Evaluation of Maine's Public Investments in Research & Development

This report prepared for Maine Science and Technology Foundation as part of the initial evaluation of Maine's Public Investments in Research and Development

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Executive Summary

Since 1995, Maine has increased its ongoing science and technology (S&T) and research and development (R&D) investments substantially. The Maine legislature has boosted funding tenfold in the past six years, from $2.5 million to over $20 million annually. Existing organizations such as the University of Maine System, as well as new programs such as the Maine Technology Institute, the Maine Biomedical Research Fund and the Applied Technology Development Centers have benefited from these increased funds. The investments were undertaken to strengthen Maine's economy, improve the competitiveness of its businesses, and enhance the quality of life of its citizens.

Maine's new investments in R&D represent a large share of the state's discretionary budget. Both the Governor's Office and state legislators, as well as members of Maine's science and technology community, want assurance that the R&D programs that the state is currently funding make sense given Maine's existing industry and S&T base and potential for developing new S&T strengths. In keeping with both national and state-level precepts on governmental performance, they also want evidence of program accountability, specifically substantial positive relationships among state funds, program outputs, and state-level objectives.

This Maine Science and Technology Foundation (MSTF)-sponsored initiative is intended to develop an analytical framework and empirical database about the R&D programs funded by the state of Maine. Central to this initiative is developing a systematic way of measuring the inputs, outputs, and outcomes of those programs that respond to the positive challenges identified above. The approach to evaluation undertaken by MSTF is both programmatically responsive and methodologically innovative in this regard. It views evaluation as a broad-based process that entails the ongoing generation, dissemination, analysis, and interpretation of data that can be used by state officials and program managers to calibrate expectations, measure performance, and revise programs and plans.

The legislature and MSTF have divided the evaluation into two sections. This report is the initial evaluation of Maine's public investments in research and development. It also contains recommendations for assembling the primary data for a five-year comprehensive evaluation to be completed by July 1, 2006 and every five years thereafter.

The legislature and MSTF have posed three specific questions to be answered in this report:

1. *How competitive is Maine's sponsored R&D and has it improved over time?*
2. *What is the impact of Maine's R&D investment on the development of Maine's R&D industry? and*
3. *What is the impact of Maine's R&D investment on the level of innovation and innovation-based economic development?*

Full answers to these questions require a longer period of time than what has elapsed since the enactment and implementation of Maine's new R&D programmatic initiatives. State officials indeed have voiced a nuanced understanding that a period of gestation is necessary before the impacts of the state's heightened efforts in R&D can be discerned or measured. Still, they expect evidence that the programs are heading in the right direction.

Our answers to MSTF's three questions have two objectives. One is to contribute to MSTF's ongoing work to develop and refine an analytical framework, set of metrics, and data collection procedures. The second is to provide the Governor's Office and the legislature an early indication of progress of recently enacted and enhanced state R&D programs. The answers provide analysis, reports of events, and harbingers of trends. They, however, do not constitute an evaluation of any single program or an impact assessment of Maine's overall R&D initiatives.

The three questions posed by Maine's legislature relate to the impacts of the targeted R&D programs that are directed at promoting economic development. The questions highlight the dual character of R&D's contribution to a state's economy. First, it can be a thriving, high-growth industry itself, creating high-wage employment opportunities for those engaged in R&D-related activities, funded and/or performed by the private, public and not-for-profit sectors. Second, it creates the opportunity for economic development, with the new knowledge created through investment in research and development, serving as the key "asset" that undergirds the growth of new industries, new companies, and new jobs.

Methodology and Organization of Report

Answers to the three questions posed by MSTF are based on review of an extensive set of performance indicators, augmented by interviews with representatives from the stakeholder organizations that operate the R&D programs, Maine's universities and not-for-profit research laboratories, and firms that receive funds from Maine's R&D programs. The time and scale of the study limited the number of interviews, and thus portions of answers that draw on interviews and case studies are based on illustrative, rather than necessarily representative, information.

The report is divided into three parts. Part I presents the findings, limitations and methodology for the initial evaluation. It also describes the implications of its findings for future data collection.

Part II presents recommendations for MSTF's future management of systematic evaluations of Maine's R&D programs. In particular, it offers a blueprint for the process and content of future data collection activities. The blueprint emphasizes the importance of MSTF, working with all the stakeholders in the state, developing and implementing a single data collection system capable of informing a comprehensive evaluation of state R&D investments as well as providing for the monitoring of single programs.

Part III is a Technical Appendix that contains the data and analyses that support the answers presented in Parts I and II. These include the program theory and impact analysis that led to the choice of indicators, the analysis of indicators for Maine and relevant benchmark states, and five case studies.

Answers to the Three Questions

1. How competitive is Maine's sponsored R&D and has it improved over time?

Performance metrics and interviews indicate that some modest progress has been made in the competitiveness of Maine's R&D-related activities. More subtle, but nevertheless important, progress has also been made in creating a culture within the state and a perception on the part of the private and public sectors outside of Maine, that the state understands and supports the activities of R&D-intensive firms.

Maine has put into place a portfolio of R&D programs spanning the research-development-commercialization continuum that approximate those in most other states. These state investments range from support of the basic physical and human capital infrastructure needed to make researchers competitive for large-scale federal agency research grants, to support of the R&D initiatives by private sector firms that enable them to develop new products and processes, to financing mechanisms that provide added capital to conduct in-house R&D and attract external capital to expand output and employment. The limited review permitted of these programs during the short period of this study indicates they are operating consistently with the best practices among the states, albeit not without some reported teething problems.

Maine's R&D-performing institutions have established a bridgehead in selected R&D areas, particularly related to biomedical research, and have begun to realize some modest economic returns from these investments. Academic R&D has improved somewhat as a result of the state's R&D investments, as evidenced by greater activity and success in securing competitively awarded NSF and other earmarked funds. Maine's gains in absolute terms approximate national increases in federal funding of academic R&D, however, so its relative ranking has not changed. Also, there is little evidence yet of effective cross-program cooperation that could further increase the state's return.

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

Maine's not-for-profit biomedical research laboratories have developed distinctive, nationally competitive niches. As a result, they have experienced noticeable increases in federal government awards in recent years. They have also benefited from Maine's designation as an EPSCoR (Experimental Program to Stimulate Competitive

Research) state, receiving set-aside funds. Jackson Laboratory and the Maine Medical Center Research Institute (MMCRI) currently conduct research and have specialized facilities in areas that are likely to continue to enjoy increases in federal agency support. The laboratories differ, however, in the extent to which their research activities are likely to generate spillovers, including backward linkages to Maine-based suppliers, in the extent to which their research will yield direct quality of life benefits to Maine residents, and the probability that they will spawn complementary, locally-based economic activity.

The University of Maine has focused its efforts in a few disciplines, mainly using the new state funds for capital investments. These new research facilities have only recently come on line, and it is too early to project their impact on the university's long-term research competitiveness. Maine's universities, particularly the University of Maine, have recently benefited from successful earmarking initiatives by its two U.S. Senators, receiving an estimated $17 million in the FY2002 budget, and thus likely will show marked increases in annual R&D totals in the near term. The relationship between this increase in earmarking and the universities' long-term competitiveness is unknown.

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

Preliminary evidence on the level of innovation and development of an innovation-based economy in Maine is mixed. The level of patent activity has remained static against a backdrop of gains in the comparison states. SBIR awards, on the other hand, have almost tripled between 1997 and 2000, although the absolute number, fourteen, is still low in comparison to other states.

Maine's R&D programs are comprehensive in coverage. Ranging from support for basic research at the state university and local not-for-profit research institutions, to business support at the new incubator network through a broad assortment of financing programs and tax credits, Maine has many of the program elements of other strong science and technology states.

However, linkages among state programs that could make the whole greater than the sum of the parts, are still quite weak. First, there are several disconnects between research expertise and industry clusters. For instance, while the Jackson Laboratory and Maine Medical Center Research Institute are very competitive in biomedical research, the existing biotechnology industry in Maine is concentrated in medical diagnostics. Further, a nascent group of systems integration and software companies is forming in southern Maine, but the computer science programs at the University of Maine and the University of Southern Maine have relatively few students graduating with advanced degrees. A third example is wood composites. The state has made a $6.2 million dollar investment in a wood composites research center with only a small local composites industry to be served.

Other successful state science and technology programs, (for example in North Carolina and Virginia), include mechanisms to ensure that university-based research with commercial potential is protected as intellectual property and brought from the laboratory to the marketplace. We did not find such mechanisms to be well developed in Maine. So, if the university did have commercializable research, we suspect it would be harder to unlock from the laboratory.

Finally, many other states have mechanisms that help companies find out what programs are available to them and how to navigate the various agencies and organizations. In Maine, a scarcity mentality resulting from many lean years of state appropriations is widely reported. According to several of those interviewed during the study, the consequence of this protracted austerity has been that the stakeholders involved in science and technology have spent their time fighting with each other over next years' funding, not working together to enhance their collective R&D competitiveness or to develop close linkages among themselves or with Maine companies.

Study Limitations

The study has several limitations. First, the secondary data we have used are best suited to indicate broad trends and are of limited use in evaluations of specific R&D programs. The compilation and reporting of these data can lag behind emerging trends, and they are typically too highly aggregated level to capture the impacts of specific state-funded R&D programs.

Second, the study's limited scope and duration permitted only a small number of interviews and case studies to be conducted. Thus, while informative and illustrative of main themes and emerging trends, the data collected during the study do not necessarily constitute representative samples; that limits our ability to generalize from them.

Third, the primary data that have been collected from R&D stakeholders in Maine are generally not comparable. No single evaluation-focused data collection system is in place. Therefore, primary data collected in a centralized and coordinated manner is required in the future to provide an adequate understanding of the interactions that are occurring. Centralized data collection will also eliminate the duplication of outcome metrics inherent in any combining of single agency reporting.

Fourth, Maine's R&D programs are of recent origin. It is early in the life cycle of the investments to expect many tangible results from them. Many of the substantial investments made in the mid-1990s, for instance, involved capital outlays. Those buildings and equipment are just coming on line in 2000 and 2001, and research that has been enabled by these investments is just starting. Even later stage investments, such as Small Enterprise Growth Fund, still have several years of operation before the overall success or failure of the client businesses can be determined. Even then, the nature of the science and technology enterprise, especially the entrepreneurial one, is characterized by an uneven trajectory.

Implications for Metrics and Data Collection

This initial evaluation shows the critical need for primary data to be collected from the recipients of the state's R&D investment. Absent primary data on program outputs and outcomes, it will not be possible to determine program impacts, to test for cause-and-effect relationships, and thus, to conclude with reasonable confidence that the programs, in the aggregate or singularly, have been effective.

Second, the initial evaluation underlines the critical need for a centralized data collection system, enabling a company- and researcher-focused view of outcomes rather than a program-oriented view. If understanding the overall impact of the R&D investment is the objective, then the interactions among programs must be taken into account.

Third, the initial evaluation shows the importance of an evaluation process that is replicated year after year, to capture outcomes as they emerge, sometimes many years after the initial investment. An ongoing process will also enable the R&D investment system to improve over time as intermediate outcomes emerge, suggesting the need for mid-term course corrections.

Part II of this report details the process for future evaluation, including a specification for an annual survey of all recipients including researchers and companies. Part II calls for a collaborative and interactive process among MSTF and all the stakeholders that operate programs included in the evaluation — one that can build bridges and linkages to better serve the people of Maine.

Introduction

Since 1995, Maine has substantially increased its investments in research and development (R&D). The Maine legislature has boosted research and development funding tenfold in the past six years, from $2.5 million to over $20 million annually. Existing organizations, such as the University of Maine System, as well as new programs such as the Maine Technology Institute, the Maine Biomedical Research Fund, and the Applied Technology Development Centers, have benefited from these investments.

The investments were undertaken to strengthen Maine's economy, retain its population though improved business and employment opportunities, increase per capita incomes toward national levels, improve the competitiveness of its businesses, and enhance the quality of life of its citizens. Maine's support of R&D is intended to facilitate the generation and utilization of new knowledge necessary for contemporary economic growth. It is intended to help existing state industries modernize, nurture the development of new firms and industries, attract new industries, retain and attract high wage jobs and populations, and enhance the overall attractiveness of Maine as a state in which to live and work.

The establishment of new programs and the increase in funding followed a systematic rethinking about the structure of the state's economy. Acknowledging the slow growth and declining national and international competitiveness of several of Maine's traditional natural resource and manufacturing sectors, notably, forest-related products, shipbuilding, and fisheries, there was an increasing concern among Maine's state officials, industry representatives, and officials from the state's universities and not-for-profit laboratories that Maine was not competitively positioned to garner the economic gains associated with emerging science-based and technology-intensive industries.

Maine's new investments in R&D represent a visible portion of the state's discretionary budget. Funds for these programs have an opportunity cost in reduced levels of support for other deserving state priorities. State legislators, understandably concerned about the effectiveness and efficiency of these programs and the press of other state needs, ask if they are producing the intended outcomes and the maximum level of attainable improvements given their levels of funding. Both the Governor's Office and state legislators, as well as members of Maine's science and technology (S&T) community, require documentation that the R&D programs the state is currently funding make sense given Maine's existing industry and S&T base, and the potential for developing new S&T strengths. In keeping with contemporary national and state-level precepts on governmental performance, they want evidence of program accountability, specifically evidence of substantial relationships among state funds, program outputs, and state-level objectives.

This report is part of Maine's continuing effort to evaluate its R&D policies. This effort includes the *Maine Science and Technology Action Plan 2001*, the annual *Innovation Index* and the cluster study. The report was commissioned by the Maine Science and Technology Foundation (MSTF) in response to 5 MRSA §13122-J and §13122-K,[1] that calls for MSTF to establish outcome measures considered appropriate by public and private practitioners in and outside of the state in the fields of R&D and economic development, and for the use of nationally recognized independent reviewers to assess the competitiveness of technology sectors in Maine and the impact of research and development in Maine on the state's economic development.

The report builds on a 2000 report, *A Comprehensive Guide to Evaluating Maine's Public Investment in Research and Development*, by Dr. Julia Melkers, Michael Ryan, Dr. Charles Colgan, Dr. Marianne Clark, Kathryn Hunt, and David Keeley. Adding new analytical refinements and increased empirical detail, our report represents another building block in a continuous evaluation process for which Maine has received national recognition.

The Questions to be Addressed

Responding to the terms of the legislature's mandate, MSTF posed three specific questions to be answered in this report:

1. *How competitive is Maine's sponsored R&D and has it improved over time?*
2. *What is the impact of Maine's R&D investment on the development of Maine's R&D industry? and*
3. *What is the impact of Maine's R&D investment on the level of innovation and innovation-based economic development?*

MSTF has taken an innovative approach to evaluation in responding to its legislative mandate. The approach treats evaluation as a broad-based process that entails the ongoing generation, dissemination, analysis, and interpretation of data that can be used by state officials and program managers to calibrate expectations, measure performance, and revise programs and plans. The approach is also closely linked to the state's economic development plans, Maine's *S&T Innovation Index*, and related analytical studies. It incorporates the objectives and key indicators of these documents as part of the objectives against which R&D activities are to be evaluated. It also provides information on about the selection and refinement of appropriate indicators and data to measure progress towards the attainment of objectives and it outlines a fully implementable data collection plan that can be used by MSTF in subsequent evaluation activities.

[1] The relevant statute and public law are included in Appendix 7.

These questions must be addressed within a broad policy context. Answers to them require strategic thinking as well as a more conventional accounting of "bang for the buck." Therefore, this report has two objectives. One is to contribute to MSTF's ongoing work to develop and refine an analytical framework, set of metrics, and data collection procedures to improve future evaluation efforts. The second is to respond to the interests of the Governor's Office and the legislature for an early indication of progress under the terms of recently enacted and enhanced state R&D programs.

The report's answers thus document recent events and emerging trends. They do not constitute an evaluation of any single program or an impact assessment of Maine's overall R&D initiatives to date, however. Moreover, the limited time and resources available to this study to collect primary data from R&D funding recipients means that only modest attention could be devoted to findings related to improvement of the programs' operations, and none to attempting to assess the impacts of these programs.

The Subjective and Objective Challenges

Answering MSTF's questions poses both subjective and objective challenges. The subjective challenge is that the content of the answer depends, in part, on the standards that one establishes. The objective challenge is that the relationship between policy interventions and outcomes is typically complex and difficult to model. The design of the study is directed at overcoming both challenges.

Public policies "make sense" or are "successful" against expectations and criteria that are set *ex ante* or *ex post*. Expectations and criteria relate to specific outcomes, for example, the creation of new jobs, establishment of new businesses, or reduction of inequality. The *ex ante* expectations, objectives and criteria are established in legislation or statutes, or from the record of discussion among legislators. These expectations are often global and sweeping in nature (e.g., "competitiveness"); they employ general and broad language but refrain from setting numerical targets. For that reason, subjective judgments can affect assessments of the degree of success of public policies. How much is enough to be considered successful? Even viewing the same data, parties may differ in their conclusions. Expectations and criteria also change over time, as increased understanding is gained of the complexity of a setting or the limited resources that are in fact available to pursue desired objectives.

The relationship between policy interventions directed at promoting research and development and outcomes related to economic development and quality of life is complex. Correlation needs to be separated from causation; single examples of success, while often newsworthy anecdotes, may not constitute representative results. The interactions of multiple programs also need to be considered; sometimes, nominally parallel or similar programs work in the same direction. But they also can work against one another or be so entangled that it is difficult or impossible to separate the effects of one from the other. If there are induced effects, they can take many years to materialize.

It is generally recognized that there exists a long gestation period between the initiation of a public sector R&D program and attainment of the program's objectives.

Recently established programs, such as those that characterize Maine's new R&D investments, run the risk of being judged prematurely, especially in periods of tightened state budgets, and thus not given time to demonstrate their contribution to state objectives. This reminder holds with special force in the case of Maine, as these initiatives follow a sustained period of deferred investment that left the state in an uncompetitive position. Many of state's new initiatives are just beginning to affect the construction of new laboratories, the recruitment of additional researchers and the conduct of new research.

This report provides snapshots at a single point in time of a dynamic process. Thus, initial analyses of the state's competitiveness must involve a comparison of its investments in R&D relative to other states, as opposed to the outputs from this R&D, and ultimately on outcomes related to the state's economic development and quality of life.

Selection of appropriate metrics and collection of relevant data are recurrent issues in evaluation studies. Precision in measurement is a laudable objective, but if the wrong things are measured, performance measurement as a public management technique may drive a program away from, rather than toward, the state's intended objectives. Data problems exist as well. In some cases no data exist to measure desired outcomes; in other cases, the data may be of poor quality, sporadic, or unreliable. And without coordination among stakeholder organizations, the data that are collected may be inconsistent, making comparison difficult, if possible at all. The data system must also eliminate the duplication that could occur when combining outcomes from single agencies that may share clients. Attention to data must also be shaped by considerations of cost, administrative feasibility, and compliance.

To manage the subjective challenge, the empirical evidence, data, and other forms of information must be understood within the relevant context. For example, the same outcomes from a new venture capital fund are likely to be viewed differently in a region where there already is a concentration of high-tech, high-value industry, than in most regions of Maine, which are still dominated by traditional, low value-added activity. A second overarching purpose of the MSTF-sponsored initiative, therefore, is to help state policy makers forge a consensus about the S&T/R&D context in Maine. This activity will help calibrate expectations about any present or future research and development activities.

Research and Development Contrasted with Science and Technology

The three questions are cast in terms of research and development, not science and technology. Typically, R&D programs are differentiated from science and technology programs primarily in motivation, relative emphasis, and program techniques, not necessarily in the importance of specific activities or involvement of key institutions or performers. R&D programs frequently encompass fundamental research, providing the knowledge base that permits subsequent innovative activities. Fundamental research activities also include training the skilled researchers and technicians that provide the human resources necessary for technology-intensive firms in the state to find qualified employees. It creates the intellectual and cultural life necessary to attract entrepreneurs, managers, professionals, and investors who form a vibrant, technologically advanced, and dynamic state economy.

Although more generally clustered in the applied research and development portions of this continuum, state S&T programs extend across the fundamental-applied-development continuum. State science and technology interventions frequently extend beyond the boundaries of R&D to include various programs designed to provide capital, management, and technical assistance to start-up or small- and medium-sized firms.

Maine's R&D programs reflect both these national patterns. About two-thirds of the state's investment is in fundamental research, seeking to strengthen the more global research competitiveness of its major universities and not-for-profit research laboratories. However, Maine's R&D programs also include support for product development and financing.

Understanding Maine's R&D Performance in Regional and National Perspective

The three questions posed above are cast in terms of the state's competitive position. Competitive, as used in these questions, is a matter of both absolute improvement and relative standing. Thus, the questions inquire not only whether Maine is doing better (or worse) or more (or less) than it did in previous years with respect to key measures of economic well-being, but also whether its standing has improved relative to the nation and to specific "peers" or "competitors."

At both the national and state levels, jurisdictions (state, region, nation) "benchmark" their progress against others as a way to gauge relative standing and track rank order improvements. Benchmarking is important for several reasons. First, it recognizes the relative nature of success. Without a benchmark, it is difficult to judge whether the public cost of new job creation or the rate of innovation is high or low. Should a high tech job cost $20,000 in subsidies to create, or $500? Are twenty patents a year a lot or a little? These questions can be answered within the context of common practice. (That, of course, is not to say that all programs of a given type used nationally are necessarily efficient.)

Benchmarking also helps account for differences between absolute changes and relative position. Maine does not exist in a vacuum; as it increases its investments in R&D and adds programs, other states do as well. That creates a classic "moving target" problem. Even with a tenfold increase in R&D investments, Maine may find itself falling further behind the states against which it competes.

Benchmarking requires that a jurisdiction choose the pond in which it wants to (or must) swim. The critical question here is "with (against) whom does Maine want to be compared?" Answer(s) to this question are quite complex, and will likely vary with the issue at hand. Maine's economic base is quite different from California's, Connecticut's, and Massachusetts', for example, so comparisons against those states might not be productive. On the other hand, Maine finds itself competing for high tech businesses with Massachusetts, so it may be necessary to benchmark its efforts against that state anyway.

As a participant in the National Science Foundation EPSCoR[2] program, Maine has several occasions to benchmark against the nineteen other states plus Puerto Rico now participating in the program. The heterogeneous character of those states limits the usefulness of this comparison group. For example, Alabama, Louisiana, and Kentucky, unlike Maine, have Research I universities (the top classification given by the Carnegie Commission on Higher Education). The increasing diffuseness of the criteria used to justify a state's eligibility for the program, and the geographic distance of Maine from most of the other EPSCoR states also limits the usefulness of the comparison with EPSCoR states.

Answers to the three questions posed by MSTF are based on a review of an extensive set of performance indicators on Maine's R&D activities, garnered from national and Maine sources, including those included in Maine's *S&T Innovation Index*. These indicators are benchmarked with the nation, New England, and the EPSCoR states.

The answers rely on more than R&D indicators, however. They also are based on interviews with representatives from the agencies and organizations that administer the state's R&D programs, Maine's universities and not-for-profit research laboratories, and firms that receive funds from Maine's R&D programs. The time and scale of the study limited the number of interviews, and thus provide illustrative rather than necessarily representative information.

Juxtaposition of information garnered from performance indicators and interviews helps us to interpret these indicators and to identify additional or revised indicators. That is necessary in order to interpret Maine's position relative to other states in the performance of R&D. The relative importance of universities and not-for-profit research laboratories in Maine's R&D community differs substantially from most other states. This difference can significantly affect the interpretation one gives to conventional indicators.

Assessing Progress toward Goals, Not Just Progress

Relating this evaluation effort to the state's S&T and economic development planning allows us to assess progress toward goals — either lofty or modest — that have been set in a democratic way. Those goals can be set relative to other places (as discussed above), relative to time, or relative to particular activities.

If the people of Maine (through their elected representatives) believed that Maine should *now* be a national leader in *overall* R&D performance, for example, actual outcomes would have to be judged as disappointing. Those same outcomes would be judged promising if the expectations were to reach the national mean by some future year and perhaps a higher level later.

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[2] EPSCoR is the acronym for the Experimental Program to Stimulate Competitive Research and is used to denote the states with low levels of federal research funding. The 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.

Similarly, the appropriate expectation might not be for Maine to compete nationally in all R&D sectors, but rather, in a subset of sectors in which Maine has a competitive advantage, for example, shellfish aquaculture, or biomedical applications. Niche development is a common way for less developed economies to focus their resources and build critical mass in at least a few technology areas.

Organization of Report

The report is divided into three parts. Part I addresses the three questions listed above. The section presents the report's findings, limitations, and methodology. It also describes the implications of its findings for future data collection. Part II offers a blueprint for MSTF's future evaluation activities. The section focuses on both the process and content for future data collection. The blueprint emphasizes the importance of working with all the stakeholders in the state to develop and implement a single data collection system capable of informing a comprehensive evaluation of state R&D investments as well as providing for the monitoring of single programs. Part III is a Technical Appendix, containing data and analyses conducted by the team. These include the program theory and impact analysis that led to the choice of indicators, the analysis of indicators for Maine and relevant benchmark states, and five case studies.

PART I

Initial Evaluation

As detailed in the *State of Maine Economic Development Strategy* and *Maine's Science and Technology Action Plan 2001*, Maine's support of R&D investments is intended to help create a high quality of life for Maine citizens by building a sustainable economy. The specific goals for science and technology overall are:

- An educated and technically skilled workforce;
- A robust research and development enterprise;
- An environment that fosters entrepreneurial innovation; and
- Statewide access to the latest information technology infrastructure.

To assess progress toward these goals, the legislature and the Maine Science and Technology Foundation (MSTF) have asked three questions:

1. *How competitive is Maine's sponsored R&D and has it improved over time?*
2. *What is the impact of Maine's R&D investment on the development of Maine's R&D industry? and*
3. *What is the impact of Maine's R&D investment on the level of innovation and innovation-based economic development?*

Part I reports the answers to these three questions, summarizes the methodology used, and reviews the study limitations. Finally, implications for future indicators and data collection are discussed.

Answers to the Three Questions

1. How competitive is Maine's sponsored R&D and has it improved over time?

In this report, competitiveness is defined 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. Competitiveness is judged against absolute and relative standards; thus, the context for these gains and the continuing challenge for Maine must be kept in perspective. Competitiveness also extends to the relevance of R&D indicators to Maine's overarching economic development strategies.

In terms of overall R&D competitiveness, Maine started from a lagging position, still performs below national averages on most measures of state-level R&D activity, and continues to lag behind most other comparable states. It appears though to have modestly improved its absolute performance and relative standing on several indicators since 1995, but the magnitude and staying power of that improvement cannot readily be gauged.

An optimistic interpretation of existing data and trends is that the positive impacts of most of the state's recent initiatives are yet to be fully reflected in standard data series. Certainly, the force of the state's initiatives and the policy dialogues surrounding them have increased the attention of relevant stakeholders — the Governor's Office, the legislature, the university community, the research laboratory sector, several segments of technology-based industry in the state, and the press — about the importance of a vibrant, competitive R&D sector to Maine's long-term economic growth.

A less optimistic view is that recent state-initiated programs have yet to demonstrate their impact, and that even if they produce the gains expected of them, the state's resources committed to them, while large by historic standards, are still too small relative to those being committed by other comparable states for Maine to advance far in relative standing.

On the first measure of competitiveness, the scale of R&D programs, Maine has put into place a portfolio of programs spanning the research-development-commercialization continuum that resembles that found in most other states.[1] The state's focus has been to support the basic research infrastructure (both physical and human capital) needed to make the state's major university and research laboratories more competitive for large-scale federal agency research grants and to provide a seedbed of possibilities for technological innovation. The funding for these programs exceeded $38 million in the last biennium. During the same period, the state's efforts directed at applied research and commercialization, the nearer-term stimuli to economic development, have totaled slightly over $20 million. These programs support R&D initiatives by private sector firms that enable them to develop new products and processes, and develop financing mechanisms that both provide added capital for in-house R&D and help attract external capital to expand output and employment.[2]

The majority of states have been investing in science and technology since the late 1980s; some states started even earlier. Between 1965 and 1995, total state R&D spending increased at an inflation-adjusted annual rate of 3.3 percent, compared with a nationwide R&D spending increase of 2.5 percent.[3] Common to the states are investments in:

- Maintaining and strengthening the R&D capacity of the states' colleges and universities;

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[1] Coburn, Christopher, and Berglund, Dan, *Partnerships: A Compendium of State and Federal Coopera tive Technology Programs.* Columbus, OH: Battelle. 1995.

[2] The study was not designed as a management review of these programs. Still, limited review, based on interviews with program managers and program awardees indicates that they are operating consistently with best practices among the states, albeit not without some reported teething problems concerning eligibility, project selection, and financial terms.

[3] National Science Board, *Science & Engineering Indicators 2000.* Arlington, VA: National Science Foundation, 2000 (NSB 00 1).

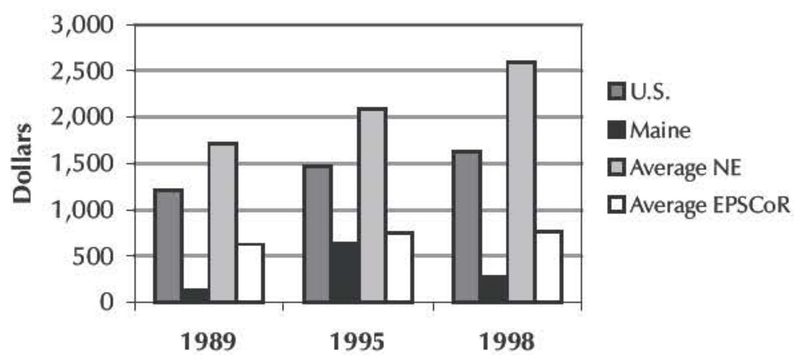
- Encouraging "home-grown" businesses by providing support to entrepreneurs and small technology-based firms; and
- Facilitating the incorporation of new technology into processes and products.[4]

Maine has increased its absolute level of state funding of R&D since 1995, but other states have as well. That has made it difficult for Maine to increase its relative ranking among the states, particularly that set of states that are meaningful competitors for the location of economic activity. National data on state funding were last compiled in FY1995,[5] but preliminary indications suggest that several states have substantially increased their investments in R&D recently, partly using allocations from the tobacco settlement. California, Michigan, and Georgia, for example, have enacted major initiatives. Among EPSCoR states, Kentucky proposed to invest $53 million annually including a $4 million EPSCoR match and $20 million for Kentucky businesses who partner with Kentucky universities for research and development leading to commercialization.[6]

Even with substantially increased state R&D investment, Maine still ranks near the bottom of state efforts in both inputs and outputs. As shown in Figure 1, R&D invested per worker is lower than the U.S., the average of the New England states, and the average of EPSCoR states. R&D per worker is up from 1989 to 1998, but down from 1995 when there was a one-time jump in industry-performed R&D.[7]

The second measure of competitiveness, the effectiveness of the investments, cannot be assessed at this time. Without specific data from the recipients of state funds, we can only look at indicators of R&D effectiveness, comparing Maine to the nation, the other New England states, and the other EPSCoR states.

Figure 1: State R&D Dollars Invested per Worker, 1989–1998



Source: National Science Foundation, Division of Science Resources Studies, http://www.nsf.gov/sbe/ses/nsf99335/appb.htm and Bureau of Labor Statistics, http://www.bls.stats.gov.

