

# Science and Technology in the Natural State

Where we are, What we have, and Where we want to be

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State Science Advisory Committee  
Arkansas Science and Technology Authority



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## Executive Summary

Over the last year and a half the Science Advisory Committee, an advisory committee to the Board of Directors of the Arkansas Science & Technology Authority, has studied the strengths and weaknesses of science and technology within the state of Arkansas. Their work has resulted in a three part document that: 1) reviews the assets of Arkansas; both natural and geographic (where we are); 2) surveys the Arkansas research institutions; analyzing research strengths along with the relationships of research clusters and economic clusters (what we have); and 3) makes a series of recommendations based on the reviews and analysis (where we want to be).

The surveys of the institutions were the result of site visits and self-identification by the campuses of unique science, technology, engineering and mathematics (STEM) educational programs, clusters of scientists working in common research areas, and key infrastructure to support that research. A total of seventeen institutions that confer science and engineering degrees and two national laboratories are reviewed in this document. The results indicate that even though limited in scale, some of the smaller four-year institutions have some outstanding research capacity in specific areas. The larger institutions have multiple clusters with impressive infrastructure, as would be expected, but surprisingly have many differing areas of research for sister research institutions, yet when viewed holistically across the state, are very complementary. This network of research efforts is supported by advocates such as Arkansas Science & Technology Authority, Accelerate Arkansas, Arkansas Research Alliance, Arkansas Biosciences Institute and STEM Coalition.

If the research clusters across the seventeen institutions and two national laboratories are viewed collectively, they can be grouped into six categories: Advanced Materials; Aerospace & Defense; Agriculture, Food & Natural Resources; Biomedical & Biotech; Information Technology & Telecommunications; and Energy. Interestingly, these six fields correspond well with the six economic clusters identified in a study by the Institute for Economic Advancement (IEA) at the University of Arkansas at Little Rock for the U.S. Economic Commission, with only two small differences. IEA splits agriculture, food, and natural resources into two categories pulling wood out as a separate economic cluster and it did not identify energy. However, overall there tends to be a good relationship between research cluster efforts and employment figures in regions surrounding the research clusters.

The Science Advisory Committee made several recommendations related to STEM education, research, and infrastructure based on the review of the campus strengths across the state:

- Create a shared statewide vision.
- Encourage collaborative efforts.
- Leverage campus resources better.
- Provide investment in instrumentation, seed funds for both research and early start-ups and support entrepreneurial training.
- Expand STEM workforce.
- Push research that can lead to start-ups and strengthen existing enterprises.
- Create an environment that will draw from all regions and retain our best and brightest.

Finally, it was also observed that Arkansas industry has greatly increased its investment in such university research efforts, and there is a need to align research in Arkansas to encourage further increases in this type of investment and to garner support of state government. Long-term strategies with economic impact factored in must be developed within the six research focal areas identified, so that campuses can build science/engineering platforms that will have long-term positive economic impact while simultaneously building stronger public support for research and adding to the state's economic fortunes.

## Where We Are

Arkansas, the Natural State, is rich in natural resources and geographic well-positioned. Its natural value includes:

- Water Resources
- Rich Agricultural Soil
- Abundant Forests
- Natural Deposits (minerals, oil, gas, bromine brine)
- Biodiversity
- Central location in North America
- Renewable Energy Resources

Arkansas is rich in **water resources**. Arkansas has over 699,293 acres of surface water, 11,900 miles of streams and rivers, and more than 600,000 acres of lakes. [1] [2] Approximately 280 billion gallons of surface water flow through the state every day, and over 800 billion liters of high quality ground water are contained in aquifers. [3] Water is closely related to the quality of life and economic prosperity of the state. Water is important for municipality needs, industry, agriculture (crop irrigation), recreation, and tourism in Arkansas. Lakes in Arkansas provide habitat for many plants and animals, hydroelectric power, drinking water, flood control, and contribute to the natural recreation and tourism industry. Stewardship of our water resources to prevent contamination, degradation, and invasive species is necessary for a prosperous future for Arkansas. [4] Aquaculture is an economic driver in Arkansas, particularly in the Delta Region, that benefits directly from water resources in the state. The nationally-recognized Aquaculture and Fisheries Center at the University of Arkansas at Pine Bluff supports the aquaculture industry through teaching, research, and extension. The aquaculture industry has an economic impact of more than \$1.2 billion dollars in the Delta region of Arkansas. [5] Arkansas ranks third in the U.S. in catfish production and is a national leader in baitfish, goldfish, sport-fish, largemouth bass, hybrid striped bass, and Chinese carp production. Recreational fishing, a significant industry in Arkansas (\$446 million in direct expenditures to AR economy; 782,000 residents and non-residents over the age of 16 fished in AR in 2001) is also vitally connected to water resources and conservation efforts in the state. Trout fishing is another significant, water-dependant economic driver in Arkansas. In total, aquaculture and fishing, which both benefit directly from water quality, provided approximately \$1.45 billion in direct and indirect benefits to the State of Arkansas in 2004. Hunting is another major economic driver in the State of Arkansas that is directly affected by the quality of the state's water resources. In 2001, more than 430,000 hunters were registered in Arkansas, and hunting related activities had a total economic impact of more than \$900 million. [2]

