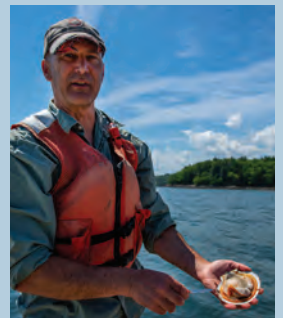
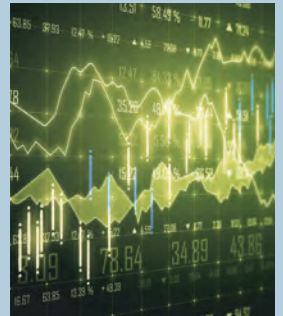
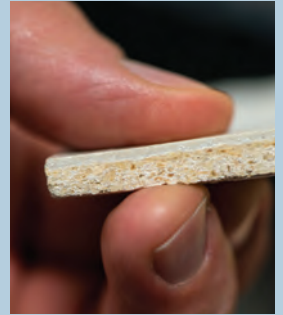
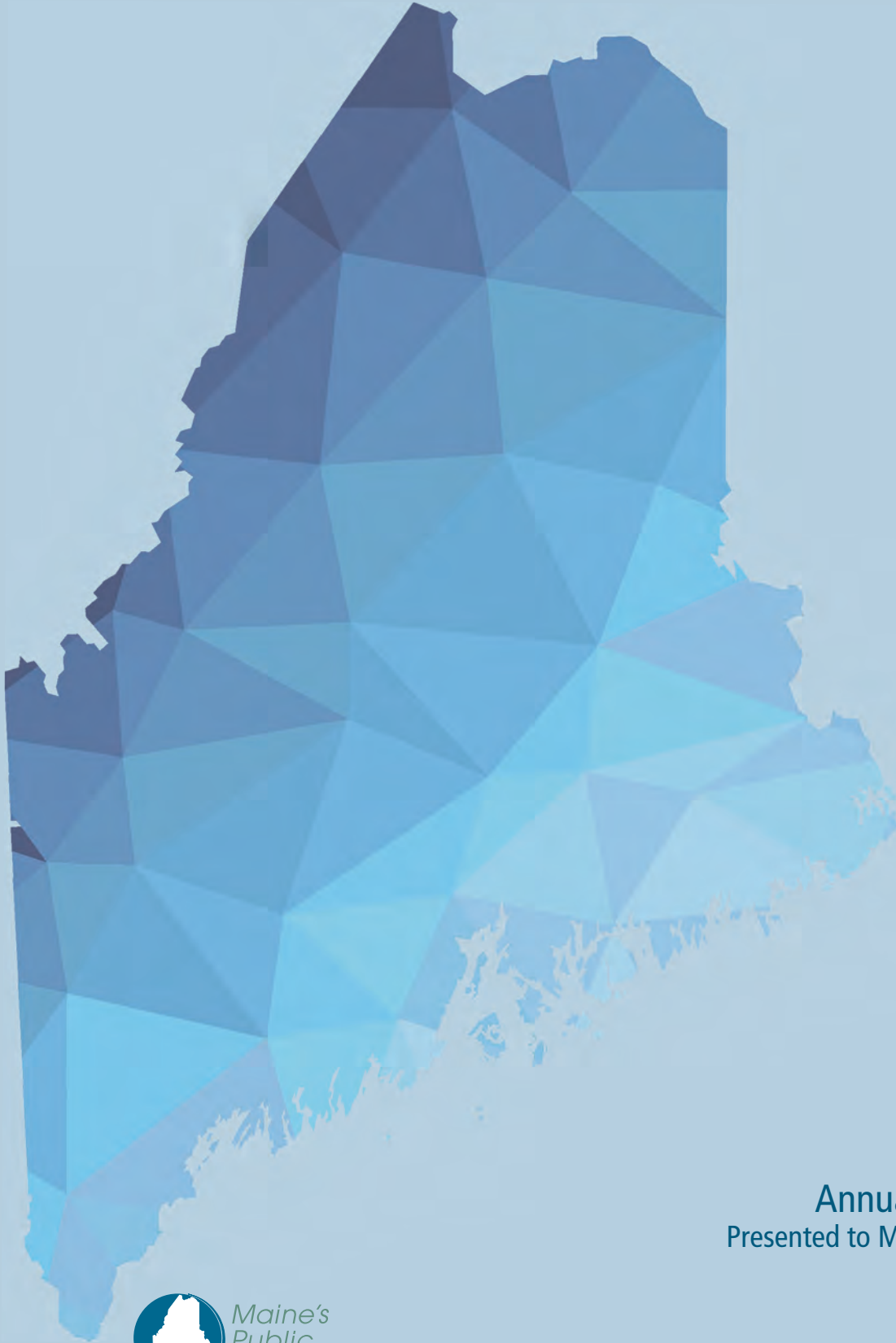


MAINE ECONOMIC IMPROVEMENT FUND



Annual Report FY2020 Presented to Maine State Legislature



A successful partnership among Maine's government, private sector and public universities to build Maine's economy and future workforce through research and development.



TABLE OF CONTENTS

Memo from the University of Maine System Chancellor	1
Background of the Maine Economic Improvement Fund (MEIF)	2
Role of MEIF	2
Progress in FY2020 Strategic Outcomes, Goals and Metrics	3
MEIF Metric 1	3
MEIF Metric 2	5
MEIF Metric 3	5
MEIF Metric 4	7
MEIF Success Stories	8
Appendix 1 — UMS Intellectual Property	22
Table A1-1 University of Maine System New Patent Applications Filed FY2020	22
Table A1-2 University of Maine System — Patents Issued FY2020	23
Appendix 2 — MEIF Financial History and Tables	24
Table A2-1 History of Legislative Actions Appropriating State Research Funds	24
Table A2-2 Legislative History of MEIF New Appropriations	25
Table A2-3 Utilization of FY2020 Research Appropriation by Targeted Sector	27
Table A2-4 Utilization of FY2020 Research Appropriation by University	28

Memo from the Chancellor

The State of Maine's investment in the Maine Economic Improvement Fund (MEIF) is a vital and ongoing commitment to advancing the research mission of Maine's public universities.

With the flagship University of Maine leading the way, the University of Maine System multiplies the impact of MEIF funding several times over by advancing knowledge and research that leads to job creation and economic growth for the benefit of all Maine people.

The importance of the UMS research mission has never been more clear than through the ongoing pandemic and public health emergency. COVID-19 has changed the world, and public research universities across the globe stepped up to rapidly respond in myriad ways unique to their research missions. In Maine, the research capacity of our public university system, bolstered by decades of MEIF and other investments, has been an important foundation for our ability to help lead Maine's fight against this global pandemic. Even as our universities successfully transitioned to remote teaching and learning, talented faculty and researchers, staff and students stepped up to serve our state, with university laboratories, centers and facilities pressed into service in new ways to protect public health and solve the problems that Maine's communities and companies faced in the pandemic.

As 2021 begins, the availability of effective COVID-19 vaccines developed with previously unheard of speed and coordination between government, private enterprise, and the academy is a powerful reminder of the importance of sustained investment in science and research capacity. But even with vaccines rolling out, the pandemic's financial toll continues to reverberate through our economy. Here in Maine, our public universities will play a central role in accelerating economic recovery and long-term resiliency by expanding the human capital and innovation that will catalyze recovery, growth, and greater prosperity for the people of this state.

Increasing investment in research through public sources like MEIF and federal grants and contracts also creates opportunity to leverage up to \$150 million in private grants awarded to the University of Maine System in October 2020 by the Harold Alfond Foundation. Unlocking these additional transformational investments will be critical to realizing our full potential for Maine, including the incredible impact of our research enterprise.

This MEIF report, which details the results of the System's research efforts over the last fiscal year, demonstrates what advancements are possible from sustained research investment. A few highlights include:

- In FY2020, the state's \$17.35 million MEIF investment was leveraged at a rate of 5.3:1 by our UMS campuses for an additional \$92.4 million in federal and private-sector grants and contracts in the seven statutory sectors.
- MEIF funds, and the external grants and contracts they leverage, supported the work of 575 researchers and technicians and 1,221 graduate and undergraduate students.
- These grants and contracts provide funds to purchase major equipment to upgrade and outfit university laboratories.
- Maine's public universities secured 11 new U.S. patents and 65 associated foreign patents, worked on development projects with large and small businesses and startups, and provided R&D support to 324 companies and individuals.

As required in the statute that created MEIF, included with this FY2020 MEIF report are financial reports and informational details.

I am available at your convenience to discuss how we use MEIF funding to expand knowledge, research, and economic opportunity in Maine. I would welcome the chance to do so.



Dannel Malloy
Chancellor

MEIF Background

The Maine Economic Improvement Fund (MEIF) represents the ongoing commitment between the state, the private sector and our public universities, working together to advance research and economic development for the benefit of all Maine people.

Since the Maine Legislature established MEIF in 1997, MEIF has positioned the University of Maine System (UMS) at the center of statewide efforts to leverage economic development through targeted investment in university-based R&D. MEIF continues to be funded through an annual state appropriation to UMS.

These funds provided through state appropriation to the University of Maine System are dollars specifically directed to support university-based research, development and commercialization in the state's legislatively designated seven strategic technology areas:

- Advanced Technologies for Forestry and Agriculture
- Aquaculture and Marine Sciences
- Biotechnology
- Composites and Advanced Materials Technologies
- Environmental Technologies
- Information Technologies
- Precision Manufacturing

The University of Maine and the University of Southern Maine have well-established research, development and commercialization activities accounting for 97 percent of the MEIF activity. In 2009, the University of Maine System established the Small Campus Initiative Fund to promote seven-sector research and development activity at the other five UMS campuses and, as of 2013, Maine Maritime Academy (MMA).

Role of MEIF

The role of MEIF is to support the solution of fundamental problems and discover new solutions, and to provide researchers at Maine's public universities with the investment necessary to:

- attain external grants and contracts to support R&D activities in Maine's seven sectors
- attract and retain world-class researchers
- provide support for modern laboratories and state-of-the-art equipment
- create new products, patents, technologies, companies and exciting job opportunities in Maine
- create and sustain economic development and innovation

MEIF funds often provide the required match to acquire federal or private-sector grants, and this investment in Maine's public university R&D helps faculty, staff and students successfully leverage tens of millions of dollars in grants and contracts annually.

MEIF directly supports faculty, grad students and staff who are working to make the universities more competitive for federal grants, expanding opportunities to support Maine companies and involve students in research learning and real applications of their education.

MEIF increasingly fosters university partnerships with business and industry through economic development collaborations, entrepreneur training programs, business incubators, technology accelerators, business research and other programs. These efforts lead to new Maine-based products, technologies, patents and spin-off businesses.

The University of Maine and the University of Southern Maine are the two universities with established research and graduate programs in the seven targeted research sectors and have received MEIF funds, with 76.6 percent to the University of Maine and 19 percent to the University of Southern Maine. In addition, 1.4 percent of MEIF funds are awarded to the University of Maine at Machias and 3 percent to the other campuses and Maine Maritime Academy.

