Institute for the Study of Earth, Oceans, and Space

Spheres Online

University of New Hampshire

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Earth Systems Science

Add Water, Grow a Career

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Earth Systems Science

Add Water, Grow a Career

Senior Connor Breton used steady undergraduate research to forge his future

AS A COLLEGE SOPHOMORE, when Connor Breton of Somersworth, N.H. found himself working in remote Panama alongside a colleague who spoke no English—and Breton knew just a few words of Spanish—he realized he was getting the bang for his UNH International Research Opportunities Program (IROP) buck.

Connor Breton with machete in Agua Salud, an experimental plantation within the Panama Canal Watershed. Photo by Katherine Sinacore.

"What needed to get done did, but for both of us it required a lot of repeating and rephrasing of what you were trying to say—definitely on my part," says Breton now a senior with four years working in Heidi Asbjornsen's Earth System Research Center Ecohydrology Lab and two summers of fieldwork in Panama under his belt.

"Those are the tough situations where you learn the most, learn how to communicate effectively and how to be patient."

And indeed, when you add complex science into the mix it becomes that much harder. How, for example, does one effectively explain "ecophysiology"—an experimental science that seeks to describe the physiological mechanisms underlying ecological observations—under such circumstances?

"A lot of times with things like that, and in this specific case the ecohydrology we study, you just shorten it to 'water use' or 'water in the tree.' There was a lot of simplifying. But by the end of this past summer, while I wasn't always grammatically correct by any means, people pretty much understood what I was saying and vice versa," Breton says.

Breton, who the summer after graduating from Somersworth High School contacted Asbjornsen about potential undergraduate research opportunities in her lab, has stayed the course through four years and came to realize he relished scientific fieldwork.

Says Asbjornsen, "When Connor approached me about working in the lab, I was immediately impressed by his enthusiasm for and commitment to forest ecology research—so it came as no surprise when he quickly expressed interest in our Panama project for his undergraduate research experience." She adds, "There's no doubt in my mind that his experience in Panama has had a huge life-changing impact on both his personal and professional growth."

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The Facilitator

A conversation with newly arrived EOS associate director David Divins

SHORTLY AFTER ARRIVING AT EOS last fall, David Divins was already relishing the change of pace and environment after ten years of managing a large National Science Foundation-funded project for the nonprofit Consortium for Ocean Leadership in Washington, D.C. It was a job that kept him on the go and out of the office, and Divins looked forward to being able to stay put and becoming the "facilitator" who helps get the day-to-day EOS details done for the institute as a whole.

“I managed the Integrated Ocean Drilling Project, which became the International Ocean Discovery Program, and was out of the office more than in—it involved a lot of travel, a lot of meetings and a lot of international collaboration and discussions. I was gone several weeks a month,” Divins says.

David Divins
Photo by Kristi Donahue, UNH-EOS.

Fittingly, Divins steps into the role of EOS associate director to devote the kind of daily attention to institute details that is simply impossible for EOS director Harlan Spence to achieve because Spence, like Divins’ former self, is often gone for weeks at a time on travel attending to projects on which he is a principal investigator or co-PI—such as the Lunar Reconnaissance Orbiter, Van Allen Probes, Magnetospheric Multiscale, and FIREBIRD satellite missions—serving on advisory committees or talking with colleagues from federal funding agencies.

“I’ll be able to help Harlan with the day-to-day operations across all the centers, and I’m hoping to be able to increase cross-center communications, have a daily presence and be somebody who can follow through on things that need to be done,” says Divins. “For example, when something comes up I can act on the idea with more immediacy in Harlan’s absence. I see that as a really big part of this job.”

Divins will become the first fulltime associate director since David Bartlett retired in June 2012. The role has been filled in an interim capacity by Scott Ollinger of the Earth Systems Research Center and, most recently, by Chris Glass of the Northeast Consortium.

A native of Framingham, Mass., Divins received his bachelor’s degree in biology, with a specialization in marine science, from Boston University and his Ph.D. in oceanography from Texas A&M University. He spent 16 years in Colorado as a research scientist at the University of Colorado Cooperative Institute for Research in Environmental Sciences and a five-year stint as a geophysicist at the National Oceanic and Atmospheric Administration in Boulder.

At the Ocean Leadership Consortium, he was vice president and director of the Integrated Ocean Drilling Program. The nonprofit consortium has a membership of approximately 100 mostly academic institutions and includes UNH. Ocean Leadership, Divins says, “Is really *the* voice for ocean science. It’s not a lobbying group, its work is around the science priorities of the U.S. with respect to the ocean. We help to work with a lot of Senate and House staffers and

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Earth Systems Science

Making a Thirsty Forest

A large-scale forest experiment at UNH's Thompson Farm Observatory aims to induce drought conditions in anticipation of changing climate

IF YOU WERE TO HAPPEN UPON the drought experiment recently set up in a forest plot at UNH's Thompson Farm Observatory in Durham, from a distance you might visualize an elaborate environmental sculpture that aims to create a alternate dimension and give added aesthetic depth to a temperate forest environment—one that accentuates a horizontal element of a largely vertical space and arrests falling leaves in midflight before they flutter to the forest floor to begin the cycle of decay and replenishment.

But get closer to the 9,700-square-foot (900 square meter) raft of 2x4s and high-durability polymer fabric and you'll see the white plastic Em50 Data Logger protruding from a PVC pipe sunk into the pine-needle and oak-leaf-laden soil. "Thompson Farm, Treatment 1, Soil #3, Asbjornsen Lab" is written on the data logger and buried beneath it are three soil sensors at varying depths.

As a whole, the forest structure is indeed very artful-looking, but what's happening here is unique, cutting-edge science that aims to put fine numbers on how drought affects the ecosystem of a temperate forest—from soil moisture content and microbes up to the leaf pores, or stomata, that regulate a tree's water usage.

The Thompson Farm throughfall manipulation structure on one of the treatment plots designed to remove 55 percent of incoming precipitation.
Photo by David Sims, UNH-EOS.

The four-year "forest throughfall manipulation experiment" that is just getting underway will try to simulate a 55-percent reduction in the annual growing season precipitation that falls on the forest floor.

While there are drought experiments, including those that are part of the National Science Foundation-funded Drought-Net global network (as the Thompson Farm experiment will be), most of these are in environments with short vegetation like grasslands where drought can be more easily induced; put simply, there are no trees to get in the way.

