

Chapter 3

Federal Research and Development in Arizona

- Approximately \$862 million of federal R&D funds are spent each year in Arizona.
- Arizona ranks 20th among the 50 states, District of Columbia, and Puerto Rico in terms of the amount of federal R&D dollars received annually.
- Approximately 8 percent of all federal funds spent in Arizona each year on matters other than the direct support of individuals (i.e., such entitlements as retirement, disability, and housing assistance) is spent on R&D.

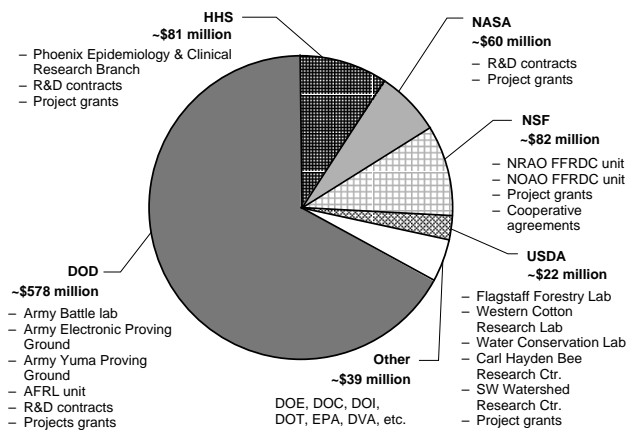


Figure 3.1 – Sources of Federal R&D Dollars Spent in Arizona (Total Federal R&D ~\$862 million)

BACKGROUND

In recent years, the federal government has spent in the neighborhood of \$862 million annually in Arizona on research and development (R&D) activities. On average, federal R&D dollars account for approximately 8 percent of all federal funds spent in Arizona each year on matters other than the direct support of individuals (i.e., such entitlements as retirement, disability, and housing assistance).

Most major federal agencies that currently support federal R&D efforts provide funding for R&D activities in Arizona. Foremost among these agencies is the Department of Defense (DOD), which accounts for 67 percent of all federal R&D dollars spent in the state. The National Science Foundation (NSF) and the Department of Health and Human Services (HHS) each account for an additional 9 percent, while the National Aeronautics and Space Administration (NASA) accounts for an additional 7 percent of federal R&D dollars spent in the state. The remaining federal R&D dollars come collectively from the Department of Agriculture (USDA) and several other agencies.³

All federal R&D dollars spent in Arizona either cover the costs of operating federal R&D units in the state, including paying the salaries of federal R&D personnel working at these units, or are awarded as grants, contracts, or cooperative agreements to entities in the state. The following is an overview of what becomes of these federal R&D dollars once they arrive in Arizona.

FEDERAL R&D UNITS IN ARIZONA

Flagstaff, Arizona, is home to Department of Interior's (DOI's) Colorado Plateau Field Station and USDA's Forestry Sciences Laboratory.

- The Colorado Plateau Field Station is a unit the Forest and Rangeland Ecosystem Science Center inside DOI's U.S. Geological Survey (USGS). It conducts research in ecoregionalism and conservation planning. Specific research activities of this unit include studying endangered species, investigating the im-

³ For a complete agency-by-agency breakdown of these R&D dollars, see Appendix C.

pact of vegetation distribution on the ecosystem, and researching wildlife ecology. This federal R&D unit annually receives approximately \$606,000 in federal R&D funds and has about 10 FTEs.

- The Flagstaff Forestry Sciences Laboratory is a unit of the Rocky Mountain Research Station inside USDA's Forest Service. The laboratory, which is located on the campus of Northern Arizona University, conducts research on vegetation, watershed, and wildlife and fisheries resources. Specific research activities include examining the impact of forest insects and diseases on the ecosystem, determining the interface between the wildlands and urban areas of the Southwest, and investigating the buildup of hazardous fuels and the potential for fire to erupt in the Southwest. Other research activities focus on studying the factors that influence populations and habitats of threatened, endangered, and sensitive species in the southwestern forest; and researching the interrelationships among hydrologic, geomorphic, and biotic processes that affect fish habitat, riparian vegetation, channel dynamics, and instream flow regimes. This federal R&D unit annually receives approximately \$4.7 million of federal R&D funds and has about 42 employees.

