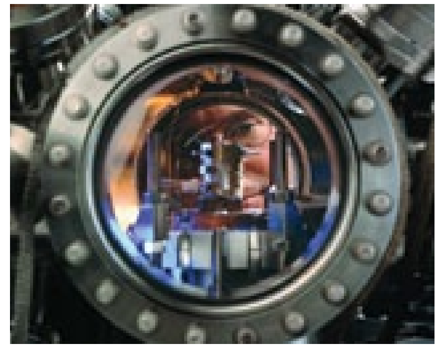
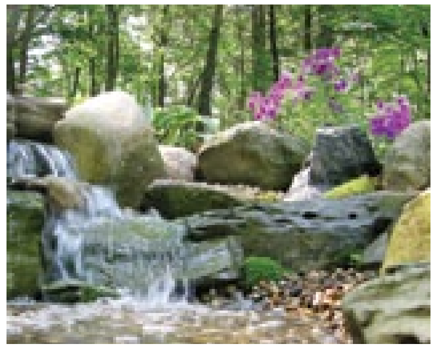
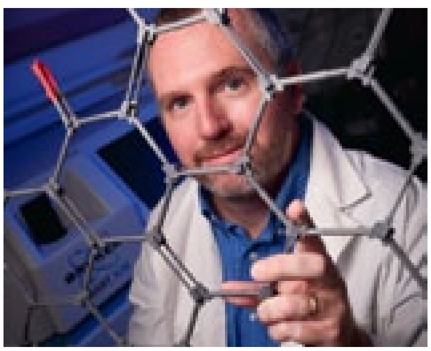
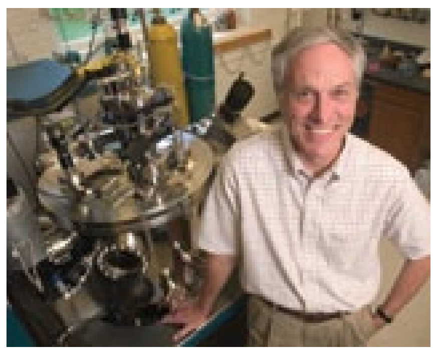
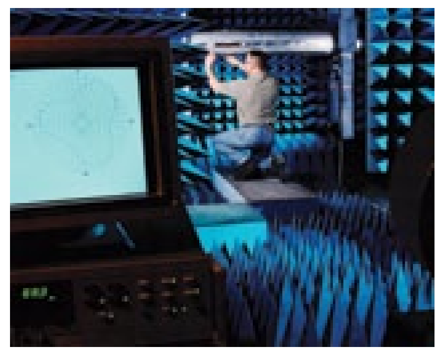






Science and Technology Plan

Shaping New Hampshire's Economic Future

EPSCoR

Ross Gittell, University of New Hampshire
John Orcutt, University of New Hampshire School of Law
October 2011

New Hampshire EPSCoR advances our state's competitiveness in science and engineering by strategically investing in research infrastructure; promoting education in science, technology, engineering, and mathematics; and by fostering partnerships with technology-based businesses that enhance job creation and economic development. With support from the National Science Foundation, New Hampshire EPSCoR is a partnership between the University of New Hampshire, Dartmouth College, Plymouth State University, Keene State College, St. Anselm College, Great Bay Community College, White Mountains Community College, UNH Cooperative Extension, Stay Work Play NH, the K-12 education system, and businesses and industrial companies.

NH EPSCoR
University of New Hampshire
Durham, NH
(603) 862-1804
www.epscor.unh.edu

This report was prepared by Ross Gittell (University of New Hampshire) and John Orcutt (University of New Hampshire School of Law) with assistance from Gregg Fairbrothers (Dartmouth College), Kevin Gardner (UNH), Karen Graham (UNH), Ben Phelps (UNH), Jeffrey Sohl (UNH), Josh Stillwagon (UNH), and Edinaldo Tebaldi (Bryant University).

Funding was provided by a grant from the National Science Foundation, # EPS 0701730.

Table of Contents

Shaping New Hampshire's Economic Future

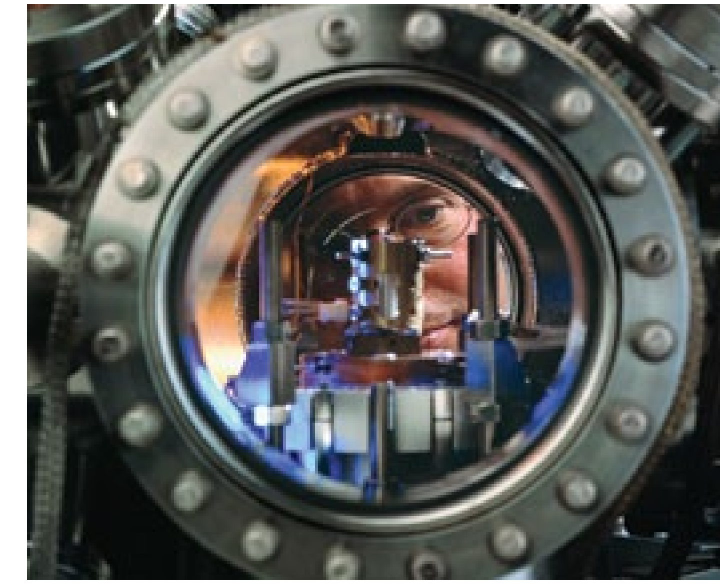
Innovation and technological advances are the keys to economic prosperity in today's knowledge-based world. Across the United States, the states with the strongest science and technology (S&T) capacity and the highest concentrations in high-technology industries also have been the most economically prosperous. New Hampshire is no exception to this reality and has been among the leading states in making the transition from an industrial economy to an innovative one. Over the last six decades, ***S&T-based development has helped to positively transform New Hampshire's economy*** from one that competed largely on its labor-cost advantage to one that has developed a more sustainable innovation advantage. New Hampshire consistently ranks as one of the top-10 states in the Milken Institute's State Technology and Science Index, including being ranked seventh in 2010.

In an increasingly competitive global economy, New Hampshire's innovation system will be the single most important factor shaping the state's economic future and its ability to:

- Grow the economy;
- Create and attract more, and better paying, jobs;
- Expand economic opportunities geographically and to a broader cross-section of the population; and
- Raise the standard of living for all New Hampshire residents.

New Hampshire cannot merely rely on the status quo if it hopes to grow, or even maintain, its current economic status. New Hampshire's economic future will depend on the strength of its innovation system, which will itself depend on the decisions that New Hampshire makes today. Coming out of the country's recent economic troubles, New Hampshire can be well positioned for both short- and long-term S&T-based economic growth if the state builds on its proven innovation system strengths and addresses its weaknesses. New Hampshire has a unique opportunity to positively shape its economic future and bring the state to an even higher level of prosperity, but will lose out on that opportunity if action is not taken soon. New Hampshire's Science and Technology Plan (the S&T Plan) provides the state with the tools that can help foster a successful innovation system and provide New Hampshire's residents with the strong economic future they deserve.

1. Innovation is the Key to Economic Prosperity for All New Hampshire Residents

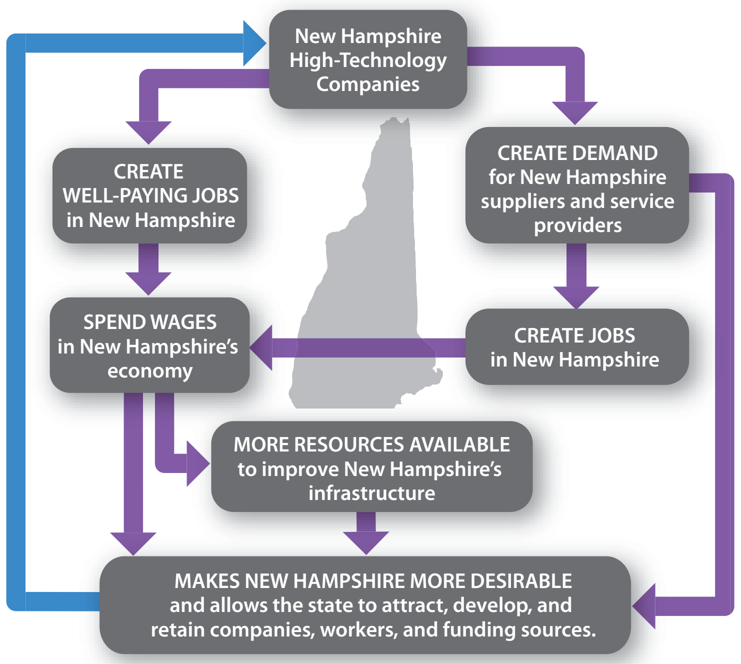


New Hampshire's innovation advantage brings the state numerous economic benefits. One of the most notable has been the ability of New Hampshire's high-technology sector to create high-paying jobs that have improved the state's per capita income and overall standard of living. From high-growth start-ups to well-established companies—and from New Hampshire-created firms to transplants attracted from other states or countries—New Hampshire's high-technology sector has proven to be a valuable source for local employment. See Annex 1 for a series of short case studies of New Hampshire company success stories. The high-technology sector currently accounts for 6 percent of New Hampshire jobs (2010) compared to the national average of 4.7 percent. These are some of the state's highest-paying jobs—high-technology average wages are 78 percent higher than all-industry wages in New Hampshire (see Figure 2)—which results in a positive ***multiplier effect*** throughout the economy. The multiplier effect refers to the fact that high-technology employees spend their wages on goods and services in New Hampshire, which drives sales and employment across all sectors of the state's economy (see Figure 1).

… the ability of New Hampshire's high-technology sector to create high-paying jobs that have improved the state's per capita income and overall standard of living.

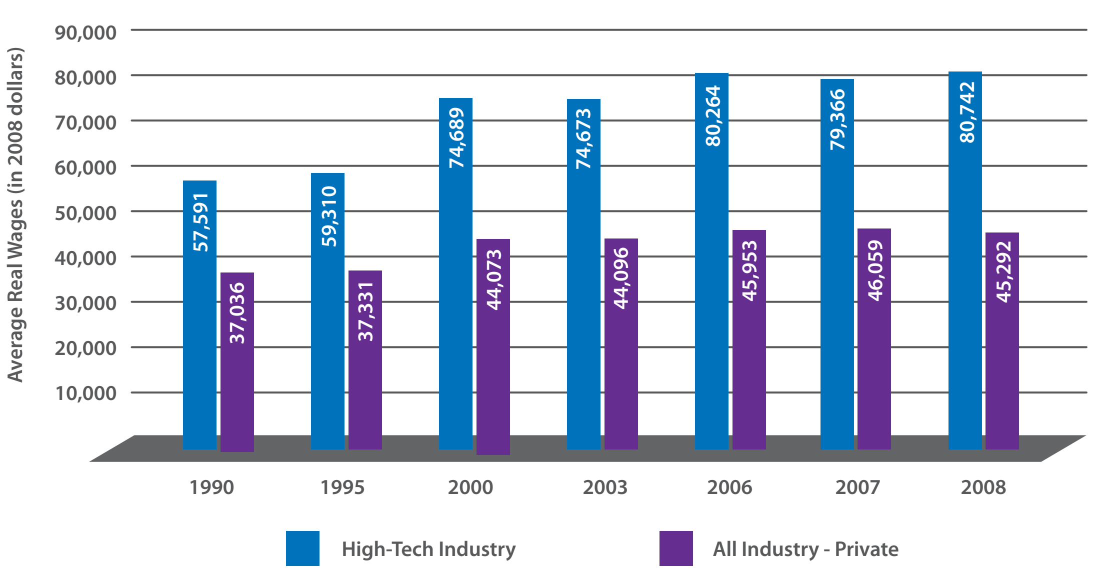
The result is that New Hampshire's per capita income has dramatically improved since the early 1970s (see Table 1). In 1970, New Hampshire's per capita income was 4.9% below the national average. In 2010, the state's per capita income was more than 10% above the national average, ***and this change correlates with New Hampshire's improvement in high-technology employment***.

