

EXECUTIVE SUMMARY

**Maine's Technology
Sectors and Clusters:
Status and Strategy**

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Economic Research
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Community Development*

March 2008

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Sectors and Clusters:
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SUMMARY
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2008**



JOHN ELIAS BALDACCI
GOVERNOR

STATE OF MAINE
DEPARTMENT OF ECONOMIC
AND COMMUNITY DEVELOPMENT



JOHN RICHARDSON
COMMISSIONER

April, 2008

In the five years since the original study, *Assessing Maine's Technology Clusters*, was published, the concept of organizing economic development activities around clusters has taken hold. We have focused on our core industry sectors and invested in building both research and development capacity and in private sector research.

This new study allows us to move forward in an even more focused fashion by building upon our intellectual assets as well as our more traditional place-based assets. The researchers ask us to think more about our assets as defined by clusters of knowledge and skills, not necessarily specific products or processes or industries. This approach also allows us to support the sixteen identified sustainable, emerging or potential clusters through investment in entrepreneurship, networks and people, the glue which keeps innovation connected to our regional economy.

This report is also important because it identifies real potential for growth in key markets, including traditional Maine industries like forest produce and agriculture. Creating and seizing opportunity through cluster development remains a long road, but one on which Maine has a respectable start and commitment to travel.

A handwritten signature in black ink that reads "John Richardson".

John G. Richardson
Commissioner



Investing in Promising Technologies

Targeted Technologies

- Advanced Forestry & Agriculture
- Aquaculture & Marine
- Biotechnology
- Composite Materials
- Environmental
- Information
- Precision Manufacturing

April 2008

What makes one region prosper economically and another struggle? An important part of the answer lies with the strength of those regions' mix of people, companies, research organizations and training programs that are able to consistently generate new ideas and transform them into commercially successful products and services.

Here in Maine, the State has designated seven technology intensive sectors, ranging from some of our mature industries (like forestry and agriculture) to our emerging ones (such as composite materials and biotechnology) for investment and other types of support. Since we began our operations in 2000, the Maine Technology Institute (MTI) has helped develop strong clusters through our Cluster Development Award program as well as our Seed Grant and Development Award programs that stimulate business investment in technology development across these seven sectors. Last year, to help inform our programs going forward, MTI commissioned a comprehensive analysis of Maine's technology clusters together with the Office of Innovation of the Department of Community and Economic Development.

This report lays out a detailed picture of our State's important sector and cluster assets. It also makes recommendations for how MTI and other programs can nurture our technology-intensive clusters in ways that will help to propel our economy forward over the next decade and beyond. Having these vibrant clusters in our economy helps Maine technology companies to expand and prosper, as well as act as magnets for start-ups and business attraction, thus providing opportunities for our residents and the next generation to have a better livelihood in Maine.

Sincerely,

A handwritten signature in black ink, appearing to read "Betsy Biemann", followed by a horizontal line.

Betsy Biemann
President



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Summary

The concept of “clusters” has been a key idea in economic development in Maine and other states for more than a decade. In 2002, the Maine Science & Technology Foundation (MSTF) released a study of the cluster characteristics of the seven technology sectors that were designated as the focus of attention for Maine’s research and development support programs. In 2006, the Brookings Institution’s report for Grow Smart Maine again identified clusters as a key to economic development and Harvard Business School professor Michael Porter presented the results of preliminary cluster assessment of the Maine economy.

This study is a step towards implementing the Brookings Institution’s recommendations for an aggressive effort to build and expand clusters. It updates and expands the 2002 MSTF cluster report and also builds upon the work of Porter and others to identify distinctive specializations in Maine’s economy by focusing in much greater detail on the knowledge, skills, networks, and entrepreneurial activities in Maine that make up clusters.

The report was funded and overseen by the Maine Technology Institute and Office of Innovation of the Maine Department of Economic and Community Development (DECD). Dr. Charles S. Colgan, Professor of Public Policy and Management in the Muskie School of Public Service and Associate Director of the Maine Center for Business and Economic Research (MCBER), was the principal investigator of the project and the principal author of the report. He was also the author of the 2002 study. Marianne Clark of the Technology Partnership Practice of the Battelle Institute, Dr. Charles Lawton of Planning Decisions, Inc., and James Damcicis of PolicyOne Research, Inc., were partners with MCBER in conducting the study.

This summary first reviews the essential elements needed for clusters to form. The emphasis is on the knowledge and skills within a region as the foundation of clusters, so the study then examines in detail what is distinctive about research, knowledge generation, and scientific and technical education in Maine. Each of the seven technology sectors identified by the Legislature is examined in detail, based on the most recent research about those sectors and on an extensive series of interviews conducted by the project team. Based on this analysis, 16 clusters are identified at various stages of evolution and other activities that might one day form clusters are identified. Recommendations for actions addressing research and development funding, ways to catalyze the development of clusters, and the need to expand the human resources needed for cluster development are presented.

