

MAINE STATE LEGISLATURE

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**EVALUATION OF MAINE'S PUBLIC INVESTMENTS IN
RESEARCH & DEVELOPMENT
FINAL REPORT**

October 2006

by

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EXECUTIVE SUMMARY

This fifth annual assessment of Maine's investments in R&D was conducted during 2005-06. With respect to the three core questions posed by the Maine legislature, we find significant progress as well as continuing challenges to make Maine more competitive in the knowledge economy of the 21st century.

QUESTION 1: HOW COMPETITIVE IS MAINE'S SPONSORED R&D AND HAS IT IMPROVED OVER TIME?

Answer: While the Goals established in the "Science and Technology Action Plans for Maine" are ambitious, the progress the state has already achieved in this decade gives credence to the State's ability to attain the goals set for 2010. However, competitiveness differs sharply among the three sectors of Maine's R&D performers – Industry, Academic and Not for Profit. The State must decide how future R&D investments will further enhance research competitiveness while maximizing economic development outcomes.

Maine's R&D Competitive Position Improving

In 1993, R&D performance in Maine totaled \$113 million. By 1998 that amount had grown at a modest rate to \$159 million. But beginning in 1999, Maine experienced rapid growth in R&D performance, increasing 169% to \$429 million by 2002.

This growth rate compared very favorably with national and peer state performance over the same period. Maine's 169% growth in total R&D performance far exceeded the national rate (13%), New England (23%).

The result has been considerable progress in Maine's national R&D position. Between 1993 and 2002, Maine improved its nationally ranking for Total R&D per Worker from 47th to 42nd and its ranking on R&D spending as a percent of Gross State Product from 49th to 38th.

Maine's Institutional R&D Strengthening but Divided

Maine's R&D institutional capacity has strengthened. But R&D performance is divided among different types of institutions. It is segmented not only along the usual university and industry lines, but also by the dominant role played by Maine's essentially autonomous non-profit research organizations. This can make it hard to gain recognition of this progress and to realize the full benefit of those gains.

There are limits to how fast Maine's R&D capacity can increase. The State must make the most of that capacity by capitalizing on synergies between its varying institutional R&D performers. Fortunately the 2005 R&D Evaluation found a positive trend developing in inter-institutional collaborations in Maine.

QUESTION 2: WHAT IS THE IMPACT OF MAINE'S R&D INVESTMENT ON THE DEVELOPMENT OF ITS R&D INDUSTRY?

Answer: Maine's new R&D strength is paying off for the state financially and academically, but the ability to generate economic benefits depends on commitment to commercialization and is not an inevitable outcome of greater R&D activity.

R&D Investments Producing Academic Outcomes

Over the past six fiscal years, the State of Maine has devoted \$204 million to programs targeting a spectrum of activities ranging from education to research to commercialization. Most of that amount (76%) has been allocated to building Maine's research capacity at its academic and not for profit institutions.

The result has been dramatic gains in funds secured for extramural institutional research funding. Since 2003, Maine's R&D institutions received \$492 million in R&D funding from government and private sources at an increasing pace reflecting the State's enhanced competitive position.

Industrial R&D Recent Decline Suggests Eroding Competitiveness

R&D performed by the state's larger companies has declined sharply in recent years. After peaking at over \$250 million in 2000, Industry R&D in Maine has declined 22% to \$200 million in 2003. During the same period Industry R&D grew 3% nationally and 14% in New England.

Falling Industrial R&D spending suggest declining future competitiveness among Maine's industries compared to its peers. In 1995 Maine's Industry R&D spending of \$448 per worker ranked the state 30th nationally. But by 2003 R&D spending per worker had fallen to \$288, dropping Maine's US ranking down to 43rd nationally.

Support Share for R&D Commercialization has Declined

State funding for Maine's commercialization efforts has grown more slowly than that for institutional research programs. As a result, the share of Maine's public investment in R&D that directly supports economic growth has declined from a high of 35% in 2000/2001 to only 23% in 2004/2005.

QUESTION 3: WHAT IS THE IMPACT OF MAINE'S R&D INVESTMENT ON THE LEVEL OF INNOVATION AND INNOVATION-BASED ECONOMIC DEVELOPMENT?

Answer: The ultimate objective of economic development is being realized despite challenges posed by Maine's economy.

Maine's company assistance programs are well established and effective

A substantial portion of Maine's public investment in R&D is for programs supporting private sector activities. The support provided is in many forms, from patenting advice

and assistance to research funding to growth capital. Maine's R&D support programs reach a broad cross-section of targeted firms across the state. Those programs provide high quality, high value assistance deemed important by the companies being served and are effective in assisting the development of new products or services.

Support of R&D companies is creating tangible economic benefits

For 2005, the Private Company Survey produced the highest response achieved for any of the Maine's R&D Evaluation Private Company Surveys conducted to date. It also yielded the broadest participation by program clients.

This year's survey found that the average firm responding employed 11 people at an annual wage of \$49,605. Collectively, the 592 surveyed firms were estimated to employ 6,266 people with a total payroll exceeding \$310 million.

MAINE'S CHALLENGE NOW – TRANSLATING R&D INTO ECONOMIC GROWTH

Maine's hard won recent gains in R&D competitiveness are the result of consistent support of competently executed strategies and programs at considerable public expense for the specific public purpose of stimulating economic development. While the performance of institutional R&D provides significant direct economic outcomes through the employment of research staff, equipment purchases, and support spending, the intent of Maine's public investments in R&D has not been to enhance R&D capacity for its own sake. Rather, those investments have been justified as public purposes because of their intended effect in stimulating job creation and economic growth external to the R&D performance setting.

Leverage Maine's R&D Capacity through Inter-Institutional Collaborations

The 2005 Evaluation found that Maine's R&D institutional capacity has strengthened but that that capacity is divided between academic and not for profit performers with very different levels of competitiveness and engagement in the Maine economy. On several measures Maine's not for profit research institutions are more competitive while Maine's universities are more engaged in research commercialization activities that directly benefit the economy. Inter-institutional collaborations between not for profit and academic researchers could capture synergies providing the best of both worlds.

Future R&D support should be used to incent such collaborations, especially in efforts that build on successful Maine public/private initiatives for the economic deployment of R&D. The experience of examples such as the Maine Aquaculture Center in Franklin, the Target Technology Center in Orono and the Maine Center for Enterprise Development in South Portland have demonstrated how academic research can support commercialization through persistent directed programs.

Expand/Leverage Company Assistance Programs to Increase Economic Benefits

The proven capabilities of Maine's R&D company assistance programs can yield increased economic development benefits if leveraged to better serve the State's innovative entrepreneurs and existing industry. While many of Maine's entrepreneurs

already benefit from multiple programs, their utilization of this assistance could be optimized through a cogently packaged program of targeted delivery. Maine is also home to many innovative existing firms not yet engaged in the State's assistance system. A proactive outreach program targeting existing small and medium industries would leverage the more specialized and high valued aspects of Maine's R&D assistance among firms with higher probabilities of success

Increase Emphasis on Commercialization

Since 1999 most of Maine's \$204 million in R&D support has gone for capacity building at academic and not for profit research institutions. This early emphasis on research support may have been needed to expand Maine's limited R&D capacity as a prerequisite for innovation-based economic development. The 2005 Evaluation found that while the efficacy of Maine's R&D commercialization programs are well demonstrated, their sufficiency is in question. At this later stage in Maine's R&D investment effort it is appropriate to substantially increase allocations for the commercialization related programs in that effort.

Increase Private R&D Commercialization by Addressing Growth Capital Scarcity

The economic growth benefits of Maine's innovation-based economy would be increased by better access to growth capital. The 2005 Evaluation found that a meager growth capital market for Maine's innovative young firms continues to limit the economic potential of the state's investments in R&D. The Maine S&T Plan has appropriately made addressing the capital market constraints a major objective of its strategy. Among its 2007 benchmarks is the development of public and private funding sources that support early stage research-intensive business development. Maine needs to also emphasize other forms of formal and informal debt and equity financing required by many more growth companies.

Track Maine's "Gazelles" to Guide Future R&D Commercialization Efforts

Much of the eventual economic development anticipated from Maine's R&D investments is predicated on the success of a generation of new innovation-based businesses emerging and growing through the state. However, it must be acknowledged that on many criteria Maine has been judged lacking as an environment for entrepreneurial success.

Fortunately, Maine is home to another even larger and more diverse population of companies that could benefit from an expansion of Maine's R&D programs. These "Entrepreneurial Growth Companies" (EGCs) are firms that while still relatively young – between 5 and 15 years in age – have achieved substantial initial commercial success. Often termed "gazelles", research has shown such firms to have a disproportionately large role in US job creation.

The 2005 Evaluation identified the a pool of more than 2,000 Entrepreneurial Growth Companies from which Maine's high growth "gazelle" firms are likely to emanate. While usually not classified as "technology companies" based on their products or services, many EGCs actively perform R&D, or adapt and utilize R&D outcomes, to increase

productivity and add value to their products and services. While there are many lessons to be drawn upon from other states in this regard, the best answers on how to improve Maine's entrepreneurial economy will come from posing the right questions to the right people already building businesses in the state.

Establish Maine R&D Strategic Oversight Authority to Direct Efforts

Maine's R&D investment program was undertaken with conviction as to its end and commitment as to its means. But the state's leaders also wisely built in an annual revaluation process to provide information on which to judge performance of the R&D investment programs and strategies.

The Office of Innovation at the Maine Department of Economic and Community Development was established to gather and assess the results of the annual assessments and provide a forum for the articulation and discussion of emerging best practices for innovation-based economic development in the state. Such a role has been essential given the diversity among the 17 different R&D programs and institutions supported by a cumulative public investment of \$203 million over the past 6 fiscal years.

The "Science and Technology Action Plan for Maine" incorporates many of the lessons learned in this effort over the past six years. More importantly, it provides the strategic roadmap for accomplishing the larger mission for which Maine has undertaken its R&D investment program. Success in this regard requires not only guidance but also enforcement of strategic discipline in adherence to the goals and priorities described in the Plan.