Drought experiments in temperate forests are few and far between. The only other one in the region is the Hubbard Brook Experimental Forest in New Hampshire's White Mountains and was the first such experiment that sought to standardize the current methodology. The Thompson Farm throughfall structure is four times the size of Hubbard Brook. The project was made possible by a grant through the New Hampshire Agricultural Experiment Station.

Ph.D. student Cameron McIntire of Heidi Asbjornsen's ecohydrology lab in the Earth Systems Research Center is

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Earth Systems Science

Of Mentors and Mentees

Undergraduates from around the nation have flourished in a UNH-based climate change research program

RUTH VARNER has had a long, rich history of mentoring undergraduates at the Earth Systems Research Center and department of Earth sciences. She was recently recognized for this by the American Geophysical Union, which officially bestowed Varner with the 2015 Sulzman Award for Excellence in Education and Mentoring at the AGU Fall Meeting in San Francisco.

But many of those who have been mentored by Varner in the past—in particular the young women who have gone on to get master's degrees under her tutelage—have honored her less formally by noting they were swept up in the "Varner vortex" as they set their sights on scientific research careers.

Sophie Burke Photo by Kristi Donahue, UNH-EOS.

Notes Sophie Burke, one of Varner's mentees and research assistants and now a Fulbright Scholar and Ph.D. student, "Ruth is a very special mentor, her enthusiasm for her research is infectious and she is so genuine in her desire to help her students succeed. I have always admired and appreciated her ability to treat everyone as a colleague whether they are an undergraduate student on their first research experience or a professor participating in a project. To her, everyone brings their experiences to the table."

The boardwalk through the Stordalen Mire Nature Preserve in Abisko, Sweden. Part of it has sunken into a thaw pond due to thawing permafrost. Photo by Jessica DelGreco, UNH-EOS.

No effort is more representative of Varner's mentoring than the NSF-funded Northern Ecosystems Research for Undergraduates (NERU) program, for which she is the founding director. NERU, a collaboration between UNH and the Abisko Scientific Research Station in Abisko, Sweden, focuses on the impacts of climate change on permafrost and lake environments in the Stordalen mire complex some 124 miles north of the Arctic Circle. A specific focus of the research has been measuring methane—a potent greenhouse gas—emissions by various means.

After four years, the program has given 37 undergraduates from colleges around the nation the opportunity to cut their teeth on state-of-the-art climate change field research abroad and in laboratories here at UNH. Students typically come from colleges and universities that lack extensive research programs and opportunities.

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Faculty, Staff, and Student News

Ocean Process Analysis Laboratory


Kai Ziervogel

Research assistant professor **Kai Ziervogel** arrived recently from the University of North Carolina-Chapel Hill where he was a postdoc and research associate in the department of marine sciences. Originally from Germany, Ziervogel graduated from the University of Rostock in 2004. His research focuses on a key aspect of understanding food web interactions and the marine carbon cycle as heterotrophic microbial communities (organisms that require organic compounds for nourishment) transform photosynthetically produced dissolved organic matter into biomass, providing food sources for higher trophic levels. He is particularly interested in heterotrophic microbial communities associated with sinking organic matter aggregates, also known as “marine snow.” Read more about Ziervogel’s research in this Gulf Of Mexico Research Initiative publication.

OPAL director **Doug Vandemark** reports that the center “is proud to serve as the longest standing node in NOAA’s coastal ocean carbon dioxide (CO_2) observing network, with our Gulf of Maine CO_2 measurement buoy northeast of Appledore Island having been in almost continuous operation since May 2006.”

Director of the Northeast Consortium **Chris Glass** notes that graduate student **Rachel Feeney** successfully defended her thesis and graduated in December. Feeney’s dissertation was titled “Catch Share Management in the Northeast Multispecies Fishery: Implications for the Commercial Groundfish Fishery in New Hampshire.” The work tests theories about catch share approaches to fisheries management, examines their validity and limits relative to the Northeast groundfish sector program, and potentially modifies them in light of research outcomes. Participants of the groundfish fishery based in NH are the particular focus of research, but broader impacts are considered.

Space Science Center

The Space Science Center team that designed and built the crucial Spin-plane Double Probe (SDP) for NASA’s Magnetospheric Multiscale (MMS) mission was recently named one of the recipients of the 2015 Robert H. Goddard Exceptional Achievement Award for Engineering (Individual and Team Recognition). The 16 probes (four on each MMS spacecraft) were designed to ever-so-gingerly pay out 60 meters (192 feet) of spaghetti-like, high-tech cable, at the end of which is an orange-sized metallic sphere that is

From the Director

All Projects Great and Small


Harlan Spence

UNBIASED, MEASURABLE assessments of scholarship provide a means for tracking research performance and trends. They can be used to measure the scientific productivity of an individual researcher, a collection of researchers, an institute such as EOS, or even an entire university. It is gratifying that several independent metrics quantify what we all believe from our own experiences: EOS is a flourishing research powerhouse comprised of individuals and groups of world-class scientists.

Here are some numbers—all for calendar years. The just-released "Web of Science (WoS)" metrics for 2015 reveal an impressive, continued upward arc of research output by EOS researchers. WoS surveys all peer-reviewed journals worldwide and counts each publication (a primary measure of scientific productivity), including authors and how/who cites those papers (which is a measure of scientific impact). In 2015, EOS scientists authored 234 publications, surpassing the 229 from 2014, which was already a record-smashing year.

These numbers represent an approximate 30 percent growth in the overall EOS publication rate from a decade ago, and approximately a doubling relative to 2000. These represent measures of outstanding productivity and upward trends with time. The scientific impact of these publications is equally impressive. In 2014, the number of citations of all EOS authored publications fell just shy of 15,000; in 2015, the number of citations exceeded

measuring electric potential in the vacuum of space—a critical measurement for mission success. Morse Hall team members for the SDP deployer included **Brian King**, **Mark Granoff**, **Pieter Beckman**, **Ivan Dors**, **Colin Frost**, **John Nolin**, **Aaron Bolton**, **Jon Googins**, **John Levasseur**, **Caleigh MacPherson**, **Dave Rau**, **John Salwen**, **Steve Turco, Phil Demaine**, **Todd Jones**, **Jerry Needell**, **Stan Ellis** and **Roy Torbert**. Click here for more about the SDP work.