Fort Huachuca, Arizona is home to DOD's Electronic Proving Ground and one of DOD's Battle Command Battle Laboratories.

- The Electronic Proving Ground is a unit of the Army's White Sands Missile Range in DOD. It supports developers by conducting tests and experiments of new electronic systems including command, control, communications, computer, intelligence, and electronic warfare equipment. Its projects have included the Enhanced Position Location Reporting System, the Single Channel Ground and Airborne Radio System, and the Mobile Subscriber Equipment. The funding and staffing information for this unit are included in those provided for the White Sands Missile Range in New Mexico.

- The Battle Command Battle Laboratory is a unit of the Army inside DOD. It is one of 11 battle laboratories established to define the horizontally integrated capabilities required to operate and field an effective Army. This unit is one of three laboratories focusing specifically on battle command matters. The other two are located in Fort Leavenworth, Kansas, and Fort Gordon, Georgia. Together, the three Battle Command Battle Laboratories teach the art and science of battle command and information warfare to commanders to enable them to operate anywhere on the battlefield, as well as on the move. This particular laboratory conducts research on intelligence collection and dissemination and electronic warfare. Specific R&D activities of this laboratory include developing the net battle command vehicle, conducting experiments on the impact of information on decisionmakers and their staffs, developing a decision support system for battle commanders, and studying how best to focus intelligence information on the tactical decisionmaker. This federal unit annually receives about \$825,000 of federal R&D funds, only a portion of which is spent in-house, and has two civilian personnel.

Mesa, Arizona, is home to a unit of DOD's Air Force Research Laboratory Warfighter Training Research Division.

- The Human Effectiveness Directorate Warfighter Training Research Division is a unit of DOD's Air Force Research Laboratory. The directorate is headquartered in Dayton, Ohio, with an additional site in San Antonio, Texas. This division develops warfighter training techniques and technologies, conducts research into night vision device training, and develops head-tracking systems for aircraft simulators. This federal unit annually receives about \$13 million, only about 25 percent of which is spent on in-house activities, and employs about 37 civilians, only a portion of whom are involved in R&D activities.

Phoenix, Arizona, is home to HHS's Phoenix Epidemiology and Clinical Research Branch, USDA's Western Cotton Research Laboratory

and U.S. Water Conservation Laboratory, and a Department of Veterans Affairs (DVA) R&D unit.

- The Phoenix Epidemiology and Clinical Research Branch is a part of the National Institute of Diabetes and Digestive and Kidney Diseases inside HHS's National Institutes of Health (NIH) that is headquartered in Bethesda, Maryland. It conducts research on diabetes and its complications, obesity, and digestive and kidney diseases, all of which are disproportionately common among southwestern American Indians. Specifically, the branch studies diabetes mellitus and obesity, including the conduct of clinical investigations, among Pima Indians. This federal unit has an average annual budget of approximately \$4.7 million and has about 80 employees.
- The Western Cotton Research Laboratory is a unit of the USDA's Agricultural Research Service (ARS). It is composed of two research management divisions focusing on cotton insect pest management, biocontrol, and genetics; cotton physiology and genetics; and host plant resistance. One of these research divisions develops and improves ecological and genetic methods to reduce losses by cotton insects and mites. Research in this unit includes investigations of the mode of action and role of semiochemicals, genetic approaches, genetic engineering, and cultural practices in basic biology, ecology, and population dynamics of cotton insect pest and beneficial species. The second division conducts research on the physiological, genetic, and entomological aspects of short- and extra-long-staple cotton. This federal R&D unit, in combination with the U.S. Water Conservation Laboratory described below, annually receives approximately \$7.7 million of federal R&D funds and has about 109 FTEs.
- The U.S. Water Conservation Laboratory is a unit of the USDA's ARS. It is composed of two research divisions focusing on irrigation water quality and environmental and plant dynamics. The laboratory conducts research on the development of more

efficient irrigation systems, better management criteria for irrigation systems, and better methods for scheduling irrigations. Specific research activities of this laboratory include exploring the potential uses of remote sensing techniques and technology, investigating ways to protect groundwater from agricultural chemicals, and predicting the effect of future increases of atmospheric CO₂ on climate and on yields and water requirements of agricultural crops. The staffing and funding information for this federal R&D unit is included in those provided for the Western Cotton Research Laboratory described immediately above.

