TCN Quarterly Progress Report

TCN Name

Building a global consortium of bryophytes and lichens: keystones of cryptobiotic communities (GLOBAL)[1]

Person Completing the Report

Miranda Zwingelberg (GLOBAL Project Manager)

Share Progress in Digitization Efforts

This report covers progress completed during the period of April 1 – June 30, 2025.

Workflows, Equipment, and Personnel

Most GLOBAL institutions continued GLOBAL progress during 2025-Q2.

Specimen digitization at ASU funded by the grant has now finished. The employment of their student worker Ramisa Zaman, who was in charge of specimen digitization, ended in May of this year, when Ramisa graduated. A last batch of images 190 lichen specimens with 202 labels was then uploaded. The total of specimens barcoded, labeled, imaged and uploaded to the portals, both of bryophytes and lichen specimens, exceeds the number ASU were committed to digitize according to the grant proposal: For the lichens more than five times the original amount of

[1] Throughout this report, herbaria are referred to by their Index Herbariorum acronyms, which correspond to institutional names as follows: ALA = University of Alaska, Fairbanks, ASU = Arizona State University, BISH = Bishop Museum, BRY = Brigham Young University, CINC & MU = University of Cincinnati & Miami University, COLO = University of Colorado, DUKE = Duke University, F = The Field Museum, FLAS = University of Florida, ILL & ILLS = University of Illinois at Urbana-Champaign & Illinois Natural History Survey, LSU = Louisiana State University, MICH = University of Michigan, MIN = University of Minnesota, MO = Missouri Botanical Garden, MSC = Michigan State University, NY = New York Botanical Garden, OSC = Oregon State University, PH = The Academy of Natural Sciences of Drexel University, PTBG = National Tropical Botanical Garden, TENN = University of Tennessee, Knoxville, UC = University of California, Berkeley, WIS = University of Wisconsin, YU = Yale University

specimens were barcoded (557%), one and a half times the amount of labels digitized (157%), and more than one and a half times the amount of specimens imaged (148%). For the bryophytes three times the amount of specimens were barcoded (317%), almost twice the amount of labels digitized (185%), and more than one and a half times the amount of specimens imaged (163%).

BISH barcoded 2,000 bryophytes and 200 lichens, imaged 2,000 bryophytes and 200 lichens, and data entered and fully transcribed 1900 bryophytes and 200 lichens. 200 lichen identifications by C.W. Smith were made, some only to genus level.

CINC added 1,431 bryophyte and 104 lichen records to the portal, 873 bryophyte images, and fully transcribed 1089 bryophyte and 125 lichen records.

COLO captured 681 lichen packet images and skeletal records, 1,212 specimen images for the lichen collection. 681 specimens were barcoded. Images and all skeletal data captured through 6/30/2025 have been uploaded to the portal. 466 transcriptions were completed. COLO captured 3,947 bryophyte packet images and skeletal records, 3,787 specimen images for the bryophyte collection. 3,947 specimens were barcoded. Images and all skeletal data captured through 6/30/2025 have been uploaded to the portal. 1,589 transcriptions were completed. COLO is finding it increasingly difficult to staff student positions. The campus minimum will go to $16.82 in July 2025, which will only add to the problem. The former work study student they hired in January 2025 finished his appointment in May, most of his time was working on transcriptions. COLO decided to submit a no-cost extension at the start of July 2025 and is waiting for approval.

DUKE barcoded 2,660 bryophyte specimens. They imaged 3,116 bryophyte labels and 376 bryophyte plants. All images and skeletal data have been uploaded to the bryophyte portal. They fully transcribed 168 bryophyte specimens and georeferenced 38 bryophyte records.

At F, 14,774 bryophyte specimens and labels were imaged. In the next quarter they are returning to lichens. Using their new pipeline they have fully transcribed 12,500 labels that are undergoing human review.

FLAS has now spent all grant funds.

MO barcoded 1,730 bryophyte specimens and imaged 9,526 bryophyte labels. They created 9,526 skeletal records and fully transcribed 1 label.

OSC completed the imaging of lichen specimens.

PTBG continued to digitize any new specimens that have been added to their collection.

TENN continued work on georeferencing bryophyte specimens. A no-cost extension to continue work into Year 6 was requested from and approved by the NSF.

