THE ECONOMICS OF UNIVERSITY RESEARCH

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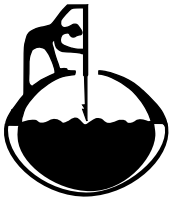


1. RESEARCH ACTIVITY IN THE UNITED STATES AND ALASKA

United States

Research and Development (R&D) is a $284 billion business in the United States, accounting for 2.5 percent of the Gross Product.[1] The output of this spending is new knowledge—advances in basic understanding of the world and technological and other improvements in the way we produce goods and services. The increases in productivity that come from research account for a large share of the overall growth in the economy. Capital investment and increases in the quantity and quality of the work force account for the rest.

California leads the nation in research spending with $48 billion followed by Michigan, New York, Texas, and Massachusetts (Table 1). However R&D accounts for a larger share of the economy in several smaller states, as measured by the ratio of spending to Gross Product, including New Mexico, Rhode Island, and Maryland.

Table 1. Top Research and Development States in 1999

	Share Amount (Billion $)		Share of GSP (Percent)
1 California	$48.0	New Mexico	6.4
2 Michigan	$18.8	Michigan	6.1
3 New York	$14.1	Rhode Is	5.1
4 Texas	$12.4	Mass	4.6
5 Mass	$12.2	Maryland	4.6

Source: National Science Foundation, Science Resource Statistics, June 2002

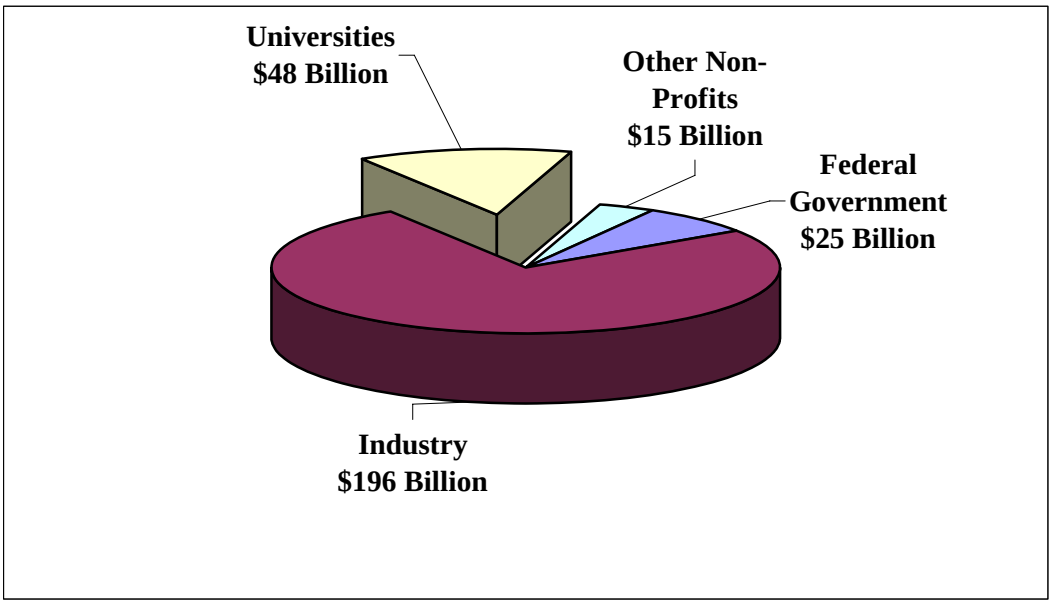
Most (69 percent as measured by dollars spent) research and development is done directly by private industry (Figure 1). About 14 percent takes place within the federal government and non-profits. Universities and Colleges account for the remaining 17 percent--about $48 billion in 2003 (including Federally Funded Research Development Centers administered by Universities).

While Industry is also the source of most funding for research and development, the federal government provided 30 percent (Figure 2). Universities contributed only 4 percent and other non-profits the remaining 3 percent.

Basic research accounted for 19 percent of total spending, but 55 percent was conducted by universities with 61 percent of the funding provided by the federal government. In contrast most applied research, which accounted for 24 percent of the total was performed by private industry. Development expenditures, 57 percent of the total, were primarily spent by private industry.

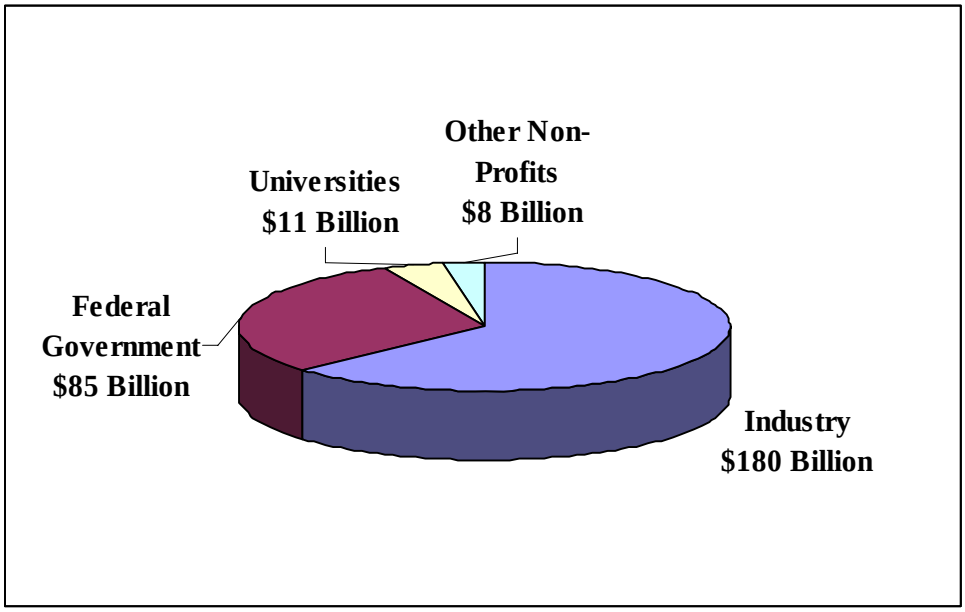
[1] Data for 2003 from National Science Foundation, Science Resources Statistics

Figure 1. National Expenditures for Research and Development, 2003



Source: National Science Foundation, National Patterns of Research and Development Resources, 2003

Figure 2. Sources for Research and Development Funding, 2003



Source: National Science Foundation, National Patterns of Research and Development Resources, 2003

Alaska

Alaska ranks near the bottom among the states in the total amount of R&D activity. Most research in Alaska is conducted by the University of Alaska and directly by the federal government, and very little is done by industry. Alaska ranks 47th among the states in total research, 50th in industry research, and 42nd in University research (Table 2).

Alaska's performance is better in per capita terms, but spending on R&D per person is only half the U.S. average. Only federal R&D is above the per capita U.S. average. In terms of the "intensity" of R&D spending (R&D/Gross Product), Alaska is ranked number 41. About 1 percent of Alaska Gross State Product is devoted to R&D spending.