Arkansas has a **diversity of rich soils** that provide a foundation for the agriculture industry in the state. Alluvial soils, found in the major and minor river valleys and primarily in the Arkansas and Mississippi river valleys, are the most productive agricultural soils in the state. [6] According to the Arkansas State Agricultural Overview of 2004, produced by the U.S. Department of Agriculture, farmland covers approximately 36% of the state. The steep topography and rocky soil of the Ozark, Boston, and Ouachita mountain region directs its use as primarily pasture, woodland or wildlife habitat rather than row crop agriculture. [6] The geographical limitation on crop agriculture and the strategic location of northwest Arkansas, close to many important economic markets, encouraged the development of a strong poultry industry in the state. According to the "Economic Contribution of Arkansas Agriculture – 2012" Arkansas's top five agricultural products, in terms of revenue, are broilers (young chickens), rice, soybeans, cotton, and cattle and calves. Agriculture accounted for \$16 billion in value added to the

Arkansas economy in 2010, and one in every six jobs in Arkansas. In 2011, Arkansas ranked in the top 25 states in the production of 24 agricultural commodities including #1 in rice, #2 in broilers, #3 in catfish (foodsize), #3 in cotton (upland), #3 in turkeys, #4 in cottonseed, #5 in sweet potatoes, #6 in grain sorghum, and #9 in soybeans. [7] Arkansas is the leading producer of rice in the United States, producing approximately 50% of all rice produced in the US in 2009. [8]

The **abundant forests** of Arkansas have created a strong forestry industry in South Arkansas. Forests cover 56% of Arkansas acreage (18.8 million acres; 9<sup>th</sup> largest timberland area in US). Approximately 14% of Arkansas timberland is National Forest and 80% is privately owned. The majority of forested acreage in Arkansas is populated with oak-hickory, loblolly-shortleaf pine, oak-pine, and oak-gum-cypress. [9] In 2001, the forest industry in Arkansas employed 97,183 workers and had a total economic impact of \$12.4 billion. [10] Forests and water resources in Arkansas are interdependent. Forests maintain water quality by acting as a buffer and filter for drinking water supplies and watersheds, protecting them from possible pollution sources. The Arkansas Forestry Commission reports that fragmentation, parcelization, urban and exurban sprawl, insects, diseases, non-native plants, wildfire, and climate change are the greatest threats to forestlands in Arkansas. [9]

Arkansas' **central location** in the United States has aided the development of a strong transportation industry. Arkansas is a natural transportation hub with a central location on a major east-west interstate highway traffic corridor, north-south waterways, air transportation, and multiple railways passing through the state. The diversity of transportation modes provides flexibility in the Arkansas transportation industry to change based on rising energy costs and has encouraged intermodal transport, like truck and rail. Transportation and the accompanying logistics and trade industries have a significant economic impact on Arkansas. [11] The Arkansas trucking industry is supported by major thoroughfares and Arkansas' central location between large cities including: Memphis, TN; St. Louis, MO; Oklahoma City, OK; Kansas City, KS; Houston and Dallas, TX. [12] Arkansas water transportation benefits from 1000 miles of commercially navigable waterways in the state. The Mississippi River, which defines the Arkansas-Mississippi/Tennessee borders, is the primary inland waterway in the US. The McClellan-Kerr Arkansas River Navigation System enables water transport between Catoosa, OK and the Mississippi River, which benefits Arkansas industry across the state. [11] Airports in Little Rock (LIT) and Northwest Arkansas (XNA) recorded more than 1.5 million commercial passenger boardings in 2010 [13] and the Clinton National Airport serves eight freight carriers. Arkansas neighbors the largest cargo airport in the US, Memphis International, and is connected directly to Memphis by the I-40 corridor. Rail accounted for 18% of the total freight transported in Arkansas in 2007. [14]

Arkansas has **deposits** of natural gas, bromine brine (#1 in world), and oil and **mineral deposits** of coal (32,000 short tons produced each year), crushed (37.2 million metric tons produced in 2005) [15] and dimension stone, diamonds, cement rock, clay (#6 producer in US), silica stone, silica sand, shale, slate, syenite, novaculite (only producer in US), marl gemstones (#7 producer in US), marble, serpentine rock, barite, tripoli (#3 in US), quartz crystal and lasca (#1 producer in US), gypsum (#9 in world), chalk, bauxite, phosphate rock, vermiculite, soapstone/talc, green sand, silver, iron, vanadium and other base metals. [16] [3] The Fayetteville Shale, located on the Arkansas side of the Arkoma Basin and underlying a large portion of northern Arkansas, contains large, unconventional natural gas deposits that have become accessible through new mining technologies in recent years. Arkansas is the 7<sup>th</sup> largest producer of marketed natural gas in the United States. [17] Gas production in North Arkansas has increased more than 400% from 2006 – 2013. [18] Arkansas has significant bromine brine deposits in Columbia and Union counties. Arkansas is the nation's lead producer of bromine (97% of all US production) and Arkansas' production accounts for 40% of the world's bromine production. [16] Ten counties in the

Coastal Plain region of southern Arkansas produce oil. Approximately 6,000,000 bbls of oil were produced in South Arkansas in 2011. The Arkansas Oil and Gas Commission serves the Arkansas people by regulating the natural gas, brine, and oil production in Arkansas.