Indicators of success show that Maine's MEIF investment is paying dividends by:

- Creating businesses and jobs, including the jobs of 575 faculty and staff, and 1,221 students working on MEIF-funded projects.
- Boosting Maine's economy by leveraging MEIF funds to bring federal and private-sector grants and contracts to Maine.
- Building capacity and expertise to help Maine companies solve problems and commercialize innovation.
- Generating new intellectual property and working to commercialize patents and innovations.
- Capitalizing on natural resources and core strengths by focusing R&D efforts on economic sectors where Maine can make real gains. University research personnel use MEIF resources to support the staff, equipment and facilities they need to successfully pursue and develop research projects.

Progress in FY2020: Strategic Outcomes, Goals and Metrics

In December 2018, the University of Maine System Board of Trustees issued a Declaration of Strategic Priorities, the first of which is Advancing Workforce Readiness and Economic Development, with a priority action item: Strengthen research and economic development efforts to support Maine industries, and to foster business formation and expansion. The five-year University of Maine System Research and Development Plan was approved in the spring of 2019 with three specific goals that drive the UMS research activities, including the Maine Economic Improvement Funds.

Goal One - Make Maine the best state in the nation in which to live, work, and learn by 2030

Goal Two - Establish an innovation-driven Maine economy for the 21st century

Goal Three - Prepare the knowledge-and-innovation workforce for Maine

The the following metrics help measure the progress against these goals and recognize that MEIF activity is restricted to Maine's legislatively selected seven R&D sectors.

UMS MEIF Metric 1 - Increase Research Capacity and Activity

UMS MEIF Metric 2 - Support New Technologies, Licensing, and Commercialization

UMS MEIF Metric 3 - Increase Economic Development Partnerships

UMS MEIF Metric 4 - Support R&D Workforce Development

This report addresses these goals. In addition, the University of Maine System reports R&D outcomes annually through the statutorily required survey of Maine R&D activity administered by the Maine Department of Economic and Community Development Office of Innovation (5 MSRA 13107).

The R&D Strategic Outcomes and related MEIF goals are:

MEIF Metric 1: Increase Research Capacity and Activity

UMS maintains a sponsored programs grant and contracts effort growing greater than 3 percent annually on a three-year rolling average from a 2013 baseline of \$45 million and NSF-defined total research expenditures of \$45 million in the MEIF sectors. Activity from the seven MEIF sectors will account for 50 percent of the total R&D grants and contracts, with a 3 percent annual growth on a three-year rolling average. The utilization of MEIF funds will leverage other resources, including grants and contracts from the federal government and the private sector, thus increasing the impact of the State's investment.

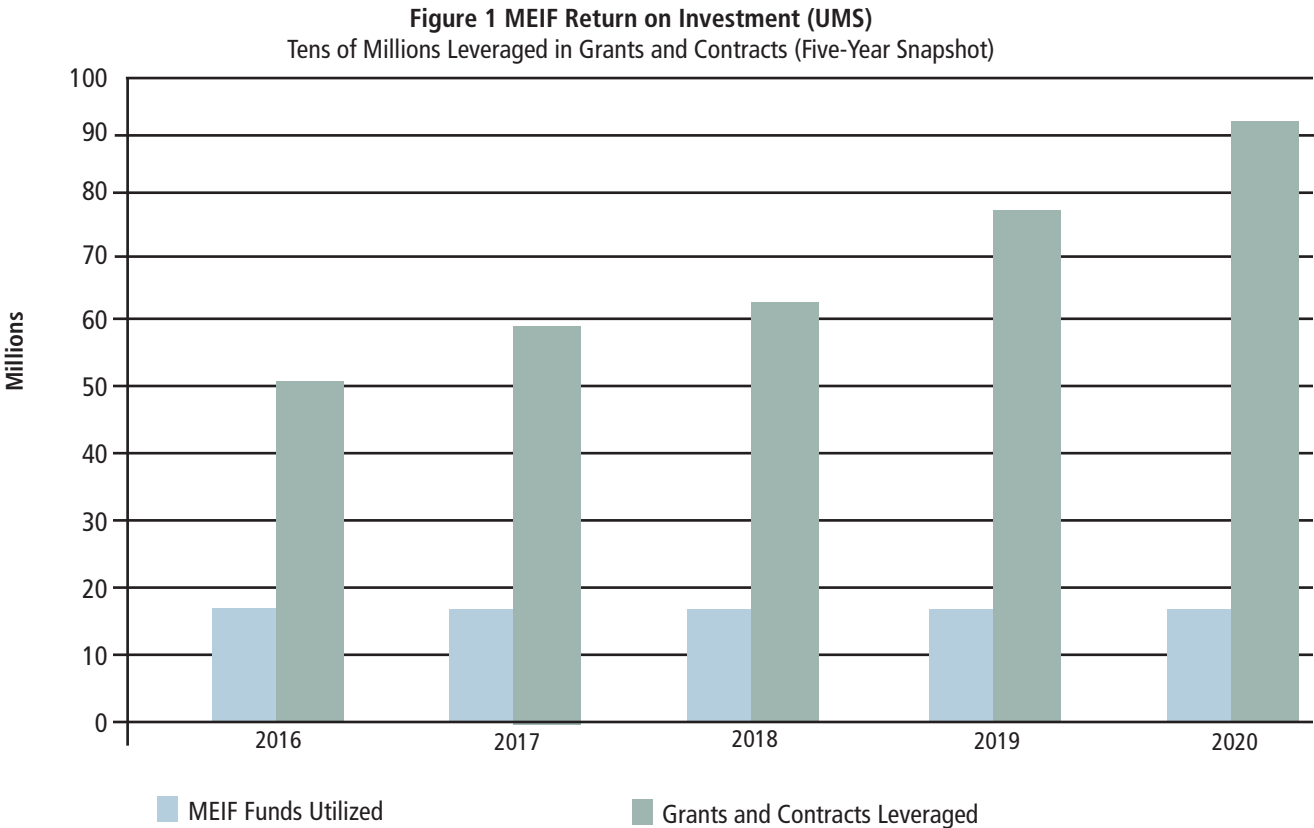
Table 1

FY2020 Total Grants and Contracts (ALL Activity Inclusive)	Number of proposals	Total Value	Number of proposals	Total value	number of proposals	total value
	UM/UMM	UM/UMM	USM	USM	ALL	ALL
Total Proposals Submitted	852	\$202,300,441	203	\$40,000,000	744	\$239,956,026
Total Proposals Awarded	666	\$107,552,997	150	\$34,000,000	497	\$138,194,536

Grants and Contracts

Awarded in MEIF Sectors ONLY	FY2016 Awards	FY2017 Awards	FY2018 Awards	FY2019 Awards	MEIF Awards		
					FY2020 UM/UMM	FY2020 USM	FY2020 Total
Aquaculture and Marine	12,631,690	21,229,069	16,032,068	8,084,961	8,566,617	132,144	8,698,761
Biotechnology	2,399,487	3,821,390	6,552,964	16,035,473	14,412,593	199,313	14,611,906
Composites	6,974,264	13,504,642	9,952,947	11,478,611	31,070,913	22,738	31,093,652
Cross Sector	507,842	4,274,394	3,034,812	21,301,337	2,040,950	742,480	2,783,430
Environmental Technologies	5,045,536	5,543,121	7,407,213	7,250,820	6,918,715	548,272	7,466,987
Forestry and Agriculture	10,317,799	4,660,014	10,685,631	9,598,475	17,528,845	95,721	17,624,566
Information Tech	11,497,199	5,292,726	5,582,266	951,594	5,842,585	1,226,528	7,069,113
Precision Manufacturing	1,009,921	1,602,646	3,099,123	1,870,527	3,077,779	0	3,077,779
Total	\$50,383,738	\$59,334,874	\$62,347,023	\$76,571,798	\$89,458,997	\$2,967,197	\$92,426,194
					FY2019–FY2020 Increase 21%		

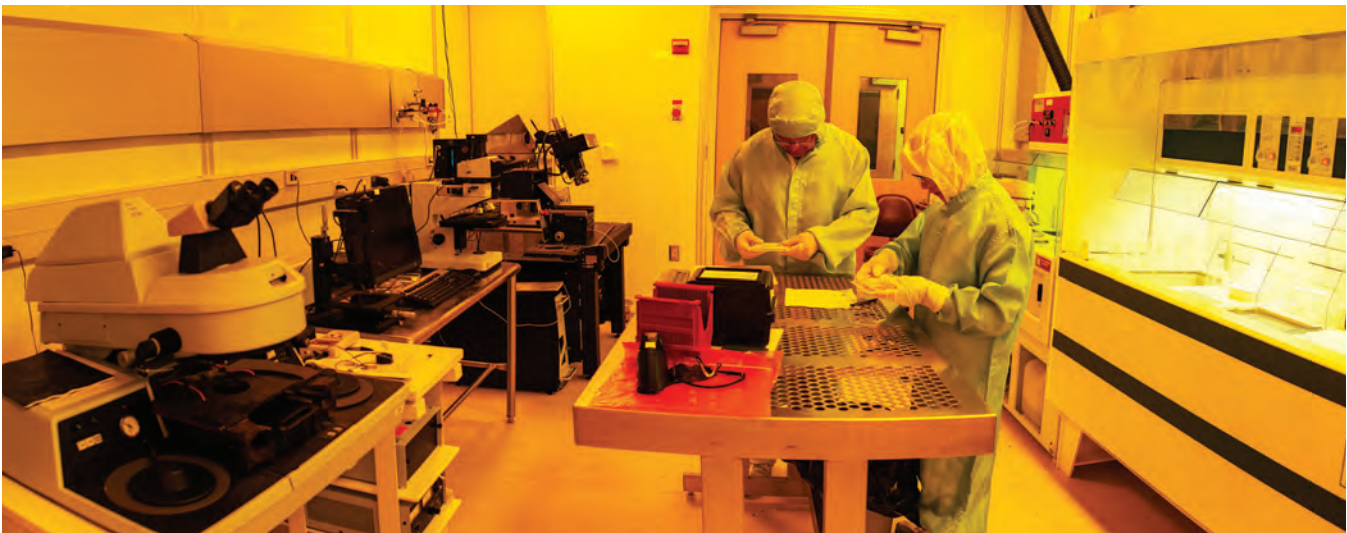
Strategic Outcomes, Goals and Metrics



In summary, MEIF Metric 1 for increasing external grants and contracts leveraged through MEIF investments saw an increase of 21 percent over the previous fiscal year exceeding the goal of 3 percent per year. This favorable trend continues in a positive direction after decreases over the last five years. Continued growth can be attributed to the efforts of UMS researchers and energized by the turnover in faculty researchers resulting in over 150 new faculty in the last few years. New faculty researchers typically need several years of

start-up activity to become competitive proposal writers, and their success is starting to show. Another key contributor to this growth is larger multi-principle investigator proposals at well-established centers.

Recognizing the lead time for proposal preparation, sponsor review and selection, and contract activity to begin, there can be a one- to two-year lag in output. Proposal preparation and submissions remain steady. For the purpose of this report, a private-sector contract is counted as a single proposal submission.



MEIF Metric 2: Support New Technologies, Licensing, and Commercialization

UMS annual revenue from commercialization including intellectual property licensing from the MEIF sectors increases at least 10 percent annually on a three-year rolling average.