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[4] Ibid.

[5] State Science and Technology Institute, *Survey of State Research and Development Expenditures, FY1995.*

[6] State Science and Technology Institute, Weekly Digest, May 26, 2000.

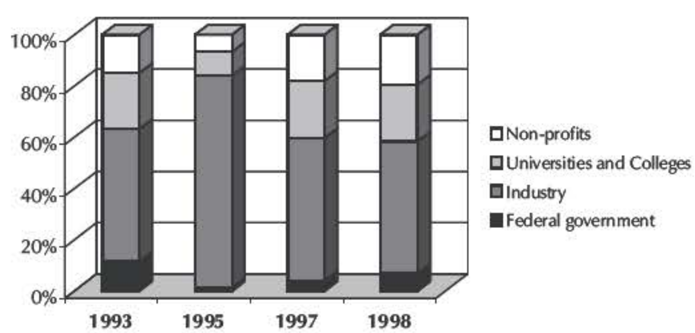
[7] National Science Foundation, Division of Science Resources Studies, http://www.nsf.gov/sbe/ses/nsf99335/appb.htm and Bureau of Labor Statistics, http://www.bls.stats.gov.

An important challenge in assessing Maine's competitiveness in R&D is the distinctive character of the state's R&D enterprise. Nationally, the largest portion of a state's total R&D (e.g., expenditures, and employment of scientists and engineers) is undertaken by industry. Also, nationally, the largest portion of publicly funded R&D within a state is performed either by universities or federal government laboratories. In Maine, by contrast, the not-for-profit sector is much more prominent than in the nation as a whole (see Figure 2). Therefore, Maine will tend to have low rankings on many mainstream indicators of state R&D that center about the flow of funds into or the performance of academic institutions. Considerable care is in order in using aggregate measures of R&D performance when assessing Maine's competitive performance and position.

At the aggregate level, Maine tends to place below its population rank in most measures of total R&D performance. The state ranks 40th in population, 38th in personal income per capita and 44th in gross state product. In comparison, the state ranks 47th in total R&D performance, 44th in industry R&D, 43rd in federal R&D obligations and 51st in academic R&D.[8]

One reason that Maine lags in R&D overall is that the level of federal funding of R&D also lags in Maine. While per capita federal obligations for research and development have risen in Maine from 1990 to 1998, including a sharp increase since 1995, Maine remains well below the average EPSCoR states, the U.S. overall, and the average of the New England states.[9] On a per capita basis, federal R&D expenditures in Maine are substantially below the U.S., although they have risen slightly since 1997.[10] This is shown in Figure 3.

Figure 2: R&D Spending in Maine per Performer, 1993–1998



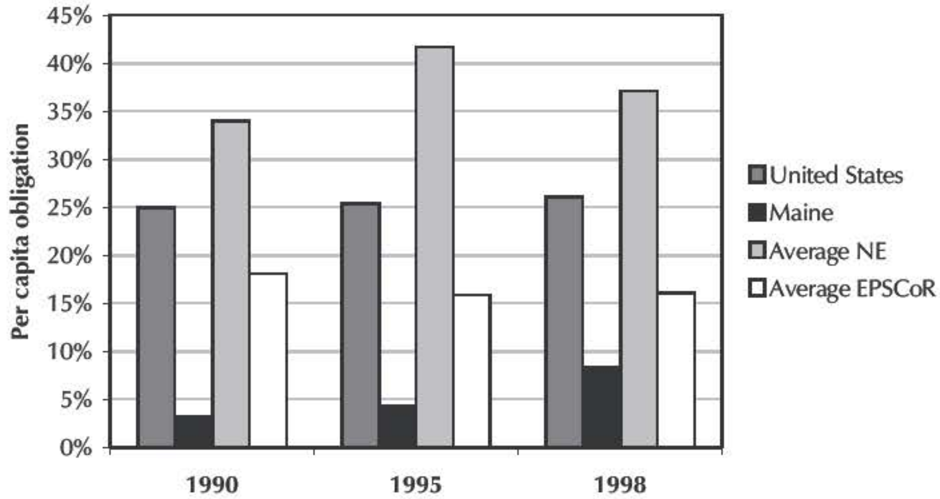
Source: National Science Foundation, Division of Science Resources Studies, *National Patterns of R&D Resources: 2000 Data Update*, http://www.nsf.gov/sbe/srs/nsf01309.

[8] National Science Foundation, *Science and Engineering State Profiles: 1998 1999*.

[9] National Science Foundation, Division of Science Resources Studies. *Survey of Federal Funds for Research and Development: Fiscal Years 1998, 1999, and 2000*, Table 55.

[10] National Science Foundation, WebCASPAR Database System. Maine also ranks 39th in the amount of earmarked federal funds for the period 1997 2001, jumping to 26th in FY2001. *Chronicle of Higher Education*, August 10, 2001, p. A24.

Figure 3: Federal Obligations for Research and Development, 1990–1998



Source: National Science Foundation, Division of Science Resources Studies, *Survey of Federal Funds for Research and Development: Fiscal Years 1998, 1999, and 2000.*

Industrial funding of research and development remains low in Maine.[11] Maine's industry mix is dominated by businesses with low historical levels of research and development investment, such as agriculture, pulp and paper, and fisheries.[12] Averaging around 0.25 percent of Gross State Product (GSP), industrial funding in Maine lags the national average of 1.91 percent of GSP in 1998. (Adding the Maine Technology Institute investment of $6.4 million annually would only change the industrial funding to 0.27 percent of GSP.)

At first glance, these statistics signify that Maine is not competitive and has not markedly improved its position. However, there are some indicators of improvement. One early measure of competitiveness is the winning percentage of federal awards. As detailed more fully in our answer to Question Two, the University of Maine's recent performance in obtaining awards from the National Science Foundation and the Jackson Laboratory's and Maine Medical Center Research Institute's successes in having proposals funded by the National Institutes of Health are indicative of increased competitiveness.

Finally, to return to the state's overarching objective in its recent increased commitments to R&D, the ordering of means and ends must be kept in mind. From the state perspective, as repeatedly noted by state officials, state funding of R&D is intended to improve the state's economic performance and quality of life. The state's

[11] National Science Foundation, Division of Science Resources Studies, *National Patterns of R&D Resources: 2000 Update,* as quoted in *2001 Maine Science and Technology Innovation Index.*

[12] In 1997, companies in Maine's traditional industries invested a low percent of their net sales in R&D. Paper and allied products invested 1.1 percent; lumber, wood products, and furniture invested 0.9 percent; food products invested 0.5 percent. This compares to high investors such as drug and medicine (10.5 percent) and office, computing and accounting machines (9.2 percent). Source: National Science Board, *Science and Engineering Indicators 2000.*

standing, both in absolute and relative terms, on various metrics of R&D performance have relevance only to the extent that they are significantly and substantially related to these objectives.[13]

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

We define R&D industry as those organizations, including universities, not-for-profits, and companies, whose primary product is research and development. That includes the doctoral-granting university, University of Maine, the members of the Biomedical Research Coalition (the Jackson Laboratory, Maine Medical Center Research Institute, Mount Desert Island Biological Laboratory, the Foundation for Blood Research, and the University of New England College of Osteopathic Medicine), other not-for-profits such as Bigelow Laboratories, and the few companies in Maine that do research as their main business.

The study was directed at "Maine state-funded R&D" and therefore did not consider the R&D activities of Maine-based firms, other than those that receive funds through one of the state-funded programs such as the Maine Technology Institute.

Based on available data, including interviews with a number of the above institutions, it appears that some segments of Maine's R&D industry are more competitive than before the state started its increase in R&D investment. However, the data are not sufficiently representative or detailed to estimate orders of magnitude of improvement or to imply causality. Interviews and data on recent awards indicate that Maine's R&D-performing institutions have established a bridgehead in selected R&D areas, particularly related to biomedical research, and have begun to realize some modest economic returns from these investments. Its performance in academic R&D appears mixed; it evidences improvement in activity and success in securing competitively awarded NSF funds, but no noticeable improvement in total federal R&D funds garnered by Maine universities.

The University of Maine has increased its outside funding for research and development over the past ten years. Specifically, federal funding for science and engineering at the University of Maine has gone from $11.064 million in 1990 to $19.580 million in 1999, measured in constant 1996 dollars. On a per capita basis, this translates to $9.01 in 1990 and $15.63 in 1999.[14] (This includes capital expenditures, as well as research and development.) However, in the same time period, federal funding for R&D overall has risen at a faster rate than that experienced by the University of Maine. Federal funding for science and technology in the U.S. on a per capita basis moved from $48.91 in 1990 to $63.16 in 1999. Compared to its cohorts on federal funding for research and development alone (no capital expenditures), the other land grant universities in New England, and the land grant universities in the EPSCoR states, the University of Maine has remained in the same relative position (see Figure 4).

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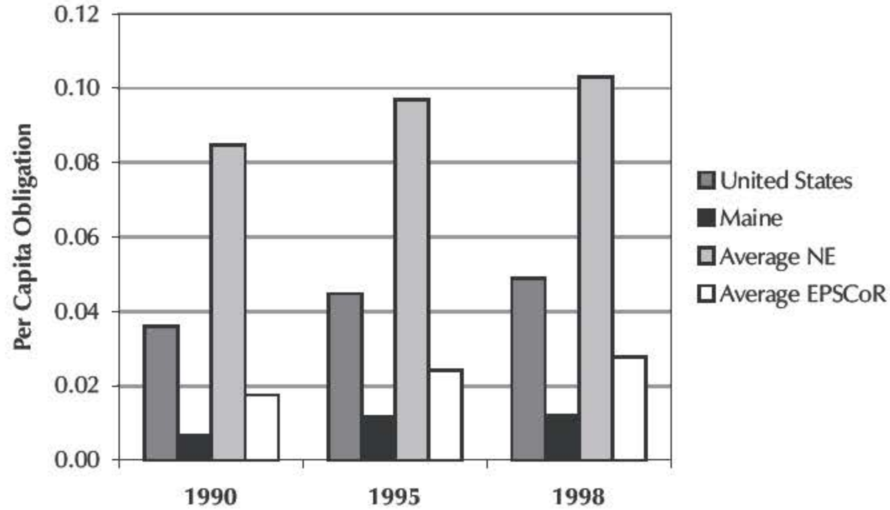
[13] "Significance" here is used in the formal sense of theoretically and statistically connected. "Substantial" here is used to mean order of magnitude.

[14] National Science Foundation, WebCASPAR.

Figure 4: Federal Obligations to Universities and Colleges for Research and Development, 1990–1998



Source: National Science Foundation, Division of Science Resources Studies, *Survey of Federal Funds for Research and Development: Fiscal Years 1998, 1999, and 2000*.

Moreover, an appreciable portion of the university's increase in federal funds has come from EPSCoR, a set-aside program specifically targeted at states and universities that historically have received low levels of National Science Foundation (NSF) and selected other federal agency support. Thus, the increase in science and engineering funding at the University of Maine includes two $1–2 million EPSCoR grants in 1996 and 1997, which were matched by state funds. In addition, the University of Maine received additional NSF funds to purchase equipment. The university was able to leverage other funds to complete the construction of the Advanced Engineered Wood Composites (AEWC) building and the Marine Culture Laboratory at the Darling Center, among other capital projects. New faculty has been hired and research has just started, so the impact from these investments would not be expected to be visible at this time.

Maine's universities and colleges received their federal academic R&D funding from several agencies, with no single dominant sponsor. Of total R&D funding of $103 million in 1999, the leading agency sponsors were Agriculture, National Science Foundation (NSF), Department of Defense (DOD), Health and Human Services (HHS), Commerce, and NASA, with the remainder distributed among other agencies.[15] The statistics on federally funded academic R&D coupled with the state's low ranking on number of science and engineering graduate students, 50th in 1997,[16] reflect the limited orientation of the state's universities and colleges toward research and doctoral degrees in science and engineering.

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[15] National Science Foundation, Division of Science Resource Studies; http://www.ehr.nsf.gov/epscor/statistics/start.cfm.

[16] U.S. Department of Commerce, Technology Administration, *The Dynamics of Technology based Economic Development: State Science and Technology Indicators.* 2000.

Competitiveness implies that one is a player; in terms of Maine's academic sector, the more appropriate observation may be that it was seldom actively in the game. More generally, the above statistics on sources of R&D funding, especially from the federal government, require that competitiveness be measured in terms of each sponsor, or at least for those that produce, or have the potential to supply significant R&D funds. Here data and interviews provide insights for NSF and HHS (NIH), but not for DOD or other agencies.

Faculty from Maine colleges and universities, primarily the University of Maine, submitted 138 competitive proposals to NSF in 2000 and received 47 awards; each of these activities represent advances over FY1997, when the respective numbers were 83 and 30. The funding ratio for Maine's faculty was 34 percent in 2000, which was higher than for all but two of the EPSCoR states (and comparable with that of several states with Research I universities.)[17]

Maine's not-for-profit biomedical research laboratories have developed distinctive, nationally competitive niches. They conduct research in areas of rising national interest that have a high likelihood of continuing increases in total levels of federal agency support. The first funds from the state's Biomedical Research Program were released in July 2001 and so their impact will not be measurable for some time.

The Jackson Laboratory remains a highly competitive actor in NIH. In 1997, 52.1 percent of Jackson's NIH requests were funded, compared with 34.4 percent nationally for institutions belonging to the American Independent Research Institutes.[18] A steady increase in both ranking, numbers of grants received and total NIH funding is evident over the past decade.[19]

Maine Medical Center Research Institute received a $10.6 million grant from NIH in 2000 to establish the Center for Excellence in Angiogenesis. Dr. Thomas Maciag, the Principal Investigator on that grant, is one of the leading investigators in this field.

The laboratories differ, however, in the extent to which their research activities are likely to generate spillovers in the form of backward linkages to Maine-based suppliers, in the extent to which their research will yield direct quality of life benefits to Maine residents, and the probability that they will spawn complementary, locally-based economic activity. These differences are based on the types of research being performed, the number of Maine suppliers used by the laboratories, and on their technology transfer strategies. For instance, despite the Jackson Laboratory's seventy-two year history in Bar Harbor and exceptional track record in obtaining federal funding, it has had only one company spin off from it.

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

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[17] Comparable data on proposal submissions, awards, and dollar amounts of awards (range, average, and distribution) are not available for other agencies.

[18] http://silk.nih.gov

[19] Ibid.

An innovation-based economy is one that performs highly on many indicators of innovation output, while at the same time developing a network of relationships among the institutions and sectors that are engaged in the activities that link the generation, development, and commercialization of knowledge into new products and processes. Many measures of innovation output exist. Each has recognized limitations, but assembled together provide an acceptable approximation for the underlying dynamism of a national or state economy. Measures of interaction among the sectors are less well developed.

The importance of this distinction rests in the character of the study's answer to Question Three. In sum, as noted above, the state's initiatives, in general, are too recent to either expect or observe much in the way of impacts on innovation-based economic development as measured by mainstream indicators. Case studies, however, provide limited evidence that the programs are having an impact in the intended directions. The case studies also highlight the need for careful interpretation of conventional indicators and the need to develop new indicators. Most important, they suggest that only limited progress has been made toward creating linkages between and among the state's R&D-performing and using sectors.

The level of innovation in an economy is traditionally measured using surrogates for new knowledge, such as patents and new products. Patents are particularly important on the industry side, because there is no national database of new products or processes developed by companies.

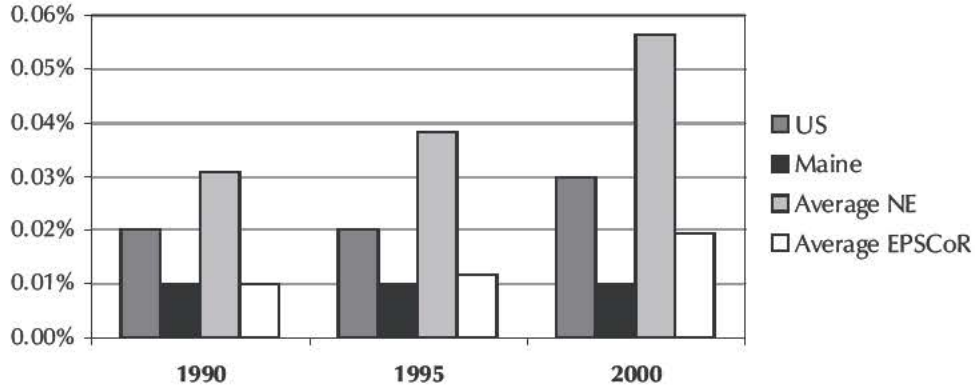
These surrogates have their own problems. Patents, for example, only apply to certain types of new knowledge, and even then their number is dependent on individual firms' decisions about how best to protect intellectual property. Simple counts of patents also do not distinguish between patents that have economic value and those that do not. Counts of patent citations, an increasingly popular technique to gauge the technical value of an invention, are limited by availability of information. Currently, the voluminous database of patent citations is privately held and expensive to access. Software innovations, for instance, are often not patented. Companies instead rely upon copyright registration and speed to market to protect their products instead. In other scientific fields, some researchers believe that innovations should not be converted into property owned by or licensed by single firms, and therefore do not seek patents. The scientists at the Jackson Laboratory, for example, do not patent the mutant strains of mice they develop.

The level of inventive activity in Maine, as measured by patents (and subject to the caveats noted above), has remained static, and appears to be falling behind other states. On a per capita basis, the number of patents awarded to Maine residents was flat between 1990 and 2000, while the averages for the U.S., the other New England states, and EPSCoR states were steady between 1990 and 1995, and all rose between 1995 and 2000 (see Figure 5).[20]

It is not clear whether this pattern reflects low inventive activity on the part of Maine's private and public sector R&D institutions, a lower propensity for these insti-

[20] U.S. Patent Office.

Figure 5: Patents per capita, 1990–2000



Source: U.S. Patent Office.

tutions to patent new knowledge than their counterparts in other states, or some combination of the two. None of the companies or research organizations interviewed during the course of this study pointed to patents as either a business strategy or metric of interest. We can only speculate whether this is the result of Maine's particular constellation of technologies and industries or a combination of lack of knowledge about patenting procedures and entrepreneurial drive.

Another preliminary indicator of the level of innovation in Maine is the number of Small Business Innovation Research (SBIR) awards. The SBIR program sets aside federal R&D money for small businesses. It is a competitive program that tracks the level of innovation among small businesses in a state. Its use as a measure of innovative activity is limited because some R&D firms are reported as opting out from participation in the program. Some firms consider the application and review process to be too long and the amount of funding too low to be worth the investment of time required. However, small companies in all states face these hurdles, so the number of SBIR awards on a comparative basis is instructive.

Maine's SBIR awards almost tripled from 1997 to 2000, moving from five to fourteen.[21] During that same period, many other states in the comparison groups saw decreases in numbers of awards.

Two common measures of an innovation-based economy are technology employment and number of technology establishments. The construction and interpretation of these measures have been found in previous studies to be sensitive to the definition chosen for technology. Our approach employs the definition of technology-intensive SICs (standard industrial codes) developed by the Bureau of Labor Statistics.

[21] http://www.sba.gov/sbir/library. Maine Science and Technology Foundation ran a Phase Zero SBIR program in 1997 and 1998, funded by National Science Foundation, to increase the number and quality of Phase 1 and Phase 2 applications. This included a SBIR proposal writing course and grants to companies to seek professional help. This program, although no longer federally funded, now resides at the Maine Technology Institute and is subcontracted out to the former service providers. Since we do not have data on which SBIR winners did or did not attend these workshops, no causal link can be established.

Technology employment as a percent of the population increased in Maine from 1.12 percent in 1990 to 1.55 percent in 1996.[22] However, the percent of employment in technology increased faster in the EPSCoR states and even faster in New England, so that Maine's relative position declined.

The number of technology establishments increased between 1990 and 1996, the latest date for which data are available. Yet, technology companies are under-represented in Maine's economy, producing a location quotient of only 0.70. (A location quotient of 1.00 means that the state has the same relative concentration of technology companies as the U.S. overall.) Three of the other New England states, New Hampshire, Connecticut, and Massachusetts, have location quotients for technology establishments over 1.00, as do EPSCoR states Nevada and Oklahoma. The average location quotient for EPSCoR states is 0.72, basically the same as Maine's.[23]

Venture capital investments are another indicator of an innovation-based economy. Because of the level of risk and investment required to start many technology companies, venture capital is the major funding mechanism. Here, the data are promising. Venture capital is an infrequent but slowly increasing source of capital for Maine-based start-ups. The number of venture investments rose from one to two investments a year from 1990–1996 to an average of ten deals a year in 1998–2000.[24] Some of the funding is coming from outside of Maine. In the last quarter of 2000, for instance, two deals were funded by New York venture capitalists and one by a Maine firm.[25]

These data need to be put in context. The venture capital industry is extremely cyclical with wide variations between peaks and troughs. U.S. venture investments were extraordinarily high between 1997 and 2000 as well. Given the sharp drop-off in venture investments across the nation in 2001, the fact that there were no venture investments in Maine in the first quarter of 2001 is not alarming.[27]

Table 1: Venture Capital Investment in Maine Companies[26]

Year	Number of Companies	Investment ($M)
1990	1	0.5
1991	2	4.3
1992	2	30.2
1993	2	3.0
1996	2	10.3
1997	5	12.5
1998	10	41.8
1999	8	43.0
2000	12	166.8

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[22] U.S. Census Bureau, County Business Patterns. These are the most recent data that categorizes employment by SIC code.

[23] Ibid.

[24] http://www.ventureeconomics.com/stats/2000Q4/state me.html. Venture Economics tracks capital invested by traditional private equity venture funds, angel investors and corporate venture firms and programs. They collect their data from National Venture Capital Association (NVCA) members. In contrast, the other major source of venture investing statistics, Money Tree, collected by PriceWaterhouseCoopers, tracks activities in key technology industries only. Money Tree statistics for Maine vary from these, but show the same trend of significantly higher numbers of investments in 1998 2000.

[25] Ibid.

[26] Ibid.

[27] Ibid.

Another element of an innovation economy is the level of science and technology expertise in the workforce. Companies may decide to move to a region with high levels of this asset. Companies already in a region may have a hard time finding qualified workers to support expansion or location there.

Measured as a percentage of population, Maine has a lower number of science and engineering graduates in its workforce than the nation as a whole. The location quotient is 0.43.[28] This ratio is consistent with the EPSCoR states whose average location quotient is 0.42, but is lower than the average for New England states (0.71), and much lower than Massachusetts (1.03). Here, the impact of this ratio on Maine's high-tech economic potential may be filtered by quality of life considerations. Since it is only a two-hour drive from Boston to Portland, a company could conceivably choose to locate on the Maine-New Hampshire border to gain some of the quality of life amenities of Maine, but attract the highly educated technical workers in greater abundance in Massachusetts.

On the other hand, none of the companies interviewed during the study complained about the lack of skilled workers in Maine. The software companies, in particular, were pleased with the quality of the workers they were able to hire in Maine, even though many were educated in other states. Jackson Laboratory was proud of their high percentage of Maine workers and has invested in training programs to keep that level high.

One way to sustain a high of quality of life in an economy is to increase average per capita income. Innovation-based jobs typically receive higher wages than traditional, natural resource-based jobs, providing the economic development linkage to the investments in science and technology. However, per capita income may be the last indicator to move as a result of the state's investments in R&D, being the "downstream," only gradually reached destination of the state's voyage. This induced effect can take several years to occur; however, it should be evident at an earlier stage in ancillary investments and measures.

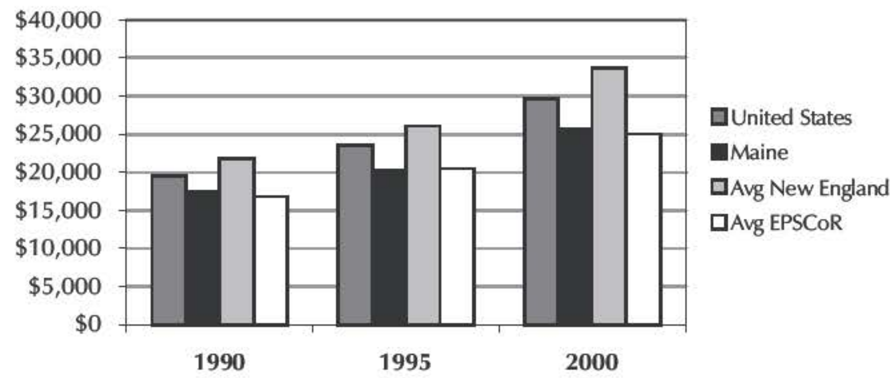
Per capita income in Maine increased between 1990 and 2000, peaking at $25,263 in 2000 (see Figure 6). However, the rate of increase and position of Maine relative to the U.S., the average of the EPSCoR states, and the average of the New England states, remains the same. Maine is about the same as the EPSCoR states, and well below the U.S. and the rest of New England.[29]

A final measure of innovation is the level of industry R&D. The absolute level of industry funding has remained steady in Maine as a percent of total R&D, excepting a one-time jump in 1995. The Maine Technology Institute (MTI) has funded over 100 companies to perform new product or process development, with the impacts of these investments still in gestation. At the four companies we interviewed, these projects were reported as ones that would not have occurred without the MTI funding. Most

[28] National Science Foundation, Division of Science Resource Studies. Total civilian workers from http://states.bls.gov.

[29] Bureau of Economic Analysis.

Figure 6: Per Capita Income, 1990–2000



Source: Bureau of Economic Analysis, http://www.bea.doc.gov

of the projects are still in progress, and, according to company representatives, show promise of contributing to new products, processes and business strategy.

Innovation Networks

One element of Maine's potential competitiveness in an innovation-based economy is the way in which the science and technology programs and stakeholders in Maine are organized. As shown in Table 2, Maine's programs seem to be quite comprehensive. Ranging from support for basic research at the state university and local not-for-profit research institutions, to business support at the new incubator network through a broad assortment of financing programs and tax credits, Maine has many of the elements of other strong science and technology states.

The fact that Maine has perhaps as many as fifteen different stakeholders in science and technology without a central authority is not unusual. Other states, including California, Georgia, and North Carolina, also have this type of institutional set-up.

Missing, however, are the linkages that can hold these programs together and to the innovation-based businesses in the state. First, there are several disconnects between research expertise and industry clusters. For instance, while the Jackson Laboratory and Maine Medical Center Research Institute are very competitive in biomedical research, the existing biotechnology industry in Maine is in medical diagnostics. A nascent group of systems integration and software companies is emerging in southern Maine, but computer science programs at the University of Maine and the University of Southern Maine are not sizable. According to the "University of Maine Report to the Governor," in 1998–1999, they awarded only 40 Bachelor's degrees in computer science, 8 Master's, and 18 Associate degrees. A third example is wood composites. The state has leveraged federal and private funds to make a $6.2 million dollar investment in a wood composites research center with only a small local composites industry to be served.

Also commonly found in the successful state science and technology programs are mechanisms to identify and protect new knowledge and to transfer that knowledge to local industry. Research has detailed how the creation of a licensing and patenting group at Stanford University in the 1950s fueled the growth of Silicon Valley.

Similarly, the expansion of such offices at the public universities in North Carolina, Virginia, and elsewhere, resulted in sizable increases in patent applications and awards, with associated increases in start-up company activity.[30]

Table 2: Roadmap of Maine's Science and Technology Programs

	Basic Research	Applied Research	Product/Process Development	Product/Process Introduction	Production	Product and Process Improvement
Technical Assistance to Industry	• Biomedical Research Fund (biomedical) • Gulf of Maine Aquarium (marine science) • Governor's Marine Fellowship (marine science) • Marine Connectivity (marine science) • EPSCoR • Marine Technology Fund (marine science) • Research Challenge Grants • Capital improvements • Research and development funds • R&D Bond	• MAFES (agriculture and forestry) • *Sea Grant (marine)* • Strategic Research Initiative (wood composites)	• MAFES (agriculture and forestry) • *Sea Grant (marine)* • Strategic Research Initiative (wood composites)		• *Manufacturing Extension Partnership* • *MAFES Cooperative Extension (agriculture and forestry)* • *Sea Grant Cooperative Extension (marine)*	• *Manufacturing Extension Partnership* • *MAFES Cooperative Extension (agriculture and forestry)* • *Sea Grant Cooperative Extension (marine)*
Business Assistance to Industry	• Applied Technology Development Centers (aquaculture; biotechnology; agriculture and forestry; information technology; environmental technologies; precision machinery and composites)	• Applied Technology Development Centers (aquaculture; biotechnology; agriculture and forestry; information technology; environmental technologies; precision machinery and composites)	• Applied Technology Development Centers (aquaculture; biotechnology; agriculture and forestry; information technology; environmental technologies; precision machinery and composites)	• Applied Technology Development Centers (aquaculture; biotechnology; agriculture and forestry; information technology; environmental technologies; precision machinery and composites)		
Financial Assistance to Industry		• Maine Technology Institute Seed Grants • SBIR assistance • Seed capital tax credit • Expensing of R&D expenditures tax credit • Research expenditures tax credit	• Maine Technology Institute Development Awards • SBIR assistance • Seed capital tax credit • Expensing of R&D expenditures tax credit • Research expenditures tax credit	• Maine Technology Institute Development Awards • VC Revolving Investment Program • Small Enterprise Growth Fund • High tech tax credit • Super credit	• VC Revolving Investment Program • Small Enterprise Growth Fund • High tech tax credit • Super credit	• High tech tax credit • *Agricultural Development Grant* • *Potato Marketing Improvement Fund (agriculture)*
Broad Industry Support	• Center for Innovation in Biotechnology (biotechnology) • Maine Aquaculture Innovation Center (aquaculture) • Maine Technology Institute Cluster Enhancement Awards • S&T Clearinghouse • Maine Space Grant Consortium (aerospace)					

Programs which are shaded are for research performers, not industry. Programs in italics were not included in the R&D Evaluation. Where only certain sectors are served, these are indicated in parentheses.

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[30] Luger, Michael I. and Harvey A. Goldstein. *Technology in the Garden: Research Parks and Regional Economic Development*. Chapel Hill, NC: University of North Carolina Press, 1991. Feser, Edward J., Goldstein, Harvey, and Luger, Michael, *At the Crossroads: North Carolina's Place in the Knowledge Economy of the Twenty First Century,* 1998. The Association of University Technology Managers, Inc., *AUTM Licensing Survey, Fiscal Year 1999.*

The University of Maine has a limited capacity to protect and license its technology.[31] This responsibility is placed in the Department of Industrial Cooperation along with industrial R&D, sponsored programs and economic development. The not-for-profit research institutes also seem to place technology transfer low on their list of priorities. For example, the Jackson Laboratory does not patent its mice, and has experienced only one spin-off despite a long history of successful R&D.

Finally, many other states have mechanisms to help companies find out what programs are available to them and how to navigate the various agencies and organizations.[32] According to interviewees, the many lean years have produced a "scarcity mentality" in which the stakeholders involved in science and technology spend their time fighting with each other over next years' funding, not working together to deliver quality services to Maine companies.