Figure 1: High-Tech's Multiplier Effect on the New Hampshire Economy



Rapidly increasing competition from other states and internationally, however, means that New Hampshire cannot rest on its past accomplishments and instead must strategically prepare itself for the future. This increased competition has shown itself in a number of ways. The current level of high-technology employment in the state, for example, has dropped precipitously from its 2000 peak of just under 50,000 jobs (see Figure 3). Current high-technology employment is down nearly 25 percent to less than 38,000 jobs. Over the last decade, New Hampshire has been the worst performing state in terms of percentage change in high-technology jobs, losing more high-technology jobs on a percentage basis than any other state. Much of the decline was associated with lower-end component-part manufacturing employment drops. This portion of the manufacturing sector first declined with the technology bust in the early 2000s and is not likely to return to New Hampshire. Today, commodity-like high-technology manufacturing of parts for products such as Apple iPhones and iPads is done in low-wage countries such as China and increasingly will be done using automated manufacturing processes and robots. Well-paying high-technology jobs in the United States will continue to derive from the most sophisticated technology areas such as computer and software systems design and support, research and development, commercialization of new technology, and advanced manufacturing of sophisticated and customized goods. These are areas in which states have to draw extensively on their S&T infrastructure to be competitive. The quality of that infrastructure will determine their ability to create, attract, and grow vibrant high-technology businesses and benefit from the resulting creation of well-paying technology jobs.

Figure 2: Average Real Wages in New Hampshire (2008 Dollars), 1990-2008



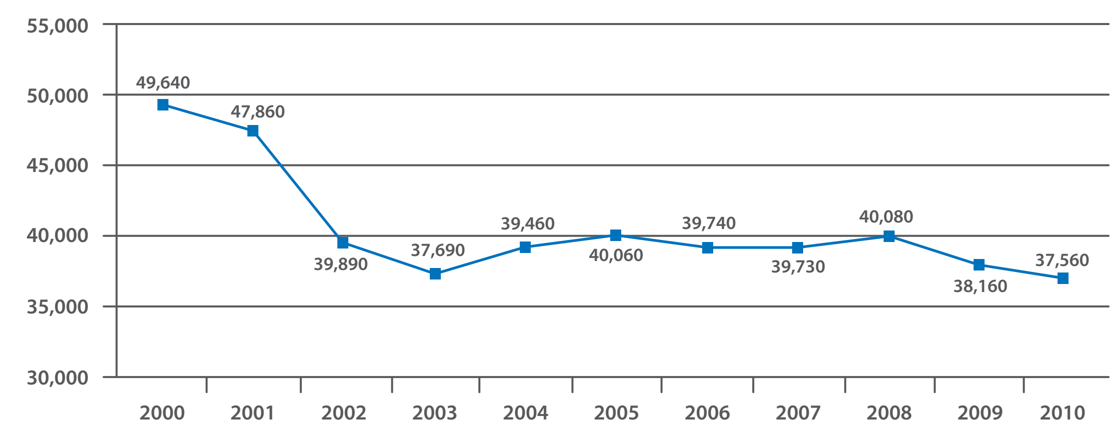
Source: Authors' calculation using data from the Bureau of Labor Statistics (BLS)

Table 1: State's per capita personal income as a proportion of the U.S. average per capita personal income, 1969-2010

1970			2010			
State	Rank	State's per capita personal income compared to the U.S. average per capita personal income	State	Rank	State's per capita personal income compared to the U.S. average per capita personal income	Per capita personal income
Colorado	18	-1.1%	Maryland	4	19.4%	49,025
Florida	19	-2.1%	New York	5	19.1%	48,821
Wisconsin	20	-2.5%	Wyoming	6	17.5%	47,851
Oregon	21	-3.8%	Virginia	7	11.8%	44,762
Wyoming	22	-4.3%	Alaska	8	10.6%	44,174
New Hampshire	23	-4.9%	New Hampshire	9	10.4%	44,084
Iowa	24	-5.0%	Washington	10	9.3%	43,564
Missouri	25	-5.6%	Illinois	11	8.5%	43,159
Arizona	26	-6.2%	California	12	8.4%	43,104
Kansas	27	-6.4%	Minnesota	13	7.8%	42,843
Nebraska	28	-7.1%	Colorado	14	7.7%	42,802

Source: Authors' compilation using data from the Bureau of Economic Analysis

Figure 3: The number of high-tech jobs in New Hampshire has dropped by nearly 25 percent since 2000



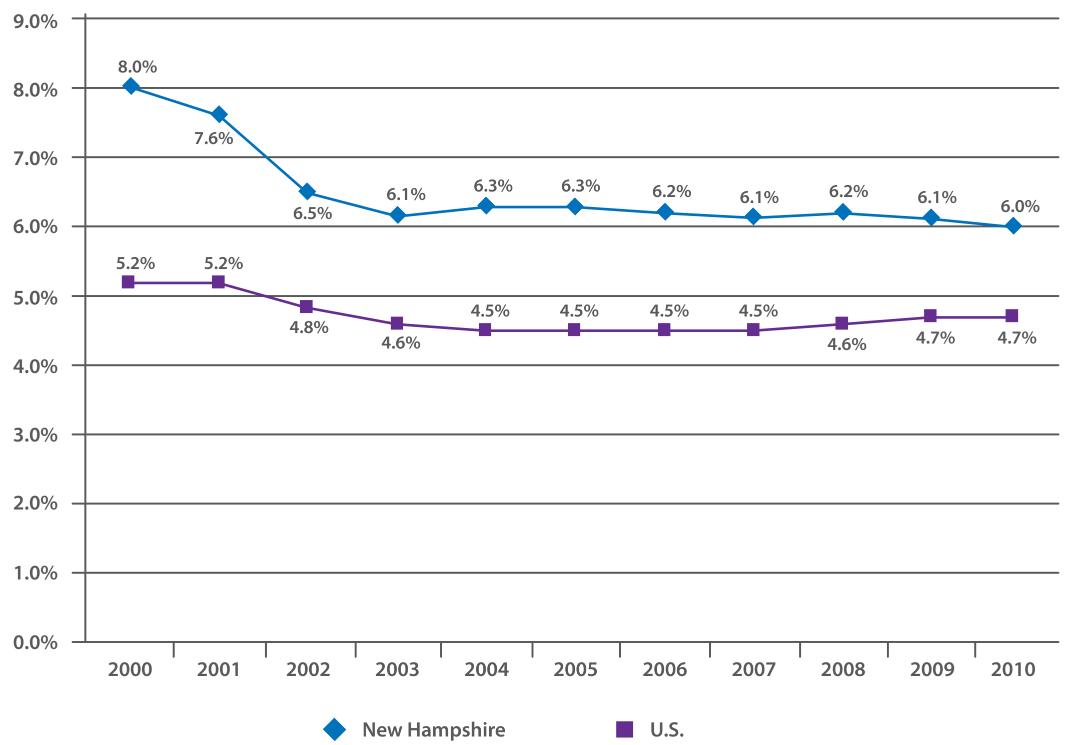
Source: Authors' calculation using data from the Bureau of Labor Statistics (BLS)

New Hampshire's decline in high-technology employment in the first decade of the 21st century has generated a corresponding drop in its high-technology overall job concentration (see Figure 4). High-technology overall job concentration measures the percentage of the state's jobs that are high-technology jobs. In 2000, New Hampshire's high-technology industries accounted for 8 percent of total state employment, which was more than 50 percent above the national average. In 2010, New Hampshire's high-technology overall job concentration has dropped to 6 percent, which is only one-third above the national average. New Hampshire was ranked third in the United States in high-technology overall job concentration in 2000 (behind only Massachusetts and Colorado), but dropped to fifth in 2005 and to ninth in 2010. Since 2000, Virginia, California, Maryland, Washington, New Jersey, and Utah all have moved ahead of New Hampshire in high-technology overall job concentration.[1]

Rapidly increasing competition from other states and internationally, however, means that New Hampshire cannot rest on its past accomplishments …

[1] Derived from data and high-technology industry definition from Moody's Analytics 2011.

Figure 4: High-technology overall job concentration has been dropping in New Hampshire



Source: Authors' calculation using data from the Bureau of Labor Statistics (BLS)

2. *Purpose of the S&T Plan: Improve Decision-making of New Hampshire's Various S&T Actors*

The S&T Plan provides New Hampshire's various S&T actors with information, data, and analytical tools to make better decisions and strengthen the state's position as an innovative economy. Specifically, the S&T Plan seeks to do four things:

1. Help policymakers understand New Hampshire's "innovation system"
2. Offer a user-friendly "Toolkit" of innovation system measurements to monitor innovation system performance systematically
3. Provide data-driven analyses of New Hampshire's S&T strengths and weaknesses as they relate to economic growth and opportunity
4. Provide recommendations for addressing system weaknesses

The focus of the S&T Plan is on assembling data and information that lead to intelligent decisions. The S&T Plan is not designed to be a static pick-the-winners plan that seeks funding for any particular actor or function. It also is not designed to be an advocacy piece. The data can speak for itself. Finally, the S&T Plan has been purposefully designed to be updatable in a cost-effective manner. As strengths and weaknesses change over time, this data-driven approach will automatically adapt to those changes.