Most of the recommendation of this evaluation will require hard choices often contrary to established interests:

- Require commercialization-directed collaboration between not for profit and academic research institutions as prerequisite for R&D funding
- Increase emphasis and funding share for direct R&D commercialization programs
- Expand assistance beyond early-stage firms to include existing companies

Maine needs an entity with appropriate statutory and budgetary authority to provide strategic oversight to Maine's public investments in research and development. States that have undertaken substantial investments in R&D have typically also provided a means of governing, guiding or advising their states' leaders in their funding decisions.

However, such an authority will not be universally welcomed, especially as many R&D funding recipients have well established constituencies positioned to influence funding decision irrespective of their strategic relevance. The necessity for such a role is nonetheless real if Maine is to realize the significant economic potential of its R&D investments.

**EVALUATION OF MAINE'S PUBLIC INVESTMENTS IN RESEARCH &
DEVELOPMENT
FINAL REPORT 2005-06**

This fifth annual assessment of Maine's investments in R&D, conducted during 2005-06, finds Maine is making progress but questions whether these accomplishments are adequate to achieve stated and implicit goals, and indeed whether those goals – even if achieved – are sufficient to fulfill these investments' broader economic development mission. The report's findings also call into question the strategic relevance of some of Maine's public investments in research and development given the ultimate economic development goals of those investments. The report concludes with recommendations on how to optimize the state's R&D investments.

CHAPTER ONE: STUDY DESCRIPTION

Despite improvements in the U.S. economy in 2005-06, states continue to struggle with tight budgets. Modest increases in revenues are being offset by deferred commitments from even worse budget years and higher federally mandated spending on programs such as Medicaid.

These continuing challenges require states' elected officials and legislatures to scrutinize every direct and tax expenditure program, and to seek alternative sources of revenue. This year's final Evaluation of Maine's Public Investments in Research & Development is presented within that context. The governor and legislature have maintained their commitment to grow the state's science and technology capacity. This commitment, in light of Maine's sustained fiscal pressures, recognizes the promise of technology-led economic development in the new economy of the 21st century.

What the R&D investments are intended to do

The ultimate goal for Maine's governor, legislature, and economic developers in supporting R&D initiatives is to create more jobs, income, wealth, and opportunities for Mainers. That is done by attracting and growing more businesses, retaining and attracting the best minds, and strengthening what is already in the Maine economy. The key engines to achieve those ends are for-profit businesses, not-for-profit organizations, and the higher-education sector. The R&D investments being made in Maine are intended to make each of those sectors more competitive.

Evaluating Maine's R&D investments

This report is the fifth annual assessment of Maine's investments in R&D. It is part of a multi-year effort to collect and assess relevant information in the context of economic developments in Maine, New England, comparable "benchmark" states, and the nation. This project is unique in its systematic inclusion of stakeholders around Maine, continuity over time, and periodic interplay between the evaluation team and policy-makers in Augusta.

THE LEGISLATURE'S "THREE QUESTIONS"

Ultimately, the goal of this evaluation is to provide advice to the governor and legislature on policies to help create a more competitive Maine. Toward that end, the report addresses and answers three questions specifically posed by the Maine legislature in 2001:

1) How competitive is Maine's publicly funded R&D and has the state's competitiveness improved over time?

The first question is about Maine's relationship to its competitors. For this evaluation, we define Maine's competitors in different ways.

First, Maine's competitiveness can be assessed in relation to the U.S. as a whole. Second, and perhaps foremost in the minds of the general public, Maine competes with its neighbor states in New England. Such comparisons, while of obvious interest, are of limited utility given the disproportionate scales involved. Therefore, Maine's competitiveness in the arena of research and development funds and resources is also examined within a set of 20 more comparable states. Known as "EPSCoR states" after a federal government acronym for the "Experimental Program to Stimulate Competitive Research" that denotes states with low levels of federal research funding.¹

2) What is the impact of Maine's R&D investment on the development of Maine's R&D industry?

The second question is about the impact of the R&D industry on Maine. The R&D industry consists of those entities whose primary output is research and development. Those include the doctoral universities, non-profit research entities and some companies.

3) What is the impact of Maine's R&D investment on the level of innovation and innovation-based economic development?

The third question asks how Maine's level of innovation and the innovation-based economy have changed as a result of the R&D investments to specifically identify what has improved, declined or not been impacted.

STUDY METHODOLOGY

We organize the report this year, as in past years, around these three questions, noting, as in earlier reports, that there is considerable overlap among them. Maine's competitiveness in R&D (question 1) affects the relationship between R&D investments and the R&D industry (question 2), and one measure of that effectiveness is the state's level of innovativeness (question 3). We use three types of evidence to answer these questions:

¹ EPSCoR states are: Alabama, Alaska, Arkansas, Idaho, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, North Dakota, Oklahoma, Puerto Rico, South Carolina, South Dakota, Vermont, West Virginia and Wyoming.

- 1) surveys of recipients of state R&D assistance that is channeled to them through stakeholder organizations, and of research institutions in Maine;
- 2) economic and technology indicators constructed with data for Maine, New England, all EPSCoR states, the EPSCoR states that entered the program with Maine in 1980, and the U.S. as a whole; and
- 3) case studies of specific programs.

The results we report below are subject to two possible biases: not all institutions provided data on all items, meaning that we may be underreporting some activity, and comparisons over time may be compromised by the changing composition of annual cohorts. We note particular places where these may affect the interpretation of results, but generally, we do not believe they affect the general thrust of the analysis.

Survey of recipients of state R&D assistance

To answer the impact questions posed by the legislature, the evaluation team conducts an annual survey of all final recipients of Maine's R&D investments. Final recipients are companies, institutions or individuals who use the funding to perform R&D, or build or operate R&D facilities.² The data collected from the survey paint a clearer picture of the impacts of those investments.

The evaluation team undertakes two types of surveys, one for companies and individuals and one for research institutions. For companies, the recipient is the corporate entity at the location where the funded work occurred. In some cases, individuals who have not yet formed companies are also recipients. For research institutions, the recipient is the parent organization of the individuals and/or laboratories that received the funding or matching funds. For each program, the mix of recipients is somewhat different. With input from the stakeholder advisory group, the evaluation team developed a survey instrument for both the research institutions and the companies.

Institutional survey

The research institution survey was administered by email in September 2005. An email explanation and attached .pdf file were sent to all research institutions that had received state R&D funds in the past five years. The 2005-06 survey was the fifth in a series of annual assessments conducted in the Maine R&D Evaluation. These annual assessments provided a basis for a long-term evaluation of Maine's research institutions.

The institutions surveyed for the 2005-06 evaluation included:

Institution Name

- Downeast Institute for Applied Marine Research and Education

² Most Maine R&D funds flow through intermediate recipients, usually stakeholders, who allocate the funds to companies and/or individuals. For instance, although R&D funds flow to MTI, they in turn grant funds to companies and individual researchers. Final recipients who are companies or individuals not at research institutions will be surveyed. Data for individual researchers at not-for-profit research and educational institutions will be collected by the institution and reported to the evaluation team.

- Bigelow Laboratory for Ocean Sciences
- Foundation for Blood Research
- Gulf of Maine Research Institute
- Maine Maritime Academy
- Maine Medical Center Research Institute
- Mount Desert Island Biological Laboratory
- The Jackson Laboratory
- University of Maine, Orono
- University of Maine at Machias
- University of New England
- University of Southern Maine
- Wells National Estuarine Reserve

The survey of institutions essentially asked about R&D inputs and outputs. The former (inputs) includes additions to research space and equipment, new faculty and post-docs who then are available to conduct research and train scientists and engineers, and the preparation of research grants. The latter (outputs) include spin-offs, licenses, and patents, the development of new degree programs and graduates, the production of peer-reviewed articles, and the receipt of research awards from the government and industry.

Private Company Survey

The company survey was administered via the Internet in fall 2005. Each company or individual was sent an email verifying that he was the appropriate recipient. Then, they were sent a link to the web survey and a password. Reminders were sent by email and via telephone asking recipients to complete the web survey.

The companies surveyed for the 2005 evaluation included those receiving assistance from one or more of the following organizations:

- Applied Technology Development Centers (ATDCs)
- Centers for Innovation (Biotechnology & Aquaculture)
- Maine Patent Program
- Maine Technology Institute
- Seed Capital Tax Credit Program
- Small Enterprise Growth Fund

The population of companies that received assistance from the R&D investment programs in 2005 (either new or continuing grants) was 592. These constituted the total population of companies surveyed. Of those, 346 companies completed the survey, a response rate of 58.4 percent.

Economic and Technology Indicators

While it has been widely accepted since at least World War II that R&D is important to economic development, various theories exist to demonstrate exactly how that is accomplished. Regardless of the model used, research and development appears to yield two types of outcomes. The end outcome, economic development, is often measured in terms of jobs, companies, and quality of life, while intermediate outcomes are those steps along the way that lead to these outcomes. For researchers, whether in educational or non-profit research institutions, these intermediate outcomes are publications, patents, graduate students, etc. For companies, patents are also one important measurable intermediate step as is getting financing.

The evaluation team chose the following indicators to be used in this evaluation. While other indicators may also be of interest, such as new products and processes, national and state data on the indicators are not generally available for comparison purposes.

Intermediate outcomes for researchers:

- S&E graduate students
- Recent S&E Ph.D.s and Masters in the workforce
- Federal R&D obligations by agency
- University-performed R&D expenditures
- Patents and patent citations
- Publications
- New sponsored research programs with Maine companies

Intermediate outcomes for companies:

- Patents and patent citations
- New capital raised including venture capital, SBIRs and other federal grants, mergers and acquisition, initial public offerings (IPOs)

End outcomes, by industry sector:

- Average annual earnings
- Employment
- Number of company births
- Number of establishments
- Revenue per employee
- Percent of revenue from outside of Maine

At the global level, we collected statistics for the indicators listed above for the state of Maine from secondary sources. Then, we compared those statistics with the same indicators for the aggregate (average) of the other New England states, the EPSCoR states, and the nation. To the maximum extent possible, we developed time series of data

to allow analysis of trends as well as absolute values. Data including 1990 and 1995 have established a baseline of performance prior to Maine's increased investment.

In addition, we included in the comparison the statistics defined by "30 and 1000,"³ specifically the R&D expenditures by employed worker and per capital income as defined by the State Planning Office.