Terry Forbes

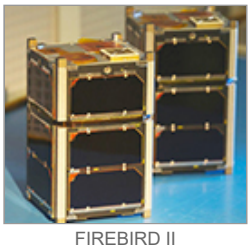

Katharine Reeves

SSC professor emeritus **Terry Forbes** recently received the 2016 George Ellery Hale Prize from the solar physics division of the American Astronomy Society. The prize is given annually to an astronomer who has provided outstanding contributions to the field of solar astronomy. According to AAS, Forbes was recognized "for his significant contributions to the theory of magnetic reconnection, for his development of important new models of the physics of solar flares and coronal mass ejections, and for his achievements mentoring students and junior scientists in the solar physics community." Read more in a recent article in Foster's Daily Democrat. Also, Forbes' former Ph.D. student, **Katharine Reeves**, received the 2016 Karen Harvey Prize "for her work elucidating the energetics of solar flares and coronal mass ejections, for her leadership within the multi-national Hinode/X-Ray Telescope project, and for her strong role in scientific education and public outreach," according to the AAS Solar Physics Division website. Reeves, who graduated from UNH in 2006, currently works at the Harvard-Smithsonian Center for Astrophysics in Cambridge, MA.

Peter Bloser and **Jason Legere** attended the 2015 IEEE Nuclear Science Symposium in San Diego in early November and presented posters on "A Field Deployable Imaging Neutron Detector (FIND) for Special Nuclear Materials" and "The Advanced Scintillator Compton Telescope (ASCOT) Balloon Project." Also, on November 21 high school students participated in a Project SMART high-altitude balloon flight that tested a prototype detector built by Bloser to measure gamma rays and energetic neutrons. Students built the data collection electronics. The detector successfully recorded increasing levels of radiation at high altitudes in the atmosphere. Says Bloser, "In addition to giving the students an exciting opportunity to assemble and fly a radiation detector, the flight also provided a useful test of new detector technology in the near-vacuum environment of the upper atmosphere. The test helped to verify that these types of detectors will function properly on a much larger balloon payload that is currently under development."

Chuck Smith notes that two high school students involved in Project SMART 2015 continue to work in the SSC. One is completing a project on expanding flux ropes with Ph.D. student **Kristoff Paulson** while the other is working with Smith on waves due to interstellar pickup ions.

Harlan Spence and **Sonya Smith** note that on January 31, the FIREBIRD II CubeSats reached the milestone of one full year in orbit and 5,503 orbits completed. Both pintsized spacecraft are doing well, even now, well beyond their three-month mission lifetime goal. The FIREBIRD team is busy


FIREBIRD II

16,000 a growth of approximately seven percent from the previous year and another strong indicator of the prominence of EOS research.

"SciVal" is a second independent organization that analyzes scholarship using similar objective metrics, but in a way that allows us to explore down to individual EOS authors with a comparison to all others at not only UNH but also to all institutions worldwide. According to SciVal, between 2010 and 2015, UNH's net scholarly output comprises 6,091 publications written by a total of 2,738 unique UNH authors.

In that same time period, our 49 EOS faculty (approximately evenly split between research and tenure-track) authored 1,142 papers. Said another way, EOS authors, representing roughly just two percent of all possible UNH authors, accounted for approximately 19 percent of all UNH publications. Even more impressive, nearly all of our 49 faculty rank in the top 100 most productive authors at UNH, including 23 of the top 50, and 10 of the top 20. These and other metrics (including similar leadership in science impact) demonstrate how prominently EOS research factors into the overall published scholarship at UNH. Equally impressive comparisons with other institutions, demonstrate that we are not only leaders at UNH, but that we are also top-ranked internationally in many domains that define EOS. These facts are unassailable, yet are not commonly known nor regularly celebrated, all fueled by the institute's primary focus on research excellence.

How do we accomplish such feats? It is through a combination of high performance on research projects that span small, focused, single-PI awards to large, and broad, multi-institution awards. You will find that this issue and recent issues of Spheres highlight the full range of project size, some great and some small, but all bright and beautiful, collectively contributing to the high overall quality of scholarly output of EOS.

My own awards are a microcosm of EOS as a whole, from the small but productive NSF FIREBIRD-II CubeSat mission and Sun-to-Ice project, to the mid-scale NASA Lunar Reconnaissance Orbiter and Van Allen Probes missions, to the flagship NASA Magnetospheric Multiscale mission. Owing to this incredible wealth of projects, I am particularly grateful to EOS

downlinking data from their 7th science campaign in which the instruments were operated in a new, faster mode. First publications are detailing newly discovered properties of relativistic electron microbursts.

Joe Hollweg was appointed Honorary Professor with the School of Agricultural, Computational and Environmental Sciences at the University of Southern Queensland, Australia and serves on the committee of a Ph.D. physics candidate there. The student's thesis is on radio studies of the solar corona, which was the subject of Hollweg's Ph.D. thesis, and a topic that he has pursued occasionally ever since. Hollweg's last paper on the topic was published in The Astrophysical Journal in 2010 in collaboration with **Ben Chandran**.

UNH postdoc **Matt Argall** published a paper in Geophysical Research Letters on research looking for cyclotron waves caused by helium pick-up ions in the solar wind. Drifting neutral ions are unaffected by electric and magnetic waves and slowly wander through our solar system—unless they lose an electron either through charge exchange with another particle or by getting bombarded by solar photons. Once they become positively charged, they are immediately "picked-up" by the inter-planetary magnetic field and swept outward. Their free energy generates "cyclotron" waves. "Our paper provides an analysis of waves generated by helium pick-up ions and shares our method with the community to stimulate pick-up ion and solar wind research."

associate director David Divins (profiled in this issue), who's arrival in the Fall of 2015 has provided much needed breathing room for my own scholarly pursuits; thank you, David!

As you read this issue of Spheres, please consider that these stories are representative of the larger body of work at the institute, which individually and collectively makes EOS an amazing research engine. Thanks to all in the institute for your contributions to that ultimate goal!
– *Harlan Spence*

Jeanne Davis, former Space Science Center director of finance and contract administration, passed away on Tuesday, February 2 after a long illness. Davis began her career at UNH in 1975 as part of the newly created Research Office. She then moved to the SSC where she became the business manager for the Gamma Ray Observatory/Comptel project in 1981. In 1985, the Institute for the Study of Earth, Oceans, and Space was created and Davis became the assistant director. She finished her career at the SSC as assistant director of space science/director of finance and contract administration. Read Davis' obituary...


Jeanne Davis

Earth Systems Research Center

In March, **Ruth Varner** was named the recipient of the UNH Outstanding Associate Professor Award.