One case study, however, provides some insight into the way that state-funded investments at the University of Maine can be translated into innovation-based economic development. In 1997, the state matched a $1.2 million EPSCoR grant for investment in aquaculture. As detailed in the case study (see Part III, Appendix 1), the grant leveraged the hiring of five new marine scientists and the construction of the Marine Culture Laboratory at the Darling Center in Walpole. Largely because of the efforts of the Maine Aquaculture Innovation Center and several key industry players, a strategic plan for aquaculture in Maine was developed in 1990 and updated in 1997. These plans detailed Maine's competitive advantages in aquaculture and listed key actions that needed to be completed to build upon those advantages. The actions included the hiring of specific expertise in marine science and the development of key laboratories and facilities — goals that were accomplished with the EPSCoR funding and state match and other investments. The actions also included working on specific non-technical barriers such as regulation of marine leases, and training on the business of aquaculture. Further, definitive research agendas were identified and pursued by University faculty in conjunction with industry. The results of the research have already paid off as evidenced by the growth of shellfish aquaculture firms in the state.

Study Limitations

This study has several limitations. First, except for information garnered from case studies, it has had to rely on secondary data. These data reflect broad trends but their compilation and reporting can lag behind emerging trends. Also, they are typically too highly aggregated to capture the impacts of specific state-funded R&D programs. For instance, the most recent technology employment data in the Bureau of Labor

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[31] The Maine Patent Program is, by statute, aimed at serving individuals and companies. It is not intended nor planned to assist the state's public or private not for profit research entities. A complete description of the Maine Patent Program is included in Appendix 2.

[32] A website, mainescience.org, contains detailed information and links on programs and services available to businesses and the public. The Department of Economic and Community Develop ment, the Finance Authority of Maine, and Maine & Company also have service and informa tion mechanisms to help with this function. However, no one organization has overall respon sibility that is client focused. In other states, these functions are given to technology transfer agents from a statewide entity with specific science and technology objectives.

Statistics' *County Business Patterns* are for 1996, not recent enough to provide much useful information relative to investments between 1996 and 2001. Indicator data alone are not sufficient to provide a timely understanding of what has happened.

Second, as noted, the study's limited scope and duration permitted only a small number of interviews and case studies to be conducted. Thus, while informative and illustrative of main themes and emerging trends, the data collected during the study are not necessarily generalizable to the states as a whole, or to other states.

Third, the primary data that do exist are heterogeneous and not comparable. No single evaluation-focused data collection system is in place. Primary data were not available on the range of indicators identified as relevant by the evaluation team for most of the programs identified above. That is largely because the stakeholders have not been required to collect outcome data prior to this specific effort. Insufficient time and resources were available during the course of this project to complete new primary data collection on all the programs included in the evaluation.

Fourth, not all of Maine's R&D programs were subjects of case studies. Therefore, the results of these five studies do not provide information about programs not included. For example, the case study of aquaculture contains information about the Maine Aquaculture Innovation Center but nothing about the Center for Innovation in Biotechnology.

Fifth, as noted in several places in this report, Maine's R&D programs are of recent origin. It is very early in the life cycle of the investments to expect tangible results. Many of the substantial investments made in the mid-1990s, for instance, involved capital outlays. Those buildings and equipment are just coming on line in 2000 and 2001, and research that has been enabled by these investments is just starting. Even later-stage investments, such as Small Enterprise Growth Fund, require several years of operation before the overall success or failure of the client businesses can be determined. Even then, the nature of the science and technology enterprise, especially the entrepreneurial one, is characterized by economic uncertainty, as evidenced by EnvisioNet's recent history.

Sixth, the study was not designed to evaluate the performance of specific programs. More generally, the report's emphasis on indicators is a step removed from determination of causality. Multiple methods exist to more formally test for cause-and-effect relationships; for example, the performance of recipients of state R&D funds can be compared with a control group to establish the difference between outcomes with intervention and outcomes without intervention. The evaluation process described in Part II indeed proposes this type of analysis. To conduct such an examination requires data from the recipients that are not currently available.

Methodology

Criteria for Choosing Programs to Include

The first task of the initial evaluation was to decide the criteria to be used to determine whether a program or investment was part of Maine's public R&D investment. The criteria we chose were:

- The program's objectives should be to fund or support research and development in Maine, or the commercialization of research.
- The program should be publicly funded in the form of a state appropriation, deferred revenues, or bonds.
- The program should support the development of new science, technology, products, or processes as opposed to the application of existing science, technology, products or processes.

This is a refinement of the Comprehensive Guide's definition of Maine's publicly funded enterprise: "Those activities, expenditures and facilities whose purpose is to discover new scientific knowledge that can be developed into commercially viable products or processes." This definition does not encompass all science and technology activities in the state, but it does include a broad range of R&D programs. The legislature stipulated that the investments fall into two categories: capital investment programs and research and development programs.

Capital investment programs involve funds used exclusively for equipment and capital improvements intended to support R&D activities. Investment in R&D programs includes funds for a range of expenses including personnel costs and other operating expenses.

As mentioned in the Comprehensive Guide, educational programs and programs designed to increase productivity were not included, although they are related to the broader science and technology enterprise. However, programs that support graduate student stipends are included as they are a vital component of the R&D environment. A complete list of programs included in this evaluation is included in Part III, Appendix 2.

Several programs were considered for inclusion in the evaluation and eventually dropped. The Department of Agriculture's Potato Marketing Improvement Fund and the Agriculture Development Grant programs were dropped because they were judged to be bringing only existing technologies to farmers. Similarly, the Aquaculture Research Fund and the various specific fishery programs (e.g., Eel and Elver Management) were dropped because they are supported by fees, not state funds, and because they are tracking stocks, not performing new R&D. Finally, research and development programs in the Department of Conservation, the Department of Environmental Protection, and the Department of Inland Fisheries and Wildlife were judged to be not material upon review of the agencies' strategic plans.

Program and Impact Theories

Once we chose the programs for inclusion, we analyzed each one for its statutory and operational objectives and activities. Based on reviews of legislation, documents provided by the program's management, interviews with the leadership of the programs, and review of relevant agency strategic plans, we prepared a description of each program. These descriptions are included in Part III, Appendix 2. During interviews with the program leaders, important stakeholders in the evaluation process, we also identified what input, output, and outcome data are currently being collected by the programs. A list of all interviews conducted for this phase and the case studies is included in Appendix 8.

We used the data on the programs to construct program theories for each program. These included a description of the inputs, outputs, intermediate and end outcomes expected. When combined, the program theories showed remarkable consistency, allowing the selection of thirty-six indicators to describe Maine's progress in research and development. The program theory analysis is shown in Part III, Appendix 3. Appendix 4 contains the specific recommendations on how to collect data for each program.

Indicator Analysis

The study relied primarily on indicator analysis and case studies to formulate answers to the three questions. Using the indicators chosen from the program theory analysis conducted above, we collected data for each indicator for Maine, the U.S., other EPSCoR states, and other New England states. Data were not readily available for the adjacent provinces of Canada (Quebec, New Brunswick, Prince Edward Island and Nova Scotia), although we suggest that data for these jurisdictions be included in future evaluations because they constitute economic competitors for several of Maine's targeted industries. The results of the indicator analysis are included in Part III, Appendix 5.

Our analysis of the indicator data compared Maine's progress against the following regions:

- Aggregate or average of the United States;
- Aggregate or average of other states that have been designated by the federal government under the Experimental Program to Stimulate Competitive Research (EPSCoR); and
- Aggregate or average of other New England states (Connecticut, Rhode Island, Vermont, New Hampshire, and Massachusetts).

We included the U.S. as a whole to capture national trends due to international competitiveness changes (fluctuating exchange rates, macroeconomic conditions, trade policy changes). We included the EPSCoR states as a whole because they are considered to have many of the same structural characteristics in their R&D and state innovation systems (small populations, below average per capita income, limited university success in competing for federal academic R&D awards, etc.) as does Maine. Moreover, the EPSCoR states constitute a well-defined group, whose members frequently compare their standing and progress against one another. We chose to include the New England states because of geographical proximity, which leads them to compete in product and labor markets. They tend to be compared by businesses seeking to establish or expand their location in the northeast and, by workers and their families seeking to locate in or commute from or to. The adjacent Canadian provinces should also be included due to proximity and similarities in their natural resources that also lead certain types of businesses to consider locations there as well as Maine.

Case Studies

The study team conducted five case studies. Our objective was to use the case studies to collect primary data on a subset of the programs and to gain a detailed understanding of the dynamics of innovation-based economic development in Maine.

Based on an analysis of the programs included in the evaluation, we determined that the appropriate case study model was a program operated by a stakeholder combined with a specific recipient of that program. In practice, institutions and firms can and do participate in a number of different state programs. To maximize the value of the information received from a limited number of case studies, when possible, we chose recipients with multiple ties into the range of R&D investments over those with fewer ties.

During the period of the project where interviews with stakeholder organizations, legislators, and other interested parties were being conducted, each was asked to provide candidates for the case studies. Linkages between multiple programs and other data were collected about each candidate.

We used four criteria to choose among the list of candidates. First, the case studies should represent the wide geographic diversity of the state of Maine, with a cross-section of both rural and metro-based recipients. Second, the seven industry sectors should be represented, if possible. Third, cases should cover the range of stage of development represented by the programs in the evaluation. Not all should be in advanced stages of commercialization, for instance. Finally, the range of different types of recipients should be covered: researchers, not-for-profit organizations, and for-profit companies.

We conducted interviews with individuals associated with each case. The Case Study Protocol is enclosed in Part III, Appendix 6. All case studies were reviewed by the persons interviewed and factual corrections were made. The evaluators collected other documents and secondary data to verify, confirm, augment, and expand the scope of the information obtained from the case study interviews. These documents included:

- Statutes authorizing the programs in question;
- Program descriptions;
- Program operational guidelines;
- Program funding history;
- Recipient history and background;
- Industry background and trends; and
- General Maine economic trend information.

We completed the following case studies. They are presented in Part III, Appendix 1.

- Aquaculture;
- Maine Biomedical Research Program;
- Small Enterprise Growth Fund;
- Maine Technology Institute; and
- Wood Composites.

While this was not an explicit criterion, it turns out that the programs covered by these case studies represent the vast majority of the R&D funds publicly invested in Maine. (It is hard to quantify this exactly because the funds were spent in different years. However, each of these programs is a multi-million dollar investment, compared to many of the other state programs that are less than $250,000 annually.)

Implications for Metrics and Data Collection

This initial evaluation shows the critical need for the primary data from the recipients of the state's R&D investment. Without these data we can only glimpse what has happened so far. Absent primary data on program outputs and outcomes, it will not be possible to determine program impacts, to test for cause-and-effect relationships, and thus, to conclude with reasonable confidence that the programs, in the aggregate, or singularly, have been effective.

Second, the initial evaluation underlines the critical need for a centralized data collection system, enabling a company and researcher-focused view of outcomes rather than a program-oriented view. If understanding the overall impact of the R&D investment is the objective, then the interactions among programs must be taken into account.

Third, the initial evaluation shows the importance of a process of evaluation that is replicated year after year, to capture outcomes as they emerge, sometimes many years after the initial investment. A process will also enable the R&D investment system to improve over time as intermediate outcomes emerge and suggest the need for mid-term course corrections.

Part II of this report details the process for future evaluation including a specification for an annual survey of all recipients including researchers and companies. Part II calls for a collaborative and interactive process among MSTF and all the stakeholders that operate programs included in the evaluation, one that can build bridges and linkages to better serve the people of Maine.

PART II

Process for Future Evaluations

The process of evaluating public investments is beneficial to all participants — legislators, stakeholders, and recipients alike. It can shed light on outcomes with respect to legislative intent and may provide valuable data so that program managers can improve their delivery of services. Investment recipients get a clear indication of what outcomes are desired up front to help them decide whether or not a program is appropriate for their needs.

In a case like Maine's, where many programs are involved, the process itself, especially if it is highly participatory and collaborative, can build bridges between stakeholder organizations and among the recipients. Since evaluation requires discussion and agreement about specific outcomes, organizations that might have previously worked at cross-purposes now have a tool to help forge a consensus.

This document outlines a collaborative process to build an evaluation system for public investment in research and development (R&D) in Maine. The process outlined below is necessary, if not sufficient, for analysts to begin to address not just the correlation between inputs (i.e. Maine's R&D investments) and outcomes (innovation-based economic development), but causality as well.

Maine's Three Questions

The three questions posed by the legislature are:

1. *How competitive is Maine's publicly funded R&D and has the state's competitiveness improved over time?*
2. *What is the impact of Maine's R&D investment on the development of Maine's R&D industry?*
3. *What is the impact of Maine's R&D investment on the level of innovation and innovation-based economic development?*

The first question is a question of Maine's R&D performance in relation to its competitors. For this evaluation, we are defining Maine's competitors in four ways. First, Maine competes with its neighbors in New England. Second, in the R&D arena, Maine competes with the other EPSCoR[1] states. Third, Maine competes with the adjacent Canadian provinces — Quebec, New Brunswick, Nova Scotia and Prince Edward Island. Finally, Maine competes with the U.S. as a whole.

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[1] EPSCoR is the acronym for the Experimental Program to Stimulate Competitive Research.

The second question is an impact assessment question asked about the R&D industry. The R&D industry consists of those entities whose primary output is research and development. These industries include the doctoral universities, not-for-profit research entities, and some private businesses.

The third question asks about the impact on overall economic development in Maine. How has Maine's level of innovation and innovation-based economy changed as a result of these investments?

Stakeholder Involvement

The key to a successful evaluation project is stakeholder involvement and commitment. With the stakeholders' partnership, this process can be relatively simple and provide important information for all involved. Without stakeholders' support, this process will likely be laborious and, perhaps, impossible.

A stakeholder is defined as any organization that operates one of the programs defined as being included in the evaluation. Other, related organizations, such as the Department of Economic and Community Development and the State Planning Office, might also be included. The following steps are recommended to gain stakeholder commitment and partnership.

1. The Maine Science and Technology Foundation (MSTF) should engage all stakeholders in informational meetings and general discussions. An advisory panel of key stakeholders and recipients should be empanelled to work with the evaluation team at a more detailed level during the process. The advisory panel should include representatives of both the stakeholders who serve companies (i.e. Maine Technology Institute) and the stakeholders who serve researchers (i.e. University of Maine). Other members should be selected by MSTF based on interest and experience.

2. MSTF should review this plan with all stakeholders to the maximum extent possible to achieve individual stakeholder aims without compromising other, broader goals. Topics to be discussed by the advisory panel would include:

- What are the appropriate numerical goals for each indicator?
- What specific questions should be asked in the surveys? A limited number of questions could be included that respond to specific stakeholder issues as long as the total length of the survey is kept to a minimum.
- What is the best way to organize the data collection effort, especially the survey?
- How should the data be managed and maintained? Who has the right to use or publish the data, and what approach should be used to maintain confidentiality?

3. MSTF may find it appropriate to execute a Memorandum of Understanding with each stakeholder regarding the decisions made by the advisory board.

4. After each year's survey and analysis, each stakeholder should be provided with an individual report of its impacts, as well as access to its individual data. The level of detail in these reports will likely depend upon the response rate. If, for in-

stance, a program only has three recipients that respond to the survey, it will be difficult to provide anything other than aggregate results without compromising the confidentiality of the individual company/researcher's data.

5. MSTF should hold annual meetings with stakeholders after the results have been disseminated to discuss how to improve the process during the following year. Potential areas for improvement include the data management system, exact wording of the survey, and the addition of new indicators.

Maine's Evaluation of R&D Investments: What to Include

Enacted in 1999, 5 MRSA §13122-J and §13122-K directed MSTF to develop a plan for a comprehensive evaluation of state investments in research and development. In 2000, MSTF developed "A Comprehensive Guide to Evaluating Maine's Public Investments in Research and Development." In late 2000, MSTF held a nationwide competition to choose nationally recognized, independent reviewers to conduct an initial evaluation and to develop a strategy to assess these investments in the future.

The "Comprehensive Guide" included the following definition of Maine's publicly funded enterprise [as]: "Those activities, expenditures and facilities whose purpose is to discover new scientific knowledge that can be developed into commercially viable products or processes."[2] This definition does not encompass all science and technology activities in the state, but it does include a broad range of R&D programs. The legislature stipulated that the investments fall into one of two categories: capital investment programs and research and development programs.

Capital investment programs involve funds used exclusively for equipment and capital improvements intended to support R&D activities. Investments in R&D programs include funds for a range of expenses, including personnel costs and other operating expenses.

Educational programs and programs designed to increase productivity were not included in the "Comprehensive Guide," although they are related to the broader science and technology enterprise. However, programs that support graduate student stipends are included as they are a vital component of the R&D environment.

Therefore, the three criteria for including a program in this evaluation are:

- The program's objectives should be to fund or support research and development in Maine, or the commercialization of research.
- The program should be publicly funded in the form of an appropriation or bond.
- The program should support the development of new science, technology, products, or processes as opposed to the application of existing science, technology, products, or processes.

[2] Maine Science and Technology Foundation, *A Comprehensive Guide to Evaluating Maine's Public Investments in Research and Development,* 2000.

Establishing Relevant Outcomes

Experts generally assess the effectiveness of R&D in stimulating economic development by measuring "end outcomes" such as jobs and businesses created, and income generated, and/or "intermediate outcomes," such as the number of publications or patents, or volume of research generated. Those intermediate outcomes are regarded as "leading indicators" or harbingers of success.

For all programs in the evaluation, a program analysis, such as the one included in Part III, Appendix 3, should be conducted to ensure that all relevant outcomes are being considered.

The indicators to be used in this evaluation are listed below.

Intermediate outcomes *for researchers*:

- Science and engineering (S&E) graduate students;
- Recent S&E PhDs and Masters in the workforce;
- Federal R&D obligations by agency;
- University-performed R&D expenditures;
- Patents;
- Patent citations;
- Publications; and
- New sponsored research programs with Maine companies.

Intermediate outcomes *for companies*:[3]

- Patents;
- Patent citations; and
- Amount of new capital raised including venture capital, SBIRs and other federal grants, mergers and acquisitions, initial public offerings (IPOs), etc.

End outcomes, by industry sector:

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

Setting Goals

Since evaluation is a process, it needs to be an ongoing exercise in which each year's results inform the next year's actions. To do this, a normative judgment needs to be made. Are these results good, bad, or indifferent? A normative judgment requires a standard or a benchmark. For example, if the recipients of Maine's R&D investments file twenty patents during the next year, would that be good?

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[3] New products and processes would be an obvious intermediate outcome. However, there is no national database for this measure, so comparable data would be impossible to get. Therefore, this indicator is not suggested at this time.

Setting goals for each of the indicators is a key task of the stakeholders and MSTF. There needs to be a realistic assessment of where Maine is, where Maine could go, and what resources are available. Good goals are stretch goals, requiring a sustained effort by the entire team, but are not set so high that they seem unattainable. Goals that are set too low will reduce the credibility of the entire enterprise, since reaching them will not be much of an accomplishment.

Monitoring the Outcomes

Having decided upon the outcomes and indicators of interest, how should they be used to answer the three questions? An analysis conducted on three levels is required: global, recipients only, and case studies. This approach is richer than a recipient-based evaluation on its own which tends to understate the social benefits of these types of programs.[4]

Global indicators

On the global level, statistics for the indicators listed above should be collected from secondary sources for all of Maine. These statistics should then be compared with the same indicators for the aggregate (average) of the other New England states, the EPSCoR states, the adjacent Canadian provinces, and the nation.

In addition, the statistics defined by "30 and 1000,"[5] specifically, R&D expenditures per employed worker and per capita income as defined by the State Planning Office, should be included in the comparisons.

Recipients only

Most of the stakeholders currently collect some data on inputs and outputs. Few collect any outcome data and none collect data on all the indicators needed. The details of data collected, when applicable, are included in Part III, Appendix 2.

To answer the impact questions posed by MSTF and the legislature, an annual survey of all ultimate recipients of Maine's R&D investments should be conducted. Through this mechanism, a clearer picture will emerge of the impacts of those investments. As discussed later, this comparison between the recipients' results and Maine as a whole will advance an understanding of causal links between R&D investments and economic development.

The ultimate recipients — not the intermediate stakeholders — should be surveyed, for several reasons. First, the recipients are in the best position to say what the impact has been, whether in terms of employment or knowledge generation. Second, surveying the stakeholders would mean relying on a variety of data collection techniques on their part, lessening the validity of the combined data. Third, keeping the

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[4] Feller, Irwin and Nelson, Jon P., "The microeconomics of manufacturing modernization pro grams," *Research Policy,* 1999, 28:807 818.

[5] State Planning Office, "30 and 1000: How to Build a Knowledge based Economy in Maine and Raise Incomes to the National Average by 2010," October 2000.

monitoring task separate relieves stakeholders of the operational burden that would otherwise by borne if evaluation were part of their task.

Case studies

Five-to-ten case studies should be performed annually to augment the global indicator analysis and the recipient impact analysis. The case studies will help reveal the process of commercialization in Maine and identify what is working and what needs improvement. It is important, of course, for the case studies to be designed and conducted according to best scholarly practices.[6]

Data Collection

Global

To complete this evaluation, data for every indicator need to be collected from secondary sources. Data for the initial evaluation, including sources, are shown in Part III: Appendix 5. To the extent possible, time series data should be developed to allow an analysis of trends. Data from 1990 and 1995 will establish a baseline of performance prior to Maine's increased investment.

Recipients

An annual survey of all recipients of Maine's R&D investments should be conducted to capture information while it is fresh in the recipients' memory, even if analysis is done less frequently. The recipients already perform annual tallies (e.g., annual reports, annual accounting, etc.); the proposed surveys could be coordinated with these activities.

Case studies

Case studies should be chosen to cover a broad range of circumstances in Maine. Diversity of the following types is important for selection of cases:

- Geographic location;
- Industry sector;
- Stage of development being addressed by the program; and
- Type of recipient.

Case studies require pairings of a stakeholder/program and a recipient. The complete case study protocol is included in Part III: Appendix 6.

Annual Survey

Who to survey

The question of what is an appropriate unit of analysis has challenged many economic development evaluation projects. The first instinct is to evaluate the specific project that has been subsidized by taxpayer funds. The biggest challenge is that many

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[6] For example, as defined by Dillman, Don A., *Mail and Internet Surveys*, 2nd ed., New York: John Wiley & Sons, Inc., 2000.

recipients, especially companies, do not maintain records on a project basis. Research work may support a specific product line, or it may support all of the company's products. Companies, especially smaller ones, often do not keep records at the product-line level. Larger companies, which may have the sophisticated accounting systems to track results at the product-line level, are often reluctant to release this information.

In the evaluation of Maine's publicly supported R&D, another challenge arises because so many programs are included. How will a recipient track the difference in impact between a Maine Technology Institute (MTI) grant, for instance, and the assistance received from being a tenant in an Applied Technology Development Center incubator? How will a researcher separate the results achieved from having a new laboratory from the results achieved by having a new post-doc for assistance?

Because the impact assessment requested by the legislature is for the overall R&D investment, and for the reasons outlined above, the appropriate unit of analysis is the company and the researcher, not the project.

Definition of a recipient

As implied above, two types of surveys should be done, one for companies and one for researchers. For companies, the recipient is the location where the funded work occurred. For researchers, the recipient is the individual or laboratory that received the funding or matching funds. For each program, the mix of recipients will be somewhat different. The appropriate survey format for each program is described in Part III: Appendix 4.

Sample frame. All recipients should be surveyed, not a sample of the recipients, since the total number of recipients to survey is relatively small. Taking a statistically representative sample would be difficult, especially considering that it is likely that the range of impacts will be quite wide. If the survey were done with a sample, the probability of missing a significant impact would be high. Also, sampling would limit the statistical validity of the results. Surveying all recipients creates another complication — the results will be directly dependent upon the response rate: the results will understate the real impact unless the response rate is 100 percent, which is unlikely.

In addition, once recipients are added to the survey list, they will be surveyed each year they are on the active list and for the five years thereafter. For instance if a company is in an incubator for three years, it will be on the active list for three years, and the follow-up list for five years thereafter for a total of eight years. This is to capture the out-year impacts that accrue from R&D investments. Note that although some of the programs have completed their grant-making duties, their recipients would be included until a total of five years has passed since they received their grant.

Attribution to specific programs, multiple attributions. Once a year, approximately two months before the survey is to be done, all stakeholders should submit to MSTF the list of their recipients that fit the definitions above. That would be considered the active list for that particular year. MSTF (or the evaluation contractor) would then consolidate the list. This involves the following steps:

1. Find duplications of researchers and companies submitted by different stakeholders. Attribute companies and researchers to their stakeholders. Find duplications of researchers and companies submitted by different stakeholders. A company and researcher can have multiple attributions. For instance, ABC Company may be attributed to three stakeholders — MTI, The Center for Environmental Enterprise, and the Patent Program.

2. Add to the survey list any companies and researchers who are no longer on the active list, but are in their five-year follow-up period. This is best accomplished by consolidating the new list for each year with the previous year's list, and removing any recipient who is past their five-year limit.

Since there are often many different spellings associated with companies, and abbreviations, we suggest that stakeholders start maintaining records of companies they have worked with by the company's Federal ID number. That will reduce the opportunity for confusion. (It may also be helpful to maintain researcher records by a unique identifier — their Social Security Number, perhaps, but there are privacy issues.)

Another concern is with company contact names, especially with larger organizations. Those are the people that will actually be asked to respond for the company. It is also difficult to maintain records for the five-year follow-up period and find individuals able to attribute particular impacts to earlier interventions. The stakeholders need to work on keeping in touch with their client companies and researchers and maintaining accurate records.

When to survey

It is also important to time the survey appropriately. For the convenience of the legislature, it would be most helpful to have results by the end of the calendar year in preparation for the new budget cycle. This implies a data collection schedule in July and August, with September and October designated for analysis and reporting.

This calendar might also be agreeable to agencies and university personnel whose fiscal years start on July 1. Reports completed in the summer would include data useful for this evaluation. This schedule may be problematic for companies that operate on a different fiscal year, since gathering data for July to June is not part of their normal data management procedures. However, we find the government's schedule compelling in this case and recommend that the annual survey be conducted immediately following the end of the government's fiscal year in July.[7]

What to ask

The specific questions to ask of researchers and companies are probably best decided by the stakeholders as a group. The University of Maine, for instance, collects a Research and Development Annual Report from each researcher. This report includes:

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[7] In the worst case, the evaluation could use data from companies with a different fiscal year that came from a different reporting period.

- Proposals made;
- Presentations made;
- New companies formed;
- Patents;
- Copyrights;
- Disclosures;
- Collaborations;
- Plant breeder's rights;
- Licensing agreements;
- Publications; and
- Industry Sponsored Activity Positions (FTEs) Supported on R&D Funds or Extramural Funds.

If, in fact, this sort of report were also done at the other Maine universities or at the not-for-profits, it would behoove us to figure out how to obtain those data as opposed to asking the researchers to provide it again. Furthermore, as the University and other research organizations begin to collect and maintain these data electronically, an agreement to share the data for the evaluation should be executed to minimize the amount of time researchers need to spend documenting their activities.

Similarly, the questions asked of companies need to cover the indicators of interest and other data of importance to the stakeholders. A critical trade-off, however, is to limit the length of the survey instrument as much as possible since there is a correlation between length of survey and non-response.

The survey instrument should include a series of questions about the respondents' demographics — size, age of company, industry sector, location (by region, to later check rural versus metro) — and then include questions to cover the indicators, such as: "according to our records, your company has received the following assistance from the State of Maine for research and development from (list of stakeholders and years they claim the company)." Based on this assistance:

1. How many jobs have been created, saved, or lost this year?

2. What is your total employment at the end of this period? What is your total payroll at the end of the year?

3. How much new capital have you raised this year (split into venture capital, other new funding)? Did you go public? Did you merge with or acquire a company?

4. Did you receive any new federal grants this year? SBIRs, STTRs, ATPs? How many grants and how much money?

5. How many new patents have you applied for this year? How many have been awarded this year? How many new products or processes were introduced?

6. How many new projects were started with Maine university researchers? How many projects with Maine non-profit research organization?

The survey needs to assure companies that their information will only be revealed publicly in aggregate. Most companies that are recipients are not public and do not have to reveal this information.

How to survey

There are two possible methods for administering this type of survey. Both have their pluses and minuses. Both should be used in the early years and adjustments made as experience warrants.

The traditional method for conducting these sorts of surveys is by a combination of mail and telephone follow-up. In this method, a cover letter (from the Governor or MSTF president) would go out with a hard copy of the survey instrument. The letter would thank the recipient for their participation in the survey, stress its importance, and ask for a prompt reply. A self-addressed, business-reply envelope would be included. After a reasonable period of time, follow-up postcards would be mailed, and then the survey team would phone non-respondents and ask for their information.

Another method is a combination of e-mail/Web. The advantage of this approach is that it will substantially reduce the costs by reducing postage and data entry time.

Difficulties still exist in using Web and e-mail based surveys. Connectivity is not universal. Considerable heterogeneity exists in browser capabilities and line transmission speeds available to respondents. Designing a Web-based survey that will generate adequate response rates is still a new art.[8]

Using this method, the cover letter is sent in the form of an e-mail. Included in the e-mail is a pointer to a Website where the survey appears. The respondent would fill in the survey (the same questions as the hard copy version.) Their answers would automatically be included in the master database. Response rates can be tracked and follow-up e-mails sent.

The e-mail/Web combination should be tried in some preliminary fashion before the actual first survey to ascertain what type of response rate is likely to be obtained. In either case, the survey instrument should be tested each time it is altered before a full-blown data collection effort is mounted.

Defining a control group for survey

With the data collected from the survey instrument described above, the evaluators will be able to say, "The recipients of Maine's R&D investment attribute the following results to that investment." This is not as strong as being able to say that the investment caused the impact. One way to address causality is to compare outcomes for the recipients against outcomes for a control group of businesses and individuals.

Ideal control groups are defined randomly before interventions are made. This is not appropriate for this case. Most recipients of Maine's R&D investment are chosen via a merit-based application procedure. When this is not true, the recipients are self-selected, that is, they chose to take advantage of a tax credit, the SBIR, or a patent assistance program.

This self-selection/merit-selection process also makes it difficult to identify a matching group of companies or researchers who are the same in every respect except whether or not they have used the programs. Presumably, many of the recipients are

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[8] Dillman, Don A., *Mail and Internet Surveys*, 2nd ed., New York: John Wiley & Sons, Inc. 2000. Chapter 11.

in fact better qualified than the non-recipients, since they were primarily chosen through competition.

This leaves us with the choice of a generic control group, in this case other companies and researchers in Maine as a whole. (A less acceptable alternative would be other companies and researchers in another state, but that adds other variables, such as state-level differences in the economy, geography, competition, etc.) While the generic control is clearly not ideal, it is the best possible.

Data Analysis

The first step in the analysis of the data collected from the surveys will be simple. Add together all the results from a particular question and compare to known statistics from the population as a whole. For instance, if the total new employment reported from companies responding to the survey is 200, we compare it to statistics for the State of Maine for the same year for net employment. Since all recipients are being surveyed, no adjustment is necessary for the sample size. (However, response rate will dramatically affect the totals. Unless a 100 percent response rate is gained, the results will be understated.)

Segregate the results by the various demographic and programmatic attributes that have been collected and compare these, where possible, to statewide numbers. For instance, the number of net jobs can be tabulated for each region, each sector, by age of company, by size of company.

Next, the impact numbers — which in aggregate form the direct impact — may be used with economic impact assessment software, such as IMPLAN, to ascertain the indirect and induced impacts.

