifier for Snapshots
- Blanka cleaned 1/5 of the exsiccatae library on the Bryophyte Portal

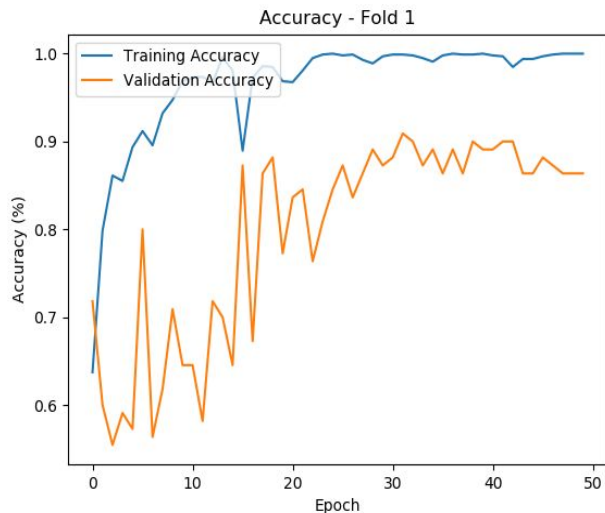


GloBaL: Deep-learning approaches

- taxonomy
- natural history collection management
- species identification, co-occurrences



von Konrat et al. in review



Accuracy
Training: 100%
Validation: 86%

Convolutional Neural Networks (CNN)

Step 1: Train NN

Step 2: Test & use NN

Training & Validation images

Testing images

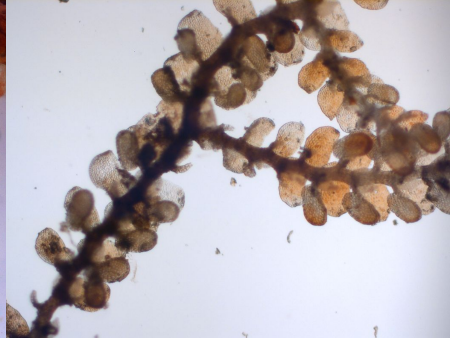
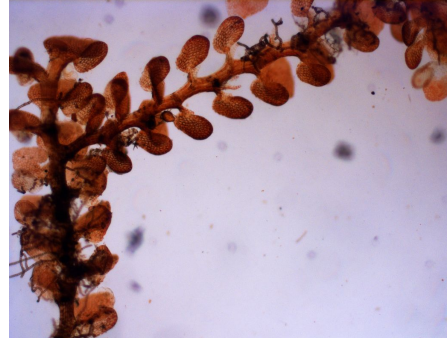


Epochs - rounds of training (5 epochs = each training image is used 5 times)

Results

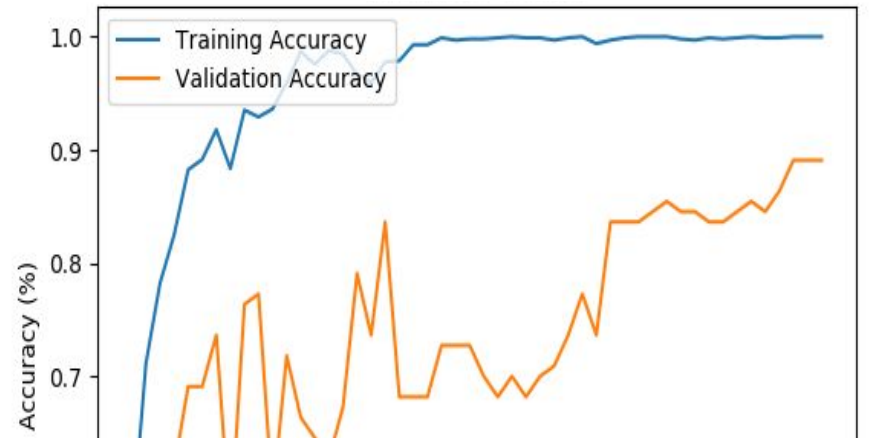
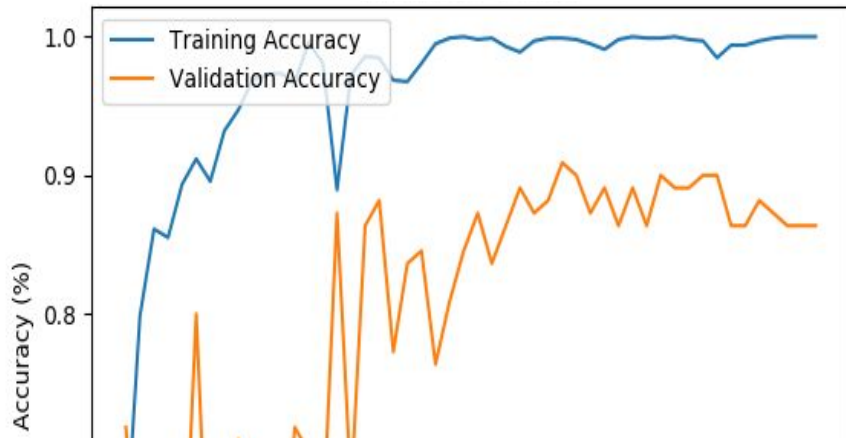