Steve Frolking

Steve Frolking was named a American Association for the Advancement of Science (AAAS) Fellow. Frolking, a research professor of biogeochemistry in ESRC and department of Earth sciences, was recognized for his contributions in understanding the Earth's carbon cycle and its relationship to climate. Election as an AAAS Fellow is an honor bestowed upon AAAS members by their peers. Frolking was recognized during a ceremony for new fellows on Saturday, Feb. 13, 2016 during the 2016 AAAS annual meeting in Washington, D.C.

Research assistant professor **M. Christina Jolejole-Foreman** recently joined the ESRC with a joint appointment in the Carsey School of Public Policy—a first for EOS. She specializes in agricultural policy and international development, environmental economics, and applied econometrics. Jolejole-Foreman is an applied economist and her research has mostly been multidisciplinary in nature and encompasses the linkages and interactions among the areas of environment, agriculture and food security. Prior to coming to UNH she was a postdoctoral research fellow at Harvard University. She earned her Ph.D. at the University of Illinois at Urbana-Champaign.

Cameron Wake was appointed to the New Hampshire Coastal Risks and Hazards Commission. The commission was established in 2013 by legislation aimed at helping coastal communities and the state prepare for projected sea level rise and other coastal and coastal watershed hazards.

NASA funded **Jingfeng Xiao** and **Alexander Prusevich** for a three-year, $540K project to develop ecosystem carbon indicators for the U.S. National Climate Assessment (NCA). Assessing the impacts of climate change on ecosystem carbon uptake and plant productivity has profound scientific, societal and policy implications. The development of clear and concise ecosystem carbon indicators is essential for future NCAs, the evolution of national-level policy regarding climate change, and better understanding of the feedbacks between the terrestrial biosphere and the atmosphere.

Because of her work on Digital Earth Watch and Picture Post, **Annette Schloss** was invited to an invitation-only event on citizen

science at the White House on September 30. Schloss also landed a two-year Sea Grant grant titled “Capitalizing on Digital Tools to Expand Environmental Literacy Around Coastal Resources”—the first such grant NH Sea Grant had funded. And with funding from the National Park Service, Schloss and colleagues launched a fully mobile web facility for the Picture Post program in December. The NPS is piloting the use of picture posts in six parks as part of their climate change action plan (an example of an NPS post can be seen here.)


Annette Schloss


Barry Rock

Barry Rock, professor emeritus in the ESRC and the department of natural resources, is initiating a new K-12 STEAM (Science, Technology, Engineering, Art, and Mathematics) outreach program called WOW (World Ocean Watch). The WOW pilot program will be initiated in south Florida in the fall of 2016. Patterned after the UNH’s K-12 Forest Watch and the international Global Learning and Observation to Benefit the Environment (GLOBE) Program, WOW students will study a range of classroom and field activities focused on the impacts of sea level rise on the Florida Keys and the Miami-Dade School District. Rock is working with a team on Key Largo representing a diversity of interests. The art aspect of STEAM will involve students photographing, painting and drawing aspects of each project as a means of documenting progress and findings.

Mark Twickler and **Joe Souney** report that on January 23, 2016, the South Pole ice core project reached its final depth of 1,751 meters (5,745 feet or just over one mile), recovering the longest ice core to date from the geographic South Pole. The combination of low temperature, relatively high accumulation rate, and low impurity concentration at South Pole will yield a detailed record of atmospheric trace gases from the ice core. The approximately 50,000-year-old ice core will also provide a record of the climate history of a unique area of the East Antarctic plateau that is partly influenced by weather systems that cross the West Antarctic ice sheet. Thus far, 555 meters of the ice core have been processed at the National Ice Core Laboratory (NICL) and samples sent to various laboratories across the USA for analysis. UNH's role in the project involves the planning of the fieldwork and ice core drilling at the South Pole, the coordination of the core processing and sampling at the NICL, and the overall scientific management of the project. The project is funded by the National Science Foundation Division of Polar Programs and is a collaboration between UNH, the University of California-Irvine, and the University of Washington, with assistance from NASA’s Goddard Space Flight Center. For more information visit spicecore.org.


Ryan Cassotto


Danielle Grogan

UNH Ph.D. students **Ryan Cassotto** (ESRC), **Anthony Saikin** (SSC), and **Danielle Grogan** (ESRC) all received Outstanding Student Paper Awards from the American Geophysical Union (AGU). The winners were notified in January following their poster presentations at the 2015 AGU Fall Meeting held in San Francisco December 14-18. Ph.D. student Pamela Moyer (UNH department of Earth science) also received an award. Cassotto presented initial results of his research on the Columbia Glacier in Alaska showing how a major rain event re-invigorated flow along the glacier's termini and how the additional rain altered the response of the glacier's termini to ocean tides. Saikin's research focuses on the generation, spatial distribution, and wave properties of electromagnetic ion cyclotron waves in the Earth's magnetosphere. Grogan's work assesses the amount of groundwater that is used for agriculture globally and quantifies how many times groundwater is re-used by way of agricultural wastewater entering streams, rivers, and percolating back into aquifers.

Mike Palace was lead author on the paper “Estimating forest structure in a tropical forest using field measurements, a synthetic model and discrete return lidar data” in Remote Sensing of Environment and coauthor on two papers in Journal of Biogeography and Global Change Biology, respectively.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

Share this:

"I have always admired and appreciated (Ruth's) ability to treat everyone as a colleague whether they are an undergraduate student on their first research experience or a professor participating in a project."
—Sophie Burke

The uplands of Vassijaure, Sweden west of Abisko. Mike Palace (left) and Kellen McArthur collect photographs using the drone Palace carries on his back. The yellow Xs McArthur holds were placed on the ground and used as control points for the drone imagery and referenced using the GPS unit also carried by McArthur. Photo by Jessica DelGreco, UNH-EOS.

One of the key benefits for these undergraduates is having the opportunity to present their findings at the American Geophysical Union's annual Fall Meeting in San Francisco where 20,000-plus scientists gather to share the latest findings in geophysical research. But in order to participate, the NERU students must prepare their abstracts for submission shortly after their return from Sweden and just two days before the summer program ends.

Says Varner, "They have to have really synthesized their work by the end of this intensive program and be able to write a coherent, professional scientific abstract about their research project, and it's really us—me as the director and the mentors working with the students—looking over their whole body of work from ten weeks to make sure it makes sense." Of the AGU meeting Varner adds, "It's an opportunity for them to network and think about graduate schools, meet potential advisors or look for jobs. Not too many undergraduates have that kind of opportunity."

