UMaine Today

CREATIVITY AND ACHIEVEMENT AT THE UNIVERSITY OF MAINE

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Special Edition

Engineering

In recent years, senior capstone students in mechanical engineering technology and construction engineering technology have been involved in numerous projects at Leonard's Mills, the Maine forest and logging museum in Bradley. MET students have spent many semesters under the guidance of professor Herb Crosby helping restore a Lombard steam log hauler to running condition. In spring 2014, CET students led by associate professor Will Manion replaced the cedar shingle roof on the museum's covered bridge (pictured here). This semester, 15 CET students installed a new cedar shingle roof on the sawmill building, complete with a new roof extension over the water wheel. The students spent several weeks planning the project, followed by the construction. It was an opportunity for the students to apply and practice construction management skills learned through coursework and life experiences to meet a need, while gaining relevant employment experience. The building houses one of the only wooden-geared, water-powered operating sawmills in existence.

THE COLLEGE of Engineering is proud to be one of the seven Signature Areas of Excellence at the University of Maine. Moreover, we are closely connected to the remaining six Signature Areas. In fact, there is no other unit on the UMaine campus with as much collaboration. This makes perfect sense, since so many disciplines partner with engineers to turn ideas into practical solutions that power our economy and make life better for the citizens of Maine and beyond.

In this issue, we'll learn about how engineers are critical to Maine's aquaculture industry, and how a new timber construction technique and an initiative to turn biomass into liquid fuels could provide new markets for Maine's forest product industry.

Engineering also is playing a critical role in expanding STEM education in our K–12 schools. Climate change is posing challenges to engineering designers, but UMaine engineers are providing solutions through the discipline of hydroclimatology.

The College of Engineering has a long-standing partnership with the Honors College. We'll hear from an alumnus who used his electrical engineering degree, combined with honors, as the springboard for a career in medicine.

The college has seen unprecedented period of growth — a more than 70 percent increase in undergraduate enrollment since 2001. As we continue to grow engineering enrollment and make pioneering advances through our research, it is critical that the university and the state of Maine invest in the faculty and facilities needed to meet the increased demands for engineering graduates and new products for businesses in Maine and the nation.

Dana H. Humphrey

Dr. Dana Humphrey
Dean, College of Engineering
Saunders Professor of
Engineering Leadership and Management

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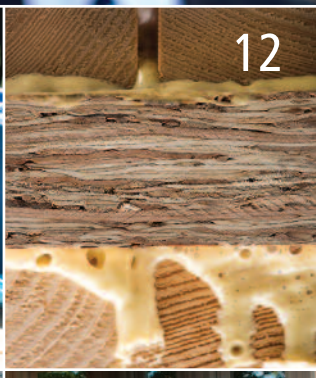

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ENGINEERING

Leadership in engineering

A legacy of depth, breadth and innovating for the future

Students and faculty field test bridges for Maine DOT to assess load capacity.

WHEN THE College of Engineering was named as one of seven University of Maine Signature Areas of Excellence in research and education in 2014, it was in recognition of the national and international distinction that the engineering program has achieved over the years.

The designation also recognizes the college's breadth and depth. Indeed, College of Engineering faculty, staff and students are increasingly involved in each of the six other Signature Areas — Forestry and the Environment; Marine Sciences; STEM Education; Climate Change; Advanced Materials for Infrastructure and Energy; and the Honors College — as well as several of UMaine's Emerging Areas of Excellence.

Whether it's finding ways to utilize forest by-products as a source of fuel, designing aquaculture pens that withstand an ocean environment, creating materials for offshore wind generation and the techniques to build them; developing better methods to predict how climate change will affect the availability of surface water; providing early education for potential engineers through K–12 STEM programs; or engaging in advanced education through the Honors College — the College of Engineering is there, actively engaged in

each of those Signature Areas. That involvement developed not so much by design, according to Dana Humphrey, the dean of the College of Engineering, but as the result of the basic nature of engineers.

"Engineers are able to look at complicated, challenging problems and devise practical solutions. That's just what engineers do for a living," Humphrey says. "Engineers are inherently a part of so many things, but most people don't think about it. We're just 0.8 percent of the Maine workforce, but we have a huge impact. Look around. The lights overhead; the chair you're sitting in; the room or the building you're in. Almost everything around you, an engineer was a part of designing it or making it."

Mechanical engineering students are designing, building, and testing fully autonomous land drones that can traverse unstable, muddy terrain and navigate using GPS.

That involvement has profound implications for how the College of Engineering helps prepare tomorrow's workforce. While the fundamental concepts of engineering remain largely unchanged, Humphrey says today's students need to be exposed to a wide range of disciplines, working not only with other engineers, but in interdisciplinary areas like never before.

THE COLLEGE of Engineering is among the oldest of the University of Maine programs, established with just three majors when the land grant college was created in 1865. Today, the college offers 11 ABET-accredited engineering and engineering technology degree programs, and graduates 90 percent of the new engineers in Maine each year.

"We have a tremendous responsibility to the state, both to do research relevant to Maine residents that moves the Maine economy forward, and to provide the graduates needed to power Maine's economy," Humphrey says. "That's the role we play in Maine, and we take that role very seriously."

As an educational and research institution, the College of Engineering has become a key engine for economic development in the state. Nearly 60 percent of graduating UMaine engineers get their first job in Maine, working for companies large and small. For example, half of the engineers at the Pratt & Whitney plant in North Berwick are UMaine engineers. There are UMaine engineers working at all levels in the state's electrical utility companies and in paper mills in Maine.

UMaine engineers also work for large or small family-owned companies, and some draw on UMaine research and innovation to start new companies.

As a resource to Maine industry, the college's engineering departments and its industrial outreach centers — the Advanced Manufacturing Center (AMC) and the Process Development Center — worked with 70 Maine companies in the past year.

Some were small startup, one-person operations, while others, like Hussey Seating in North Berwick, one of the oldest family-owned businesses in the country, are well established. Or, like General Electric, among the nation's largest industries.

AMC staff worked with Strainrite in Auburn, which makes industrial-duty strainers, to develop an automated system to produce filter socks. The new, more efficient process allowed the company to keep the same number of employees while increasing production and profits.

That kind of community partnership is key to the College of Engineering's leadership in the state. The college partners with Maine companies to undertake research, testing and development of new products or processes.

And while focused on economic development in Maine,

The annual Engineering Job Fair has grown to include more than 110 companies that converge on campus each fall to recruit engineering graduates. The 2017 Engineering Job Fair is set for October 18.

The College of Engineering has a placement rate for graduates that approaches 99 percent. Since 2005, there has been a 15 percent growth in engineering employment in Maine.

Engineering faculty members have long been recognized for their outstanding accomplishments. Honors have included Maine Distinguished Professor and the Carnegie Foundation Award, given to the best professor in the state.

the results of that research can be far-reaching with implications regionally, nationally and internationally.

While the College of Engineering has an obligation to use its technical expertise to help Maine companies prosper, the relationship with those companies is a two-way street, Humphrey says. Students work with faculty and staff members on the research projects for Maine companies, gaining hands-on, real-life experience. In addition, that cooperation with Maine industry has created what Humphrey calls a "virtuous cycle."

"Our graduates go off to found and head Maine companies; they name our laboratories; they provide internship opportunities for our students; they hire our graduates, who go on to head great companies that provide jobs for the next round of graduates," he says.

THE CHALLENGE over the next decade, Humphrey says, is for the College of Engineering to graduate an increasing number of engineers to meet the needs of industries in Maine. Currently, about 27 percent of the engineers in the state are 55 years old or older. There will be pressure on the College of Engineering to provide new engineers to not only replace those leaving the workforce, but to fill the growing needs of Maine's economy, Humphrey says.

"Look at some of the new ideas that are coming out of the University of Maine. If the research and development we're doing is actually going to work, we've got to have engineers to make it work, and we're going to need engineers for our existing companies to prosper," he says.

The demand for more engineers is already there. During a recent 12-month period, there were 1,450 job postings for engineers in Maine, ranging from entry-level to senior management positions. Last year, the university awarded 375 bachelor's degrees in engineering, but, according to Humphrey, UMaine needs to at least double that number in order to meet the engineering needs of the state.

With that in mind, the College of Engineering has made a strong effort to engage students at a young age in a way that encourages them to get excited about engineering.

Students of all ages learn what engineers do, including research on hydrogen and fuel cell technology, at the Maine Engineering EXPO during Engineers Week each spring.

The College of Engineering grants roughly 90 percent of the engineering degrees in Maine.

Last year, the College of Engineering faculty, staff and students met with nearly 5,000 K–12 students statewide through a variety of programs, including campus visits, school outreach programs and the Maine Engineering Expo.

Under the leadership of associate dean Mohamad Musavi, the college is now in its third year of the SMART (Stormwater Management Research Team) program, funded by the National Science Foundation, which adapts surface water issues to high school STEM curricula. Although still in the early stages, SMART programs are now operating in six high schools in the state, giving participating students the opportunity to complete up to one year of courses toward an engineering degree while still in high school.

Student interest in engineering also is growing. With 1,819 undergraduate students — an increase of nearly 70 percent since 2001 — and 160 graduate students, enrollment in the College of Engineering is near an all-time high. The 375 bachelor's degrees awarded in 2016 also were a record high.

"The demand for students who want to study at UMaine, the demand for our graduates in Maine industries and the demand for the kinds of research we produce is outstripping our capacity to provide it. My biggest focus right now is to grow the capacity of the college so we can produce the graduates and the new technologies that are essential to moving Maine forward," says Humphrey.

Preliminary plans are being developed for a new Engineering Education and Design Center that will include an expanded undergraduate design lab.

"This is an incredibly exciting time and we're going to have to make a major investment to make it happen. But the college is a resource for the entire state and we take that role very seriously. Our goal is to ensure that the economy of Maine is better because of the work we do here in the College of Engineering," says Humphrey. ■

College of Engineering

The College of Engineering, a University of Maine Signature Area of Excellence, focuses on the role of the state's only comprehensive engineering program in teaching, research and public service. Engineering leads the state's flagship university in the quality of students it attracts, in retention and graduation rates, and in job placement.