Third, use statistical analysis to compare the results from the recipients with the results from the control group. This analysis will reveal to what extent the impacts are a result of the interventions being tested and to what extent they are a result of chance.

These three steps will enable the evaluators to answer the questions: *What is the impact of Maine's R&D investment on the development of Maine's R&D industry? What is the impact of Maine's R&D investment on the level of innovation and innovation-based economic development?* Separate out the University of Maine, the non-profit research institutions, and the few private research companies to answer question two specifically.

Fourth, the evaluators will compare recipient results with statewide results and the average results of neighboring states, other EPSCoR states, the adjacent Canadian provinces, and the nation. The data should be adjusted by population or other appropriate norm to facilitate comparisons. The most important outcome of this analysis is the direction of trends in the data over time. Is Maine's share of total federal R&D increasing or decreasing compared to the other EPSCoR states? To what extents do the results of the recipient researchers lead this trend? This will help answer the question: *How competitive is Maine's publicly funded R&D and has the state's competitiveness improved over time?* Comparing the results for the University of Maine, for instance, with other land grant universities in New England, and the Jackson Laboratory with other independent research institutions that support NIH, will also support Question Two.

Finally, the evaluators will use the case studies to demonstrate the trends at a micro-level, as well as illuminate any issues that may be holding Maine back.

Reporting Findings

An annual report to the Governor and the legislature is envisioned, containing the findings as they relate to the three questions. A section on methodology should be included, noting any changes from previous years. Adequate documentation of all sources is critical. Whenever possible, findings should be set in the context of other statewide science and technology documents, including the *Action Plan for Science and Technology* and the *Science and Technology Innovation Index*.

APPENDIX 1
Five Case Studies

Five case studies were conducted as part of the initial evaluation. The objective of the case studies was to collect primary data on a subset of the programs and to gain a detailed understanding of the dynamics of innovation-based economic development in Maine.

These case studies, however, are limited in scope. They do not represent a program evaluation of the case in particular and have limited applicability to other programs. They are useful for the insights provided, but are not representative of Maine's R&D programs.

Case studies, when used in this way, should be interpreted as a collection of facts about a certain circumstance, and are not evaluations. A description of the methodology used is included in Appendix 6, Case Study Protocol.

1. *Advanced Engineered Wood Composites*

The Industry: Engineered Wood

In recent years, the wood industry has been experiencing a dwindling supply of high-grade structural timber. A new class of materials — advanced engineered wood composites — allows the use of lower-grade wood to achieve the same, if not better results than structural timber. Engineered wood products, including "plastic wood" decking, reinforced floor joists, and various laminated structural beams, are expanding quickly in housing and construction markets. New methods of combining wood fibers with resins, plastics and glass have created elaborate composite materials that are more durable and stable than regular lumber, stronger than steel, and environmentally friendly because they use wood waste.[1]

Wood-nonwood composites are potential replacements for concrete and steel, and make use of the lower-grade wood timber prevalent in Maine. The benefits of wood composites include reduced construction costs, decreased pressures on wood supply, increased strength and stiffness, enhanced ductility, improved creep characteristics, reduced variability in mechanical properties, allowance for use of low-grade wood in construction, increased structural efficiency, and improved serviceability.

The markets for many of these products are growing. For instance, the APA-the Engineering Wood Association says that over 40.3 billion square feet of structural wood panels were manufactured in 2000; marking the eighth consecutive year that industry production had set a record. Among other engineered wood products, glulam output increased in 2000 while wood I-joists and laminated veneer lumber fell slightly.[2]

Maine's share of this market is negligible.[3] The major engineered wood product companies, such as TrusJoist, Boise Cascade, Louisiana Pacific and Willamette, already have production facilities in place, mainly in the South, Northwest and across Canada.

However, more than 80 percent of Maine's land base is forested. Most of the 17.7 million acres of forestland is privately owned. Small wood lot owners own about half of this acreage, with the other half owned by large industrial forest companies[4]. Be-

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[1] Day, Adam, "Not your ordinary wood," *Mainebiz,* Vol. 7, No. 1., January 8, 2001.

[2] http://www.apawood.org

[3] One related company in Maine, Brunswick Technologies, is a leading producer and developer of engineered fiberglass reinforced fabrics. Established in 1984, Brunswick Technologies went public in 1997 and reported revenues of nearly $45 million in 1999. Brunswick is a leading Maine supporter of advanced engineered wood composites research at the University of Maine.

[4] Maine Agricultural and Forest Experiment Station, "Plan of Work Federal Fiscal Years 2000 2004," University of Maine.

tween 1998 and 2000, 4.8 million acres have changed hands, often going to companies with little or no experience in the pulp and paper industry. Instead, institutional investors — pension funds, insurance companies, and private investors — now own 15 percent of Maine's timberland.[5]

The timberland has traditionally supported a pulp and paper industry in Maine. However, that industry has undergone quite a lot of change over the past twenty years. Employment has dropped from 18,000 to 14,000. There are only 500 loggers working today; in the late 1950s there were 6,000. Consolidation is occurring among Maine's sixteen paper mills.[6]

The Stakeholder: Advanced Engineered Wood Composites Center

In the mid 1980s, Professor Habib Dagher of the University of Maine started looking at engineered wood using new adhesive technologies to build stronger materials. He received an early Innovative Bridge Program grant from the federal Department of Transportation to work on demonstration bridges.

The Center began in 1991 as a small pilot study (2 percent of a National Science Foundation (NSF) EPSCoR grant to the University of Maine). This study culminated in 1995 when the University developed the first fiber-reinforced polymer timber ocean pier. In 1996, NSF awarded $2.1 million to the University; $900,000 was used to establish the Advanced Engineered Wood Composites Center (AEWC).

The construction of the laboratory/center was funded by a $2.1 million grant from the U.S. Department of Commerce, Economic Development Administration, and an additional $2.1 million was raised through a variety of public and private sources including $350,000 from Governor King and the legislature. In 1998, the NSF awarded an additional $700,000 equipment grant for the laboratory. The match raised by the university brought the total to $1.1 million. This funded the Composite Materials Manufacturing Science Laboratory.

The Center officially opened its doors on June 1, 2000 in a new, 33,000 square-foot facility that is a state-of-the-art shop for integrated composite-materials/structural component development. The Center is an interdisciplinary group, including engineering, wood science, and business. Its goals are service to local industry, training and research.

The Center's capabilities are designed to allow the development of a composite material or structure from conceptual stage through research, manufacturing of pilot or full-scale prototypes, and subsequent comprehensive testing and evaluation. The Center's resources include:

- Composite materials manufacturing science laboratory;
- Microscopy laboratory;
- Micromechanics and NDE laboratory;

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[5] Clark, Jeff, "Are Maine's Paper Mills Doomed?" *Down East,* August 2001.

[6] Ibid.

- Computer modeling and visualization laboratory;
- Structural testing laboratory;
- Polymer and interface science laboratory;
- Mechanical testing laboratory;
- Machine shop; and
- Environmental testing laboratory.

From 1991 to 1998, the research team grew from one to twenty-one faculty members, professional and support staff. In 1998 alone, three new faculty members were hired. Sixteen were educated outside Maine. Ninety-seven undergraduates, sixty-five from Maine, eighteen from the rest of the U.S. and fourteen from around the world, have been supported by the Center since 1997. Over the past three years, an additional twenty-five students have attended a nine-week summer program, Research Experience for Undergraduates, sponsored by NSF. Students are selected nationwide based on field of study, academic record and recommendations.

The Recipient: Kenway Corporation

Kenway Corporation, located in a facility in Augusta, Maine, is a custom fiberglass fabricator, with 80 percent of its $3–$3.5 million revenue from the pulp and paper industry. Eighty percent of their revenues come from within a 100-mile radius (basically, within Maine). Ken Priest and his brother now own the company, which was founded in 1947 by their father to make wooden pleasure boats.

Kenway employs 32 workers. About 50 percent are entry-level laminators who are trained in-house. Another 35 percent are machinists while 10-to-15 percent are mold and toolmakers, the most advanced trade. Kenway has three engineers on staff, including Priest. Only one of the engineers has a master's degree; the other two have bachelor's degrees.

Since most of the work is custom, a high level of handwork is involved in the manufacture of existing Kenway products. Most of the companies in this field are located either in southern New England or in the South. Priest also noted that they are suppliers to the Advanced Engineered Wood Composites Center (AEWC) as well as partners.

Ken Priest served on the Targeted Industries Committee that developed the Maine Technology Institute (MTI) initiative. Out of that connection, they decided to apply for two grants from MTI; both were awarded in June 2000. One was for a wood core composite crane mat based on technology developed by Habib Dagher, the director of AEWC. The second is for a continuously monitored composite double-walled pipe that includes a fiber optic sensor between the walls. Priest had heard about Dagher's technology from Jake Ward. (They are both members of the Maine Composite Alliance.) Priest is also a University of Maine alumnus.

The crane mat is flat, heavy wood, sandwiched under composites. The mat may be used under the wheels of heavy equipment, to create a cofferdam, or for temporary bridging. The wood core is made of oriented strand board (OSB), which is made out of the lowest grade of wood. The composites give the OSB the strength to compete with much more expensive mats made out of oak or other expensive hard woods. Dagher has a patent for the wood mat. Kenway has an agreement with University of Maine to license the product for the eastern U.S., if they find an appropriate market.

The double-walled pipe would be used to transport highly hazardous waste in areas not easy to inspect. The embedded fiber-optic sensor would isolate any leaks and make repairs much easier. This product was developed based on Kenway customer needs. Kenway has applied for a patent for this product. A National Institute for Standards and Technology (NIST) representative introduced them to Luna Technologies, a Virginia company (a spin-off of Virginia Tech) which developed the fiber-optic sensor technology.

Priest says the technology was essential for them to try to diversify the company. With its strong reliance on the pulp and paper industry, Priest sees the importance of identifying other product lines and customers. Priest indicated that these grants have the ability to completely alter the way Kenway does business. He hopes that the company will have less reliance on the pulp and paper business, and will export more products out of Maine.

Interviews Conducted

- Jake Ward, Director, Department of Industrial Cooperation, University of Maine, May 23, 2001 and June 20, 2001
- Ken Priest, President, Kenway Corporation, June 19, 2001
- Stephen Shaler, Assistant Director, AEWC, June 20, 2001

2. *Aquaculture Research and Development in Maine: The Blue Mussel Story*

The Industry

Aquaculture is the controlled cultivation of aquatic plants and animals during all or parts of their life cycle for either commercial purposes or the enhancement of wild stocks. Worldwide aquaculture production totaled 30,863,067 metric tons in 1998, with over 20 million tons being produced in China alone. Of this total, 1,377,830 tons were mussels compared to 248,293 metric tons live catch.[1] Domestic (U.S.) mussel producers have been facing a growing domestic demand for their products evidenced by a continued growth in mussel imports. The value of mussel imports rose 41 percent to $47.4 million in 2000 — almost double that of 1997. The majority of mussels are farm-raised, in either Canada or New Zealand. The weak Canadian dollar is expected to again expand Canadian mussel exports to the U.S. in 2001.[2]

One important factor is that countries such as Canada, Chile, Norway, China and Japan have made aquaculture a national priority. They heavily subsidize their aquaculture industries and environmental and food safety laws are less rigorous[3].

In Canada, for instance, where Prince Edward Island's 1999 production of 13,890 tons was 90 percent of total Canadian farmed mussels, the aquaculture industry supports over 8,000 workers. Canadian federal government support comes from the Department of Fisheries and Oceans, which has a Federal Aquaculture Development Strategy. Further, the Office of the Commissioner for Aquaculture Development coordinates the activities of over seventeen departments and agencies at the federal level. Memoranda of Understanding have been signed between the federal government and the provinces to meet the specific needs of the aquaculture industry in each province. Federal support for research and development is quite substantial with a recent $(C) 75 million announced for work in sustainable aquaculture, for instance.[4]

The aquaculture industry in Maine is comprised of finfish, shellfish and sea vegetable farms. The finfish farms produce Atlantic salmon and steelhead trout and for the most part are vertically integrated corporations owned by multi-national firms.

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[1] National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics and Economics Division, U.S. Department of Commerce. *Fisheries of the United States, 1999.* Page 47.

[2] Economic Research Service, U.S. Department of Agriculture. *Aquaculture Outlook.* LDP AQS 13, March 14, 2001.

[3] Maine Department of Marine Resources, "Maine's Aquaculture Strategy," November 1997; http://www.state.me.us/spo.mcp/final.htm.

[4] Office of the Commissioner for Aquaculture Development, Canada. http://Ocas bcda.gc.ca

(Most processing is done outside of Maine.) The shellfish farms, on the other hand, are mostly family owned and operated companies that produce Eastern oysters, clams, bay scallops and mussels. Maine had one aquaculture company that grew nori, the seaweed used in sushi. In 1999, the estimated value of the aquaculture harvest was $70 million with 49 farms (12 finfish, 26 shellfish, 1 seaweed, 10 experimental).[5]

Aquaculture is an important opportunity for Maine.[6] The demand for seafood is expected to continue to grow over the next thirty-to-forty years. The U.S. currently imports much of the seafood consumed, being the second largest importers of seafood. Maine, it is asserted by the 1997 Aquaculture Plan, with its long coastline and productive waters, is positioned to meet the growing demand by expanding its aquaculture industry.[7] Less than 1 percent of Maine's marine waters are leased for aquaculture. (It should also be noted that several Maine firms are experimenting with innovative new uses for aquaculture products with biotechnology and pharmaceutical uses.)[8]

Maine's share of the total value of mussel production has risen since 1980 (see Table 7.1). Other New England states have dropped out of the mussel production over the past fifty years. The 1998 National Census of Aquaculture showed Maine fourth overall in all aquaculture behind Florida, Mississippi and Arkansas (mainly catfish). However, Maine is the top producer in the U.S. in terms of ocean aquaculture. Maine's Atlantic salmon, oyster and mussel harvests in 1998 totaled $67 million at the farm gate.[9]

In 1997, it was reported that there were twenty-seven shellfish leases in Maine covering 302 acres. At that time, two-thirds of the acreage was for bottom-cultured

Table 7.1: Landings of Blue Mussels, 1980-1998[12]

	United States		Maine		Maine's Share	
	Pounds	**Dollars**	**Pounds**	**Dollars**	**Pounds**	**Dollars**
1980	3,071,526	$978,650	2,331,500	$546,415	76.0%	55.8%
1985	8,173,567	$4,133,741	6,090,000	$2,079,349	74.5%	50.3%
1990	8,491,199	$3,657,959	2,786,625	$865,895	32.8%	23.7%
1995	6,878,009	$4,740,248	6,429,214	$2,321,533	93.5%	48.9%
1998	3,112,750	$3,532,371	2,795,127	$1,061,195	89.8%	30.0%

[5] http://www.maineaquaculture.org

[6] Ibid.

[7] Department of Marine Resources, Ibid.

[8] http://www.maineaquaculture.org

[9] Testimony of Carter Newell, Great Eastern Mussel Farms in support for the Regional Aquaculture Centers to the House Subcommittee on Agriculture, Rural Development, Food and Drug Administration and Related Agencies, 2001.

[10] DMR, Ibid.

[11] http://www.maineaquaculture.org

[12] National Marine Fisheries Service, June 6, 2001.

mussels.[10] In 2001, there were more leases — thirty-nine leases, but they covering only slightly more acres (395). Total leased acreage for all species in 2001 is 1,203 acres.[11]

The Recipient: Great Eastern Mussel Farm, Inc.

From its mussel production facility in Tenant's Harbor, Maine, Great Eastern Mussel Farm has turned an ignored shellfish into a seafood delicacy. Great Eastern Mussel Farm mussels can be seen in many East Coast supermarkets and over 2,000 bushels are shipped nationwide each week. Having built demand for the product, Great Eastern Mussel has turned its attention to producing the highest-quality, lowest-cost, sustainable fishery possible. Employing over fifty people year-round and contracting with another fifty fishermen that supply the plant, Great Eastern Mussel Farms provide over $5,000,000 to mid-coast Maine's revenue stream.

Great Eastern Mussel Farms was started in 1978 in the cellar of an old farmhouse in Sheepscot, Maine. There, Chip Davison learned the techniques of mussel farming from Ed Myers, the grandfather of mussel farming in Maine. Chip decided to go out on his own with partner Frank Simon, duplicating the rope culture technique learned from Myers. In 1980, after traveling through Europe investigating the latest mussel farming techniques, Davison and Simon decided to try the Dutch bottom-culture method in order to have a more consistent product and to develop more mussels. Bottom-culture mussels produce a high quality mussel that can compete with the industry-standard raft culture mussels grown in Prince Edward Island, Canada.

Recently, Great Eastern Mussel has added a third production method to its arsenal, raft culture. Raft culture produces a meaty mussel with a durable and attractive shell. The raft supports thirty-five-foot long suspended lines covered with seed mussels, which grow to market size in twelve-to-eighteen months.

Using rafts based on a European design, Great Eastern Mussel Farm is helping local fishermen get into the mussel business. A program supported by a MSTF grant to Carter Newell of Great Eastern Mussel Farm and Mike Hastings of the Maine Aquaculture Innovation Center (MAIC) trains commercial fishermen in the mechanics and economics of mussel aquaculture using rafts. In addition, Great Eastern Mussel Farm founders put together a financing mechanism[13] to arrange loans to purchase the $15,000 rafts. Finally, Great Eastern Mussel Farm guarantees a market for the mature mussels for two years at the current market price. Part of the proceeds from the catch goes to paying down the loan on the raft.

One aquaculture farm that works with Great Eastern Mussel, Aqua Farms, has been in business for three years. It currently has three rafts near Great Chebeaque Island in Casco Bay.[14] Aqua hopes to have the first (of three) 40 by 48.6 foot rafts in place by September and to harvest two-to-six thousand bushels of mussels for sale annually.[15]

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[13] The funding mechanism, Gem Mara LLC, included funding from the Maine Technology Invest ment Fund. Oversight was later transferred from MSTF to MTI.

[14] Cavallaro, ibid.

[15] Eschholtz, Lori, "Clapboard Island aquaculture mooring stirs debate," *The Forecaster*, Vol. 15, No. 27. July 5, 2001.

In late June, Aqua Farms faced a standing-room only crowd at their public hearing for the lease for a 1.666 acre-site just off Clapboard Island in Falmouth. Despite the fact that Department of Marine Resources, the Army Corp of Engineers and the Coast Guard have approved the application, local officials are still undecided. Neighbors on Clapboard Island argued that the rafts would mar their view of the ocean. They also stated that the rafts would be a hazard to navigation. A local lobsterman felt that the rafts would take up prime lobstering area. Others supported the project; predicting that mussel farming and aquaculture are the way of the future.

The 1997 Strategic Plan for Aquaculture recommended that the Department of Marine Resources (DMR) institute a "experimental" license which would allow mussel farmers to try out a site for three years with substantially less red tape than the full licensing process. While experimental leases were implemented, the licensing process is still a bottleneck in the development of aquaculture for mussels and other shellfish in Maine, as illustrated by Aqua Farm's experience. Mussel farming applications can currently take one year or more to process. The number of requests for licenses appears to be overwhelming DMR. According to Sebastian Bell, formerly the aquaculture policy specialist for the DMR and now the executive director of the Maine Aquaculture Association, "The experimental lease has had the effect [of stimulating entrepreneurial activity] it was designed to have, but it has swamped our staff resources."[16]

Research Agenda. Great Eastern Mussel Farm has consistently used research to help it grow and harvest mussels more productively. For instance, one method that Great Eastern Mussel Farm uses is bottom culture. In this method, seed mussels are applied to specific areas of the ocean floor, which are then harvested later. Great Eastern Mussel Farm used SBIR Phase I and II grants from NSF[17] to develop a method for measuring the ideal amount of seed mussels to use to maximize production on these beds. Quantification of the effects of mussel density and current depletion on the boundary layer yielded a mathematical model predicting the correct seeding density and potential yield for a given area. It turned out that the optimum amount of seed was less than what they had been using, thus lowering their costs of production.

When Great Eastern Mussel Farm turned to raft grown mussels to augment their wild harvest and bottom culture harvest, they left few areas to chance. A flow model and biological growth model developed with an SBIR Phase I grant from USDA[18] allows Great Eastern Mussel Farm to look at potential locations on the Maine coast and identify which have the ideal conditions (volume flux, current speed and particle concentration) to support mussel raft culture. The combination of large-scale and small-scale flow modeling and biological models of mussel growth and feeding behavior help improve raft yields and seed to harvest ratios. The results were also applied to mussel farm site selection, seeding densities and raft design. Yet another project de-

[16] Cavallaro, Michaela, "Maine flexes its mussels," *Mainebiz,* Vol. 7, No. 1, January 8, 2001.

[17] NSF Phase I for $40,000 awarded 1987. Phase II for $229,609 awarded 1989. "Development of a Model to Seed Mussel Bottom Leases to Their Carrying Capacity."

[18] USDA Phase I for $52,000, awarded 1999. "Optimization of Mussel Raft Production through the Use of Oceanographic and Biological Models in Maine and the U.S."

veloped a mussel-processing barge that comes up to the raft and harvests and processes the mussels on the site.

A recent Maine Technology Institute grant will assist Great Eastern Mussel Farm with the development of a new form of retail packaging, looking for further advantages in the freshness and appearance of the final product.[19] Great Eastern Mussel hopes that this innovative packaging will get their mussels to market fresher.

The Stakeholder: University of Maine, School of Marine Science

Great Eastern Mussel Farm does most of its work in collaboration with faculty from the School of Marine Science, University of Maine and the Darling Marine Center. The School of Marine Sciences is the center of excellence for marine education in Maine. The School has more than forty faculty, including six new faculty hired as a result of a $1.17 million EPSCoR grant awarded in 1997 and matched by the Maine Science and Technology Foundation. The faculties' interests range from molecular biology and biotechnology to fisheries science, fisheries economics and anthropology and from marine geology and coastal engineering to aquaculture, marine ecology and oceanography. The School grants undergraduate degrees in aquaculture, marine biology and physical marine science and graduate degrees in oceanography, marine biology and marine policy. The new faculty hired includes:

- Dr. Ione Hunt Von Herbing, Ph.D. Dalhousie;
- Dr. Eric Anderson, Ph.D. University of Washington;
- Dr. Carol Kim, Ph.D. Cornell University;
- Dr. Mark Wells, Ph.D. University of Maine, University of California, Santa Cruz;
- Dr. Paul Rawson, Ph.D. University of South Carolina, Scripps Institution of Oceanography; and
- Dr. Sara Lindsay, Ph.D., University of South Carolina, Scripps Institution of Oceanography.

The new faculty and facilities have enabled work on selective breeding, genetic selection, detection of diseases, and development of technology for the aquaculture of new species. For instance, the molecular genetics lab allows work in stock structure, population structures and parasitic organisms. The types of outcomes that might be expected would be to reduce the time to maturity for oysters from three-to-four years to two years, thus increasing productivity and yield.[20]

In addition to labs and academic space on the Orono campus, the School's facilities include SCUBA support, research vessels and wet lab space at the Darling Marine Center.

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[19] Maine Technology Institute grant June 2000 entitled, "A New Method for Selling Mussels in Retail Markets."

[20] Interview with Dr. Bruce Barber and Dr. Paul Rawson, U Maine Orono, School of Marine Science, June 20, 2001.

Located in Walpole, Maine, on the banks of the Damariscotta River, the Darling Marine Center was founded in 1965 with the donation of a 127-acre farm by Ira C. Darling, with the purpose of establishing a marine laboratory. Today, the center occupies 170 acres of wooded property with a two-kilometer water frontage. The Center is used both as a research location and a teaching facility. A flowing seawater laboratory, a wet lab for culturing marine organisms, environmental chambers and an electron microscopy center support the research activities. A conference center, meeting spaces, dorms, a library and other outbuildings support the educational mission.

Over the last five years, 467 visiting scientists from thirty-two states and twenty-two foreign countries have come to the Center for short or extended stays. Nearly 1,100 undergraduates from out-of state colleges have participated in their programs. The Semester by the Sea program allows Maine undergraduates to enhance their experience by residing at the Center while undergraduate internships bring over thirty students to Darling to do marine research each summer.[21]

A new aquaculture facility at Darling is nearing completion. The University of Maine and the Maine Science and Technology Foundation, through the State of Maine's research and development bond issue, are building the facility using 2.5 million dollars raised from part of the 1997 EPSCoR grant and another NSF grant. Opening Fall 2001, the Marine Culture Laboratory will be a state-of-the art cold water research facility. The Laboratory will provide the space and equipment for the study of ocean phytoplankton and optical oceanography (supporting a recent opportunity hire, Mary Jane Perry, Ph.D. University of California at San Diego), the study of genetics and diseases in aquaculture species, and the culture of living cold water species. The building will also include a thirty-student flowing seawater classroom and molecular biology laboratory.

According to the University of Maine, the flowing seawater system in the new wet lab will double the Center's current capacity to raise living marine organisms and it will be the most advanced system in the state. The new wet lab will have chillers built into the seawater system, allowing researchers to maintain cold, deep-water research temperatures year-round.

The Darling Center will also be one of three locations for an aquaculture incubator to be operated by the Maine Aquaculture Innovation Center and funded by the Applied Technology Development Centers program. The incubator at the Darling Center will be immediately adjacent to the existing flowing seawater laboratory and will enable start-up aquaculture companies to grow seed stock on site. The existing flowing seawater laboratory is currently being used by the private sector on a contract basis. The new incubator will enable this small effort to expand.

The Stakeholder: Maine Aquaculture Innovation Center

Emphasizing the importance of universities in building human capital and social capital, it should be noted that Carter Newell, Chris Davis, Bill Mook, Kevin Scully and Dick Clime are five contemporaries who attended the University of Maine and studied

[21] http://www.dmc.maine.edu

together at the Darling Marine Center under Herb Heidu, now retired. Carter is the marine biologist behind all of Great Eastern Mussel Farm's research and development. In addition, he and Chris are partners in Pemaquid Oyster Company. Bill Mook owns Mook Sea Farms; Dick Clime operates Dodge Cove Marine Farm. Kevin Scully owns Glidden Point Oyster Farm.

These five men form the core of a tight group of entrepreneurs that are trying to bring Maine into a competitive position in shellfish aquaculture. For instance, they were behind the application for an innovation center in 1990 that became the Maine Aquaculture Innovation Center. (There were ultimately four innovation centers started by the Maine Science and Technology Foundation, but only aquaculture and biotechnology remain.) MAIC has operated with state funding of approximately $190,000 annually since 1993.

MAIC has been extremely effective in bringing together key members of the aquaculture community to work with the public sector to help support this emerging industry. The most relevant project is the work that MAIC's Mussel Suspension Culture Working Group has done with Great Eastern Mussel Farm to develop raft mussel technology in Maine. The working group consists of about seventy-five participants. In Maine, early starts at suspension culture were plagued by eider duck predation, poor site selection, lack of culture technology transfer, insufficient capital, and lack of an established market for high quality mussels. The joint efforts of the working group and Great Eastern Mussel Farm reflected the importance of raft culture. The use of rafts, not just suspension technology, meant that the mussels could be protected from eider ducks. Work (already mentioned) by Great Eastern Mussel Farm resulted in a methodology for improved site selection. MAIC gave the working group a grant in 1997 to study different types of material for mussel seed collection[22] and funds from a private foundation supported the purchase of Spanish mussel graders and seeding machines.

Interviews Conducted

- Michael Hastings, Executive Director, Maine Aquaculture Innovation Center, May 23, 2001
- Carter Newell, Great Eastern Mussel Farm, Inc., June 22, 2001
- Bruce Barber, School of Marine Sciences, University of Maine, June 20, 2001
- Paul Rawson, School of Marine Sciences, University of Maine, June 20, 2001
- Kevin Ecklebarger, Director, The Darling Center, University of Maine, June 21, 2001

[22] http://www.maineaquaculture.org.

3. *Finance Authority of Maine (FAME) and Small Enterprise Growth Fund*

Venture Capital

Entrepreneurs are an important source of new company and new job growth for any economy, but frequently require outside capital before they can tap into traditional sources of debt from banks or equity from the public stock markets. Private equity, in the form of venture capital or from high net worth individuals (angels), fills the gap that owner equity cannot address.

Venture capital is an important economic development driver. According to an economic impact study conducted for the National Venture Capital Association by WEFA, a leading economic information and consulting firm, U.S. companies backed originally by venture capital have created 4.3 million new jobs. These companies generated $736 billion in revenues in the year 2000. According to the study, venture capital-backed companies represented 3.3 percent of the nation's total jobs and 7.4 percent of GDP in 2000. These include companies such as Intel, Compaq, and Home Depot that received funding in the 1970s and 1980s.[1]

Venture capital availability is quite uneven across the country. A few regions, notably California, Boston, Austin, and New York, receive the lion's share of institutional venture capital investments. There is a low level of venture capital investment in Maine. As shown in Table 7.2, there were twelve venture investments in Maine in 2000 for a total of $166.8 million compared to 616 deals for all of New England, and a total of $10,408 million.

Table 7.2: Venture Capital Investment in Maine Companies[2]

Year	Number of Companies	Investment ($M)
1990	1	0.5
1991	2	4.3
1992	2	30.2
1993	2	3.0
1996	2	10.3
1997	5	12.5
1998	10	41.8
1999	8	43.0
2000	12	166.8

For close to fifteen years, states have been working to increase venture investing in their regions. Four basic strategies have been pursued:

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[1] http://www.ncva.org/nvca05 02 01.html.

[2] http://www.ventureeconomics.com/stats/2000Q4/state me.html. Venture Economics tracks capital invested by traditional private equity venture funds, angel investors and corporate venture firms and programs. They collect their data from National Venture Capital Association (NVCA) members. In contrast, the other major source of venture investing statistics, Money Tree, collected by PriceWaterhouseCoopers, tracks activities in key technology industries only. Money Tree statistics for Maine vary from these, but show the same trend of significantly higher numbers of investments in 1998 2000.

- Expand the knowledge of seed and venture investing;
- Promote the visibility of entrepreneurs to investors and of investors to entrepreneurs;
- Create investment capital to fill a gap or grow a sector; and
- Create investment capital to build a seed and venture capital industry.[3]

The Stakeholders: The Finance Authority of Maine (FAME) and the Small Enterprise Growth Fund (SEGF)

In Maine, the Finance Authority of Maine (FAME) and the Small Enterprise Growth Fund (SEGF) have embraced the last two strategies. Starting in 1987 with the Maine Seed Capital Tax Credit Program, the establishment of the Small Enterprise Growth Fund in 1995, and the founding of the Venture Capital Revolving Investment Program in 2000, FAME and SEGF have sought to provide Maine entrepreneurs with a range of options for financing new businesses and new products and processes.

The mission of FAME is to foster the hopes and dreams of Maine people by providing innovative financial solutions. They provide tools and information to help Maine citizens pursue business and educational opportunities, and, in doing so, strengthen Maine's economic vitality and prosperity.