At UC, the lichens are completely imaged. Their focus during this quarter continued to be on transcribing, and having finished the lichen records they have moved fully into bryophytes. They appear to have overestimated the number of eligible bryophyte specimens – they have completed one pass through the bryophyte collection to image the clearly eligible specimens, but are now making a second pass through the bryophytes to image eligible specimens that were hidden due to our filing system. These will then be transcribed. A no-cost extension to continue work into Year 6 was requested and from the NSF.

WIS shifted focus to georeferencing the Hawaiian PEN specimens. The records available were downloaded from the snapshot collections on the portals and collaboratively by country or region with records from other institutions when applicable. Their main student georeferencer finished his PhD program and thus ended his time with them earlier this year. Due to the amount of money left in the grant for WIS, they were unable to hire student employees and moved away from imaging specimens to georeferencing. They also reviewed corrections and prepared files to send to snapshot collections for upload to their databases. They sent JPEG and CR2 files to institutions that had sent specimens for WIS to image and transcribe for their long term storage. WIS has now used all funds allocated from the grant and PEN award.

YU continued transcribing label data. Volunteers generated 330 fully transcribed records.

Digitization

Eleven GLOBAL institutions (ASU, COLO, DUKE, F, FLAS, MO, OSC, TENN, UC, WIS, and YU) reported progress on digitization deliverables, with a total of 11,029 specimens barcoded (9,768 bryophytes and 1,261 lichens), 34,893 labels imaged (33,736 bryophytes and 1,157 lichens), 23,000 specimens imaged (21,310 bryophytes and 1,690 lichens), 11,266 specimen records uploaded to the portal (10,370 bryophytes and 896 lichens), 30,649 skeletal records created (29,864 bryophytes and 785 lichens), 24,835 labels fully transcribed (24,135 bryophytes and 700 lichens), and 830 specimens georeferenced (673 bryophytes and 157 lichens) (See Table 1 & Figure 1).

PEN partners BISH and PTBG reported a total of 2,247 specimens barcoded (2,007 bryophytes and 240 lichens), 2,365 labels imaged (2,100 bryophytes and 265 lichens), 1,265 specimens imaged (1,000 bryophytes and 265 lichens), and 2,247 labels fully transcribed (2,007 bryophytes and 240 lichens). WIS completed georeferencing of 3,259 PEN specimens (3,182 bryophytes and 77 lichens).

Table 1: Digitization progress by GLOBAL collaborators in 2025-Q2, separated by Bryophyte (B) and Lichen (L) specimens.

	# Barcodes Added		# Labels Imaged		# Specimens Imaged		# Uploaded to Portal		# Skeletal Records Created		# Fully Transcribed		# Georeferenced	
	B	L	B	L	B	L	B	L	B	L	B	L	B	L
ALA														
ASU		109		109		109		109				109		
BRY														
CINC & MU	1,431	104	873		873		1,431	104	1,431	104	1,089	125		
COLO	3,947	681	3,947	681	3,787	1,212	3,947	681	3,947	681	1,589	466		
DUKE	2,660		3,116		376	2	3,492	2	2,460		168		38	
F			14,774		14,774				12,500		12,500			
FLAS			1,500		1,500		1,500				497			
ILL & ILLS														
LSU														
MICH														
MIN														
MO	1,730		9,526						9,526		1			
MSC														
NY														
OSC		367		367		367								
PH														
TENN											18		14	
UC											7,943			
WIS													621	157
YU											330			
Totals	**9,768**	**1,261**	**33,736**	**1,157**	**21,310**	**1,690**	**10,370**	**896**	**29,864**	**785**	**24,135**	**700**	**673**	**157**
B+L Totals		**11,029**		**34,893**		**23,000**		**11,266**		**30,649**		**24,835**		**830**