Changes in the **ebb and flow**

Ocean engineering helps ensure a productive estuary

> We know that aquaculture activity will continue to increase in the future and **the information we are gathering is important to help inform sustainable growth, particularly within a changing climate."** Kim Huguenard

AT 6 in the morning, beneath the pastel hues of dawn's first light, the 26-foot University of Maine research vessel *Nucella* pushes through the calm waters of the Damariscotta River as the full moon sinks slowly beyond the western horizon.

Onboard, Kimberly Huguenard and a team of researchers, armed with a suite of high-resolution sensors, prepare to collect data that will help build a baseline understanding of the hydrodynamic properties of the Damariscotta River estuary system.

Huguenard, an assistant professor of ocean and marine engineering who joined the Department of Civil and Environmental Engineering in 2015, is conducting research to help understand the impacts of a changing climate and the potential expansion of aquaculture on the Damariscotta River.

"We know that aquaculture activity will continue to increase in the future, and the information we are gathering is important to help inform sustainable growth," says Huguenard, "particularly within a changing climate."

In 2014, the economic impact of Maine's aquaculture industry totaled just over $137 million, and the Damariscotta River has become largely synonymous with high-quality sea-farmed oysters, mussels and seaweed. The river has sustained successful aquaculture farms for decades — 80 percent of Maine's oysters are grown within the highly productive estuary.

An estuary is a tidal interface between river and ocean where freshwater and marine ecosystems meet, and due to the Damariscotta's unique bathymetry, water temperature and current velocities can vary widely throughout. This creates prime opportunities for farmers to grow multiple species, each best

Maine is the largest producer of farm-raised marine food in the country and the continued increase in demand for fresh seafood worldwide presents a tremendous opportunity for economic growth in the state. Climate change will influence the region's sea level, precipitation rates and tidal flow.

Kim Huguenard and her research team are beginning to understand the complex processes at work in the Damariscotta. Exploring and understanding those present-day conditions will allow them to be accurately modeled in the future using projected climate change scenarios.

suited for specific environmental conditions, all within the same estuary system.

Maine is the largest producer of farm-raised marine food in the country and the continued increase in demand for fresh seafood worldwide presents a tremendous opportunity for economic growth in the state.

However, climate change will influence the region's sea level, precipitation rates and tidal flow, each of which will have a direct impact on the flow of water and materials through the estuary system, says Huguenard.

ESTUARINE CIRCULATION is the process that governs long-term material transport in an estuary system. This transport can significantly vary spatially throughout the estuary and during different forcing conditions; for example, during spring and neap tides, and seasonal precipitation increases and decreases. Huguenard and her crew are beginning to understand these complex processes so they can be accurately modeled in the future using projected climate change scenarios.

Throughout the 13-hour cruise, the researchers collect detailed measurements along a lateral transect of the river using an Acoustic Doppler Current Profiler (ADCP), an Acoustic Doppler Velocimeter (ADV) and a Vertical Microstructure Profiler (VMP). These instruments record a variety of parameters, including current speed, turbulence, temperature and density, as well as turbidity and fluorescence throughout the water column.

In the cramped deckhouse on the boat, two laptops collect data as the vessel tracks slowly, back and forth, across the width of the Damariscotta River. Combined, the varied data build a comprehensive profile of the underlying physics of the river as it changes throughout a complete tidal cycle.

Huguenard and her team will conduct other data collection cruises throughout the year and in different locations in the estuary to reflect a variety of environmental conditions.

She also is investigating the physics of tidal and subtidal variability, and how these might change with an increase in sea level. Tidal flow and subtidal water level can vary greatly throughout an estuary system. The physical nature of these variations is important to understand because the flows are directly connected to material transport, Huguenard says.

Sixteen pressure and temperature sensors at different locations throughout the estuary collected data throughout the summer and fall to build a baseline understanding of the tidal and subtidal dynamics of the Damariscotta River. Huguenard is planning to scale up the project to include volunteer citizen scientists and aquaculture stakeholders in this and other estuary systems along the coast. She hopes to capture data on future storm surge events and their effects through the networks of sensors.

> "I'm applying my research to an industry that **matters to the people of Maine.** It affects where they live and where they work." Kim Huguenard

MUCH OF the data from these studies will be used to help develop and enrich predictive and analytical models of the Damariscotta River estuary. The models will be capable of simulating a number of different variables, including current velocity, temperature, salinity and material transport throughout the estuary system.

Researchers also will be able to model how systems critical to estuary health and aquaculture productivity will respond to a variety of changes.

In addition, Huguenard will model the hydrodynamic changes that aquaculture infrastructure — farm size, placement or equipment design — induce on the circulation in the Damariscotta estuary. She asks an important question: How much can aquaculture activities be expanded before they unfavorably change the natural characteristics of the system?

"The impact of larger and more prevalent aquaculture farms can be modeled so that expansion activities can be conducted in a sustainable manner, for both the industry and the environment," says Huguenard.

Previous studies have shown that aquaculture farms can reduce flow up to 40 percent. Understanding the impact of aquaculture infrastructure on the flow of the estuary system is important. Flow influences water quality, material transport and nutrient supply to farms.

Not considering these effects can result in the overestimation of the supply of nutrients essential for some aquaculture species like bivalves, and by extension, overestimation of the carrying capacity of the system itself, says Huguenard.

She hopes the study will help aquaculture farmers make informed decisions about farm location, size, design and sustainable growth strategies, and shed light on how the carrying capacity of the Damariscotta River might change with expansion of the rapidly growing industry.

Huguenard's research is supported by UMaine's Sustainable Ecological Aquaculture Network (SEANET) project. Funded by a five-year, $20 million research grant from the National Science Foundation, the SEANET project is the largest award NSF has granted in aquaculture research.

Interdisciplinary researchers from UMaine and 10 other institutions — are working collaboratively throughout the coast of Maine to determine the social, economic and ecological potential and impacts of aquaculture expansion in Maine.

"I'm applying my research to an industry that matters to the people of Maine," says Huguenard. "It affects where they live and where they work. It affects their livelihood." ■

Marine Sciences

The University of Maine Signature Area of Excellence in Marine Sciences includes a multidisciplinary Marine Research Solutions initiative to improve understanding of the physical, biological and socioeconomic processes that shape the ocean. Goals include being a reliable, deeply engaged partner with policymakers, fisheries stakeholders, marine industries and coastal communities, helping to develop solutions for the broad array of issues associated with Maine's marine resources; and providing high-quality, interdisciplinary undergraduate and graduate education, outreach and research for the Gulf of Maine.

Engineering high-tech lumber for a sustainable future

> A goal of this research is to **help bring a CLT plant to Maine.** We have the forests and the infrastructure."
>
> Edwin Nagy

IN 1885, the world's first "skyscraper" towered 10 stories — 138 feet — above the busy streets of Chicago. Residents marveled at its height, but were afraid to walk near it, and city officials, so worried the new and untested steel frame construction would collapse, temporarily halted progress to investigate the building's structural integrity.

Four short years later, in 1889, as the final pieces of steel were being riveted onto the frame of the 1,063-foot Eiffel Tower, city skylines across the globe were being transformed, and reaching ever higher, as engineers continued to push the boundaries of construction methods and materials.

Today, tall buildings are a hallmark of urban landscapes around the world and, since the latter years of the 19th century, they have largely been constructed from steel and concrete. Now, engineers and wood scientists at the University of Maine are looking to Maine's forests to find new, more sustainable, alternatives for the large buildings of the future.

Mass timber is a quickly developing group of engineered wood products that can be used to construct a variety of mid- and high-rise buildings, says UMaine engineer Edwin Nagy, who is researching the structural properties and potential of Maine-made cross-laminated timber (CLT) at UMaine's Advanced Structures and Composites Center.

CLT, a type of mass timber, is touted to be as much of a revolution to tall buildings of the 21st century as steel and concrete were to those

Cross-laminated timber (CLT) made from solid-sawn and composite lumber under development at the Advanced Structures and Composites Center could translate into new markets and increased commercial value for Maine's forest products industry.

Stronger timber

Advanced Materials for Infrastructure and Energy

The University of Maine's Signature Area in Advanced Materials for Infrastructure and Energy is focused on developing the use of advanced materials in civil infrastructure, energy, aerospace and defense applications. A cornerstone of the Signature Area is the Advanced Structures and Composites Center, an interdisciplinary research facility dedicated to the development of novel advanced composite materials and technologies that capitalize on Maine's manufacturing strengths and natural resources, while creating new industries and job opportunities, and educating students.

of the 20th, and it is changing the way engineers, architects, contractors and lumber producers are viewing the built environment of the future.

In Europe for more than two decades, CLT has been used as a construction alternative to concrete and steel. And an 18-story wood dormitory has been completed at the University of British Columbia.

In the United States, however, it is a relative newcomer to the construction scene, says Nagy, but it has quickly gained a lot of attention.

CLT IS made from three or more layers of dimensional lumber, stacked at right angles, and bonded with an adhesive to form robust structural panels. The panels exhibit strength, dimensional stability and rigidity while being architecturally flexible. They can be used in walls, roofs and floors.

It is a renewable, cost-effective building alternative that benefits from reduced waste, improved thermal performance, and aesthetic and design versatility. CLT has the added benefit of sequestering, rather than contributing, atmospheric carbon dioxide — an invaluable property, considering new buildings account for nearly half of the nation's total carbon emissions.

Large structures can be constructed rapidly and many pieces, including entire rooms, can be customized and prefabricated off-site prior to installation, drastically reducing the time, labor and, ultimately, cost of construction.

"There are still some hurdles to overcome before CLT is widely accepted in the United States," says Nagy. "Some are based in the public's perceptions of wood and others are based in our current building codes."

In 2015, CLT was incorporated into the international building code, allowing it to be an option in building construction in the U.S., provided it meets specific manufacturing standards. To date, only two plants in the country, both in the West, are approved for manufacturing the panels. Closer to home, a Canadian plant in Quebec currently serves the CLT needs of much of the northern half of the eastern U.S., says Nagy.