Two of FAME's programs and the investment fund administered by the SEGF aim at the research and development companies capable of achieving rapid growth and higher wages for Maine citizens. They are:

- *The Maine Economic Development Venture Capital Revolving Investment Program*, which allows the state to invest as an equal partner with others in eligible private venture capital funds to support emerging and early-growth businesses in Maine.
- *The Maine Seed Capital Tax Credit Program*, which encourages equity investment in young business ventures, directly and through private venture capital funds.
- *The Small Enterprise Growth Fund*, which can provide up to $500,000 in patient[4] capital to promising companies that demonstrate a potential for high growth and public benefit. (SEGF is administered by the Small Enterprise Growth Board, an independent entity that contracts with FAME to provide management and other services for the Fund.)

Operationally, the programs fill different roles in the development of venture capital and seed capital in Maine. Through the first program, Maine Economic Develop-

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[3] Heard, Robert G., and Sibert, John, *Growing New Businesses with Seed and Venture Capital: State Experiences and Options,* prepared for the National Governor's Association by the National Association of Seed and Venture Funds, 2000.

[4] Patient capital refers to investments where the investors are willing to wait longer than usual for a return.

ment Venture Capital Revolving Investment Program, FAME invests in established venture capital funds that have a strategy for the creation and retention of jobs in Maine. The funds must plan to invest in Maine high-growth businesses as well as provide marketing and technical assistance, and appropriate monitoring of its investments. The maximum investment in each fund is $1,000,000. This program follows best practices developed in other states (notably Maryland and Pennsylvania) where some state funding has leveraged other investments to create a viable and enduring local venture capital community.

Maine Seed Capital Tax Credit Program, on the other hand, seeks to encourage high net worth individuals to invest in Maine companies. FAME is responsible for evaluating applications for state income tax credit certificates, which may be authorized for up to 40 percent (was originally 30 percent) of the cash equity provided to eligible Maine businesses. Investment may be used for fixed assets, research or working capital. Businesses must be located in Maine. Investors must own less than 50 percent of the business. Immediate relatives of principal owners are not eligible. Annual gross sales must be less than $3 million. Investors may provide up to $200,000 per business with aggregate investment limit per business of $1 million for which tax credit can be received.

Finally, the Small Enterprise Growth Fund represents Maine's version of a seed capital fund. Often seed capital is required for companies to mature enough to be able to get investment from private venture capital firms. The SEGF's strategy is to invest a maximum of $500,000 in small businesses with the potential for high growth and public benefit with 50 or fewer employees or less than $5 million in sales. To be eligible, the businesses should be in one of the following sectors: marine science, biotechnology, manufacturing, software development, out-of-state exporters, environmental services, financial/insurance services, or natural resources. Terms and rate of return are adjusted based on risk.

The venture funds that receive funding from the Maine Economic Development Venture Capital Revolving Investment Program are required to report at least semiannually to FAME on the businesses in which the private venture capital fund invests and the administration of the program. The report must include a description of each business, the amount, type and terms of assistance the business received, the amount of funds invested, the number of jobs that were created or retained and other information. The report must contain an accounting of the investment portfolio and any investments that are in default, as well as an accounting of the fund's administrative and technical assistance expenses incurred and charged. The names of the funds receiving an investment, the amount invested in a fund, the names of the businesses benefiting from the investments, the nature of the business and the intended use of proceeds shall be public information. To date, the Program has decided to invest in five funds. Only one, Coastal Ventures II, LLC, has closed on its initial installment (3/08/01).

Public information gathered for the Seed Capital Tax Credit Program include the names of participating investors and funds, the amount of certificates issued to each investor, the names of businesses benefiting from investments, the nature of the business and the intended use of proceeds. Since its inception in FY89, 563 tax-credit certificates have been issued with a cumulative value of $4.926 million have been made. These credits correspond to $16.093 million in investments. Approximately sixty individual businesses have received investments.

Recipients of the Small Enterprise Growth Fund are required to report to the SEGF Board on financial performance, technological progress, market progress and any other factors as the board may require. Like any venture fund, SEGF maintains a current record of its investments, their most recent valuations, employment and status. The following information is considered public: names of recipients or applicants, amounts, types and general terms of assistance, description of projects and businesses, names of transferors or transferees, number of jobs and amount of tax revenues projected and resulting. Confidential information includes financial statements and tax records, competitive information.

As of May 30, 2001, the Small Enterprise Growth Fund has invested $3,808,000. Another $1,150,000 has been approved. The value of the holdings based on last transaction is $3,291,642 ($300,000 has been charged off). Employment growth is reported from 164 at time of investment to 1,677 now. One company, EnvisioNet, is responsible for 1,500 of these jobs.

However, the path to entrepreneurial success is often rocky. In late May, EnvisioNet announced that it had lost a contract with a major Seattle company and therefore had to lay off over 700 employees. In June, the company filed for Chapter 11 Bankruptcy reorganization. In September, the company was bought for $10.7 million by MicroDyne, a Torrance, California-based company. Reportedly, operations will remain in Maine.

The Recipient: IntelliCare

One of the most promising companies in the SEGF portfolio is IntelliCare, a provider of healthcare communication technology and services. They are deploying a leading-edge medical call and contact center technology focused on Electronic Patient Relationship Management. They currently operate a medical call and contact center in South Portland and are expanding by allowing other medical call centers to use their technology by subscription or hosting their call centers in Portland. Targeted clients are health plans, hospitals, physicians and employers.

The company was founded in 1997 in Portland. They developed a $2 million business as an outsource call center, but wanted to take the business into a technology-based direction by becoming a developer and integrator of medical call center technology. They have been operating with the new technology for the past year. Current revenues are $6 million and the company employs over 100 people. (Before the SEGF investment, the company had twenty employees.) The call center operation is profitable.

According to Victor Otley, Chairman and CEO of IntelliCare, two state programs were critical to IntelliCare's growth and ability to stay in Maine. First, the Maine Seed Capital Tax Credit encouraged several angel investors, with management participation, to invest early funds into the company. Second, the SEGF investment came at a transition time for the company. Other sources of funding that were approached during this period wanted the company to move to Cambridge, MA. The company did not see the need to be in the Boston area, having found an appropriate and affordable pool of software developers in the Portland area.

SEGF invested $150,000 in a convertible debenture in an initial round in August 1998, and then purchased $350,000 of Series A Preferred Stock in a second round. The proceeds were used to fund product development from proof of concept through the completion of a production version of the product. The technology application moved the company from being a call center to being a developer of patient-to-provider communications technology and infrastructure. This transition funding allowed the company to get its products closer to the market by the time they needed to approach professional venture capitalists for their next round of funding. Otley says that the maturity of their product allowed them to get venture funding despite having to overcome skepticism about their location in Maine.

The SEGF funding required a one-to-one match. These funds were raised by the company from private investors and from Coastal Ventures. The follow-on $7 million professional round came from Salix, Nashville, TN and Cardinal Partners, Princeton, NJ, as well as a sophisticated private investor. The company expects to do another professional round of financing before exit. They have assembled a seasoned management team capable of taking the company through profitability and future growth.

Otley reported several surprises along the way in their relationship with SEGF. First, when they did the financing for the second SEGF round of $350,000, the rules for the match were not consistently defined. After they had raised an investment from Coastal Ventures, SEGF ruled that these funds did not count for the match. The company had to scramble quickly and go out to raise additional funds to make up the difference.

Otley also reported that early versions of the term sheet were onerous and they delayed closing almost one year until the terms were eased. He suggested that, at that time, SEGF still acted much like a bank. "They wanted equity deals with debt risk," he said. Otley believes that "over time the terms became more reasonable and we were able to move forward with the financing. IntelliCare was one of the first companies applying for investment and it just took some time for SEGF to iron out its investment strategy."

One future uncertainty is about how SEGF will react to the upcoming (2002) conversion of the original $150,000 convertible debenture. Otley hopes that they will convert to equity so that the company will not have to use precious cash to buy back the shares. (Deals done later than 1999 were equity deals, not convertible debentures.)

Intellicare has no formal relationships with Maine universities but 70 percent of the technology employees have been educated in Maine. (Otley himself went to Bates College for an undergraduate degree in economics.) The majority of the clinical knowledge for their application comes from some of the nation's leading medical centers and three out-of-state employees and contractors.

Otley indicated that IntelliCare has definitely developed new products and processes as a result of the investment. The new technology has been copyrighted, but they determined that the costs of patenting would outweigh the gain from that protection. New investment leveraged by the SEGF funding includes the $7 million professional round (85 percent from out of state). Another indicator suggested is the effect on their investors as they gain confidence about investing in Maine companies (those from out of state) and in technology companies (those from in state).

Another observation was that "You can build a business in Maine, but you do business outside of Maine." Otley suggested that revenue being derived from out of state is an extremely important indicator of the growth of Maine businesses.

Interviews Conducted

- Charles Spies, CEO, Finance Authority of Maine, May 22, 2001;
- John F. Burns, Fund Manager, Small Enterprise Growth Fund, May 22, 2001; and
- Victor Otley, Chairman and CEO, IntelliCare, June 25, 2001.

4. Maine Biomedical Research Program

The Industry

The U.S. biotechnology industry grew rapidly during the 1990s, encompassing between 1,200 and 1,500 companies, depending upon one's definition.[1] A recent impact analysis conducted for the Biotechnology Industry Organization (BIO), estimates the 1999 contribution to the U.S. economy as:

- 437,400 jobs (150,800 direct, 286,600 indirect);
- $47 billion in revenues ($20 billion direct);
- $11 billion in research and development spending; and
- $10 billion in federal, state and local taxes.[2]

In Maine, the biotechnology industry is small. The Maine Biotechnology Association has sixty-five members, but several members are organizations or in related fields such as aquaculture. The number of Maine biotechnology companies is estimated to be around thirty.[3] Only one of the biotechnology companies is of significant size: Idexx Laboratories, which is a publicly traded company in the diagnostics field with 2,000 employees and $91 million in sales.

However, Maine has a competitive position nationally in biomedical research at non-profit institutions. It is the only state to be home to five independent biomedical research organizations. Bar Harbor, home to the Jackson Laboratory and Mount Desert Island Biological Laboratory, ranks in the top 100 U.S. cities for per capita National Institute of Health (NIH) funding.

Advocates for the biomedical industry in Maine, including the Maine Biomedical Research Coalition and the State Planning Office, believe that linking these five biomedical research organizations and the University of Maine System into a coalition can begin to approximate a virtual Tier I university, thus bringing the type of economic development that is enjoyed by other states with strong research and development cultures and medical schools. NIH funds $20 billion of health-related research each year and both the President and the Congress are committed to significant growth

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[1] See http://www.signalsmaps.com, the online magazine of Biotechnology Industry Analysis.

[2] Ernst and Young, "The Economic Contributions of the Biotechnology Industry to the U.S. Economy," Biotechnology Industry Organization, May 2000.

[3] Biotechnology Association of Maine membership. www.mainebiotech.org.

in that budget, so the biomedical research industry in itself is an attractive target industry segment.

Thus, the Maine Biomedical Coalition was formed. It consists of:

- The Jackson Laboratory;
- Maine Medical Center Research Institute (MMCRI);
- Mount Desert Island Biological Laboratory (MDIBL);
- The Foundation for Blood Research (FBR); and
- University of New England College of Osteopathic Medicine.

These five partners currently provide more than 1,420 full time jobs and bring $90 million of outside research funding to the state.

The Coalition worked together to convince the Maine Legislature to invest in biomedical research to generate more jobs and outside research dollars. The Coalition forecasts that the proposed $10 million in new state funding would generate 191 new jobs and $54 million in outside grant spending and over $100 million in spin-off benefits.[4]

Although the Coalition was unsuccessful in its efforts to secure this new funding from Maine's tobacco settlement allotment, it eventually received a $10 million commitment from general funds, the Maine Biomedical Research Fund, in 2000.

The Stakeholder: Maine Biomedical Research Fund

The objectives of the Maine Biomedical Research Fund are to focus on economic development and jobs in the State primarily by making investments in organizations with a good record of attracting biomedical research funds from sources outside of Maine. A secondary purpose is to provide incentives for small eligible organizations to grow.

The Maine Biomedical Research Program allocates funds to eligible institutions using a formula based on the amount of funding received from federal agencies and private foundations in the previous two years. The Program completed its first round of funding in June 2001. Funds were dispersed to ten institutions. Jackson Laboratory received 65 percent of the funds, University of Maine received 16.8 percent, Maine Medical Center Research Institute received 9.1 percent and Mount Desert Island Biological Laboratories received 5.6 percent. The other seven institutions received less than 1.5 percent each.[5] Funding can be used for project funding, facilities funding,

[4] Maine Biomedical Research Coalition, "2001 Report Card to the Maine Legislature."

[5] The 2000 Biomedical Research Fund Grant Allocations are: The Jackson Laboratory, $6,153,000; Foundation for Blood Research, $81,000; Mount Desert Island Biological Laboratories, $616,000; Maine Medical Center Research Institute, $948,000; University of Maine, $1,657,000; University of Southern Maine, $47,000; Eastern Maine Medical Center, $24,000; Bates College, $98,000; Maine Medical Assessment Foundation $100,000; University of New England, $163,000. Source: Department of Community and Economic Development.

equipment purchases, or ancillary support. Overhead charges may be included consistent with federal research granting criteria.

The Recipient: The Jackson Laboratory

In 1929, C.C. Little, one of the first genetics researchers, founded the Jackson Laboratory in Bar Harbor, Maine, as a cancer research center. In 2001, the Laboratory has a total budget of $88.4 million that includes over $69.4 million for research and related activities. In addition to being the world's largest mammalian genetic research facility, the Laboratory also serves as the provider of critical genetic resources to laboratories worldwide and as a training center. The National Cancer Institute of the NIH has designated the Laboratory as one of ten cancer centers to perform basic research in cancer genetics.

A distinctive aspect of Jackson Labs' operation is that it supplies virtually every major university, medical school, and research laboratory (12,000 labs in the U.S.; 55 foreign countries) in the world with approximately 2 million JAX© mice annually from more than 2,700 varieties, 97 percent of which are available only from the Jackson Laboratory. Revenue from this line of business was $34.2 million in 2000.

The high quality of Jackson Labs' research is demonstrated by its NIH funding rate. In 1997, 52.1 percent of Jackson Labs' grant requests were funded, compared to 34.4 percent nationally for institutions belonging to the American Independent Research Institutes (AIRI) and 30.5 percent for all institutions. Overall, Jackson ranks eighty-eighth out of the thousands of non-profit institutions receiving NIH funding and sixth in NIH funding according to the Association of Independent Research Institutes.[6] A steady increase in both ranking among AIRI institutions, number of grants received, and total NIH funding is evident over the past decade.

With more than 1,000 employees, the Jackson Laboratory is the largest employer on Mount Desert Island and the second largest employer in Hancock County. It is the eighty-second largest employer in Maine.

The Jackson Laboratory received some state funds prior to the Biomedical Fund. For instance, a 1993 DOE EPSCoR grant for $1.25 million was used to recruit a principal investigator, Dr. John Schimenti, who is working on the Genome Project. Using mutagenesis technologies, Dr. Shimenti is identifying genes involved in particular biological processes and concentrating on the isolation of novel genes. Last year alone, Dr. Shimenti's work generated $1.3 million in research grants; the mutagenesis strategy is responsible for $30.3 million in new NIH grants for the Jackson Laboratory.

In addition, the DOE funds enhanced interaction with the University of Maine (veterinary pathology training grant) and Eastern Maine Medical Center (DOE EPSCoR grant), and facilitated a joint graduate studies program in molecular and cellular biology among U Maine, The Jackson Laboratory, Maine Medical Center Research Institute and Mount Desert Island Biological Laboratory. An automated DNA sequencer was purchased with the DOE funds as well, the first in the state of Maine. With this

[6] http://silk.nih.gov

technology, the Jackson Laboratory was able to apply for and receive NIH funding for allele-typing equipment.

A second infusion of state funds was the 1999 MSTF Challenge Grant based on funding from the 1998 R&D Bond. Jackson Laboratory received $107,000 for telecommunications equipment. The institution matched those funds and renovated a special video teleconference classroom, which is now used to provide graduate education between the University of Maine and the Jackson Laboratory. In the future, they expect to have a teleconferencing link to the other biomedical institutions and support more interactive research and training. The project is on hold, waiting for a piece of equipment to arrive.

A joint center of excellence is being planned by the University of Maine with the Jackson Laboratory. U Maine submitted a grant for this center to NIH, but it was not funded. U Maine is also planning similar centers with MMCRI and MDIBL. Now that the human genome sequencing is completed, Jackson Laboratory researchers will need to do more computation and physics along with lab work to understand complex interactions between genes and genetic susceptibility to disease. They need to be able to evaluate the genetic makeup of mice quickly, in a nondestructive way. Jackson Laboratory planners believe that the various strengths of other organizations, for instance computation, surface chemistry, and geospatial computation at University of Maine, and MMCRI's expertise in blood vessel formation (angiogenesis), can be combined to move biomedical research forward.

The Biomedical Research Fund awarded $6.153 million to the Jackson Laboratory. Of this amount, $3.25 million will complete the funding package for the Genetics Resource Building.[7] This building will house state-of-the-art laboratories to detect and measure diseases in mice as well as quarantine and cryopreservation facilities where imported mice are brought to the highest health status and are preserved against accidental loss by freezing embryos or sperm. These functions will ensure that JAX © mice will remain the standard for purity and the resource for induced mutant strains in mice worldwide.

The other $2.8 million of the funding will go to improvements in the Research Animal Facility. The renovations will provide facilities for maintaining mice with deficiencies in their immune systems, upgrading the overall health status of mice used in biomedical research at Jackson, improve protection for workers against mouse allergens, and create additional laboratory space for developing and testing new models of human diseases.

The Jackson Laboratory, and indeed the entire Maine Biomedical Coalition, describe their economic contribution is terms of jobs in Maine and increased research funding from outside Maine. Jackson expects that the new funding will add between 125 and 145 new jobs. An economic impact model run by the Maine State Planning Office for Jackson Laboratory translated these new jobs and construction expendi-

[7] The Genetics Resource Building was already under construction when state funding was requested.

tures into secondary effects of $11 million in new retail sales, $37 million in services, $12 million in additional wholesale sales and $2.5 million in construction. These new sales support an additional 1,200 jobs with new payroll and local owners' profits of almost $30 million.

Other Members of the Coalition

Maine Medical Center Research Institute (MMCRI). With 184 employees, this subsidiary of Maine Medical Center is the second largest of the Coalition members. A member of the Alliance of Independent Academic Medical Centers, Maine Medical Center is a relatively rare type of institution — a medical center not tied to a medical school. About 80 such centers exist in the country; approximately 30 have research arms like MMCRI.

MMCRI has a research budget of $12 million. It is organized into four divisions, supporting its mission to provide outstanding patient care, to teach and train new doctors and to perpetuate higher knowledge through research. The four divisions are:

- *The Center for Molecular Medicine*. The Center specializes in angiogenesis, the growth of blood vessels. Thomas Maciag, Ph.D., who leads the angiogenesis work at MMCRI, is one of the leading authorities in the field. A $10.6 million grant from NIH in 2000 established the Center for Excellence in Angiogenesis at MMCRI.
- *Clinician Researcher Division*. Clinical program directors spend part of their time in disease-oriented research. The areas of focus are thrombosis and psychiatric research.
- *Clinical Research Center*. Phase I, II and III trials are conducted in partnership with hospital and community-based physician groups.
- *The Center for Outcomes Research and Evaluation* supports health services research to help clinicians make decisions on the very best and most cost-effective treatment methods.

Mount Desert Island Biological Laboratory (MDIBL). A world leader in the genomics and biology of marine species, notably dogfish, MDIBL has 20 year-round employees and 170 seasonal investigators and staff. They are one of only five NIH-funded Marine and Freshwater Toxicology Centers.

Foundation for Blood Research (FBR). With 60 employees, the FBR is a national leader in maternal/child health and serum protein research.

University of New England, College of Osteopathic Medicine (UNE). With 130 employees, UNE has been rated by U.S. News and World Report in the top 50 medical schools nationally for primary-care education.

Interviews Conducted

- E.J. Lovett III, Ph. D., Director, Maine Medical Center Research Institute, June 26, 2001;
- Peggy Schaffer, Policy and Planning Specialist, Department of Economic and Community Development, May 28, 2001 (by phone);
- Tish Tanski, Director, Institutional Relations, The Jackson Laboratory, June 29, 2001; and
- Barbara Tennent, Ph.D., Manager, Scientific Program Development, The Jackson Laboratory, June 21, 2001.

5. Maine Technology Institute

The Stakeholder: Maine Technology Institute

Responding to the Report of the Joint Select Committee on Research and Development (December 1998), the Maine legislature created the Maine Technology Institute (MTI) in 1999. In its recommendation, the Joint Select Committee stated that "a significant state investment is needed to promote job creation in the target technology areas through applied research, development and product commercialization."[1]

The purpose of the Institute is to stimulate and support research and development leading to commercialization of new products and services in the State's targeted technology sectors: advanced technologies for forestry and agriculture; aquaculture and marine technology; biotechnology; composite materials technology; environmental technology; information technology; and precision manufacturing technology.

In FY00, the Institute received $3.2 million and in FY01, $6.4 million. The Institute's FY02/03 appropriation is $6.34 million annually. The Maine Technology Institute operates four programs. They are:

- Seed grants: Grants of up to $10,000 are offered four times each year. The grant requires a one-to-one cash match. Eligible projects include: small R&D projects leading to commercialization, technical or consulting assistance for Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR), MTI, or other commercialization proposal preparations, market analysis, intellectual property filing, or other activity leading to commercialization.

- Performance/Development awards: Awards of up to $500,000 are offered twice a year. Requires a one-to-one cash match. Requires a payback if the funded technology is commercialized. Eligible projects include comprehensive R&D leading to commercialization including proof of concept work, prototype development, feasibility studies, alpha and beta testing, engineering and manufacturing design, etc.

- Cluster enhancement awards: Awards of up to $100,000 for collaborative, comprehensive projects that address specific needs within or among the targeted industry sectors. Eligible projects include: common equipment purchases, common research facilities, development of technology-oriented programs, or other programs and projects that address the MTI purpose. Requires a one-to-one cash match.

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[1] Office of Policy and Legal Analysis, Maine Legislature, "Final Report of the Joint Select Committee of Research and Development," December 1998.

- Technical assistance and information related to the federal SBIR and STTR programs.[2]

MTI operates with a 15-member Board of Directors, nine of whom are appointed by the Governor. The Commissioner of Economic and Community Development, the President of the Maine Technical College System and the Chancellor of the University of Maine, or their designees, also sit on the board *ex officio*. Separate Technology Boards for each of the seven targeted sectors have also been established. Service on the MTI Technology Boards is purely voluntary and is "open to private sector representatives, scientists and others determined appropriate representatives of the targeted technology sectors."[3]

MTI is also required by statute to produce an independent evaluation every two years starting January 2003. The statute requires that the evaluation include: "firm survival, new product development and process innovations, jobs created and other measures that the evaluator . . . may establish." Further, the "evaluation must consider the Institute's strategic roles in stimulating economic growth in Maine's targeted technologies."

MTI has made 123 awards to 100 organizations since it started. (Two did not sign the contract.) These are summarized at right.

Table 7.3: Grants Made by MTI by Type of Grant, 2000-2001[4]

	Seed Grants	Performance/ Development Grants	Cluster Enhancement Grants
June 00		37[5]	
July 00			1
September 00	21		
October 00			1
December 00	17		1
March 01	16	10	
June 01	17		
TOTAL	**71**	**47**	**3**

A survey of the fifteen completed seed grants and two completed performance grants was conducted recently for MTI by the Maine Manufacturing Extension Partnership. These companies reported thirty-one new jobs created and six patents and/or trademarks filed. An increase in company R&D investments of $2,324,296 was also reported. On a scale of one-to-five, with five being "Very Satisfied," the survey found the recipients ranked their customer satisfaction at 4.66 and 4.00 for seed grant and performance grants, respectively.

[2] This set of programs is contracted out.

[3] Sec. AAA 3. 5MRSA c.407

[4] http://www.mainetechnology.org

[5] These grants were awarded under the Performance Grant program that required no payback.

Recipient: Terralink

Terralink received two grants from MTI, one entitled "Dalmatian" in June 2000 and one entitled "TAXI" for $90,000 in March 2001. David Fernald is a member of the Information Technology Board for MTI.

David Fernald and a partner formed Terralink in 1995 in Boston. They heard from a friend about the difficulties in tracking and reporting hazardous waste information to the government. They decided to build a software system to help companies with this task.

The company split in two in 1997 and Fernald moved his half to Portland since he lived there. The company was the first tenant in the Center for Environmental Enterprise (CEE) that was just opening at the time. The company is also the first graduate of the CEE, moving to their present office space in 1999. They currently have revenue of $500,000 and 6 employees.

According to Fernald, the grants "did not make or break Terralink, but they were helpful." The grants did allow them to hire one or two software developers and reduce risk to allow them to make a further investment in R&D.

The grants resulted in two new products. One, "Dalmatian," is a prototype product aimed at state agencies. It reports state-required information that companies are supposed to report annually. With this information, states can better plan emergency response for each company that handles and stores hazardous waste. The second product, Terralink Automated 'eXchange of Information (TAXI), is an extension to XML that is essentially middleware. TAXI makes Terralink's existing software web-based and easier to use.

The next step for Terralink is to raise some capital for expansion. Fernald notes that there are a lot of high net worth individuals in the state, but that they are hard to find and need to be educated about technology investments. There is a gap, however, for companies like his. He does not wish to pursue SBIRs because he believes they take too long.

Fernald notes that TAXI is "marginally patentable." He stated that if they had the resources to pursue patenting, they might. Fernald believes that the appropriate indicators are progress towards milestones and ultimately jobs, especially high-paying jobs. He also noted the importance of MTI's grants in bringing credibility to his company. Without it, he feels that it would be difficult to get the attention of Maine investors who are "comfortable with jams and jellies, not technology."

Fernald believes that MTI's process is getting too cumbersome and that there are too many people involved with the decision-making. He estimates that there are seven sector boards with eight or so people on each, plus the MTI Board plus two peer reviews per proposal.

Fernald also feels that there are too many organizations in the science and technology community in Maine. He thinks there is "tons of overlap," even though many of them do define specific areas or stages of interest. He emphasized the importance of streamlining the process.

Although Fernald is Bowdoin College and Stanford University educated, he spent most of his career in Boston and Texas before returning to Maine. Two of his staff are

Maine educated. They have no contact with Maine universities. According to Fernald, "Orono is not a real resource for us. They only graduate eighteen computer scientists a year and many leave the state."

Recipient: Kenway Corporation

Another MTI awardee with multiple grants is Kenway Corporation.[6] Kenway Corporation was started in 1947 to manufacture wooden pleasure boats. In 1958, the company focused on the advantages of fiberglass. By 1965, a conversion in operations from the production of Kenway Boats to industrial fiberglass products was complete. The company, located in a facility in Augusta, Maine, is now a custom fiberglass fabricator, with 80 percent of its $3–3.5 million revenue from the pulp and paper industry.

Ken Priest, President of Kenway and son of the founder, served on the Targeted Industries Committee that developed MTI. Out of that connection, Kenway decided to apply for two grants from MTI. Both were awarded in June 2000.

One was for a wood core composite crane mat based on technology developed by Habib Dagher, the director of Advanced Engineered Wood Composites Center. The wood mat grant is a $100K Performance Grant from MTI, and required them to produce a one-to-one in-kind match. The grant is for market research and to develop the equipment to efficiently laminate the oriented strand board (OSB) and to develop other production enhancements.

The second grant is for a continuously monitored composite double-walled pipe that includes a fiber optic sensor between the walls. The double-walled pipe would be used to transport highly hazardous waste in areas not easy to inspect. The embedded fiber-optic sensor would isolate any leaks and make repairs much easier. This grant is also for commercialization. They have developed a prototype and tested it. They anticipate doing a beta test shortly.

Priest says the grants were essential for them to try to diversify the company. With its strong reliance on the pulp and paper industry, Priest sees the importance of identifying other product lines and customers. However, he notes the riskiness of the project and the importance of the MTI funding. "If this was a sure thing, I could go down to the bank," he said. If the market research and production engineering is successful, the next step would be to get additional investment. (He has hired a sales person, the first for the company, on the strength of early results from the project. Up to now, he has used manufacturer's representatives.) Priest indicated that these grants have the ability to completely alter the way Kenway does business. He hopes that the company will have less reliance on the pulp and paper business, and will export more products out of Maine.

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[6] Kenway Corporation was interviewed as part of the Wood Composites case study. They are included here to broaden the MTI case study.

Recipient: Great Eastern Mussel Farm, Inc.

Great Eastern Mussel Farm, Inc. (GEM) is another recipient of an MTI grant.[7] Over 2,000 bushels of Great Eastern Mussel Farm mussels are shipped nationwide each week. Having built demand for the product, Great Eastern Mussel has turned its attention to producing the highest-quality, lowest-cost, sustainable fishery possible. Employing over fifty people year-round with another fifty fishermen that supply the plant, Great Eastern Mussel Farms provides a revenue stream of over $5,000,000 to mid-coast Maine.

A recent Maine Technology Institute grant will assist GEM with the development of a new form of retail packaging, looking for further advantages in the freshness and appearance of the final product.

Recipient: Advanced Engineered Wood Composites Center, U Maine

The Advanced Engineered Wood Composites Center at the University of Maine has received a Cluster Enhancement Award for the purchase of a Wood/Thermoplastic Extruder; a highly specialized piece of equipment used to manufacture new products from a combination of wood mill waste and recycled plastics. The MTI award was for $100,000; another $250,000 was raised from other sources. The "woodtruder" will be available to industry on a contract basis and will help provide a market for sawdust, a waste product of the sawmills prevalent in Maine.

Interviews Conducted

- Janet Yancey-Wrona, Director, Maine Technology Institute, May 24, 2001, June 19, 2001;
- David Fernald, CEO, Terralink, June 26, 2001;
- Ken Priest, President, Kenway Corporation, June 19, 2001; and
- Carter Newell, Great Eastern Mussel Farm, Inc., June 22, 2001.

[7] Great Eastern Mussel Farms, Inc., was interviewed as part of the Aquaculture case. They are included here to broaden the MTI case study. The company requested that the details of their project not be revealed. The President of Great Eastern Mussel, Chip Davison, became a member of the MTI Board of Directors some time after the award was made.

APPENDIX 2

Program Descriptions by Stakeholder

Following are descriptions of each program included in this evaluation. The descriptions include the stakeholder's name, statutory reference, and funding levels. Program objectives and descriptions are drawn from statute and documents provided by the program or stakeholders themselves. Data currently being collected are described including any issues of confidentiality that may be of concern in future evaluations.

Program: **Applied Technology Development Center System**

Stakeholder: Department of Economic and Community Development

Statutory Reference: §15321 of 2001 Supplemental Budget

Funding Levels: $5.426 million appropriated in FY00–01; $300,000 in FY02–03.

Objectives of the Program: To permit early stage development of technology businesses while minimizing or eliminating overhead expenses. The goals are to: retain successful start-up businesses in Maine, to improve opportunities for workers through the creation of technologically advanced jobs, to encourage private-sector initiatives, to renovate and utilize vacant commercial real estate and generate new sources of revenue for local and state tax bases.

Program Activities: The Applied Technology Development System will create business incubators in each of seven sectors: environmental technologies; biotechnology; forestry and agriculture; information technology, aquaculture, precision machinery and composites. ATDCs are being constructed in Fairfield (biotechnology), Loring (forestry and agricultural biotechnology), Orono (IT). The aquaculture incubator will be run by MAIC in three locations. The Center for Environmental Enterprise is being renovated. A center in Rumford is planned for precision machinery. There is a construction grant of up to $750,000 and one-year operational grants of $50,000. No future funding is promised.