Table 2

MEIF Metric 2 — Commercialization Activity	FY2016	FY2017	FY2018	FY2019	FY2020
Revenue from Commercialization	\$204,709	\$329,840	\$914,120	\$289,088	\$519,019
Rolling three-year average	\$276,063	\$298,091	\$482,890	\$511,016	\$574,076
Number of Patents Filed (US/PCT)	19	18	20	17	16
Number of Patents Issued (US)	5	8	6	6	12
Number of License Agreements and License Options	8	7	9	11	8

FY2019–FY2020 Change in Three-Year Average Revenue 11%

In summary, three-year rolling average revenue from commercialization has shown an overall increase over the last decade. Commercialization relies on private companies utilizing UMS intellectual property to secure private investment to advance technology, products and services into markets. Maine continues to rank very low in comparison to other states for its industry R&D and innovation. This has been recognized by the state economic development agencies and is addressed in the 2020 Maine Economic Development Strategy.

The timeline for commercialization of newly invented technology is hard to predict, but it is lengthy. U.S. patent

applications take four to five years from initial application to issuance. Newly issued UMS patents reported above and detailed in Appendix 1 were filed four to five years ago. In addition, UMS technologies generally fall into categories, such as transportation infrastructure, pulp and paper and sensors and biotechnology.

These sectors have longer timelines from lab to market at five to 10 years. UMS is focusing additional effort to accelerate commercialization with private-sector partners and other investment programs, such as the Maine Technology Institute and Maine Venture Fund.

MEIF Metric 3: Increase Economic Development Partnerships

The UMS annual revenue from activities with business and industrial partners in the MEIF sectors continues to increase. Revenue reached \$10,876,661 in FY2020, bolstered by a few large projects started before the pandemic, while a number of business and industry contracts in the MEIF sectors dropped off primarily in the last quarter of FY2020, due to the pandemic.

Table 3

MEIF Metric 3 — Business and Industry Contracts	FY2016	FY2017	FY2018	FY2019	FY2020
Revenue from Business and Industrial Contracts	\$4,836,138	\$5,035,394	\$6,339,260	\$7,211,422	\$10,876,661
Number of Business and Industrial Contracts	519	565	528	530	327

FY2019–FY2020 Change in Revenue 50.83%

In summary, many MEIF investments not only leverage external grants and contracts, but through a combination of MEIF funds, and grant and contract funds, help UMS campuses build capacity to work directly with industry partners. Figure 2 illustrates the breadth of contract work with companies throughout the state. Some industry partners are companies licensing and commercializing UMS intellectual property, while many companies are working with UMS campuses to get

assistance with problem solving or product development. UMS projects with business and industry are steady and activity is meeting the goals and metrics of this target. Figure 2 demonstrates the statewide nature of these partnerships for those contracts that are currently tracked. Many additional companies, inventors, and entrepreneurs receive advice and guidance that does not result in formal contracts.

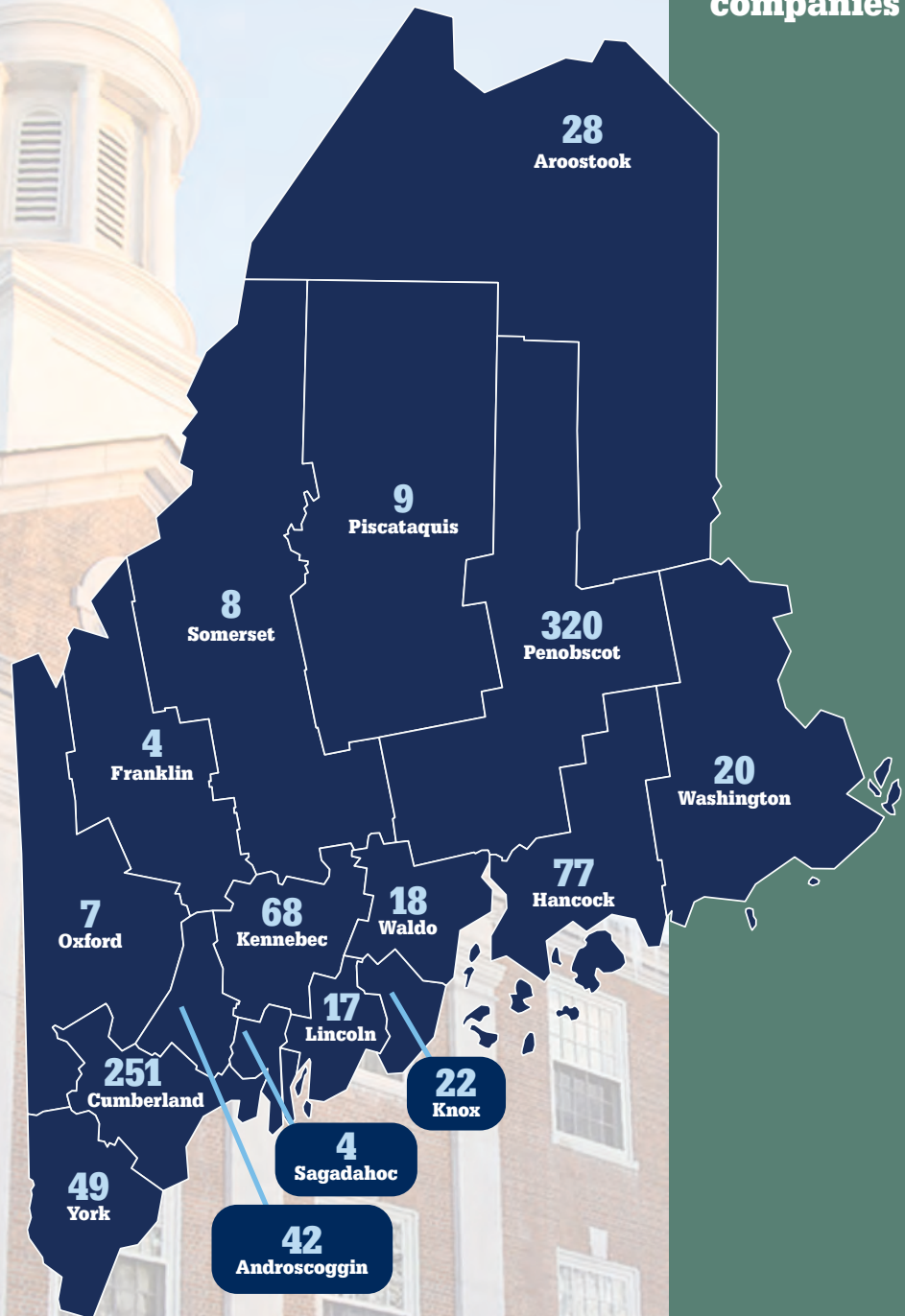
Office of Innovation and Economic Development

Figure 2
Innovation projects
with Maine companies
FY2016–FY2020

944
Innovation
projects
with Maine
companies

Every day, the University of Maine strives to turn research and development activities into new opportunities that will create jobs and grow Maine's economy.

In the past five years, UMaine has supported 944 innovation projects, providing access to facilities and expertise to help organizations with research, new products and business development.



MEIF Metric 4: Support R&D Workforce Development

UMS shall maintain a concerted effort to involve faculty, staff and students participating in research, development and commercialization, and shall report annually the number of employees directly supported by MEIF funds and by grants and contracts in the MEIF sectors. As external funding is hard to predict, there is no specific numerical goal for employee count, but UMS shall report the annual number of faculty, staff and students to indicate trends and identify opportunities for growth.

In summary, state economic analysis predicts economic growth in Maine based on an available trained and educated workforce. Growth in the seven MEIF sectors is especially dependent on the available workforce. MEIF seven-sector projects at UMS rely on regular faculty and staff, as well as many “soft money” employees — those hired to work on specific grants and contracts, and paid by those grant and contract funds. UMS employees and students gain valuable on-the-job training and experience, and may then contribute to the employment base within these sectors after completion of the grants or graduation. Grant and contract revenue is a strong contribution to this workforce development. UMS counts employees involved in this activity, and will continue to pursue the growth in employment numbers related to growth in grant and contract activity. Non-student employees are tracked as full-time equivalents (FTEs) based on a 40-hour/52-week work year. Student employees, tracked by head count, generally work fewer than 20 hours per week during the academic year.

Grant and contract revenue also is an important source of funding for students’ salaries, tuition and other types of support, allowing many research-active students to offset their cost of education while getting valuable skills and on-the-job experience, positioning them well to be leading contributors to Maine’s key growth sectors.

Success and Strategic Impact

By investing MEIF funds in researchers, facilities and matching for grants, UMS has attracted more than \$340 million over the last five years in federal and private-sector grants and contracts related to the seven strategic research areas. This funding directly results in Maine products and technologies, such as biofuels, pulp and paper products, biomaterials and bridges, new potato varieties, aquaculture technologies, offshore wind hulls, and software, which lead to improvements in Maine’s industries.

Return on Investment

Each year, the power of the state’s MEIF appropriation is expanded by tens of millions of dollars in federal and private funds for important research, development and commercialization. The University of Maine, as the state’s land grant, sea grant, and space grant institution, utilizes its long-established research capacity and infrastructure to attract the majority of these external funds. Other UMS schools continue to build and partner within federal and private-sector grants and contracts.

Developing Workforce and Creating Jobs

Five hundred plus full-time equivalent jobs are funded in Maine through the grants and contracts leveraged and expended related to MEIF. These positions include faculty, technicians and research staff. Currently, 1,221 graduate and undergraduate students are funded for their involvement in research, development and commercialization. This student involvement in research, development and commercialization projects is comparable to an internship and gives students great real-world experience as well as life-long networks and connections.

Table 4-A FY2020

MEIF Metric 4 — Workforce Development	Wages Paid from MEIF	Wages Paid from External Grants/Contracts	Totals
Number of Faculty and Staff Supported (FTE = Full-Time Equivalent)	156	418.95	574.95
Number of Graduate Students Supported (Headcount)	17	445	462
Number of Undergraduate Students Supported (Headcount)	91	668	759

Table 4-B

Graduate and Undergraduate Student Costs Paid from Grants and Contracts

	FY2016	FY2017	FY2018	FY2019	FY2020
Student Salaries and Wages from Grants and Contracts	\$5,255,861	\$4,957,536	\$4,853,956	\$6,361,381	\$6,869,073
Student Tuition Paid by Grants and Contracts	956,963	870,787	795,339	916,618	\$1,384,425
Student Fellowships Paid by Grants and Contracts	197,744	233,111	373,118	457,884	\$422,111
Student Health Insurance Paid by Grants and Contracts	247,960	203,406	214,000	298,386	296,807
Total Soft Money Student Support	\$6,658,528	\$6,264,840	\$6,236,413	\$8,034,269	\$8,792,417

FY2019–FY2020 Change 12%

MEIF Success Stories

MEIF in FY2020: Responsiveness and Resilience

The Maine Economic Improvement Fund has been a critical driver of R&D at Maine's public universities for the last 23 years, helping to establish and sustain infrastructure and expertise to support and grow Maine's seven sectors.

FY2020, defined largely by the COVID-19 pandemic, did not represent a typical year for the state of Maine or the University of Maine System.

The story of FY2020, for both our state and our university system, is one of responsiveness and resilience. Thanks to ongoing investment in our facilities and programs, including MEIF, Maine's public universities have been able to mount a robust response to many challenges the public health crisis has brought to our state. Our commitment to advance research and economic development for the benefit of all Maine people will bolster Maine's resilience in responding to the myriad effects of the pandemic, across sectors, in the coming months and years.

Events of the past year have highlighted the important role Maine's public universities play in supporting the state's major economic sectors at all times, with this crisis serving to reinforce the universities' existing bonds with our communities, and forge new ones.