Frullania rostrata

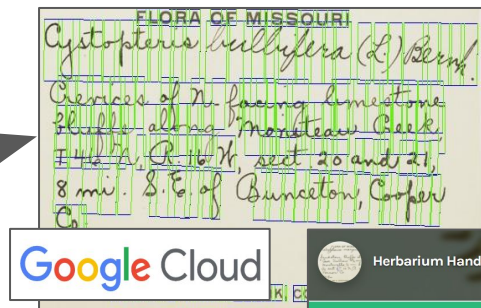
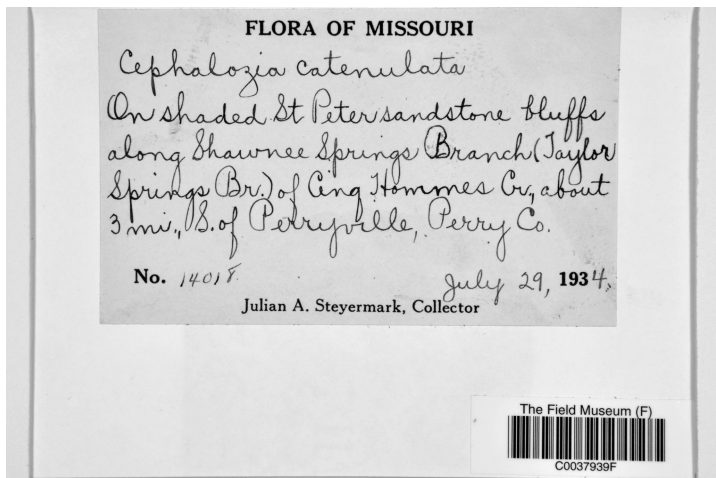


undescribed species

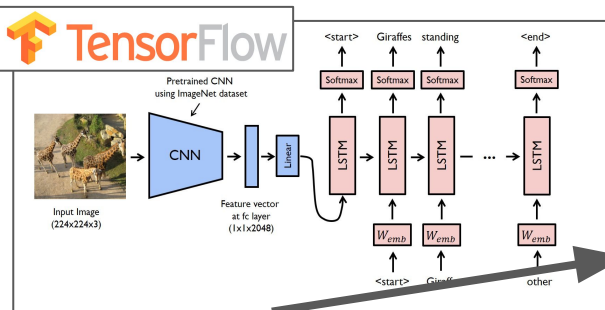
CNN: ~91% accuracy in differentiating species



Unlocking handwritten text using Machine learning solutions



Existing tools can get us started...



Field Museum

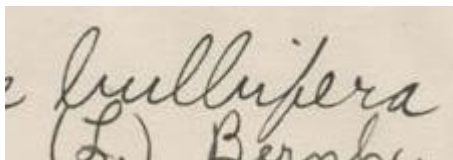
Catalog #: C0037939F
Occurrence ID (GUID): b1e5a1bc-4d92-4f0a-8986-eb72476ea438
Secondary Catalog #: 886028
Taxon: *Cephalozia catenulata* (Huebener) Lindb.
Family: Cephaloziaceae
Collector: J. A. Steyermark
Number: 14018
Date: 1934-07-29
Verbatim Date: 7/29/1934
Locality: United States of America, Missouri, Perry, Shawnee Springs Branch
Cinque Homme Creek, about 3 miles south of Perryville
Habitat: On shaded St. Peter sandstone bluffs