Specific sources for each indicator are listed in the "2005 Innovation Index" issued as a separate research supplement to this report.

Case Studies

Case studies of specific R&D programs are conducted each year to augment the global indicator and recipient impact analyses. The case studies are intended to illustrate the process of commercialization in Maine and help identify what is working and what needs improvement. Interviewees for the case studies are chosen to cover a broad range of circumstances in Maine.

³ State Planning Office, "30 and 1000," November 1999.

CHAPTER TWO: EFFECTIVENESS OF R&D EFFORTS

In this chapter we apply the survey results, case studies, and indicator data to the three questions developed for the Initial Evaluation, and explain how our answers may have changed since last year as a consequence of another year's data. Our discussion is organized by the three questions and we highlight the most important findings in response to those questions.

For the purposes of this study, we define competitiveness in terms of the character and quantity of state support of R&D relative to other states and in terms of the effectiveness of the state's programs as measured by the outputs and outcomes arising from state initiatives.

This fifth annual assessment of Maine's investments in R&D was conducted during 2005-06. With respect to the three core questions posed by the Maine legislature, we find significant progress as well as continuing challenges to make Maine more competitive in the knowledge economy of the 21st century.

QUESTION 1: HOW COMPETITIVE IS MAINE'S SPONSORED R&D AND HAS IT IMPROVED OVER TIME?

Answer: While the Goals established in the "Science and Technology Action Plans for Maine" are ambitious, the progress the state has already achieved in this decade gives credence to the State's ability to attain the goals set for 2010. However, competitiveness differs sharply among the three sectors of Maine's R&D performers – Industry, Academic and Not for Profit. The State must decide how future R&D investments will further enhance research competitiveness while maximizing economic development outcomes.

For the purposes of this study, we define competitiveness in terms of the character and quantity of state support of R&D relative to other states and in terms of the effectiveness of the state's programs as measured by the outputs and outcomes arising from state initiatives.

Maine's R&D Capacity is Improving

Maine's strengthened institutional R&D position has been achieved through consistent and strategically focused investment by the state. This commitment has produced increased current R&D capacity and a sense of momentum necessary to achieve the longer-term goals described in the S&T Action Plan.

Early investments made in Maine's R&D capacity took some time to overcome the state's R&D "inertia". Once achieved, however, the pace of progress has accelerated. Most of the progress identified in the 2001-2005 Evaluations was achieved in the period from 2003 to 2005 when:

- institutional personnel in R&D increased 67%
- faculty involved in R&D grew 66%
- institutional R&D space grew 40%

If the state's R&D capacity could be viewed as a single research institution, the progress achieved in this decade would gain Maine recognition as an increasingly formidable R&D performer:

- Enrolls 3,248 undergraduates and 790 graduate students in science and engineering degree programs and awards 350 science and engineering degrees annually
- Employs 7,000 personnel in R&D, including 1,989 faculty and other Principal Investigators, as well as 4,988 support personnel
- Possesses 400,000 square feet of R&D space valued at \$442 million

MAINE R&D'S RELATIVE COMPETITIVE POSITION

Unfortunately, while signs of improvement are clear, the significance of Maine's gains in R&D is diminished when viewed in the context of the broader US economy. Those impressive programmatic achievements are often not translating into overall gains for Maine's relative position nationally and among peer states. This phenomenon is particularly demonstrated in three key measures of R&D competitiveness: 1. Science and Engineering (S&E) Education, 2. Total R&D Performance and 3. R&D Performance by Sector.

1. Science and Engineering (S&E) Education

Without a doubt, the R&D investments undertaken by Maine beginning in 1999-2000 are positively correlated with increases in degrees awarded and graduate enrollments in science and engineering. Since 1998, steady increases in the number of degrees awarded and graduate enrollments in science and engineering in Maine, have reversed several years of decline.

In 1994 S&E degrees awarded in Maine totaled 2,270. But by 1998 that number had fallen to 2,084. However, since that year degrees awarded have increased steadily, totaling 2,453 in 2004. Graduate enrollments in S&E programs have demonstrated a similar growth pattern over the same period.

Science & Engineering Degrees Awarded Maine 1994-2004		
Year	Total All Levels	Masters or Higher
1994	2,270	229
1995	2,225	231
1996	2,142	221
1997	2,255	244
1998	2,084	241
2000	2,282	288
2001	2,207	293
2002	2,329	280
2003	2,386	272
2004	2,453	332

S&E Degrees Lagging on Per Capita Basis

Despite these gains, however, Maine continues to lag well behind other states in New England and among EPSCoR states, even falling further as many peer states have experienced even greater increases.

On a per capita basis, Maine has made little or no progress in closing the gap with the US, New England, and EPSCoR states in S&E degrees awards. In 1994 S&E degrees awarded per 1,000 residents in Maine (1.789) lagged behind the US (1.978), New

England (2.424), and EPSCoR states (1.959). In 2004, despite increasing S&E degrees awarded per 1,000 residents in Maine (1.865), comparable gains in peer states resulted in Maine still trailing behind the US (2.195), New England (2.551), and even other EPSCoR states (1.963). These continuing gaps are even more pronounced among graduate student enrollments.

While these values have fluctuated over the past decade, Maine's relative position has essentially been unchanged. In 1995, Maine was

ranked 33rd in the US in the number of S&E degrees awarded per 1,000 population. By 2000 the state had fallen to 34th and to 35th by 2004.

US Rank	S&E Degrees Awarded Per 1,000 Pop.		
	1995	2000	2004
Maine	33rd	34th	35th

2. Total R&D Performance

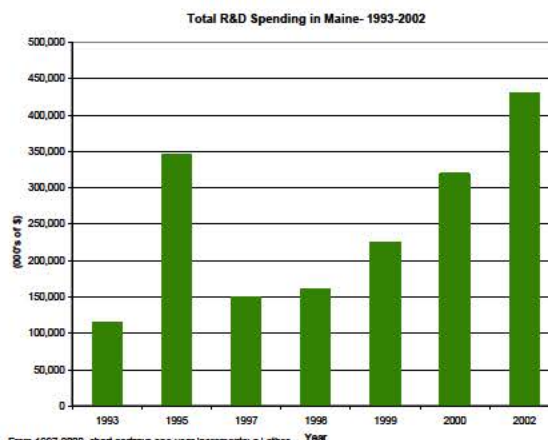
A core objective of Maine's R&D investments has been to stimulate increased R&D performance throughout all sectors of the state, with the expectation that increased R&D activity would enhance the state's economy directly and indirectly. R&D investments undertaken by Maine beginning in 1999-2000 are positively correlated with an acceleration in growth of R&D performance in the state.

Recent R&D Acceleration

In 1993, R&D performance in Maine totaled \$113 million. By 1998 that amount had grown at a modest rate to \$159 million. But beginning in 1999, Maine experienced rapid growth in R&D performance, increasing 169% to \$429 million by 2002.

This growth rate compared very favorably with national and peer state performance over the same period. Maine's 169% growth in total R&D performance far exceeded the national rate (13%), New England (23%) and EPSCoR states (49%).

Though the significance of the gains can be diminished by the fact of Maine's relatively very low R&D base level, the acceleration of growth can reasonably be viewed as the outcome of enhanced R&D capacity and competitiveness.



Gaining Ground, Not Yet Caught Up

The result has been considerable progress in Maine's national status. But despite these gains Maine continues to lag behind other states in New England and among EPSCoR states in measures of the R&D intensity of its economy.

R&D \$ per Worker

Total 2002 R&D spending per worker in Maine (\$626) remains well behind figures

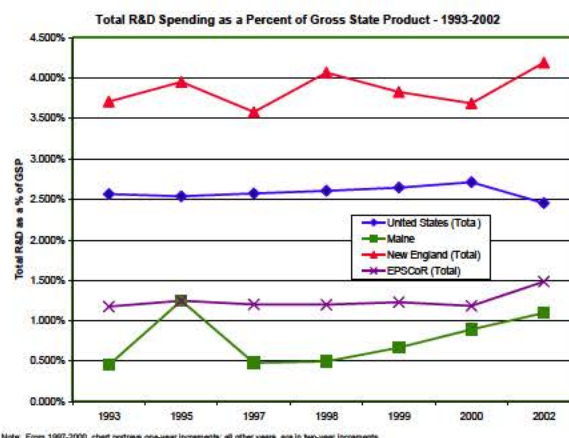
US Rank	R&D \$ per Worker		
	1993	1998	2002
Maine	47th	48th	42nd

for the US (\$1,765), New England (\$3,328) and even EPSCoR states (\$913). Still, between 1993 and 2002, Maine improved its nationally ranking for Total R&D per Worker from 47th to 42nd.

R&D \$ as Share of GSP

Similarly, measures of total R&D spending as a percent of Gross State Product (GSP) for Maine has shown strong growth since 1998 but the state still lags national and peer states.

Total 2002 R&D spending as a percentage of GSP in Maine (1.099%) remains well behind figures for the US (2.456%), New England (4.193%) and even EPSCoR states (1.486%). Nonetheless, between 1993 and 2002, Maine improved its nationally ranking for from 49th to 38th.