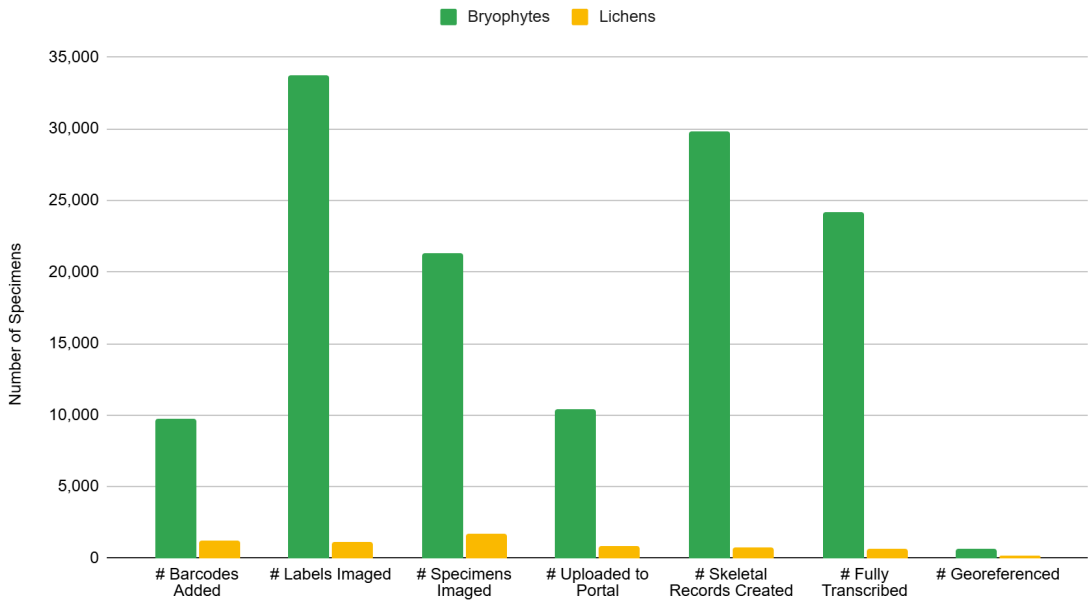

Figure 1: Digitization progress for the GLOBAL collaboration in 2025-Q2, separated by Bryophyte and Lichen specimens.

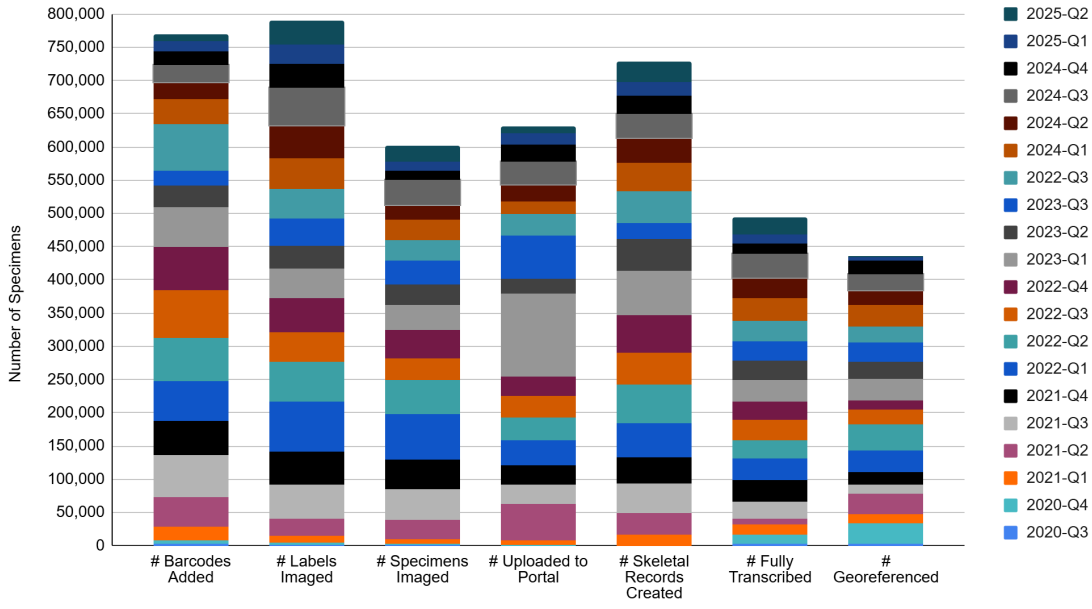

Figure 2: Cumulative digitization progress for the GLOBAL collaboration by quarter.

Share Best Practices, Standards, and Lessons Learned

Flexible Workflows

At COLO, based on preliminary work, the quality of specimen images is hampered by using a fixed imaging system to capture both packet/label data and specimens. They started capturing raw images to create a stacked image for our cryptogams. The workflow in place involves capturing 8 images of each specimen. In a second step they will use depth compositing tools to combine these series into a single image. This should allow for a better-quality specimen image with all of the specimen in focus, but also takes more time than it takes to capture an image (4-5 minutes for 8 images), so it does not pair well within the imaging process. Summer staffing is generally lighter than during the school year, so they have focused on getting as many image stacks as possible. They are still working on a process to automate the process to minimize the human time needed to process the bracket stacks into a single image.