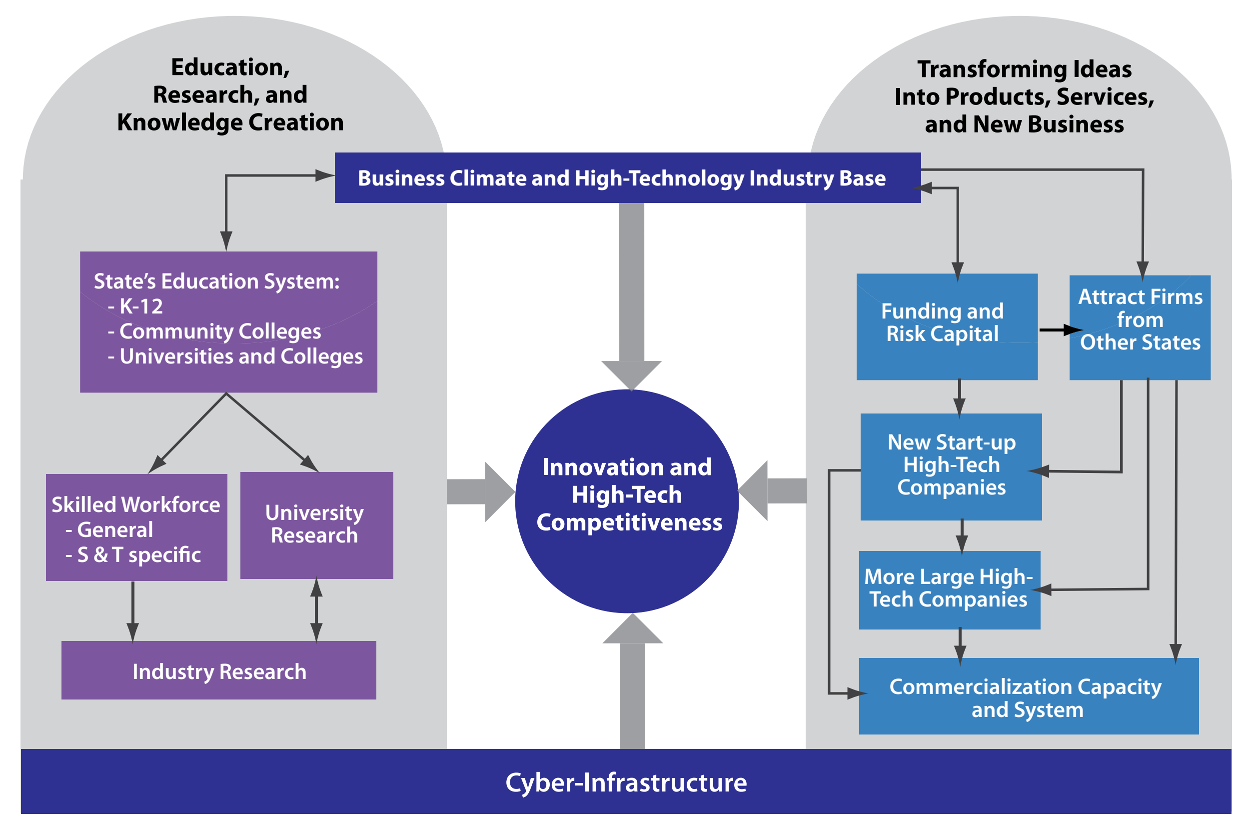
The focus of the S&T Plan is on assembling data and information that lead to intelligent decisions.

3. *Understanding New Hampshire's "Innovation System" and its Impact on State Policymaking*

Innovations and technological advances take place within a complex system—frequently referred to as an "innovation system." Effective S&T policies require policymakers to have an in-depth understanding of their particular innovation system—including the system's strengths and weaknesses—and to craft policies that take advantage of those strengths and address the system's weaknesses. Innovation systems are inherently complex and involve lots of actors, inputs, and relationships (see Figure 5).

Innovation systems that provide better linkages and coordination between the various actors and activities will be more efficient and productive than innovation systems with weaker linkages. Innovation comes from flows of knowledge and technology among individuals, businesses, government officials, and academic institutions, and requires productive connections among each of these actors to turn potential ideas into valuable innovations, business ventures, and employment. Innovation systems need strong education and research institutions, highly skilled and creative people, and financial resources to fund the various levels of research and development (from basic to applied research). To launch (or attract) innovation-based ventures, a critical mass of R&D-centric businesses (both large and small) and entrepreneurs throughout the system that can provide help in moving innovations from the laboratory to the marketplace are needed, as are various linkages to efficiently and effectively connect all of the above.

Figure 5. New Hampshire's Innovation System

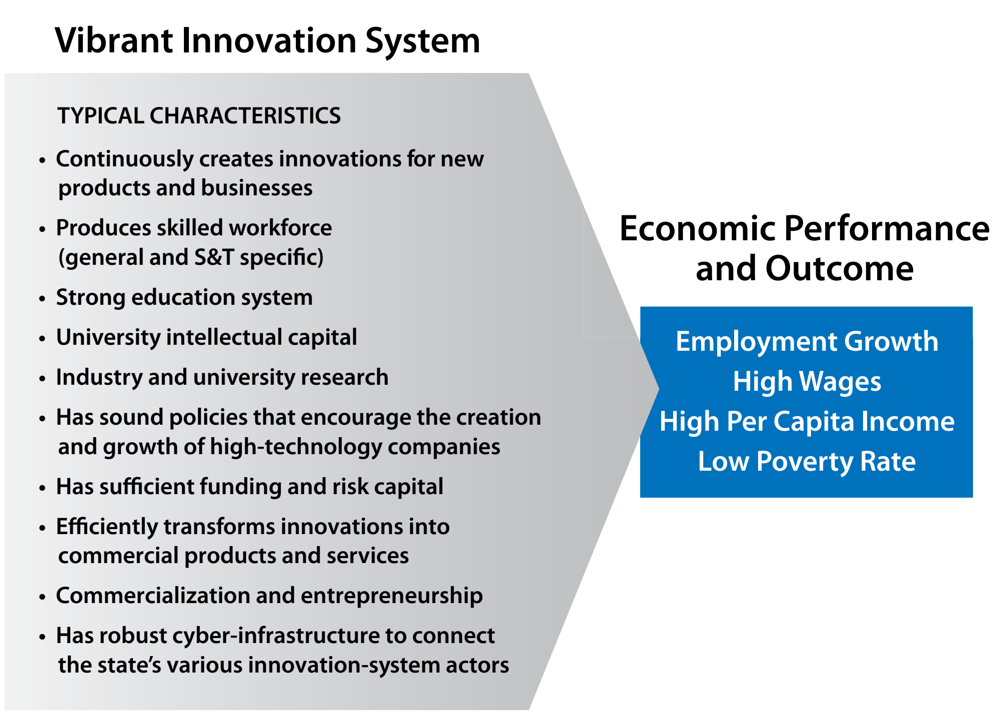


S&T development needs to become an integral part of New Hampshire's economic development policy. State policymakers play a crucial role in fostering an innovative economy. In contrast to state economic development policies that subsidize individual companies or industries (e.g., with tax breaks and incentives) and have government officials trying to differentiate between market winners and losers, state policies that invest in innovation systems provide the foundation to spur innovation and long-term sustainable economic growth across a range of industries and even help to launch entirely new industries. Strong innovation systems stimulate private investment and encourage and support entrepreneurs who then can create the next generation of companies and industries in the state that can provide well-paying jobs and foster economic growth (see Figure 6). Investments in innovation systems can position a state to create, attract, support, and retain innovators, entrepreneurs, and private investors to compete effectively in global markets. This is in contrast to some traditional state economic development policies, which use subsidies and tax breaks that displace market incentives.

Because of the complexity of an innovation system, ***policies that weaken the system unfortunately are far too common***. A well-intended tax, regulatory or education policy, for example, that seeks to address one issue can inadvertently but seriously weaken New Hampshire's innovation system and cost the state significant economic growth and jobs. Having a better understanding of New Hampshire's innovation system and having access to analytical tools that track the impact of policies on the state's innovation system can improve the policy environment for creating, developing, and attracting high-technology companies and their accompanying high-paying jobs.

> **Strong innovation systems stimulate private investment and encourage and support entrepreneurs who then can create the next generation of companies and industries in the state that can provide well-paying jobs and foster economic growth. This is in contrast to some traditional state economic development policies, which use subsidies and tax breaks that displace market incentives and are not sustainable.**

Figure 6: Outcomes from a Vibrant Innovation System



4. *The New Hampshire Science & Technology "Toolkit"*

Generating timely data about the core components of New Hampshire's innovation system will provide New Hampshire's S&T actors with information they need to make wise decisions. For example, does New Hampshire provide a business climate that supports entrepreneurs and technology-based businesses? Does New Hampshire have sufficient research capacity to support an innovative economy? Does New Hampshire have a sufficiently educated and skilled workforce to support a technology-based economy? The S&T Plan offers a user-friendly "Toolkit" (Table 2) that provides data on a regular basis to answer these types of questions.

The Toolkit reports the current status, and also the performance over time, of key variables for New Hampshire's innovation system. The Toolkit includes eight core categories, and 58 variables in those categories, that provide a comprehensive picture of New Hampshire's innovation system. The Toolkit will help to:

- Clearly and empirically identify strengths and weaknesses in the state's innovation system
- Benchmark progress
- Measure the effectiveness of policymaking efforts
- Form a common framework and knowledge base for the various S&T actors to work together
- Guide strategic planning efforts by S&T actors and inform future innovation system investments (both public and private)
- Allow businesses and academic institutions to build complementary innovation capacity by consciously aligning their interests
- Communicate New Hampshire's S&T strength to entrepreneurs, investors, and companies that are considering New Hampshire opportunities

For purposes of general usability, the Toolkit does not include every detailed aspect and consideration of the innovation system in New Hampshire, but instead focuses on its key dimensions. The Toolkit is designed to be relatively easily understood, to be amenable to reporting to policy audiences and the general public, and to allow for comparisons of New Hampshire to other states. It is also designed in a manner to make data collection and updating as transparent, objective, and inexpensive as possible. The rankings provided are scaled from "1," indicating the top/best ranked state in terms of positive contributions to a state's innovation system, to "50," indicating the poorest/lowest ranked among the 50 states. Ranks are provided for 2010, 2008, 2004, and 2002 (as available) to enable consideration of performance over time, including since the so-called "technology bust" recession of the early 2000s.

In 2010, New Hampshire ranked at the median or better on 35 of the Toolkit's input variables, or 60 percent, and was in the top half for six of the eight overall input categories. Among the six New England states, New Hampshire's innovation system ranks near Connecticut. Only Massachusetts—a state consistently among the top three in the nation in innovation ranking—has a stronger innovation system than New Hampshire. Of note, the other northern New England states—Maine and Vermont—have weaker innovation systems than New Hampshire, which has resulted in their achieving weaker economic performance in terms of per capita income and poverty rate.

Table 2: New Hampshire Science & Technology "Toolkit"— Key Variables for New Hampshire's Innovation System

	New Hampshire Rankings			
	2002	**2004**	**2008**	**2010[3]**
BUSINESS CLIMATE AND HIGH TECH INDUSTRY BASE				
Business Tax Climate Index	–	–	8	7
Foreign Direct Investment	8	–	5	4
Creative Destruction Factor (Job Churning)	34	–	12	15
Number of High Technology Sectors with Above-Average Employment Concentration	10	10	9	9
Technology Concentration and Dynamism	10	7	10	8
Industry Investment in R&D	18	–	8	6
High Technology Overall Employment Concentration	6	9	9	9
Group Average	**14**	**9**	**9**	**8**
UNIVERSITY-BASED S&T ACTIVITY				
Academic R&D Dollars per Capita	19	4	5	5
Competitive NSF Proposal Funding Rate	2	4	25	2
NSF Funding per $100,000 of GSP	29	22	16	10
Per Capita State Appropriations for Higher Education	47	50	50	50
Percentage University R&D from State and Local Government	41	46	42	49
Percentage University R&D from Industry	32	33	30	37
Percentage University R&D from Institution Funds	30	32	26	34
Academic R&D Public Financing Index	43	43	43	–
University Patents (per 100,000 persons)	22	17	18	31
University Invention Disclosures (per 100,000 persons)	19	28	25	34
University Total Active Licenses and Options (per 100,000 persons)	16	12	9	28
University New Patent Applications Filed (per 100,000 persons)	18	23	18	36
Group Average	**27**	**26**	**26**	**29**
SKILLED S&T WORKFORCE				
Percentage Bachelor Degrees in Science & Engineering	20	35	33	45
Percentage Graduate Students in Science & Engineering	35	37	29	30
Recent Phd Degrees in Science & Engineering (per 1,000 workers)	31	30	35	23
Scientists and Engineers	25	–	25	9
Percent of 8th graders at or above proficient in mathematics	4	5	6	4
Percent of 4th graders at or above proficient in mathematics	1	2	2	2
Migration of Knowledge Workers from Other States to NH	–	–	9	10
Immigration of Knowledge Workers from Foreign Countries to NH	–	–	3	2
IT Professionals	24	20	15	9
Group Average	**20**	**22**	**21[4]**	**17[4]**