- While the principal focus of the Carl T. Hayden VA Medical Center in Phoenix is providing medical care to veterans, it is also the location of a number of research activities. In a recent year, this federally owned and operated facility was the site of 125 projects with total funding of less than \$100,000. These R&D activities focus on a wide range of topics, including endoscopy, diabetes, and gastrointestinal disorders.

Tucson, Arizona, is home to USDA's Carl Hayden Bee Research Center and Southwest Watershed Research Center, DOI's Arizona Cooperative Fish and Wildlife Research Unit and Arizona District Office of Water Resources, a portion of NSF's National Radio Astronomy Observatory and the headquarters of NSF's National Optical Astronomy Observatories, and a DVA R&D unit.

- The Carl Hayden Bee Research Center is a unit of the USDA's ARS located on the campus of the University of Arizona. It conducts research to improve crop pollination and honeybee colony productivity through quantitative ecological studies of honeybee behavior, physiology, pests and diseases, and feral honeybee bionomics. Specific research activities focus on improving honeybee pollination of fruit and seed crops and other ecologically important plant species, assessing the impact of mites and their associated microbes honeybee colonies, and developing new techniques for the detection and control of feral Africanized

honeybees. This federal R&D unit, in combination with the Southwest Watershed Research Center described immediately below, annually receives approximately \$3.5 million of federal R&D funds and has about 41 FTEs.

- The Southwest Watershed Research Center is a unit of the USDA's ARS located on the campus of the University of Arizona. It conducts research on hydrology and water resources, erosion and sedimentation, and water quality. Specific research activities seek to improve decision support systems and are conducted in conjunction with a global climate change project. Recent studies have focused on temporal, spatial, and intensity scales affecting erosion processes on rangelands. Other research has explored the interactions of long-term climatic, hydrologic, and vegetation records to evaluate potential climatic change impacts on semiarid rangeland water resources. The funding and staffing for this federal R&D unit are included in those for the Carl Hayden Bee Research Center described immediately above.
- The Arizona Cooperative Fish and Wildlife Research Unit is part of DOI's USGS. This unit is on the campus of the University of Arizona. It conducts research on fishery ecology and management. Specific research activities of this unit include investigating habitat utilization of native fishes, looking into better management of game fishes, investigating nontraditional forms of aquaculture, and studying the effects of environmental contaminants on aquatic systems. This R&D unit annually receives approximately \$278,000 in federal R&D funds and has about three FTEs.
- The Arizona District Office of Water Resources is a unit of DOI's USGS. It oversees the R&D activities of USGS's National Water-Quality Assessment (NAWQA), Ground-Water Resources Assessment, Toxic Substances Hydrology, and Federal State Cooperatives programs. The NAWQA program conducts research on the nation's surface and groundwater resources to better understand the effect of pesticides, erosion, and bacterial

contamination on water quality. The Ground-Water Resources Assessment program studies groundwater systems to develop models and simulations to better understand the workings of these systems. The Toxic Substances Hydrology program studies the behavior of toxic substances in hydrologic environments. These research activities investigate subsurface contamination at local releases and aquatic ecosystem contamination on a watershed and regional scale. The Federal State Cooperatives program studies the effects of agricultural chemicals, floods, droughts, and waste disposal on water supply and groundwater quality. This federal unit annually receives approximately \$2.4 million in federal R&D funds.