The small amount of private industry spending on R&D in Alaska is due to several factors. The first is the absence of manufacturing industry within the state, except for seafood processing. Second is the dominance of the public sector within the economy both in terms of jobs and resource ownership. Third is the absence of Alaska based resource businesses large enough to financially support investments in R&D. Finally Alaska has not been an attractive location for private research facilities due to cost and distance from clients and customers.

Table 2. Alaska Research and Development Profile

Indicator	Rank	Amt	% U.S. Average	Date
Total R&D (mill $)	47	$196		2000
Industry R&D (mill $)	50	$9		2000
Academic R&D (mill $)	42	$116		2001
Population (% US)	48	0.22%		2002
Total R&D ($ per capita)	32	$467	49%	2001
R&D Intensity (R&D/GSP)	41	1.04%	38%	2001
Federal R&D ($ per capita)	13	$335	116%	2001
Fed R&D / Total Fed $	22	3.30%	72%	2001
SBIR Awards	51	9		97 to 01
Patents	51	50		2001

Source: National Science Foundation, Science and Engineering State Profiles, 2000-2001
Note: SBIR is the Small Business Innovation Research Program of the Small Business Administration.

2. UNIVERSITY RESEARCH IN THE UNITED STATES AND ALASKA

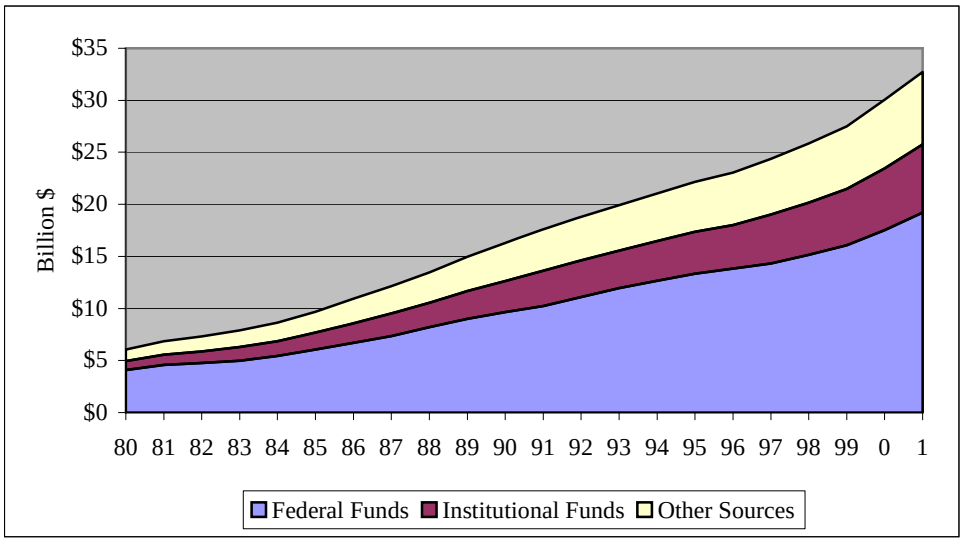
United States

University R&D is a growth industry. Since 1980 University R&D spending has increased at an average rate of 7.6 percent a year, compared to a 6.3 percent growth rate for the economy in total. Furthermore, University R & D spending has increased in every year while the overall economy has gone through two recessions during that period (Figure 3).

The federal government supplies the majority of funding for University R & D (59 percent in 2001). This funding source continues to grow, but its share of the total is falling as other sources grow in importance. Institutional funds supplied directly by the Universities account for 20 percent of total funding and industry, state and local government, and non-profit providers account for the remainder.

Institutional support for University R&D has been increasing as a share. In the early 1980s Universities spent 16 cents of their own money for every $1 of research funding attracted from outside academia (from federal, private, and non-profit sources). By 2000 institutions committed on average 25 cents for every $1 attracted from outside.

Figure 3. University Research and Development by Funding Source



Source: National Science Foundation

The majority of University research (75 percent) is basic rather than applied.

The largest research University in the nation, Johns Hopkins, spent $1 billion on R&D in 2002 (Table 3). The next largest research Universities—each with more than half a billion in research spending—were public institutions: UCLA, University of Wisconsin,

University of Michigan, and University of Washington. The University of Alaska at Fairbanks was ranked 95th with spending of $110 million.

Table 3. University R&D Spending: 2002

Rank	Institution	Budget (Million $)
1	Johns Hopkins	$999
2	UCLA	$693
3	U of Wisconsin	$604
4	U of Michigan	$601
5	U of Washington	$590
95	U of Alaska Fairbanks	$110

Source: National Science Foundation, Science Resources Statistics

Alaska

Total R&D revenue generated at the University of Alaska in 2003 was $133 million, primarily at Fairbanks and its associated campuses (Table 4).[2] However Anchorage and Juneau were also sites of research activity. The research budget not only funded the activities directly associated with research ($121.6 million), but also contributed $11.5 million to the general support of the University budget through payments to other departments within the University (redistributed indirect cost recovery (ICR)).

Table 4. University of Alaska Research Revenue in 2003

	(Thousand $)
UA Anchorage	$11,529
UA Fairbanks	$108,948
UA Southeast	$1,110
UA Total	**$121,587**
Plus: Redistributed Indirect Cost Recovery	$11,496
TOTAL	**$133,083**

Source: University of Alaska, Statewide Budget and Institutional Research

Growth in University R&D in Alaska has been strong and consistent. It has increased from $77 million in FY98 to $133 million in FY03—an increase of 73 percent in 5 years (Table 5). This growth has consistently exceeded the national average.

[2] The University defines research to include program evaluation and training, both of which contribute to productivity growth in organizational structure and the labor force.

Table 5. Growth in University of Alaska Research Revenue

	(In Thousands of Dollars)	Growth Rate
FY98	$77,204	
FY99	$81,458	5.5%
FY00	$90,664	11.3%
FY01	$109,407	20.7%
FY02	$119,753	9.5%
FY03	$133,083	11.1%

Source: University of Alaska Statewide Budget and Institutional Research

A small share of funds for research comes from the state General Fund as part of the University of Alaska appropriation, but the majority comes from other sources (Table 6). In 2003 there was $8 of total research spending for each $1 of State General Fund support for research (Total R&D / General Fund). This "General Fund Multiplier" has been growing over time from a level of 5.1 in 1998.

Table 6. University of Alaska Research Revenue: Sources of Funds
(in Thousands of Dollars)

	State General Fund	All Other	Total	General Fund Multiplier (Ratio: Total / General Fund)
FY98	$15,058	$62,146	$77,204	5.1
FY99	$12,956	$68,502	$81,458	6.3
FY00	$15,392	$75,272	$90,664	5.9
FY01	$16,313	$92,890	$109,407	6.7
FY02	$16,322	$103,431	$119,753	7.3
FY03	$16,618	$116,465	$133,083	8.0

Source: University of Alaska Statewide Budget and Institutional Research

Most outside funding for University research comes from the federal government (Table 7). In 2003 University research expenditures totaled $109.9 million. [3] $98.8 million came from the federal government--$80.6 million directly and $18.1 million indirectly through state agencies and other sources, mostly private. Private sources directly accounted for $9.2 million (plus $15.7 million that originated with the federal government but was channeled through private sources). The state accounted directly for $2 million, plus $2.4 million of federal funding channeled through government.