Continued next page

	New Hampshire Rankings			
	2002	**2004**	**2008**	**2010[3]**
SKILLED WORKFORCE (NOT S&T SPECIFIC)				
Human Capital Investment Composite	25	21	12	17
Percent of Age 25+ with Bachelors Degree	7	9	10	7
Percent of Age 25+ with PhD	36	16	13	17
Percent of 8th graders at or above proficient in reading	2	2	5	5
Percent of 4th graders at or above proficient in reading	1	2	3	3
Group Average	**14**	**10**	**9**	**10**
COMMERCIALIZATION CAPACITY AND SYSTEM				
Patents Issued per 100,000 Persons	31	–	38	30
Independent Inventor Patents Issued	–	–	9	8
SBIR Awards per 10,000 Business Estab. – Phase I	14	4	7	6
SBIR Awards per 10,000 Business Estab. – Phase II	16	6	2	2
University Licensing Income Received ($ per capita)	30	33	22	29
University Licensing Income – Running Royalties ($ per capita)	37	34	32	–
Group Average	**26**	**19**	**18**	**15**
FUNDING AND RISK CAPITAL				
Average Annual SBIC Funds Disbursed per $1,000 of GSP	17	13	2	5
Federal R&D Dollars per Capita	13	10	18	14
Risk Capital and Entrepreneurial Infrastructure	14	6	18	7
STTR Award Dollars per $1 Million of GSP	15	42	13	8
Venture Capital Investment in Clean Technology as % of GSP	–	–	16	16
Venture Capital Investment as % of GSP	6	3	15	16
Group Average	**13**	**15**	**14**	**11**
START-UP AND HIGH-GROWTH VENTURES				
Business Starts (per 100,000 people)	16	14	35	30
Fastest-Growing Firms	–	–	20	13
Gazelle Jobs	9	–	32	–
Index of Entrepreneurial Activity	–	–	36	26
IPOs	27	–	41	14
University Start-ups (per 100,000 people)	28	34	41	37
University Licenses/Options Executed to Start-ups (per 100,000) people)	44	37	16	36
Group Average	**25**	**28**	**32**	**26**
CYBER-INFRASTRUCTURE				
Broadband Telecommunications	20	–	12	9
E-Government	44	–	47	43
Health IT	–	–	14	38
Internet Domain Names	16	–	18	–
Online Population	2	–	4	5
Technology in Schools	45	–	39	–
Group Average	**25**	**–**	**22**	**24**

[2] The Toolkit's primary data sources are the Kauffman Foundation (the organization's State New Economy Index) and the Milken Institute (State Technology and Science Index).

[3] The most recent data available is presented for each of the variables in the "2010" column. Most of the data comes from the Kauffman Foundation and Milken Institute reports published in 2011, with 2010 being the most current data available. However, because of data reporting delays from public sources, some of the data presented as "2010" is from earlier years. The data on 8th grade and 4th grade performance in mathematics and reading came from the National Assessment of Educational Progress (NAEP). NAEP reports its data in odd years only, and 2009 is the last year for which data is available. As a result, the 2002, 2004, 2008, and 2010 ranks for 8th grade and 4th grade performance in mathematics and reading actually reflect New Hampshire's ranks in 2003, 2005, 2007, and 2009.

[4] In calculating the Group Average for 2008 and 2010, we did not include the rankings for "Migration of Knowledge Workers from Other States to NH" and "Immigration of Knowledge Workers from Foreign Countries to NH." Because that data was not available for 2002 and 2004, inclusion in the 2008 Group Average unduly skews the results. When those rankings are included, New Hampshire's Group Average for the Skilled S&T Workforce category was 17 in 2008 and 15 in 2010.

New Hampshire's input strengths have consistently generated positive economic outcomes for the state. Table 3 provides New Hampshire's performance on a number of common economic outcome indicators. Like the Toolkit data, the data in Table 3 is presented in comparison to the other 49 U.S. states. "1" indicates the top/best ranked state, and "50" indicates the poorest/lowest ranked state.

Regionally, New Hampshire's innovation-based economic performance has historically trailed Massachusetts (see Table 4). Much more troubling, however, is the fact that New Hampshire's innovation-based economic performance has also recently begun to trail that of Vermont and Connecticut. Vermont and Connecticut have been able to generate recent growth in their gross state product and per capita income that New Hampshire has not been able to match. New Hampshire's performance drop suggests some weakening in the state's S&T position.

New Hampshire's innovation-based economic performance has also recently begun to trail that of Vermont and Connecticut.

Table 3: New Hampshire's National "Report Card"— Economic Impact of New Hampshire's Innovation System

	2002	2004	2007	2008	2010
Per Capita Gross State Product	18	20	20	22	24
Gross State Product Growth	41	28	38	25	43
Per Capita Income Level	5	6	7	8	9
Per Capita Income Growth	22	18	33	43	27
Unemployment Rate	15	9	13	7	4
Total Employment Growth	40	18	40	22	24
High Tech Employment Growth	50	–	24	25	33
Poverty Rate	1	1	1	1	1
Average for all outcomes	**24**	**14**	**22**	**19**	**19**

Table 4: New Hampshire's Regional "Report Card"— 2010 Economic Impact of the Innovation Systems for the Six New England States[5]

	THE EIGHT ECONOMIC PERFORMANCE AND OUTCOME MEASUREMENTS								
	Average for all Outcomes	Per Capita Gross State Product	Gross State Product Growth	Per Capita Income Level	Per Capita Income Growth	Unemployment Rate	Total Employment Growth	High-Tech Employment Growth	Poverty Rate
MA	8	6	4	2	12	23	3	9	7
VT	13	33	10	19	4	6	6	34	12
CT	15	4	12	1	22	28	34	47	4
NH	19	24	43	9	27	4	24	35	1
RI	20	23	18	15	13	47	11	18	16
ME	26	42	27	29	21	17	20	45	23

New Hampshire trails Massachusetts, Vermont and Connecticut in leading indicators for economic performance.

[5] For annual position data (e.g., per capita gross state product), the most recent data available is presented (2010 in most cases). For growth data (e.g., gross state product growth), this table tracks the most recent changes (2008 to 2010 in most cases).

5. *New Hampshire's Innovation System Strengths*

New Hampshire's "innovation system" successfully competes on both a regional and a national basis. In 2010, the state ranked among the top-ten states in 26 of the 58 input categories (or 45 percent) and three of the eight economic performance measurements (or 38 percent). New Hampshire's greatest innovation system strengths include:

- Existing high-technology industry base
- Skilled workforce
- Growing R&D strength of the academic sector generally
- Some university R&D strength in a number of crucial technologies
- Increased industry investment in R&D
- A more supportive funding environment for high-technology start-ups than is generally appreciated

These strengths have played a major role in the state's consistently strong overall economic performance. Because of these fundamental strengths, attempts to improve New Hampshire's innovation system will involve incrementally building on the state's existing and "proven" strengths. New Hampshire's innovation system does not require dramatic changes—the system does not require "overhaul"—and attempts to improve it do not require policymakers to take high risks or have blind faith that innovation can take hold in New Hampshire's economy. New Hampshire is an innovative state that already derives considerable economic rewards from innovation. The only question is whether New Hampshire can become even more innovative and thereby restore significant growth in gross state product and income and generate even greater economic rewards and job creation from innovation. There can be significant short- and long-term economic returns from thoughtful investments in New Hampshire's innovation system.

... attempts to improve New Hampshire's innovation system will involve incrementally building on the state's existing and "proven" strengths.

6. *Strategically Improving New Hampshire's Innovation System*


© Bill Truslow

Despite the success of New Hampshire's innovation system, there are significant weaknesses, or gaps, in the innovation system that threaten the state's current strong position and future innovation-based economic development.

There are a wide variety of strategies that a state can take to try to address innovation system weaknesses, and many states have adopted S&T plans to help with the effort (see Box 1). Some state plans have tried to identify a winning R&D focus within the state and encourage a greater emphasis on that particular R&D area.[6] Some plans request that dedicated funds be established to increase R&D and entrepreneurial companies within the state.[7] Many state plans take the opportunity to set specific goals for their state. The goals can be quantitative (e.g., 10 percent increase in high-technology employment)[8] or more qualitative (e.g., increase per capita income by increasing the skills of the state's workforce).[9] It is unclear what impact goal setting has had in most cases, however, because accountability tends to be weak in most state plans; even when accountability is assigned, those involved with setting the goals frequently have moved on to other projects by the time progress on the goals is measured.

...there are significant weaknesses, or gaps, in the innovation system that threaten the state's current strong position and future innovation-based economic development.

[6] *See e.g.,* Rhode Island's S&T Plan.
[7] *See e.g.,* Maine's S&T Plan and Vermont's S&T Plan.
[8] *See e.g.,* Maine's S&T Plan and West Virginia's S&T Plan.
[9] *See e.g.,* Maine's S&T Plan and Rhode Island's S&T Plan.

Box 1: Select Examples of Recent State S&T Plans

STATE	PLAN TITLE	AVAILABLE AT
Maine	2010 Science and Technology Action Plan: A Bold Approach to Stimulate Maine's Economy	http://www.maine.gov/decd/innovation/pdfs/2010_S&T_Plan.pdf
Nevada	Nevada Science and Technology Plan	http://www.nevada.edu/epscor/nevadascience.pdf
Oklahoma	A Plan for Using Innovation and Technology to Strengthen Oklahoma's Economy	http://www.ok.gov/edge/RESOURCES/Innovation_and_Technology_Plan/
Rhode Island	Accelerating Innovation Through Collaboration in the Ocean State: Science and Technology Infrastructure Plan for Rhode Island	http://stac.ri.gov/state-science-and-technology-plan/
Vermont	Vermont's Science & Technology Plan	http://www.uvm.edu/~epscor/pdfFiles/Vermont_Science_&_Technology_Plan.pdf
West Virginia	Vision 2015: The West Virginia Science and Technology Strategic Plan	http://www.wvresearch.org/

This S&T Plan has tried to incorporate lessons learned from prior state S&T-planning efforts and to provide a strategy for improving New Hampshire's innovation system that is tailored to New Hampshire's particular environment. As a result, this S&T Plan seeks to employ a data-driven, market-based approach to improving the state's innovation system. Through data-driven analysis, this S&T Plan seeks to identify resolvable weaknesses on a continuous basis. Once a weakness is identified, a deeper analysis can be conducted and verifiable solutions can be crafted to address the weakness. The Toolkit has identified a number of weaknesses, but it is unrealistic to try to address all of them at once. The 2011 version of the S&T Plan highlights four key, addressable weaknesses that offer opportunities to substantially improve New Hampshire's overall innovation system. The four key, resolvable weaknesses are:

1. Lack of high-growth companies
2. Untapped university technology commercialization
3. Sub-optimal pipeline for future highly skilled S&T workers
4. Need for better broadband access throughout the state

In future years, other weaknesses will be highlighted and addressed.