Joining Varner this past summer as part of the mentoring crew were Erik Hobbie, Michael Palace, and Carrie McCalley of EOS, Joel Johnson of the department of Earth science, high school teacher Alison Hobbie, and graduate student Natalie Kashi. The 2015 contingent of NERU students included: Jessica DelGreco, UNH; Christopher Horrultiner, University of Florida; Erin Marek, Transylvania University; Kellen McArthur, University of Minnesota; Adam Nicastro, Miami University of Ohio; Clarice Perryman, Earlham College; and Melissa Schwan, University of Arizona.

"To be funded to do research and be able to see if this is the path you want to follow and make all these connections for graduate school is invaluable.
—Kellen McArthur

A panoramic shot of the Stordalen Mire Nature Preserve.
Photo by Jessica DelGreco, UNH-EOS.

A tale of two students

Kellen McArthur and Erin Marek are two of the seven 2015 NERU fellows. McArthur is a geology major from the University of Minnesota-Morris and Marek is a biology major from Transylvania University. Upon their return from the four weeks studying at the Abisko Scientific Research Station—and squeezed in between finalizing their data for a final poster session and submission of abstracts for the 2015 Fall AGU meeting—they provided Spheres with a brief summation of their summer NERU experience and how it influenced their future plans.

McArthur's research project in the Stordalen Mire consisted of extracting "pore" water from 20 centimeters beneath the peatland/permafrost surface to see what kind of correlation there is between the cover vegetation and the type of process microbes belowground are using to make methane. The NERU experience was McArthur's very first foray into research.

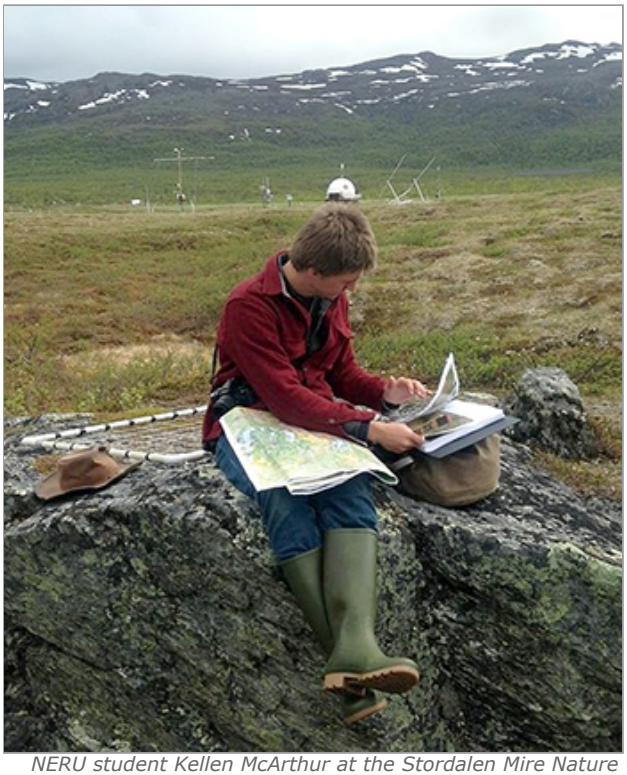
"It was a great experience, an amazing opportunity," McArthur says. "To be funded to do research and be able to see if this is the path you want to follow and make all these connections for graduate school is invaluable. Simply can't put a price on it."

He adds, "That said, it was frustrating at times and always challenging because things never work quite the way you planned. You have to be able to think on your feet, adapt, and stay calm and not freak out when things go completely south. Being able to shift gears and find a new game plan and overcome those challenges was probably the most rewarding part of the field experience for me—and being able to figure things out on my own."

"It's been really valuable having a diverse group of students in terms of gender, ethnicity, age and experiences. To me, that's made for great group dynamics, they learn a lot

He says the Abisko venture was a "solidifying experience" with respect to his future plans.

from each other."
—Ruth Varner



NERU student Kellen McArthur at the Stordalen Mire Nature Preserve in Abisko, Sweden maps out the location of the team's next plot site in the mire using areal photographs collected in 2014 by NERU students.
Photo by Jessica DelGreco, UNH-EOS.

"I learned that I like research and being in the field a lot and like having a specific project to work on. I learned I could be very happy doing that exact thing and this will help guide me in terms of my plans for graduate school."

Marek's work in Abisko investigated how soil microbial activity might be playing a role in the expansion of shrubs into open areas or heath systems.

"Shrub expansion is a really hot topic because, essentially, they are expanding and releasing more carbon dioxide to the atmosphere so it's a positive feedback system that could potentially escalate global warming but it's still not very well understood."

Of the experience she adds, "What was really surprising was the sheer amount of work we had to do. There were days when I'd wake up at 8 a.m., be out in the field for six to seven hours, and come back and have to do lab work till one or two in the morning. And that wasn't a rarity, it was most days and we were working seven days a week for four weeks."

Marek has known for some time that she wants to go to graduate school but wasn't sure what type of research she wanted to focus on (her undergraduate focus is an eclectic mix of animal behavior, ecology and evolution and a second major in art history). Post-Abisko, Marek says, "I like the mix of lab and field work a lot, I like the fact that the overarching theme of this summer's research—climate change—is a critical area of research. So I think I'm going to be looking at graduate schools that offer biogeochemistry as a program and looking for labs that might allow me to continue some of the research I did here."

Varner notes that she was particularly impressed this past summer by how much the students helped each other even when their projects did not necessarily overlap.

For example, students like Marek had field samples they had to process in a timely fashion "and might have to stay up till early morning to get the job done and they'd all help out, even the ones who were working on totally different projects. And this was stuff that was boring and repetitive but they wanted to help each other out. That was really nice to see," Varner says.

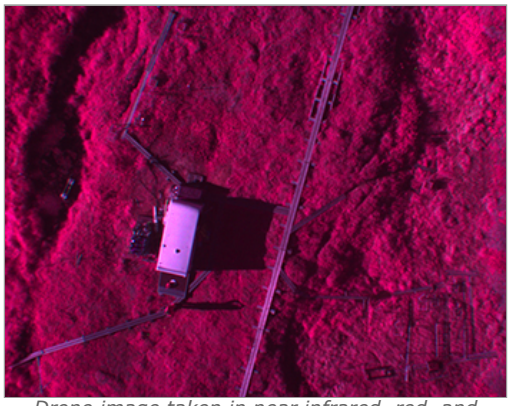
And four years and 37 students later, Varner says it's also very nice to know that the NERU program has been very successful in creating a diverse group of students who are getting an international research experience that would never be possible at their home institutions. The students who have gone through the program have been 63 percent female, 21 percent from underrepresented groups and included a number of non-traditional students.