As significant as the pandemic's impact has been, it did not define 2020. Campus research activities persisted, enjoying significant growth at UMaine and showing the resilience of the university's research enterprise in the face of an unprecedented challenge. As with our ability to respond to needs related to the pandemic, our ability to sustain our research commitment is thanks to years of investment coupled with strategic emphasis on the growth and development of the research enterprise and its resulting impact on Maine and beyond.

Following are stories that bear out these themes, some focused on COVID-19 response efforts, others sharing progress in key research areas focused on Maine.

■ Covid-19 Response

While COVID-19 interrupted the 2020 spring semester, forcing us to empty campuses and pivot swiftly to a remote learning model, the ongoing pandemic has offered unique opportunities for collaboration across Maine and within our campus communities.

University of Maine System COVID response efforts are governed by an umbrella agreement between the University of Maine System and the Maine Emergency Management Agency (MEMA) that allows the system to provide goods and services to Maine health care facilities and agencies as coordinated by MEMA.

These systemwide efforts have taken many forms since the start of the



pandemic, many advanced by a UMaine-led rapid-response innovation team that brought together university researchers and staff, representatives from health care and government and community partners. All have relied on the expertise and infrastructure available at Maine's public universities.

■ Hand sanitizer a signature effort

In the early days of the public health crisis, UMaine's pilot-scale pulp and paper research facility was at the center of efforts to manufacture hospital-grade hand sanitizer and produce large batches of fit-test chemicals. The Process Development Center (PDC), part of UMaine's department of Chemical and Biomedical Engineering, helped health care centers avert a supply crisis by making and delivering locally made hospital-grade hand sanitizer in the face of global shortages.

With its existing capacity for commercial-scale products and chemical engineering processes, the facility was able to pivot swiftly to scale up production of hand sanitizer to meet urgent early needs. From there, the center partnered with Maine's craft distillers and brewers to obtain a steady supply of ethanol, and then helped distillers ramp up their own production to form an in-state supply chain. Maine-made sanitizer was able to meet health care needs and beyond, buoying Maine's brewing and craft distilling industries at a time of great uncertainty. More than 3,000 gallons of sanitizer were produced on the UMaine campus alone and distributed to more than 100 health care facilities.

The PDC's capacity and expertise also proved useful in response to an urgent request from the Maine Center for Disease Control and Prevention. The agency needed chemical solutions used to fit medical workers with N95 masks, a key piece of personal protective equipment (PPE), and was facing a national shortage of fit-testing kits and test solutions.

Chemical solutions with a distinctive taste or odor are used in the N95 fitting process to ensure that the mask forms a tight seal with the wearer's face and keeps contaminated air out. In May and June, UMaine delivered more than 4,200 bottles of fit-testing solutions for Maine CDC to distribute to the Maine National Guard and partner agencies that conduct the tests.





■ Aiding manufacturers

The Advanced Manufacturing Center (AMC) — UMaine’s manufacturing business and engineering support and service center — has also been busy in response to COVID-19. The center is dedicated to promoting economic and workforce development and was established to provide a high-level technical resource that would be readily accessible to businesses, entrepreneurs, students and researchers throughout Maine.

In the COVID-19 era, this mission has taken on new meaning as AMC has served Maine manufacturers and other sectors in unexpected ways.

Since the pandemic started, AMC has provided design, prototyping and materials testing services for a variety of companies looking to respond to shortages and emerging needs.

The center has helped a number of Maine companies, including L.L.Bean and Strainrite, gauge the particle filtration properties of different types of material they intended to use to make face coverings. As part of this effort, the center tested in excess of 100 different types of material, everything from basic cotton t-shirts to technical fabrics.

In some cases, this work has expanded beyond initial testing. AMC has worked closely with Hermon-based Ntension as the company leveraged existing fabric manufacturing capacity to develop a general-use mask that could be used in certain health care settings. Ntension, which supplies masks to Northern Light Health, is exploring creation of an automated medical product line, and has continued to work with the AMC on product development and process improvements as they begin to build capacity and pursue FDA approval for their masks.

In a similar vein, the AMC has also tested N95 masks before and after different sterilization treatments to ensure the filtering performance has not been degraded, part of an effort to support hospitals exploring the limited reuse of PPE.

AMC also assisted Maine plastics manufacturers with new products, including evaluating prototype designs for clear plastic face shields that were eventually produced by the hundreds of thousands in Maine.



A request from MaineHealth led to AMC prototyping two designs for “aerosol boxes” that can be used to protect medical workers during transportation and intubation procedures in patients suspected to have COVID-19. AMC’s designs, developed in coordination with UMaine biomedical engineering researchers and with help from the Maine Manufacturing Extension Partnership, were tested in area hospitals and refined based on feedback from the front lines. Both variations of the boxes were manufactured in Maine for Maine hospitals.

Since late summer, the AMC has been a key partner in a sweeping project aimed at helping Maine’s manufacturing sector weather the ongoing economic effects of the pandemic.

The COVID Countermeasures Project is a collaborative effort that marries the AMC’s product and process development and research expertise with services provided by the Maine Manufacturing Extension Partnership (MMEP) and the Manufacturers Association of Maine (MAME), two regional trade organizations. Supported by \$286,000 in CARES Act funding and a \$100,000 grant from the Maine Technology Institute, they have surveyed more than 250 companies about impacts related to the pandemic and are conducting 50 in-depth assessments for companies that requested additional support. From these assessments, the group is developing a series of customized remediation projects to solve individual challenges.

It’s a big lift for a critical sector that accounts for more than 54,000 Maine jobs and a \$5.9 billion share of the state’s GDP. Projects run the gamut from marketing assistance to engineering work and draw on the expertise of a statewide network of consultants, including AMC.

Through it all, AMC’s regular support services to Maine manufacturers have continued, sometimes taking on new urgency as the center helps companies respond to pandemic-related needs.

For example, when Enercon Technologies in Gray, a precision contract manufacturer specializing in medical, life sciences, military and industrial devices, was asked by a national client to swiftly ramp their production to support the COVID-19 testing effort, they turned to AMC for solutions. The center designed and built an automated, robotic system that allows around-the-clock production with minimal operator intervention so the company could generate what was previously a year’s worth of production on a monthly basis.

■ Research expertise key

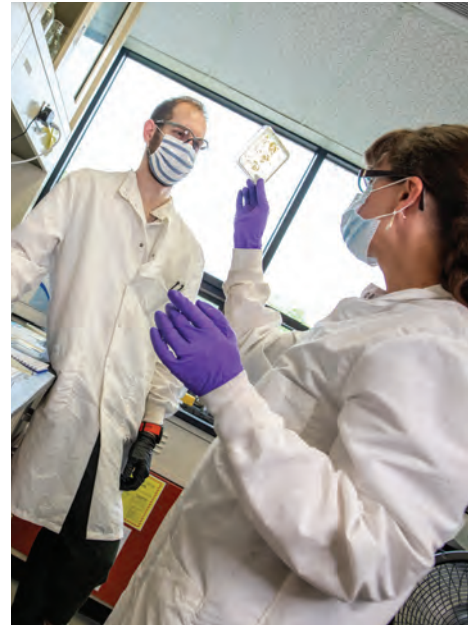
From providing expert counsel to Maine's health care community on decontamination and sterilization of PPE to supplying public health briefing documents to Bangor Public Health that help the municipality and its partners navigate the epidemic, university researchers and their students have provided essential community support.

As part of its mission to stay fully abreast of fast-breaking scientific developments in areas relevant for universities and the pandemic, including testing, contact tracing and vaccine development, the UMS COVID-19 Science Advisory Board is another valuable resource that supports not only the university community, but also shares knowledge with benefit for Maine at large.

Established by Chancellor Dannel Malloy and chaired by University of Maine President Joan Ferrini-Mundy, the council comprises faculty members from UMaine and USM and draws support from other UMS researchers involved in task groups and subcommittees. The team provides evidence-based guidance to inform UMS planning efforts and also has presented to the Maine Legislature and other groups.

In addition to public health support, UMaine has also worked with government partners in an effort to mitigate the economic impact of prolonged shutdowns related to the pandemic.

Andrew Crawley, an assistant professor of regional economic development with the UMaine School of Economics, and six graduate students are collaborating with the State Economist's Office to develop forecasts for how much COVID-19 will affect Maine's economy. They are building models to evaluate the possible loss in tourism spending, travel-related spending, cruise ship spending, state revenues and overall sectoral output changes. The forecasts will also include prospects for recovery.



■ Extending a hand to growers and producers

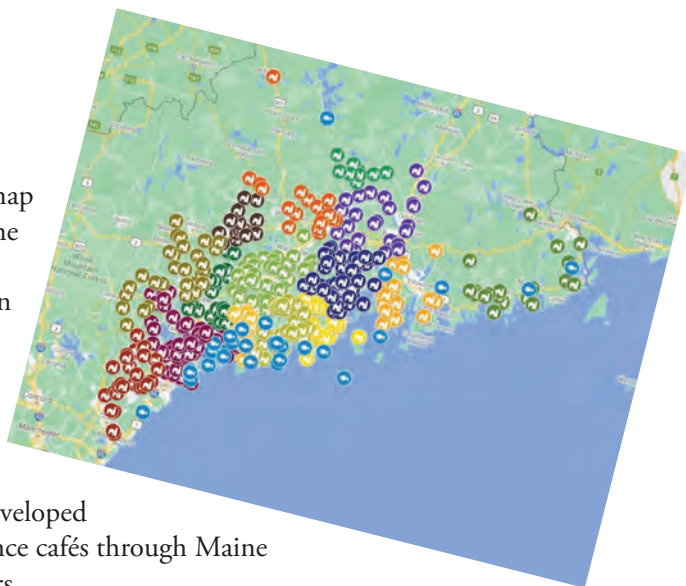
The University of Maine Cooperative Extension's mission to put university research to work in homes, businesses, farms, and communities in every corner of Maine has been especially critical in the face of uncertainty created by the pandemic.

An early and visible Extension response effort was the development of a database that connects producers with retail customers looking to purchase local food. Allison Lakin, owner of East Forty Farm and Dairy, and Lakin's Gorges Cheese in Waldoboro, first conceived the idea when business from restaurant clients declined as the pandemic forced eateries to close. Lakin developed an initial spreadsheet and worked with the Extension team to expand the list of producers offering alternative pickup options for Maine meat, seafood, produce and other items.

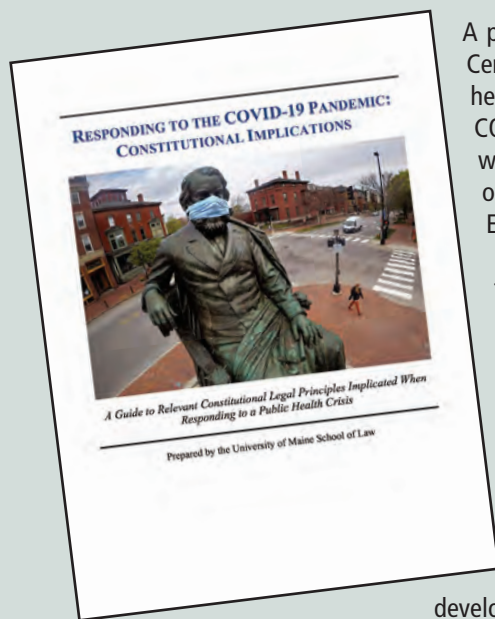
Launched in late March 2020, the database is hosted on the University of Maine Extension website as both an interactive map and a searchable spreadsheet and contains more than 400 Maine producers.