[3] Accounting definitional differences result in total expenditures being slightly less than revenues.

Table 7. University of Alaska Research Expenditures by Funding Source for FY2003
(In Thousands of Dollars)

FUNDING SOURCE	Direct			Federal Indirect Through		
	Federal Agency	State Agency	Other Sources	State Agency	Private, Local, Other	TOTAL
GRAND TOTAL	**$80,650.0**	**$2,011.2**	**$9,200.2**	**$2,423.6**	**$15,685.7**	**$109,970.7**
FEDERAL	$80,650.0			$2,423.6	$15,685.7	$98,759.3
STATE		$2,011.2				$2,011.2
PRIVATE, LOCAL, OTHER			$9,200.2			$9,200.2

Note: These numbers represent research expenditures (including ICR) and not the awarded amount. Excludes state General Fund support. Keep in mind that many grants are multi-year awards and so are the expenditures associated with them.
Source: University of Alaska, Statewide Budget and Institutional Research.

Among federal agencies the largest contributors to University research in 2003 were the National Science Foundation, NASA, the Department of Defense, and NOAA (Table 8).

Table 8. Largest Federal Funding Sources for University of Alaska R&D in 2003

	(Thousand $)
National Science Foundation	$24,685.3
NASA	$15,595.4
Dept of Defense	$11,528.2
NOAA, Dept of Commerce	$9,893.5
National Institutes of Health, Dept HSS	$5,842.0
US Geological Survey, Dept of Interior	$4,119.6
Cooperative State Research Service, Dept of Agriculture	$3,726.4
Subtotal	$75,390.5
All Other Federal	$23,368.8
TOTAL	**$98,759.3**

Source: University of Alaska Statewide Budget and Institutional Research

Private, local and other sources directly contributed $9.2 million as well as $15.7 million through federal agencies

Corporations and other universities are the largest non-government sources of funding, although a majority of the funds they provide originate with the federal government (Table 9).

Table 9. Largest Non-Government Funding Sources for R&D in 2003

	(Thousand $)
Other Corporations	$7,659.5
Other Universities	$5,666.5
University Foundations	$2,343.2
Other Nonprofit Organizations	$1,664.8
International Corporations	$40.9
Native Corporations	$2.4
Other	$7,508.5
TOTAL	**$24,885.8**

Source: University of Alaska Statewide Budget and Institutional Research

The state contributed $4.4 million for specific studies over and above the General Fund appropriation. The largest state agency contributors to University research were the Departments of Health and Social Services and Fish and Game. Some of this funding also originated with the federal government.

About 2/3 of University research takes place through the organized institutes and centers. Faculty and staff within the different schools and departments account for the remainder (Table 10). Most research funding is obtained through the competitive process, although some is earmarked for specific purposes, and thus obtained non-competitively.

Table 10. New Research Awards to University of Alaska in 2003 by Type

	Organized Research		Other Sponsored Activities		Total FY New Awards	
	# of Grants	Grant Amt ($ 000)	# of Grants	Grant Amt ($ 000)	# of Grants	Grant Amt ($ 000)
Total 2003	**322**	**$66,935.0**	**323**	**$39,956.4**	**645**	**$106,891.4**
Competitive	212	$53,096.8	174	$22,299.2	386	$75,396.0
Non-Competitive	88	$11,279.1	104	$11,170.2	192	$22,449.3
Other	22	$2,559.0	45	$6,487.0	67	$9,046.1

Source: University of Alaska Statewide Budget and Institutional Research

University of Alaska research is concentrated in several areas, as can be seen by its national rank for expenditures by discipline. The University of Alaska Fairbanks is 12th in the nation in the field of Mathematics and Computer Science, largely due to the Arctic Region Supercomputing Center (Table 11). It also ranks high in spending for research in the field of Atmospheric, Earth, and Oceanography Science. In contrast it ranks low in Life Science research.

Table 11. University of Alaska Fairbanks R & D Profile for 2001

Indicator	Rank	Amount (Million $)
Total R&D	**95**	**$110.0**
Math and Computer Science	12	$16.3
Atmospheric, Earth, Oceanography	16	$30.5
Physical	54	$13.6
Life Science	150	$16.6
Federal Funding	105	$55.3
Total R&D --All UA Campuses	**68**	**$115.0**

Source: National Science Foundation

In 2003 new awards totaling $106.9 million were concentrated in Science, Mathematics & Technology and in Education (Table 12).

Table 12. Number and Value of New Research Awards in 2003
(in Thousands of Dollars)

	Organized Research		Other Sponsored Activities		Total	
	#	Value	#	Value	#	Value
Total	**322**	**$66,935.0**	**323**	**$39,956.4**	**645**	**$106,891.4**
Science, Math & Technology	191	$55,503.1	35	$2,238.0	226	$57,741.1
Education	7	$380.1	87	$14,563.6	94	$14,943.7
Social Sciences	38	$3,401.0	46	$6,423.2	84	$9,824.3
Other	17	$1,822.0	49	$6,645.2	66	$8,467.2
Health & Medicine	22	$2,781.6	22	$2,725.9	44	$5,507.5
Cooperative Extension	3	$74.9	22	$2,181.2	25	$2,256.1
Business, Management & Commerce	5	$263.6	21	$1,854.7	26	$2,118.3
Agriculture & Food Sciences	7	$260.4	5	$1,441.5	12	$1,701.9
Inter-Disciplinary	10	$768.0	13	$726.2	23	$1,494.2
EPSCoR Research Focus Area	8	$1,293.1			8	$1,293.1
Engineering	9	$188.8	3	$555.8	12	$744.7
Arts and Humanities	2	$132.7	20	$601.2	22	$734.0
Energy	3	$65.4			3	$65.4

Source: University of Alaska Statewide Budget and Institutional Research

Research spending is concentrated in a handful of institutes on the campus at Fairbanks, with lesser amounts broadly distributed across many organizations on all campuses of the University (Table 13).