US Rank		R&D as Share of GSP		
Year	1993	1998	2002	
Maine	49th	46th	38th	

3. Maine's R&D Performance by Sector

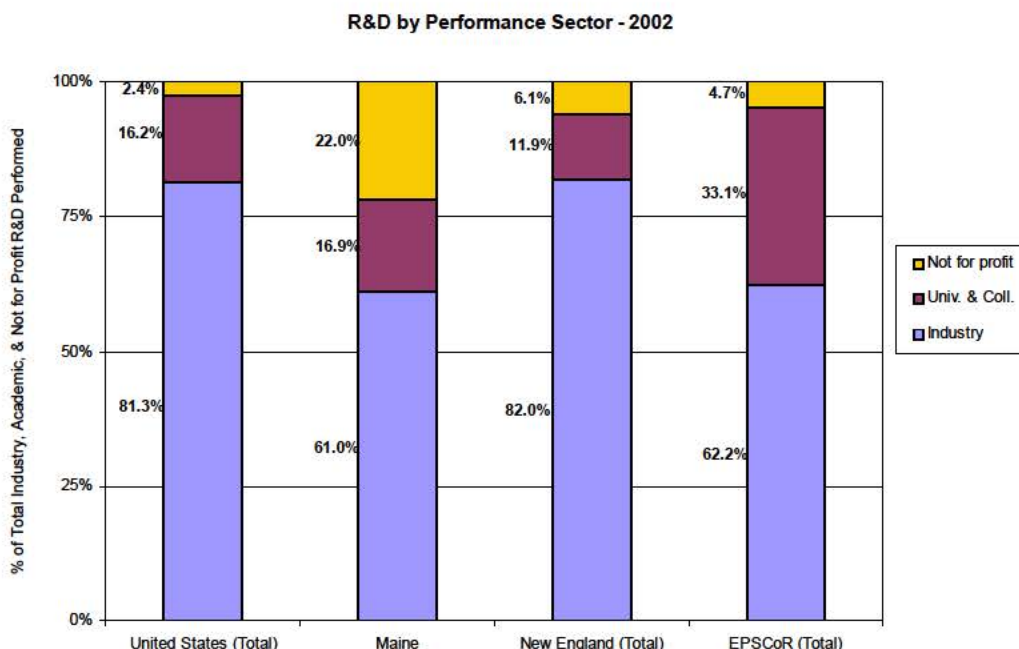
Growth in Maine's R&D performance suggests strengthening capacity and competitiveness but does not differentiate the basis of the state's R&D strengths or weaknesses. But analysis of the state's R&D by performance sector indicates that Maine's R&D is not monolithic and exhibits significant differences from its peer states.

As reported by the National Science Foundation, performers of R&D are defined as either Industry, Academic or Not for Profits. Industry performers include for-profit businesses. Academic performers include colleges, universities and equivalent educational institutions. Not for Profit performers include a diverse range of organizations structured for a variety of purposes but all legally incorporated as nonprofit corporations according to the US Internal Revenue Service.

Status	Maine Research Performing Institutions
Nonprofit	Bigelow Laboratory
Nonprofit	Downeast Institute for Applied Marine Research
Nonprofit	Foundation for Blood Research
Nonprofit	Gulf of Maine Research Institute
Nonprofit	Jackson Laboratory
Nonprofit	Maine Medical Center Research Institute
Nonprofit	Mount Desert Island Biological Laboratory
Nonprofit	Wells National Estuarine Research Reserve
Academic	Maine Maritime Academy
Academic	University of Maine, Machias
Academic	University of Maine, Orono
Academic	University of New England
Academic	University of Southern Maine

Maine's R&D Distribution Distinctive

The distribution of R&D performance across these categories in Maine contrasts sharply with that of the US, and to a lesser but still significant extent with its New England and peer EPSCoR states. Nationally, R&D is overwhelmingly an industrial activity, with



more than 81% of all 2002 US R&D being performed by Industry and most of the balance (16%) being performed by Academic institutions. Of the US total for 2002, only 2.4% was performed by Not for Profits. In Maine, on the other hand, the role of Industry R&D performers was much less (61% for Maine vs. 81% for the US) and Not for Profits (22% for Maine vs. 2.4% for the US) much greater.

Maine Industrial R&D - Recent Declines Reveal Eroding Competitiveness

Total annual R&D performance in Maine increased by nearly \$300 million between 1998 and 2003. But R&D performed by the state's companies, after growing rapidly between 1997 and 2000, has declined in more recent years.

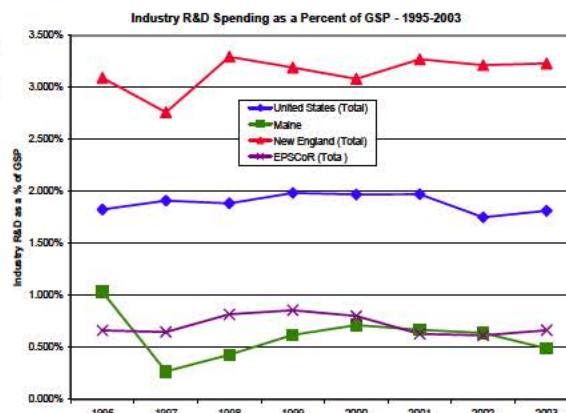
After peaking at over \$250 million in 2000, since that time, Industry R&D in Maine has actually declined, dropping 22% to \$200 million in 2003. During the same period Industry R&D grew 3% nationally, 14% in New England, while EPSCoR states experienced a much more modest decline of less than 6%.

Industry R&D	
Geographic Area	% Chg 00-03
United States (Total)	3%
Maine	-22%
New England (Total)	14%
EPSCoR (Total)	-6%

Such a decline is troubling for Maine given the already diminished role Industry R&D plays in the state compared to its peers. Maine's Industry 1995 R&D spending of \$448 per worker ranked the state a healthy 30th nationally. By 2003 R&D spending per worker had fallen to \$288, dropping Maine's US ranking down to 43rd nationally and placed it well beneath the \$428 per worker figure of other EPSCoR states.

Falling R&D spending suggest declining future competitiveness among Maine's industries. Moreover, because of its for profit nature, market-driven nature, Industry R&D can reasonably be expected to produce greater and more direct economic benefits to Maine than Academic and Not for Profit R&D.

It is especially troubling then that industrial R&D as a percentage of Maine's Gross State Product has also declined over the past decade. In 1995, Maine ranked a remarkable 29th nationally. But the state rapidly dropped to the position of 40th by 1999, a position it has yet to rebound from despite Maine's public investments in R&D.



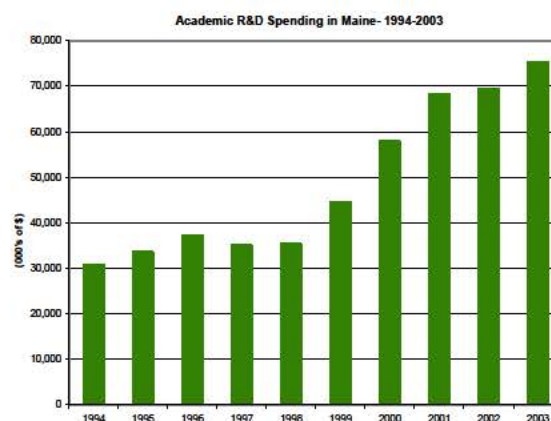
US Rank	Industry R&D as Share of GSP		
	1995	1999	2003
Maine	29th	40th	40th

Maine's Academic R&D – Large Gains from a Small Base

Academic R&D, which accounts for nearly 17% of the total R&D performed in Maine, has more than doubled over the past decade. From a base of \$31 million in 1994, Academic R&D in Maine increased to \$35 million in 1998 and to more than \$75 million in 2003.

Much of that growth has occurred since the initiation of strategically targeted state R&D support in 1999 and provides the clearest indication of the success of those efforts. The aggregate incremental increase (over the 1998 amount) in Academic R&D between 1999 and 2003 totaled \$138 million.

This rate of growth (144%) far exceeded the national rate (91%), as well as the rate (68%) for New England states over the same period. Even given the small base upon which the growth occurred; Maine still well exceeded the 101% growth rate of EPSCoR states.

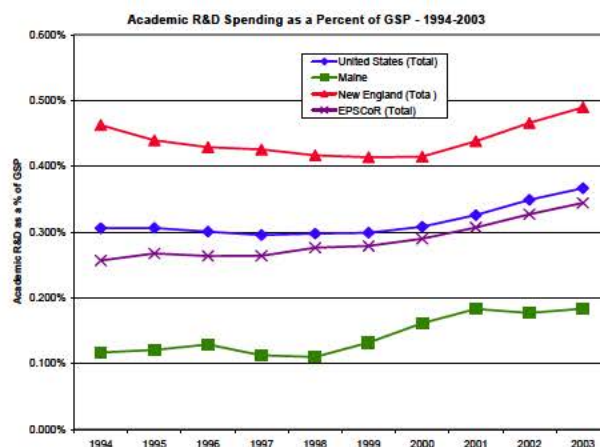


Academic R&D Growth	
Geographic Area	% Chg 94-03
United States (Total)	91%
Maine	144%
New England (Total)	68%
EPSCoR (Total)	101%

Academic R&D Position Stagnant

Unfortunately, even such impressive growth has failed to shift Maine's competitive position nationally. It must be emphasized that Maine's Academic R&D is still painfully thin compared to the state's US peers.

When stated in terms of percentage of the state's Gross State Product (GSP), Maine's 2003 Academic R&D amounted to less than 0.2% of Maine's GSP. This share placed the state 49th nationally in 2003, the same ranking it held in 1999.

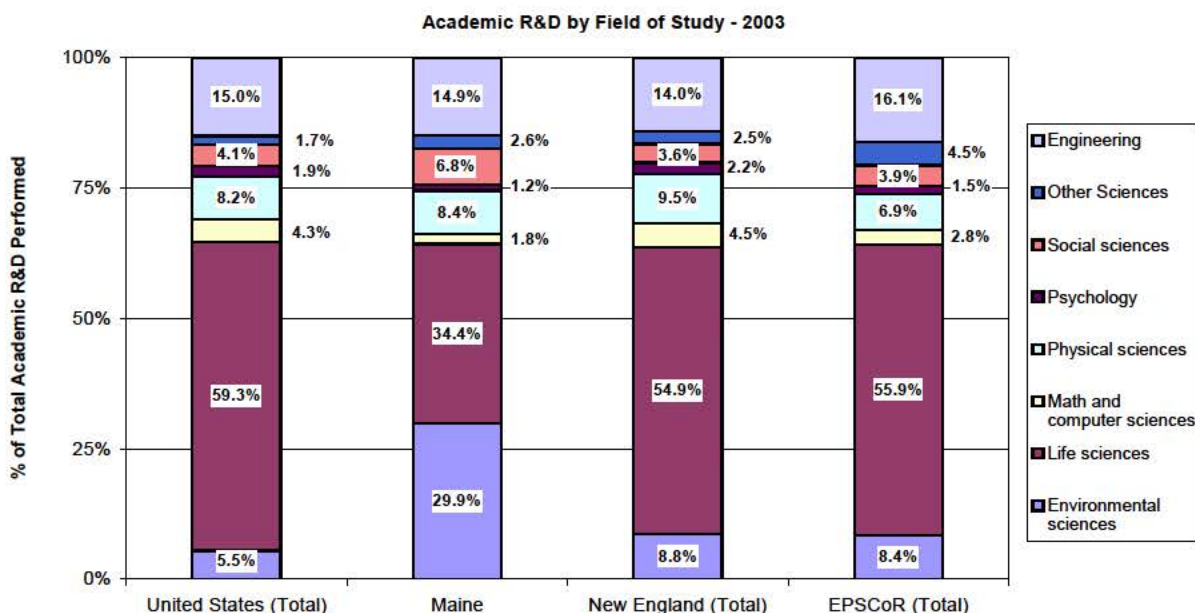


US Rank	Academic R&D as Share of GSP		
Year	1995	1999	2003
Maine	51st	49th	49th

Comparison Reveals Environmental Sciences Strength

Comparisons of Academic R&D by field of study demonstrate that the type of R&D performed by Maine's academic institutions differs markedly from the US and peer states. For 2003, the Life Sciences dominated the R&D fields of study nationally (59.3%), New England (54.9%) and EPSCoR states (55.9%). However, the Life Sciences accounted for only 34.4% of Maine's Academic R&D that year.