MAINE’S SEVEN TECHNOLOGY SECTORS

- **Biotechnology**
- **Composites & Advanced Materials**
- **Environmental Technologies**
- **Forest Products & Agriculture**
- **Information Technology**
- **Marine Technology & Aquaculture**
- **Precision Manufacturing**

Clusters are defined not by what products are made, but the knowledge and skills that reside or are developed within a region.

1. The Concept of Clusters

The term “cluster” is so widely used that the term has become very difficult to define. Political leaders, economists, geographers, and economic development specialists are all still struggling with the concept of clusters. The ideas underlying clusters are intuitively attractive, and there is much evidence in many places that clusters do exist. The essential idea that clusters define an important element of regional economic success is largely undisputed, and there are some things about clusters that have become clear from the experience in the U.S., Europe, and elsewhere. These include:

- **Industrial sectors are defined by their products. Clusters are defined by knowledge generation and knowledge spillovers**, the transmission of information among the elements of the cluster. Clusters are thus defined not by what products are made, but the knowledge and skills that reside or are developed within a region.
- **Geography is important, but the exact borders of the region where knowledge and skills matter are highly variable**; there is no single size of region that encompasses a cluster. We do know that clusters are more likely in urban areas than rural areas because of proximity, but rural areas still have clusters.
- **Innovative organizations like universities, research laboratories, and the R&D centers of private firms are critical**. But it is how these organizations interact and share knowledge with one another that is critical to a cluster. These interactions occur in networks, which make the transmission of both explicit and tacit information much more likely. Explicit information is the type shared through publications, meetings, etc. Implicit knowledge is the “shop floor” knowledge communicated as employees shift jobs.
- **Entrepreneurship links research and innovation to the market**. Connections with organizations that spur entrepreneurship, for example financing, technical assistance, or specialized services (such as intellectual property protection specialists), within the region strengthen the cluster and make commercial success more likely.
- **Size matters**. Moving knowledge around requires sufficient numbers of organizations and institutions (actually sufficient numbers of people) such that knowledge generation and commercial success become self-sustaining. Small regions and small clusters are always challenged to generate enough research, innovation, and commercial activity to spur wider development in the economy.

These conclusions lead to a simple view of a complex phenomenon. In this view, clusters have four elements that relate to one another, as summarized in Figure A.

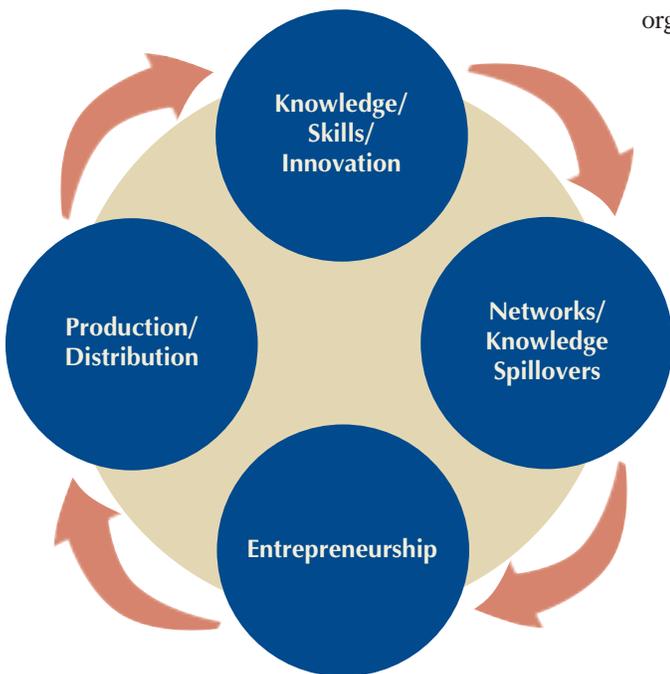


Figure A



2. The Knowledge and Skill Foundations of Clusters

Since knowledge and skills and innovation are the defining elements of clusters, the first question is, “What are Maine’s distinctive knowledge and skills?” To answer this question, a detailed analysis of patent, grant funding, and peer reviewed publications was undertaken, followed by an examination of the “human capital” in Maine that is responsible for technology research and innovation.

The analysis of Maine research and development strengths was conducted by Battelle, using a sophisticated text analysis tool that examined the content of over 7,300 records of patents, grants, and publications to determine which areas of research may be said to be distinct in Maine. The result identifies a number of areas of research strength which can be further grouped into the major areas of research strength (or “metaclusters”) shown in Table A.