1. Lack of high-growth companies

Small businesses are frequently credited as the key to job creation. Such claims, however, are misleading because they inaccurately view small businesses as a homogenous group. Most small businesses are not particularly strong job creators, as they tend to "destroy" as many jobs as they create due to rapid job turnover, layoffs, and frequent bankruptcies. The small businesses that have demonstrated a capacity to create a disproportionate number of net new jobs and macroeconomic growth in an economy are the so-called "gazelles." The term "gazelle" refers to companies with annual revenues that have grown 20 percent or more for four straight years. Gazelles are the rapid-growth companies in an economy, and are frequently represented by high-technology start-ups. Gazelles are some of the most valuable companies that a state can have in its economy and are a sign of a dynamic, adaptive, and innovative economy.

> **The small businesses that have demonstrated a capacity to create a disproportionate number of net new jobs and macroeconomic growth in an economy are the so-called "gazelles." … Gazelles are the rapid-growth companies in an economy …**

One of the more important facts highlighted by the Toolkit is New Hampshire's declining position in fast growing companies (Table 5).

Table 5: Gazelle Jobs for the Six New England States

	% of Employment in Gazelle Firms	2010 Rank
Rhode Island	8.0%	19
Massachusetts	7.6%	21
Connecticut	6.8%	25
New Hampshire	6.2%	23
Maine	4.3%	43
Vermont	3.8%	48

New Hampshire ranks poorly in its percentage of jobs in gazelle firms. New Hampshire's rank in this variable has declined from ninth in 2002 (at 14.5 percent of jobs) to 23rd in 2010 (at 6.2 percent of jobs). New Hampshire's percentage of jobs in gazelle firms is now less than one-half what it was in 2002. In 2002, New Hampshire was above the national average in this variable, but now is below the national average. Why is this important? The data show that in any given year, the top-performing 1 percent of firms generates roughly 40 percent of new job creation in the United States. And gazelles, comprising less than 1 percent of all companies, generate roughly 10 percent of new jobs in any given year (Kaufman Foundation Report, March 2010).

What can be done to increase the presence of gazelles in New Hampshire? The Kaufman Foundation (2010) offers valuable insights from the national experience and suggests:

1. **Encourage the start-up of more companies:** Based on simple math, this will mean more high-growth companies and therefore more job growth.
2. **Remove barriers:** Typical barriers that prevent existing companies from achieving gazelle-like growth include difficulty accessing financing, excessive regulation, and excessive taxation.
3. **Focus on universities and immigrants:** These groups have shown themselves to be rich sources for gazelles. To assist universities, the report recommends encouraging innovation by removing barriers to commercialization of university research. To attract immigrants who plan to start businesses, the report recommends starting a new visa program or expanding the existing EB-5 visa program for immigrant investors.

What can be done in New Hampshire? New Hampshire has a unique tax structure that appears to have helped the state's standing based on New Hampshire's seventh ranking on overall tax burden by the Tax Foundation. This unique tax structure has some specific benefits to the economy, such as the absence of a personal income tax, which has encouraged high-income workers, entrepreneurs, and households to locate to the state, and the absence of a broad-based retail sales tax, which has encouraged retail sales activity. Yet the state's unique tax structure also presents some challenges and barriers to growth, which is suggested by the state's 50th ranking by the Tax Foundation on corporate tax burden.

Some aspects of the state's unique tax structure can be particularly problematic for gazelles. The area of concern is the state's business enterprise tax (BET). The New Hampshire Department of Revenue Administration provides the following explanation of the BET:

- **What is the Business Enterprise Tax (BET)?** A 0.75 percent tax, for taxable periods ending on or after July 1, 2001, is assessed on the enterprise value tax base, which is the sum of all compensation paid or accrued, interest paid or accrued, and dividends paid by the business enterprise, after special adjustments and apportionment.
- **Who pays it?** Enterprises with more than $150,000 of gross business receipts, for taxable periods ending on or after July 1, 2001, from all their activities or an enterprise value tax base more than $75,000, for taxable periods on or after July 1, 2001, are required to file a return.[10]

The BET is not an income tax and, therefore, is not designed to avoid companies that are not yet generating profits. The BET's focus on wages paid and interest payments can be a burden for rapid-growth firms that are adding jobs, paying wages, and growing—but are not yet profitable. These rapid-growth firms would not be subject to similar taxes in most other states, including New Hampshire's neighboring states. To compound matters, the BET has the possibility of first being triggered when the rapid-growth firm is beginning its expansion phase and is already required to relocate to larger facilities that will support its growth. Such companies could be particularly ripe for relocation to neighboring states. We do not, however, want to overstate the impact of the BET on rapid-growth firms as it is only 0.75 percent of wages and is significantly lower than income taxes on workers in other states.

[10] New Hampshire Department of Revenue Administration, Frequently Asked Questions: What is the Business Enterprise Tax?, available at http://www.nh.gov/revenue/faq/dra_2400.htm.

What could be a more substantive burden on gazelles trying to grow in New Hampshire is New Hampshire's business profits tax (BPT). The New Hampshire Department of Revenue Administration provides the following explanation of the BPT:

- **What is the Business Profits Tax (BPT)?** An 8.5 percent tax is assessed on income from conducting business activity within the state. For multistate businesses, income is apportioned, using a weighted sales factor of 2 and the payroll and property factors. Organizations operating a unitary business must use combined reporting in filing their N.H. return.
- **Who pays it?** Any business organization, organized for gain or profit, carrying on business activity within the state is subject to this tax. However, organizations with $50,000 or less of gross receipts from all their activities are not required to file a return.[11]

This "tax trap" can be a significant deterrent to forming and retaining rapid-growth firms in New Hampshire …

The BPT is applied not only to traditional profits but also to increased firm valuations. And at 8.5 percent it can be much more significant than the BET. How does this relate to gazelle firms? The BPT can be applied when rapid-growth firms receive new equity funding and their valuations increase. The BPT is applied to the increased valuation at the firm level and may also be applied against the firm's venture capital and angel investors. There is not a similar tax in Massachusetts or other states. This "tax trap" can be a significant deterrent to forming and retaining rapid-growth firms in New Hampshire, and the data on New Hampshire's declining gazelle ranking suggests this may be the case.

2. Untapped university technology commercialization potential

In many states, universities serve as both valuable developers of commercial technology and as the focal point for local and state technology-based economic development clusters (technology clusters). Universities can serve as the physical (or virtual) meeting point for many of the most important actors in the innovation system and thereby help to create more productive relationships between those actors (see Table 6).

Table 6: Sample University-Centric Technology Clusters

TECHNOLOGY CLUSTER	UNIVERSITIES
Silicon Valley	Stanford, U.C. Berkeley, and U.C. San Francisco
Route 128 Corridor	Boston University, Harvard, MIT, and University of Massachusetts
North Carolina Research Triangle	Duke University, University of North Carolina, and North Carolina State University

New Hampshire has two world-class research universities that each has total annual research expenditures of roughly $100 million or more: Dartmouth College and UNH. Dartmouth has made considerable progress in commercializing its academic research (e.g., transferring technology developed in its laboratory to the commercial sector where it can be put to productive use). Those commercialization efforts have allowed Dartmouth to develop a successful technology cluster in the Lebanon region with a particular focus on medicine and medical devices. UNH, on the other hand, has not yet been able to generate corresponding success with its technology commercialization efforts or at developing UNH-centric technology clusters on the Seacoast and in the I-93 corridor in New Hampshire.

On traditional university-specific measures of technology commercialization, Dartmouth outpaces UNH by a significant degree (see Table 7).

Part of Dartmouth's commercialization success stems from the Dartmouth Hitchcock Medical Center and Dartmouth Medical School—both of which conduct significant R&D efforts that, by their very nature, are aimed at developing commercially viable medical treatments and devices. Such a simplistic explanation (i.e., the presence of a medical school at Dartmouth and the lack of one at UNH) does not do justice to the considerable efforts that Dartmouth has made to enhance its commercialization performance. The Dartmouth Entrepreneurial Network (DEN), for example, provides a useful model for what can be done in New Hampshire to encourage economic development from university-developed technology. Since January 2001, DEN has provided support for more than 200 projects and companies, including more than 30 new operating companies. DEN works with each of Dartmouth's schools—including the College of Arts and Sciences, the Tuck School of Business, the Thayer School of Engineering, Dartmouth Medical School, and Dartmouth-Hitchcock Medical Center—and connects to the broader Dartmouth community of alumni across the nation.

[11] New Hampshire Department of Revenue Administration, Frequently Asked Questions: What is the Business Profits Tax?, available at http://www.nh.gov/revenue/faq/dra_300.htm.

Table 7: Commercialization of University-Developed Technology—2006 through 2008 Statistics for UNH and Dartmouth

	UNH			DARTMOUTH		
	2007	2008	2009	2007	2008	2009
Total Research Expenditures (in millions)	$116.75	$98.82	$97.87	$179.47	$174.11	$145.95
Invention Disclosures	20	14	14	50	47	66
Licenses and Options Executed	22	11	7	27	8	9
Total Active Licenses	81	85	85	124	128	132
University Start-ups Formed	0	0	1	1	1	1
New Patent Applications Filed	13	6	6	28	25	26
U.S. Patents Issued	2	5	5	17	13	10
License Income (in millions)	$0.22	$0.24	$0.31	$2.53	$4.94	$1.83

Source: AUTM, U.S. Licensing Activity Surveys (2007–2009)

There is an opportunity to enhance UNH's commercialization and business launching capacity for the betterment of New Hampshire's economy. The ability for universities to contribute to their local economies by consistently commercializing technology is an inherently complex endeavor that involves a matrix of interconnected components, including:

- Talented university scientists;
- Companies that are capable of absorbing the developed technology and informing future developments;
- A highly skilled workforce that is capable of operating in an innovation-based environment;
- Adequate funding for university research;
- Local entrepreneurs who are capable of starting, growing, and managing early-stage, intellectual-property-based companies;
- Adequate funding for start-up and other high-technology companies to develop businesses based on university-developed technology; and
- University administrators that build institutions within the university to support the commercialization process and create a technology commercialization culture.

Effectively building and linking these various components can go a long way toward creating a successful university commercialization environment. Much of DEN's success comes from its ability to engage the faculty in the disclosure process and effectively link these various components at Dartmouth and in the Hanover area, thereby creating a more vibrant innovation system for Dartmouth's commercialization efforts.

UNH, under the leadership of President Huddleston, clearly understands the problem and is taking concrete steps to improve its commercialization results and its impact on New Hampshire's innovation economy. The University recently hired a new head of technology transfer who has experience both in university technology transfer as well as running a small technology-based start-up company. The UNH Office of Research Partnerships and Commercialization also added a new licensing associate who will be focused on technologies in interoperability, research computing, engineering and space science. A systematic overview of university policies has been conducted to ensure that they represent the current state-of-the-art for incentivizing technology commercialization. The UNH technology transfer office also has created a regular outreach program in the form of a monthly seminar that engages the faculty, outside entrepreneurs, funding sources, and service providers. These monthly events ensure that all sides of the commercialization process are engaging regularly and informing each other's needs.

UNH … clearly understands the problem and is taking concrete steps to improve its commercialization results and its impact on New Hampshire's innovation economy.

To more actively support entrepreneurship based on faculty inventions, UNH has formed strategic partnerships with the New Hampshire Innovation Commercialization Center (NH-ICC) and the Idea Greenhouse to provide space, mentorship, and additional contacts.