In contrast, nearly 30% of Maine's Academic R&D was performed in the Environmental Sciences, a much higher share than for the rest of US. Nationally, only 5.5% of Academic R&D was in the Environmental Sciences, and only 8.8% and 8.4% for New England and the EPSCoR states respectively. Of the \$75 million in Academic R&D performed in Maine during 2003, the 29.9% share in Environmental Sciences amounted to \$22.5 million.



Not for Profit R&D – Strong, Getting Stronger

Not for Profit R&D performers account for a disproportionately large share (22% in 2002) of Maine's R&D compared to US and peer state distributions.

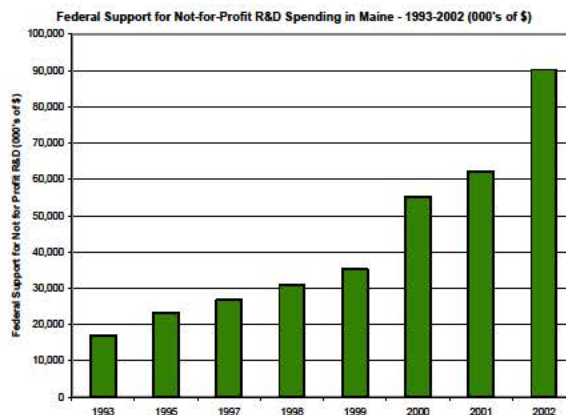
Over the past decade, federally funded R&D performed by Not for Profits in Maine grew rapidly from \$17 million in 1993 to \$31 million in 1998 to more than \$90 million in 2003. In the process, Not for Profits passed Academic institutions as Maine's primary institutional R&D performers.

This rate of growth (429%) far exceeded the national rate (92%), as well as the rate (142%) for New England states over the same period.

Not for Profits Very Competitive

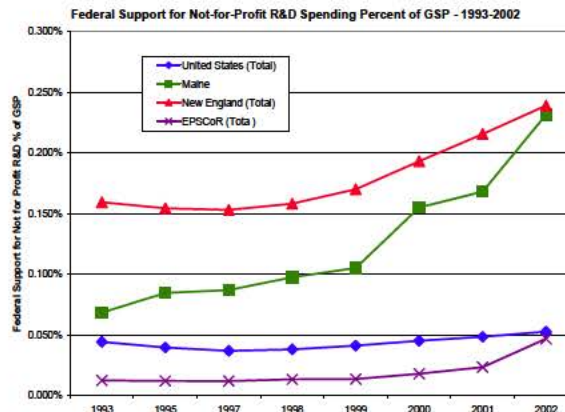
Maine's Not for Profit R&D performers have not only greatly increased their federal funding, they have also strengthened their competitive position nationally.

When stated in terms of percentage of the state's Gross State Product (GSP), Maine's 2003 Not for Profit R&D amounted to 0.23% of Maine's GSP. This share placed the state 3rd nationally in 2003, behind only Massachusetts and the District of Columbia.



Notes: From 1997 on, chart portrays one-year increments; prior to 1997 data is in two-year increments.

Not for Profit R&D Growth	
Geographic Area	% Chg 93-02
United States (Total)	92%
Maine	429%
New England (Total)	142%
EPSCoR (Total)	478%



Notes: From 1997 on, chart portrays one-year increments; prior to 1997 data is in two-year increments.

US Rank	Not for Profit R&D as Share of GSP		
Year	1995	1999	2003
Maine	6th	4th	3rd

QUESTION 2: WHAT IS THE IMPACT OF MAINE'S R&D INVESTMENT ON THE DEVELOPMENT OF ITS R&D INDUSTRY?

Answer: Maine's new R&D strength is paying off for the state financially and academically, but the ability to generate economic benefits depends on commitment to commercialization and is not an inevitable outcome of greater R&D activity.

Maine's R&D investments are intended to increase the capacity for and amount of research being done by the state's businesses and research institutions, and ultimately, the production of knowledge useful for economic development. While data from the 2005 evaluation suggest that challenges remain in certain areas, Maine's public and private sector R&D capacity has expanded and deepened during the past decade.

Maine's R&D institutional capacity has strengthened but the distinctly disaggregated nature of that capacity presents challenges to gaining recognition of progress and realizing the full benefit of those gains. As recognized in the S&T Action Plan, the state's institutional R&D capacity is segmented not only along the traditional university and industrial lines, but also by the often-dominant role played by essentially autonomous non-profit organizations.

Maine's R&D investments are intended to increase the capacity for and amount of research being done by the state's businesses and research institutions, and ultimately, the production of knowledge useful for economic development. Research inputs are used by research organizations to produce research outputs. Then, some of those research outputs improve economic development, nationally and in Maine.

There is a close relationship between the quality of higher education and the economic development consequences for the state. Colleges and universities, in general (regardless of quality), are like any other economic actor – they have payrolls, buy goods and services, and invest in plant and equipment. As such, they set in motion an economic multiplier that has been estimated to be larger in some cases than for private businesses.

Increasing Success in Competing for R&D Funds

Those changes, especially when combined with the improvements achieved since 1996, indicate a substantial and steady enhancement of Maine's R&D competitiveness is underway. Dramatic gains have been achieved in funds secured for institutional R&D. Since 2003, Maine's R&D institutions secured \$492 million in R&D funding from government and private sources at an increasing pace reflecting the State's enhanced competitive position

During 2005, Maine's institutions brought in \$171 million in total R&D awards, a 42% increase since 2003, already surpassing the \$150 million goal stated in the S&T Action Plan for 2007. That amount included \$141 million in new Federal research grants, contracts, subcontracts, an increase of 41% from 2003's total of \$100 million

This growth in competitively obtained R&D support is being achieved despite a general decline in receipt of funds on a less competitive basis. Such funds have declined

markedly. Nonetheless, congressionally “earmarked” R&D funds remain important sources of Maine’s R&D support with their number and value rising considerably.

Maine is thus achieving significant improvement in its researchers’ ability to compete successfully for federal R&D funds while also retaining its advantage in securing federally designated support. The state is developing a dual-pronged competitive position of both merit and political influence that serves its interest well in enhancing R&D funding. Both capabilities are highly valuable and worthy of continued emphasis.

R&D Funding Sources Broadening

Another encouraging trend is the broadening of sources of R&D support within Maine. Industrial support for R&D showed a comparable trend to higher value projects. A significant upward trend in the amount and average value of industry-sponsored research support is discernable despite reporting inconsistencies. For 2005, the number of industrial research grants, contracts and subcontracts awarded, 262, while a modest increase of increase of 7% from 2003’s total, represented a major recovery from a steep decline in 2004. This trend bears further investigation for more accurate validation.

Similarly, new foundation gifts and awards to Maine research organizations rose dramatically between 2003 and 2005. The number of new foundation grants and gifts received in 2005, 131, increased 220% from 2003’s total of 41, and increased in dollar value 55% to \$12.2 million. This is the continuation of a longer-term trend. In 1996, there were only 19 foundation awards totaling less than \$2 million to Maine research institutions. The growth in such funding marks this emergence of foundations as significant new resource that both broadens and deepens Maine’s R&D capacity.

Academic Publication Activity Reflects Growth

Equally important are the traditional currencies of academic progress, the publishing of research findings in varying media. As measures of academic strength, the results of the past three years appear to be lagging, but may be expected to rebound as on-going research reach fruition.

- Number of scientific peer-reviewed journal articles published, 854, decreased 22% from 2003’s total of 1089
- Number of scientific peer-reviewed book chapters published, 31, declined 85% from 2003’s total of 210
- Number of scientific peer-reviewed books published, 23, declined 51% from 2003’s total of 47
- Number of other papers published, 1206, increased 126% from 2003’s total of 533

Intellectual Property Outcomes Slowly Rising

The significance of intellectual property outcomes in our R&D evaluation is heightened given the ultimate economic development benefits desired from Maine’s R&D capacity development investments. Measures of intellectual property outputs of academic research are particularly significant where a specific objective of that research is to yield or contribute to the commercialization of technological innovations. While intellectual

property outcomes inevitably lag the performance of the underlying research, institutional research in Maine is beginning to demonstrate its economic potential.

The intellectual property being created as a result of investments in Maine's institutional R&D continues to show, at best, modest progress. As a result, even small increases and decreases yield exaggerated percentage shifts in overall performance. This volatility is also a reflection of the periodicity of Maine's "innovation pipeline" – as a generation of research matures it progresses through the pipeline from disclosure to license, creating apparent "bulges" of activity that can vary dramatically from year to year.

Over the past three years those trends have accelerated. Since 2003, Maine R&D institutions have applied for 43 patents and been awarded 20 new patents, spun-off 13 new entrepreneurial ventures. During that period 155 Licensing agreements have been executed and \$1.1 million in License income received. For 2005 alone institutional License income collectively exceeded \$458,000, increasing 64% from the 2003 total. Of that amount, not for profits institutions generated 76% or \$348,000, and academic institutions generated \$110,000.