Major Areas of Research Strength	Number of Records
Advanced Coatings, Deposition, Membranes, & Films	166
Astrophysics	224
Crop & Soil Sciences	458
Earth Sciences	78
Electronics & Semiconductors	395
Food & Dairy Sciences	193
Forestry	188
Glaciology/Ice Cores/Climatology	271
Marine Biology - Marine Animals	372
Marine Biology - Phytoplankton & Nutrients	261
Medical Sciences - Bone & Hematopoiesis	264
Medical Sciences - Cancer & Oncology	134
Medical Sciences - Cardiovascular	220
Medical Sciences - Genetics & Genomics	542
Medical Sciences - Immunology & Infectious Diseases	138
Medical Sciences - Surgery	135
Wildlife/Habitat Conservation	206
Wood, Fiber Reinforced Plastics, & Composites	250

Table A

Maine is home to a number of research institutions with distinctive capacities on which clusters can be built...

Of these 18 areas of research strength, only three (astrophysics, glaciology, and earth sciences) are not areas where research is not immediately relevant to commercial activities in Maine. The other areas of research strength indicate:

There is significant research strength in medical sciences, marine sciences, crop and soil sciences, and forestry/environmental sciences.

Strong grant and publication levels indicate these areas provide the most extensive research base in the state as measured by this data. The volume of medical sciences research emanating from The Jackson Laboratory dwarfs the rest of the current biotechnology industry. The potential connections to Maine's industries and the translation of these areas into economic drivers for the state of Maine will require additional evolution of research in these areas, as much of the current research is "basic" in nature. Additionally, while the state's research enterprises demonstrate strengths in a full spectrum of marine sciences, the translation of pieces of this vast research portfolio into "aquaculture" may require significant applied research efforts and both academic as well as private sector entrepreneurs.

Research in wood/fiber-related composites is robust.

The cluster analysis highlighted Wood, (Fiber Reinforced Plastic/Polymer), and Composites as a research niche within the state. This (and, potentially, in combination with identified research strengths in Forestry and Advanced Coatings, Deposition, Membranes, and Films) provides the state with a uniquely "Maine" avenue to pursue advanced materials development that is the foundation for the composites and advanced materials sector.

Innovation in IT and manufacturing clusters is dominated by industry efforts/patents.

While some academic research efforts exist, through the patent and cluster analysis it is apparent that much, if not most, of the innovation that occurs in the IT, computer, and manufacturing clusters is led by industry efforts.

Maine has distinctive research capacities in a number of fields directly related to its cluster strengths.

In addition to the wide ranging research strengths demonstrated by the outputs of research, Maine is home to a number of research institutions with distinctive capacities on which clusters can be built, especially in biomedical and biological research, composites and advanced materials, chemical engineering, forest management, and geographic information systems.



3. The Human Resources Foundations of Clusters

Research and innovation are done by people, and a key question is whether Maine is producing the workforce needed to sustain and expand a technologically innovative economy. There are questions about the distribution of the appropriate skills in the existing workforce and also about the education and training of new entrants. To address these questions, an occupational analysis of the STEM (science, technology, engineering, and mathematics) workforce is undertaken along with an assessment of graduates in these fields from Maine's institutions of higher education. *These analyses showed that Maine has a substantially smaller proportion of its workforce in STEM occupations than the U.S. as a whole and, despite some growth, is not producing the numbers of technically trained workers needed to create a competitive advantage for Maine.* Specifically:

- The proportion of Maine's workforce in STEM occupations is 30-40% less than the national average, and Maine lost many jobs in these fields between 2000 and 2006. The strongest area for Maine and the one showing significant growth is in the physical and biological sciences. The biological and environmental sciences account for much of this strength in Maine.
- Maine has seen a slight growth (7.5%) in higher education degrees with STEM majors/concentrations over 1996-2006. All of the growth was accounted for by women, primarily studying in the biological/biomedical fields and in natural resources and conservation related fields. Computer-related fields have also shown growth; these fields are still primarily made up of men.
- The University of Maine is by far the largest producer of STEM-related degrees in Maine. The private liberal arts colleges of Colby, Bates and Bowdoin are second, although most of the graduates of these institutions leave Maine.
- STEM degrees are disproportionately concentrated at the bachelor's level in Maine compared with the U.S. Maine is disproportionately below the U.S. in the production of graduate degrees in STEM fields.

The analysis of research strengths and the technical workforce shows definite patterns of knowledge and skills that underlie clusters in Maine. There are clearly distinct elements of strength in the biological and biomedical sciences and in fields related to the environment and natural resources. Emerging technological research areas such as composites also appear. However, many key knowledge areas do not show up in this data. Aquaculture-related research does not appear as a distinct field because it is subsumed within the major research area of marine biology and aquatic sciences. It should also be noted that there is also an enormous volume of what cluster researchers call "tacit" knowledge, the knowledge that is found on the shop floor that is not measured by this data.