Data Collected

Outputs: ATC will report on construction progress.
Outcomes: ATC incubators will report on their tenants, their status, and payroll.

Program: **Centers for Innovation Program**

Stakeholder: Center for Innovation in Biomedical Technology

Statutory Reference: Established in 1989.

Funding Levels: $118,000 appropriated each year from FY98–99 through FY02–30

Objectives of the Program: Catalyze the growth of Maine's biotechnology and biomedical sector by promoting the interaction of scientific excellence, commercial innovation and business development.

Program Activities: Prior to FY01 and the establishment of the Maine Technology Institute, CIB was a granting agency. Grants were made to companies, non-profit labs and universities for research projects ranging in size from $1,000-to-$25,000.

This granting role is now being done by MTI, so the CIB has changed its role to give priority to programs that facilitate collaborative efforts and commercial potential, to initiatives that promote networking among community members and to the brokering and facilitation of access to needed development services.

Data Collected

Outputs: CIB has data available on grants made including recipients, amounts and project titles.
Outcomes:

Program: **Governor's Marine Studies Fellowship Program**

Stakeholder: Department of Marine Resources

Statutory Reference:

Funding Levels: $50,000 appropriated each year from FY98–99 to FY02–03

Objectives of the Program: To encourage the study of disciplines important to the conservation, management and utilization of marine resources.

Program Activities: Funds 13 graduate and undergraduate projects.

Data Collected

Inputs:
Outputs:
Outcomes:

Program Name: **Small Enterprise Growth Fund (SEGF), Maine Economic Development Venture Capital Revolving Investment Program, Maine Seed Capital Tax Credit Program**

Stakeholder: Small Enterprise Growth Board, Finance Authority of Maine (FAME)

Statutory Reference:

Maine Economic Development Venture Capital Revolving Investment Program: 10 MRSA § 1026-N

Maine Seed Capital Tax Credit Program: PL 1987, c.854 §2 (new)

Small Enterprise Growth Fund: Chapter 13, PL 1995, c. 699 §3 (new)

Funding Levels:

Maine Economic Development Venture Capital Revolving Investment Program: $3 million from another program's excess.

Maine Seed Capital Tax Credit Program: $12,000,000 as of Fall 2001

Small Enterprise Growth Fund: $8 million ($5 mm bond issue; $3 mm appropriation)

Objectives of the Program: The mission of FAME is to foster the hopes and dreams of Maine people by providing innovative financial solutions. They provide tools and information to help Maine citizens pursue business and educational opportunities, and, in doing so, strengthen Maine's economic vitality and prosperity.

Maine Economic Development Venture Capital Revolving Investment Program: to allow the state to invest as an equal partner with others in eligible private venture capital funds and thereby encourage private funds to support emerging and early-growth businesses in Maine.

Maine Seed Capital Tax Credit Program: To encourage equity investment in young business ventures, directly and through private venture capital funds.

Small Enterprise Growth Fund: Provides up to $500,000 in patient capital to promising companies that demonstrate a potential for high growth and public benefit.

Program Activities:

Maine Economic Development Venture Capital Revolving Investment Program: FAME invests in established venture capital funds that have a strategy for the creation and retention of jobs in Maine through investments in Maine high-growth businesses; marketing and technical assistance plan; appropriate monitoring of its investments; a process for complying with proposed measurement and goals. Maximum investment $1,000,000.

Maine Seed Capital Tax Credit Program: FAME is responsible for evaluating applications for state income tax credits certificates which may be authorized for up to 40 percent (was originally 30 percent) of the cash equity provided to eligible Maine businesses. Investment may be used for fixed assets, research or working capital. Businesses must be located in Maine. Investors must own less than 50 percent of the business. Immediate relatives of principal owners are not eligible. Annual gross sales must be less than $3 million. Investors may provide up to $200,000 per business with aggregate investment limit per business of $1 million for which tax credit can be received.

Small Enterprise Growth Fund: As the state funded venture capital fund, SEGF selectively invests in small businesses in the following sectors (marine science, biotechnology, manufacturing, software development, out-of-state exporters, environmental services, financial/insurance services, natural resources). Companies must demonstrate potential for high growth and public benefit, and have 50 or fewer employees or less than $5 million in sales. The SEGF is limited to a maximum of $500,000 of staged investment per company. Terms and rate of return are adjusted based on risk.

Data Collected

Outputs: FAME reports annually on disbursements from its funds.

Outcomes: In FAME's strategic plan, performance measures include: number of investments and number of jobs created or maintained by business assisted by FAME financing.

The venture funds which received funding from the Maine Economic Development Venture Capital Revolving Investment Program, are required to report at least semiannually to the authority on the business in which the private venture capital fund invests and the administration of the program. The report must include a description of each business, the amount, type and terms of assistance the business received, the amount of funds invested, the number of jobs that were created or retained and other information. The report must contain an accounting of the investment portfolio and any investments that are in default, as well as an accounting of the fund's administrative expenses incurred and charged. The names of the funds receiving an investment, the amount invested in a fund, the names of the businesses benefiting from the investments, the nature of the business and the intended use of proceeds shall be public information. To date, the Program has decided to invest in five funds. Only one, Coastal Ventures II, LLC, has closed on its initial installment (3/08/01).

Public information gathered for the Seed Capital Tax Credit Program include the names of participating investors and funds, the amount of certificates issued to each investor, the names of businesses benefiting from investments, the nature of the business and the intended use of proceeds. Since its inception in FY89, 563 tax credit certificates have been issued with a cumulative value of $4.926 million. These credits correspond to $16.093 million in investments. Approximately 60 individual businesses have received investments.

Companies which receive an investment from the Small Enterprise Growth Fund are required to report to the Small Enterprise Growth Board on financial performance, technological progress, market progress and any other factors as the board may require. Like any venture fund, SEGF maintains a current record of its investments, their most recent valuations, employment and status. The following information is considered public: names of recipients or applicants, amounts, types and general terms of assistance, description of projects and businesses, names of transferors or transferees, number of jobs and amount of tax revenues projected and resulting. Confidential information includes financial statements and tax records, competitive information. As of May 30, 2001, The Small Enterprise Growth Fund has made $3,808,000 of investments. Another $1,150,000 have been approved. The value of the holdings based on last transaction is $3,291,642. ($300,000 has been charged off.) Employment growth is reported from 164 at time of investment to 1677 now. One company, EnvisioNet, is responsible for 1500 of these jobs. In late May, EnvisioNet announced major layoffs based on the loss of a contract with Microsoft. June 14, 2001, EnvisioNet entered Chapter 11 bankruptcy. In early September, MicroDyne, a Torrance, CA based company, purchased EnvisioNet for $10.7 million.

Program Name: **Gulf of Maine Aquarium Research Laboratory**

Stakeholder: Department of Economic and Community Development

Statutory Reference: Chapter 718, S.P. 819 - L.D.2205 Part A; Sec. A-6.

Funding Levels: $2.0 million to build research lab. Part of 1998 research and development bond.

Objectives of the Program: Part of a $6.1 million project to build 20,000 sq.ft. research laboratory to support fishery research, marine biotechnology development and science education for K–12 students and the general public.

Program Activities: Site selection and acquisition complete. Final design underway. Expect to break ground August 2002.

Data Collected

Outputs: Amount of matching funds, size of building, number of net new scientists housed, funding dollars attracted.
Outcomes:

Program Name: **Maine Agricultural and Forest Experiment Station**

Stakeholder: University of Maine

Statutory Reference: PL 1997, c. 711 §2

Funding Levels: MAFES received $1,755,914 in Hatch Funds for FY1999, with a required match of equal size.

Objectives of the Program: The Maine Agricultural and Forest Experiment Station is a department of the University of Maine. The Experiment Station was established under the Hatch Act passed in 1886. The Station's purpose is to identify and address the basic and applied research needs of the state in the areas of agriculture, forestry, marine and rural economic development.

Program Activities: The plan for FY2000 to FY2004 covers research to meet four goals. These are:

Goal 1: An Agricultural System that is Highly Competitive in the Global Economy

Program Area: Plant-based Agricultural Production Systems

Program Area: Animal-based Agricultural Production Systems

Goal 2: To Provide a Safe, Affordable and Nutritious Food Supply

Program Area: Food Safety and Quality

Goal 3: To Achieve a Healthier, Better Nourished Population

Program Area: Human Nutrition

Goal 4: Greater Harmony Between Agriculture and the Environment

Program Area: Soil and Water Quality

Program Area: Pest Management

Program Area: Fish, Wildlife and Other Natural Resources

Data Collected

Inputs: Funds are tracked based on sources and used by project.
Outputs: These vary by goal and program, but include things such as new varieties of plants, design of a delivery system for the identification of *e. coli* in fruit juices.
Outcomes: These vary by goal and program, but include broad indicators.

Program Name: **Centers for Innovation Program**

Stakeholder: Maine Aquaculture Innovation Center

Statutory Reference: Enacted in 1989

Funding Levels: FY89: $35,000; FY90: $301K; FY91: $242K; FY92: $214K; FY93 to present: $190K.

Objectives of the Program: The mission of the MAIC is to assist in the development of economically viable aquaculture opportunities along the cost of Maine and at appropriate inland sites.

Program Activities: Activities from FY89 to FY00 have included sponsoring and facilitating innovate research and development projects involving food, pharmaceuticals, and other products from sustainable aquatic systems; investing in the enhancement of aquaculture capacity in Maine; serving as a clearing house of educational information to enhance public visibility and acceptance of aquaculture and encouraging strategic alliances tasked with promoting research, technology transfer and the commercialization of aquaculture research.

In FY01, MAIC has signed an agreement with the Advanced Technology Center to construct and operate a three-location aquaculture business incubator. MAIC assisted the University of Maine in the preparation of a proposal to U.S. Economic Development Administration for $1.2 million to partially fund the construction of a marine species culture facility. MAIC has stopped its granting activities in light of the Maine Technology Institute funding.

Data Collected

Outputs: MAIC reports regularly to its Board on the activities that it has sponsored.

Outcomes:

Program Name: **Maine Biomedical Research Program**

Stakeholder: Department of Economic and Community Development (moving to Maine Technology Institute)

Statutory Reference: 5 MRSA c. 383 sub-c. V-A §13103, amended 2001.

Funding Levels: $10 million for FY00–01. $4.15 million for FY02. In addition, an R&D bond package will be presented to the voters in Fall 2001 that includes $4 million for the fund.

Objectives of the Program: The objectives of the program were amended in 2001 to focus on economic development and jobs in the State primarily by making state investment in organizations with successful results in attracting biomedical research funds from sources outside Maine. A secondary purpose is to provide incentives for small eligible organizations to grow.

Program Activities: The Maine Biomedical Research Board (utilizing the Maine Technology Institute as its fiscal agent) is established to disburse program funds to eligible institutions. Funding can be used for project funding, facilities funding, including debt service, equipment purchase, including debt service and ancillary support. Overhead charges may be included consistent with federal research granting criteria. The Program allocates fund to eligible institutions based on a formula. The formula is based on federal and foundation funds attracted in the previous two years.

The Program is just completing its first round of funding (June 2001). Funds were dispersed to 10 institutions. Jackson Laboratories received 65 percent of the funds, University of Maine received 16.8 percent, Maine Medical Center Research Institute received 9.1 percent and Mount Desert Island Biological Laboratories received 5.6 percent. All others received less than 1.5 percent.

Data Collected:

Outputs: Applications for funding include a plan showing how the funds would be used and its research and economic benefits; peer review journal articles showing the competitiveness of the institution's research; amount of funding from outside sources and its use. The recipient is required to maintain an accounting of how funds are used.

Outcomes: Recipients are required by legislation to undertake an evaluation of the direct and indirect economic impact of the funded research and an assessment of the contribution of the funded research to scientific advancement and the institution's competitive position.

Program Name: **Maine Patent Program**

Stakeholder: Technology Law Center, University of Maine School of Law

Statutory Reference: 10 MRSA c. 317 §1921 (1999)

Funding Levels: $300,000 annually for FY2000, FY2001. Expecting same level for FY02 and FY03.

Objectives of the Program: "To support the commercialization and manufacturing of innovations in the State by providing education and assistance with the patent process of the United States Patent and Trademark Office to companies, inventors and entrepreneurs in the State." 10 MRSA c. 317 §1921

Program Activities: The program is currently being designed. The legislation requires workshops on the patenting process, screening of preliminary potential patent applications, patent searches, preparation of patent applications, and licensing assistance. The program is operated at the Technology Law Center at the Law School of the University of Southern Maine in Portland.

Data Collected:

Inputs:

Outputs:
Outcomes:

Program Name: **Expensing of R&D Expenditures; High-technology investment tax credit; Research Expense Tax Credit, Super credit for substantially increased R&D**

Stakeholder: Maine Revenue Service

Statutory Reference: 36 MSRA c. 882 §5219-K, L, M.

Funding Levels:

Expensing of R&D Expenditures: approximately $200,000 offset in FY98 and FY99

High-technology investment tax credit: $657,657 offset in FY98 and FY99

Research Expense Tax Credit: $854,100 offset in FY98 and FY99

Supercredit for substantially increased R&D: $838,976 offset in FY98 and FY99

Objectives of the Program:

Program Activities:

Research expense tax credit: A taxpayer is allowed a credit against tax due equal to 5 percent of the excess of any qualified research expense over the average of the past 3 years. The credit is limited to 100 percent of a corporation's first $25,000 of tax due plus 75 percent of the tax due over $25,000. The credit may be carried over for 15 years. The credit allowed may not reduce the tax due to less than zero.

Super credit for substantially increased research and development: If a taxpayer increased their research qualifying for the research expense tax credit by 50 percent over the average of the past three years, they may take a tax credit limited to 50 percent of the taxes due after other credits are taken. This credit may carry forward five years. It may not reduce the tax liability below zero.

High-technology investment tax credit: This tax credit is limited to companies involved in the design, creation and production of computer software, computer equipment, supporting communications components and the provision of Internet or electronic communications access services r support. These companies may take a credit equal to its investment in equipment. The credit may not reduce the tax liability below zero and may be carried forward 5 years.

Data Collected

Outputs: The Maine Revenue Service can list the corporations (and starting this year, the individuals) who take advantage of these tax credits. However, tax records are confidential. Statistics obtained from the tax returns are permitted. In the aggregate, all the tax credits taken together for FY98 totaled less than $750,000. For instance, 10 companies took the R&D tax credit, 3 corporations and perhaps a dozen individuals took the super credit. However, a number of large corporations have taken advantage of the high-technology investment tax credit. The credit was designed for small businesses and legislation to amend the credit is pending.

Outcomes: In July 1998, the Maine legislature passed a law requiring annual reports from employers that receive more than $10,000 from certain economic development incentive programs. The incentives covered include the Research Expense Tax Credit. Annually, by August 1, employers covered by this law must report on the amount of funds received from each incentive, the total company funds expended on training and capital, the number of jobs created and retained, company total employment levels and average wages and benefits paid by job classification. This survey is conducted and tabulated by DECD.

Program Name: **EPSCoR, Marine Technology Fund, Research Challenge Grants Program; Marine Connectivity, mainescience.org**

Stakeholder: Maine Science and Technology Foundation

Statutory Reference: Chapter 718, S.P. 819, L.D. 2205

Funding Levels:

EPSCoR:

DOD (1993-2000) no state match;

DOE (1993-2000) $5,204,011 state match;

NIH (2000) no state match;

[NSF (1980-2000): $1,200,000 state match; $3,971,544 from UMaine funds.]

Marine Technology Fund: $3 million (Marine Connectivity $1 million and R&D, $2 million)

Research Challenge Grants Program: $1.5 million

Objectives of the Program:

Marine Technology Fund: To provide funds to enhance research and education capability in public and private educational institutions conducting marine research and not-for-profit organizations engaged in research.

Research Challenge Grants: To provide funds for research institutions in the for-profit, not-for-profit and academic sectors to enhance research and development capacity and productivity.

Marine Connectivity: Increased capacity through connectivity: access to broad bandwidth; enhanced communication or collaborative opportunities.

Program Activities:

Marine Technology Fund: Between $10,000 to $500,000 awarded for equipment and associated instrumentation, facility improvements and renovations and telecommunications infrastructure.

Research Challenge Grants: Between $10,000 and $400,000 awarded for equipment and associated instrumentation, facility improvements and renovations and telecommunications infrastructure.

Marine Connectivity: Grants were made to install ATM capability (up to $90,000) and compressed video networking capability (up to $40,000).

Data Collected

Outputs: EPSCoR reports are made to the federal government.

Outcomes: Project status reports from recipients of the Marine Technology Fund and The Research Challenge grants include: uses of funds, how physical infrastructure contributed to project outcomes, measures of impacts (e.g., joint R&D efforts pursued, products/processes developed, jobs created, patents filed, new companies started, number of students trained, courses designed.

Program Name: **Maine Space Grant Consortium**

Stakeholder: Maine Space Grant Consortium

Statutory Reference:

Funding Levels: $100,000/year from Maine matching $256,000/year in NASA funding.

Objectives of the Program: As part of NASA's National Space Grant College and Fellowship Program, the mission of MSGC is to work with and through the affiliate organizations to strengthen Maine's space and aeronautics-related research and education assets that are important to NASA and to the international space and aeronautics community.

Program Activities:

- Scholarships and fellowships for undergraduate and graduate students studying space and aeronautics-related fields at Maine colleges and universities;
- Seed research grants and travel grants to stimulate collaborative endeavors between Maine-based researchers and researchers at NASA's field centers;
- Outreach to Maine schools and communities promoting opportunities in space and aerospace-related research and education;
- Extension activities that transfer NASA technologies and knowledge to the private and public sectors as well as the community-at-large.
- NASA EPSCoR grant coordinator (award expected June 2001)

Data Collected

Outputs: MSGC supplies output data to its Board and the legislature annually. This includes the number of fellowships, number of students exposed to NASA, and number of collaborative relationships between Maine companies and NASA.

Outcomes: MSGC supplies outcome data such as the amount of federal funds leveraged with the state match, new NASA funding in Maine to researchers and educators receiving MSGC support, other federal funding.

Program Name: **Cluster Enhancement Awards; Development Awards, Seed Grant Program, SBIR assistance**

Stakeholder: Maine Technology Institute

Statutory Reference: 5 MSRA c. 407 (1999)

Funding Levels: $3.2 million FY00; $6.4 million FY01. FY02/03 appropriation $6.4 million annually.

Objectives of the Program: To stimulate and support research and development leading to commercialization of new products and services in the State's targeted technology sectors: advanced technologies for forestry and agriculture; aquaculture and marine technology; biotechnology; composite materials technology; environmental technology; information technology; precision manufacturing technology.

Program Activities: All programs require a minimum 1:1 cash match.

Seed grants: Grants of up to $10,000 offered four times each year. Requires 1:1 cash match. Eligible projects include: small R&D project leading to commercialization, technical or consulting assistance for SBIR/STTR, MTI or other commercialization proposal preparation, market analysis, intellectual property filing or other activity leading to commercialization.

Development awards: Awards of up to $500,000, offered twice a year. Requires 1:1 cash match. Requires a payback if the funded technology is commercialized. Eligible projects include comprehensive R&D leading to commercialization including proof of concept work, prototype development, feasibility studies, alpha and beta testing, engineering and manufacturing design, etc.

Cluster enhancement awards: Awards of up to $100,000 for collaborative, comprehensive projects that address specific needs within or among the targeted industry sectors. Eligible projects include: common equipment purchases, common research facilities, development of technology-oriented programs, or other programs and projects that address the MTI purpose.

Technical assistance and information related to the federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer STTR programs.

Data Collected

Outputs: MTI submits quarterly financial statements and award disbursement summaries. MTI reports annually to the legislature on all activities of the Institute including the awards it has made and the funding dispersed. (Funding is dispersed based on milestones attained by the recipient(s).)

Outcomes: MTI is required by statute to produce an independent evaluation every two years starting January 2003. The statute requires that the evaluation include: "firm survival, new product development and process innovations, jobs created and other measures that the evaluator....may establish." Further, the "evaluation must consider the institute's strategic roles in stimulating economic growth in Maine's targeted technologies."

Program Name: Capital improvements and equipment, capital improvements to support research, Maine Economic Improvement Fund, Research and Development Funds, Strategic Technology Initiative

Stakeholder: University of Maine System

Statutory Reference:

Capital improvements and equipment: PL 1997, Ch 718 S.P. 819 – L.D. 2205 Part $, Sec. A-6

Funding Levels: All amounts are split 80/20 U Maine/University of Southern Maine

Capital improvements and equipment: 1998 Referendum Bond. $13,500,000 total; $10,800,000 to UMaine, $2,700,000 to University of Southern Maine.

Capital improvements to support research: $25 million University Bond

Maine Economic Improvement Fund: $20 million

Research and development activities:

Strategic Technology Initiative: $200,000

Objectives of the Program: To improve the Maine economy by supporting innovative research and development.

Program Activities:

Data Collected

Inputs:

Outputs: The University of Maine System provides annual reports on the utilization of state research appropriations for operations and state research capital bonds.

Outcomes: The annual report includes data on external grant and contract funding attracted as a result of the state's appropriation. For instance, UMS reported that in FY2000 they attracted $36.6 million in external grant and contract funding, a ratio of 3.5 to 1 on the state's $10.5 million investment. The report also includes progress reports on capital programs. In addition, each faculty member completes a report on their research accomplishments for the year. The university also tracks its patents and license activity. (Currently, they have 5 patents and apply for 2-to-3 a year.)

APPENDIX 3

Outcome and Indicator Analysis for Programs Included in the Study

To look at outcomes for all of the programs included in this study, we first clustered them into groups according to their objectives, linking them to the state's overall economic development objective as articulated in the *State of Maine Economic Development Strategy*, which is:

> "Our vision is a high quality of life for Maine citizens. Central to this vision is a sustainable economy that offers the opportunity for everyone to have rewarding employment and for business to prosper, now and in the future."[1]

Supporting this vision is the "Maine Science and Technology Action Plan 2001: Positioning Maine for the New Economy." There, four relevant goals are articulated:

1. An educated and technically skilled workforce
2. A robust research and development enterprise
3. An environment that fosters entrepreneurial innovation
4. Statewide access to the latest information technology infrastructure.[2]

Next, the evaluation team visited with each stakeholder, the organization to whom the legislature appropriated the funds being included in this evaluation. As a result of these visits, the objectives of each program were compiled and are included in Appendix 2.

Based on these visits and review of statutes, strategic plans and other operating plans, the evaluators identified the outputs, intermediate and end outcomes for each program. Then, for each outcome, appropriate indicators were chosen. When possible, indicators were chosen from the U.S. Department of Commerce, Office of Technology Policy publication, "The Dynamics of Technology-based Economic Development: State Science and Technology Indicators." The evaluators believe that the use of these indicators will facilitate future comparisons with other states. Details of this analysis are included in Tables 3.1–3.4, which follow.

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1 State of Maine Economic Development Strategy (January 2000).

2 MSTF, *Maine's Science and Technology Action Plan 2001: Positioning Maine for the New Economy*. A fifth goal, "A supportive public and well informed policymakers," is not relevant to the pro grams being evaluated.

Table 3.1: Link Vision, Objectives with Programs and Stakeholders

State of Maine Economic Development Strategy (January 2000) Vision: "Our Vision is a high quality of life for Maine citizens. Central to this vision is a sustainable economy that offers the opportunity for everyone to have rewarding employment and for business to prosper, now and in the future."

Goals[1]	Objectives	Program	Stakeholder
An educated and technically skilled workforce	*Increase the percentage of Maine's adults with Associate and Baccalaureate Degrees*		
	Continue to Expand Maine's S&E Graduate Degree Programs	Governor's Marine Studies Fellowships	Department of Marine Resources (DMR)
		Aerospace research, education and public service infrastructure	Maine Space Grant Consortium
	Preserve Maine's K-12 Science and math system		
	Increase percentage of Maine's workforce engaged in training and lifelong learning		
A robust research and development enterprise	*Expand Publicly sponsored R&D to strengthened Maine's public/private research institutions*	Maine Economic Improvement Fund	University of Maine System
		Capital improvements and equipment	U Maine System
		Capital improvements to support research	U Maine System
		Research and Development Activities	U Maine System
		Strategic Technology Initiative	U Maine System
		Research Challenge Grants	MSTF
		Marine Technology Fund	MSTF
		Biomedical Research Fund	Department of Economic and Community Development
		Maine EPSCoR	MSTF
		R&D Programs of the Maine Agricultural and Forest Experiment Station (MAFES)	MAFES, U Maine
		Gulf of Maine Aquarium Research Laboratory	Department of Economic and Community Development
	Foster Alliances		
	Expand Models for technology Transfer and Commercialization		
An environment that fosters entrepreneurial innovation	*Promote the expansion of entrepreneurial research and development*	Maine Technology Institute	Department of Economic and Community Development
		Applied Technology Development Centers	Department of Economic and Community Development
		SBIR Technical Assistance	MSTF, MTI, Dept of Economic and Community Development
		Centers for Innovation Program (old charters)	Center for Innovation in Biotechnology (CIB), Maine Aquaculture Innovation Center
	Strengthen Maine's Business and Financial Support Programs	Maine Economic Development Venture Capital Revolving Investment Program	Finance Authority of Maine
		Maine Seed Capital Tax Credit Program	Finance Authority of Maine
		Small Enterprise Growth Fund	Finance Authority of Maine
		High-technology Investment Tax Credit	Maine Revenue Services
		Research Expense Tax Credit	Maine Revenue Services
		Expensing of Research and Development Expenditures	Maine Revenue Services
		Super Credit for Substantially Increased R&D	Maine Revenue Services
	Strengthen Maine's Capacity to support Intellectual Property Rights for entrepreneurs	Maine Patent Program	University of Maine School of Law

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Goals[1]	Objectives	Program	Stakeholder
Statewide access to the latest information technology infrastructure	*Fully connect Rural businesses to state-of-the-art broadband infrastructure*		
	Expand Statewide Access to S&T information	S&T Clearinghouse: Mainescience.org	MSTF
	Provide State of the art technologies to Maine students		
	Expand intra- and inter-state research collaborations using the Internet	Marine Connectivity Grants	MSTF

[1] Goals and objectives are taken from *Maine's Science and Technology Action Plan 2001*.

Table 3.2: Link Projects with Outputs, Intermediate and End Outcomes

Program	Output	Intermediate Outcome	Intermediate Outcome	End outcome
Governor's Marine Studies Fellowships	Number of new students engaged in applied marine research[1]	Increased advanced degrees in marine science; increased capacity in research in marine science	Attraction of increased federal funding in marine science	Attraction/growth of industry based on marine science expertise; jobs, increased sales
Maine Space Grant Consortium (MSGC)	Projects, fellowships	Increases number of Maine students who study science and engineering; increased collaborations between Maine researchers and NASA.	Increased science and engineering capability of workforce; increased NASA funding of R&D in Maine	Attraction/growth of industry requiring educated S&E workforce; jobs, new/enhanced companies, per capita income
Maine Economic Improvement Fund	Capital improvement projects; new faculty, post docs; matching funds.	Increased federal grants; new R&D funding from new faculty and facilities.	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	New/enhanced companies, jobs, increased revenues; per capita income
Capital improvements and equipment	New research facilities	Increased federal grants; new R&D funding from new faculty and facilities.	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	New/enhanced companies, jobs, increased revenues; per capita income
Capital improvements to support research	New research facilities	Increased federal grants; new R&D funding from new faculty and facilities.	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	New/enhanced companies, jobs, increased revenues; per capita income
Research and Development Activities	Matching funds	Increased federal grants and other new R&D funding	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	New/enhanced companies, jobs, increased revenues; per capita income
Strategic Technology Initiative	Business plans new uses of wood based natural resources	Adoption of business plans by new company or existing company	Funding of new activities	New/enhanced companies, jobs, increased revenues; per capita income
Research Challenge Grants	Applied research projects	Increased federal grants;	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New/enhanced companies, jobs, increased revenues; per capita income

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Table 3.2, continued

Program	Output	Intermediate Outcome	Intermediate Outcome	End outcome
Research Challenge Grants	Applied research projects	Increased federal grants;	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New/enhanced companies, jobs, increased revenues; per capita income
Marine Technology Fund	Research projects	Increased federal grants;	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New/enhanced companies in marine fisheries and aquaculture, increased revenues; steady employment in marine fisheries and growing employment in aquaculture; increased value of seafood landed in Maine[2]
Biomedical Research Fund	Build facilities	New Research Projects	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New/enhanced companies, jobs, increased revenues; per capita income
Maine EPSCoR	Increased research capacity at Maine's universities	Attraction of increased federal funding	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New/enhanced companies, jobs, increased revenues; per capita income
R&D Programs of the Maine Agricultural and Forest Experiment Station	Applied research projects	Increased federal grants;	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New/enhanced companies, jobs, increased revenues; per capita income
Gulf of Maine Aquarium Research Laboratory	Build facilities	New research projects	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New/enhanced companies, jobs, increased revenues; per capita income
Maine Technology Institute	Grants for starting businesses, product development, research and development	Patents, New product Development, SBIRs and other federal grants		New/enhanced companies, jobs, increased revenues; per capita income
Applied Technology Development Centers	Business incubators for technology companies	Increased productivity and competitiveness	Venture capital and other funding	New/enhanced companies, jobs, increased revenues; per capita income
SBIR Technical Assistance	Assistance rendered to firms	New federal funding for R&D	Disclosures, Patents, Licenses, New Products	New/enhanced companies, jobs, increased revenues; per capita income
Center for Innovation in Biotechnology (CIB) (old charter)	Collaborative Projects; venture funding	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New Products	New/enhanced companies, jobs, increased revenues; per capita income

Program	Output	Intermediate Outcome	Intermediate Outcome	End outcome
Maine Aquaculture Innovation Center (MAIC) (old charter)	Establishment of strategic alliances, R&D projects	Disclosures, Patents, Licenses, New Products, publications, joint research projects with ME companies	New Products	New/enhanced companies, jobs, increased revenues; per capita income
Maine Economic Development Venture Capital Revolving Investment Program	Increased availability of private venture capital	Increased investment in entrepreneurial ventures in Maine		New/enhanced companies, jobs, increased revenues; per capita income
Maine Seed Capital Tax Credit Program	Increased availability of private venture capital	Increased investment in entrepreneurial ventures in Maine		New/enhanced companies, jobs, increased revenues; per capita income
Small Enterprise Growth Fund	Increased availability of private venture capital	Increased investment in entrepreneurial ventures in Maine		New/enhanced companies, jobs, increased revenues; per capita income
High technology Investment Tax Credit	Increased investment in research and development	Disclosures, Patents, Licenses	New Products	New/enhanced companies, jobs, increased revenues; per capita income
Research Expense Tax Credit	Increased investment in research and development	Disclosures, Patents, Licenses	New Products	New/enhanced companies, jobs, increased revenues; per capita income
Expensing of Research and Development Expenditures	Increased investment in research and development	Disclosures, Patents, Licenses	New Products	New/enhanced companies, jobs, increased revenues; per capita income
Super Credit for Substantially Increased R&D	Increased investment in research and development	Disclosures, Patents, Licenses	New Products	New/enhanced companies, jobs, increased revenues; per capita income
Maine Patent Program	Provide patent assistance to entrepreneurs and manufacturers	Disclosures, Patents, Licenses	New Products	New/enhanced companies, jobs, increased revenues; per capita income
S&T Clearinghouse: mainescience.org	Increased public information on science and technology in Maine	Increased awareness by researchers, graduate students, businesses, and citizens of R&D/S&T activities and opportunities in Maine	Continued support for S&T investment	New/enhanced companies, jobs, increased revenues; per capita income
Marine Connectivity Grants	Increased collaboration among marine research institutions	Enhanced research capability and increased federal funding	Disclosures, patents, licenses, new products/processes	New/enhanced companies, jobs, increased revenues; per capita income

[1] From Maine Department of Marine Resources, Strategic Plan, September 2000.