Table 13. Research Revenue by Campus and Program in 2003
(in Thousands of Dollars)

TOTAL	**$133,082.6**
UA Fairbanks	**$108,948.0**
Geophysical Institute	$32,013.4
School of Fisheries and Ocean Sciences	$20,602.3
Institute of Arctic Biology	$13,469.4
Arctic Region Super Computer	$9,500.7
International Arctic Research Center	$9,397.7
School of Natural Resources and Agric Sciences	$7,113.5
Institute of Northern Engineering	$4,538.8
College of Science, Engineering, and Mathematics	$4,298.1
Mineral Industries Research Laboratory	$1,494.8
Museum	$845.5
Petroleum Development Lab	$813.3
Alaska Native Language Center	$165.0
School of Management	$73.3
Center for Cross Cultural Studies	$0.4
College of Rural Alaska	
Other	$4,621.8
UA Anchorage	**$11,529.0**
Institute of Social & Economic Research	$3,835.2
Environment and Natural Resources Institute	$1,620.5
Institute for Circumpolar Health	$1,469.7
Psychology	$785.8
School of Engineering	$630.4
Alaska Natural Heritage	$624.2
Justice Center	$532.6
Center for Alcohol and Addiction Studies	$312.2
Community & Technical College	$136.4
Biomedical Program	$74.2
Other	$1,507.9
UA Southeast	**$1,109.5**
UA Total	**$121,586.5**
Plus: Reallocated Indirect Cost Recovery	**$11,496.0**

Source: University of Alaska Statewide Budget and Institutional Research

3. UNIVERSITY RESEARCH AS AN ECONOMIC ENTERPRISE

Economic Impact

The overwhelming majority of money funding University research in Alaska comes from sources outside the state. For this reason University research can be viewed as an economic enterprise similar to the metal mining industry, the seafood industry, the timber industry, or the oil and gas industry. Each sells its output to customers outside the state and each brings new dollars into the state in the process.

These new dollars lead to expansion of the economy of Alaska. They pay the salaries of Alaska workers and support sales to Alaska businesses. Their economic impact extends beyond the direct effect of paying for the cost of research. Through the mechanism of the economic multiplier, employment, payroll, and sales are generated in the private economy throughout the state.

Over half of the University research budget in 2003 [4] was paid out in wages and benefits to 1,228 full and part time University employees (Table 14). The next largest budget item was contracted services, comprising a diverse array of services from computer and aircraft maintenance, to facilities rental, to freight services. Capital equipment purchase was largely computer related and miscellaneous research equipment, but also included less esoteric items such as safety and transportation equipment. Commodity purchases included things like field camp supplies, food for animals, and fuel for planes and boats. Travel included both instate and out-of-state travel. Small amounts were budgeted for student aid and miscellaneous expenses.

Table 14. UNIVERSITY RESEARCH AS AN ECONOMIC ENTERPRISE

DIRECT ECONOMIC IMPACT IN 2003 (Million $)

TOTAL UA RESEARCH	**$121.6**
Wages	45.2
Benefits	17.5
Contracted Services	33.6
Capital Equipment	8.4
Commodities	8.1
Travel	5.7
Student Aid	2.0
Miscellaneous	1.0

Source: University of Alaska Statewide Budget and Institutional Research

[4] This excludes the $11.5 million of indirect cost recovery that provided general University support.

Although some of these purchases, like computer and other research equipment, were made outside the state and had little impact on the Alaska economy, most of the research budget does result in either wages to Alaska workers or purchases from Alaska businesses. Because of this, the total impact on Alaska's economy is large relative to the total amount spent on University research.

Adding to the direct impact of University research on the economy is the spending associated with visiting scholars who travel to Alaska to conduct their own research activities funded through their home academic institutions in other states.[5] The economic impact of these visitors is exactly analogous to that of tourists visiting Alaska from other parts of the world, bringing outside money into the state and spending it to the benefit of the Alaska economy.[6]

The total economic impact of University Research can be measured in jobs created, payroll produced, and total business sales generated within the state (Table 15). More than 2,300 jobs can be traced back to University research spending. About 1,200 are within the University—faculty, staff, student assistants, and others—and nearly 1,100 are in a large variety of businesses in the private economy scattered throughout the state—from construction, to transportation and trade, to services.

The total payroll associated with these jobs is more than $80 million, with a little over half going to University employees and the rest to workers in the private economy.

We estimate direct instate procurement of $42 million associated with the University research budget. As indicated, this includes purchases of a wide array of services, and commodities as well as some construction and transportation services. Employees spending their paychecks and companies (who do business with the University) making local purchases from other businesses generated an estimated $65 million more in business sales within Alaska.

[5] For example Toolik Field Station every year hosts large numbers of non-resident researchers during the summer field season.

[6] University and other research facilities in Alaska also attract other visitors to the state, and help to enhance the quality of the experience of visitors. Examples include the Sealife Center in Seward and the Museum at the University in Fairbanks.

Table 15. UNIVERSITY RESEARCH AS AN ECONOMIC ENTERPRISE
TOTAL ECONOMIC IMPACT IN 2003

JOBS	
Total	2,310
University	1,228
Private	1,082
PAYROLL (Million $)	
Total	$80.3
University	$45.2
Private	$35.0
PRIVATE BUSINESS SALES (Million $)	
Total	$106.8
Direct Procurement	$42
Other Sales	$64.8

Source: ISER Calculations.

Industry Characteristics

Viewed as an economic enterprise, University research has a number of attractive features including:

- Labor Intensive—Over 1/3 of the revenues from this industry (37 percent) went directly into payroll.
- High Wage—Although faculty make up only a portion of jobs in this industry, the average wage is higher than the economy-wide average.
- Quality Jobs—Most jobs in the industry come with a full benefits package that adds considerable value over and above the wage.
- Year Round Employment—Although some jobs are seasonal, most are not, and tend to offset the summer seasonal decline in teaching activity at the University.
- Diverse Job Mix—The variety of research activities generates a diverse job mix in the private economy dependent on research spending.
- High Resident Job Share—Residents hold most of the jobs in University research.
- Stable—The level of spending on University research nationally has increased each year for at least the last 20 years.

- Growing—Growth in spending on University research has outpaced growth in the overall US economy.

- Footloose—Most research can be conducted wherever there is a decent laboratory with support for the scientists. It need not be located in proximity to resource deposits, as is the case for our natural resource industries, or close to markets, as is the case for most services.

- Environmentally Benign—University research is a clean industry with minimal impacts on the quality of the environment.

- Low Burden on Government—Government regulation and oversight of the industry is not required.

- Non-Competitive with Other Industry—Unlike oil and gas, mining and our other natural resource industries, University research does not generate conflicts over appropriate and conflicting uses of the environment and natural resources.

- Stable Potential Tax Base—Although it does not directly create a product that is taxable, the large payroll and instate procurement per dollar of spending on research create potential tax bases of personal and business income.

- Backward Linkages—Unlike some industries (like oil and gas and rural tourism) that are "enclaves" physically located in Alaska but not linked to the rest of the economy through purchases of local inputs, the large procurement budget and urban location for most research activities result in strong backward linkages that foster economic activity in support industries.

- Forward Linkages—There are no direct forward linkages in the form of sales to other sectors of the economy, but this is a characteristic of most of our resource industries as well.

- Value Added "Spin-offs"—The objective of private businesses is profit and they create spin-offs that benefit other industries only indirectly or by chance. In contrast, the objective of University research is new knowledge that can be applied to increase productivity in business and government. New knowledge can also be applied to the non-profit sector to improve economic and social well-being. These value added spin-offs are the most unique feature of University research, an added bonus that other industries do not provide.