Maine's R&D Network Emerging but Weak

We noted in the 2001 Initial Evaluation the distinctive character of Maine's R&D enterprise. Nationally, industry performs the largest portion of a state's total R&D, and universities and federal government laboratories usually perform the largest portion of publicly funded R&D. Maine's situation is quite different. In Maine, the role of the state's not-for-profit sector is much more prominent in the performance of R&D than is typically the case nationally.

Given the unavoidable scalar limits placed on Maine's R&D capacity, it is imperative that the state identifies and capitalizes on potential synergies between and among the state varying institutional R&D performers. Fortunately the 2005 R&D Evaluation found a positive trend developing in inter-institutional collaborations in Maine. During 2005:

- The number of peer-reviewed and/or competitive research proposal submitted by Maine institutions grew to 1,215, an increase of 22% from the total of those submissions for 2003. Of that number, 28% were joint proposals involving multiple institutions
- A total of 126 proposals were submitted jointly with other Maine institutions, an increase of 163% from 2003's total; another 147 proposals were submitted jointly with non-Maine institutions, an increase of 158% from 2003.

QUESTION 3: WHAT IS THE IMPACT OF MAINE'S R&D INVESTMENT ON THE LEVEL OF INNOVATION AND INNOVATION-BASED ECONOMIC DEVELOPMENT?

Answer: The ultimate objective of economic development is being realized but at a pace retarded by suboptimal market conditions.

While enhancement of the R&D capacity of Maine's universities and research institutions is yielding economic benefits within the state, the dominant mechanism for achieving economic growth is assumed to be through R&D commercialization. In recognition of this premise, a substantial portion of Maine's public investment in R&D has been for programs supporting private sector activities.

The 2005 evaluation drew upon an extensive survey of program recipient companies, the 2005 Innovation Index and program case studies to assess these efforts.

The company survey was especially useful, as the companies surveyed had been assisted by one or more of the nine designated agencies and programs during the period of the evaluation. The common thread in each case was that the company was engaged in both performing and commercializing R&D.

Maine's Company Assistance Programs Are Well Established and Effective

For 2005, the Private Company Survey received 346 responses from 592 companies surveyed. This response rate of 58% was the highest response achieved for any of the Maine's R&D Evaluation Private Company Surveys conducted to date. It also yielded the broadest participation by program clients. This year's survey therefore afforded the most representative sample of private companies served by Maine's R&D programs.

The great majority of responding companies (72%) had participated in a program offered through the Maine Technology Institute. However, it was also common that a responding firm had benefited from more than one of several company assistance programs.

The 2005 Evaluation found that the portion of Maine's R&D investment dedicated directly to company support is effective in increasing the level of innovation and innovation-based economic development in the state. Maine's R&D support programs for private companies have primarily focused on serving the state's emerging generation of innovative ventures. The companies surveyed in 2005 reflect that the programs are successfully reaching a broad population of that target company population across the state.

Types of Assistance

The support provided was in many forms, from patenting advice and assistance to research funding to growth capital. The most common type of assistance utilized by the respondents was prototyping (48%), market research, planning and development (43%), product design (40%) and business planning (40%).

Type of Assistance Received	% of Firms
Prototyping	48%
Market Research, Planning and Development	43%
Product Design	41%
Business Planning	40%
Concept	36%
Alpha Test	34%
Manufacturing Design	28%
Preparation of Intellectual Property Protection	27%
Beta Test	26%
Production for Market	23%
Seeking External Financing (Debt or Equity)	21%

Assistance Program Used

The companies surveyed were assisted by a broad array of service programs and other sources in Maine. Most firms were served by more than one agency, program or organization.

The most commonly used programs were the Maine Technology Institute (63%), non-Maine firms from the respondents' industry (51%), a Maine System university (46%), Maine firms from the respondents' industry (44%) or a trade association (41%).

Program Use by Surveyed Companies	% of Firms
Maine Technology Institute (MTI)	63%
Other firms in your industry, outside Maine	51%
Any campus of the University of Maine System (UMS)	46%
Other Maine firms in your industry	44%
Trade associations in Maine	41%
Trade associations outside Maine	41%
Maine Patent Program (MPP)	36%
Maine Small Business Development Centers (MSBDC)	34%
Educational or research institutions, outside Maine	33%
Maine Manufacturing Extension Partnership (MEP)	33%
Any other educational institution in Maine	23%
Any non-profit research institution in Maine	23%
Applied Technology Development Centers (ATDC)	20%
Market Development Center (MDC)	20%

Satisfaction with Program Assistance

The companies surveyed were asked to rate their level of satisfaction with the assistance received. Companies reported with respect to their research and development activities whether the assistance received ranged from 1="completely unimportant" to 5="critically important".

The assistance providers most highly rated – receiving either a 4 or 5 – were the Maine Technology Institute (67%),

Program Use Rated Important by Surveyed Companies	
Maine Technology Institute (MTI)	67%
Any campus of the University of Maine System (UMS)	50%
Maine Patent Program (MPP)	48%
Other firms in your industry, outside Maine	48%
Applied Technology Development Centers (ATDC)	41%
Other Maine firms in your industry	41%
Any non-profit research institution in Maine	38%
Educational or research institutions, outside Maine	36%
Trade associations outside Maine	35%
Any other educational institution in Maine	34%
Maine Small Business Development Centers (MSBDC)	32%
Maine Manufacturing Extension Partnership (MEP)	31%
Trade associations in Maine	25%
Market Development Center (MDC)	20%

campuses of the University of Maine system (50%), and the Maine Patent Program (48%).

Economic Impact of Surveyed Firms

The average firm responding in 2005-06 employed 11 people with a total payroll of \$525,000 and an average annual wage of \$49,605. While average employment was down from prior years, the average wage was significantly higher than the \$30,393 reported in the 2004 survey.

Extrapolating average values of the respondent firms to the survey population estimates that the 592 firms surveyed in 2005-06 employed an estimated 6,266 people. At the average wage of \$49,605, these firms accounted for a total payroll exceeding \$310 million.

FINDINGS

Maine Economy Weak in Some Areas Vital to R&D Commercialization Success

Inevitably the success of Maine's efforts to capitalize upon the commercial potential of its R&D will require a supportive economy that provides the requisite private sector resources. Research commercialization always entails many risks and relying on entrepreneurial ventures as the primary vehicles for R&D commercialization only exacerbates those risks. The 2005 R&D evaluation, drawing on a combination of survey results and the indicator data compiled in the 2005 Innovation Index, certainly identified several key elements of the Maine "innovation economy" present challenges in that regard.

Emerging Technology Industry Still Lacks Critical Mass

In total and industry R&D performed as a percent of gross state product, Maine spiked above 1 percent in the mid-1990s, then dipped. The figure is now back near 1 percent, slightly below EPSCoR and cohort states. Performance is particularly problematic in the university and college sector, where Maine is the lowest of all groups. Its college-university R&D is half the rate of New England's. There is growth in this indicator, but not faster than benchmark regions. Most promising, however, is a large concentration of R&D in environmental and social sciences R&D, compared to other regions.

Maine also has the smallest percentage of its labor force in high tech businesses and in science and technology occupations, compared to the other areas. Maine also is graduating the smallest percentage of S&T degree recipients into its labor force. Perhaps because of the small base in high tech, Maine's rate of new high tech businesses is higher than the other groups.

Historic Scarcity of Growth Capital Remains Obstacle

An essential element of an innovation-based economy is the ready availability of debt and equity capital to finance new and expanding enterprises. In that regard Maine's young R&D companies face a very challenging environment. It is little solace that Maine's situation is similar to that experienced by young growing firms throughout most of the United States during 2005. All areas had shown a spike in venture capital availability in the late 1990s to early 2000s. All areas have returned to their mid-1990s levels. That effectively means that Maine and the other EPSCoR states have very little venture capital flow today.

Results of the 2005 private company survey suggest a meager capital market for the growth financing requirements of Maine's innovative young firms. Insufficiency of growth financing in Maine's private capital markets constrains the ultimate economic development intent of the state's investments in R&D. Unfortunately, the private company survey findings of the 2005 Evaluation indicate that access to growth capital is a problem that is getting worse and not better.

The 2005 Evaluation found that a meager growth capital market for Maine's innovative young firms continues to limit the economic potential of the state's investments in R&D. Only 10% of firms surveyed in 2005 received new equity capital, a decrease from the

12% reported in 2004 and the 17% reported in 2003. The average \$325,000 of equity capital invested per firm in 2005 was a big decrease from the \$496,000 average in 2004 and the \$2 million average in 2003. The steepest decline was in equity financing received from venture capital funds, down to an average of \$102,000 in 2005 from the \$1.1 million average in 2003.

SBIR Financing a Bright Spot

An exception to the downward trends in debt and equity financing reported in 2005 has been Maine's steady improvement in the number of federal Small Business Innovation Research (SBIR) awards. Maine companies received 13 SBIR awards worth a total of \$3.3 million. That amount had increased to 29 SBIR awards worth \$9.6 million by 2004. Collectively, Maine firms received nearly \$20 million in SBIR funding between 2001 and 2004.

Although the number of SBIR awards is not significant in the larger context of the Maine economy, they may reflect improvements in support for the performance of R&D by the state's innovative young ventures. SBIRs are extraordinarily useful as sources of R&D financing; however, they are no substitute for the private sector debt and equity financing necessary for the commercialization of R&D.

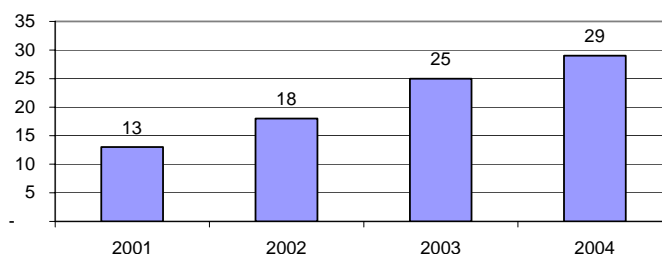
The Maine S&T Plan has appropriately made addressing the capital market constraints a major objective of its strategy. Among its 2007 benchmarks is the development of public and private funding sources that support early stage research-intensive business development.