With 17 million acres of forestland, Maine is well positioned to become a leader in CLT production in the Northeast.

"A goal of this research is to help bring a CLT plant to Maine," says Nagy. "We have the forests and the infrastructure."

Spruce-Pine-Fir (SPF) South is the grouping of wood species found throughout the Northeast that are used for home construction and industrial applications. A recent project led by Russell Edgar, the center's wood composites manager, and the Northeastern Lumber Manufacturers Association (NELMA) has resulted in the inclusion of Norway spruce into the lumber grouping. Sawmills and forest landowners in Maine are already benefitting from what is being dubbed a new "timber age" for the region.

EDGAR AND professors of civil and environmental engineering Roberto Lopez-Anido and Bill Davids, along with School of Forest Resources professors Douglas Gardner, Mehdi Tajvidi, Robert Rice and Stephen Shaler recently completed a three-year project to evaluate the mechanical and thermal/moisture performance of CLT made from SPF South, as well as new CLT assembly configurations. Those include hybrid panels made with solid sawn SPF and laminated strand lumber (LSL), another type of engineered wood composite manufactured in Maine.

In addition, a new project to evaluate the role of finger-joints on the hybrid composite performance is now underway.

While the majority of the world is focused on building with CLT panels, the UMaine researchers spend much of their time breaking them in half at the Advanced Structures and Composites Center to test for flexure, shear, block shear, delamination and fatigue.

And most recently, Nagy has been blowing them up with explosives.

He is working in collaboration with WoodWorks, a trade group dedicated to promoting the use of wood in nonresidential constructions, as well as contractors, manufacturers and government agencies to investigate the blast-resistant properties of CLT buildings.

Static testing and modeling of the CLT was conducted at the UMaine Composites Center and in October, a series of live blast tests was performed on three two-story CLT structures at Tyndall Air Force Base, Florida.

Three explosions, in increasing strength, were detonated near each CLT structure. The first two smaller blasts were designed to stress the structures to within their respective limits, but the third was designed to push them beyond.

After the dust settled, the structures remained standing.

"The wood performed predictably when compared to our static testing models," says Nagy, "and each of the structures remained intact with relatively minimal levels of damage."

While the full analysis of the results aren't yet in, initial observations from the tests were positive, according to Nagy. The next step, he says, is to test how CLT structures handle explosive force under load.

"As we continue to come up with new and innovative ways to use CLT, it becomes very important to get an accurate handle on its properties," he says.

These results will be used to further expand on the use of wood solutions for Department of Defense applications and other blast-resistant constructions, such as the development of hotels on military bases.

Nagy hopes the research and development of CLT and other wood composite materials at UMaine helps to facilitate the growth of the mass timber industry in Maine. ■

CLT is sometimes referred to as plywood on steroids. The product consists of two-by laminated lumber or composite — two-by-fours, two-by-sixes, or two-by-eights — stacked at right angles — with as few as three and as many as nine laminated layers — and bonded with an adhesive. In the Advanced Structures and Composites Center, researchers are testing a hybrid CLT panel made from a combination of solid-sawn SPF South lumber, as well as an engineered wood composite — laminated strand lumber (LSL). The composites are tested for flexure, shear, block shear, delamination and fatigue, as well as blast resistance.

State of **the state**

Alumna Lynn Farrington spearheads Maine's infrastructure report card

WHEN LYNN FARRINGTON was elected president of the Maine Section of the American Society of Civil Engineers (ASCE) last May, she already knew the biggest project for this year — completion of the state infrastructure assessment.

The 2006 University of Maine graduate led the effort conducted every four years in many states under the auspices of ASCE. The assessment analyzes the state's infrastructure — from aviation to wastewater, bridges to roads and rail, drinking water to ports and parks — looking at existing conditions, capacity, operations and maintenance, public safety and security, risk and funding. A letter grade is assigned to each area, as well as an overall composite grade.

Farrington brings a wealth of experience to her role as ASCE–Maine president. She has worked as a transportation engineer and project manager for more than 10 years and has expertise in traffic evaluation, roadway and intersection design and 3-D traffic modeling. At Louis Berger, a global transportation solutions company, Farrington has worked on transportation projects throughout Maine, New England and beyond, including Georgia, New Mexico and Jamaica.

The attraction of working as a transportation engineer, she says, is the diversity in the projects.

"You can learn so many different aspects of civil engineering and how they all fit together. It's hard to be successful if you focus on just one thing. You learn to get a wide overview, and that's the challenge, as well.

"My company is involved in nationwide and worldwide projects, where the client expectations and standards may be very different. You need to learn the nuances of each standard for each project you work on," she says.

In early November, Farrington and her team put the final touches on the infrastructure report card in preparation for its release on Nov. 28. The task of gathering all that information is not as difficult as it seems.

"We live it and breathe it every day," she says. "For example, we know the people who work with airports and wastewater facilities for a living, and we rely on them to collect the data. The hard part is assigning the grades, because we want to be fair and uniform in each category. We actually have a worksheet with a number of parameters that will calculate each grade."

There is now 12 years of infrastructure assessment data — publicly available information — in a format that everyone can understand, not just the engineers, Farrington says.

Farrington's overall assessment of the state of the state's infrastructure is that "there are definitely more areas that are trending down than trending up."

"Overall, we're moving in the wrong direction. And that's tied directly to funding," she says. "Most infrastructure owners are doing a great job prioritizing with current funding, but in spite of that, funding levels are not enough.

"This is definitely not a report card I would want to bring home to my parents when I was in college," Farrington says.

One of the biggest challenges the state faces is the cost of maintenance related to the cold and snow that come with a Maine winter. There are solutions for that, she says,

> There are not a lot of new roads that we need to build. **We have to start making the most of what we have. And that's true of all civil infrastructure."**
>
> Lynn Farrington

but they can be expensive, and it becomes a balancing act looking at how we use the 23,000 miles of roads in Maine and how much we want to invest in them. Maintenance is the key.

"There are not a lot of new roads that we need to build. We have to start making the most of what we have," Farrington says. "And that's true of all civil infrastructure. Costs have grown exponentially. We're starting to realize that it may be better to pay a little more up front for something that will last 10 more years and the annual operating cost will be reduced over the life cycle. We need to find ways to use the money we have more intelligently and in a way that is going to serve the public better, longer."

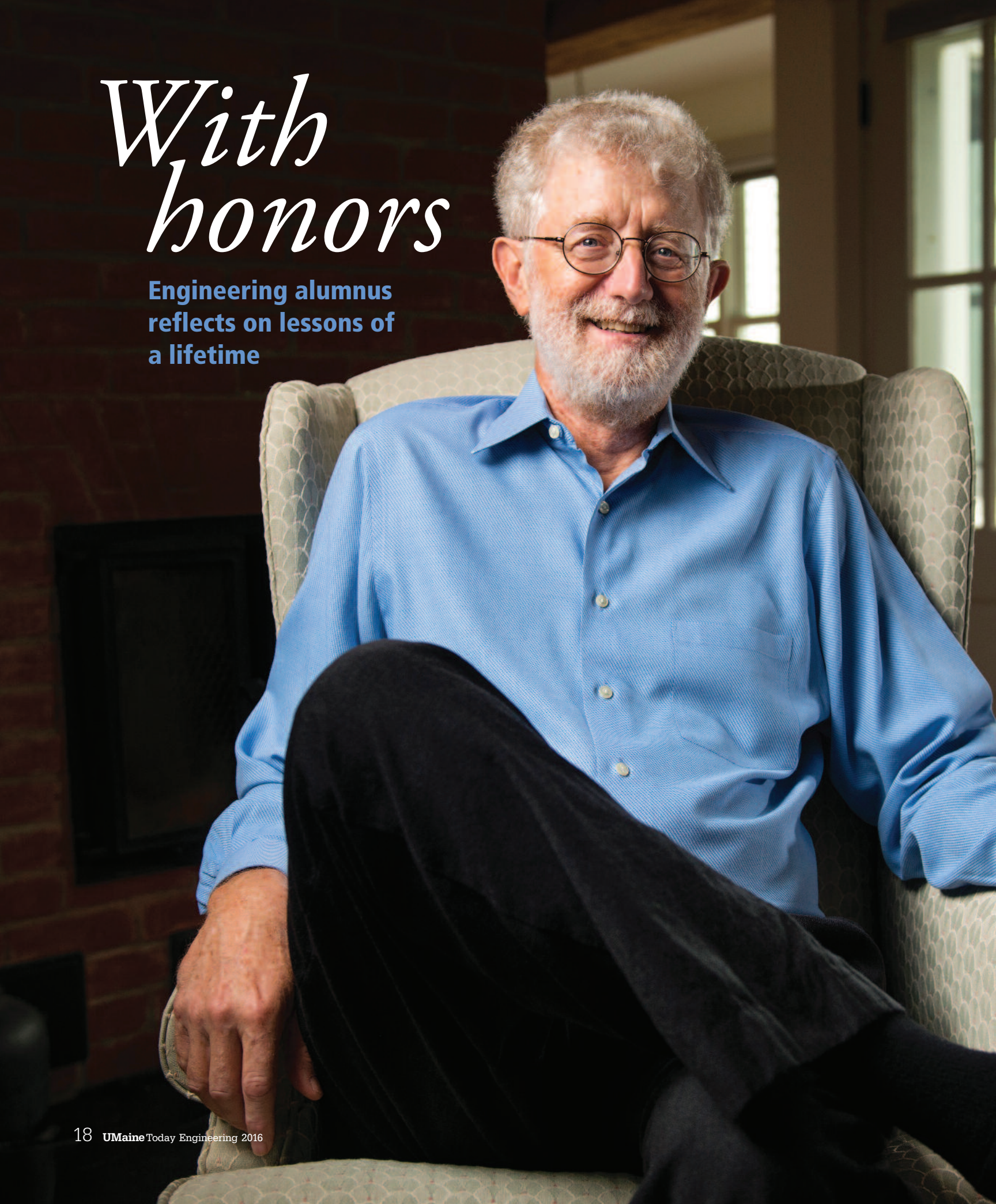
While the infrastructure report card has been the big project for ASCE–Maine and Farrington this year, it has not been the sole focus of her presidency. She also works to provide professional development opportunities for the 700 society members, and also has worked to strengthen the outreach efforts to elementary, high school and college students, including offering a $4,000 scholarship each year for an engineering student.