Since no transcription work was completed on their non-North American specimens before the project they did not have records for the first wave of georeferencing work at WIS. They have been prioritizing records from Australia, Chile, England, Finland, France, Japan, Norway, Scotland, Sweden and Wales for transcription to build sets for georeferencing. They have now added Central America, South America and Africa and lichens from Polynesia, Micronesia, Melanesia. They are also transcribing specimens from Sweden and Norway for their Bryophytes as they are added to the database. Moving forward they are starting to target specimens from countries that have the fewest specimens with a goal of getting to 100% transcription for as many countries as possible. They are continuing to work with the team at University of Michigan in the hope that VoucherVision will be integrated into future transcription work and specifically advocating for a plugin that will work with Symbiota.

F has developed new pipelines for transcription using large language models and humans. This is described and published here: https://www.sciengine.com/DI/doi/10.3724/2096-7004.di.2025.0011.

Collaboration

Team members continued to make use of Basecamp, Zoom, and email to communicate and collaborate during 2025-Q2. New collaborators and students were given access to

Basecamp group resources. A Management Committee Meeting was held in May open to all GLOBAL members to review progress from 2025-Q1 and to provide an open forum to the GLOBAL team.

WIS continued its collaborative georeferencing, creating new communities in the CoGe interface and georeferencing as fully transcribed records become available. The GLOBAL Georeferencing Manager (WIS) and Portal Manager (ASU) continued to consult on georeferencing workflows, especially those involving GEOLocate CoGe.

Share Identified Gaps in Digitization Areas and Technology

New Software Tools

Please note: Ongoing further technical developments mentioned below continue through a grant supporting the Symbiota Support Hub and are no longer supported by the current TCN, which for ASU is ending this year.

Symbiota Version 3.3

After Symbiota version 3.2 was launched, work continued on fixing several technical glitches. The new version 3.3 will be applied to the portals after the Botany 2025 conference.

Taxonomic Thesaurus

Work on streamlining how the taxonomic thesaurus can be updated more efficiently using unique identifiers continues.

Literature Management

Parsing literature reference from Recent Literature of Lichens into the MySQL backend of the Lichen Consortium database is on hold while we investigate how a routine can be established to assure that newly added records from that online resources can regularly be added.

Data Exchange between Platforms

Ed Gilbert recently defended his PhD demonstrating vastly improved data

interoperability between Symbiota platforms, using the API developed as part of the GLOBAL TCN.

Imaging Workflow Application

The taxonomic dropdown for the ImagingWorkflow application was missing many of the names we use in our collection. In Fall of 2021, COLO worked with Katie Pearson to get an export of the lichen taxonomic thesaurus and Ryan Allen reformatted this list so it could be added to the application. It is difficult to quantify the impact since every imaging session is different, but most specimens do not require manual entry. COLO has been exploring a new version of the ImagingWorkflowApp that can run without JAVA. Sully Harrer has been working on this with the hope of including the option of populating the collector field like they add taxonomy to make the app more functional.

Share Opportunities to Enhance Training Efforts

The GLOBAL Project Manager (TENN) and Georeferencing Manager (WIS) continued compiling resources during 2025-Q2 to share on Basecamp and all resources were posted to the project website (https://globaltcn.utk.edu).

Two new tutorials were recently added to the Help & Resources site of the Lichen Consortium, one outlining standard collection routines and a second one with recommendations on how to best curate lichen specimens for long-term archival. These tutorials will be presented at the annual meeting of the Botanical Society of America (Botany 2025: July 26 to 30) as part of the session meetings of the American Bryological and Lichenological Society (ABLS). A workshop on building advanced checklists using the Symbiota tools built into the Lichen Consortium will also be taught at the same conference.

At UC, multiple Herbarium staff worked on standardized protocols for transcribing so that data entered aligned with accepted text in each field per their in-house system, CSpace.