UMaine Extension has also worked closely with producers in other ways, developing fact sheets, FAQ documents and other information for Maine's agricultural community, surveying producers to gauge their needs and concerns, and hosting weekly online meetings for farmers to connect and share information.

To support the wider community, UMaine extension has developed educational materials for distance learning, offered virtual science cafés through Maine 4-H, and provided new resources for home cooks and gardeners.



■ Maine Law interns assisting economic recovery efforts



A partnership among Maine Law, the Maine Regulatory Training and Ethics Center (MeRTEC), and the Maine Small Business Development Center (SBDC) is helping Maine's small business community navigate the complex world of COVID-19 regulations and guidance. The work is built upon a USM collaboration with the Greater Portland Chamber of Commerce, the Greater Portland Council of Governments, the Maine Small Business Development Centers, the Maine Economic Improvement Fund, and the University of Maine School of Law.

Under the supervision of Professors Andrew Kaufman and Ross Hickey, two recent Maine Law graduates prepared weekly newsletters on a variety of business and regulatory topics in multiple sectors, including restaurants, food service, tourism and hospitality, and retail. These newsletters were distributed to the SBDC's broad network of small business advisors around the state, as well as to the Volunteer Lawyers' Project recently launched Small Business Clinic. The partnership continued through the fall with the help of current law students, who also assisted in responding to questions raised by business owners.

Beginning in June 2020, four MEIF-supported interns also assisted the Governor's Economic Recovery Committee (ERC) that is charged with developing specific policy recommendations to stabilize the state's economy and

build a bridge to future prosperity in the wake of the COVID-19 pandemic. The quartet of law school interns assisted in managing all affairs of the subcommittees and supported subcommittee chairs and lead staff to meet goals and deliverables. They also played active roles in supporting the ERC in drafting the Committee Report on Economic Support and Stabilization Recommendations shared with Governor Mills on July 15, 2020.

In addition, two law students under the supervision of Professors Dmitry Bam and Jeff Thaler researched and drafted "Responding to the COVID-19 Pandemic: Constitutional Implications: A Guide to Constitutional Legal Principles Implicated When Responding To A Public Health Crisis." The guide explores how restrictions implemented to "flatten the curve" of the COVID-19 pandemic relate to constitutional issues, procedural and substantive due process issues, and infringements on rights related to restrictions on business operations and gathering sizes. The analysis in this guide is intended for legislators, governors and their staffs, as well as lawyers and non-lawyers.

Funding for all these initiatives and internships has been provided by the Maine Economic Improvement Fund (MEIF).

MEIF supports the research that matters to Maine. In the pages that follow, learn more about some notable ongoing initiatives that support R&D and economic development for state benefit.

■ Advanced Technology for Forestry and Agriculture

UMaine research supports innovation and resilience in Maine's heritage industries. Work related to agriculture and forestry serves growers, landowners and businesses across the state in myriad ways, helping them solve operational problems and introduce new technologies to drive efficiency.

Many Maine communities have felt the effects of declining paper industries. In order to revitalize the economies of these towns across the state, it is crucial to find alternative and innovative uses for the mills and resources that are currently underutilized.

The University of Maine's Forest Bioproducts Research Institute is leading work that addresses this issue and breaking new ground in the development of a variety of bioproducts made from woody biomass from Maine forests.

UMaine is nationally recognized for research into nanocellulose and biofuels, and recent federal funding will allow FBRI to complete significant upgrades to its Technology Research Center (TRC) in Old Town, Maine, and Process Development Center (PDC) on campus to bolster ongoing efforts to create new bioproducts, increase production and find uses for woody biomass materials typically considered waste. Investment in FBRI's pilot-scale infrastructure will help institute researchers simulate the commercial-scale production of a variety of biobased goods, particularly biomass-derived jet fuel and diesel, and expand nanocellulose production.

FBRI is actively engaged with Maine's forest industry stakeholders and is a key collaborator in Forest Opportunity Roadmap / Maine (FOR/Maine), a coalition focused on identifying new markets for Maine wood products and advancing technology innovations to commercialize new uses of wood.



Turning to agriculture, ongoing UMaine wild blueberry research is helping to address pests, improve fruit quality and yield, and explore the impact of climate warming on one of Maine's major agricultural industries. Researchers have uncovered promising foliar fertilizer products and are testing mulching and biochar as drought, warming, and pest management tools. The UMaine Cooperative Extension wild blueberry team — a group of extension specialists and researchers who do field and lab work directly with growers, graduate students, other researchers in the U.S. and Canada, and the Wild Blueberry Commission of Maine — dispenses research-based knowledge directly to farmers.



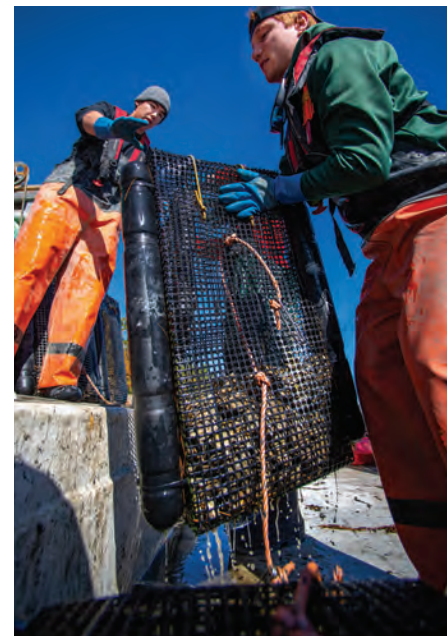
Integrated pest management research is also key to sustaining Maine's \$500 million potato industry, providing support to growers through field monitoring, disease forecasting, and distribution of educational materials that can offer specific and timely strategies in order to minimize pesticide applications and maximize potato yield. UMaine's leading potato-breeding program continues efforts to develop attractive, highly productive disease- and insect-resistant potato varieties that can be employed by small and large producers to enhance marketing opportunities, farm sustainability and profits. It takes 12 to 14 years to develop a new potato variety, and in recent years UMaine's breeding program has released several varieties, including the Caribou Russet, which has white flesh and lightly russeted skin, and the Pinto Gold, a yellow-flesh gourmet potato.

■ Aquaculture and Marine Sciences

As with agriculture and forestry, research supporting Maine's diversifying marine economy is a major area of focus. Anchored by lobstering, this sector also includes fishing, rapidly expanding aquaculture, life sciences, and value-added processing. UMaine is a key collaborator in statewide efforts to develop an industry-led roadmap and action plan for economic growth and greater resiliency, a three-year project that will provide strategies to match Maine's marine-related products with global markets and develop strategies to attract investment in new markets; identify new opportunities and barriers to value-added production; seek ways to maximize efficiencies and returns across the seafood value-chain; and address current and future workforce challenges in Maine's marine resource economy.

Over the past decade, Maine has seen 2.2% annual growth in aquaculture, which has had an overall economic impact of \$140 million annually.

Aquaculture research at UMaine is helping to pave the way for the growth of sustainable aquaculture in the state, addressing challenges and providing support for innovation. Researchers are collaborating with aquaculture industry and community partners in several areas, including new aquaculture opportunities, accelerating the development of collaborative networks to support aquaculture growth, and exploring gaps in social, behavioral and economic knowledge relating to aquaculture and communities it impacts and serves. A Maine Aquaculture Hub, coordinated by Maine Sea Grant, is working to build capacity for industry-driven innovation, diversification and workforce development. The hub will help the aquaculture industry overcome barriers associated with commerce, permitting and policies, new species, production systems, and seafood safety and quality. A new sustainable aquaculture certificate program aims to prepare students to become competent in a wide range of aquaculture fields, such as husbandry, recirculating and hatchery systems, and aquatic animal health. Through this program's experiential





curriculum and industry internship, students develop the technical skills to work in diverse professional environments. The internship provides 12 weeks of experience at a range of industry sites throughout the state and significantly expands career opportunities. Open to all applicants with at least a high school degree, this low-cost program was designed to address aquaculture industry workforce and extension needs in Maine by facilitating alternative career opportunities.

Adding to these efforts, an Aquaculture Experiment Station has been established by the University of Maine Aquaculture Research Institute (ARI), in partnership with the U.S. Department of Agriculture Agricultural Research Service (ARS) and Auburn University. This cooperative agreement is a commitment to an ongoing conversation between researchers and the aquaculture industry to increase sustainable production and industry stability.

Business incubation facilities at UMaine's Center for Cooperative Aquaculture Research in Franklin and the Darling Marine Center in Walpole support the growth of aquaculture businesses in Maine by offering pilot-scale, land-based research and culture facilities, office space, and direct access to university experts. Not only can entrepreneurs take advantage of research expertise, but also business counseling and support services and access to talent, including interns.

UMaine researchers are project leaders in the \$2 million Sea Grant American Lobster Initiative to understand physical and chemical changes affecting American lobster in the Gulf of Maine. The initiative addresses critical gaps in knowledge about American lobster responses to environmental change and how to provide opportunities to increase economic resilience and adaptation in the lobster fishery. Researchers are working to facilitate partnerships, communication and collaboration among the lobster industry, management agencies and lobster scientists throughout the region and help to ensure that coastal communities benefit from the funded research. "The Sea Grant American Lobster Initiative will target critically important areas of concern for our most valuable fishery," said Carl Wilson, director of the Maine Department of Marine Resources Science Bureau. "It will also reinforce and amplify efforts in Maine, and regionally, to ensure the resilience of the resource, and the ability of managers to adapt to changes in the dynamic marine environment."



Ongoing research at the University of Maine at Machias funded through the MEIF Small Campus Initiative has examined the effects of ocean acidification on commercially important, calcified marine organisms, such as lobsters, crabs, clams, mussels and scallops — a global problem that has implications for healthy, sustainable wild and cultured fisheries in Maine. Recently published results from three years of field experiments led by

researchers at UMM and the Downeast Institute (UMM's marine science field station in Beals, Maine) showed that spreading clam and oyster shells on the mudflats in an effort to counteract the effects of coastal acidification does not increase numbers of juvenile clams and quahogs, but found that efforts to exclude predators (such as invasive green crabs) led to improved density of both bivalve species. The findings have practical application for fisheries managers in Maine who can focus attention on mitigating effects of predators in order to enhance clam populations.

At USM, MEIF is supporting feasibility research to understand the specific needs of the fishing industry/economy in Maine, and how the university could support those needs.

Eighty-three stakeholders representing commercial fishing, tourism and sport fishing, aquaculture, marine biology, processing, and other groups were interviewed about their biggest challenges, their workforce needs, and what they think impedes expansion of the fishing industry/economy in Maine.

Participants reported that the biggest challenges facing the industry are climate change, regulations, lack of government support, and lack of skilled workforce. They also cited the need for better coordination among business, government, and education/research.

Recommendations for USM include developing more USM faculty expertise in the fishing industry, offering more incubator/accelerator business development spaces, developing a relationship with Gulf of Maine Research Institute to offer programs, designing a cross-disciplinary minor in fisheries and aquaculture business, developing fishing industry business counseling expertise at Maine SBDC, and establishing a business support unit staffed by USM business practicum students at the New England Ocean Cluster in Portland. MEIF will work with faculty to explore how to integrate these findings into initiatives and programs at USM.