[2] Ibid.

Table 3.3: Link Objectives, Programs, Intermediate Outcomes and Indictors for these Outcomes

Objective	Program	Intermediate Outcome	Intermediate Outcome	Indicators[1]
Continue to Expand Maine's S&E Graduate Degree Programs	Governor's Marine Studies Fellowships	Increased advanced degrees in marine science; increased capacity in research in marine science	Attraction of increased federal funding in marine science	S&E Graduate Students; Recent S&E PhDs and Masters in the Workforce; Federal R&D Obligations
	Maine Space Grant Consortium (MSGC)	Increased number of Maine students who study science and engineering; increased collaborations between Maine researchers and NASA	Increased science and engineering capability of workforce; increased NASA funding of R&D in Maine	S&E Graduate Students; Recent S&E PhDs and Masters in the Workforce; *NASA R&D Funding; # of collaborations with NASA researchers*
Preserve Maine's K 12 Science and math system				
Expand Publicly sponsored R&D to strengthened Maine's public/private research institutions	Maine Economic Improvement Fund	Increased federal grants; new R&D funding from new faculty and facilities	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	University performed R&D Expenditures; Federal R&D Obligations; Patents; *Patent Citations, publications, new sponsored research programs with Maine companies*
	Capital improvements and equipment	Increased federal grants; new R&D funding from new faculty and facilities	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	University performed R&D Expenditures; Federal R&D Obligations; Patents; *Patent Citations, publications, new sponsored research programs with Maine companies*
	Capital improvements to support research	Increased federal grants; new R&D funding from new faculty and facilities	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	University performed R&D Expenditures; Federal R&D Obligations; Patents; *Patent Citations, publications, new sponsored research programs with Maine companies*
	Research and Development activities	Increased federal grants; new R&D funding from new faculty and facilities	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	University performed R&D Expenditures; Federal R&D Obligations; Patents; *Patent Citations, publications, new sponsored research programs with Maine companies*
	Strategic Technology Initiative	Adoption of business plans by new company or existing company	Funding of new activities	New or existing companies, Venture capital or new funding raised.

Objective	Program	Intermediate Outcome	Intermediate Outcome	Indicators[1]
	R&D Programs of the Maine Agricultural and Forest Experiment Station	Increased federal grants;	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	University performed R&D Expenditures; Federal R&D Obligations; Patents; *Patent Citations, publications, new sponsored research programs with Maine companies*
	Gulf of Maine Aquarium Research Laboratory	New research projects	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	University performed R&D Expenditures; Federal R&D Obligations; Patents; *Patent Citations, publications, new sponsored research programs with Maine companies*
Promote the expansion of entrepreneurial research and dev.	Maine Technology Institute	Patents, new product development, SBIRs and other federal grants	New product development	Patents; *Patent Citations,* SBIRs and other federal obligations
	Applied Technology Development Centers	Increased productivity and competitiveness	Venture capital and other funding	Venture capital, new funding, SBIRs and other federal awards
	SBIR Technical Assistance	New Federal funding for R&D	Disclosures, Patents, Licenses, New Products	Federal R&D Obligations; Patents; *Patent Citations*
	Center for Innovation in Biotechnology (CIB) (old charter)	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	New Products	Patents; *Patent Citations, publications, new projects with Maine researchers*
	Maine Aquaculture Innovation Center (MAIC) (old charter)	Disclosures, Patents, Licenses, New Products, publications, joint research projects with Maine companies	New Products	Patents; *Patent Citations, publications, new projects with Maine researchers*
Strengthen Maine's Business and Financial Support Programs	Maine Economic Development Venture Capital Revolving Investment Program	Increased investment in entrepreneurial ventures in Maine		Venture Capital; *mergers and acquisition activity,* IPOs, Inc. 500 companies; Technology Fast 500 Companies.
	Maine Seed Capital Tax Credit Program	Increased investment in entrepreneurial ventures in Maine		Venture Capital; *mergers and acquisition activity,* IPOs, Inc. 500 companies; Technology Fast 500 Companies.
	Small Enterprise Growth Fund	Increased investment in entrepreneurial ventures in Maine		Venture Capital; *mergers and acquisition activity,* IPOs, Inc. 500 companies; Technology Fast 500 Companies.

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Table 3.3, continued

Objective	Program	Intermediate Outcome	Intermediate Outcome	Indicators[1]
	High technology Investment Tax Credit	Disclosures, Patents, Licenses	New Products	Patents; *Patent Citations*
	Research Expense Tax Credit	Disclosures, Patents, Licenses	New Products	Patents; *Patent Citations*
	Expensing of Research and Development Expenditures	Disclosures, Patents, Licenses	New Products	Patents; *Patent Citations*
	Super Credit for Substantially Increased R&D	Disclosures, Patents, Licenses	New Products	Patents; *Patent Citations*
Strengthen Maine's Capacity to support Intellectual Property Rights for entrepreneurs	Maine Patent Program	Disclosures, Patents, Licenses	New Products	Patents; *Patent Citations*
Expand Statewide Access to S&T information	mainescience.org	Continued support for S&T investment		*Net new state investment in S&T*
Expand intra and inter state research collaborations using the Internet	Marine Connectivity Grants	Enhanced research capability and increased federal funding	Disclosures, patents, licenses, new products/processes	University performed R&D Expenditures; Federal R&D Obligations; Patents; *Patent Citations, publications, joint research projects with Maine companies*

[1] All indicators except those in italics are from U.S. Department of Commerce, *The Dynamics of Technology based Economic Development: State Science and Technology Indicators* , June 2000.

Table 3.4: Link Objectives and Programs with End Outcomes and Their Indicators

Objective	Program	End Outcome	Indicators[1]
Continue to Expand Maine's S&E Graduate Degree Programs	Governor's Marine Studies Fellowships	Attraction/growth of industry based on marine science expertise; jobs, increased sales	New or retained establishments in marine science, jobs in marine science companies; sales of marine products
	Maine Space Grant Consortium (MSGC)	Attraction/growth of industry requiring educated S&E workforce, jobs, new/enhanced companies, per capita income	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*
Preserve Maine's K 12 Science and math system			

Table 3.4, continued

Objective	Program	End Outcome	Indicators[1]
Expand Publicly sponsored R&D to strengthened Maine's public/private research institutions	Maine Economic Improvement Fund	New/enhanced companies, jobs, increased revenues, per capita income	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*
	Capital improvements and equipment	New/enhanced companies, higher wage jobs, increased revenues	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*
	Capital improvements to support research	New/enhanced companies, higher wage jobs, increased revenues	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*
	Research and Development activities	New/enhanced companies, higher wage jobs, increased revenues	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*
	Strategic Technology Initiative	New/enhanced companies, higher wage jobs, increased revenues	*Wood product Establishments; Wood product Establishment Births; Average Annual Earnings in wood products industry*
	Research Challenge Grants	New/enhanced companies, higher wage jobs	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*
	Marine Technology Fund	New/enhanced companies in marine fisheries and aquaculture, increased revenues, steady empolyment in marine fisheries and growing employment in aquaculture, increased value of seafood landed in Maine.	Marine fisheries and aquaculture employment, establishments (new, and retained), value of seafood landed in Maine
	Biomedical Research Fund	New/enhanced companies, higher wage jobs, increased revenues	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*

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Table 3.4, continued

Objective	Program	End Outcome	Indicators[1]
	Maine EPSCOR	Attraction/growth of industry; jobs, increased sales	Technology Intensive Establishments; Technology Intensive Establishment Births; Average Annual Earnings, *Revenue per employee*
	R&D Programs of the Maine Agricultural and Forest Experiment Station	New/enhanced companies, higher wage jobs, increased revenues, per capita income	*Business establishments in rural Maine, establishment births in rural Maine, average annual earnings in rural Maine*
	Gulf of Maine Aquarium Research Laboratory	New/enhanced companies, higher wage jobs, increased revenues, per capita income	Marine fisheries and aquaculture employment, establishments (new, and retained), value of seafood landed in Maine

[1] All indicators except those in italics are from U.S. Department of Commerce, *The Dynamics of Technology based Economic Development: State Science and Technology Indicators* , June 2000.

In summarizing this analysis, the evaluators realized that there are really two types of participants or recipients in the wide range of programs being evaluated: researchers, both at universities and at private, nonprofit organizations, and companies. We also realized that the objectives of the programs covered sometimes break into two categories: those aimed at increasing new technology development in existing, natural resource-based industries and those aimed at new, emerging industries. So we summarized both intermediate and end outcomes along these lines. In some cases, indicators cover both categories. These summaries are shown in Tables 3.5 and 3.6, which follow.

Table 3.5:
Summary Table of Intermediate Outcome Indicators

Researchers	Other	Companies
• S&E Graduate Students • Recent S&E PhDs and Masters in the Workforce • Federal R&D Obligations by agency • University performed R&D Expenditures • Patents • Patent citations • Publications • New sponsored research programs with Maine Companies	• Net new state investment in S&T • State R&D investment per worker • INC 500 companies • Technology Fast 500 companies	• New companies • Venture capital or new funding raised • SBIRs and other new federal grants or contracts • Patents • Patent citations • New projects with Maine researchers • Merger and acquisition activity • IPO

Table 3.6: Summary Table of End Outcome Indicators

	Researchers	Other	Companies
Existing Industries		• Value of seafood landed in Maine	• New or retained establishments in marine sciences and aquaculture • Jobs in marine sciences companies • Sales of marine products • Wood product establishment • Wood product establishment births • Average annual earnings in wood products industry
Emerging Industries			• Technology intensive establishments • Technology Intensive establishment births • Average annual earnings • Revenue per employee • Employment by establishments with less than 500 employees as percentage of total employment
Both			• Business establishments in rural Maine • Establishment births in rural Maine • Average annual earnings in rural Maine

APPENDIX 4

Definition of Recipients to be Surveyed Annually by Program

Program	Definition of Recipient	Type of Survey
Governor's Marine Studies Fellowship	A student who has received a fellowship during the past year.	Researcher
Maine Space Grant Consortium	A student who has received a fellowship in the past year. A researcher who has received funding in the past year. A company who has participated in a substantial project in the past year.	Researcher/Company
Maine Economic Improvement Fund	A researcher who has received matching funds in the past year. A researcher who has been hired from these funds in the past year. A researcher whose lab/office space has been built or renovated with these funds in the past year.	Researcher
Capital improvements and equipment	A researcher whose lab/office space has been built or renovated with these funds in the past year, or who has received new equipment from this fund.	Researcher
Capital improvements to support research	A researcher whose lab/office space has been built or renovated with these funds in the past year, or who has received new equipment from this fund.	Researcher
Research and Development Activities	A researcher who has received matching funds in the past year.	Researcher
Strategic Technology Initiative	A company who has participated in joint research or market development activity in the past year.	Company
Research Challenge Grants	A researcher who has received funds in the past year. A company who has received a grant in the past year.	Researcher/Company
Marine Technology Fund	A researcher who has received funds in the past year. A company who has received a grant in the past year.	Researcher/Company
Biomedical Research Fund	A research entity who has received funds in the past year.	Researcher/Company
Maine EPSCoR (Experimental Program to Stimulate Competitive Research)	A researcher who has received funds in the past year.	Researcher
Governor's Marine Fellowships	A student/researcher who has received funds in the past year.	Researcher
R&D Programs of the Maine Agricultural and Forest Experiment Station	A researcher who has received funds in the past year.	Researcher
Gulf of Maine Aquarium Research Facility	A researcher who has received funds in the past year.	Researcher

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Program	Definition of Recipient	Type of Survey
Maine Technology Institute	A company who has received a grant in the past year.	Company
SBIR Technical Assistance	A company who has received substantial assistance in the past year. (I.e. at least 8 hours)	Company
AppliedTechnology Development Centers	A company that is a client of an ATC incubator	Company
Center for Innovation in Biotechnology	A researcher who has received funds in the past year. A company who has received a grant in the past year.	Researcher/Company
Maine Aquaculture Innovation Center	A researcher who has received funds in the past year. A company who has received a grant in the past year.	Researcher/Company
Maine Economic Development Venture Capital Revolving Loan Fund	The companies invested in by the VC firms that receive money from this fund	Company
Maine Seed Capital Tax Credit Program	The companies invested in by the investors that take this tax credit	Company
Small Enterprise Growth Fund	The companies that receive investment from this fund	Company
High technology investment tax credit	The companies invested in by the investors that take this tax credit	Company
Research Expense Tax Credit	The companies that take this tax credit	Company
Expensing of Research and Development Expenditures	The companies that take this tax credit	Company
Super credit for Substantially Increased R&D	The companies that take this tax credit	Company
Maine Patent Program	A company who has received substantial assistance in the past year. (i.e. at least 8 hours)	Company
Science & Technology Clearinghouse: mainescience.org	n.a.	
Marine Connectivity Grants	A researcher who has received funds in the past year. A company who has received a grant in the past year.	Researcher/Company

APPENDIX 5

Indicator Analysis

Using the indicators chosen in the Program Theory analysis, secondary data were collected for Maine, the EPSCoR states, and the New England states. Canadian data proved elusive, and are not included here.

Table 5.1: Enrolled Science & Engineering Graduate Students, 1998

	1998	Population	Students Per Capita	Rank
United States	462,328	270,248,003	0.17%	10
MAINE	**704**	**1,247,554**	**0.06%**	**16**
New England States				
Connecticut	7,538	987,704	0.76%	3
Massachusetts	24,116	6,144,407	0.39%	5
New Hampshire	1,574	590,579	0.27%	8
Rhode Island	1,938	3,272,563	0.06%	16
Vermont	685	1,185,823	0.06%	16
Average NE	7,170			
EPSCoR States				
Alabama	6,687	730,789	0.92%	2
Alaska	723	4,351,037	0.02%	18
Arkansas	2,627	2,751,335	0.10%	15
Hawaii	1,753	4,362,758	0.04%	17
Idaho	1,649	3,934,310	0.04%	17
Kansas	6,764	1,811,688	0.37%	6
Kentucky	4,753	3,839,578	0.12%	13
Louisiana	6,942	480,045	1.45%	1
Mississippi	2,914	1,743,772	0.17%	10
Montana	1,304	1,230,923	0.11%	14
Nebraska	2,825	879,533	0.32%	7
Nevada	1,513	2,638,667	0.06%	16
New Mexico	3,675	1,733,535	0.21%	9
North Dakota	1,238	1,190,472	0.10%	15
Oklahoma	4,373	3,339,478	0.13%	12
Puerto Rico	3,384			
South Carolina	3,890	637,808	0.61%	4
South Dakota	1,056	2,538,202	0.04%	17
West Virginia	2,826	1,660,772	0.17%	10
Wyoming	873	615,205	0.14%	11
Average EPSCoR	3,088			

Sources: National Science Foundation, Division of Science Resource Studies; http://www.ehr.nsf.gov/epscor/statistics/start.cfm

Table 5.2: Science & Engineering Graduates in the Workforce, 1999

	S&E	Civilian Workforce	S&E as Percent of Civilian Workforce	Location Quotient[1]	Rank
United States	625,770	71,446,000	0.88%	1.00	
MAINE	**2,570**	**677,300**	**0.38%**	**0.43**	**10**
New England States					
Connecticut	10,790	1,704,100	0.63%	0.72	3
Massachusetts	29,730	3,283,100	0.91%	1.03	2
New Hampshire	2,610	670,900	0.39%	0.44	9
Rhode Island	2,980	511,100	0.58%	0.67	5
Vermont	2,020	341,000	0.59%	0.68	4
EPSCoR States					
Alabama	6,850	2,176,900	0.31%	0.36	14
Alaska	1,330	311,900	0.43%	0.49	7
Arkansas	3,120	1,248,700	0.25%	0.29	19
Hawaii	2,660	601,300	0.44%	0.51	6
Idaho	2,350	655,200	0.36%	0.41	12
Kansas	4,220	1,449,500	0.29%	0.33	17
Kentucky	4,920	1,952,200	0.25%	0.29	19
Louisiana	6,200	2,042,600	0.30%	0.35	15
Mississippi	3,500	1,299,300	0.27%	0.31	18
Montana	1,940	472,300	0.41%	0.47	8
Nebraska	2,980	927,900	0.32%	0.37	13
Nevada	2,180	959,000	0.23%	0.26	20
New Mexico	8,860	831,100	1.07%	1.22	1
North Dakota	1,430	333,400	0.43%	0.49	7
Oklahoma	5,030	1,664,800	0.30%	0.34	16
Puerto Rico	1,320	1,303,400	0.10%	0.12	21
South Carolina	5,360	1,952,100	0.27%	0.31	18
South Dakota	1,150	394,000	0.29%	0.33	17
West Virginia	2,440	813,800	0.30%	0.34	16
Wyoming	960	260,600	0.37%	0.42	11

Sources: National Science Foundation, Division of Science Resource Studies; http://www.ehr.nsf.gov/epscor/statistics/start.cfm. Total Civilian Workers from http://stats.bls.gov.

[1] Location Quotient = (State S&E Workforce/State Civilian Workforce)/US S&E Workforce/US Civilian Workforce).

Table 5.3: Federal R&D Money Invested by Agency, 1998

	TOTAL	Agriculture	Commerce	Defense	Energy	HHS	Interior	DOT	EPA	NASA
United States	69,838,400	1,376,000	1,035,900	34,030,400	5,636,300	13,127,400	595,600	666,100	553,900	9,272,000
MAINE	**103,901**	**3,943**	**6,370**	**48,148**	**223**	**31,072**	**3,976**	**565**	**996**	**2,701**
New England States										
Connecticut	692,341	6,151	5,728	283,579	54,480	236,460	1,467	14,327	891	63,436
Massachusetts	3,112,271	22,399	44,145	1,439,986	100,568	1,124,925	6,062	38,016	19,434	143,063
New Hampshire	269,132	4,673	7,824	184,392	670	35,610	1,971	2,191	889	18,349
Rhode Is and	385,411	1,835	3,727	291,853	2,356	49,613	2,477	1,001	12,007	3,308
Vermont	57,596	5,418	776	13,640	584	29,291	1,378	497	743	699
Average NE	903,350	8,095	12,440	442,690	31,732	295,180	2,671	11,206	6,793	45,771
EPSCoR States										
A abama	2,012,829	14,781	610	1,157,497	152,195	164,201	4,662	3,465	4,531	498,536
A aska	106,939	7,574	24,261	27,262	50	2,109	22,129	1,296	290	12,250
Arkansas	97,026	26,191	388	8,420	50	49,208	4,443	1,405	381	1,881
Hawaii	160,826	21,859	13,772	60,283	3,541	21,868	5,810	548	0	18,574
Idaho	213,625	17,793	1,320	19,502	157,221	2,869	9,068	2,228	0	912
Kansas	128,697	13,736	1,028	31,276	3,890	48,338	6,466	1,373	2,842	5,555
Kentucky	188,955	7,845	588	9,613	98,213	53,102	3,689	3,418	1,840	1,533
Louisiana	223,555	43,348	3,124	38,025	4,319	68,012	16,097	1,676	4,962	33,797
Mississippi	280,366	60,342	6,275	132,867	1,833	13,914	6,320	1,923	1,542	47,604
Montana	80,670	17,657	5,091	12,793	984	12,861	14,887	1,229	321	6,177
Nebraska	84,982	27,427	744	7,617	705	30,566	6,956	905	250	2,305
Nevada	290,853	2,869	115	43,753	194,692	9,894	9,508	4,946	14,637	2,914
New Mexico	1,891,565	7,431	1,400	586,781	1,175,695	46,423	9,351	6,371	4,278	40,943
North Dakota	52,088	26,003	659	2,556	5,167	2,872	6,893	1,720	1,100	1,854
Ok ahoma	175,497	17,712	6,642	41,440	26,475	34,946	5,489	11,787	14,326	3,212
Puerto Rico	61,938	13,273	994	1,953	841	26,837	1,166	0	157	3,755
South Caro ina	186,221	14,864	10,699	52,269	28,331	50,813	4,501	1,812	2,312	3,296
South Dakota	46,003	7,007	677	1,799	50	2,578	13,526	781	275	15,950
West Virginia	242,844	20,579	647	18,068	101,577	39,299	7,089	2,453	187	18,286
Wyoming	33,549	6,833	24	2,951	3,787	1,938	7,454	1,778	450	850

Source: Nat ona Sc ence Foundat on, D v s on of Sc ence Resource Stud es; http://www.ehr.nsf.gov/epscor/stat st cs/start.cfm

Figure 5.1: Federal R&D Invested by Agency, 1998

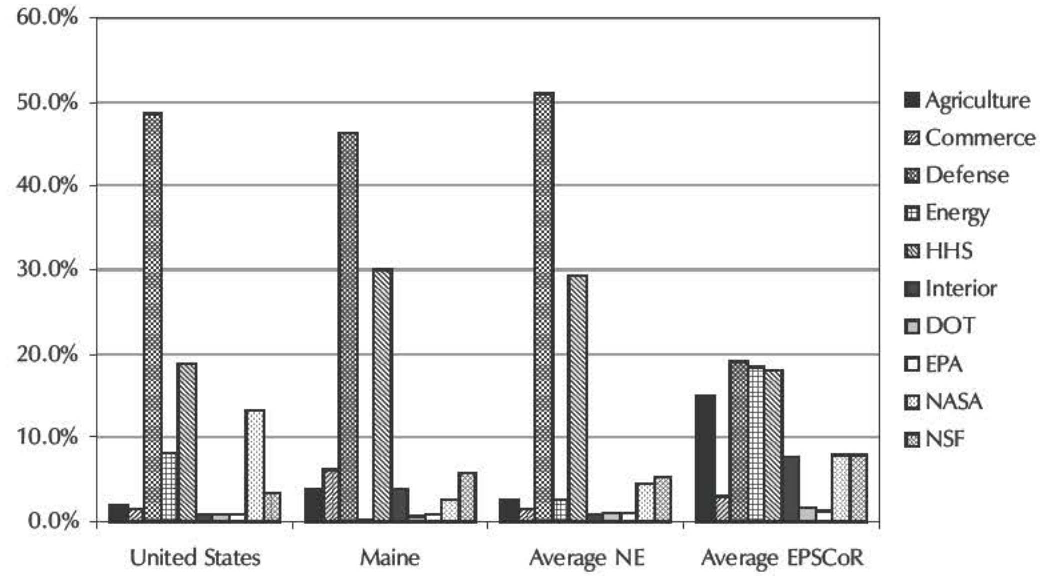
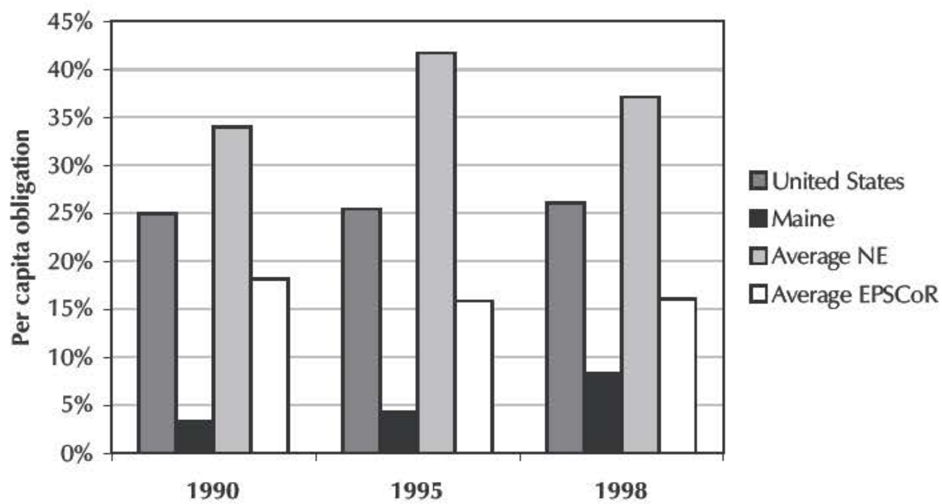
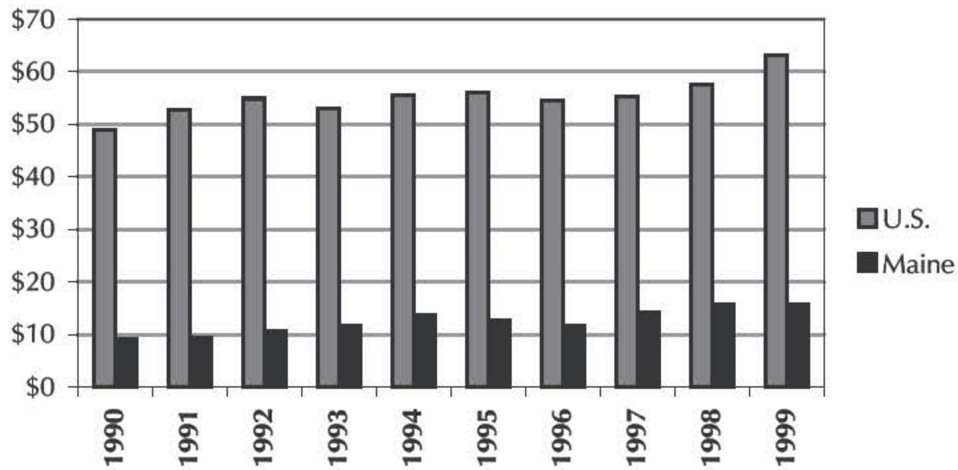


Figure 5.2: Federal Obligations for Research & Development, 1990–1998



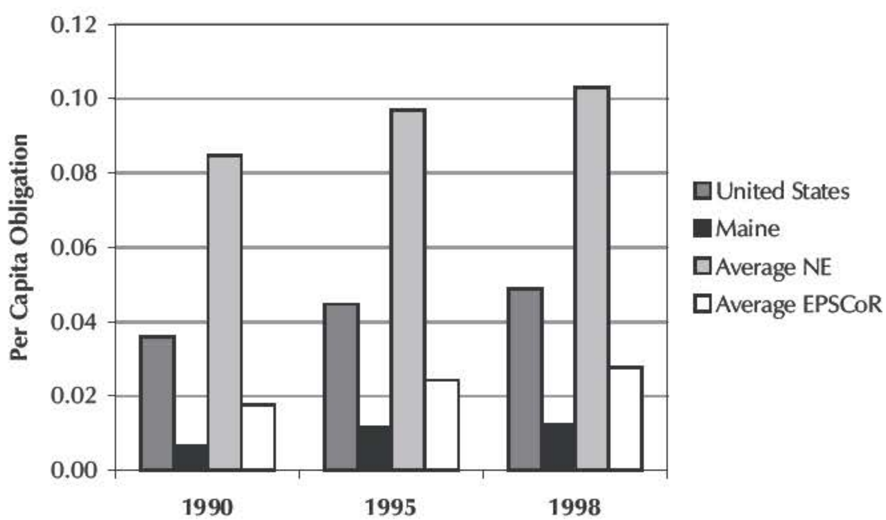
Source: National Science Foundation, Division of Science Resources Studies, *Survey of Federal Funds for Research and Development: Fiscal Years 1998, 1999, and 2000.*

Figure 5.3: Federal R&D Expenditures Per Capita, 1990–1999



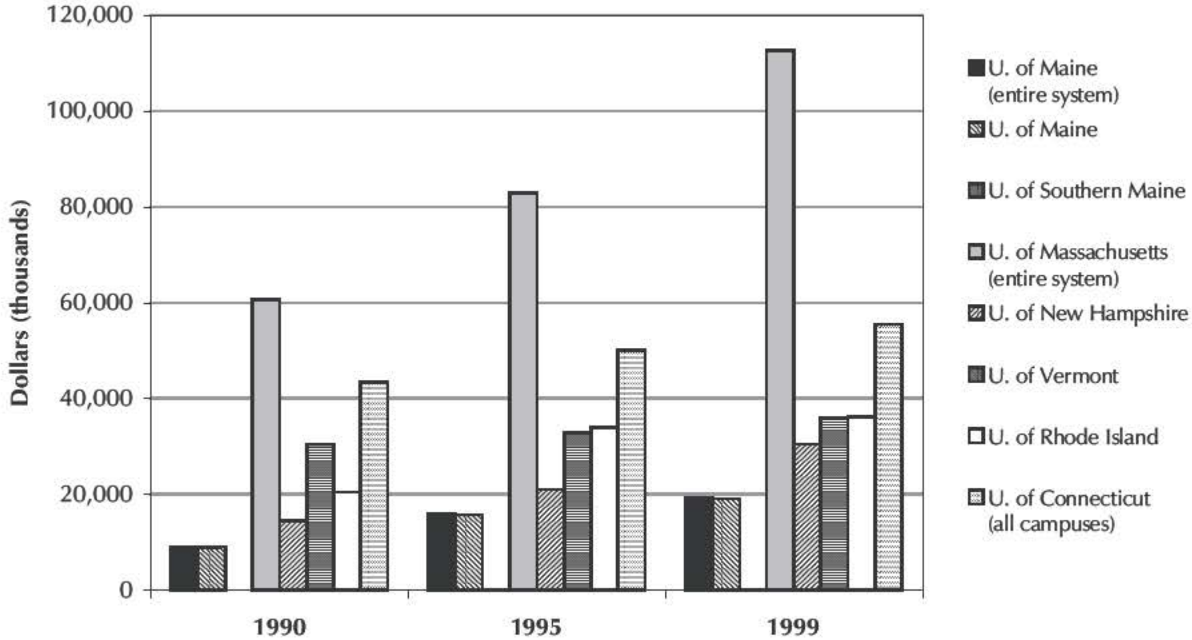
Source: National Science Foundation, WebCASPAR Database System.

Figure 5.4: Federal Obligations to Universities and Colleges for R&D, 1990–1998



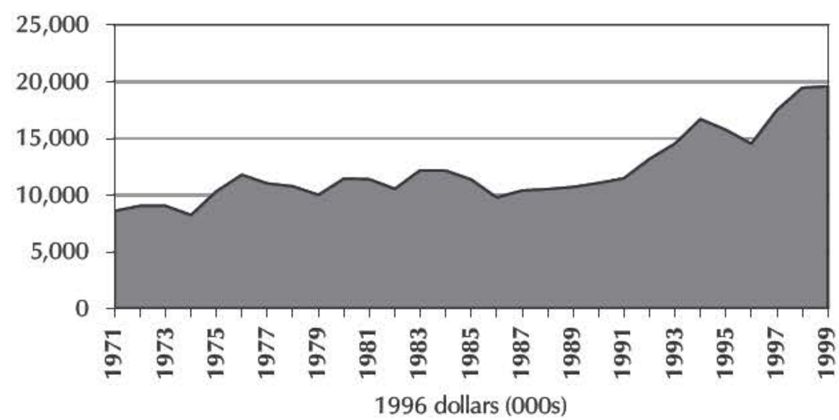
Source: National Science Foundation, Division of Science Resources Studies, *Survey of Federal Funds for Research and Development: Fiscal Years 1998, 1999, and 2000.*

Figure 5.5: Federally funded R&D Expenditures at the New England Land Grant Universities, 1990–1999



Source: National Science Foundation, WebCASPAR Database System.