Share Collaborations with other TCNs, Institutions, and/or Organizations

GLAL: ASU's collaboration with the Grupo Latinoamericano del Liquenologos (GLAL)

continues. Unfortunately they received no news from the Mitsubishi Foundation, whether their grant application to receive funding has been successful.

INABIO (Ecuador): ASU's partners in Ecuador decided against moving their national Symbiota database to our servers. Apparently the energy situation has improved (the country almost exclusively relies on hydroelectric power and after heavy winter rains the reservoirs are now filled again, blackouts are not expected to occur anytime soon again). Moving the platform to ASU's server to guarantee 24/7 service is therefore no longer necessary. INABIO is working on updating their version of Symbiota to the newest version that includes enhancements to the API facilitating data exchange.

COLO is also a member of the SoRo TCN and the All-Asia TCN. They will continue to share info and technology between projects to help optimize workflows.

Share Opportunities and Strategies for Sustainability

Portal Management

With the recent move of the Symbiota Support Hub to the University of Kansas, strategies for long-term sustainability of the Lichen and Bryophyte Consorcia will be discussed at the next ABLS business meeting.

Back-Ups

At COLO, raw images and JPGs are being uploaded to the University of Colorado Research Computing. These images are in addition to the local copies housed in the CU Herbarium. The hope is that these images will never need to be accessed, but to serve as a catastrophic backup if they have a computer or hard drive failure. Monthly backups of the COLO database in the Lichen and Bryophyte portals are made on the first working day of the month. These files are housed locally and will be archived on Research Computing in case they ever need a point in time backup of their data.

Outreach Videos

TENN PI and Project Manager discussed uploading GLOBAL outreach videos to the TENN Herbarium YouTube Channel, to increase searchability and provide a secondary location after the end of the formal project period.

Share Education, Outreach, Diversity, & Inclusion (EODI) Activities

The GLOBAL TCN website (https://globaltcn.utk.edu) was maintained and updated with additional links to developed protocols and workflows. Social media accounts belonging to collaborators continued using #GlobalTCN as a way to share progress with the community.

At ASU, recently graduated Mexican student Eduardo Gutierrez will be presenting his research at Botany 2025 in July.

CINC hosted a specimen mounting workshop, gave tours to two classes, and five additional tours to individuals and small groups.

DUKE's B. Aguero led "Botany Spotlight: Mosses of Duke Gardens" and "Botany Spotlight: Mosses of Duke Forest" moss walks for the public on April 8 and 30, co-organized with Duke Gardens.

F held a Collections Club and WeDigBio in April 2025 with public volunteers.

PTBG hosted a bryophyte hike with staff from Nature Conservancy, Kokee Resource Conservation Program, and USFWS as a follow-up to their bryophyte workshop that was held September 2024.

TENN hosted a Specimens and Scones open house event and TENN staff participated in the annual Wildflower Pilgrimage in Great Smoky Mountain National Park in April. Tours of the Herbarium were given to the Library Department, Loghaven Art Residency, and Field Botany Class in April and June.

Share Information About Your Website and/or Portal Usage

The GLOBAL project website, https://globaltcn.utk.edu, was utilized by 342 users during 2025-Q2, including 94 from Asia, 35 from Europe, 12 from South America, and 2 from Oceania, and 1 from Africa (see Figure 3).

The Bryophyte and Lichen Portals, created as part of the original LBCC grant, host new images and data produced by the GLOBAL collaborators. Usage for the Bryophyte Portal and Lichen Portal during 2025-Q2 are included in this report, but the dramatic increase seen at the end of the reporting period reflects bot activity (see Figures 4 & 5).