"It's been really valuable having a diverse group of students in terms of gender, ethnicity, age and experiences. To me, that's made for great group dynamics, they learn a lot from each other," Varner says. "The NSF REU program emphasizes a commitment to recruiting students from teaching-focused institutions and recruiting students that are under represented in the discipline."

Mike Palace's airborne drone.
Photo by Mike Palace, UNH-EOS.

And what has been learned scientifically after four years?

"I think what we've been able to understand, especially working with Mike Palace and his drones or unmanned aerial vehicles, is how fast the system is changing," Varner says. "We've observed really significant changes in the amount of vegetation cover. We've observed the system thawing and getting wetter over the last four years using the UAVs and also our measurements of emissions. So we're mapping the vegetation but also measuring emissions of methane from different vegetation types. And since we've collected these data for several years now we can look at the variability year to year, and begin to publish."



Drone image taken in near infrared, red, and green bands—the same bands as the Landsat satellite. Photo by Mike Palace, UNH-EOS.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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heading up the effort—Asbjornsen is the principal investigator of the project. Ecohydrology is an interdisciplinary field that studies the interactions between water and ecosystems.

"We're trying to simulate a moderate-to-severe drought in a temperate forest ecosystem…"

"We're trying to simulate a moderate-to-severe drought in a temperate forest ecosystem," says McIntire, whose Ph.D. work involves the tree physiology of white pine—one of the dominant species along with red oak in the Thompson Farm plot.

To do so, McIntire dug into precipitation records for the region back to 1900 to find the top one percent of the driest years based on the 100-year record.

"I compiled all the precipitation data and looked at the driest years and then the top one percentile of that and it ended up correlating to years in the early 1960s when we had a severe drought," he says.

To recreate the 60s drought conditions, McIntire and company will have to remove some 55 percent of the rainfall that would typically fall through the trees and reach the ground. The "throughfall" structure that is now in place will achieve this by, in fact, not allowing this percentage of rain—or close to it—to fall through and reach plot's layer of soil.

Ph.D .student Cameron McIntire checks on a soil moisture sensor modified to measure sapwood water content in a northern red oak.
Photo by David Sims, UNH-EOS.

"The 60s drought was about half of what we get in a normal year so the structure will remove somewhere between 55 to 60 percent of throughfall, which is the rain that doesn't get intercepted by the forest canopy or runs down stems and hits the ground," McIntire explains.

He adds, "We'll capture all the water that falls through and then have a system that funnels it away from the plot to where we can collect and quantify it. So we'll be validating the experiment both by measuring the soil moisture and measuring the amount of water that actually comes out of it."

The all-important soil moisture measurements will be made by four of the soil sensors located strategically in four places 120-degrees apart around the 900-square-meter plot. And each sensor will take measurements at four different soil depths—5, 10, 20, and 30 centimeters.

"The 60s drought was about half of what we get in a normal year so the structure will remove somewhere between 55 to 60 percent of throughfall…"

"We have a lot of replication for the soil moisture measurements by design," McIntire says. "We really want to be able to validate whether the experiment is working or not and how water is percolating through different layers of the soil, so it's one of the most important aspects of it. And the soil moisture measurements end up being the most expensive aspect of this project."

There is additional and critical replication and validation that will make this unique experiment that much more robust: a replicate throughfall structure plot located about a half mile away to compare and validate the data from the first plot, and a full year's worth of "pretreatment data" gathered by soil and sap flow sensors installed and tree cores taken at the site prior to the throughfall structure being built.

"Not many researchers get pretreatment data before they put in a field experiment like this because it takes a lot of time and effort. We've managed to do that and it will be great from a statistical standpoint because we'll be able to compare the two datasets," McIntire says.

He adds that a big criticism with these experiments is that if researchers do end up seeing a difference between two plots, people might say, 'How do you know those plots weren't just different from the get-go?' Says McIntire, "Now, we can at least show the difference from the beginning and when we do the statistical analysis four years later we'll have something to compare to and validate the data."

As climate goes, so goes NH's forests

Forests make up the majority of New Hampshire's land cover and are an essential part of the state's natural resource base and economic livelihood. Understanding how to better manage them in a changing climate is crucial for maintaining a healthy balance of natural resources and economic growth.

Both temperature and average annual precipitation are projected to increase in the state over the next century. Indeed, total annual rainfall has already increased more

than nine percent over last century and is projected to increase another seven to 14 percent by 2100.

Notes McIntire, “All of the predictions are saying we’re going to see an increase in total rainfall, so you might be thinking, ‘Why measure drought?’ But what we’re predicting, and actually seeing in the last few years, is that most of those rain events are coming in the wintertime and it’s warmer, so we’ll have more rain and less snow in winter and we’ll see longer durations between those rain events. So, for example, we might get a big pulse and not get another rain event for several weeks to a month, and this can dramatically alter the ecohydrology of the ecosystem.”

During the growing season, longer periods without rainfall threaten summer water availability, and water stress in plants adapted to a cooler climate will be exacerbated by hotter summer temperatures. Water is not typically regarded as a limiting resource in New Hampshire’s forested ecosystems and thus the impacts of a moderate to severe drought in the region are largely unknown.

“Our experiment will run the entire year but we’re mostly interested in growing-season water availability because plants aren’t really using water during winter, McIntire says.

Series of parallel troughs capture rainfall and funnel it away from the treatment plots where is can be measured and diverted.
Photo by David Sims, UNH-EOS.

The experiment will allow the researchers to measure growth response of trees subjected to a water-limited climatic regime and quantify the impacts this may have on tree health, water use, carbon sequestration, and production of wood products such as timber and bioenergy feedstock.

“One of the things we do expect to see is significant growth reduction, which we will be able to gauge by the pre-treatment tree cores we’ve taken,” McIntire notes.

The work will enhance understanding of how forests will respond to anticipated climate change-induced alterations in rainfall regime and the influence it may have on the ecosystem services (i.e. water quality and quantity), quality of life and economic security in the region, with particularly important implications for foresters, land managers, and landowners.

Drought-Net, led by Melinda Smith of Colorado State University, is developing a standardized and relatively inexpensive method for conducting drought experiments in both grassland and forest ecosystems as part of an effort to establish a global network of drought experiments across diverse ecosystems worldwide.