Benefit to Cost Comparison

The State General Fund appropriation to the University for general support of research in 2003 was $16.6 million, about 8 percent of the total University general fund budget of

$211 million. Total University research expenditures in that year were $121.6 million, producing 2,310 jobs and $80.3 million in payroll. [7]

If we think of the State General Fund appropriation for research as "seed money", then we can calculate the return to the economy from that expenditure as the jobs and income created. Specifically the "Bang Per Buck" for each $1 million of General Fund appropriation for research was 139 jobs and $4.8 million in payroll within the state.

There are indirect benefits to the University from research activities as well. World-class research[8] adds prestige to the University which in turn leads to a greater demand from students and an increased ability to attract quality faculty.

The General Fund appropriation to University research also generates value added "spillovers" that we will address in more detail below.

Comparisons to Other Selected Alaska Private Sector Basic Industries

Each Alaska basic sector industry has different features and characteristics. In this section we review some features of selected industries simply to provide some comparisons with University Research as an economic enterprise.

Each of these industries receives support from state government, just as does University Research, through a variety of mechanisms. These include operating expenditures for management, tax expenditures, capital expenditures, and loans. We have not attempted to quantify the support provided each industry to make any comparisons with our "Bang per Buck" calculation for University Research as such data is not readily available for most industries.

Metal Mining. The value of metal minerals production in Alaska, primarily zinc, gold, and silver, was $823 million in 2002, generating a payroll of $77 million in the industry, and annual average employment of 1,153 in the mining sector. Mining is very capital intensive (as reflected in the low ratio of payroll to value of production), high wage, resource dependent (and subject to market price fluctuations and location dependent), and environmentally sensitive. It produced $2.5 million in revenues to the state in 2002 as well as additional revenues to local governments and resident resource owners.[9]

[7] Not counting the impact of the $11.5 million of reallocated indirect cost recovery.
[8] For example the research of Brian Barnes of the Institute of Arctic Biology has been highlighted on the cover of Science magazine. The first Rasmuson Chair in Economics was held by Dr. Vernon Smith, a Nobel Prize Laureate.
[9] Alaska's Mineral Industry 2002, Division of Geological and Geophysical Surveys, and Alaska Department of Labor.

A legislative research study done in the 1990's calculated that the revenues to the state generated by mining at that time ($4 million) were exceeded by the direct government cost to manage the resource ($8 million).[10]

Tourism. Non-resident vacationers spent $811 million in Alaska in 1998, directly generating 12,835 wage and salary jobs and 3,584 proprietor jobs for a total of 16,419 jobs. Wages were $249 million and proprietor income was an additional $65 million.[11] These jobs were concentrated in the lodging, restaurant, retail, and transportation services sectors of the economy. Tourism related employment tends to be highly seasonal with a large non-resident share. Tourism is a rapidly expanding industry and the growth potential is significant for Alaska.

There has not been a comprehensive analysis of either the public expenditures or public revenues associated with the tourism industry in Alaska. However, continued expansion of this industry will require substantial public investments in infrastructure, marketing, and other services.

Seafood. The annual value of the Alaska seafood harvest exceeds $1 billion and after processing it has a wholesale value in excess of $2 billion. During 2000 45,550 people were engaged in commercial fishing and processing in Alaska, including the adjacent federally managed waters. This was equivalent to 27,877 full time jobs, of which Alaskans held 36 percent. Total personal income was $437 million.[12] Taxes from fishing activity averaged $47 million in the 1990s, with about half going to local communities.[13]

A 1996 analysis calculated state revenues of $67 million from commercial fishing and $21 million from sport fishing, compared to $102 million in fisheries-related state expenditures.[14]

International Air Cargo. Employment associated with international air cargo operations at Ted Stevens International Airport in 2000 has been estimated to be 3,058 with a payroll of $126 million.[15] The operation is labor intensive and is part of a rapidly expanding industry. It is somewhat sensitive to environmental issues and the business cycle, as well as technological developments that could impact the relative attractiveness of Anchorage as a location for air cargo services.

Air cargo operations produce revenues for the airport, but the amount of revenue generated for the state general fund has not been calculated. State expenditures in

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[10] State of Alaska Natural Resource Revenues and Expenditures in FY 95, Legislative Research Series, June 1996.
[11] Alaska Visitor Industry Economic Impact Study, 1999 Update, McDowell Group, 1999.
[12] Alaska Economic Performance Report 2002, Alaska Department of Community and Economic Development., 2003.
[13] Ibid.
[14] State of Alaska Natural Resource Revenues and Expenditures in FY 95, Legislative Research Series, June 1996.
[15] Ted Stevens Anchorage International Airport: Economic Significance 2000, ISER, 2001.

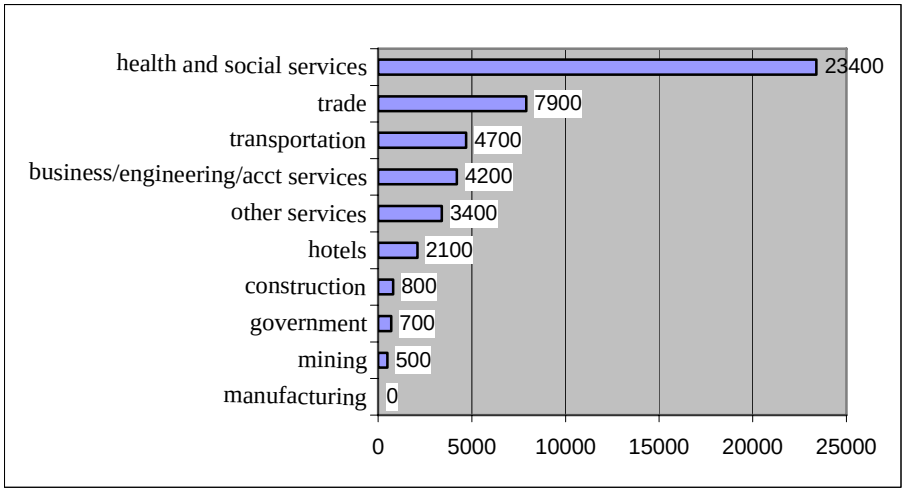
support of the industry have also not been specifically studied, but are probably modest, although the industry does enjoy a tax advantage on fuel sales.

4. Future Growth Opportunities for Alaska University Research

Jobs and income have been growing in Alaska, but much of the growth is tied to federal spending which has increased rapidly in the last 5 years and cannot be counted on to continue expanding or even to stay at its current high level. Strength in the tourism, international air cargo, and mining sectors has also contributed to the strong economy, but timber, seafood, and oil and gas have been struggling because of global competition and other challenges.

Looking ahead, the Alaska Department of Labor projects employment to increase by 48 thousand (1.6 percent growth per year) between 2000 and 2010. Compared to the 40 thousand jobs added in the previous decade this would be a solid performance. However, the Department expects that 97.5 percent of new jobs will be in service producing industries and only 2.5 percent in the goods producing industries of mining (including oil and gas), construction, and manufacturing (including seafood processing and timber) (Figure 4).[16] Most new jobs will be in health and social services (49 percent) and trade (17 percent). These new jobs will have a lower wage than the current average, consequently pulling down the economy-wide average as time passes.