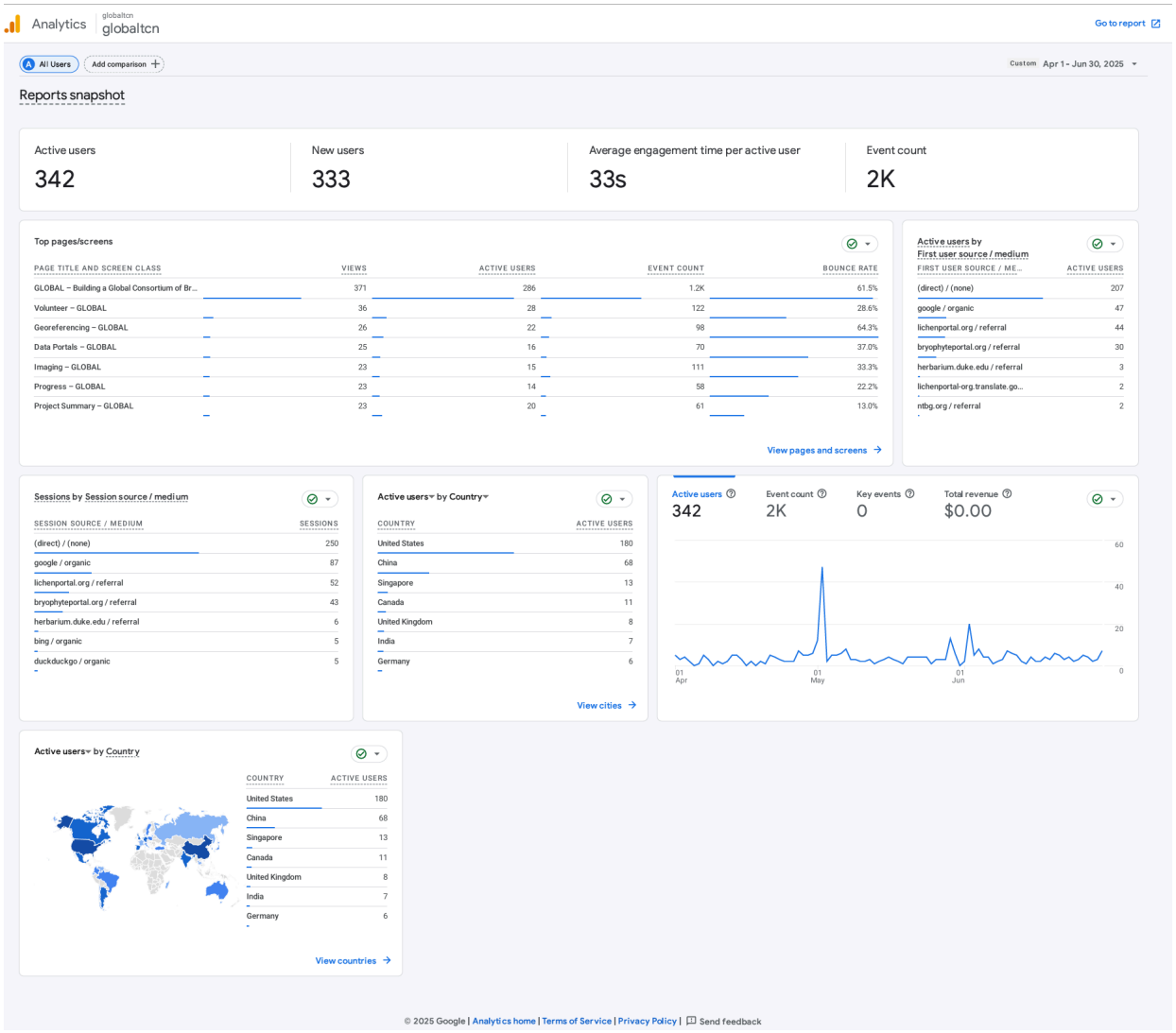

Figure 3: Use metrics for the GLOBAL project website (https://globaltcn.utk.edu) from April 1 – June 30, 2025.