- **Idea Greenhouse (http://www.ideagreenhouse.biz/about#durhamoffer):** The Idea Greenhouse is a classic incubator with flexible office space and regular contact with the local business community.
- **NH-ICC (http://nh-icc.com/our-program/):** The NH-ICC has more of an "accelerator" model, utilizing a team of seasoned entrepreneurs to provide guidance, mentorship, and focused effort whereby the staff members take on the relevant roles for the company and accomplish the tasks necessary to advance the company to a stage where it may hire full-time employees.

The lessons that UNH learns from its focused commercialization efforts can be shared with other New Hampshire universities and colleges so that more higher education institutions in the state can participate in the technology commercialization effort.

3. Suboptimal pipeline for future highly skilled S&T workers

While New Hampshire has made considerable progress in developing a highly skilled general workforce, the S&T strength of that workforce has not been as reliable. A state cannot develop a consistently successful, technology-based economy without a critical mass of highly skilled workers that are specifically trained to operate in S&T fields. Individuals with advanced science and engineering knowledge (e.g., science and engineering PhDs) are needed to develop the commercial technology around which high-technology businesses can be built. Highly educated scientists and engineers as well as skilled technical workers are needed to populate the high-technology work force so that companies can absorb new technology and transform it into new commercial products and services. There are two ways for a state to develop an effective S&T workforce:

- The state can prepare its own citizens to become S&T workers; or
- The state can import S&T workers from out of state.

Historically, New Hampshire has relied heavily on the domestic "importation" of skilled workers (both general and S&T specific). Underpinning New Hampshire's transition to a knowledge-based economy over the last quarter of the 20th century was the state's ability to use its high-quality but low-cost status to attract skilled workers and able entrepreneurs from other states. This in-migration of innovation system talent was part of the foundation for the buildup of the state's innovative economy. This in-migration reached its peak during the 1980s and early 1990s. A survey in 2000 revealed that three-quarters of New Hampshire residents with bachelor's degrees or higher were born in another state—with many coming from Massachusetts and other states in the Northeast. There are strong indications and factors suggesting that New Hampshire's reliance on in-migration for innovation system workers is not sustainable. The strategy's success during the 1980s and 1990s was fueled by the large pool of young and mobile baby boomers (those born between 1946 and 1964) in the northeastern U.S. that came of age and started families in the 1970s, 1980s, and early 1990s. The baby boom generation was at a particular age and phase in life and concentration in the Northeast when the New Hampshire cost-of-living advantage had a particular pull on them.

There are strong indications and factors suggesting that New Hampshire's reliance on in-migration for innovation system workers is not sustainable.

The confluence of factors has been less fortuitous for New Hampshire in the 2000s. The generations following the baby boomer are significantly smaller, particularly in the Northeast, which makes the competition to attract them more intense, hence lessening New Hampshire's advantage in attracting young families. New Hampshire's innovation system workforce is aging and needs replacements.

New Hampshire's innovation system workforce is aging and needs replacements.

With the in-migration strategy faltering, New Hampshire has to be prepared to develop its own S&T workers. New Hampshire has yet to make that commitment. On a regional basis, New Hampshire consistently ranks in the lower half of New England states in S&T workforce (see Tables 8–11). This does not bode well for the future.

Table 8: % of Recent Bachelor Degrees in S&E-—The Six New England States (2010)

Vermont	19%
Maine	17%
Massachusetts	16%
Rhode Island	15%
New Hampshire	14%
Connecticut	13%

Table 9: % of Graduate Students in S&E— The Six New England States (2010)

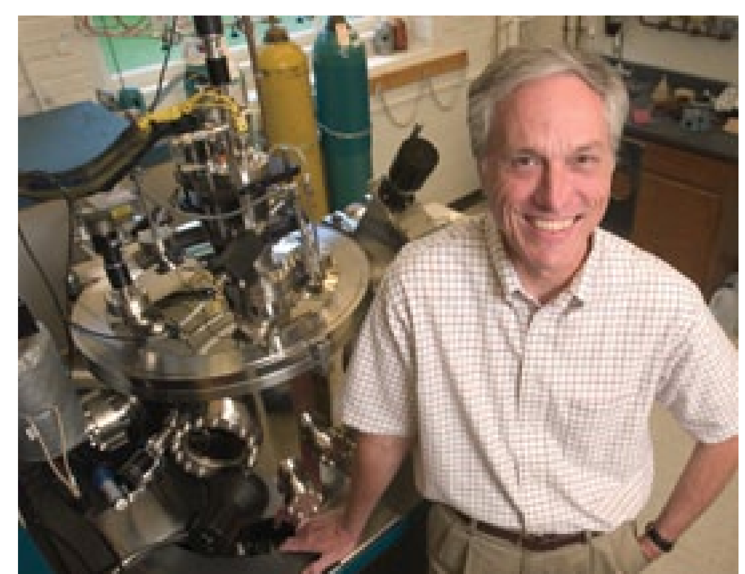
Massachusetts	3%
Connecticut	2%
Rhode Island	2%
Maine	1%
New Hampshire	1%
Vermont	1%

Table 10: Recent PhDs in S&E per 1,000 Workers— The Six New England States (2010)

Massachusetts	0.63
Rhode Island	0.30
Connecticut	0.24
New Hampshire	0.19
Vermont	0.12
Maine	0.05

Table 11: Scientists and Engineers (per capita)— The Six New England States (2008)

Massachusetts	0.77
Rhode Island	0.49
Connecticut	0.46
Vermont	0.39
New Hampshire	0.29
Maine	0.28



The S&T strength of New Hampshire's workforce should be a major concern for New Hampshire's policymakers. As the United States continues its evolution toward becoming a more knowledge-based economy, the need for highly educated workers will become more important. Nearly two of every three new jobs in the country will require some college education. None of New Hampshire's counties have two of three graduates going on to college. New Hampshire's underdeveloped S&T workforce will limit the state's ability to generate technology-based economic development. In particular, its underdeveloped S&T workforce will restrict the state's ability to grow when the nation's current economic troubles subside and the next technology growth period occurs. New Hampshire will be restricted in its ability to reach higher plateaus of technology employment and economic prosperity.

... the need for highly-educated workers will become more important. Nearly two of every three new jobs in the country will require some college education.

To compound matters, there is the added element that developing a robust pool of S&T workers is a long-term undertaking that offers no quick fixes. All aspects of New Hampshire's S&T education pipeline (primary, secondary, and post-secondary) need to be examined for weaknesses and targeted improvement efforts. Is the biggest problem at the primary school level, with students not being sufficiently engaged in math and science in their early years to develop a pipeline of motivated math and science students as they mature? Is the problem at the high school level, or at the college and university level? Does the problem stem from a lack of cooperation/coordination between the math and science curriculum of primary schools, secondary schools, and colleges and universities? Could greater outreach from New Hampshire's colleges and universities to the primary and secondary school students and teachers serve as a cost-effective solution? If the problem begins at the primary school level—which is the explanation most often heard—then the benefits from resolving the problem might take decades to come to full fruition. Not surprisingly, time is of the essence in finding and resolving this issue.

... there is the added element that developing a robust pool of S&T workers is a long-term undertaking that offers no quick fixes.

When one considers the foundational role that math and science education plays in an innovation system's success ... the state should begin to systematically track, analyze, and report data on its education infrastructure as it relates to the state's innovation system.

In writing this report, the authors expected that more data would be available to help answer these types of education infrastructure questions. For example, the authors were surprised at how little data was easily accessible to help analyze the strengths and weaknesses of New Hampshire's K–12 math and science capabilities. When one considers the foundational role that math and science education plays in an innovation system's success, this lack of data is particularly troubling. Going forward, the state should begin to systematically track, analyze, and report data on its education infrastructure as it relates to the state's innovation system.

On the positive side, and indicative of the "find a way" attitude of New Hampshire's citizens, a number of programs have developed in New Hampshire (see Table 12) to try to improve workforce skills, with a focus on improving the math, science, and technology strength of the state's critical younger population.

Table 12: New Hampshire Programs to Improve the Population's Math, Science, and Technology Strength

PROGRAM	GENERAL DESCRIPTION
FIRST (For Inspiration and Recognition of Science and Technology)	Founded by entrepreneur Dean Kamen in 1989, and based in Manchester, N.H., FIRST is a nationwide program to inspire young people's interest and participation in science and technology, FIRST provides a variety of competitive mentor-based programs for youth. Such programs include: • FIRST Robotics • FIRST Tech Challenge • FIRST Lego League • Junior FIRST Lego League • FIRST Scholarship Program
KEEPERS (Kids Eager for Engineering Program with Elementary Research-based Science) and KEEPERS for Teachers	UNH outreach programs that offer engineering education and training for grade K – 8 students and teachers.
UNH Tech Camp	Summer programs (made possible through industry support) in engineering applications for grade 7 – 12 students.
UNH Interoperability Laboratory Internships	Paid internships (made possible through industry support) for high school students in UNH's computer networking laboratory.
Project Lead the Way	Nationwide nonprofit with a state affiliate at N.H. Technical Institute. The program provides professional development for teachers in STEM (science, technology, engineering and math) education and principles of engineering design.
Academy for Science and Design	Located in Merrimack, it is an open-enrollment chartered public school for grades 7 – 12 specializing in STEM education. It is tuition-free for New Hampshire students.
ProjectSMART	ProjectSMART is a four-week summer Iinstitute at the University of New Hampshire that challenges, educates, and motivates talented high school students in science and mathematics while acquainting them with the environment and resources of the University as a place for higher education and research.

4. Need for Better Broadband Access throughout the State

Affordable broadband access has been and will continue to be an important determinant of the state's economic vitality. Several studies have identified strong linkages between broadband access and economic development.

A comprehensive, statewide broadband expansion, titled Network New Hampshire Now, is funded by $44.5 million in economic stimulus money and matched with $21.5 million in private and in-kind funding. Network New Hampshire Now is a collaboration of public and private organizations, led by the University of New Hampshire, to develop a high-speed broadband network throughout the state, including fiber optic networks in all 10 counties of the state, fiber optic networks in the limited access right of way of Interstate-93, a microwave wireless network for public safety and fiber-to-the-premises in Rindge and Enfield. Providing access to high-speed Internet, next-generation wireless and fiber access to those areas without access to broadband — or where access is only available through dial-up or satellite services — will create an estimated 700 new jobs.

Improved broadband access will allow New Hampshire businesses to capitalize more fully on the state's S&T assets. Greater and more affordable broadband access will enable broader geographic economic competitiveness throughout the state. Such connectivity provides New Hampshire businesses with easy access to skilled workers and to the S&T infrastructure of the state's colleges and universities no matter where they are located in the state.

Greater and more affordable broadband access will enable broader geographic economic competitiveness throughout the state.

Improved broadband access may also hold the key to training New Hampshire's future generations of skilled workers (both S&T specific and non-S&T specific). Education and training can be efficiently delivered to all corners of the state from K – 12 students through adult learners.

To help measure residential, commercial, and institutional access to broadband, the New Hampshire Broadband Mapping and Planning Program (NHBMPP) at UNH is coordinating a five-year effort funded by $6.1 million in federal awards to inventory and map broadband availability across the state. This mapping effort involves a semi-annual collection of data from each of the active providers in the state on the broadband technology they offer and the associated access speed. The data collection yields a suite of detailed map products that compile and display where broadband coverage does and does not exist, as well as areas where broadband access may be available, but inadequate to support appropriate applications. This mapping effort also involves inventorying more than 3,500 Community Anchor Institutions in the state—including schools, hospitals, libraries, public safety entities, colleges and universities, governmental community institutions, and non-governmental community institutions. Each institution is being mapped and broadband information is being collected and maintained. Results from the NHBMPP are integrated into the National Broadband Map, which identifies broadband availability nationally, and provides a solid foundation for future broadband deployment efforts at the state and national level.