Figure 5.6: Federal Obligations for Sciences and Engineering at U Maine, 1971–1999



Source: National Science Foundation, WebCASPAR Database System.

Figure 5.7: Patents per capita, 1990–2000

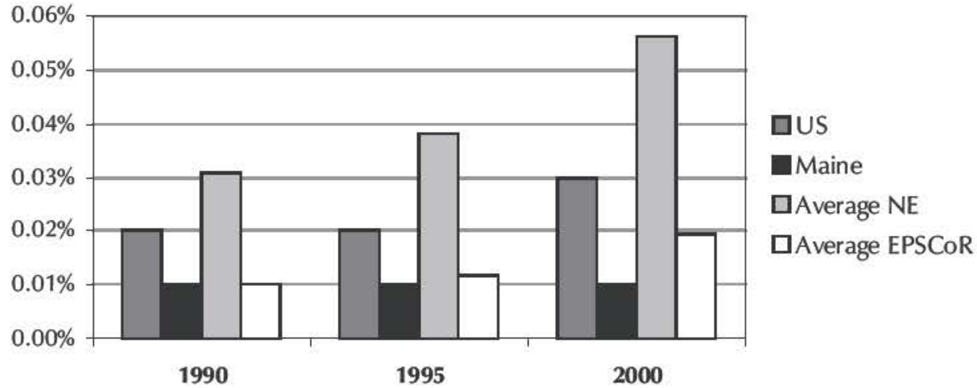


Table 5.4: Number of Patents Issued, 1990, 1995, and 2000

	Patents Issued			Patents Per Capita		
	1990	1995	2000	1990	1995	2000
United States	52,976	64,510	97,016	0.021%	0.025%	0.034%
MAINE	**115**	**137**	**151**	**0.009%**	**0.011%**	**0.012%**
New England States						
Connecticut	1,513	1,768	2,086	0.046%	0.054%	0.061%
Massachusetts	2,111	2,427	3,841	0.035%	0.040%	0.060%
New Hampshire	329	460	679	0.030%	0.040%	0.055%
Rhode Island	181	263	389	0.018%	0.027%	0.037%
Vermont	145	171	416	0.026%	0.029%	0.068%
EPSCoR States						
Alabama	365	359	395	0.009%	0.008%	0.009%
Alaska	30	49	57	0.005%	0.008%	0.009%
Arkansas	151	143	248	0.006%	0.006%	0.009%
Hawaii	85	84	93	0.008%	0.007%	0.008%
Idaho	192	329	1,614	0.019%	0.028%	0.125%
Kansas	328	319	475	0.013%	0.012%	0.018%
Kentucky	310	341	517	0.008%	0.009%	0.013%
Louisiana	506	413	579	0.012%	0.010%	0.013%
Mississippi	130	138	211	0.005%	0.005%	0.007%
Montana	74	141	144	0.009%	0.016%	0.016%
Nebraska	145	150	298	0.009%	0.009%	0.017%
Nevada	128	216	406	0.011%	0.014%	0.020%
New Mexico	205	280	347	0.014%	0.017%	0.019%
North Dakota	51	63	98	0.008%	0.010%	0.015%
Oklahoma	633	545	616	0.020%	0.017%	0.018%
Puerto Rico	16	24	31			
South Carolina	408	521	629	0.012%	0.014%	0.016%
South Dakota	41	44	98	0.006%	0.006%	0.013%
West Virginia	167	151	158	0.009%	0.008%	0.009%
Wyoming	37	75	67	0.008%	0.016%	0.014%

Source: U.S. Patent Office; http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst all.pdf

Figure 5.8: State R&D Dollars Invested per Worker, 1989–1998

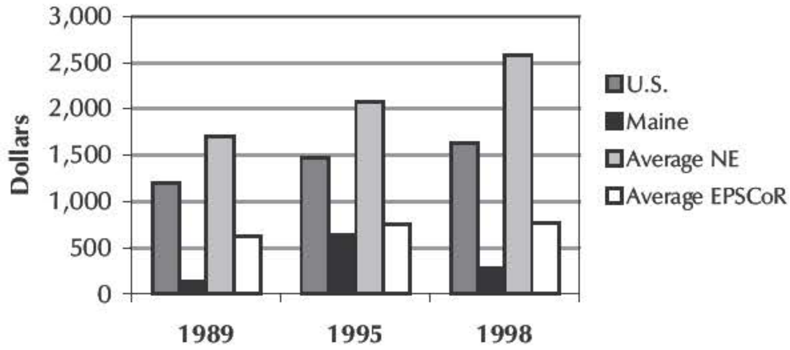


Table 5.5: State R&D Dollars Invested per Worker, 1989, 1995, and 1998

	1989	1995	1998
United States	1,206	1,466	1,633
MAINE	**135**	**642**	**280**
New England States			
Connecticut	1,648	2,761	2,165
Massachusetts	2,557	3,349	4,210
New Hampshire		1,107	2,275
Rhode Island	927	2,037	3,662
Vermont		1,141	616
EPSCoR States			
Alabama	769	932	1,015
Alaska	520	624	482
Arkansas	135	308	252
Hawaii	243	318	455
Idaho		1,915	2,159
Kansas	491	637	1,157
Kentucky	239	361	368
Louisiana	251	239	287
Mississippi	292	293	323
Montana		340	511
Nebraska	257	411	359
Nevada	263	566	616
New Mexico	4,765	4,829	4,211
North Dakota	292	323	374
Oklahoma	437	402	356
South Carolina	384	605	555
South Dakota	80	159	165
West Virginia		691	585
Wyoming		395	286

Source: National Science Foundation, Division of Science Resource Studies, http://www.nsf.gov/sbe/ses/nsf99335/ appb.htm and Bureau of Labor Statistics, http://www.bls.stats.gov

Table 5.6: Establishment Births

	1996 Technology SIC Code[1]	1996	1997
United States	46,919	697,457	822,582
MAINE	**184**	**3,724**	**4,218**
New England States			
Connecticut	691	7,941	9,540
Massachusetts	1,527	15,118	18,330
New Hampshire	344	3,705	4,222
Rhode Island	168	2,611	2,867
Vermont	116	1,880	2,265
EPSCoR States			
Alabama	505	10,465	12,143
Alaska	93	1,815	2,156
Arkansas	201	6,446	7,456
Hawaii	138	2,812	3,223
Idaho	178	3,973	4,779
Kansas	381	6,897	8,474
Kentucky	382	8,556	10,263
Louisiana	461	9,718	11,589
Mississippi	214	6,115	6,951
Montana	149	3,092	3,598
Nebraska	178	4,129	4,974
Nevada	379	5,414	7,179
New Mexico	253	4,703	5,532
North Dakota	48	1,619	1,866
Oklahoma	486	8,614	10,289
South Carolina	398	9,909	12,021
South Dakota	94	2,083	2,540
West Virginia	127	3,782	4,575
Wyoming	90	1,836	1,996

Source: U.S. Census Bureau;
http://www.census.gov/csd/susb/susb2.htm#godyn1

[1] Technology SIC codes are defined by the Bureau of Labor Statistics analysis of employees engaged in R&D activities. They are:

SIC Code	Industry	SIC Code	Industry
131	Crude petroleum and natural gas operations	362	Electrical industrial apparatus
211	Cigarettes	366	Communications equipment
281	Industrial inorganic chemicals	367	Electronic components and accessories
282	Plastic materials and synthetics	371	Motor vehicles and equipment
283	Drugs	373	Aircraft and parts
284	Soap, cleaners and toilet goods	376	Guided missiles, space vehicles and parts
285	Paints and allied products	381	Search and navigation equipment
286	Industrial organic chemicals	382	Measuring and controlling devices
287	Agricultural chemicals	384	Medical instruments and supplies
289	Miscellaneous chemical products	386	Photographic equipment and supplies
291	Petroleum refining	737	Computer and data processing services
335	Nonferrous rolling and drawing	871	Engineering and architectural services
355	Special-industry machinery	873	Research and testing services
357	Computer and office equipment	874	Management and public relations services

Source: Paul Hadlock, Daniel Hecker, and Joseph Gannon; High technology employment: Another view, *Monthly Labor Review* , July 1991: 26-30.

Table 5.7: Venture Capital Invested or New Funding Raised

	1998	2001, Quarter One	
	Amount Invested	Deals	Amount Invested
United States	14,200,000,000	657	9,325,347,500
MAINE	**8,500,000**	**0**	**0**
New England States			
Connecticut	245,700,000	7	66,000,000
Massachusetts	1,697,300,000	71	1,120,000,000
New Hampshire	137,300,000	3	10,500,000
Rhode Island	13,700,000	3	19,000,000
Vermont	1,400,000	1	10,000,000
EPSCoR States			
Alabama	76,700,000	3	11,480,000
Alaska	0	0	0
Arkansas	7,200,000	0	0
Hawaii	600,000	0	0
Idaho	41,200,000	0	0
Kansas	18,100,000	1	5,100,000
Kentucky	36,600,000	0	0
Louisiana	47,900,000	2	5,000,000
Mississippi	5,000,000	2	28,000,000
Montana	0	1	1,500,000
Nebraska	4,500,000	0	0
Nevada	4,200,000	1	20,000,000
New Mexico	4,000,000	0	0
North Dakota	500,000	0	0
Oklahoma	31,500,000	0	0
Puerto Rico	0	0	0
South Carolina	66,100,000	0	0
South Dakota	0	0	0
West Virginia	1,100,000	0	0
Wyoming	0	0	0

Source: (2001)PricewaterhouseCoopers MoneyTree Survey;
http://204.198.129.80/index.asp

Table 5.8: Initial Public Offerings

	1998		1999		2000	
	Deals	**$ Value (millions)**	**Deals**	**$ Value (millions)**	**Deals**	**$ Value (millions)**
United States	353	40,800.0	537	95,300.0	445	108,200.0
MAINE	**1**	**7.7**	**1**	**370.0**	**1**	**67.5**
New England States						
Connecticut	6	195.1	7	542.4	4	386.6
Massachusetts	14	615.8	35	2,618.7	30	6,892.5
New Hampshire	1	54.7	2	89.2	1	43.4
Rhode Island	0	0.0	1	22.0	0	0.0
Vermont	0	0.0	0	0.0	0	0.0
EPSCoR States						
Alabama	1	11.0	0	0.0	0	0.0
Alaska	0	0.0	1	140.0	0	0.0
Arkansas	0	0.0	1	55.7	0	0.0
Hawaii	0	0.0	1	52.5	0	0.0
Idaho	0	0.0	1	25.0	0	0.0
Kansas	1	499.1	4	268.2	0	0.0
Kentucky	1	27.8	0	0.0	1	136.0
Louisiana	1	24.0	0	0.0	1	88.0
Mississippi	1	13.6	1	168.8	0	0.0
Montana	0	0.0	1	40.0	0	0.0
Nebraska	0	0.0	0	0.0	1	67.2
Nevada	1	59.5	2	108.0	1	11.7
New Mexico	1	9.6	0	0.0	0	0.0
North Dakota	0	0.0	0	0.0	0	0.0
Oklahoma	1	28.6	2	828.1	2	556.0
South Carolina	3	162.8	1	11.0	0	0.0
South Dakota	0	0.0	1	6.4	0	0.0
West Virginia	0	0.0	0	0.0	0	0.0
Wyoming	0	0.0	0	0.0	0	0.0

Source: Hale and Dorr, LLP; http://www.haledorr.com/ipo/fr1.html

Table 5.9: Small Business Innovation Research Awards

	1997		2000	
	Awards	Dollars	Awards	Dollars
United States	4,756	1,200,518,000	4,464	1,070,438,908
MAINE	**5**	**1,579,000**	**14**	**2,968,789**
New England States				
Connecticut	118	30,883,000	70	18,406,387
Massachusetts	710	166,131,000	652	163,847,312
New Hampshire	63	18,093,000	52	13,553,051
Rhode Island	6	3,346,000	24	4,380,072
Vermont	15	1,883,000	16	4,487,128
EPSCoR States				
Alabama	92	27,498,000	82	24,971,467
Alaska	2	155,000	3	978,459
Arkansas	3	222,000	6	2,127,984
Hawaii	14	2,434,000	19	4,634,611
Idaho	4	942,000	9	985,782
Kansas	9	2,268,000	15	2,752,923
Kentucky	11	4,007,000	16	2,738,160
Louisiana	8	939,000	11	2,176,901
Mississippi	5	1,083,000	11	3,659,206
Montana	5	330,000	24	5,618,391
Nebraska	9	1,406,000	9	2,580,684
Nevada	12	2,320,000	8	2,010,483
New Mexico	82	17,945,000	75	18,414,889
North Dakota	7	649,000	7	2,135,000
Oklahoma	12	2,648,000	12	2,250,658
Puerto Rico	1	70,000	1	558,868
South Carolina	8	1,341,000	19	3,786,945
South Dakota	7	756,000	4	668,949
West Virginia	3	1,242,000	9	2,050,483
Wyoming	7	2,148,000	9	1,668,049

Source: Small Business Association; http://www.sba.gov/sbir/library.html

Table 5.10: Technology Intensive Establishments

	1990	1996
United States		336,795
MAINE	**969**	**1,300**
New England States		
Connecticut	4,326	5,700
Massachusetts	8,151	11,668
New Hampshire	1,489	2,340
Rhode Island	975	1,263
Vermont	571	910
EPSCoR States	1,990	1,996
Alabama	2,309	3,429
Alaska	535	695
Arkansas	1,170	1,763
Hawaii	907	1,131
Idaho	625	1,133
Kansas	2,150	3,025
Kentucky	1,966	2,824
Louisiana	2,992	3,921
Mississippi	1,175	1,578
Montana	580	1,028
Nebraska	960	1,450
Nevada	1,020	2,115
New Mexico	1,256	1,991
North Dakota	358	484
Oklahoma	3,047	4,159
South Carolina	2,057	3,113
South Dakota	292	573
West Virginia	918	1,274
Wyoming	407	678

Technology Intensive SIC's are defined by the Bureau of Labor Statistics. Source: U.S. Census Bureau, County Business Patterns

Figure 5.9: Technology Employment as a Percent of Population, 1990, 1996

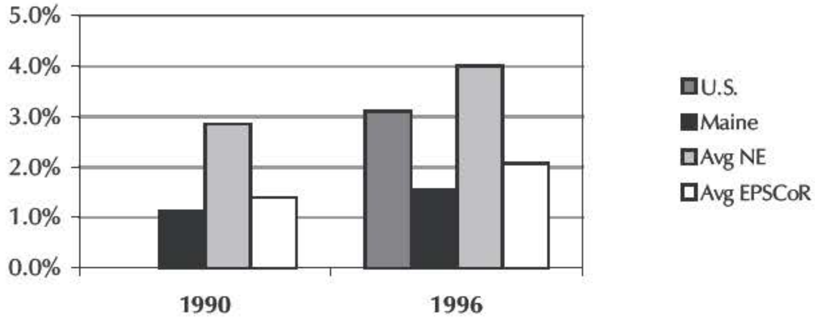


Table 5.11: Employment, Technology-intensive Industry, 1990, 1996

	1990	1996
United States		8,238,385
MAINE	**13,808**	**19,209**
New England States		
Connecticut	121,082	151,688
Massachusetts	298,169	329,980
New Hampshire	32,927	49,235
Rhode Island	18,627	26,089
Vermont	4,650	17,936
EPSCoR States		
Alabama	77,588	101,350
Alaska	7,992	9,399
Arkansas	32,764	49,931
Hawaii	12,016	11,200
Idaho	9,109	34,247
Kansas	47,367	87,309
Kentucky	61,364	96,307
Louisiana	93,109	93,485
Mississippi	21,741	45,644
Montana	5,238	8,164
Nebraska	26,624	43,618
Nevada	16,226	24,876
New Mexico	32,246	45,676
North Dakota	3,786	8,206
Oklahoma	52,963	73,846
South Carolina	78,313	120,892
South Dakota	5,115	17,986
West Virginia	19,666	31,204
Wyoming	4,568	6,399

Source: U.S. Census Bureau, County Business Patterns; Technology Intensive SIC's are defined by the Bureau of Labor Statistics

Figure 5.10: Per Capita Income, 1990, 1995, 2000

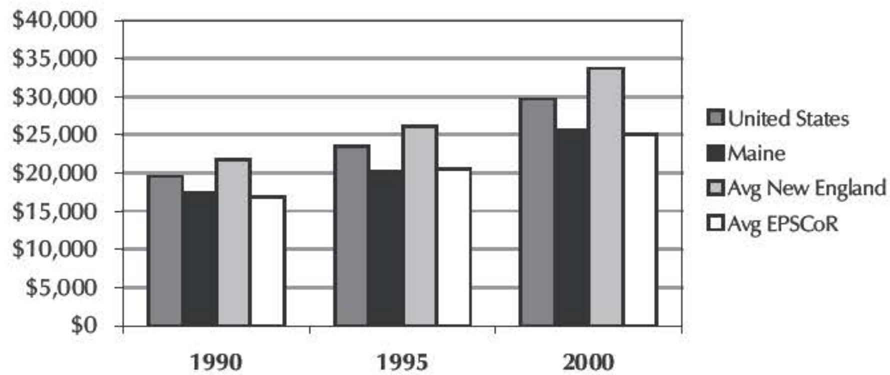


Table 5.12: Per Capita Income, 1990, 1995, 2000

	1990	1995	2000
United States	19,584	23,562	29,676
MAINE	**17,479**	**20,240**	**25,623**
New England States			
Connecticut	26,736	31,947	40,640
Massachusetts	23,223	28,051	37,992
New Hampshire	20,713	25,008	33,332
Rhode Island	20,194	24,046	29,685
Vermont	18,055	21,359	26,901
EPSCoR States			
Alabama	15,832	19,683	23,471
Alaska	22,719	25,798	30,064
Arkansas	14,509	18,546	22,257
Hawaii	22,391	25,584	28,221
Idaho	15,866	19,630	24,180
Kansas	18,182	21,889	27,816
Kentucky	15,484	19,215	24,294
Louisiana	15,223	19,541	23,334
Mississippi	13,164	17,185	20,993
Montana	15,524	18,764	22,569
Nebraska	18,088	22,196	27,829
Nevada	20,674	25,808	30,529
New Mexico	14,960	18,852	22,203
North Dakota	15,880	19,084	25,068
Oklahoma	16,214	19,394	23,517
South Carolina	16,050	19,473	24,321
South Dakota	16,238	19,848	26,115
West Virginia	14,579	17,913	21,915
Wyoming	17,996	21,514	27,230
Canada			
Quebec			
New Brunswick			
Nova Scotia			22,191

Sources: Bureau of Economic Analysis, http://www.bea.doc.gov; Statistics Canada, http://www.statcan.ca

APPENDIX 6
Case Study Protocol

Overview of the Case Study

This document, Case Study Protocol, defines the objectives, processes and analyses to be used in the case studies.

The case studies should be conducted to answer the three questions posed by the sponsors and to test additional questions. These questions include:

1. Are appropriate intermediate outcomes being achieved?
2. Are end outcomes being achieved?
3. What elements of the entire R&D investment infrastructure in the state are working well?
4. Are there roadblocks being encountered to achieving either intermediate or end outcomes? If so, what are they?

Choice of Case Study Participants

Based on an analysis of the programs included in the evaluation, it has been determined that the appropriate case study model is a program operated by a stakeholder combined with a specific recipient of that program. In operation, it appears that a single recipient may be the beneficiary of a number of different programs. So, to maximize the value of the information received from a limited number of case studies, when possible, recipients with multiple ties into the range of R&D investments should be chosen over those with fewer ties.

The list of candidates should be chosen based on four criteria set in advance. First, the case studies should represent the wide geographic diversity of the state of Maine, with a cross-section of both rural and metro-based recipients. Second, the seven industry sectors should be represented, if possible. Third, cases should cover the range of stage of development represented by the programs in the evaluation. Not all should be in advanced stages of commercialization, for instance. Finally, the range of different types of recipients should be covered: researchers, non-profit organizations and companies.

Setting Up Case Study Interviews

For each case, a number of interviewees have been identified as important elements of the study. These included: the stakeholder, the recipient, and other related organizations that had worked with the recipient or had influenced the environment. The specific names of potential interviewees should be gained from discussions with the sponsor and stakeholders.

The sponsor, MSTF, should mail a letter to each stakeholder introducing the project and the project team. The evaluation team should follow-up each letter with a phone call and/or email asking for an appointment. When the appointment is confirmed and directions obtained, a confirmation email should sent with the specifics of the appointment, a list of the programs to be discussed and a list of questions. (See Stakeholder Questions.)

Stakeholders should be asked to introduce the evaluation team to their respective recipients and related organizations. Once the introductions were made, the evaluation team should call and/or email with a specific request for an appointment. Occasionally, meetings can not be scheduled with the original person identified. In these cases, the original person should be asked to identify another person within their organization that would have appropriate knowledge of the subject. Then, that person should be contacted and the process completed. A confirmation email should be sent to each person with the details of the meeting and an abbreviated list of the types of questions that will be asked. (See Case Study Questions.)

Case Study Visit Procedures

Two members of the evaluation team should visit each stakeholder and recipient, when possible. One evaluator should direct the conversation while the other listens and takes notes. All documents obtained should be collected and filed in a central location. After each meeting, a write-up of the information obtained should be completed in a common format. Each report should be shared with the individuals that provided the information to ensure the validity of the report.

Additional Information

The evaluators should collect other documents and secondary data to verify, confirm, augment and expand the scope of the information obtained from the case study interviews. These documents will include:

- Statutes authorizing the programs in question;
- Program descriptions;
- Program operational guidelines such as RFPs;
- Program funding history;
- Recipient history and background;
- Industry background and trends; and
- General Maine economic trend information.

Case Study Questions

An introduction at the meeting might begin as follows:

> "Maine Science and Technology Foundation has asked us to complete a legislatively-mandated evaluation of the impact and competitiveness of Maine's R&D investment. The investment includes about thirty separate programs including , which you are (the operator of/recipient of a funding from). Our charge is to collect and analyze data in the future to continue to answer these questions.
>
> We're here to learn and listen and to collect data. We are not assessing the specifics of your project or to audit your program. We would like to know, generally, how your program operates (if stakeholder), or how the project funded by the state is going (if recipient)."

Stakeholders

Identify the specific programs that this stakeholder operates that have been included in the evaluation.

Discuss the following:

1. What is your understanding of the objectives of each program? Where do the objectives come from? (Enabling legislation? Board of Directors?)
2. How are these objectives operationalized? (Obtain program descriptions, guidelines for applying for grants, statutes, etc.)
3. Do you collect data for these programs now? What? How do you collect it? Is it in a database or file? (Obtain any data that are available.)
4. Do you have any suggestions of recipients of your programs that could be case studies?
5. What do you think the appropriate indicators are for your program?
6. What constraints/concerns/ideas do you have about the evaluation process?

Recipients who are researchers or non-profit research entities

Identify the relevant funding sources and discuss the following:

1. What research have you been able to conduct as a result of this funding? How many new faculty were hired? Post-docs? Graduate students?
2. What led you to apply for the grant or get this funding?
3. How did you hear about it?
4. How did you respond?
5. What were your initial expectations? (Probe here.)
6. What's the status of the project?
7. Where are you on the timeline?
8. Where has the money been spent?
9. What were the results of the research? Did you publish the findings? Did you file any disclosures from the work? Were any patents applied and/or awarded as a result of this work? Were any licenses awarded? With whom?
10. How do you interact with Maine industry in this endeavor?

11. What sort of follow-on work have you been able to do? Any new funding, especially federal as a result of this work?
12. What has been the impact of this work in the broader sense?
13. What have you liked about the process of working with these funding sources? What have been your frustrations?
14. What would you like to see changed, if anything?
15. What do you think are the appropriate indicators for your type of work?
16. How do you think we should capture information about these indicators from recipients such as yourself? What concerns do you have about the process?

Recipients who are companies

1. What led you to apply for the grant?
2. How did you hear about it?
3. How did you respond?
4. What were your initial expectations? (Probe here.)
5. What's the status of the project?
6. Where are you on the timeline?
7. Where has the money been spent?
8. Has the funding/support helped you leverage other resources?
9. Tell us about any expected and/or unexpected events as a result of the funding/support.
10. What have been the results so far? New products and processes? Patents applied for and/or granted? New funding including SBIRs, venture capital, other grants?
11. How do you measure the success of the project?
12. Do you currently have any reporting requirements from the grantor organization?
13. How do you monitor the results?
14. How do the results you are seeing match your expectations?
15. Given your experience, what process and what indicators should be put in place?
16. Ask about relationship with grantor organization: Explicitness, timeliness of review process/award, responsiveness to questions, flexibility, reporting requirements, etc.
17. What do you think are the appropriate indicators for your type of work?
18. How do you think we should capture information about these indicators from recipients such as yourself? What concerns do you have about the process?

APPENDIX 7

Statute and Public Laws Relating to Evaluation

SCIENCE AND TECHNOLOGY

5 § 13122-J. Comprehensive research and development evaluation

The foundation shall develop and submit to the Governor and the Legislature by July 1, 2006 and on July 1st every 5 years thereafter an evaluation of state investments in research and development. The evaluation must: [1999, c. 731, Pt. XXX, §1 (amd).]

1. Outcome measures. Establish outcome measures considered appropriate by public and private practitioners in and outside of the State in the fields of research and development and economic development. Practitioners in this State must include, but not be limited to, a representative from the University of Maine System, a representative of the targeted technology sectors, a representative of the Department of Economic and Community Development and representatives of other state agencies having economic development responsibility;

[1999, c. 401, Pt. BBB, §1 (new).]

2. Independent reviewers. Utilize nationally recognized independent reviewers to assess the competitiveness of technology sectors in this State and the impact of research and development activities in this State on economic development in this State; and

[1999, c. 401, Pt. BBB, §1 (new).]

3. Recommendations. Include recommendations to the Legislature on existing and proposed state-supported research and development programs and activities to affect technology-based economic development in this State.

[1999, c. 401, Pt. BBB, §1 (new).]

Section History:
1999, c. 401, § BBB1 (NEW);1999, c. 731, § XXX1 (AMD); 1999, c. 790, § F1 (AMD); 1999, c. 790, § F2 (AFF).

5 § 13122-K. Reporting requirements of recipients of research and development funding

To assist the foundation in preparing a comprehensive research and development evaluation, a recipient of state funding for research and development shall, in addition to any other reporting requirements required by law: [1999, c. 731, Pt. XXX, §2 (new).]

1. Data. Collect, maintain and provide to the foundation data relating to each investment's performance, outputs and outcomes;

[1999, c. 731, Pt. XXX, §2 (new).]

2. Report card indicators. Identify the indicators in the report card developed by the foundation that will be affected as a result of the proposed research and development activity; and

[1999, c. 731, Pt. XXX, §2 (new).]

3. Action plan goals. Identify the goals in the action plan developed by the foundation that will be advanced by the recipient's research and development activity.

[1999, c. 731, Pt. XXX, §2 (new).]

Section History:1999, c. 731, § XXX2 (NEW).

Maine Public Law 2000, c. 731, p. XXX-3 and XXX-4

Sec. XXX-3. Initial evaluation of research and development. The Maine Science and Technology Foundation shall develop and submit to the Governor and the Legislature by July 1, 2001 an initial evaluation of the State's public investments in research and development that provides a composite overview of the State's long-standing research and development investments using existing data and qualitative evaluation methods and that includes no fewer than 5 case studies.

Sec. XXX-4. Appropriation. The following funds are appropriated from the General Fund to carry out the purposes of this Part.

		2000-01
MAINE SCIENCE AND TECHNOLOGY FOUNDATION		
Maine Science and Technology Foundation	All Other	$145,000

Provides funds for the Maine Science and Technology Foundation to develop, prepare and submit to the Governor and the Legislature the initial evaluation of the State's public investments in research and development.

APPENDIX 8

Interviews Conducted for this Evaluation

Stakeholders and Recipients

Michael Allen, Director of Research, Maine Revenue Service

Bruce Barber, Professor, School of Maine Science, University of Maine

John F. Burns, Fund Manager, Small Enterprise Growth Fund

Merrie Cartwright, Assistant Director, Maine Space Grant Consortium

Claire Collins, Maine Science and Technology Foundation

Kevin Eckelbarger, Director, Darling Marine Center

David Fernald, CEO, Terralink

Michael Hastings, Executive Director, Maine Aquaculture Innovation Center

Philip Helgerson, Director, Applied Technology Development Centers

Brian Hodgkin, Director, Bioscience Research Institute, University of Southern Maine

Mary Ellen Johnston, Department of Agriculture

Kerri Ann Jones, EPSCoR Coordinator, Maine Science and Technology Foundation

Rita Logan, Director, Technology Law Center

E.J. Lovett III, Director, Maine Medical Center Research Institute

Linda Mercer, Director, Bureau of Resource Management, Department of Maine Resources

Carter Newell, Marine Biologist, Great Eastern Mussel Farms, Inc.

Victor Otley, Chief Executive Officer, Intellicare

Don Perkins, President, Gulf of Maine Aquarium Development Corporation

Ken Priest, President, Kenway Corporation

Paul Rawson, Professor, School of Marine Science, University of Maine

Stephen Reiling, Associate Director, MAFES, University of Maine

Peggy Schaffer, Policy and Planning Specialist, Department of Economic and Community Development

Terry Shehata, Director, Maine Space Grant Consortium

Charlie Spies, Chief Executive Officer, Finance Authority of Maine

Tish Tanski, Director of Institutional relations, The Jackson Laboratory

Barbara Tennent, Manager, Scientific Program Development, The Jackson Laboratory

Cheryl Timberlake, Executive Director, Center for Innovation in Biotechnology

Jake Ward, Director, Department of Industrial Cooperation, University of Maine

Janet Yancey Wrona, Director, Maine Technology Institute

Governor Angus King

Senate President Michael H. Michaud
Senate President Pro Tempore Richard A. Bennett
Speaker Michael V. Saxl
Representative Irvin G. Belanger
Mr. Tarron Bragdon
Representative Joseph C. Brannigan
Senator Lynn Bromley
Representative Bruce Bryant
Senator Mary Cathcart
Representative Harold A. Clough
Representative Patrick Colwell
Representative Susan Dorr
Representative Brian M. Duprey
Representative David M. Etnier
Senator Jill M. Goldhwait
Representative Paul R. Hatch
Representative Ken Honey
Representative Sharon Jones
Representative Richard H. Mailhot
Mr. Rickmond McCarthy
Representative Marc Michaud
Senator Peter Mills
Representative John R. Morrison
Mr. Greg Nadeau
Representative Richard A. Nass
Representative William S. Norbert
Representative John Richardson
Evan Richert, Director, State Planning Office
Representative Richard W. Rosen
Senator Kevin L. Shorey
Representative Paul L. Tessier
Representative Jonathan Thomas
Representative Tom Winsor
Senator Edward M. Youngblood