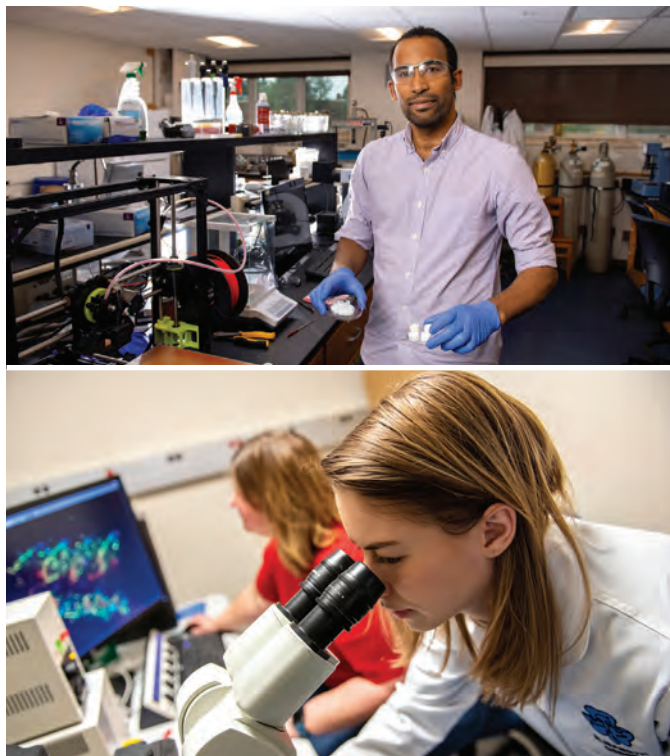
■ Biotechnology

Life sciences are a rapidly expanding industry in Maine, with life science job growth of 14 percent for the five years ending in 2019 according to the Bioscience Association of Maine. UMaine is among the state's largest life science employers, and research from the university further helps to drive industry growth.

The University of Maine's MIRTH accelerator program, designed to help advance research from the lab to the marketplace, has recently supported two promising made-in-Maine biomedical innovations.

One, a nanocellulose composite material for use in orthopedics, promotes the growth of strong natural bone while safely dissolving over time, eliminating the need for metal devices that can be expensive, dense, stiff, prone to infection, and often require costly follow-up surgeries for removal. The nanocellulose composite developed at UMaine, by contrast, is a cost-effective, customizable, resorbable, porous platform biomaterial with the potential to help optimize the healing process for patients. It could be used as a synthetic bone, surgical bone scaffold, or bone grafting implement, designed for dissolution and gradual replacement with native bone cells.

A second product draws on the wound-healing properties of bioactive compounds found in Maine wild blueberries. Two classes of compounds extracted from wild blueberries — anthocyanins and phenolic acids — that have documented benefits in the treatment of chronic diseases and UMaine researchers are developing a biomedical product prototype with embedded bioactive compounds for the commercial marketplace.



■ Composites and Advanced Materials Technologies

Maine's reputation as a hub for the development of composites and advanced materials only grew in FY2020 with the debut of the world's largest 3D printer at the UMaine Advanced Structures and Composites Center (ASCC). The center now claims three Guinness World Records for the world's largest prototype polymer 3D printer, largest solid 3D-printed object, and largest 3D-printed boat.

Beyond the record books, ASCC research is helping to advance composite manufacturing and use in Maine and support markets for products from other Maine economic sectors.

The UMaine ASCC and the Department of Energy's Oak Ridge National Laboratory (ORNL) in Tennessee are advancing efforts to 3D print with wood products, creating a new market for Maine's forest products industry.

The \$20 million project supports fundamental research in key technical areas in large-scale, biobased additive manufacturing, as well as efforts to produce new biobased materials conducive to 3D printing of large, structurally demanding systems. The research is focused



on cellulose nanofiber (CNF) production, drying, functionalization and compounding with thermoplastics, building on UMaine's leadership in CNF technology and extrusion research. By placing CNF from wood into thermoplastics, bioderived recyclable material systems can be developed with properties that may rival traditional materials, possibly even metals. CNF's incorporation into plastics shows great promise for a renewable feedstock suitable for additive manufacturing.

The collaboration provides students, faculty and companies associated with UMaine's Advanced

Structures and Composites Center access to ORNL's assets and expertise in advanced manufacturing. ORNL researchers, in turn, gain access to UMaine's facilities and expertise in CNF and composites. A key goal of the partnership is to strengthen regional manufacturing by connecting university–industry clusters with DOE's Manufacturing Demonstration Facility at ORNL.

■ Environmental Technologies

The release of Maine's Climate Action Plan in late 2020 lays out concrete action steps for Maine's goals to decrease greenhouse gas emissions by 45% by 2030 and 80% by 2050 and achieve carbon neutrality by 2045. More than 20 UMS researchers and staff are members of the Maine Climate Council subcommittees and working groups that developed Maine's plan, and UMS research and support will be essential to its successful implementation.

Clean energy innovation is central to the plan, and technology created at UMaine's Advanced Structures and Composites Center is driving the growth of offshore wind in Maine and beyond. The university's patented VoltturnUS floating hull technology will be deployed in a demonstration project off Monhegan Island and is slated to be used in a small-scale research array part of the ongoing Maine Offshore Wind Initiative announced by Gov. Mills in 2019.



The University of Maine will collaborate with New England Aqua Ventus, LLC (NEAV), a joint venture between Diamond Offshore Wind, a subsidiary of the Mitsubishi Corporation, and RWE Renewables, the second-largest company in offshore wind globally, to develop the Monhegan demonstration project. This project will deploy a single 10–12 MW turbine on VolturnUS, the floating concrete semi-submersible hull designed by UMaine.

NEAV has pledged to involve Maine companies in permitting, construction and assembly, deployment, and ongoing operations and maintenance of the project. In addition, NEAV has committed to working with the University of Maine on research, development and design to take the technology elsewhere in the U.S. and the world. The concrete hulls are designed to be built in communities adjacent to potential projects, generating local construction jobs and other benefits during the building and assembly phase.

The demonstration project is projected to produce more than \$150 million in total economic output and create hundreds of Maine-based jobs during the construction period.

Expanding the use of green building products is another key focus area in Maine's Climate Action Plan. UMaine research into mass timber products, including cross-laminated timber (CLT), contributes to efforts to revitalize and diversify Maine's forest-based economy by bringing innovative mass timber manufacturing to the state of Maine. Construction materials incorporating nanocellulose also show great promise, and this is another area of ongoing research.

Information Technologies

Information technologies are revolutionizing the way we interpret and solve a range of real-world problems and graduates with related skills will help build Maine's innovation economy. The recently announced University of Maine Artificial Intelligence Initiative aims to transform the state into a world-class hub for artificial intelligence research and education and develop AI-based solutions that enhance social and economic wellbeing in Maine and beyond.

Related research shows great promise for Maine's heritage industries, including forestry. UMaine researchers are leading a multidisciplinary regional project to compile data to better assess, understand and forecast complex forest landscape changes. An economically important and ecologically critical component of New England's working landscape, forests support biodiversity, conservation, recreation and a forest-based workforce. However, current and quality data on forest



health or tree species composition remains highly varied, inconsistently available, and relatively coarse in resolution. UMaine researchers, working with teams from the University of New Hampshire and the University of Vermont, are building a digital framework that integrates, analyzes and visualizes complex data streams across the region's vast forest. The project integrates emerging computational, monitoring, remote sensing and visualization technologies that will provide comprehensive spatial and temporal measurements of the forest that can be readily accessed by scientists, land managers and policymakers.

At USM, the Community Research Assistantships program conducted by the Data Innovation Project matches graduate students to community-based organizations interested in improving their use of data, evaluation, and monitoring to achieve their organizations' missions.

In recent assistantships, USM students from the policy, planning, and management and public health programs were matched with five site organizations. Students were able to apply their skills in program evaluation/monitoring, logic models, performance measurement, public presentations, qualitative research methods, data visualization, and data dashboards in the real world. Community partners were left with an increased capacity to use data and a clear implementation path for using data in their work and strategic planning.

Notable successes include overhauling data dashboards, developing an evaluation plan, and facilitating a performance indicator workshop for MaineHealth's Access to Care program; and developing a new logic model, performance measurement framework, and data dashboard for Operation HOPE, a police-assisted addiction and recovery program at the Scarborough Police Department. One student was invited to continue as a consultant to help a community organization with ongoing data technology needs.



■ Precision Manufacturing

Modern, computer-controlled production and facilities are the future of manufacturing in Maine. The growth of this sector will rely on skilled workers trained on state-of-the-art systems and equipment and support for businesses integrating new systems and technologies.

UMaine's Advanced Manufacturing Center (AMC) is central to those efforts, helping businesses with custom, innovative solutions and training the workforce they need.

A key area of focus is making 3D metal printing accessible to Maine businesses at the Center for Additive Manufacturing of Metals (CAMM), based at the AMC. It is the only Maine facility currently offering these services, which focus on the process of fusing small metal particles together through 3D printing to form solid metal objects. The technology is ideal for creating small parts used in tooling or fixturing, and with CAMM's support Maine companies can experience the benefits of the emerging technology without risk, paving the way for their own adoption.

"Additive metal manufacturing represents an epochal shift in manufacturing technology on par with the advent of multi-axis machining in the 1980s," according to Larry Robinson, president of the Maine Manufacturing Extension Partnership. "In order for the technology to become widely adopted, there has to be a nascent infrastructure to scale from." CAMM's goal is to help companies develop that infrastructure, offering services that employ the latest advanced metal manufacturing technology and offer access to the AMC's full suite of machining and post-processing facilities, including CNC machining, turning, and surface finishing machines.

CAMM's funding comes from a nearly \$500,000 Maine Technology Institute (MTI) cluster initiative program grant, with matching funds from the university and 35 Maine companies, bringing the total to \$1 million. The funds also will be used as a partial match for a \$750,000 U.S. Economic Development Administration grant AMC received in FY2020 for equipment upgrades, including a Desktop Metal FDM additive metal machine with testing equipment, 5-axis machining center, hybrid metal additive cell, wire EDM (electrical discharge machining), and 4-axis lathe with live tooling.

During the COVID-19 pandemic, CAMM has been a critical resource for Hermon-based manufacturer Ntension, developing a 3D-printed metal mold to make filter pods for half-face respirator masks that the company is developing.