ASCE–Maine also does K–12 outreach to prepare students and get more people interested in the field — an effort that appears to be working. Teachers and students are enthusiastic and enjoy seeing ASCE members in the classroom. Students ask a lot of questions and that generates a lot of excitement. And the engineers enjoy doing it.

"It's a change of pace for us," she says. "When you're designing all day, you tend to forget how cool the job really is." ■

With honors

Engineering alumnus reflects on lessons of a lifetime



Dr. Denham Ward came to UMaine in 1965 to major in electrical engineering. He received a Distinguished Maine Scholarship and was enrolled in the Honors Program. It was in honors that he discovered a wide world of possibilities. His honors thesis focused on a computer simulation of the suspension system of a wire-guided self-driving automobile. His professional career moved into medicine. To recognize the importance of the Honors College throughout his career, Ward and his wife Debra Lipscomb created a scholarship for first-year UMaine engineering students in the Honors College.

DOWN A quiet, rural road in Bowdoinham, Maine, engineering alumnus Denham Ward settles into retired life and collects antique maps of the state. The maps, which collectively illustrate the dynamic evolution of Maine's historical borders, hang on the walls of a more than century-and-a-half-old house — a family home that Ward's great-great grandfather built.

Ward graduated from UMaine as an electrical engineering major and an honors student in 1969, and much like the borders of the state, his career has changed shape and direction over time. It has spanned both the engineering and medical fields, and has carried him between both coasts — twice.

But through it all, his passion for mentorship and a deep appreciation for the pursuit of new knowledge has remained constant. Ward says the seeds for his illustrious career were planted during his time in UMaine's Honors College.

Ward grew up in Clinton, Maine, and when he finished high school in 1965 he was the only youth from a graduating class of 27 to go to college.

"If you weren't working in the mill or in the forest, you went to school for engineering and you got a 'good' job," says Ward.

During the fall of his senior year, Ward's father, then the principal of Clinton High School, took him to visit MIT. However, coming from a town with a population of less than 2,000, Boston proved to be too overwhelming for the young student. Instead, he applied to UMaine.

Ward entered UMaine during its centennial year to pursue a degree in electrical engineering. He was admitted as a Distinguished Maine Student, a scholarship reserved for Maine's brightest students attending the university. The scholarship covered the student's first semester's tuition and granted entry into the first semester of the university's Honors Program.

UMAINE'S HONORS College gathers students from diverse academic focuses across campus in an intensive interdisciplinary curriculum that exists alongside the coursework of their chosen majors. The four-year program culminates with the development of a written thesis, one that is based in research and has a strong focus in faculty mentorship. The Honors Program, founded in the 1930s, is one of the oldest in the country.

"Coming from a small high school with not a lot of opportunity, the Honors College really set the stage for my diverse career," says Ward.

In the Honors College, Ward was immersed in new readings and intellectual discussions with students and faculty from many different academic backgrounds and goals. Late UMaine Professor Emeritus Geddes Simpson was the preceptor of Ward's first honors colloquium.

"I remember writing an honors paper my first year about the Vietnam War and learning a lot about things that I felt most Americans didn't know," says Ward. "(The Honors College) opened my eyes to much larger academic and intellectual worlds."

Ward also was particularly inspired by late Professor Emeritus of Mechanical Engineering Richard "Dick" Hill, who was one of his preceptors for honors seminars in the College of Engineering. His honors thesis focused on a computer simulation of the suspension system of a wire-guided self-driving automobile.

> "To be successful, you must be **adaptable, curious and hardworking.** You must be **willing to walk through open doors and chase new ideas."** Dr. Denham Ward

FROM UMAINE, Ward headed west to attend graduate school at the University of California Los Angeles. A fellowship with Hughes Aircraft Company provided funding for his graduate work and he received his M.S. in systems science in 1971, with a thesis that developed a mathematical model of highway traffic flow.

Ward continued at UCLA, working toward a Ph.D. in systems science. In 1973, he left his fellowship at Hughes and began looking for a more traditional research assistantship on the UCLA campus. Ward received a position with a newly hired medical school professor, J. Weldon Belleville, who was seeking engineering students to help set up a medical research lab to study respiratory physiology.

"Before, I didn't really have much of an interest in biology but during my time working in the lab, I developed a strong interest in biology and physiology," he says, "and that's how I went from modeling traffic patterns to modeling how the brain controls breathing."

Ward received his Ph.D. in 1975 and headed back to the East Coast for an intensive M.D. program at the University of Miami. The two-year medicine program was tailored for those who already held Ph.D.s in science or engineering.

He received his M.D. in 1977 and completed an internship in internal medicine at Jackson Memorial Hospital in Miami the following year.

Ward returned to UCLA to complete his anesthesiology residency and serve as chief resident. He remained at UCLA following his residency and did research in the same anesthesiology lab he helped set up as a graduate student. A few years later, he became the lab's director.

In 1992, Ward, his wife Debra Lipscomb and their daughter Hannah relocated to Rochester, New York, where he was named the chair of the Department of Anesthesiology at the University of Rochester. There, he split his time between research, clinical practice and teaching.

In 2011, he retired from the University of Rochester as a professor of anesthesiology and biomedical engineering, chair of the Anesthesiology Department, and associate dean for faculty development – medical education. The establishment of the Denham S. Ward Chair of Anesthesiology honored his contributions to the university.

Ward moved back to Maine and settled into his family home in Bowdoinham. "Quasi-retired," he served for four years as president and CEO of the Foundation for Anesthesia Education and Research, a nonprofit dedicated to advancing medicine through research and education in anesthesiology.

Today Ward is the co-director for The Academy at the Maine Medical Center Institute for Teaching Excellence and is a mentor for students in the Tufts Medical School Maine Track Program. For the past few years, he has hosted a "dinner club" for the Maine Track students, several of whom are UMaine graduates. Once a month, the students and Ward gather for dinner to discuss clinical research relating to the patients the students are seeing and to share their medical school experiences.

Looking back on his time at UMaine, Ward regards his experience in the College of Engineering and the Honors College as having a significant impact on his academic and professional career.

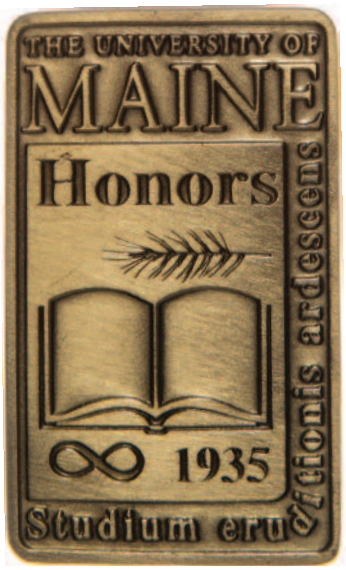
"Many Maine students are from rural areas and the Honors College gives them an opportunity to be exposed to a much wider and eye-opening intellectual world," says Ward, who was inducted as a Distinguished Engineer in the Francis Crowe Society in 2008.

He stresses the importance for engineering students not to become overly focused on their areas of specialization. "Engineering students need the broader intellectual perspective that the Honors College can provide," says Ward.

"To be successful, you must be adaptable, curious and hardworking. You must be willing to walk through open doors and chase new ideas."

To recognize the importance of the Honors College throughout his career, Ward and his wife created a scholarship for first-year UMaine engineering students in honors. The scholarship pays for the student's first year of tuition, and is in the spirit of the Distinguished Maine Student program that launched Ward's academic career.

The family hopes to continue expanding the scholarship, enabling the support of more students in the future. ■



In the 2016–17 academic year, 183 engineering majors are among the 902 students enrolled in UMaine's Honors College.

Honors College

In the University of Maine Honors College, a Signature Area of Excellence, students are engaged in critical analysis of the foundations of our society, fostering global civic responsibility. Students focus on independent research, taking advantage of the resources of a research university, and receive a rigorous, unified approach to the liberal arts core. Small classes combined with the living-learning communities of Colvin, Estabrooke and Balentine Halls provide Honors students with an exemplary student-centered and community-engaged learning experience. The college, built on one of the nation's oldest honors programs, continues to innovate, build capacity, create partnerships and enhance the lives of Maine's future leaders in business, science, engineering, education, and the arts.

The Stormwater Management Research Team (SMART) provides high school students with opportunities to be involved in engineering innovative solutions to stormwater problems. Girls and minority students — those underrepresented in STEM — are strongly encouraged to apply. The 10th- and 11th-grade students partner with teachers or community leaders.

Engaging environment

Community water research a focus of successful UMaine program to broaden participation in STEM

THE UNIVERSITY of Maine is one of 37 colleges, universities and educational groups nationwide to receive first-ever awards for the National Science Foundation's INCLUDES program, a comprehensive initiative to enhance U.S. leadership in science and engineering by broadening participation in the fields of science, technology, engineering and mathematics (STEM).

UMaine will receive $300,000 for a two-year pilot project that builds on its successful Stormwater Management Research Team (SMART) program based in the College of Engineering that has created a diverse STEM pathway with community water research. The pilot projects were selected for their potential to deliver prototypes for bold, new models that broaden participation in STEM, according to NSF.

Near the end of the two years, projects by UMaine and the other organizations in the national INCLUDES Alliance will be eligible to be one of the five initiatives selected for up to $12.5 million each in funding.

"The College of Engineering is leading the way in implementation of STEM education in Maine by helping K–12 schools integrate engineering practices in their curricula and training their teachers," says Mohamad Musavi, associate dean of the College of Engineering and SMART project director.

"Through its nationally recognized and award-winning SMART project, the college is engaging students and their teachers in real-world inquiry-based projects to solve important environmental challenges, such as stormwater and its impact on our communities."

NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) aims to improve access to STEM education and career pathways at the national scale, making them more widely inclusive to underserved populations. Over the next decade, NSF will expand the program, with the goal of developing a science and engineering workforce that better reflects the diversity of U.S. society.

At UMaine, the NSF-EPSCoR Track III funded SMART program is a hands-on, project-based education initiative to engage high school girls and minority students in engineering and sciences.

In 2014–15, the initiative trained and engaged 150 high school students and 15 teacher mentors in researching the effects of stormwater pollution. About 85 students and nearly 20 teachers took part in the multiday SMART Institute in June 2016.

Program student-mentor research groups are located around the state, including Kittery, Portland, Lewiston, Bangor and Eastport.

The SMART program is "a bold approach to changing the face of the STEM workforce," Musavi says. "This experiential learning approach is breaking down barriers between K–12 education and higher education institutions, and focusing on applying collective knowledge and workforce immediately in local communities."

The SMART Institute is held during the summer at UMaine to kick off a yearlong program for students and teachers by introducing them to the science and engineering of stormwater management, including its impact on the environment and local economy. The institute is open to 10th- and 11th-grade students.

The program, which is offered in collaboration with Bangor High School, also trains high school teachers to co-facilitate the academic-year internships.

During the institute, students collect water samples on the Stillwater River, analyze that data, build their own digital temperature sensors and present their findings. The hands-on projects are led by STEM professionals in areas such as engineering design, water chemistry, data analysis, and visualization and information technology.

Throughout the academic year in collaboration with their teacher-men-

UMaine's program begins with a three-day SMART Summer Institute based on campus. During the yearlong SMART internship program, the high school students work with their teachers and communities to help create innovative solutions to stormwater management, an important environmental problem for Maine. The participants monitor and map water quality, use the latest sensor technology for data collection, and learn to use computer modeling for data analysis to help solve local stormwater issues.

tors, students are required to apply the skills they learned at the institute to research a local water body and perform outreach to younger students and their community.

THIS PAST summer during the program's third year, the SMART Institute welcomed its first out-of-state participants, with students attending from New York and Missouri, as well as 16 high schools in Maine.

In the new initiative, led by Musavi and Jennifer Isherwood in the College of Education and Human Development, UMaine's SMART project will be introduced at City College of New York, Mississippi State University, University of South Florida, University of North Carolina at Charlotte and Boise State University.

The goal of the pilot project is to engage an effective system of partners in improving opportunities for women and minority students in STEM fields using stormwater as a topic throughout their education.

The collaborative effort will aim to diversify the face of STEM education. It also will focus on particular challenges for women and underrepresented minorities, while addressing an important community environmental issue: storm-water contamination and management and its effect on water quality in both freshwater and saltwater environments.

The globally important issues of water quality and stormwater unifies students and easily translates anywhere to active, community-connected research. ■

STEM Education

The University of Maine Signature Area of Excellence in STEM Education includes research that investigates the complex intersection of individual content knowledge, social learning environments, pedagogical knowledge of our teachers, and development and use of materials for the classroom. Understanding this complex system requires deep knowledge of disciplinary content and of models of teaching and learning. This area supports expanded and improved teaching and learning of STEM from pre-school through graduate school.

University of Maine Pulp & Paper Foundation President Carrie Enos, center, with UMaine chemical engineering majors and Pulp & Paper Foundation Scholarship recipients, left to right, Josh Gordon '18; Sage Duguay '17; Ming Schnorr '19; and Lauren Tingley '17.

Talent scout

Carrie Enos is dedicated to meeting the needs of students and the industry counting on them

CARRIE ENOS discovered her career path — and her passion — in the Consider Engineering program, offered annually by the University of Maine Pulp & Paper Foundation. Now she's ensuring that today's aspiring engineers have the same opportunities. Enos, who received a bachelor's degree in chemical engineering in 1999 from UMaine and went on to a successful career in industry, is now president of the University of Maine Pulp & Paper Foundation. In addition to the Consider Engineering program, the foundation supports more than 80 scholarships at full tuition and at other levels, which support students to consider a career in the pulp and paper industry. And by recruiting and encouraging the talented engineers of tomorrow, Enos and the Pulp & Paper Foundation are helping meet the workforce needs of the industry. We asked Enos about her early days in engineering and her leadership role today.

Why did you choose chemical engineering as your field of study? As a high school student, I loved math and science, but also was involved in a myriad of extracurricular activities — from music to sports to student council and beyond. I was struggling to find my purpose and wondering how on Earth I would choose a field of study in college. Stan Marshall, then the University of Maine Pulp & Paper Foundation executive director, invited me to attend the Consider Engineering program in the summer following my junior year of high school. I spent a week on the UMaine campus immersed in solving engineering problems, completing lab experiments, and getting an introduction to many different disciplines of engineering. When I left campus, I knew that I wanted to study chemical engineering at UMaine. The education you get on this campus is world class, the faculty is accessible, and the mentoring provided by the Pulp & Paper Foundation is exemplary.

What difference did your participation in Consider Engineering and a scholarship make in your academic career? I was so fortunate to receive a full tuition scholarship from the Pulp & Paper Foundation. I left college debt-free, and I walked into a career making an exceptional salary. What a wonderful way to begin life: with the resources to pursue passions, such as traveling the globe while working at a job that was challenging and fun.

How did UMaine help prepare you for your career? And what are the lessons that continue to influence you today? UMaine and the Pulp & Paper Foundation taught me how to approach problem solving and work hard, as well as the importance of soft skills, such as networking.

You worked in the paper industry since 1997, with increasing levels of responsibility. What are the milestones in that chapter of your career? I began my career as a process engineer at Champion International, worked as a shift supervisor there and at Sappi North America, and was a machine coordinator at International Paper. I returned to this part of the state as a machine superintendent and then became finished products business unit manager, responsible for four production lines and 350 employees. I found the impact that could be made on people's lives was so rewarding.

What do you tell prospective students interested in chemical engineering fields, including how they can contribute to the future of the pulp and paper industry? There continues to be so much demand for our graduates. The Pulp & Paper Foundation not only supports chemical engineering students, but also mechanical, electrical, civil and bioengineers, as well as forestry students. All of these disciplines work together in industry to bring new perspective, first-tier technical knowledge and an excellent work ethic to their employers. These degrees from UMaine are a wonderful starting point for a career, and the sky is really the limit for our graduates.

What is most important for the public — especially Maine residents — to know about the pulp and paper industry today? There are companies in this state working hard on research and development, and making investments to propel their facilities forward. University of Maine graduates will continue to innovate the industry and get us through this period of transition.

How does your experience in industry inform your work today as president of the foundation? I was a student of this program, so I understand the demands of the curriculum and what undergraduates need for support. I also worked in industry and have hired both co-op and full-time engineers, so I very much understand what employers need from the students. I coordinate both of those sets of needs to bring a unique perspective to this role. ■

Pulp & Paper Foundation Scholarship fast facts

THE SCHOLARSHIPS, awarded annually and renewable, are designed to allow students to prepare for a technical career in the paper industry. For high school students, the merit-based scholarships are awarded to those in the top 15 percentile of their high school class. College students at or beyond their sophomore year also are eligible.

Students from all engineering disciplines are eligible.

The current demand exceeds supply for engineering graduates in the pulp and paper industry. One hundred percent of Pulp & Paper Foundation Senior Scholarship recipients are employed or choosing to attend graduate school.

Since 1950, the Pulp & Paper Foundation has supported more than 4,000 UMaine students with scholarships.

UMaine's 2016 Outstanding Teacher

HOWARD M. "MAC" GRAY, professor of construction engineering technology, received the University of Maine's 2016 Presidential Outstanding Teaching Award.

Gray has consistently had some of the highest student evaluations in the School of Engineering Technology, reflecting his innovative teaching style, knowledge and relevant experience and motivation. Whether teaching structural design, building construction, soil mechanics and foundations, or any of his other courses, students cite the effectiveness of his teaching methods. That includes bringing his experience as a structural design engineer and researcher to bear on theoretical lessons in the classroom, and using technology to enhance the learning environment. They also note his compassion, patience and genuine caring for students and their success.

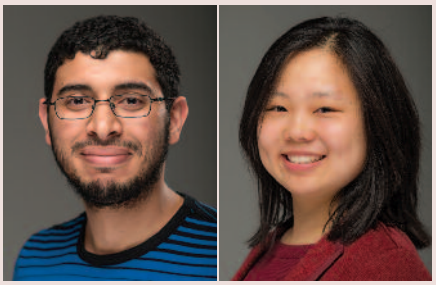
Gray's teaching has a memorable, positive and commendable impact on graduates. Alumni surveyed note that Gray's ability to effectively teach complex, technical subjects has far-reaching, positive impact on their employment and advancement in their professional careers.

Most of Gray's former students are managers or leaders in the profession; many now own and operate their own firms, the majority of which are in Maine.

During his tenure as coordinator of the Construction Management Technology Program, 1987–2011, enrollment quadrupled. He also was instrumental in developing the bachelor's degree program in construction management technology.

Gray is a cooperating professor with UMaine's Advanced Structures and Composites Center. His research led to a patent awarded in 2011, "Slip Method for Prestressing Beams with Bonded Tendons."

Gray received bachelor's and master's degrees from UMaine, and joined the faculty in 1981. His industry experience as a licensed professional engineer includes five years as a structural design engineer for Chicago Bridge & Iron Co., Oak Brook, Illinois. ■



The top graduating students in 2016

AHMED ALMAGHASILAH of Qatif, Saudi Arabia, was the 2016 Outstanding Graduating International Student in the College of Engineering.

Almaghasilah majored in electrical engineering and had a minor in mathematics. In 2014, he was invited to China and New Zealand to attend the Envision Global Forum on engineering and technology.

Almaghasilah was a teaching assistant in the Department of Electrical and Computer Engineering, and assisted electrical and mechanical engineering students in their senior projects.

YI PENG of Chongqing, China, was the 2016 Outstanding Graduating Student in the College of Engineering.