“To date,” notes Asbjornsen, “there are many low-stature grassland and shrubland research sites participating in this network but forest sites are still poorly represented.”

Both the Thompson Farm and Hubbard Brook drought experiments were implemented to test different methodologies for conducting throughfall manipulations, according to Asbjornsen.

Challenges faced when conducting drought experiments in forest ecosystems include removing snow during winter months, designing the infrastructure to withstand falling branches and go around tree stems, keeping costs relatively low despite the need for more elaborate infrastructure and larger size plots, and ensuring that trees do not have access to water supplies outside of the plot or from

deeper soil layers.

McIntire notes that great care was taken to make sure trees were not getting access to water outside the treatment plots by establishing them in areas in which the topography of the landscape ensured little or no movement of soil water laterally into the soil layers beneath the structure. For example, one treatment plot is oriented atop the center of a small knoll, while the replicate plot sits at the apex of a moderate slope. Additionally, a five-meter buffer was applied to the perimeter of the drought structures in order to account for the horizontal extension of tree roots.

Says Asbjornsen, “The results of these two UNH drought experiments are now being synthesized into a standard protocol designed specifically for forest ecosystems, which will be used to encourage researchers worldwide to establish similar experiments across a wide range of climate conditions and ecosystem types.”

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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A data logger used for soil moisture sensors mounted in the foreground. Volumetric water content and soil temperature will be recorded at multiple depths every 15 minutes throughout the four-year study period.
Photo by David Sims, UNH-EOS.

policymakers to present the needs and concerns of our members and explain why a particular type of science is important. It also has a role in managing large projects for the NSF, with the IODP an example of these large, community-driven projects. The IODP had a $600M budget over ten years."

"Be it Earth, oceans, or space… we (should) function as one institute and not four centers. We should all be moving towards the same vision."

Late last year, Spheres Online asked Divins some questions about his new role as EOS associate director.

Spheres: What in particular attracted you to this position?

Divins: I really wasn't looking for another job but a colleague of mine sent the UNH posting to me, and when I first read the job description I said to myself, "That sounds just like me." The job brought together what I've been doing and took it to the next level so I thought I'd try something new. I was at a point where I was transitioning from managing a large project and going back into doing my own research and other things when this came up. It was pure serendipity and it was a melding of my science and management skillset.

The next day I called Larry Mayer (director of the UNH Center for Coastal and Ocean Mapping and of the School of Marine Science and Ocean Engineering) who told me he wasn't aware that the job had been advertised yet. I've known Larry for many years through our ocean drilling connections and had been up here many times in the 15 years Larry's been at CCOM to work on projects together. I'm a geophysicist and geomorphologist and fit really well into the ocean mapping work that CCOM does.

When I was at Ocean Leadership I didn't do a lot of science—it was more on the administration and advocacy side of things. But currently I am working on a Department of Energy-funded project with the University of Texas looking at methane hydrates in the Gulf of Mexico investigating the potential for sand-rich hydrate reservoirs producing natural gas. I am looking at seismic profiles to locate methane hydrates—you have to use seismic data to find them. So my role is on the seismic and operations side. In this work you use a drill ship to go in and test these things and that's something I know how to do—use a drill ship.

"I see myself as a facilitator and less as a manager and… if we have a meeting and come up with a great idea… I'm going to be that momentum to make sure we keep moving it forward."

Spheres: How do you anticipate the position of EOS associate director will compare to your previous job?

Divins: At the International Ocean Discovery Program I was managing strictly marine and Earth science-oriented projects, building teams and disciplines. It was similar in that I had to deal with different entities but those entities had more of a common focus, there was not as much interdisciplinary variety as here, which is an aspect I'm looking forward to.

And part of what I'm going to try to do as associate director is increase the multidisciplinary aspect of things at EOS, because as funding opportunities become more competitive we're going to have to start looking at how we can team up across centers, across campus, and also with other universities and institutes.

I was a research scientist at the University of Colorado for ten years before D.C. and it's good to come back to an academic environment and work with faculty—most of the time. It's a very different structure compared to working with one organization where everyone is on the same mission with the same goals, it's easier to keep everybody on track. Here, we should all be on the same page while doing things from different perspectives. Be it Earth, oceans, or space we should be trying to float all boats, if you will, not just our own. What I see that's not happening and really should, and perhaps never did, is that we function as one institute and not four centers. We should all be moving towards the same vision.

And in that regard, the biggest challenge I see is enabling more effective communication, providing the interaction between Harlan and the different centers, CCOM, The School of Marine Science and Ocean Engineering, and other university colleges and departments. How can we improve our communication between all entities?

Spheres: What's another top priority for you?

Divins: The School of Marine Science and Ocean Engineering is a virtual school of marine science at this point and is comprised of a few entities brought together under one umbrella—the old UNH marine program, CCOM, Sea Grant, the Northeast Consortium—and we're trying to create more of a presence for the school. Having the first floor of Morse Hall dedicated to the school will help in that regard but we need to have an identity.

The "new" marine school has actually been around for several years but if you were to ask people what it is they'll likely say, "I don't know," or they might describe the old marine program. We need to integrate all the different entities, really pull things together so the marine school has a very recognizable face that people can describe. And so we're really working on how to build that up.

"… historically UNH has done a great job at funding various marine components individually—we just haven't put it all together. We have done

Spheres: Do you have any sense of what the pieces are for accomplishing that?

Divins: There's a lot of activity that's been ongoing and we just have to keep pushing. What I've noticed is there's a lot of spin but not a lot of momentum, and I hope to be the momentum. I see myself as a facilitator and less as a manager and, so, for example, if we have a meeting and come up with a great idea and agree it's something we need to do, I'm going to be that momentum to make sure we keep moving it forward.

that now with the creation of the UNH School of Marine Science and Ocean Engineering."

The process is there, and Harlan and Larry Mayer and Jon Pennock, the deans of the colleges —everybody involved in the marine school—we're in dialog about how we make it take shape and how we attract people to be a part of it. That's really what we're trying to do.

UNH has done a great job of securing marine funding and there's a lot of great and exciting stuff coming out of here but I don't think UNH can quantify all it does in a coherent way, and that's where the marine school can come into play. Not only is it an opportunity to have an umbrella to put all the marine parts under but it's also a place for us to work with each other and even expand what we do in interdisciplinary ways so, for example, chemists and biologists can work together and have a place to help them initiate those dialogues—that's really part of the big vision for the school.