Specimen Images



CNN-RNN-CTC + handwritten *word* images

Raw Google Cloud images



Manually cleaned



Thresholding



Cropped whitespace

Padded all words to
the same image size

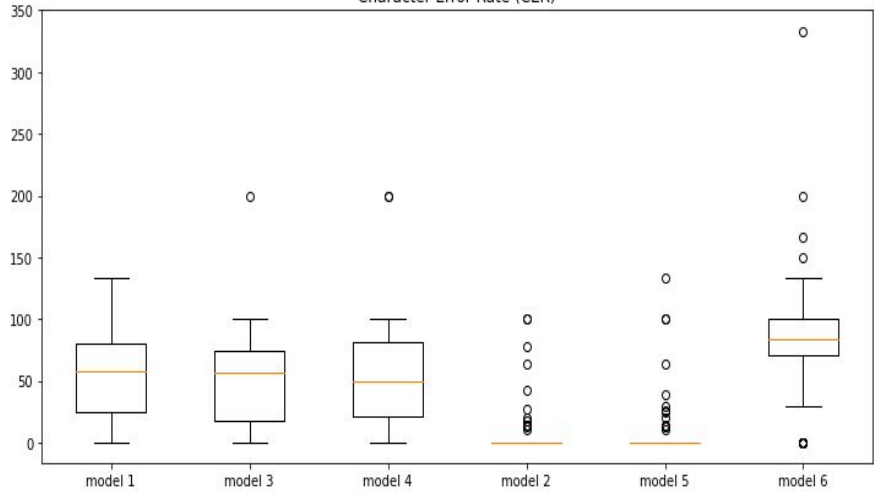


CNN-RNN-CTC initial models

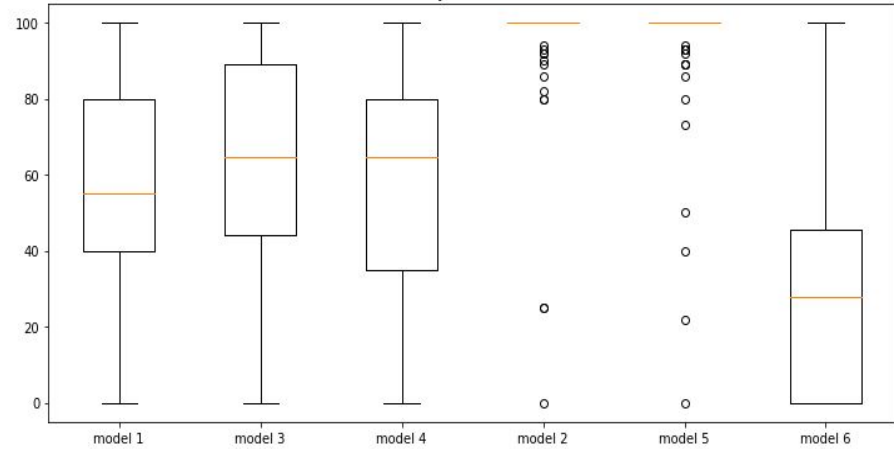
626 training images, 70 testing images

random seed	1	2	3	4	5	6	7
Run #	1	2	3	4	5	6	7
label	prediction	prediction	prediction	prediction	prediction	prediction	prediction
1 Howell	Soadlt	Nol	Hoel	Howell	Howell	Duriuers	
2 T53	T5W	T23	T13	T53	T53	T2,	
3 Stone	Sian	Shon	Sre	Stone	Stone	Proek	
4 Camptosorus	Cart	Patu	Cap	Camptorus	Camptosorus	laigsaCaolu	
5 Hollow	Ciro	bl	Slo	Hollow	Hollow	biufsn	
6 Creek,	Creek	Creek	Creek	Crek	creek	Creek	
7 northwest	norhest	at	rorhet	northwest	nortwest	arguats	
8 Michx.	Mie.	Mihx.	Micx.	Michx.	Michx.	Boner	
9 at	to	t	of	at	at	S.	
10 miles	sess	mily	nile	miles	miles	nirth	
11 Shaded	Sade	Bae	leme	Shaded	Shaded	limelas	
12 margin	magy	mrne	ay	margin	margin	margpgerc,	
13 W,	N	W	N,	W,	W,	W	
14	658 T5	Aune		368	658	658 Hug	
15 R9W,	R1W,	R13W,	R2W,	R9W,	R9W,	R23W	
16 Willow	Can	bl	tar	Willow	Willow	bats	
17 Watt	Wat	Mot	Mect	Mear	Wat	Oect.	
18 mi	mi.	mi	min	mi.	mi.	we.	
19 May,6,1939	No.619	Mar,9	Mar,13	May,6,19	May,6,19	narpne	
20 mi.	mi.	mi	mid	mi.	mi.	nia	
21 St.	Co.	Set.	Co.	St.	St.	So.	
22 Pi	Co.	Pi	Co.	Pi	Pi	Pi	