Appendix 1 — University of Maine System Intellectual Property

Table A1-1

University of Maine System — Patent Applications FY2020

Title	Application Type	Filing Date	Inventor	Campus
DOPPLER RADAR BASED BEE HIVE ACTIVITY MONITORING SYSTEM	PCT	7/5/19	HERBERT AUMANN NURI EMANETOGLU	ORONO
NON-ORTHOGONAL ADDITIVE MANUFACTURING AND THE TREATMENT OF PARTS MANUFACTURED THEREOF	PCT	8/6/19	MATTHEW IRELAND JAMES ANDERSON	ORONO
IMPROVED METHODS OF CANCER DETECTION	US - DIVISIONAL	9/20/19	ANDRE KHALIL KENDRA BATCHELDER	ORONO
LIGNOCELLULOSIC FOAM COMPOSITIONS AND METHODS OF MAKING THEREOF	US - PROVISIONAL	10/29/19	ISLAM HAFEZ SEYED ALI HAJI MIRZA TAYEB AILEEN CO MICHAEL MASON MEHDI TAJVIDI	ORONO
TUNED MASS DAMPER FOR FLOATING STRUCTURES	PCT	11/4/19	ANDREW GOUPEE HABIB DAGHER ANTHONY VISELLI CHRISTOPHER ALLEN	ORONO
PARASITE TREATMENT COMPOUND	US (PCT)	3/11/20	DEBORAH BOUCHARD IAN BRICKNELL	ORONO
METHOD TO PRODUCE MARKET PULP AND PAPER WITH ENHANCED PROPERTIES	(PCT) US	4/8/20	MICHAEL BILODEAU MARK PARADIS	ORONO
PARASITE TREATMENT COMPOUND	EP	4/9/20	DEBORAH BOUCHARD IAN BRICKNELL	ORONO
MULTI-BODY FLOATING OFFSHORE WIND TURBINE FOUNDATION WITH HANGING STABILIZING MASS AND METHOD OF INSTALLATION	PCT	4/16/20	ANDREW GOUPEE HABIB DAGHER ANTHONY VISELLI JACOB WARD CHRISTOPHER ALLEN	ORONO
PHENOLIC AND ANTHROCYANIN FRACTIONS FROM WILD BLUEBERRIES (VACCINIUM ANGUSTIFOLIUM) DIFFERENTIALLY MODULATE ENDOTHELIAL CELL MIGRATION	US (PCT)	4/28/20	PANAGIOTIS TSAKIROGLOU DOROTHY KLIMIS	ORONO
IMPROVED FILAMENTS FOR 3D PRINTING	US	5/6/20	DOUGLAS GARDNER JORDAN SANDERS LU WANG	ORONO
METHODS AND DEVICES FOR TREATMENT OF NEUROPATHY	US - PROVISIONAL	5/8/20	ROSEMARY SMITH KRISTY TOWNSEND	ORONO
IMPROVED FILAMENTS FOR 3D PRINTING	EP	5/16/20	DOUGLAS GARDNER JORDAN SANDERS LU WANG	ORONO
PATHOGEN COLLECTION AND HANDLING SYSTEM	US-PROVISIONAL	6/30/20	CAITLIN HOWELL DANIEL REGAN	ORONO
Total 14				

Table A1-2

University of Maine System — Patents Issued FY2020

Title	Patent Number	Country	Issue Date
METHOD OF ASSEMBLING A FLOATING WIND TURBINE PLATFORM	10336404	United States	7/2/19
IMPROVED METHODS OF CANCER DETECTION	10467755	United States	11/5/19
HYBRID COMPOSITE CONCRETE BRIDGE AND METHOD OF ASSEMBLING	10947779	United States	1/24/20
HYBRID CONCRETE-COMPOSITE TOWER FOR A WIND TURBINE AND METHOD OF MANUFACTURING	10519685	United States	12/31/19
LIQUID MODULATED ANTENNA	9046405	United States	1/24/20
PROCESSING PHOTOREACTIVE MATERIALS WITH OPEN OPTICAL WAVEGUIDES	7050690	United States	1/24/20
ENERGY EFFICIENT PROCESS FOR PREPARING NANOCELLULOSE FIBERS	10563352	United States	2/18/20
METHODS OF CONTROLLING THE HYDROPHILICITY OF CELLULOSE	10570563	United States	2/25/20
HYBRID COMPOSITE MATERIAL SYSTEMS FOR OFFSHORE FLOATING PLATFORMS	10598155	United States	3/24/20
STYLIZED ADAPTIVE MOBILITY DEVICE	10667979	United States	6/2/20
COMPOSITE BUILDING PRODUCTS BOUND WITH CELLULOSE NANOFIBERS	10695947	United States	6/30/20
			Total
			76
			United States
			11
			Non-U.S.
			65

Above chart lists U.S. patents only.

Appendix 2 — Maine Economic Improvement Fund Financial History and Tables

Table A2-1

A History of Legislative Actions on Appropriating State Research Funds

The following is a summary of the actions of the 118th–129th (first regular session) Maine Legislature with regard to appropriating research and development funds to the University of Maine System.

118th LEGISLATURE

March 26, 1997: Governor signed into law the Economic Improvement Strategy (Chapter 24) that appropriated \$500,000 to UMS for research.

April 1, 1998: Governor signed into law the Economic Improvement Strategy (Chapter 643, Part LL, Sec. S-3) that appropriated \$4 million to UMS for research. These funds were allocated from the FY1998 year-end state surplus for use in FY1999.

119th LEGISLATURE

March 15, 1999: Governor signed into law the Part I Current Services budget (Chapter 16) that appropriated \$4 million in 1999–2000 and 2000–01 to UMS on a “base budget” basis for research. This extends the one-time FY1999 \$4 million research appropriation that was funded from the FY1998 year-end state surplus.

June 4, 1999: Governor signed into law the Part II Supplemental Appropriation budget (Chapter 401) that appropriated an additional \$5.55 million in 1999–2000 and an additional \$50,000 in 2000–01 to UMS on a “base budget” basis for research.

April 25, 2000: Governor signed into law the Part II Supplemental Appropriation budget (Chapter 731) that appropriated \$300,000 in 2000–01 to UMS on a “base budget” basis for the Maine Patent Program.

120th LEGISLATURE

June 21, 2001: Governor signed into law the Part II Supplemental Appropriation budget (Chapter 439) that appropriated an additional \$2 million in 2002–03 to UMS on a “base budget” basis for research.

March 25, 2002: Governor signed into law a deappropriation (Chapter 559) that reduced the FY2003 \$2 million Supplemental Appropriation by \$1 million.

July 1, 2002: Governor signed a Financial Order that curtailed the FY2003 \$2 million Supplemental Appropriation by an additional \$1 million. This eliminated the FY2003 increase of \$2 million for research, bringing the FY2003 research and development appropriation back to the FY2002 level of \$10.1 million.

November 18, 2002: Governor signed into law a Supplemental Appropriation budget (Chapter 714) that deappropriated the \$1 million curtailment that was signed July 1, 2002.

121st LEGISLATURE

March 27, 2003: Governor signed into law the Part I Current Services budget (Chapter 20, Part RR) that appropriated \$100,000 in 2003–04 and 2004–05 on a “base budget” basis for research.

January 30, 2004: Governor signed into law a Supplemental Appropriation budget (Chapter 513, Part P, Sec. P-2) that includes a provision to transfer to MEIF up to \$2 million of any unbudgeted State revenue remaining at the close of FY2004. The full amount was subsequently transferred to UMS. This same Chapter 513, Part P, Sec. P-3 made the \$2 million part of the MEIF FY2005 base appropriation.

122nd LEGISLATURE

March 29, 2006: Governor signed into law a Supplemental Appropriations budget (Chapter 519, Part A, Sec. A-1) that includes providing one-time funding of \$600,000 in FY2007 for the commercialization of research and development activity, and for the Gulf of Maine Ocean Observing System.

123rd LEGISLATURE

June 7, 2007: Governor signed into law a budget (Chapter 240, Part A, Sec. A-68) that provides an increase of \$1.5 million in FY2008 and an additional \$1 million in FY2009 on a “base budget” basis for research.

124th LEGISLATURE

May 28, 2009: Governor signed into law a budget (Chapter 213, Part A, Sec. A-67) that maintains the annual funding at the FY2009 level of \$14.7 million.

125th LEGISLATURE

June 15, 2011: Governor signed into law a budget (Chapter 380) that maintains the annual funding at \$14.7 million. May 29, 2012: PUBLIC Law (Chapter 698) creates the formula funding for the Small Campus Initiative, reserving a percentage of MEIF exclusively for the five smaller campuses of the University of Maine System.

126th LEGISLATURE

June 10, 2013: Governor signed into law (Chapter 225) an amendment to the MEIF statute to include Maine Maritime Academy as a MEIF-eligible small campus.

June 26, 2013: Legislature approved into law a budget (Chapter 368) that maintains the annual funding at \$14.7 million.

127th LEGISLATURE

June 30, 2015: Legislature approved into law a budget (Chapter 267) that increases the annual funding by \$2.65 million in each year of the biennium.

128th LEGISLATURE

July 4, 2017: Governor signs into law the state budget that maintains the annual funding at \$17.35 million (FY2017/FY2018).

129th LEGISLATURE

June 17, 2019: Governor signs into law the state budget that maintains the annual funding at \$17.35 million (FY2018/FY2019)

Table A2-2

Legislative History of MEIF New Appropriations

118th LEGISLATURE

	<u>FY1998</u>	<u>FY1999</u>	<u>Total 2-Year</u>
UMaine	\$400,000	\$3,200,000	\$3,600,000
USM	100,000	800,000	900,000
Total	\$500,000	\$4,000,000	\$4,500,000

119th LEGISLATURE

	<u>FY2000</u>	<u>FY2001</u>	<u>Total 2-Year</u>
UMaine	\$4,440,000	\$40,000	\$4,480,000
USM	1,110,000	10,000	1,120,000
Total	\$5,550,000	\$50,000	\$5,600,000

120th LEGISLATURE

	<u>FY2002</u>	<u>FY2003</u>	<u>Total 2-Year</u>
UMaine	\$0	\$0	\$0
USM	0	0	0
Total	\$0	\$0	\$0

121st LEGISLATURE

	<u>FY2004</u>	<u>FY2005</u>	<u>Total 2-Year</u>
UMaine	\$80,000	\$1,600,000	\$1,680,000
USM	20,000	400,000	420,000
Total	\$100,000	\$2,000,000	\$2,100,000

122nd LEGISLATURE

	<u>FY2006</u>	<u>FY2007</u>	<u>Total 2-Year</u>
UMaine	\$0	\$540,000	\$540,000
USM	0	60,000	60,000
Total	\$0	\$600,000	\$600,000

123rd LEGISLATURE

	<u>FY2008</u>	<u>FY2009</u>	<u>Total 2-Year</u>
UMaine	\$1,200,000	\$720,000	\$1,920,000
USM	300,000	180,000	480,000
S.C. Initiatives	0	100,000	100,000
Total	\$1,500,000	\$1,000,000	\$2,500,000

124th LEGISLATURE²⁰

	<u>FY2010</u>	<u>FY2011</u>	<u>Total 2-Year</u>
UMaine	\$0	\$0	\$0
USM	0	0	0
S.C. Initiatives	0	0	0
Total	\$0	\$0	\$0

125th LEGISLATURE

	<u>FY2012</u>	<u>FY2013</u>	<u>Total 2-Year</u>
UMaine	\$0	\$0	\$0
USM	0	0	0
S.C. Initiatives	0	0	0
Total	\$0	\$0	\$0

126th LEGISLATURE

	<u>FY2014</u>	<u>FY2015</u>	<u>Total 2-Year</u>
UMaine	\$0	\$0	\$0
USM	0	0	0
S.C. Initiatives	0	0	0
Total	\$0	\$0	\$0

127th LEGISLATURE

	<u>FY2016</u>	<u>FY2017</u>	<u>Total 2-Year</u>
UMaine	\$2,056,400	\$0	\$2,056,400
USM	514,100	0	514,100
S.C. Initiatives	79,500	0	79,500
Total	\$2,650,000	\$0	\$2,650,000

128th LEGISLATURE

	<u>FY2018</u>	<u>FY2019</u>	<u>Total 2-Year</u>
UMaine	\$0	\$0	\$0
USM	0	0	0
S.C. Initiatives	0	0	0
Total	\$0	\$0	\$0