Clusters do not come fully formed. They evolve as networks evolve from concentrations of research and innovation within a region.

4. Clusters and the Technology Sectors

The seven technology sectors defined by the Legislature broadly define the areas of the Maine economy where technological innovation is particularly critical to commercial success, but the sectors are very diverse in size and characteristics. The sectors have to be examined in detail to determine what clusters may be present within, or between, the sectors. Fortunately a number of studies of these sectors have been completed over the past few years with funding from the MTI Cluster Enhancement Award program. The results of these studies were supplemented by extensive interviews with individuals in research organizations, private firms, government, and higher education conducted for this study.

Clusters do not come fully formed. They evolve as networks evolve from concentrations of research and innovation within a region. This process of evolution results in three stages:

- **Potential Clusters** have high level of knowledge and skills in Maine, but there are weak networks and/or a low-level commercial activities based on that knowledge and skills.
- **Emerging Clusters** show some strength on all four elements of clusters, but are relatively small or new.
- **Sustainable Clusters** show at least some strength in all four cluster characteristics, though there may exist unevenness in the strengths. The clusters have been in existence long enough to demonstrate consistent levels of innovation over a period of time.

Biotechnology

Maine has developed distinct knowledge and skills bases in genetics/genomics and the development of commercially successful products in the diagnostics markets based on knowledge of antibodies and related biochemistry/biology fields. The large and growing volume of research indicates potential clusters that may emerge in the future, while the diagnostics/antibodies industry represents a current emerging cluster. However, biotechnology clusters are very small scale in Maine.

The keys to growing and strengthening these clusters include: continuing to support expansion of research and development in the biomedical sciences; expanding the workforce, particularly those with graduate training; supporting creation of new biotech firms; and linking to networks and alliances with major biotech firms for financing and product development.

Composites & Advanced Materials

Composites and advanced materials is the technology sector which, as a whole, best approximates a sustainable cluster in the sense developed in this study. The sector and its industries are grounded in a clearly defined set of knowledge and skills that are strongly identified with Maine. Both formal and informal networks have arisen to develop and widely diffuse the key knowledge and skills. There is strong evidence of entrepreneurship in the historic boat building industry, which has adapted to new market conditions, and in new companies looking to find new markets for products made from composite materials. Finally, there is a substantial critical mass of commercially successful firms that are selling in global markets their products based on the knowledge and skills centered in Maine.



Environmental Technologies

Environmental technologies is a highly diverse sector from which has emerged a clear set of directions in the fields of environmental services and engineering. Maine has a definable advantage in the knowledge and skills in this area, with a diversifying set of activities to meet growing markets. Maine's own commitment to a high quality environment serves as a spur to innovation in this field, which may permit national and global markets to be served. The environmental services subsector is the one part of this diverse sector that has the characteristics of a sustainable cluster.

Other parts of the sector are not of sufficient size or organization to characterize them as clusters. The environmental products subsector is difficult to measure and is still somewhat small. Renewable energy has had up-and-down cycles in Maine and is very likely poised for a significant up cycle over the next decade. There is growth potential in both these subsectors that may very well yield clusters in Maine within the next decade. The worldwide demand for certified "green" products is already growing rapidly, as is the role that Maine will play in renewable energy production using technologies such as wind.

Forest Products & Agriculture

Forest products and agriculture are both grounded in a very solid base of knowledge and skills backed by extensive research facilities centered at the University of Maine. Since these sectors have been embedded in the Maine economy for so long and have achieved significant scale of operations, both forest products and agriculture contain a number of clusters that have shown they are sustainable over time.

Though still facing mature and highly competitive markets, there are opportunities for innovation opening in each subsector that may provide new chances for growth. Some of these opportunities are variations on traditional product lines, such as the increasing market for specialized food products for niche markets, for example, gourmet foods. Others are at the cutting edge of biotechnology as in biofuels and bioplastics, which will require significant growth in Maine's research capacities.

Information Technology

Information technologies and the knowledge and skills associated with them are so widely diffused in the economy that one must look for more defined areas of specialization to identify potential clusters of competitive advantage. Maine has developed a specialization in geospatial technologies, which is an emerging cluster. In addition, there is evidence that

The seven technology sectors defined by the Legislature broadly define the areas of the Maine economy where technological innovation is particularly critical to commercial success, but the sectors are very diverse in size and characteristics.

technology development in new media, bioinformatics and the application of IT to measure and control technologies are all potential clusters. Future growth in IT in Maine is likely to depend on identifying and effectively filling a variety of niche application development for specialized users. The markets for individual niches may be small, but the overall potential is large.