Figure 4. Projected Job Growth 2000-2010



Source: Alaska Department of Labor, May 2002

Because of its attractive characteristics, expansion of University research as an enterprise can contribute to strengthening of the economy in the future. It can contribute to diversity of the economic base, growth in high wage employment, and stability in the

[16] Alaska Economic Trends, May 2002. This projection includes construction of a gas pipeline by 2010.

work force without adverse impact on the environment, little conflict with other industries, and minimal government administrative cost.

The growth potential for University research as an enterprise comes from several factors. First, University R&D spending nationally has been increasing faster than growth in the total economy for two decades. Second, Alaska University research is under-represented in several important and high growth areas, in particular, the life sciences. Third, a considerable share of research about Alaska-specific questions is currently being conducted by Universities in other parts of the country. The University of Alaska could be capturing a larger share of that research—and be benefiting to a much larger degree than it currently is by simply hosting visiting scholars who come for a short time and return to their homes outside Alaska with information collected here. Fourth, the University of Alaska could capture a larger share of research on the Arctic currently done outside Alaska.[17] Finally, there is research that Alaska governments, businesses, and non-profits fund. Some of this research is done at the University of Alaska, but much of it is exported to Universities in other states. This represents another growth opportunity for expansion of Alaska University research.[18]

A large share of University research funding comes from the federal government, either directly, or through other agencies, as is the case in other Universities in other states. Some federally funded research at the University of Alaska is the result of earmarks—research money allocated to the University non-competitively. It is University policy to use these earmarks to build research capacity within the state in order to compete more effectively for research funds in the future.

Not all funds earmarked for Alaska research is conducted in Alaska or by the University of Alaska. Some earmarked funding for Alaska research goes to support research conducted directly by agencies of the federal government like the National Marine Fisheries Service and the Department of Defense. Also some of the research funded through those agencies is placed with organizations outside of Alaska. Because a share of Alaska research earmarks is spent outside the state, the risk to the Alaska economy from a reduction in earmarked research is less than it might otherwise appear to be.

5. VALUE ADDED SPILLOVERS FROM UNIVERSITY RESEARCH: WHAT CAN WE "TAKE TO THE BANK" FROM APPLIED RESEARCH?

Much University research is "basic" meaning it has no immediate practical application, but rather increases our understanding of the world we live in. But such research may lead to important and exciting breakthroughs in unanticipated ways. For example,

[17] A Web site listing of National Science Foundation grants for Arctic Natural Sciences Research accessed March 3, 2004 identified $3.6 million out of a total of $46.2 million going to researchers affiliated with the University of Alaska.

[18] Capturing some of this exported research would be equivalent to "import substitution" as characterized in the economic development literature.

research on hibernation in small mammals, conducted at the University of Alaska Fairbanks, could provide insights into treatments for stroke patients or applications in the military.

However a considerable share of the research at the University provides a more direct benefit to Alaska over and above its value as an economic enterprise. There are several ways that University research, unlike other economic enterprises within the state, produces value added in the form of knowledge that can be applied to problems. For many of these applications a monetary value might be calculated, although this is rarely done in practice. Below we discuss some of the links between the University and economic development from applied research and give examples of each. This discussion is illustrative rather than exhaustive because of the multitude of projects underway at any time within the University research community.

- **COMMERCIAL SPINOFFS—**Sometimes a new invention discovered at the University, a new way of doing something, or a new application of knowledge results in the creation of a new business startup.[19] To many people this is the essence of the link between University research and economic development—epitomized by the experience of places like Silicon Valley. While important, this is only one of many aspects of the link between University research and economic growth and development. In Alaska this is a small, but potentially growing, part of that link.
    - **ABR Inc**., an environmental research and services firm was founded in Fairbanks in1976 by University of Alaska Fairbanks graduate Bob Ritchie. ABR Inc. is an example how expertise gained doing university research translates to private sector growth and the export of specialized services. ABR Inc. now has 40 employees serving the federal and state government, Native organizations, engineering firms, oil and gas industry, timber, utility, and other for-profit organizations, universities, and non profit groups, primarily those managing or using natural resources. Twelve of the 15 senior scientists have higher degrees from UAF. Degrees include wildlife management, natural resource management, marine biology, ecology and botany. Most of the other technical staff also have degrees from UAF. Each higher degree graduate is currently involved in research similar to, or related to, the theme of their thesis. Ritchie has continued to do wildlife surveys, primarily of raptors, which he'd done while a student at UAF. ABR Inc. scientists have used their specialized knowledge to develop an expertise using radar to monitor avian use around transmission lines and other facilities. They've exported this expertise outside of Alaska, adding an Oregon office in 1995. That office's revenues and research programs are still very dependent on radar investigations and the client base has expanded to include the military. ABR Inc. has developed a solid niche in Alaska and their services are often selected over 'outside' competitors.

[19] A new business startup could either add to the export base of the economy, or generate economic growth through import substitution.

- **RFID** is an example of movement of research outside traditional natural resource applications. Radio frequency identification has application in national defense, home electronics, medicine, and other fields where it can be used to more efficiently track inventory and cargo. University researchers are working with private industry on installation of RFID systems and developing computer programs to link information to a secured Web-based system. In addition to research that helps businesses use RFID technology, UAF's Center for Nanosensor Technology, in partnership with private industry and North Dakota State University, is building a sterile lab for research and development of high-end, custom RFID tags.

- **BUSINESS INNOVATION-**A lot of applied University research involves investigating specific problems encountered in Alaska natural resource industries. Solutions to these problems reduce the cost of doing business, increase the opportunities for business expansion, and can lead to the development of new products and ways of doing business.
  - **Fisheries**—A commercial geoduck harvest in southeast Alaska has historically supported the export of about 400,000 pounds of processed geoducks annually to the Pacific rim. University researchers helped develop a PSP (Paralytic Shellfish Poisoning) monitoring system that has allowed harvesters to ship their product to market live rather than processed. Since the market price for live geoducks is potentially $5 to $10 per pound compared to $.80 for processed products, this change is having a dramatic effect on the profitability of this industry. Furthermore it opens up the opportunity for an entirely new enterprise—geoduck farming—that is beginning to develop at sites in southeast Alaska. When fully developed the industry could be shipping 1 million pounds or more of live geoducks annually.[20]
  - **Mining**—The manager of the Fort Knox gold mine near Fairbanks moved there specifically to work with the Mineral Industry Research Lab at the University and he is currently working towards his PhD at UAF. His work involves modeling that assists in making production more cost effective. University research contributed to a $6.7 million expansion on the Fort Knox plant that has increased recovery by 2 percent—$3.8 million dollars.[21] Other employees at the Fort Knox Mine are working on degrees at MIRL and using classes to explore problems they encounter at work.