Peng, a civil and environmental engineering major and a nontraditional student, received numerous scholarships, including those from the Maine Better Transportation Association and Associated General Contractors of Maine. In 2014, she took first place in the student paper presentation at the 64th Maine Transportation Conference.

Since 2013, Peng has been employed at UMaine's Advanced Structures and Composites Center, collaborating on research on the VolturnUS floating offshore wind turbine and ultra-high performance concrete project.

She participated in the National Science Foundation 2014 Summer Undergraduate Research Fellowships in Sensor Science and Engineering at UMaine, and the following summer, interned at HNTB Corporation in Westbrook, Maine.

Peng was an officer in the UMaine chapter of the American Society of Civil Engineers and the first president of the UMaine Table Tennis and Badminton Club.

She is pursuing a master's degree in civil and environmental engineering at UMaine and plans a career as a structural engineer.

Going to extremes

Civil engineering researchers study worst-case scenarios in a changing climate

ON THE state's highways, the Maine Department of Transportation maintains an estimated 97,000 culverts. And each one is threatened by the frequency and intensity of extreme storms due to changing weather patterns and climate.

Katrina in 2005. Irene in 2011. Sandy in 2012. Matthew in 2016. Each of those hurricanes brought heavy rains and/or high storm surges that overwhelmed the existing infrastructure and resulted in widespread flooding, property damage and death.

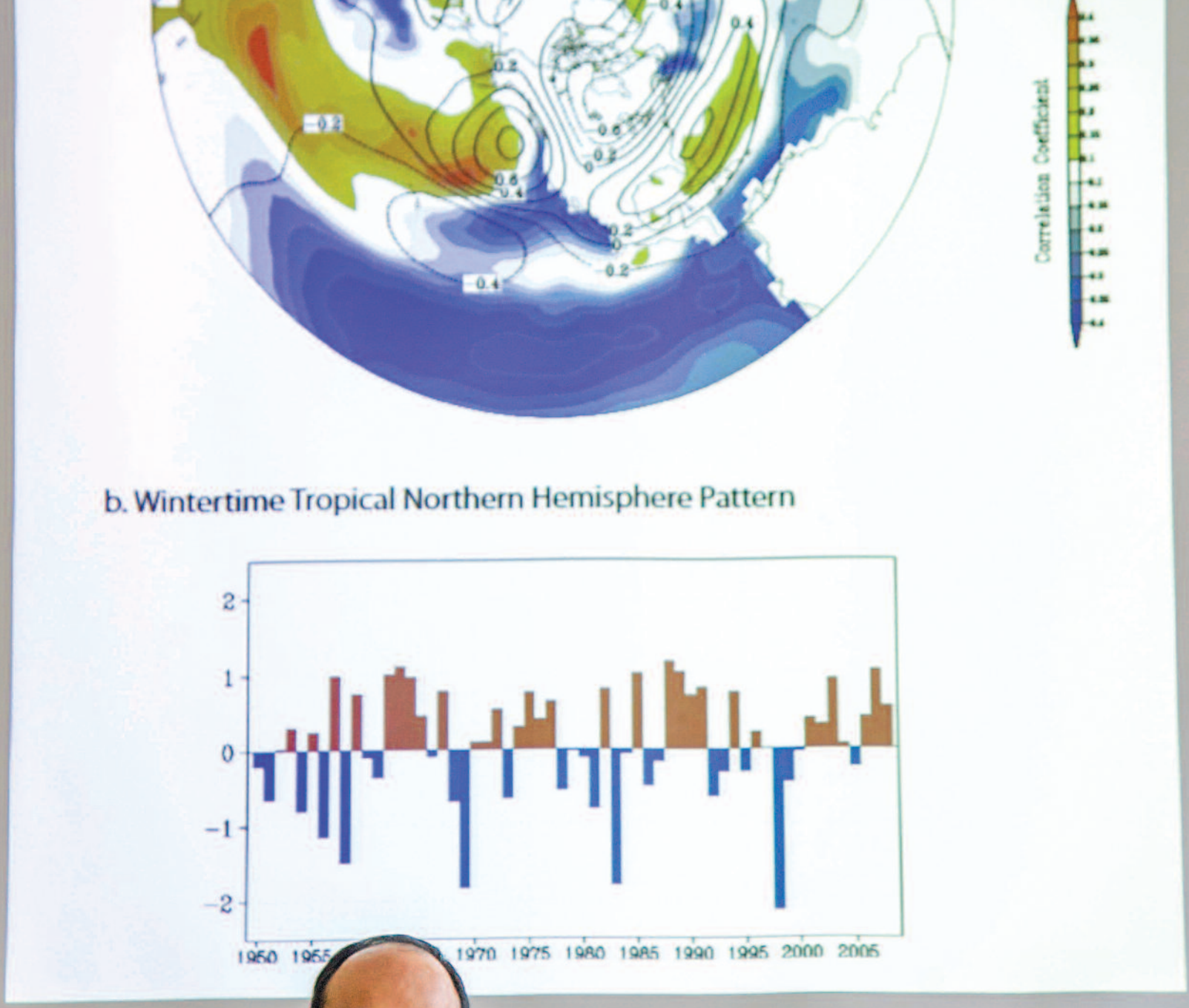
In each of those cases, the infrastructure — the levees, the seawalls, the dams and the culverts — were designed using accepted standards established in the 1960s. Those standards were based on historic weather patterns using the statistical concept known as stationarity, which assumes that the weather in the future will be similar to the weather in the past.

Research by Shaleen Jain, an associate professor of civil engineering at the University of Maine, challenges that basic assumption and promotes a nonstationarity approach to infrastructure design standards that reflects the changing weather and climate. It is a concept that is gaining recognition and acceptance nationally and internationally, and one that could give planners an invaluable tool in developing infrastructure assets designed to handle the impacts of extreme storm events.

"A lot of my work is seeking to reduce the uncertainty and come up with approaches so we can quantify or pinpoint climate-related risk," he says. "The question is, if historical data indeed is being used, are the baselines reflected in historical data adequate for designs for the future where possibly, from climatic influences, we may actually see changes in rainfall and runoff patterns? The reality would be that the future hydrology or future rainfall may indeed be quite different from the past, so the assumptions are no longer valid."

Those designs and their construction often involve large public investments and have an impact on public safety. Jain's research is two-fold: It seeks to find ways to predict extreme weather events and then translate those predictions into the risks to infrastructure in specific locations from those storms. This type of multidisciplinary research requires a

In his interdisciplinary research in hydroclimatology, Shaleen Jain studies extreme weather-climate events and engineering standards to assess risk to infrastructure and inform future engineering design.


Correlation Coefficient
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Shaleen Jain, center, has four Ph.D. students working on projects involving climate and engineering concerns. They are, left to right, Nuha Abdullah, focusing on environmental flows; Ali Aljoda, dam management; Anne Lausier, water policy; and Mussie Beyene, lake and climate interaction.

different way of looking at climate, weather and engineering standards in order to make a meaningful assessment of risks, Jain says. He is essentially suggesting a paradigm shift that solidly integrates climate into engineering design.

"The work I do is an interdisciplinary field that has been coined hydroclimatology. We seek to bridge those disciplines. As an engineer, I have a particular advantage in that there is certainly a lot of interest in improving our understanding of our climate system and all the uncertainties that come with that. At the same time, my students and I are focused on solutions and decision-making under uncertainty to address real-world problems that impact every citizen."

THE FUNDAMENTAL question, Jain says, is how to understand what aspects of the climate system affect the frequency and magnitude of storm events and the resulting flooding at a particular location. Predicting the weather is challenging, but Jain's research indicates that, to an extent, the Pacific Ocean and particularly El Niño hold the key. El Niño, the periodic warming of the surface water in the tropical Pacific Ocean, is the largest signal of year-to-year fluctuations that emerge from that region and have worldwide impacts on rainfall and temperature, Jain says. In addition, it appears that the El Niño region near the equatorial Pacific also is sensitive to the changing chemistry of the atmosphere — greenhouse gases.

"The extent to which these climatic signals from the tropics have an influence on climate over North America, eastern and southern Africa, and the Indian subcontinent are essential patterns which, if we can predict them — and we have had some success — also lead to predicting the flood risk at a location," he says.

"Those are important aspects of research that we are actively working on. And, in looking forward, we are thinking about our ability to attribute or flag specific extreme events and the likelihood that those events resulted from the warming climate or were just an upshot of the natural vagaries of weather and climate."

Being able to predict extreme storm events will

have a profound effect on what happens on the ground in terms of emergency preparedness, and in the planning, design, construction and maintenance of the infrastructure that will handle the impacts of extreme weather. Researchers will be able to use predictions based on El Niño and climatic factors to characterize the regional or local hydrology's sensitivity to a changing climate. To be able to translate global climate activity into meaningful local impacts is extremely important to those who plan and maintain municipal infrastructure. Being able to understand the levels of nonstationarity at a specific location, Jain says, can help officials to prioritize their infrastructure design, maintenance and upgrades. He anticipates the solutions will require blended approaches, wherein both natural and built infrastructures are used to, for example, mitigate flooding.

"There are practical constraints and concerns in that we're often faced with limited resources. If you have a thousand culverts and can only upgrade five, which ones do you choose? Our work is seeking how to set those priorities in a scientifically informed fashion," he says. "Depending on the state of El Niño and what we're expecting it to be, we may be able to fine-tune our flood potential for a location, and that's a wholly different approach as compared to a static idea of risk."

ALL THIS research, he says, has to be translated into risk and then society has to decide, based on its values, what level of risk is acceptable. Those risks vary from location to location and, likewise, the response will be a local one. In Maine, the key risk might be the impact future storms will have on culverts and their ability to handle increased water flows. In Louisiana, the concern may be the height or width of the levees. In other locations, it may be concerns about the height of a dam or the ability of a reservoir to contain flood waters. The research that Jain and others are doing offers approaches and technologies to develop a meaningful estimate of risks at a specific location.