A solid base of research and education in computer and related technologies exists in Maine, but it does not emerge as a research strength in the analysis of research outputs. The workforce is the key to development of this sector because of the relatively low technological barriers to entry. It does not appear that Maine's higher education institutions are producing graduates near industry demand, and that industry growth is heavily dependent on recruiting a workforce from out of state.

Marine Technology & Aquaculture

Aquaculture exhibits the characteristics of a sustainable cluster. The markers for its products are strong and could grow significantly, given the world's demand for seafood and the severe pressures on capture fisheries. It is a technically complex industry that still faces a number of challenges in mimicking the functions of natural ecosystems to grow and sustain organisms, but a robust research and skills base exists in Maine to meet these challenges.

Marine research is strong in Maine, but commercial technology developments emerging from that research have lagged behind other states. The strength of the research foundation in Maine, together with growth in demand for technologies related to ocean observing and measurement over the next decades, means that clusters may yet emerge from this sector.

Precision Manufacturing

The precision manufacturing sector comprises two distinct subsectors: metal products and electronics. Each has a small number of very large world-scale firms and a much larger number of smaller companies serving a variety of customers, primarily outside Maine. The electronics sector shows high rates of innovation as measured by patents. Innovation capacity rests primarily within the private sector, though higher education institutions provide some support. Knowledge spillovers and networks within the subsectors appear to be relatively low.

The large firms in each subsector have weak supplier/customer relationships within Maine. These are somewhat stronger for smaller firms, but still weak overall. While the subsectors may be considered sustainable clusters, the links within Maine are a noticeable weakness as a cluster. The economic development potential of this sector for Maine may be improved if this sector can develop closer relationships with other clusters as, for example, in measuring and controlling technologies.

5. Technology Clusters in Maine Today

The result of this analysis is the identification of 16 clusters of economic activity, each defined by a distinct set of knowledge and skills. Eight of these are sustainable clusters, five are potential clusters and three are emerging clusters. Some of the clusters are coincident with the technology sectors. This is the case with Composites and Advanced Materials, which rests on a set of skills in the development of New Materials combining dissimilar materials. It is also the case with Aquaculture (though not Marine Technology).

Other clusters cannot be categorized within single sectors. Bioinformatics and Measuring/Controlling Devices combine Information Technology with knowledge from other fields. Chemistry and Chemical Engineering contributes to current forest products and may contribute to major new products, such as biofuels, which might be considered Biotechnology or Environmental Products. Another overlapping cluster is Shaping and Fabricating, which represents a set of knowledge and skills that is at the core of Precision Manufacturing, but is also critical to the commercial development of Composites and Advanced Materials, as well as the wood products industry (though for simplicity, this link is not shown).

Figure B maps the clusters against the sectors. It also shows the different stages of clusters and also shows several clusters that overlap one or more sectors. Most of these overlapping clusters are potential clusters, which represent potentially important areas of opportunity.