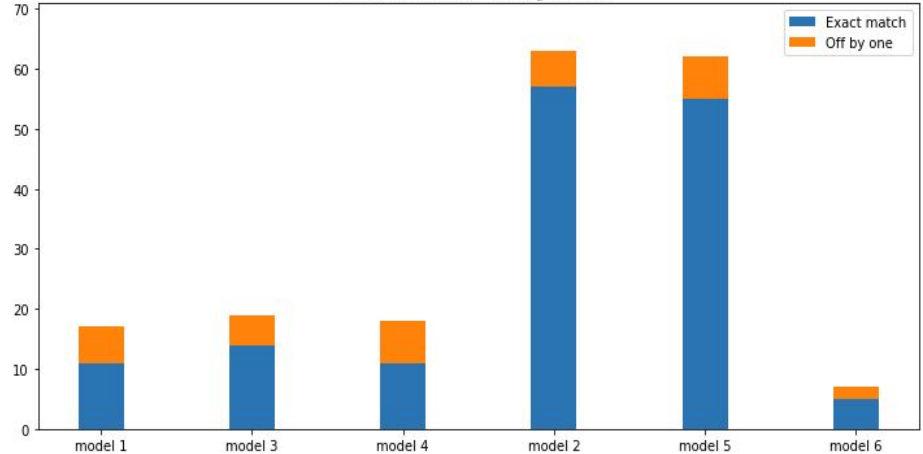
Character Error Rate (CER)



Fuzzy Match Ratio



Exact/Almost Exact String Matches



Python 3 with Tensorflow 2

Google Colab (~Jupyter Notebook with virtual GPU)

Building a Global Consortium of Bryophytes and Lichens: keystones of cryptobiotic communities

- I. Establish a novel cryptobiotic consortium integrating 6M records.
- II. Digitize label data and specimens for 1.2M bryophytes/lichens focusing on non-North American specimens from 25 US herbaria.
- III. Create a connected world: Innovative automation, integration, image tagging, and machine learning.
- IV. Focus on public engagement and education.**



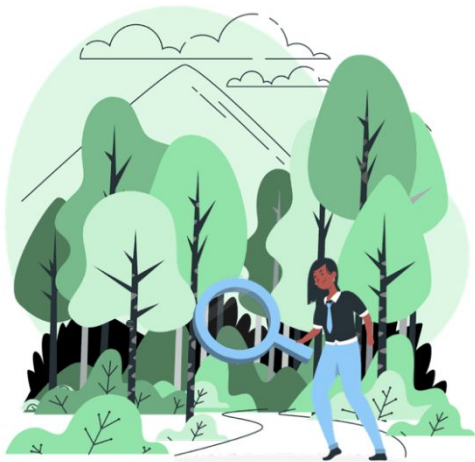
Unfolding of Microplant Mysteries

Welcome! Bienvenidos! Bem-vinda! Namaste! Marhaba! Unlock mysteries, become a scientific detective!

Help discover the microscopic
world of tiny plants

[Learn more](#)

What secrets lie within the microplants?



Microplants, scientifically named bryophytes, are a group of green land plants. They include liverworts, mosses, and hornworts. There are an estimated 25,000 species in the world. They prefer damp habitats although some species can survive in drier environments. Bryophytes are non-vascular land plants, i.e., do not have a complex transport system. They are seedless plants and do not have flowers. They reproduce asexually through spores (gametangia and sporangia).