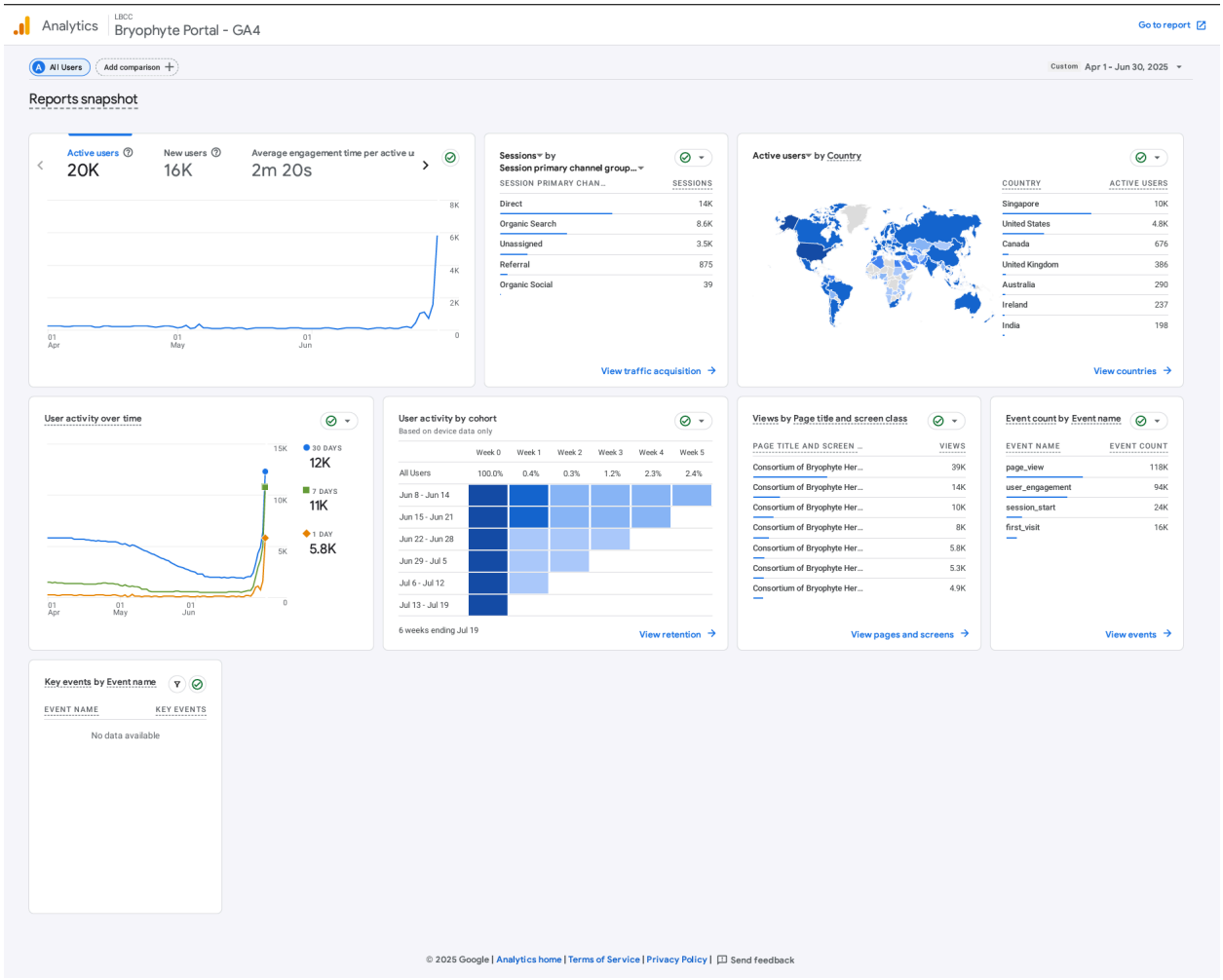

Figure 4: Use metrics for the Bryophyte Portal (https://bryophyteportal.org/portal/) from April 1 – June 30, 2025.