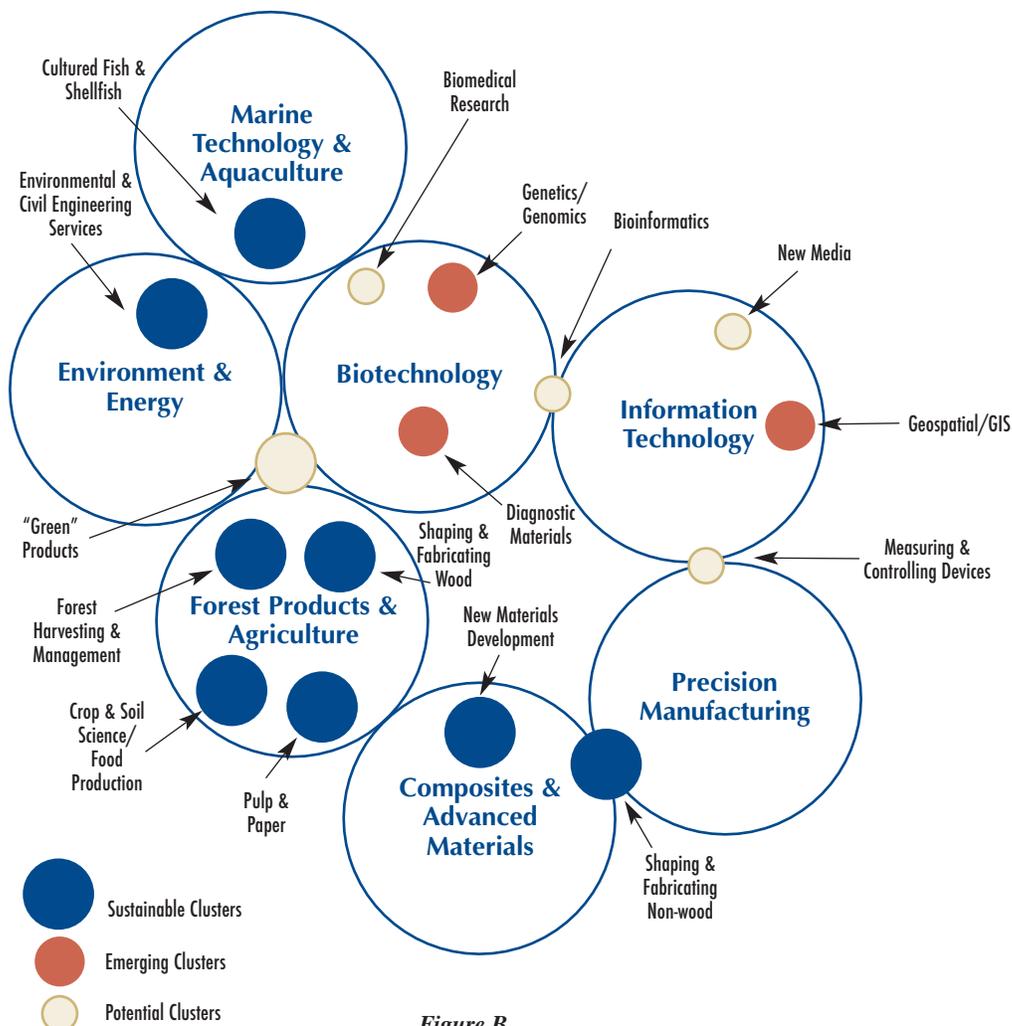


Figure B

If clusters are based on knowledge and skills, their ultimate importance to the economy depends on how they are translated into commercial products and services.

If clusters are based on knowledge and skills, their ultimate importance to the economy depends on how they are translated into commercial products and services. In table B, each of the clusters is associated with current and potential economic activity in Maine. The identification of potential economic activity is based on information gathered in the interviews and surveys of the industries that are associated with each of the clusters. Both current and potential activities comprise a wide range of contributions to the Maine economy.

Assessment of recent economic trends in the industries associated with each of the seven sectors and of the potential economic activity towards which innovation is occurring shows that economic performance as measured by employment has not been strong except in Biotechnology, Environmental Services and Food Products. Output and profitability may have grown in various industries within the clusters, but economic growth has been weak in key industries like forest products, electronics and information technologies.

At the same time, opportunities are identified in a variety of new and expanded markets, which, if exploited, could yield significant economic impacts. Examples include the possible markets for certified “green” products, the use of forest and agricultural inputs for fuel or plastics production, a wide array of new products for human health and expanded applications of composite materials.

Not all of the economic activity associated with the technology sectors can be said to be in clusters at this time. Marine technology, environmental products and many software products are examples of economic activities that are present in Maine, but with which it was not possible to associate cluster characteristic. These industries lacked either sufficient definition, networks or both.

Designation as a cluster does not imply that all clusters are equally strong in each of the four essential components. Table C shows the clusters as defined by knowledge and skills and a subjective assessment of the strength in each cluster of the other three elements. A score of 4 or 5 indicates a strong element; a score of 1 or 2, a weak element; and 3, a middle point. The color coding matches the scoring except that a cross-hatched box indicates the dominant activity in that cluster is strong, but there some elements of the commercial activity associated with that cluster are weaker than the score implies. Again, these are judgments based on the information collected for this study.

	Knowledge/Skills	Current Economic Activity	Economic Activity
Potential Clusters	Biomedical research	Improved medical treatments	Therapeutic products
	Bioinformatics	Informational analysis products and services for genetic research	Expanded research activities
	Measuring and controlling devices	Diverse electronic and other products	Integrated software/hardware approaches to measuring and controlling
	“New Media”	Diverse services for a variety of industries	Same
	Creating “green products”	Diverse	Diverse
Emerging Clusters	Genetics/genomics	Biomedical research	Same
		Products serving biomedical research	Same
	Antibodies and diagnostic materials/processes	Diagnostic materials	Same
	Geospatial analysis/GIS	Diverse	Same
Sustainable Clusters	Developing new materials by combination of dissimilar materials or finding new applications for existing materials	Boat building, construction materials, piping, fluid control and filtering systems	Renewable energy equipment, military and transportation equipment
	Chemistry and chemical engineering	Pulp and paper, other chemicals	Wood-based fuels, plastics and other products
	Marine biology/oceanography/husbandry related to aquaculture	Cultured fish and shellfish	Same
	Forest harvesting and management	Pulp and paper, lumber and wood products	“Sustainable Forestry” certified products
	Design, shaping, coating and fabricating materials of wood, metal, silicon, plastics, etc.	Pulp and paper, lumber and wood products, metal products, electronic products	Same
	Crop and soil sciences	Commodity and specialty food products	Oil-replacing products including plastics
	Agriculture and food production		
Environmental sciences, engineering, civil engineering	Environmental and civil engineering services	Same	