While climate change continues to be studied and debated in the public and policy arenas, Jain's research is gaining acceptance in some key areas. The U.S. National Academy of Sciences cited his work in its Report on Extreme Weather Events in the context of climate change. In other emerging work focused on the recent increases in compound flood events, ones related to the simultaneous occurrence of storm surge and heavy rainfall along the U.S. coastline, Jain co-authored a study published in the prestigious journal *Nature Climate Change*. And last February, the Advisory Committee for Water Information released its updated U.S. National Flood Design Guidelines and Standards, which cites his work as a key reference to guide future analysis and design approaches. Those standards, developed through a federal interagency effort, are used internationally.

"I was heartened that the national flood standards underwent a whole revision," Jain says. "In a small way, I feel encouraged that our efforts linking climate and floods are poised to shape how water infrastructure should be designed and handled in the future."

Jain's research also has informed planning for local communities in Maine and beyond. Through the National Science Foundation's Sustainability Solutions Initiative, he and a team worked with several Maine communities that are already feeling the effects of climate change. In Lincolnville, the team worked with town officials to examine the inventory that identified aging and undersized culverts; in Ellsworth, they collaborated with the city planner and provided information regarding stormwater planning and culvert maintenance. The initiatives are part of UMaine's effort to develop a system of place-based assessment.

"We're looking to involve local decision makers and help translate knowledge that needs to be vetted alongside local concerns and issues, assets and legacy infrastructure — community-level climate adaptation," Jain says. ■

Climate Change

The University of Maine's Signature Area in Climate Change features internationally recognized research, and highly integrated undergraduate and graduate educational opportunities. The emerging academic focus is on changing ecosystems and climate — impact on animal and human health. The Climate Change Institute, the cornerstone of the Signature Area, has evolved beyond a singular focus on research to be a leader and a vehicle for broad integration of climate change strengths across campus and statewide.

UMaine chemical and biological engineering students are involved in research investigating the wood-to-fuel pathway called UMaine thermal deoxygenation — one of the most promising drop-in biofuel innovations in the nation.

What's next in the **North Woods**

Jet fuel from biomass could power the forest economy

FOR DECADES, University of Maine chemical and biological engineers have looked at the North Woods on a molecular level to understand the wood components and develop processes to make papermaking the best it could be.

Today, in the wake of a changing pulp and paper industry, UMaine engineers are still focused on the wood components, but the discoveries they make also lead to innovations to develop fuels, bioproducts and advanced materials. And their collaboration with forest resource scientists is closer than ever before.

"The forest bioeconomy big picture is where the collaboration between the School of Forest Resources and the Department of Chemical and Biological Engineering makes a lot of difference," says Hemant Pendse, department chair and founding director of UMaine's Forest Bioproducts Research Institute (FBRI). "I've been working with forest landowners for 10 years and the key thing is, anything we chemical engineers propose or plan to do is going to ensure that the health of the forest is protected."

Maine landowners are committed to sustainable harvest, Pendse says, and UMaine researchers need to build on that while making sure the state's wood suppliers have alternative sources of revenue for their biomass. That's where engineering and technology come in.

"The research we are doing essentially opens up those new sources of revenue, whether we turn woody biomass into plastics, fuels or many other high-value products," says Pendse.

FBRI's multidisciplinary research involves a collaborative effort between UMaine's Department of Chemical and Biological Engineering, School of Forest Resources, School of Economics and the public policy sector. The institute focuses on products with the potential to boost Maine's economy by providing new sources of income for the forest industry. That includes new uses for idled or downsized paper mills, and new products that existing and startup companies can produce in Maine.

"By working with many partners — from pulp and oriented strand board manufacturing sectors, as well as forest landowners and industry leaders

Forestry and the Environment

The University of Maine's Signature Area of Excellence in Forestry and the Environment focuses on the state's sustainable forests and the forest-based economy. UMaine is nationally and internationally recognized in its advanced wood composites, wood processing, biofuels, wood chemistry and forest resources research. Maine's natural resources in communities statewide provide unique hands-on educational opportunities in forestry, wildlife and the environment.

Hemant Pendse

from both the energy and chemical sectors — we are saving jobs, building new businesses and training future engineers," Pendse says. "We can make a major impact on the nation through our work on converting forest biomass into fuels, chemicals and advanced materials in a sustainable manner."

FBRI WAS established in 2010 after the university, recognizing the potential for research in the use of renewable sources for fuel, had utilized about $10 million in state and federal funding to recruit faculty with expertise in certain key areas and to upgrade existing laboratories. With an additional $4.8 million in state funding, the institute created the Technology Research Center (TRC), a 40,000-square-foot facility that opened in 2012 in Old Town, Maine.

TRC features state-of-the art process control and process information systems that can validate, demonstrate and help commercialize developing fuel, chemical and advanced material technologies from forest by-products at an industrial relevant scale, making it a one-stop shop for processing and analysis of technologies, Pendse says.

"We have built the infrastructure and brought in the right people, which has made us competitive nationwide," he says. "TRC complements what we do on campus at the Process Development Center. At TRC, we work on a scale that is relevant to industrial deployment so as to help the private sector get necessary engineering data and confidence."

FBRI first began looking into ethanol-type biofuels — blended stock fuels that could be added to gasoline — but soon turned to what are known as drop-in fuels. Examples include renewable gasoline, diesel and jet fuel — those fuels that are essentially the same as those now in the pipeline. Working with several federal agencies, the institute has made substantial progress in developing technologies that make drop-in fuels.

Most recently in 2016, the Defense Logistics Agency awarded FBRI $3.3 million to advance

wood to jet fuel technology at TRC. The technology is based on FBRI's patented thermal deoxygenation (TDO) process, which yielded jet fuel test samples that have met key specifications.

FBRI is investigating co-production of advanced materials, such as nanocellulose composites, as well as some high-value chemicals from woody biomass and liquid hydrocarbon fuels. This project will explore conversion of cellulose and lignin to liquid hydrocarbon fuels, and use of hemicellulose extract and cellulose fiber slipstreams for developing high-value coproducts.

UMaine's research approach, based on a sustainable supply of woody biomass, will provide new opportunities for high-value use as an alternative to direct combustion in biomass power plants, where energy efficiency is often very low. In addition, FBRI plans to reassemble a relocated biomass hydrolysis/dehydration pilot plant for converting biomass into levulinic and formic acids. The goal is to keep this unique critical research infrastructure operating in Maine and train students to help develop technologies to produce speciality chemicals and biofuels from woody biomass.

Although FBRI researchers have produced jet fuel samples that have met key government specifications, jet fuel development will be a long-term project. Commercial development of diesel and heating fuel oil is the most likely path to commercial markets in Maine, according to Clayton Wheeler, a professor of chemical engineering and the associate director of FBRI.

THE WOOD to jet fuel research is ready to move from the university labs to TRC, where researchers hope to boost production of the basic crude oil from the batch process they have been using to a continuous process that will produce larger, pilot-scale fuel quantities with associate engineering design data.

"We're still in the early stages," Pendse says. "We're making gallons of it, pretty soon we want to be making hundreds of gallons of it. Once we demonstrate that scale, I think that's when the private industry will begin to take interest. If we can meet those specifications, we can make it here and use it here, that's an attractive proposition."

Two key elements make biofuel production a possibility in Maine: the state's vast reserve of natural growth forest land and the existence in Maine's paper mills of some of the infrastructure needed for FBRI processes. There is about a million dry tons of biomass available in Maine annually, Pendse says. That doesn't mean cutting more trees or utilizing high-value trees that currently go to the sawmills or to pulp mills. Both of those types of logs are too expensive to be used in the biofuel process. What is left,

A focus of FBRI research is on converting forest biomass into fuels, chemicals and advanced materials, all in a manner that is consistent with sustainability in the North Woods and beyond.

> The research we are doing essentially **opens up those new sources of revenue,** whether we turn woody biomass into plastics, fuels or other high-value products."
>
> Hemant Pendse

however, is biomass that is available and is not being utilized.

The creation of biofuels in Maine at a commercially viable level is possible, in part, because much of the infrastructure needed for the process exists. Early deployments can use biomass gasification and syngas to liquid fuels technologies, while UMaine's TDO technology is undergoing pilot scale validation.

Paper mills currently use some of the chemicals needed for FBRI's TDO process and those mills also have systems in place to handle biomass — the harvesting and transportation, sizing and sorting, wastewater treatment, steam and power generation. Repurposing an idle paper mill or part of a functioning mill can reduce the startup costs for a wood-to-fuel operation and help to make it viable, Pendse says.

Commercial viability is a key concern of the research at FBRI and given the current underpricing of petroleum-derived fuels, it is difficult for biofuels to be competitive in pricing, according to Wheeler. In order for this to make good process economics, he says, a biofuel enterprise also needs to be able to make co-products.

Researchers already are using the same raw materials, as well as some of the intermediate materials like the mixed acids from the biofuel process, to produce low-volume, high-value specialty chemicals.

In addition, the existing Maine infrastructure can take advantage of FBRI research on turning wood sugar into bioplastics. Pendse considers that "a near-term proposition."

With the right commercialization partner, the production of bioplastics from wood chips could begin in Maine within a two-year period, Pendse says.

USING THE same raw materials, but with a different mechanical process, researchers are developing applications for nanocellulose fibers. FBRI researchers led by Michael Bilodeau, director of UMaine's Process Development Center, have put UMaine on the national map by developing a process that involves untwisting and liberating the cellulose in wood fibers so they are sufficiently small — about 1,000 times smaller than normal wood fibers in a piece of paper. Once separated, the nanocellulose can be used in a variety of applications.

Pendse ticks off a list of the applications for nanocellulose: adding it to fiberboard to give it extra strength, and adding it to concrete to help in curing and strength. It is being used in and on specialty papers, and some companies are looking at ways to use it in cosmetics and ink.

Since it has been approved by the U.S. Food and Drug Administration, cellulose also can go into food additives. In cross-collaborations with bioengineers, they also are in the early stages of researching medical applications for nanocellulose fibers.

FBRI has moved nanocellulose-related technology from the lab and testing center to the private sector. One company is producing 2 dry tons of nanocellulose per day, and an equipment manufacturing company is marketing the technology.