- **PUBLIC INFRASTRUCTURE EFFICIENCY—**University research is involved in many areas looking at ways to reduce the costs of providing public services in Alaska. Innovations reduce the cost of government and ultimately the cost of doing business in the state.
  - **Engineering Roads**—Alaska roads from Glenallen and all points north are subject to the settling heaves of thawing permafrost. Permafrost

[20] Julie Decker, Southeast Alaska Dive Fisheries Association, personal communication.
[21] John Holloway, mill manager, personal communication.

typically takes 50 years to thaw completely making maintenance expensive. A new embankment material developed by Prof. Doug Goering at the Institute of Northern Engineering at UAF is designed to keep permafrost under roads frozen and to prevent the settling heaves. The material, which can cost up to 10 percent more than current embankment material, is being used in new road construction in Fairbanks. The Alaska Department of Transportation plans to use the material on other new road construction where it will save money over the life of the road, even though initial installation is more expensive than traditional methods.

- **Telemedicine**—Delivery of medical services to rural Alaska is expensive and time consuming—often requiring patients and health care workers to travel great distances to see each other. University research developed a method for transporting images over existing telephones lines. This technology is being used by health aides in rural Alaska who take pictures of patients and send them to doctors hundreds of miles away at considerable savings to all involved. Telemedicine is used by the Alaska Federal Health Care Access Network. (AFHCAN), which has 235 sites throughout the state and coordinates between public health nurses, the Coast Guard, Veterans Administration, military and Native community. University researchers presented a report on Alaska's telemedicine project to the eight-nation Arctic Council so that this technology could benefit other countries where great distances make it difficult to deliver health services. There are plans to expand into telepsychology, teleradiology, and teledermatology.[22]

- **PUBLIC ASSET MANAGEMENT**--University research helps to sustain and enhance the value and productivity of Alaska's natural resources.
  - **Seafood**-- The UAF Fishery Industrial Technology Center (FITC) in Kodiak is working to increase the value of Alaska's fishing industry and marine resources through research, technological development, education and service. FITC two main programs are Sustainable Harvesting and Seafood Processing.
  - **Energy for Alaska Communities**--Scientists at the Arctic Energy Technology Development laboratory at UAF are working closely with the power generation, coal, oil and natural gas industries to design and fund research projects that will make a difference for Alaska. They are particularly emphasizing proposals that involve UAF and industry collaborations.
  - **Coal**—A Coalbed Methane Project is underway to find coal seams in remote villages where importing energy is very expensive. A Coalbed Methane Project in Fort Yukon is being undertaken with support from the Department of Natural Resources.
  - **Oil and Gas**—the unbiased nature of University research often makes it desirable to private industry. This is true of a project undertaken by

[22] Prof. Carl Hild, Associate Director, College of Health and Social Welfare, personal communication.

UAF's Institute of Northern Engineering to study the environmental impact of draining tundra ponds to create ice roads on the North Slope. BP is interested in the project because it not only provides valuable information on roads the company is using to conduct business, but it also provides "unbiased" research the company can use to respond to environmentalists' concerns. The project has funding from the Department of Energy and BP is providing a cost share.

- **Methane Hydrates**—the University is conducting research on energy sources that can be used when fossil energy supplies are depleted, 50-80 years from now. This forward-looking research—which BP is supporting with money and expertise—is concentrated on extracting methane from frozen methane hydrates. Methane is a pure chemical compound from which natural gas is produced. There is as much methane in methane hydrates as in all known natural gas reserves.
- **Membrane Separation Technology**—University researchers will be junior partners in research that is planned by BP and its stakeholders to find a cheaper method to separate CO2 from natural gas. Before natural gas may be shipped through a pipeline CO2 must separated out. Costs for building a gas separation plant are currently estimated at $2.5 billion. This project would develop a process that could save $500 million from the total cost.
- **Prospects for future research**—Alaska is becoming less and less attractive to large oil companies that can extract oil other places more cheaply. This will mean smaller oil companies coming to Alaska. These smaller companies will have less in-house research capability (unlike BP that has its own geology department) and will be more likely to turn to University research to support their work.

- **INFORMATION FOR BETTER BUSINESS DECISIONMAKING--**The University provides nonproprietary information available to all for use in aiding business and government decision making.
  - **GINA**, the Geographic Information Network of Alaska, that makes digital data associated with geographic coordinates, available to scientists, policy makers and the Alaskan public,
  - **Alaska Sea Ice Atlas**, a website of ice information used for logistical and engineering-type decisions in ice covered water.
  - **ISER** economic projections produced by the Institute for Social and Economic Research are used by government, individuals and businesses to make investment and planning decisions.

- **EXPERTISE--**Expertise gained doing University research provides a source of experts on issues of importance to industry and to the public process.
  - **Seafood Markets—**Prof. Gunnar Knapp has spent many years researching Alaska fisheries issues and specifically Alaska's salmon industry for the Institute of Social and Economic Research. His expertise has been used by the Alaska Seafood Marketing Institute. Alaska salmon

processors have also relied upon Prof. Knapp's expertise, most recently in a class action antitrust case brought against them in 2003. Salmon processors relied upon Prof. Knapp as an unbiased expert since he testified based on research conducted for the University and received no pay for his testimony. Prof. Knapp's testimony helped the jury understand the downturn in the salmon markets, resulting ultimately, in the processors prevailing in court. The jury's decision preserved thousands of processing jobs and saved Alaska processors millions of dollars.[23]

- **Grant Assistance**--University faculty are experienced in developing grant proposals and use this expertise to help teach community members how to apply for grants. The Institute for Circumpolar Health Studies assisted the Aleutian Pribilof Island Association in getting a grant to study contaminants in subsistence foods. The Association was the first tribal body to obtain, independently, a competitive grant from the National Institute for Health Sciences Environmental Research.[24] They in turn contracted with the University to evaluate the program and other services. By providing expert advice—and evaluation services—University researchers enabled community members to conduct research of benefit to themselves.

- **TRAINING**--Researchers trained in Alaska do a better job than those imported from outside Alaska. Many private and public offices have close ties to University departments graduating students in their field. These students not only bring innovative ideas, up-to-date knowledge, and sensitivity to Alaska issues and problems, but they are also more likely to stay on the job thereby reducing the costs of turnover to employers.
  - **Lead Removal from Contaminated Soils—**Brice Environmental, a Fairbanks range maintenance and remediation firm, hired staff trained at UAF's Mineral Industry Research Lab (MIRL) when it made the transition 15 years ago from construction work to soil remediation. University expertise helped Brice to blend its "dirt moving" capabilities with technical lead remediation to provide clients with environmental services. The firm continues its association with MIRL—consulting with faculty, benefiting from research papers and staff taking courses. Now, ninety percent of Brice's work is done outside of Alaska. They've completed projects at the Twin Cities Army Ammunition Plant, Fort Polk Louisiana, Massachusetts Military reservation, and Fort Dix New Jersey among others. They've also done work at Fort Greeley.[25]

- **TOURISM ENHANCEMENT**--University research facilities such as the Alaska SeaLife Center, Poker Flat Research Range, and UAF Museum contribute to the

[23] Letters in support of Prof. Gunnar Knapp's testimony and research sent to University of Alaska President Mark Hamilton June 2003 from Don Giles, President & CEO Icicle Seafoods, Inc; Alec Brindle, Chairman Wards Cove Packing Company; and Charles H. Bundrant, President & CEO Trident Seafoods Corporation.
[24] Prof. Carl Hild, College of Health and Social Welfare, personal communication.
[25] Tom Benjamin, Brice Environmental, personal communication.

attractions that bring tourists to Alaska. Ongoing research provides interesting displays and current information making these institutions vital and interesting to tourists looking for uniquely Alaskan experiences.