Table B

	Knowledge/Skills	Networks/ Knowledge Spillovers	Entrepreneurship	Production/ Distribution
Potential Clusters	Biomedical research	5	2	1
	Bioinformatics	1	1	1
	Measuring and controlling devices	2	4	4
	“New Media”	3	4	2
	Creating “green products”	1	3	2
Emerging Clusters	Genetics/genomics	4	2	1
	Antibodies and diagnostic materials/processes	4	4	5
	Geospatial analysis/GIS	4	4	4
Sustainable Clusters	Developing new materials by combination of dissimilar materials or finding new applications for existing materials	5	5	5
	Chemistry and chemical engineering	5	5	5
	Marine biology/oceanography/ husbandry related to aquaculture	5	5	5
	Forest harvesting and management	5	3	5
	Design, shaping, coating and composing materials of wood	5	2	5
	Design, shaping, coating and composing materials of metal, silicon, plastics, etc.	2	3	5
	Crop and soil sciences	5	4	5
	Agriculture and food production	5	4	5
	Environmental sciences, engineering, civil engineering	4	4	5
Key	Weakness	4 - 5 Strong Element 3 Middle Point 1 - 2 Weak Element		
	Moderate Strength			
	Strength			
	Mixed Strength and Weakness			

6. Recommendations

It is clear from our analysis of clusters that they are complex and multifaceted. Clusters that can sustainably contribute to economic growth and prosperity in a region require the actions of many different types of people and organizations, sometimes in cooperation with one another and sometimes in competition. Government and public policy must play a number of different roles simultaneously, which puts great demands on public institutions particularly at a time of resource scarcity.

Maine is fortunate in that the organizational and programmatic infrastructure needed to foster cluster development is largely already in place thanks to the investments made in such organizations as the Maine Technology Institute, the Office of Innovation, the Maine Economic Improvement Fund and other elements of the research and development strategy that have been pursued now for more than a decade. The future tasks consist, therefore, of continuing and expanding what has been working and making adjustments in existing programs to take advantage of the opportunities identified here, rather than having to build entirely new efforts from scratch. Four key elements of strategy need to be followed:

- Feed the R&D Pipeline.
- Catalyze Clusters.
- Put a Priority on People.
- Continue to Fund Innovation That Contributes to Clusters.

Feed the R&D Pipeline.

Maine has made great strides in expanding research and development, but the scale of R&D in Maine remains small by national and global standards. Other states are attempting to do the same things that Maine is, and with vastly greater resources. For example, California, Massachusetts and North Carolina have already committed billions of dollars of their own resources to spur biotechnology research. Given the pace of technological change, it is likely that a significant part of the economic stimulus to Maine a decade from now will come from technological innovation that is just now being envisioned. For all these reasons, research and development support must continue at a high level.

Catalyze the Emergence and Growth of Clusters.

The Maine Technology Institute, with its Cluster Enhancement Award program, has the opportunity to take specific actions beyond the support of R&D activities. In seeking proposals to use Cluster Enhancement Award funds, MTI should give preference to projects that address one or more of the following six broad strategies. Each of the strategies can benefit each cluster, but the examples described below indicate clusters where the strategy may be particularly important.

- **Develop services.** Most attention is paid to product development, but clusters rely on networks of services that diffuse knowledge and enhance competitiveness. Examples include services that link biotech firms with researchers and pharmaceutical manufacturers, assistance to firms wishing to meet or exceed environmental quality standards and improving the competitiveness of manufactured products by improving logistical and value-added services.
- **Build tech networks.** Technology networks are essential to moving information, knowledge and skills within a region and thus to the formation and growth of clusters. The development of trade associations has been undertaken in recent years, using Cluster Enhancement Award funds with some notable successes. This should be extended to

Clusters that can sustainably contribute to economic growth and prosperity in a region require the actions of many different types of people and organizations, some times in cooperation with one another and sometimes in competition.

activities such as annual conferences and forums that regularly provide opportunities to exchange research and new knowledge among all the members of a cluster. Biomedical research, geospatial information technologies, environmental services and composites are examples that could benefit from expanded and enhanced technology networks.