In addition to these mapping activities, the NHBMPP includes a four-year planning component that is incorporating the information collected and the momentum generated by the mapping activities into regional broadband plans throughout New Hampshire. The planning activities include the creation of regional and sector-based broadband stakeholder groups that collect and analyze relevant information, identify barriers to broadband deployment, promote collaboration with service providers and facilitate information sharing between the public and private sectors regarding the use of, and demand for, broadband services. Other planning efforts include providing technical assistance to the educational, non-profit, local government and business sectors in the state, and working with partners to develop a demand stimulation and aggregation program that mobilizes key stakeholders to make commitments to increase broadband penetration on a community-by-community basis.

Overall, New Hampshire is pursuing a thoughtful and informed strategy for improving its broadband access. State leadership should be aware of these efforts to make sure that the state maximizes the benefits that can be generated from them.

7. Tracking New Hampshire's Areas of R&D Strength

One way that New Hampshire can strategically improve its innovation system is to systematically track the state's areas of R&D strength. Having a thorough understanding of the state's R&D strengths will provide a number of tangible benefits (see Table 13).

© Bill Truslow

Conducting a truly systematic review of the state's various R&D strengths is an expensive undertaking that goes beyond New Hampshire EPSCoR's capabilities. As a result, New Hampshire EPSCoR has begun the review by examining New Hampshire's strength in "clean technology." Clean technology includes providers of products and services, and supporting activities that conserve energy, use energy efficiently, generate energy from renewable and low carbon emitting sources, store energy, monitor and regulate energy usage and the pollution it generates, and efficiently manage waste, water, and other natural resources.

New Hampshire EPSCoR has begun the review by examining New Hampshire's strength in "clean technology."

The decision to focus first on clean technology came as a result of (a) a series of 2009 and 2010 meetings among New Hampshire's various universities and colleges that helped to identify common areas of R&D strengths for purposes of an EPSCoR research infrastructure improvement grant and (b) strong anecdotal evidence of New Hampshire business strength in clean technology.

Table 13: Benefits of Clearly Identifying the R&D Strength of New Hampshire Businesses, Universities, and Colleges

- Guides curriculum development in New Hampshire's colleges and universities to be more responsive to the industry's needs
- Attracts similar technology companies that hope to benefit from the existence of a technology cluster
- Signals to venture capitalists and other sources of entrepreneurial funding the existence of potential investment opportunities
- Informs New Hampshire universities seeking to commercialize their technology
- Identifies potential R&D partnerships between New Hampshire institutions
- Identifies sources of potential R&D assistance for New Hampshire businesses and businesses considering moving to New Hampshire
- Identifies areas for future business development in the state

To understand the R&D strength of New Hampshire's companies, we examined venture capital investment data and patent data for the sector.

Venture Capital

New Hampshire consistently ranks among the top states in clean technology venture capital investments. Importantly, the New England region as a whole has shown considerable strength in clean technology venture capital (see Table 14). Massachusetts (1st), Vermont (5th), New Hampshire (8th), and Rhode Island (12th) each rank in the top third of states in clean technology venture capital investments per capita from 2006 to 2008.

Patents

The patent data is not as favorable for New Hampshire as the venture capital data, but it still shows considerable strength in New Hampshire and the New England region (see Table 15) as New Hampshire is one of three New England states that rank in the top half of states in per capita number of clean technology patents (1999–2008).

Looking at the total number (not per capita) of patents in specific categories of clean technology, New Hampshire and the New England region have shown activity in all of the clean technology sectors and considerable strength in a number of particular clean technology sectors (see Table 16). Considering that New Hampshire is a small-population state, finishing in the top half of states in total patents in six of the nine categories (and roughly the top one-third of states in four of the categories) is impressive.

Table 14: Clean Technology Venture Capital Data for New England

	NEW HAMPSHIRE	CONNECTICUT	MAINE	MASSACHUSETTS	RHODE ISLAND	VERMONT
State's rank in per capita venture capital dollars invested in clean technology (2006-2008)	8	25	Tied for last with 9 states	1	12	5
Per capita venture capital dollars invested in clean technology (2006-2008)	$50.86	$8.58	$0.00	$198.22	$21.60	$86.51
Total venture capital dollars invested in clean technology (2006-2008)=	$66,154,513	$30,379,299	$0.00	$1,290,426,072	$22,727,529	$53,854,594

Source: Pew Trust (2009)

Table 15: Clean Technology Patent Data for New England

	NEW HAMPSHIRE	CONNECTICUT	MAINE	MASSACHUSETTS	RHODE ISLAND	VERMONT
State's rank in per capita number of clean technology patents (1999-2008)	23	5	45	6	27	43

Source: Pew Trust (2009)

Table 16: Rank among 50 States in Number of Patents in Category

CATEGORY	NEW HAMPSHIRE	CONNECTICUT	MAINE	MASSACHUSETTS	RHODE ISLAND	VERMONT
Batteries	25	17	49	3	27	39
Clean Coal	17	8	23	10	--	--
Fuel Cells	25	2	38	4	18	35
Geothermal	--	15	--	19	19	--
Hydro	27	14	--	10	--	--
Hybrid Renewables	17	8	--	5	--	--
Smart Meters	17	8	32	10	40	--
Solar	16	20	28	2	--	28
Wind	33	11	43	5	37	21

Source: 1790 Analytics, LLC (2010)

One clean technology sector that has experienced particularly strong patenting activity in the New England region is battery technology (see Table 17).

Importance of New England's Regional Strength in Clean Technology

New England's regional strength in clean technology could prove advantageous to New Hampshire for a number of reasons:

- **Regional technology cluster:** This clustered strength could result in the formation of a large, clean technology cluster in New England. Economic thinking highlights the importance of "clustering" in promoting growth. The idea is that geographic centers of excellence (e.g., Silicon Valley) develop with a self-reinforcing effect. Once a geographic center achieves a critical mass of excellence for a particular business-related activity, investment and knowledge that serves that activity flocks to the locality to do "more of the same" due to the benefits of a developed infrastructure and accumulated expertise. Participants in the clustered industry become stronger and more competitive as they adapt and learn from the best practices of others in their "local" industry.
- **Regional policy initiatives:** Provides opportunities for mutually beneficial regional policy initiatives to support the sector.

Table 17: Number of Battery Patents by New England States

NO. OF BATTERY PLANTS	NEW HAMPSHIRE	CONNECTICUT	MAINE	MASSACHUSETTS	RHODE ISLAND	VERMONT
1999-Q3 2010	92	180	--	500	69	11
Q3 2010	10	14	--	34	2	2

Source: 1790 Analytics, LLC (2010)

University and College Research Strength in Clean Technology

Obtaining data on statewide and regional university R&D strength is much more challenging than obtaining industry data. However, we were able to acquire detailed data on UNH's strength in clean technology. Clean technology crosses many academic disciplines (e.g., chemical engineering, chemistry, engineering, materials science, and physics). To make the inquiry more manageable, we focused on UNH's strength in Natural Resources and Environmental Science. Based on most measures for determining the R&D strength of a program, UNH's Natural Resources and Environmental Science program ranks as one of the top programs in the country (see Table 18).

UNH has been awarded a grant from the National Science Foundation to lead a five-year statewide research and education project on the impact of climate change on the environment and the consequences for the people and industries that rely on ecosystem services such as timber and abundant clean water. An innovative team of researchers from UNH, Dartmouth College, St. Anselm College, and Plymouth State University will bring together expertise from the physical, biological, and social sciences. Environmental data will be combined with data about housing and demographics; models based on this information will help policy makers determine the tradeoffs among different land uses, and will inform the development of strategies to adapt to the challenges of changes in land use and climate variability.

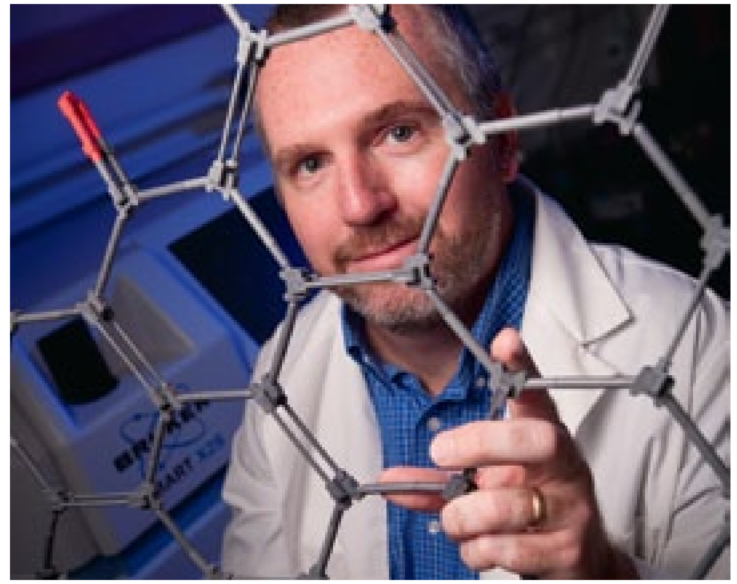
Table 18: Research Strength of UNH's Natural Resources and Environmental Science Program

	UNH'S PERCENTILE RANK AMONG ALL UNIVERSITIES									
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
Grants										
Total number of grants										X
% of faculty with a grant									X	
Grants per faculty member										X
Grant dollars per faculty member									X	
Dollars per grant										X
Faculty members with a grant									X	
Total grant dollars										X
Articles										
Total articles										X
% of faculty with an article					X					
Articles per faculty member							X			
Faculty with an article										X
Articles per author								X		
Citations										
Total citations										X
% of faculty with a citation						X				
Citations per faculty member								X		
Citations per publication										X
Faculty member with a citation									X	
Percentage of authors with a citation					X					
Awards										
Total awards							X			
% of faculty with an award				X						
Awards per faculty member							X			
Faculty members with an award				X						

8. Final Thoughts

Coming out of the country's recent economic troubles, New Hampshire can be well positioned for both short- and long-term S&T-based economic growth if the state builds on its proven innovation system strengths and addresses its weaknesses. New Hampshire has a unique opportunity to positively shape its economic future and bring the state to an even higher level of prosperity, but will lose out on that opportunity if action is not taken soon. An economic development focus on New Hampshire's innovation system, coupled with data from the Toolkit, can be used to promote the state and enhance the recruitment and retention of innovation-oriented firms, entrepreneurs, and workers to New Hampshire. It can also help the state retain its strong core of technology-based firms and help them grow. Through the attraction and retention of strong companies and skilled workers, New Hampshire can foster the growth of strong technology clusters that can develop symbiotic relationships with New Hampshire's universities and education sector, as well as other innovation system actors. The result is an efficient innovation system that can fuel New Hampshire's economic growth and prosperity for years to come.

New Hampshire has a unique opportunity to positively shape its economic future and bring the state to an even higher level of prosperity, but will lose out on that opportunity if action is not taken soon.