- The National Radio Astronomy Observatory (NRAO) is a federally funded research and development center (FFRDC) sponsored by the NSF and operated by Associated Universities, Inc. It is headquartered in Charlottesville, Virginia, with observing sites in Green Bank, West Virginia; Tucson, Arizona; and Socorro, New Mexico. NRAO was established to ensure that all qualified scientists have access to radio astronomy facilities. NRAO's 12-meter, millimeter-wavelength telescope is located atop Kitt Peak southwest of Tucson, Arizona, and is used to conduct continuum and spectral-line studies involving wavelengths between one millimeter and one centimeter long. Each year the four sites of this federally owned and consortium-operated unit collectively receive approximately \$44 million of federal R&D funds to conduct operations. The Tucson site annually receives approximately \$2 million of federal R&D funds and has about 30 employees. A substantial portion of these funds is spent on the maintenance and operation of R&D equipment and facilities.
- The National Optical Astronomy Observatories (NOAO) is an FFRDC sponsored by the NSF and operated by the Association of Universities for Research in Astronomy, Inc. Headquartered in Tucson, NOAO consists of an observatory on Kitt Peak, southwest of Tucson; an observatory north of Santiago, Chile,

on the western slopes of the Andes; and a solar observatory co-located on Kitt Peak and Sunspot, New Mexico. Together, NOAO's observatories constitute the national center for ground-based optical and infrared astronomy and solar physics. The collective parts of this federally owned and consortium-operated unit annually receive approximately \$35 million of federal R&D funds and have about 300 employees. NOAO is also the U.S. headquarters for the Gemini Observatories project, a partnership among the United States, the United Kingdom, Canada, Australia, Chile, Brazil, and Argentina. With NSF acting as the executive agent for this project, one eight-meter optical/infrared telescopes is in operation in Mauna Kea, Hawaii, and a second is under construction in Chile. Both telescopes are designed to operate on-site or remotely. The total U.S. contribution to this international R&D effort has annually totaled approximately \$35 million of federal R&D funds in recent years, only a small portion of which is spent in Arizona.

- While the principal focus of the Southern Arizona VA Healthcare System facility, the VA Medical Center in Tucson, is providing medical care to veterans, it is also the location of a number of research activities. In a recent year, this federally owned and operated facility was the site of 277 projects with total funding of approximately \$1 million. These R&D activities focus on a wide range of topics, including congestive heart failure, prostatic neoplasms, and drug therapy.

Yuma, Arizona is home to DOD's Army Yuma Proving Ground.

- The Army Yuma Proving Ground is a unit of DOD. It focuses on the planning, execution, and reporting of development and production testing of artillery, direct fire, automotive, aviation systems, mines and countermines, unexploded ordnance systems, air delivery, and soldier equipment. Testing has included the M1A1 Abrams Tank and the Unmanned Aerial Vehicle Close Range, among others. This federal unit annually receives approximately \$115 million of federal R&D funds, about \$15

million of which are spent on in-house activities, and has about 666 civilian personnel.

FEDERAL R&D GRANTS TO ARIZONA ENTITIES

Every major institution of higher education in Arizona is the recipient of significant federal R&D dollars each year through grants made by federal agencies to faculty, graduate students, and research centers. The vast majority of the R&D grants are made by HHS, NSF, NASA, and DOD to individual faculty members and therefore ultimately inure to the benefit of such institutions as the University of Arizona, Arizona State University (ASU), and Northern Arizona University (NAU). The table below shows the number of R&D grants active in FY 1998, highlighting those made by HHS, NSF, NASA, and DOD to parties at the various institutions and estimates of the total dollars transferred to them in FY 1998 pursuant to the terms of these grants. Among the grants in the “Other Agencies” category going to the University of Arizona are ones from USDA (\$5 million), DOE (\$3 million), and the Environmental Protective Agency (EPA) (\$2 million). The comparable grants in this category going to Arizona State University include \$1 million from DOE and the remainder distributed primarily by USDA, EPA, and the Department of Justice.

Table 3.1 – Sources of Federal R&D Grants to Higher Education in Arizona

Institution	HHS		NSF		NASA		DOD		Other Agencies		Total	
	Amount	#	Amount	#	Amount	#	Amount	#	Amount	#	Amount	#
U of Arizona	\$65M	303	\$17M	367	\$13M	220	\$11M	51	\$11M	304	\$116M	1,245
ASU	\$9M	53	\$12M	191	\$1M	47	\$3M	26	\$3M	46	\$28M	363
NAU	\$2M	8	\$2M	36	<\$1M	10	0	0	\$1M	21	\$5M	75
Other	\$1M	3	<\$1M	1	<\$1M	2	0	0	<\$1M	5	\$1M	11
Total	\$76M	367	\$31M	595	\$15M	279	\$14M	77	\$16M	376	\$151M	1,694

These activities are particularly significant because they fund much of the “basic research” so critical to expanding our knowledge and un-

derstanding of fundamental scientific phenomena. In addition, these funds account for a substantial portion of the dollars available each year to various academic departments within these institutions, such as the College of Medicine at the University of Arizona.