129th LEGISLATURE

	<u>FY2020</u>	<u>FY2021</u>	<u>Total 2-Year</u>
UMaine	\$0	\$0	\$0
USM	0	0	0
S.C. Initiatives	0	0	0
Total	\$0	\$0	\$0

Total Yearly Research Appropriations for FY2020**FY2019 Appropriation**

UMaine	\$13,289,194	76.6%
USM	3,290,306	19.0%
UMM	250,000	1.4%
UMFK	0	0.0
UMPI	0	0.0
UMA	0	0.0
UMF	0	0.0
UMS S.C. Init.	520,500	3.0
MMA	0	0.0
Total	\$17,350,000	100.0%

S.C. Initiatives Small Campus Initiatives

University of Maine at Augusta UMA

University of Maine at Farmington UMF

University of Maine at Fort Kent UMFK

University of Maine at Machias UMM

University of Maine at Presque Isle UMPI

Maine Maritime Academy MMA

Table A2-3 Maine Economic Improvement Fund

Utilization of FY2020 Research Appropriation by Targeted Sector

UMAINE

UMAINE		Source of R&D Funds					Utilization of R&D Funds				Balance
	Unused FY2020 R&D Initial Base Budget	Unused R&D Funds from Prior Years As Reported	Adjustment To Prior Years Unused R&D Funds	Adjusted Unused R&D Funds From Prior Years	FY2020 R&D Funding Transfers	FY2020 Total R&D Funds Available	Transferred FY2020 R&D Actual Expenditures	Transferred To Match Grants & Contracts	Total Between R&D Accounts	Funds R&D Funds Utilized	Carried Forward To FY2021 ¹
Targeted Research Area											
Adv. Technology Forestry & Agriculture	\$1,990,830	\$(1,401,378)	\$-	\$(1,401,378)	\$-	\$589,452	\$2,535,879	\$280,706	\$(1,333,392)	\$1,483,193	\$(893,741)
Aquaculture & Marine Science	2,389,659	(2,516,483)	-	(2,516,483)	-	(126,824)	2,920,686	376,987	(2,352,268)	945,405	(1,072,229)
Biotechnology	1,142,687	(1,315,211)	-	(1,315,211)	-	(172,524)	1,894,423	201,906	(1,207,331)	888,998	(1,061,522)
Composites	1,673,678	2,286,477	-	2,286,477	-	3,960,155	1,997,328	343,778	1,474,442	3,815,548	144,607
Environmental Information Technology	1,544,326	(646,096)	-	(646,096)	-	898,230	1,990,036	248,472	(956,602)	1,281,906	(383,676)
Precision Manufacturing	1,893,809	(999,936)	-	(999,936)	-	893,873	2,999,032	63,242	(1,448,489)	1,613,785	(719,912)
Cross Sector	1,475,256	327,580	-	327,580	-	1,802,836	2,099,336	33,609	(539,181)	1,593,764	209,072
Total State Funding	\$13,289,194	\$(4,796,672)	\$-	\$(4,796,672)	\$-	\$8,492,522	\$17,604,435	\$1,702,400	\$(6,791,612)	\$12,515,223	\$(4,022,701)
UM Cost Sharing Funding 2	6,791,612	-	-	-	-	6,791,612	-	-	6,791,612	6,791,612	-
Total Funding	\$20,080,806	\$(4,796,672)	\$-	\$(4,796,672)	\$-	\$15,284,134	\$17,604,435	\$1,702,400	\$-	\$19,306,835	\$(4,022,701)

¹Includes year-end equipment carry-over funds (equipment ordered, not received, and not paid).²Salary and benefits from University.

USM

USM	Source of R&D Funds						Utilization of R&D Funds			Balance	
	Unused FY2020 R&D Initial Base Budget	Unused R&D Funds from Prior Years As Reported	Adjustment To Prior Years Unused R&D Funds	Adjusted Unused R&D Funds From Prior Years	FY2020 R&D Funding Transfers	FY2020 Total R&D Funds Available	Transferred FY2020 R&D Actual Expenditures	Transferred To Match Grants & Contracts	Total Between R&D Accounts		Funds R&D Funds Utilized
Targeted Research Area											
Forestry & Agriculture	\$-	\$187,070	\$-	\$187,070	\$802,718	\$989,788	\$746,926	\$90,319	\$-	\$837,245	\$152,543
Aquaculture & Marine	-	177,737	-	177,737	650,587	828,324	451,369	-	-	451,369	376,955
Biotechnology	-	17,547	-	17,547	273,670	291,217	246,806	-	-	246,806	44,411
Composites	-	890	-	890	(890)	-	-	-	-	-	-
Environmental	-	3,462	-	3,462	19,696	23,158	17,187	-	-	17,187	5,971
Information Technology	-	247,147	-	247,147	686,536	933,683	637,658	78,827	-	716,485	217,198
Precision Manufacturing	-	3,971	-	3,971	36,978	40,949	37,403	-	-	37,403	3,546
Cross Sector	-	258,225	-	258,225	961,429	1,219,654	1,013,050	-	-	1,013,050	206,604
Unassigned	3,290,306	478,282	-	478,282	(3,430,724)	337,864	-	-	-	-	337,864
Total State Funding	\$3,290,306	\$1,374,331	\$-	\$1,374,331	\$-	\$4,664,637	\$3,150,399	\$169,146	\$-	\$3,319,545	\$1,345,092

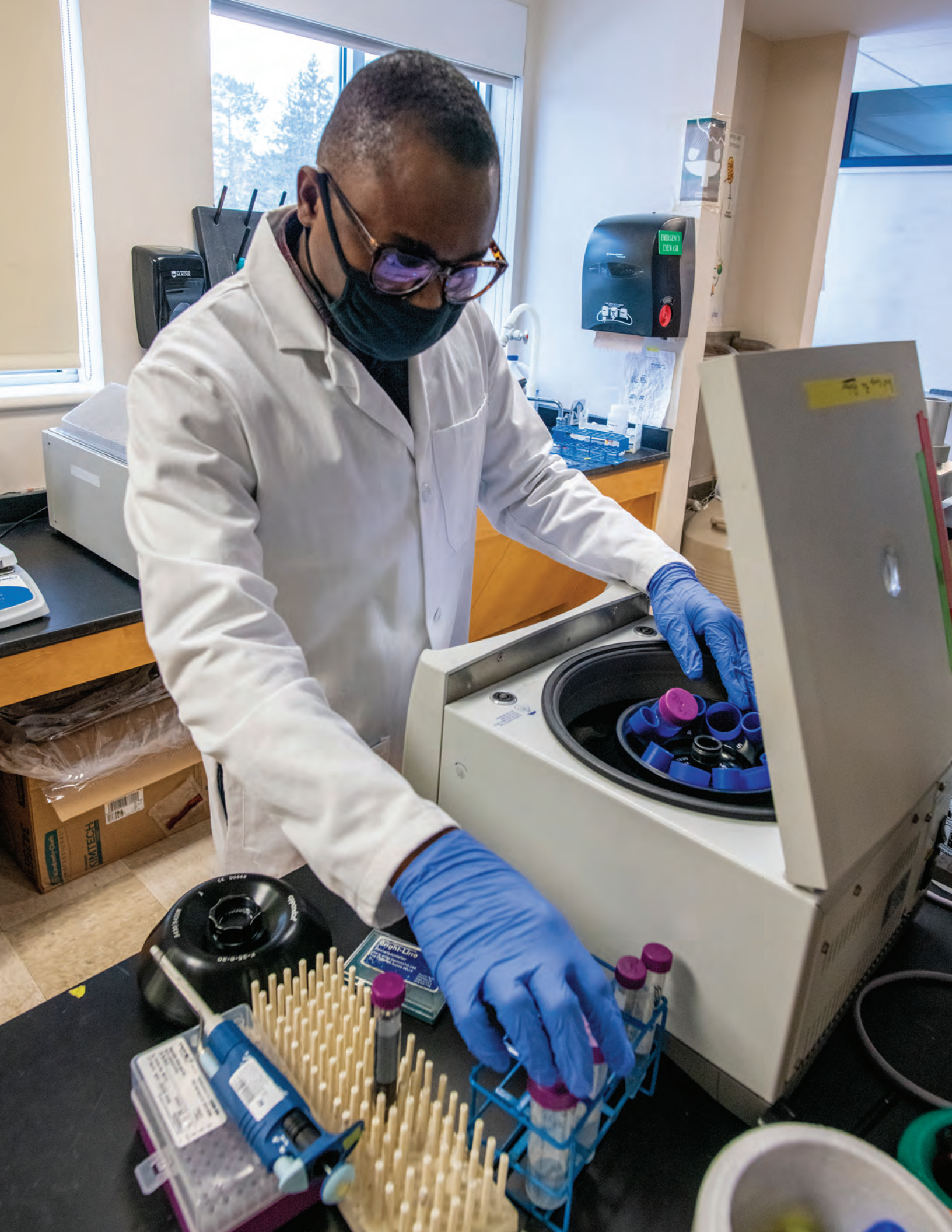
¹ Includes year-end equipment carry-over funds (equipment ordered, not received, and not paid).² At USM, projects are funded on a year-to-year basis with renewals contingent on performance. A majority of the unused funds carried forward into FY21 are committed to multiyear projects.³ Transfers for current year funding of USM R&D programs and awards from Unassigned. UM base budgets the MEIF appropriation by sector and thus does not use funding transfers.

Table A2-4 Maine Economic Improvement Fund

FY2020 Summary Utilization of Operating Research Appropriation by University

Source of R&D Funds										Utilization of R&D Funds				Balance
FY2020 R&D Initial Base Budget	Unused R&D Funds from Prior Years As Reported	Adjustment to Prior Years Unused R&D Funds	Adjusted Unused R&D Funds from Prior Years	FY2020 R&D Funding Transfers ³	FY2020 R&D Funds Available	FY2020 R&D Actual Expenditures	Transferred To Match Grants & Contracts	Transferred Between R&D Accounts ²	Total R&D Funds Utilized	Unused Funds Carried Forward To FY2021 ¹				
UMAINE	\$13,289,194	\$(4,796,672)	\$-	\$-	\$8,492,522	\$17,604,435	\$1,702,400	\$(6,791,612)	\$12,515,223	\$(4,022,701)				
USM	3,290,306	1,374,331	-	1,374,331	4,664,637	3,150,399	169,146	-	3,319,545	1,345,092				
UMM	250,000	335,521	-	335,521	585,521	486,625	-	-	486,625	98,896				
UMFK	-	61,357	-	61,357	191,357	23,944	-	-	23,944	167,413				
UMPI	-	65,621	-	65,621	65,621	65,612	-	-	65,612	9				
UMA	-	85,130	-	85,130	84,810	84,809	-	-	84,809	1				
UMF	-	9,980	-	9,980	309,980	1,794	-	-	1,794	308,186				
UMS	520,500	49,451	-	49,451	(559,680)	10,271	17,999	-	17,999	(7,728)				
MMA	-	102,726	-	102,726	130,000	232,726	15,933	-	15,933	216,793				
Total State Funding	\$17,350,000	\$(2,712,555)	\$-	\$(2,712,555)	\$14,637,445	\$21,451,550	\$1,871,546	\$(6,791,612)	\$16,531,484	\$(1,894,039)				

¹ Includes year-end equipment carry-over funds (equipment ordered, not received, and not paid).² UM Cost Sharing.³ Inter-unit R&D funding transfers related to FY2020 MMA and Small Campus Initiative (SCI) awards.



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