- **INVENTIONS AND LICENSING—**the Intellectual Property and Technology Transfer Office is encouraging the licensing, patent and copyright of products of University research and is working with government and industry to find support for University research. It is encouraging inventions and helping with marketing. In addition to Prof. Doug Goering's road embankment material that prevents permafrost thaw, other. licenses have recently been issued for musk ox feed rations; a genetic switch in bacterial form; three nanoscale sensors; a method for softening both saline and freshwater ice with biodegradeable materials that will have application in the frozen food industry; and an acoustical tree/log imager to find flaws in standing timber. Joint inventor projects include a new design for a flow field that may have use in the medical industry as well as reverse osmosis industry that may have application in the fuel cell industry. Although Prof. Goering's embankment material is being used, as is the musk ox feed, other inventions and procedures licensed may take longer to find their niche in the market and to bring financial returns.

- **NATIONAL SPILLOVERS--**Research that has a "spillover effect" providing benefits to the rest of the nation and the world, enhances the University's reputation. University of Alaska research is internationally recognized in a large number of fields within engineering, space physics, climate change, and social and policy research. Much of this research is conducted at the Big 6 Research Institutes on the UAF campus: the Geophysical Institute, International Arctic Research Center, Institute of Arctic Biology, School of Fisheries and Ocean Sciences, School of Natural Resources and Agricultural Sciences, and the Arctic Region Supercomputing Center.

6. THE BIG 6 INSTITUTES

- **GEOPHYSICAL INSTITUTE--**The Geophysical Institute conducts research from the center of the earth to the center of the sun. The largest institute on the UAF campus—with seven research groups and ten research centers—GI has a world class reputation in marine and terrestrial geophysics and receives a total of nearly $30 million in research funds from NASA, the National Science Foundation, the Department of Energy, USGS in addition to other public agencies and private industry. The products of research at the Geophysical Institute—which includes Space Physics; Atmospheric Science; Snow, Ice and Permafrost; Seismology; Volcanology; Tectonics and Sedimentation; and Remote Sensing—is exported throughout the world. Examples include:
    - **SAR**—One of the major projects at GI is the Alaska SAR (Synthetic Aperture Radar) Facility. NASA uses SARs data to study changes in the

earth's surface, including a recent project mapping the destruction of the Amazon rainforest.
    - **Sedimentary Research**—Private industry is interested in GI research such as basic sedimentary research in the Brooks Range which is being conducted with funding from the oil industry.
    - **Poker Flat Research Range**—The Geophysical Institute is home to the Poker Flat Research Range—the largest land-based rocket range in the country and only University-based rocket range.

- **INTERNATIONAL ARCTIC RESEARCH CENTER (IARC)--**Jointly established by the Japanese and United States governments the International Arctic Research Center conducts research vital to understanding climate change, global warming and Arctic phenomena. While the economic benefits of this research may not be realized for a long time, the work of IARC in determining the balance of natural and human factors contributing to global warming will be of great interest to industry as well as governments. The results may very well determine how industry conducts business in the future. Examples of activities include:
    - **CO2 Protocols**—IARC research helps countries develop CO2 protocols to address global warming.
    - **International Research**—The Center integrates the work of more then 90 international researchers.

- **INSTITUTE OF ARCTIC BIOLOGY--**The Institute of Arctic Biology has six major programs that include research in neuroscience, infrastructure research, Native health research, an Experimental Program to Stimulate Competitive Research (EPSCoR), ecological research programs; and a Resilience and Adaptation Graduate Program. These programs bring in research money from NIH, NSF, the National Center for Research Resources, among others. Program examples include:
    - **Arctic Ground Squirrel Hibernation**--University research on the hibernation of Arctic ground squirrels has been featured in national magazines such as *Nature* and created a great deal of interest. Understanding how the squirrels can nearly stop their hearts during hibernation could lead to methods for preventing tissue damage in humans during strokes, as well as many other possibilities.
    - **Toolik Field Station**--The Toolik Field Station on the north slope of the Brooks Range attracts researchers from around the world interested in high latitude ecological and global change research.
    - **Experimental Program to Stimulate Competitive Research**—EPSCoR, a University-state partnership, is intended to build Alaska-based research to support training of students for 21st century technologically based economy.

- **SCHOOL OF FISHERIES AND OCEAN SCIENCES—**Alaska's oceans supply over half the seafood for the nation and the School of Fisheries and Ocean Sciences (SFOS) has seven units and five research programs that conduct vast amounts of research to support the ocean harvest. The research done in this school is of great benefit to Alaska's seafood industry—which is the largest private employer in the state. SFOS not only provides help in the management of the resource it also contributes to expanding the resource with innovations in product and machinery. Examples of activities include:
    - **Fisheries Management**--Studies on the Steller sea lion and fishing gear impacts on endangered seabirds help with management of the fisheries—allowing fishermen to make a living and also preserving the environment.
    - **Expanding the Resource**--A new state law opened up 100 leases to shellfish aquaculture that includes clams and mussels. University research is providing information on the best way to grow shellfish and also providing information on different species that might thrive in Alaskan waters.
    - **New technology**--Research at the Fishery Industrial Technology Center in Kodiak is focused on finding innovations in product and machinery for the fishing industry.

- **SCHOOL OF NATURAL RESOURCES AND AGRIGULTURAL SCIENCES—**The School of Natural Resources and Agricultural Sciences continues to focus research on problems related to sustainable agriculture and forestry in relation to economic, social and cultural needs. This research helps Alaskans develop crops, livestock and feed in our challenging environment.
    - Turfgrass performance for golf courses in Southcentral Alaska and the development of a new feed mix for musk ox are recent research projects conducted in the School of Natural Resources and Agricultural Sciences.

- **ARCTIC REGION SUPERCOMPUTING CENTER—**ARSC provides computational resources to hundreds of scientists and researchers in Alaska and across the nation. These researchers tackle enormous computational problems for some of the Arctic's greatest challenges including global climate change, bioinformatics, permafrost, ocean circulation and sea ice. Completely funded by the Department of Defense, ARSC also brings in significant research dollars from outside Alaska. In the future ARSC may be used by private businesses, which would bring additional revenue to the University.