Several other nonacademic institutions in Arizona also receive a significant amount of federal R&D grants each year. Foremost among the institutions that received R&D grants in FY 1998 are Saint Joseph's Hospital and Medical Center in Phoenix (\$3 million), Materials and Electrochemical Research Corp. in Tucson (\$2 million), Lowell Observatory in Flagstaff (\$1 million), the Primate Foundation of Arizona in Mesa (\$1 million), and the Sun Health Research Institute in Sun City (\$1 million).

Scattered among these grants, as well as among the contracts discussed in the section below, are small business innovative research (SBIR) awards. These are special awards made by the SBIR programs supported by the 10 federal agencies with annual budgets for extramural R&D of more than \$100 million. In a recent year, small businesses in Arizona received 84 SBIR awards totaling \$19 million. Examples include a \$700,000 award from DOT to Catalina Engineering, Inc., in Tucson to develop highway capacity software using a portable graphical user interface format and a \$600,000 award from the Navy to FATS, Inc., in Phoenix for work on a virtual vertical aircraft signal trainer.

Also included among these grants are formula grants from federal agencies. Formula grants differ from the much more common project grants in that the money transmitted through formula grants is allocated to a state or one of its subdivisions in accordance with a distribution formula prescribed by law or regulation. Among the formula grants benefiting Arizona are ones valued at more than \$2 million from USDA's Cooperative State Research, Education, and Extension Service (CSREES) to State Agricultural Experiment Stations, forestry schools, and veterinary colleges for the support of research in agriculture, forestry, and animal health and disease. Similarly, a modest formula grant goes from DOI's USGS to the Water Resources Research Institute in Arizona every year to foster research in water and water-related problems.

OTHER FEDERAL R&D ACTIVITIES IN ARIZONA

Several entities in Arizona also receive notable sums in the form of contracts or cooperative agreements from federal agencies for specific R&D efforts. The majority of these funds go from DOD to the Raytheon Company (including its newly acquired Hughes subsidiaries), which in FY 1998 received close to \$296 million in R&D contracts for such efforts as the development of the AIM-9X Sidewinder Missile System and the Block Six Advanced Medium-Range Air-to-Air Missile (AMRAAM) program. In addition, Lockheed Martin (\$99 million), Orbital Sciences Corp. (\$37 million), Motorola, Inc. (\$25 million), Interop Joint Venture (\$18 million), and AlliedSignal, Inc. (\$16 million), also received very large R&D contracts from federal agencies in FY 1998. Note that these amounts are in addition to any federal R&D grants also received by these companies. The University of Arizona (\$13 million) and ASU (\$1 million) also received contracts from various federal agencies to conduct R&D for the federal government. Although these amounts are notable, they do not come close to eclipsing the funds that these institutions receive from federal R&D grants.

A total of \$10 million of federal R&D dollars was also received in FY 1998 by entities located in Arizona in the form of cooperative agreements. The largest of these cooperative R&D agreements (\$2.3 million in FY 1998) came from NSF to Arizona State University in Tempe, in support of the Arizona Collaborative for Excellence in the Preparation of Teachers (ACCEPT). Other federal agencies awarding cooperative agreements to Arizona-based entities include DOE, the Department of Interior, and NSF. Among these latter cooperative agreements is an award supporting one of NSF's Materials Research Science and Engineering Centers at Arizona State University. Not included among these cooperative agreements are the two that were awarded by NSF to the Association of Universities for Research in Astronomy (AURA) for the operation of the National Optical Astronomy Observatories, a federally funded research and development center. This FFRDC is detailed in the section on "Federal R&D Units in Arizona."