Although there are challenges when working in an emerging sector such as this, including attracting capital to foster its development here and staying ahead of international competition, FBRI remains on the cutting edge of the research, testing and development in this new and exciting field.

"We will continue the research so we have other alternatives for the future," Pendse says.

"We will help the private sector deploy our technology at higher and higher scales, and we need to continue to demonstrate it at a pilot scale first, so the private sector can decide whether the technology is ready for deployment at a commercial scale." ■

Masoud Rais-Rohani
The Richard C. Hill Professor

AEROSPACE ENGINEER Masoud Rais-Rohani is the chair of the Department of Mechanical Engineering, effective Jan. 1. He joins UMaine from Mississippi State University, where he was a professor of aerospace and computational engineering.

Rais-Rohani began his career at Mississippi State in 1991 after receiving a Ph.D. in aerospace engineering from Virginia Tech.

At UMaine, Rais-Rohani also is the Richard C. Hill Professor of Mechanical Engineering.

Hometown: A native of Tehran, Iran; spent most of my life in Starkville, Mississippi.

Years teaching/working: Nearly 29 years.

Degrees: Bachelor's and master's degrees in aerospace engineering from Mississippi State University; Ph.D. in aerospace engineering from Virginia Tech.

What courses do you teach? Engineering design optimization; aerospace structural analysis and design; composite materials; structural mechanics.

Research specializations: Structural and multidisciplinary design optimization; lightweight structures for aerospace and automotive applications; uncertainty quantification; reduced order modeling.

What is your latest research project? We are exploring different design optimization techniques that are suitable for multiscale and multiphysics process-product and material-product design problems. In addition to working on strategies to reduce the computational cost, we are considering the influence of various uncertainties on the safety and performance variability of such systems.

What is your favorite subject to teach and why? I enjoy teaching structural analysis and design courses because I like the subject and the fact that the concepts covered tend to be fairly intuitive.

Do you have any favorite strategies you use to get ideas across? I rely on visualization and experiential learning as a way of enforcing the topics discussed in the classroom.

What is your advice to students? Take ownership of your learning. Find out the best way you learn and stick to it. Don't be satisfied with a casual or flawed understanding of critical concepts. Have the courage to ask questions. Perseverance is an active ingredient for success.

What are your favorite pastimes? I like to design and build things, big and small. I also enjoy all kinds of outdoor activities.

Little-known fact about you? I've flown solo in a glider. ■

Welcome new faculty

Sheila Edalatpour

Assistant Professor of Mechanical Engineering

Ph.D., University of Utah

SPECIALTY: Nanoscale heat transfer

WHY UMAINE? To pursue my research goals in collaboration with the Laboratory for Surface Science and Technology.

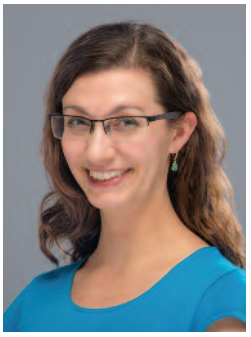
Aaron Gallant

Assistant Professor of Civil and Environmental Engineering

Ph.D., Northwestern University

SPECIALTY: Geotechnical engineering

WHY UMAINE? The University of Maine offers a great balance of teaching and research.



Caitlin Howell

Assistant Professor of Bioengineering

Ph.D., University of Heidelberg

SPECIALTY: Biointerfaces and biomimetic materials

WHY UMAINE? Not only do the faculty and staff here perform world-class research, they show true respect for students through their dedication to quality teaching and mentoring.

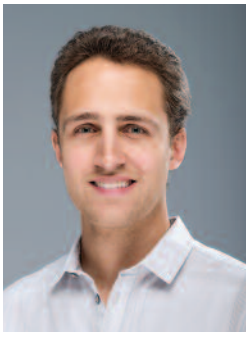
Amber Kilip

Assistant Professor of Construction Engineering Technology

M.S., University of Maine

SPECIALTY: Construction engineering technology

WHY UMAINE? UMaine has an excellent engineering program, with small class sizes and professors that care about their students.



Olivier Putzeys

Lecturer of Mechanical Engineering

Ph.D., University of California, Berkeley

SPECIALTY: Combustion, thermal-fluid sciences

WHY UMAINE? I believe in high-quality public education, and UMaine and the surrounding community/environment are an all-around great fit for my entire family.

Xenia Rofes

Lecturer of Civil Engineering

M.S., University of Washington

SPECIALTY: Structural engineering

WHY UMAINE? Family and work peers.

Jennifer (Lauren) Ross

Assistant Professor of Civil and Environmental Engineering

Ph.D., University of Florida

SPECIALTY: Coastal engineering

WHY UMAINE? UMaine had the most welcoming and friendly faculty. I instantly knew I would have the support and encouragement that I needed to succeed.

Karissa Tilbury

Assistant Professor of Chemical and Biological Engineering

Ph.D., University of Wisconsin-Madison

SPECIALTY: Biophotonics, engineering education

WHY UMAINE? I cherish land/sea grant institutions, and am thrilled to be a part of educating and learning from both students and citizens of Maine.

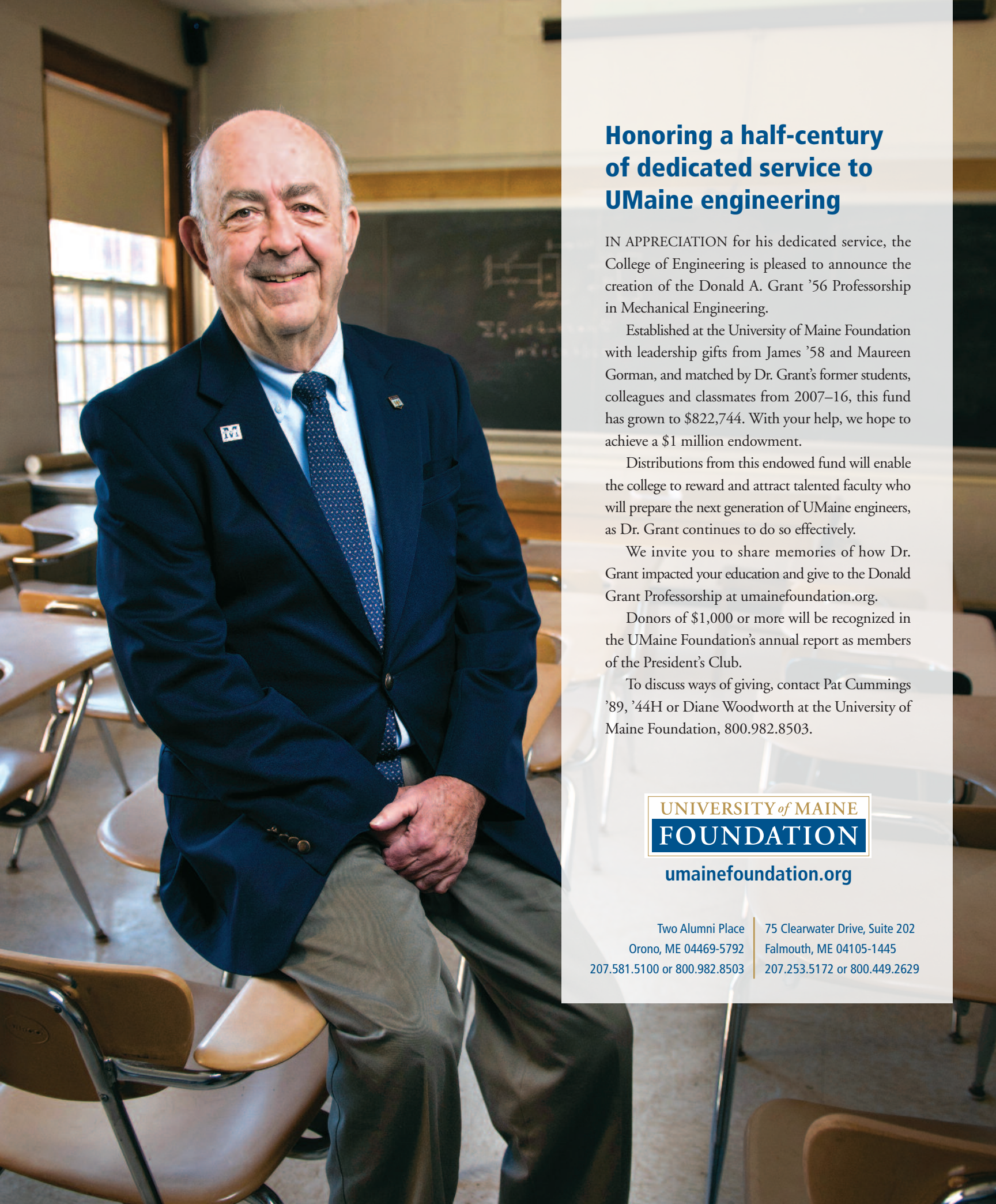
Qian Xue

Assistant Professor of Mechanical Engineering

Ph.D., Johns Hopkins University

SPECIALTY: Fluid mechanics

WHY UMAINE? Good life-work balance.



Honoring a half-century of dedicated service to UMaine engineering

IN APPRECIATION for his dedicated service, the College of Engineering is pleased to announce the creation of the Donald A. Grant ’56 Professorship in Mechanical Engineering.

Established at the University of Maine Foundation with leadership gifts from James ’58 and Maureen Gorman, and matched by Dr. Grant’s former students, colleagues and classmates from 2007–16, this fund has grown to $822,744. With your help, we hope to achieve a $1 million endowment.

Distributions from this endowed fund will enable the college to reward and attract talented faculty who will prepare the next generation of UMaine engineers, as Dr. Grant continues to do so effectively.

We invite you to share memories of how Dr. Grant impacted your education and give to the Donald Grant Professorship at umainefoundation.org.

Donors of $1,000 or more will be recognized in the UMaine Foundation’s annual report as members of the President’s Club.

To discuss ways of giving, contact Pat Cummings ’89, ’44H or Diane Woodworth at the University of Maine Foundation, 800.982.8503.

UNIVERSITY of MAINE FOUNDATION

umainefoundation.org

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