- **Decrease distance.** Despite many efforts to make connections, Maine is still a large state with much larger distances between key cluster components than are found in many urban areas where clusters flourish. New technologies, such as virtual presence and the use of new media technologies like iPods, have the potential to decrease distance. The Graduate School of Biomedical Sciences is an example of a networked institution that could benefit from such technologies.
- **Make connections outside Maine.** Cluster development in Maine may depend on making better connections with clusters outside Maine. Connecting Maine clusters to customers, suppliers and researchers outside Maine may spur growth within Maine that would not otherwise occur or would not occur until Maine clusters were substantially larger. Biotechnology and marine instrumentation and equipment are both examples of clusters that are much larger in New England, particularly Massachusetts, than in Maine, and offer opportunities for expanded networks for Maine organizations.
- **Plan infrastructure development.** Through bond issues and other support, Maine has greatly expanded support for the physical infrastructure of research and development. Such support is essential, but it has also been somewhat episodic. Long-term capital plans for research facilities could help develop a coordinated strategic perspective and assure a long-term perspective is maintained.
- **Address weaknesses.** Clusters at all levels of development have weaknesses that need to be addressed. These weaknesses include limited connections to inputs and customers within Maine (precision manufacturing), as well as the need to expand the range of commercial products available from research areas like biomedical and commodity agriculture and forest products.



Put a Priority on People.

Four major workforce issues are identified that must be addressed for successful cluster development:

- The output of technically trained people in Maine is often adequate at the associate's and bachelor's degree levels, but inadequate at the graduate level. This will require educational institutions, particularly in higher education, to expand the number of students interested in pursuing advanced education in STEM fields and, where appropriate, the degree programs available. The University of Maine System, Community College System, Maine Maritime Academy and the Department of Education all have responsibilities to address these needs. Reinvigorating the Maine Economic Improvement Fund is also a desirable action.
- Enhance and expand two-way knowledge and skills development between industry and educational institutions. The supply of a technically competent workforce in support of technological innovation is primarily a function of educational and training institutions, particularly in higher education. But the innovation that drives change emerges from both the laboratory and the shop floor. Educational institutions and training programs usually have some form of industry advisory groups, while private firms offer internship or cooperative education opportunities. These arrangements should be reviewed by all parties to make sure that they effectively incorporate and spur innovation.
- Since Maine's levels of research and workforce are likely to remain small for some time, firms in almost every technical field must recruit most of their specialized work force from out of state. Maine's quality of place will be a key to attracting critical personnel. The work of the Governor's Quality of Place Council addresses these issues and should be considered an important part of Maine's R&D and cluster development efforts.
- A number of clusters are facing severe workforce shortages caused by an aging workforce and a lack of younger people willing to move in production-type occupations. This is particularly the case with those clusters centered around traditional manufacturing industries. Collaborations among private sector firms, K-12 schools and the community colleges have formed to address this issue in specific locations and industries, but need to be expanded.

Maine's transformation into a regional economy that is increasingly driven by technological innovation originating within the state is well underway.

Funding Innovation That Contributes to Clusters.

MTI has a lead responsibility for state assistance to research and development activities and its programs have been shown to be effective at achieving the purposes for which they were established. Two modifications to the grant making process for the Seed Grant and Development Award programs would better link these programs to cluster development strategies without fundamentally altering these very successful programs.

One change would be to require applicants for assistance under these programs to identify the knowledge and skills that would be enhanced by the proposed project. Applicants might also be asked how the project would enhance networking or strengthening other cluster characteristics. It is important that these NOT be the only criteria used for awards under Seed Grants and Development Awards, which should continue to fund R&D that is not or may never be part of a cluster, but may still lead to commercially viable products and services.

The second change is an administrative change in which proposals and awards are to be identified in part on the basis of the knowledge and skills from which a grant proposal originates, rather than the product category a proposal is aimed at. This will help develop a better understanding of key knowledge and skills, identify emerging and growing areas of research and help understand the role of R&D support in cluster development.

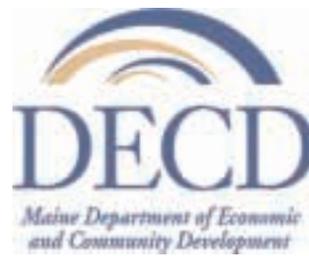
Finally, it is important that MTI and DECD continue their evaluation of R&D, MTI programs and, from time to time, the status of clusters.

Maine's transformation into a regional economy that is increasingly driven by technological innovation originating within the state is well underway. The report provides evidence of firm foundations in research, growing internal networks that transmit knowledge and skills within Maine and increased commercial success. Yet, significant weaknesses in workforce and the market for key products remain. There is real potential for growth in many key markets, even in old-line economic activities like forest products and agriculture. However, creating and seizing opportunities will still be a long road.

Above all, Maine is still too small and the global stage on which the future of the technology based economy is being decided. Other regions in the U.S. and elsewhere see the opportunities outlined in this report, and are investing substantially more than Maine in enhancing their knowledge and skills and creating their technical and scientific workforce. The very real success that Maine has had to date is still a prelude to the success it must sustain into the future if technological innovation is to become a cornerstone of Maine's economy and way of life.



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