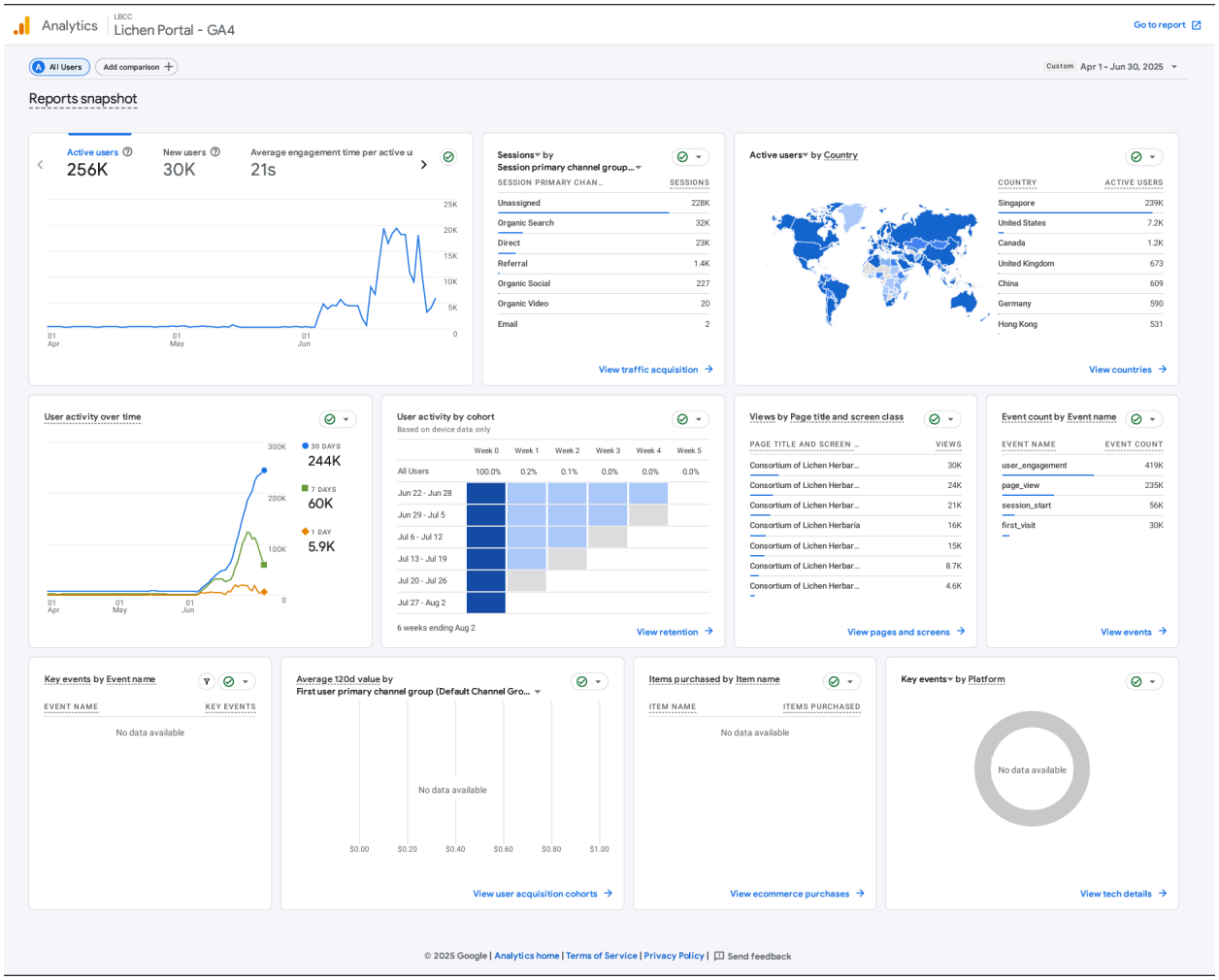

Figure 5: Use metrics for the Lichen Portal (https://lichenportal.org/cnalh/) from April 1 – June 30, 2025.

Share Other Activities and/or Progress

At ASU, images from Felix Schumm continued to be uploaded to the Lichen Consortium and linked to specimen records in the Private Herbarium of Felix Schumm (hb. Schumm).

Work on the Lichen Glossary continues, so does the efforts to build a Controlled Vocabulary to be shared through the Consortium Help & Resources site

F's paper in Data Intelligence called: "Unlocking the Past: The Potential of Large Language Models to Revolutionize Transcription of Natural History Collections" was published June 2025: https://www.sciengine.com/DI/doi/10.3724/2096-7004.di.2025.0011. This experimental study investigates the application of Large Language Models (LLMs) in automating the transcription of herbarium specimen labels. Various LLMs were tested, including OpenAI's GPT models and Anthropic's Claude, to evaluate their accuracy and efficiency in transcribing label data. Algorithms have been developed to automate the workflow, leveraging the image processing capabilities of LLMs to bypass traditional Optical Character Recognition (OCR) tools. Prompt engineering strategies were explored to enhance transcription accuracy, focusing on field-specific instructions and formatting. The study demonstrates the potential for LLMs to streamline digitization workflows in natural history collections but underscores several challenges, such as transcription errors, logic errors and inconsistency of results. Promising directions that emerge include improving prompt engineering techniques, exploring the integration of LLMs into workflows and model selection to achieve higher accuracy and reliability.

At BISH, much work has been done with identification of their Lichen collection by Dr. Cliff Smith emeritus professor at University of Hawaii, Manoa.

PTBG will echo BISH in acknowledging that Dr. Cliff Smith has continued to make significant progress in the identification of their lichen collection. Their current, primary focus is completing our moss guide and working on a Lucid key.