Additional Capacity is Warranted to Expand Assistance

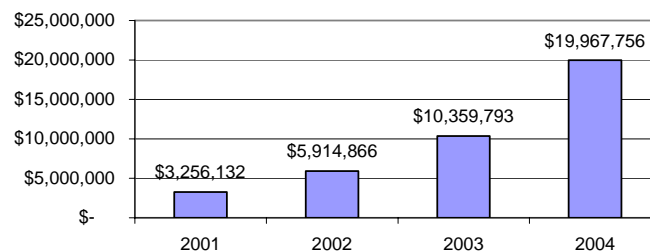
Collectively the programs supported by Maine's public R&D funding continue to reach the target audience – smaller, high tech companies. 430 companies that had participated in one or more of Maine's R&D programs were surveyed between 2003 and 2005. These companies were found to be predominantly from the category of "youthful" smaller firms targeted. Moreover, these firms were from all Maine counties, demonstrating that programs were succeeding in serving companies throughout Maine.

The current level of company participation effectively utilizes much if not all of the existing capacity of Maine's R&D commercialization programs. However, there are

Maine SBIR Awards
Number of Awards



Maine SBIR Awards
Cumulative\$ Amount



significant populations of existing Maine companies that experience in other states suggests would benefit from comparable assistance.

Moreover, these firms, because of they are more established than the earlier-stage firms that have been the primary targets of Maine's programs to date, may provide a higher likelihood of economic development outcomes. Examples of such firms can be identified in two large populations of businesses – technology firms and Entrepreneurial Growth companies – very few of which are currently utilizing Maine R&D programs.

Technology Companies

The National Science Foundation has designated a set of industrial classification as “Technology Industries” based on measures of technological intensity such as number of engineers employed and amount of R&D performed. A preliminary survey of Maine companies performed in the 2005 Evaluation identified 619 “Technology Companies” located in Maine.

Many of these companies, while more established firms than the earlier stage ventures currently targeted, are nonetheless likely, though as yet unserved, customers of the types of R&D program offerings provided in Maine.

Entrepreneurial Growth Companies

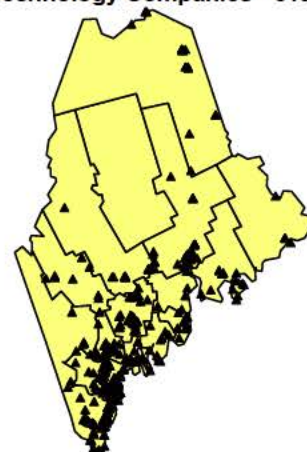
A second population of companies that could benefit from an expansion of existing R&D program capacity is even larger and more diverse. These “Entrepreneurial Growth Companies” (EGCs) are firms that while still relatively young – between 5 and 15 years in age – have achieved substantial initial commercial success.

Often termed “gazelles”, research has shown such firms to have a disproportionately large role in US job creation. While usually not classified as “technology companies” based on their products or services, many EGCs actively perform R&D, or adapt and utilize R&D outcomes, to increase productivity and add value to their products and services.

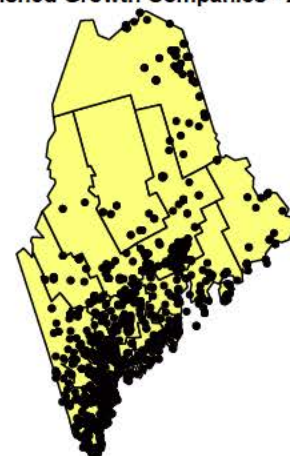
2003-05 R&D Program Companies - 430



Technology Companies - 619



Established Growth Companies - 2,092



As incorporators of R&D in their business competitiveness strategies, EGCs are particularly potent agents for regional economic development efforts because their broad industry and geographic distributions. This pattern appears to be consistent in Maine's economy. A preliminary survey of Maine companies performed in the 2005 Evaluation identified 2,092 such "Entrepreneurial Growth Companies" located throughout Maine.

CHAPTER 3: MAINE'S R&D CHALLENGES NOW

Maine's hard won recent gains in R&D competitiveness are the result of consistent support of competently executed strategies and programs. While successfully established, these efforts must be maintained and built upon to achieve the greater ambitions of the S&T Action Plan. For despite making progress on programmatic goals, however, Maine's R&D investment effort is not yet (and may not) significantly enhance the state's competitive position among its peer states.

Moreover, the successful economic development outcomes of Maine's currently directed R&D investments are constrained by the limitations of the state's private sector. There are different strategies for achieving Maine's goal of an innovation-based economy. Maine's current efforts, focused as they are on university spin-offs and entrepreneurial development, are hampered by prevailing weaknesses in the broader Maine economy. This result is attributable partly to inherent limitations and partly to a need to realign R&D efforts to Maine's economic strengths.

Build on R&D Capacity to Achieve Economic Goals

While the performance of institutional R&D provides significant direct economic outcomes through the employment of research staff, equipment purchases, and support spending, the intent of Maine's public investments in R&D has not been to enhance R&D capacity for its own sake. Rather, those investments have been justified as public purposes because of their intended effect in stimulating job creation and economic growth external to the R&D performance setting.

Too often the desired economic benefit of expanded R&D capacity is left to ill-defined osmotic processes where it is assumed that a large enough concentration of R&D in the academic or not for profit arenas will inevitably "flow" into the surrounding economy. Unfortunately, the experience in other states and regions has shown that reliance on such spontaneous processes can be like waiting for a glacier to fill a bathtub. Instead, much more directed efforts have been found necessary to achieve the desired economic development objectives, effectively creating a "pull" on R&D capacity rather than awaiting a "flow".

Maine's R&D capacity has been increased at considerable public expense and for the specific public purpose of stimulating economic development. The strategic focus of these efforts much be sharpened to emphasize those R&D investments that have shown to produce the greatest economic development return to the most Mainers.

Over the past six fiscal years, FY1999/2000 to FY2004/2005, Maine has invested more than \$200 million in public spending for R&D. Of that amount, \$156 million was

committed to various efforts in R&D capacity building at academic and not for profit institutions. As the 2005 Evaluation found, that investment has considerably strengthened Maine institutions' ability to successfully compete for additional R&D funding from federal government and other sources.

Leverage Maine's R&D Capacity Through Inter-Institutional Collaborations

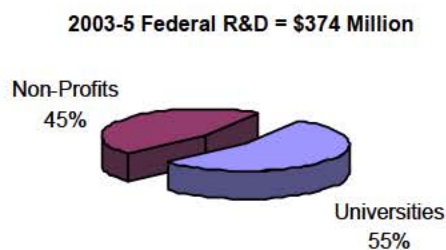
The 2005 Evaluation found that Maine's R&D institutional capacity has strengthened but that that capacity is divided between academic and not for profit performers with very different levels of competitiveness and engagement in the Maine economy.

As was described in the 2005 Evaluation, Maine's Not for Profit institutions have a much larger role in R&D performance in Maine than in nearly any other state.

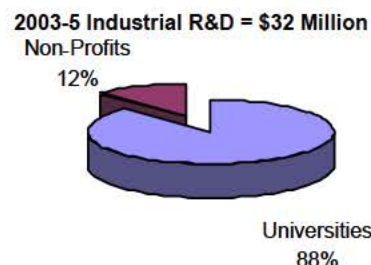
Measured on an R&D performance as share of Gross State Product, Maine's Not for Profits ranked 3rd in the US in 2003, behind only the District of Columbia and Massachusetts. On the same basis, Maine's universities' R&D performance placed the state 49th nationally in 2003, the same ranking it held in 1999. These ranking do not describe quality of R&D performance but their relative quantity compared to national peers.

US Rank	R&D as Share of GSP		
Year	1995	1999	2003
Not for Profits	6th	4th	3rd
Academic	51st	49th	49th

Both sectors have had considerable success in recent years in securing R&D funding from state, federal and other sources. Of the \$374 million in federal funding secured in 2003-2005, Maine's universities received 55% and its Non-profit institutions 45%.



In contrast, of the \$32 million in industry-sponsored R&D received in the same period, only 12% was received by non-profits, with the great majority (88%) going to the state's universities. Such disparity suggests a higher level of economic engagement by Maine universities than its non-profit R&D institutions.



To realize greater benefit from these gains, the state should identify and capitalize on synergies between and among the state varying institutional R&D performers. It should also build on successful Maine examples of public/private collaborations for the economic deployment of R&D. Fortunately the 2005 R&D Evaluation found positive trends developing in inter-institutional collaborations in Maine:

- 28% of competitive research proposals submitted by Maine institutions were joint proposals involving multiple institutions within the state, an increase of 163% from 2003's total
- proposals submitted jointly with non-Maine institutions increased 158% over the same period

This is an important organic trend, recognized and built upon in the Maine S&T Action Plan. That plan establishes benchmarks for 2007 that create explicit incentives and/or requirements that all institutions requesting state funding will demonstrate collaborative multi-institutional efforts.

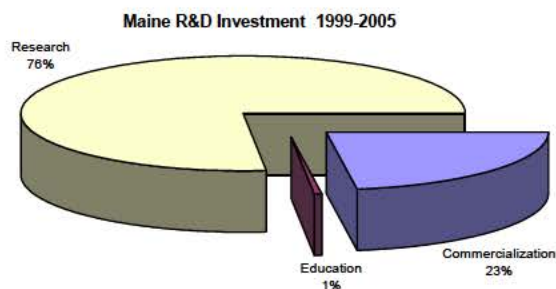
Increase Emphasis on Commercialization

Over the past six fiscal years, the State of Maine has devoted \$204 million to funding 17 R&D programs targeting a spectrum of activities ranging from education to research to commercialization.