This S&T Plan is just the start of what will be an on-going process of innovation system review and assessment that the Statewide Committee for New Hampshire EPSCoR will undertake. The Toolkit will be updated on a regular basis and be an on-going resource for the state's S&T actors, including state policymakers and business and educational leaders. We expect to make the Toolkit available in a web-based form for easy access and use in the near future.

New Hampshire's innovation system will always be confronted by challenges that should be addressed. Some solutions could require significant resource commitments from the state to resolve (e.g., are sufficient public resources committed to education in New Hampshire?), while others can be pursued with minimal-to-no state resource commitments (e.g., increasing industry/academic ties, or ensuring that innovation and S&T development become an integral part of New Hampshire's policy discussions and decisions). The state should always aggressively pursue low-cost with high-reward solutions. Regarding the higher-cost solutions, which may end up providing the state with high long-term returns on investments, current economic realities and state resource constraints cannot be ignored. The fact that a solution cannot be implemented today because of resource constraints, however, should not end the discussion. Are there less expensive solutions that, while not optimal, could still help to advance New Hampshire's innovation system on a cost-effective basis? Can implementation of the solution be delayed for some period of time until greater resources are available? Helping New Hampshire create a strong, efficient, market-based innovation system that provides the citizens of New Hampshire with the economic and quality-of-life opportunities they deserve is an endeavor that will always be important. It will be critical for New Hampshire's policymakers to keep in mind the long-term nature of this endeavor.

Helping New Hampshire create a strong, efficient, market-based innovation system that provides the citizens of New Hampshire with the economic and quality-of-life opportunities they deserve is an endeavor that will always be important.

About New Hampshire EPSCoR

The Experimental Program to Stimulate Competitive Research (EPSCoR) was established by the National Science Foundation in 1979 to strengthen science and engineering infrastructure in states that historically have received less in federal research grants. EPSCoR programs or similar models have been developed by NASA, the Department of Energy, U.S. Department of Agriculture, and the National Institutes of Health. Since New Hampshire became an EPSCoR state in 2004, more than $92 million in federal grants have been awarded to build research capacity in New Hampshire that are attributable to EPSCoR status.

The NSF EPSCoR program is administered by Jan Nisbet, UNH senior vice provost for research. The program is governed by a 16-member statewide committee composed of representatives from industry, academia, and government. The NASA EPSCoR program is administered by the UNH Institute for the Study of Earth, Oceans, and Space. The Department of Energy EPSCoR grant is directed by Amitava Bhattacharjee, Peter Paul Professor, Department of Space Physics and the Institute for the Study of Earth, Oceans, and Space.

New Hampshire EPSCoR Statewide Committee

Chair

Jenny Houston
Vice President of Business Development
Warwick Mills

Vice Chair

Mike Shipulski
Director of Advanced Development
Hypertherm

Education

Katharine Eneguess, President
White Mountains Community College

Edward MacKay
Chancellor
University System of New Hampshire

Jan Nisbet
Senior Vice Provost for Research
University of New Hampshire

John Orcutt
Professor of Law
University of New Hampshire School of Law

Martin N. Wybourne
Vice Provost for Research
Dartmouth College

Government

George Bald
Commissioner
New Hampshire Department of Resources & Economic Development

Rep. Naida Kaen
State of New Hampshire House of Representatives

Business

Mary Collins
State Director
Small Business Development Center

Joanne Donoghue
Operations Director
Mascoma Corporation

Cory von Wallenstein
Vice President, Engineering
Dyn, Inc.

Annex 1: Sample New Hampshire High-Technology Company Employment Success Stories

Active Shock

Active Shock was formed around one of the founders' coffee table in 2001 in New Hampshire with the goal of transforming the vehicle suspension market in the same way that fuel injection supplanted carburetion. A financially bootstrapped company, the core intellectual property of vehicle dynamic algorithms and a high-speed valve was developed into a product via funding provided by the Small Business Innovative Research grant program, customer contracts, and the founders' savings. This core product of a shock absorber controlled in real time by a small embedded controller and networked together on a vehicle wire harness is now in theatre improving the mobility and safety of troops on the ground in the Middle East and South Asia. The company has since expanded into the homeland security and commercial markets by applying the same algorithms, valve, and damper to seating applications in boats and construction equipment. In 2009, Active Shock was acquired by General Kinetics of Brampton, Ontario. It continues to directly employ 30 people in Manchester, including seven graduates of UNH, and rely on a network of machine shops, suppliers, and other vendors in southern New Hampshire in order to grow the business into additional commercial and military applications such as the JLTV.

Dyn

When it comes to keeping websites accessible and email delivered, no company does it better than Manchester's Dyn. A worldwide Internet Infrastructure-as-a-Service leader, Dyn powers some of the biggest and best-known brands today, like Zappos, Netflix, Pandora, Twitter, Etsy, and StumbleUpon. The company has been recognized nationally by Inc. magazine and locally by BusinessNH Magazine as a top company to work for, having placed company culture among the highest of priorities. Even in a down economy, Dyn grew to 100 employees in 2011 and opened a new 25,000-square foot office in Manchester, while opening satellite offices in London, England, and San Francisco, California.

EnerTrac

Founded in New Hampshire in 2006, EnerTrac is a private company that provides low-cost smart metering technology to propane and oil fuel dealers and lubricant dealers, as well as for waste pump monitoring and sprinkler leak detection. EnerTrac has created more than 20 jobs in New Hampshire. Since being selected in 2010 as a Green Launching Pad company, EnerTrac has accelerated its growth. This has been accomplished by focusing on the propane industry and garnering new major accounts. The company is helping propane dealers embrace breakthroughs in sensing technology and incorporate them into their normal business operations. The company's smart sensors allow fuel distributors to electronically monitor tank levels and thereby optimize service schedules.

GT Advanced Technologies

Founded in New Hampshire in 1994 with two employees and $1,000, GT Advanced Technologies has grown to become a leading global provider of proprietary technology and services for the solar energy industry. GT Advanced Technologies provides polysilicon production technology, and sapphire and silicon crystalline growth systems for the solar, LED, and other specialty markets. GT Advanced Technologies, which conducted an initial public offering in 2008 (NASDAQ: SOLR), has a market capitalization in excess of $1 billion and continues to maintain its global headquarters in New Hampshire.

ImmuRx, Inc

ImmuNext is developing the next generation of medicines that modulate the immune system to treat a wide variety of diseases including cancer and autoimmune disease. It was founded in 2011 based on discoveries made at the Dartmouth Medical School. ImmuNext is based in Lebanon, N.H. Our patented medicines have two promising applications:

1. Block cancer's defense mechanisms so that the immune system can attack the tumors; and
2. Prevent overreaction of the immune system that causes autoimmune diseases such as multiple sclerosis, Lupus, and rheumatoid arthritis. In nine months we have raised $1 million in private equity and NIH SBIR grants. ImmuNext employs three people in New Hampshire.

Kocher & Company, Inc.

Fred Kocher of Kocher & Company, Inc. makes it his job to promote New Hampshire's technology sector with a unique mix of initiatives—all at the same time. They include his own business that helps small technology companies make strategic contacts, and the presidency of the New Hampshire High Technology Council, the face of technology in New Hampshire. He also hosts a weekly business segment on New Hampshire's statewide TV station (WMUR-TV) that often profiles cutting-edge New Hampshire technology companies and New Hampshire economic conditions. Lesson learned from all of this? Advocate and strengthen the education of future engineers and scientists.

Sky-Skan

Sky-Skan creates the world's most immersive theater environments. Sky-Skan's Definiti theater brand is known internationally for taking audiences on virtual spaceflights through space and time. The company has received several awards, including being named the U.S. Small Business Administration's Exporter of the Year for New Hampshire for 2010 and receiving the New Hampshire High-Technology Council's Product of the Year award for 2010. Recently Guinness World Records recognized a Definiti 3D 8K theater in Macao, China, as the Highest Resolution 3D Planetarium.

Sky-Skan has called New Hampshire home since moving to Nashua more than 25 years ago. Sky-Skan's 150+ Definiti theater installations are in the McAuliffe-Shepard Discovery Center in Concord, the Boston Museum of Science, the Smithsonian Air and Space Museum, Notre Dame University, Artis Royal Zoo, the Nagoya Science Museum, and the Eugenides Foundation planetarium.

References

American Association for the Advancement of Science (1999), "An Overview of State Science and Technology Strategic Planning," *Science and Technology Policy Yearbook*.

Edquist, Charles (June 12-15, 2001). "The Systems of Innovation Approach and Innovation Policy: An Account of the State of the Art," lead paper presented at the DRUID Conference, Aalborg, http://www.druid.dk/conferences/nw/paper1/edquist.pdf.

Freeman, Christopher (1987). **Technology Policy and Economic Performance: Lessons from Japan**. London: Pinter Publishers.

Gittell, Ross, Tebaldi, Edinaldo (2008). "Are Research and Development Tax Credits Effective? The Economic Impacts of a R&D Tax Credit in New Hampshire," *Public Finance and Management*, 8(1).

Gompers, Paul and Lerner, Josh (2001). **The Money of Invention: How Venture Capital Creates New Wealth**. Boston, MA: Harvard Business School Press.

Griliches, Zvi (1992). "The Search for R&D Spillovers," *Scandinavian Journal of Economics*, 94: 29-47.

Grossman, Gene M. and Elhanan Helpman (2001 [1991]). **Innovation and Growth in the Global Economy**. Cambridge, MA : The MIT Press. Seventh printing. (First Printing 1991).

Hall, Bronwyn H. and Marta Wosinska (1999). Effectiveness of the California R&D Tax Credit: A Report. Prepared for The California Council on Science and Technology. University Of California, Berkeley.

Jarboe, Kenan Patrick and Atkinson, Robert D. (June 1998). "The Case for Technology in the Knowledge Economy—R&D, Economic Growth, and the Role of Government," Washington, D.C. *Progressive Policy Institute Policy Briefing*.

Jones, Charles (1995). "R&D-Based Models of Economic Growth," *Journal of Political Economy*, 103:4: 759-784.

Krugman, Paul (1991). "Increasing Returns and Economic Geography," *Journal of Political Economy*, 99(3): 483-499.

Lehr, William, Osorio, Carlos, Gillett, Sharon, and Sirbu, Marvin (Dec. 2005). "Measuring Broadband's Economic Impact," *Broadband Properties*: 12-24.

Lucas, Robert (1988). "On the Mechanisms of Development Planning," *Journal of Monetary Economics*, 22(1): 3-42.

Lundvall, Bengt-Ake (1992). **National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning**. London: Pinter Publishers.

Matthews, R.C.O. (1986). "The Economics of Institutions and the Sources of Growth," *Economic Journal,* 96: 903-918.

OECD (1997). **National Innovation Systems**. Organisation for Economic Co-Operation and Development. Paris, France.

Orcutt, John and Shen, Hong (2010). **Shaping China's Innovation Future: University Technology Transfer in Transition**. London: Edward Elgar Publishing.

Romer, Paul (1990). "Endogenous Technological Change," *Journal of Political Economy*, 98: S71-S102.

Romer, Paul (1986). "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, 94: 1002-1037.

Sala-i-Martin, Xavier X. (2002). "15 Years of New Growth Economics: What Have We Learnt?" *Central Bank of Chile*, Working Paper 172, 22p.

Schumpeter, Joseph A. (1942). **Capitalism, Socialism, and Democracy**. New York, NY: Harper Perennial (latest edition 1975).

Solow, Robert (1956). "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, 70: 65-94.