And on that interdisciplinary piece, I should note that these days you can't get funded on a project that is not multidisciplinary. I'm working on a proposal right now within Earth science that involves many sub-disciplines and not just geophysicists. You've got to have sedimentologists and geochemists and microbiologists, you've got to have that whole interdisciplinary team in order to maximize the investment in doing the science and get as much information out of it as you can. Hopefully with the marine school we can help maximize proposals in that way so there's a benefit with respect to funding coming to UNH.

Spheres: Is there a model for a marine school out there that might help UNH in its efforts to give the School of Marine Science and Ocean Engineering more of a presence?

Divins: In the oceanographic community, a lot of universities do have marine entities, Columbia and the University of Miami to name just two. The Rosenstiel School of Marine and Atmospheric Science at the University of Miami is an internationally recognized school of marine science and is independent of the main Miami campus. And that school doesn't bring in as much oceanographic funding as UNH does by itself. So the model exists, and historically UNH has done a great job at funding various marine components individually—we just haven't put it all together.

We have done that now with the creation of the UNH School of Marine Science and Ocean Engineering, administratively housed here within EOS. And there's a five year plan in place and we're somewhere in year two of that. In the next several years, and I'd like to see it happen sooner, we need to have a concrete identify for the marine school, and we're making strides in that direction. If we can get a donor to come up with a name we'd be happy to accept an endowment. And that's also part of what we're trying to do—market the good things that are happening here and get people and foundations to help support what we're doing. We're working with the UNH Foundation to identify funding opportunities.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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"Every summer since my freshman year I've been outside doing fieldwork both in the northern woods of New Hampshire and in Panama. Just being outside close to the environment I'm investigating has been really huge for me," Breton says.

As an environmental science major who recently added a minor in forestry, Breton started off in the Asbjornsen lab building the sap flow equipment that measures how water moves through trees in ecosystems in an effort to determine, essentially, how much water a tree drinks. Scaling such measurements up, adding a few additional "whole tree physical measurements" and doing a bit of multiplication can tell scientists how much an entire forest drinks.

"The ecohydrology lab has offered me so much. They have gone above and beyond to support me and invest their time, money, and energy in me."
—Connor Breton

This "heat ratio" method uses three separate probes that are inserted into sapwood—one emits a pulse of heat while two others take temperature readings. With the raw temperature measurements recorded, the velocity at which water is flowing up the tree over a given time period can be calculated.

Says Breton, "The basic principal we're looking at is the dissipation of heat as the water moves up the tree, from which we can eventually calculate how much water is moving through the tree over a period of time. That's the primary work I do and it's the foundation of the work I've been doing in Panama for these past two summers."

Seeing the forest

Breton's first experience using this equipment/method was in the Bartlett Experimental Forest in the White Mountains of N.H. while, for the past two summers, he's been working with teak trees on the Agua Salud experimental plantation located within the Panama Canal Watershed. The site is approximately an hour outside of the capital of Panama City. His first summer in Panama was funded by a Smithsonian Tropical Research Institute internship with last summer's work made possible by winning the IROP grant through the UNH Hamel Center for Undergraduate Research.

Katherine Sinacore (background), team member Martyna Głodowska (foreground), and field dog Canela (right) sit to enjoy lunch on a scenic ridge of Agua Salud.
Photo by Connor Breton.

"Teak is known as a really good cash crop and they also use quite a bit of water.
My primary work is seeing how a fifty percent reduction in competition will change the way that water is moving through those trees or changing the physiological response of those trees to that reduction," Breton explains.

"Understanding how these trees are using water and maybe how to better manage their physiological responses to certain conditions is important, especially in a country where you have a dry and wet season. Also, if local farmers are looking to plant teak, giving them the information that will help them grow big strong trees, trees they'll get a nice return on or can meet specific ecosystem services they desire, can be very beneficial. A lot of the communities I worked in are pretty rural without a lot of money and economic advantage, so reaching out and talking with these landowners can be a very important part of what I do."

"Connor is one of the most motivated, independent, and talented undergraduate students to have come through my lab. One of my goals… is to provide more undergraduate students with international research opportunities similar to Connor's, and UNH's IROP program is an incredible resource."
— Heidi Asbjornsen

Breton adds, "I'd like to provide kind of a silvicultural prescription for the best way to plant some of these teak trees and how they can be used for a desired outcome."

Breton notes that Ph.D. student Katherine Sinacore, also working in the Asbjornsen lab, has been conducting her research for the past two years in Panama looking at interactions between native species in the Agua Salud planation. Sinacore uses the same heat ratio method as Breton and has provided invaluable support and assistance.

"She's helped me every step of the way—writing grants, setting up my experiment, and now she's assisting with work on the data. I couldn't be more thankful," Breton says.

What drew him to the Asbjornsen ecohydrology lab in particular was his interest in climate change at the time—an interest he still maintains but which has become more focused during his four years of research and coursework, including picking up a minor in forestry last year.

"My interests have always been pretty broad and through taking classes like forest ecology I discovered that forestry might be a good way to connect all my interests and experiences—from climate change to the ecohydrology work—and use it to manage the trees of the forest, wildlife habitat, carbon sequestration, etcetera. My dream job would be being the forester for projects that are trying to do non-timber resource management," he says.

Connor Breton (left) and Katherine Sinacore (right) take tree canopy measurements in a mixed species plot using a compass and laser to quantify canopy structure. Photo by Eduardo Sanchez.

And he hopes to do that in the temperate forests of New England in order to stay close to home.

"I'm a pretty family-oriented person and I have a large family with everyone either in New Hampshire or Maine so I would like to go to graduate school in New England and stay in the region long term."

He adds, "The ecohydrology lab has offered me so much. They have gone above and beyond to support me and invest their time, money, and energy in me and I really like the fact that I'm able to see my work go all the way from building the sensors to implementing them in the field and, at this point, working on the data analysis. That's been really rewarding for me. How many people can say they've had the opportunity to travel internationally for two summers in a row and do their own scientific research project? I've been very lucky."

A lizard found relaxing and cooling down beneath the solar radiation shield of a teak tree. Photo by Connor Breton.

"Connor is one of the most motivated, independent, and talented undergraduate students to have come through my lab, and it's been a pleasure watching him explore his interests and discover a passion for research," Asbjornsen notes. "One of my goals as a professor at UNH is to provide more undergraduate students with international research opportunities similar to Connor's, and UNH's IROP program is an incredible resource to support students interested in taking advantage of such opportunities."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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