Maine R&D Funding – FY1999-2000 to FY2004-2005			
R&D Stage	Program	\$Amount	%
Commercialization	Maine Technology Institute	\$31,135,508	15.3%
Commercialization	Applied Technology Development Center System	\$8,928,230	4.4%
Commercialization	Centers for Innovation	\$1,584,013	0.8%
Commercialization	Maine Patent Program	\$1,643,120	0.8%
Commercialization	Small Enterprise Growth Fund	\$3,000,000	1.5%
Education	ME Research for Teachers & Students (MERITS)	\$280,000	0.1%
Education	ScienceWorks	\$441,898	0.2%
Education	Governor's Marine Studies Fellowship	\$100,000	0.0%
Education	Schoodic Education & Research Center	\$400,000	0.2%
Research	University of Maine System	\$99,749,053	49.0%
Research	Maine Marine Research Fund	\$2,000,000	1.0%
Research	Maine Biomedical Research Fund	\$44,516,000	21.8%
Research	Maine Science and Technology Foundation	\$5,901,563	2.9%
Research	ME Exp. Prog. To Stimulate Comp. Res. (EPSCoR)	\$615,000	0.3%
Research	Partnership with NASA	\$450,000	0.2%
Research	Gulf of Maine Research Laboratory	\$3,000,000	1.5%
Research	Downeast Institute for Applied Marine Research	\$30,000	0.1%
TOTAL R&D-APPROPRIATIONS & BONDS		\$203,774,385	100%

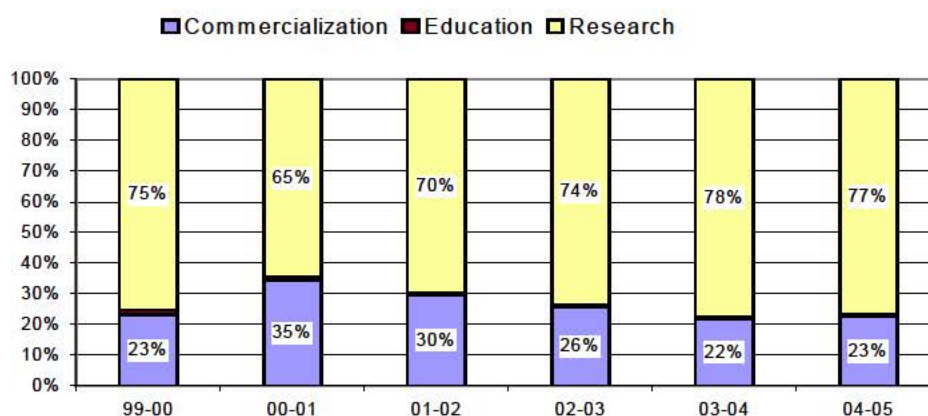
Cumulative R&D Funding	99-00	00-01	01-02	02-03	03-04	04-05
Commercialization	\$3,583,000	\$19,166,000	\$25,264,844	\$31,076,108	\$39,730,523	\$46,290,871
Education	\$225,000	\$450,000	\$525,000	\$998,775	\$1,152,550	\$1,221,898
Research	\$11,595,632	\$35,829,791	\$59,525,256	\$89,016,616	\$140,981,616	\$156,261,616
	\$15,403,632	\$55,445,791	\$85,315,100	\$121,091,499	\$181,864,689	\$203,774,385

Most of that amount (76%) has been allocated to building Maine's research capacity at its academic and not for profit institutions. Except for a small amount devoted to education-related programs, the balance of the funding (23%) has supported commercialization support programs, such as those of the Maine Technology Institute, the Maine Patent Program, the Small Enterprise Growth Fund, the Centers for Innovation and the Advanced Technology Development Centers (ATDCs).



The earlier emphasis on research support was driven by recognition of Maine's limited R&D capacity as a prerequisite for innovation-based economic development. Commercial applications of R&D were reasonably assumed to be more "downstream" or later process priorities. Funding for Maine's commercialization efforts therefore grew more slowly than that for research programs. **As a result, the share of Maine's public investment in R&D that directly supports economic growth has declined from a**

Maine R&D Annual Investment: 1999-2005



high of 35% in 2000/2001 to only 23% in 2004/2005.

At this later stage on Maine's R&D investment effort it is appropriate to increase allocations for the commercialization related programs in that effort. The 2005 Evaluation found that while the efficacy of Maine's R&D commercialization programs are well demonstrated, their sufficiency is in question.

Expand/Leverage Company Assistance Programs to Increase Economic Benefits

The proven capabilities of Maine's R&D company assistance programs can yield increased economic development benefits if leveraged to better serve the State's innovative entrepreneurs and existing industry:

- While many of Maine's entrepreneurs already benefit from multiple programs, their utilization of this assistance could be optimized through a cogently packaged program of targeted delivery
- Maine is also home to many innovative existing firms not yet engaged in the State's assistance system. A proactive outreach program targeting existing small and medium industries would leverage the more specialized and high valued aspects of Maine's R&D assistance among firms with higher probabilities of success

Maine is home to pioneering examples of synergistic co-locations of university and private sector research activities, such as the Aquaculture Center "research campus" in Franklin. The lessons drawn from those experiences should be codified and deployed strategically throughout the State's Advanced Technology Development Centers (ATDCs).

Increase Private R&D Commercialization by Addressing Growth Capital Scarcity

The economic growth benefits of Maine's innovation-based economy would be increased by better access to growth capital. The 2005 Evaluation found that a meager growth capital market for Maine's innovative young firms continues to limit the economic potential of the state's investments in R&D.

- only 10% of firms surveyed in 2005 received new equity capital, a decrease from the 12% reported in 2004 and the 17% reported in 2003
- the average \$325,000 of equity capital invested per firm in 2005 was a big decrease from the \$496,000 average in 2004 and the \$2 million average in 2003
- the steepest decline was in equity financing received from venture capital funds, down to an average of \$102,000 in 2005 from the \$1.1 million average in 2003

The Maine S&T Plan has appropriately made addressing the capital market constraints a major objective of its strategy. Among its 2007 benchmarks is the development of public and private funding sources that support early stage research-intensive business development. However, the importance of increasing professionally managed venture capital needs to be mediated by recognition of such capital's extremely limited role in the Maine economy. While more would be better, it would not necessarily be significant. There aren't enough winning VC lottery tickets to significantly benefit Maine's economy.

Instead, Maine needs to emphasize other forms of formal and informal debt and equity financing required by many more growth companies. Activities such as expanding support for the establishment of informal capital sources, "angel" investor networks and groups, and providing directed financial application assistance and loan packaging to established growth companies, should be incorporated within existing programs.

Track Maine's "Gazelles" to Guide Future R&D Commercialization Efforts

Much of the eventual economic development anticipated from Maine's R&D investments is predicated on the success of a generation of new innovation-based businesses emerging and growing through the state. However, it must be acknowledged that on many criteria Maine has been judged lacking as an environment for entrepreneurial success.

Fortunately, Maine is home to another even larger and more diverse population of companies that could benefit from an expansion of Maine's R&D programs. These "Entrepreneurial Growth Companies" (EGCs) are firms that while still relatively young – between 5 and 15 years in age – have achieved substantial initial commercial success. Often termed "gazelles", research has shown such firms to have a disproportionately large role in US job creation.

The 2005 Evaluation identified a pool of more than 2,000 Entrepreneurial Growth Companies from which Maine's high growth "gazelle" firms are likely to emanate. While usually not classified as "technology companies" based on their products or services, many EGCs actively perform R&D, or adapt and utilize R&D outcomes, to increase productivity and add value to their products and services. As incorporators of R&D in their business competitiveness strategies, EGCs are particularly potent agents for regional economic development efforts because of their broad industry and geographic distributions.

It is critical that in expanding the commercialization components of the Maine R&D effort that such initiative accurately and sufficiently target critical needs. Toward that end, Maine should study its “gazelles” to gather:

- current statistical information on the population of entrepreneurial growth companies in Maine to quantify their role, and significance thereof, to the economic growth of the state;
- characterizations of the identified population of firms (geographic distribution, industrial sectors, revenue and employment histories) to provide meaningful inputs for R&D and economic development strategy formulation; and
- identification of the resources (technology, capital, markets) which either enabled or facilitated the development of a representative cross section (industrial and geographic) of entrepreneurial growth companies.

While there are many lessons to be drawn upon from other states in this regard, the best answers on how to improve Maine's entrepreneurial economy will come from posing the right questions to the right people already building businesses in the state.

Maine's R&D Success Requires Strategic Evolution

Maine's R&D investment program was undertaken with conviction as to its end and commitment as to its means. But the state's leaders also wisely built in an annual revaluation process to provide information on which to judge performance of the R&D investment programs and strategies.

The Office of Innovation at the Maine Department of Economic and Community Development was established to gather and assess the results of the annual assessments and provide a forum for the articulation and discussion of emerging best practices for innovation-based economic development in the state. Such a role has been essential given the diversity among the 17 different R&D programs and institutions supported by a cumulative public investment of \$203 million over the past 6 fiscal years.

The “Science and Technology Action Plan for Maine” incorporates many of the lessons learned in this effort over the past six years. More importantly, it provides the strategic roadmap for accomplishing the larger mission for which Maine has undertaken its R&D investment program. Success in this regard requires not only guidance but also enforcement of strategic discipline in adherence to the goals and priorities described in the Plan.

Establish Maine R&D Strategic Oversight Authority

Not all efforts undertaken in the Maine's R&D strategy have succeeded, nor should they have. In some instances programs with tremendous merit have migrated to non-strategic roles that, while perhaps worthy of public and private support, should no longer be funded under the state's R&D strategy. In other cases the autonomous nature of many of the programs encompassed by the Action Plan will make adherence to strategy problematic.

Most of the recommendation of this evaluation will require hard choices often contrary to established interests:

- Require commercialization-directed collaboration between not for profit and academic research institutions as prerequisite for R&D funding
- Increase emphasis and funding share for direct R&D commercialization programs
- Expand assistance beyond early-stage firms to include existing companies

Currently, Maine lacks oversight authority sufficient to effect such change in programmatic implementation and budgetary allocations.

An entity with statutory and budgetary authority needs to be established to provide strategic oversight to Maine's public investments in research and development. States that have undertaken substantial investments in R&D have typically also provided a means of governing, guiding or advising their states' leaders in their funding decisions. Commonly such oversight is provided through an executive or legislative level board (North Carolina's Board of Science and Technology, created in 1962, was the first such board) to advise the Governor and/or the Legislature. Other states have adopted the model of a quasi-public agency or not for profit corporation to provide strategic program oversight.

Such an authority does not yet exist and will not be universally welcomed, especially as many R&D funding recipients have well established constituencies positioned to influence funding decision irrespective of their strategic relevance. The necessity for such a role is nonetheless real if Maine is to realize the significant economic potential of its R&D investments.

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