Microplants, scientifically named bryophytes, are a group of green land plants. They include liverworts, mosses, and hornworts. There are an estimated 25,000 species in the world. They prefer damp habitats although some species can survive in drier environments. Bryophytes are non-vascular land plants, i.e., do not have a complex transport system. They are seedless plants and do not have flowers. They reproduce asexually through spores (gametangia and sporangia).

Get started ↓

Determining the Reproductive Structure of a Liverwort - Refer to field guide and tutorial Stem and Branching Patterns:

[Determining the Reproductive Structure of a Liverwort](#)

[Stem and Branching Patterns](#)



TASK

TUTORIAL

Please identify if the image of the microplant shown best corresponds to a female, male, sterile, or both a female and a male structure.

Female

Male

Both Female and Male

Sterile

NEED SOME HELP WITH THIS TASK?

Done & Talk

Done



Thanks for volunteering your time and your efforts to help us collect data to advance the identification and classification of these microplants.

Please don't worry about a wrong

Continue



Acknowledgements



iDigBio
Integrated Digitized Biocollections

National Science Foundation

- Advancing Digitization of Biodiversity Collections

Collectors & Researchers of the past and present

2011 Bryophyte/Lichen TCN: Leadership & Participants

Especially, Tom Nash & Corinna Gries



Collaborating Herbaria: ALA, ASU, BRU, BRY, CINC, COLO, DUKE, F, FLAS, ILL/ILLS, LSU, MICH, MIN, MO, MSC, MU, NEB, NY, OSC, PH, TENN, UC, WIS, WTU, YU

CONTACT US: globaltcn@utk.edu

<http://globaltcn.utk.edu>

#GlobalTCN

GLOBAL Team

Aaron Liston

Aimee Davis

Alan Fryday

Alan Prather

Alison Staelgraeve

Amanda Chandler

Amy Harmon

Andrew Gallardo

Andy Miller

Ardath Dixon

Arthur J. Shaw

Barbara Thiers

Blanka Aguero

Brent Mishler

Brian Heitz

Brian Schuh

Cameron Lala

Campbell Webb

Carson Parham

Christina Mozzicato

Cristian Cartuche

Daniel Le

Daniel Stanton

Diego Inclan

Dina Clark

Edward Gilbert

Elana Benamy

Elizabeth H. Teresi

Emily Clark

Emma Kruse

Eric J. Tepe

Erin Tripp

Francois Lutzoni

Frank Bungartz

Gaby Mata

Garth Holman

George Weiblen

Ginger Apolo

J. Ryan Allen

Jack Haynes

Jaclyn Jones

Jake Burgoyne

Jake Henrie

James Lendemmer

James Mickley

Jason Alexander

Jeffrey Clancy

Jennifer Kluse

Jessica Budke

Jessie Uehling

Jesus Hernandez

John Brinda

Jordan Teisher

Joshua Jacobs

Julie Smith

Katie Pearson

Kayla M. Wheatley

Kenneth Cameron

Kent Perkins

Kim Kersh

Kim Watson

Klara Scharnagl

Kyelle Corcoran

Laura Briscoe

Laura Lagomarsino

Lauren Keeling

Laurie Heldman

Leanna McMillin

Leanne Sheffer

Lilli Young

Lucas C. Majure

Lucas Ferguson

Madison Dyer

Madison Latiolais

Margaret Oliver

Maria L. Montero

Matt Chansler

Matt von Konrat

Maya Mahoney

Miranda Zwingelberg

Natalie Detwiler

Nico Franz

Nicole Tineo

Nidhi Thirthamattur

Nkosi Evans

Olivia Leek

Olivia Taylor

Patrick Sweeney

Phillip Anderson

Rosa Batallas

Scott LaGreca

Stefanie Ickert-Bond

Stephanie Zaborac-Reed

Steve Leavitt

Stuart McDaniel

Thomas Barlow

Thomas Nash

Thorsten Lumbsch

Timothy Hogan

Timothy James

Timothy Whitfield

Todd Widhelm

Tyson J. Thorpe

Wendy Quinlan

William A. Rivero

William Seely

Wyatt Gaswick

Yarency Rodriguez

Zoe Ryans

Zoey Molsberry





Barbortia ischyphylla Brid.
Newbould - Bass.
1860



0278334



Yale University Herbarium
Barcode
YU.167841



Questions?



Yale University Herbarium
Barcode
YU.167840