Arkansas has a unique natural resource in its **biodiversity** which attracts researchers and eco-tourists to the state. Arkansas can be divided into 6 natural divisions; the Ozark Mountains, the Arkansas Valley, the Ouachita Mountains, the Coastal Plain, the Mississippi Alluvial Plain, and Crowley's Ridge. These regions contain uplifted plateaus, rich bottomlands, forests, woodlands, savannas, prairies, steep-sided mesas, narrow ridges aligned east-to-west, deep lakes, springs, caves, swamps, sloughs, and oxbow lakes with unique and rare species of animals and plants. The Arkansas Natural Heritage Commission protects 70 ecologically important natural areas in the state, to preserve Arkansas' biodiversity. A biodiversity database with more than 900 rare species of animals and plants is maintained by the Commission as well. [19] National research interest in native prairie acreage and wilderness areas combined with Arkansas' biodiversity facilitates unique ecology and climate change research in Arkansas. Watchable wildlife recreation is a direct economic benefit to the state from the biodiversity of Arkansas.

The National Renewable Energy Lab (NREL) has conducted various studies to estimate the **renewable energy potential** in the United States. Arkansas has renewable energy potential due to wind, solar, and biomass resources. Wind resource maps of Arkansas predict that the best wind resources (NREL Class 4-6) in the state are on the ridge and mountaintops of the Ozark Mountains in Northwest and West-Central Arkansas. At 50 meter height, wind speeds of 7-9 m/s and wind power densities of 400-800 W/m<sup>2</sup> are predicted. Many of the potential high-points are located within the Ouachita National Forest. [20] Solar resource maps for Arkansas predict 4.5-5.5 kWh/m<sup>2</sup>/Day across the state for flat-plate solar systems (such as photovoltaic panels) oriented toward the South at an angle equal to the latitude of the location in Arkansas. [21] Arkansas' biomass resource potential ranked 14<sup>th</sup> in the US based on the National Renewable Energy Laboratory's estimates from 2002 data. Arkansas biomass resources availability includes crop residues (4,796 thousand tons/year), logging residues (2,874 thousand tons/year), and primary mill residues (3623 thousand tons/year) according to 2002 data. [22]

# What We Have

## State-wide STEM Education Initiatives

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Although Arkansas is making great strides, we must make a concerted effort in the next five years if we are to achieve the Accelerate Arkansas goal of average Arkansas per capita income at or above the national average. Based on a 2011 survey (Appendix A, Table 1), in our population of workforce of 1.9 million that are 25 or older, only 19.5 % have bachelor degrees or higher. Of this 19.5% few still are bachelor degrees in STEM fields. This percentage will not support the knowledge-based economy that Arkansas desires to achieve. However, STEM strategies are in place targeting improved STEM skills and promotion of STEM career choices.

### STEM Works

In August 2011, Governor Mike Beebe and his Workforce Cabinet announced a new program - STEM Works - focused on Science, Technology, Engineering, and Math (STEM) education in high schools and universities. The goal of the STEM Works program is to change the ways in which Arkansas high school students receive STEM education and to increase the number of well-qualified STEM teachers. The secondary education component includes *New Technology Network High Schools*, *Project Lead the Way*, and *East Core*; all three projects provide rigorous curricula that emphasize project-based curriculum and hands-on, problem-based learning.

The higher education component, with a goal of preparing 1,000 new, secondary STEM teachers over 10 years, is based on replication of the UTeach model. The UTeach model, developed at the University of Texas, has been successfully replicated in other states. UTeach trained teachers earn disciplinary degrees along with teacher licensure in four-year degree programs. UTeach trained teachers are more likely to enter teaching after graduation and are retained in the classroom at higher rates than traditionally prepared teachers. Arkansas has been an early adopter of this model with three replication sites already in operation. The replication sites, at the University of Arkansas, Fayetteville, the University of Arkansas at Little Rock, and the University of Central Arkansas, enrolled their first cohorts of students in fall 2012.

### STEM Works Detail

#### U-Teach

UTeach is open to science and mathematics majors on the three participating Arkansas university campuses and offers hands on teaching experience while taking their undergrad coursework, and does so without adding extensive additional coursework. Students who complete the program are certified to teach while simultaneously completing rigorous STEM coursework necessary for medical or graduate school or the workplace. The program gives students more career options and those entering the teaching profession have extremely strong curricular backgrounds.

#### New Tech High School

The New Tech Network is a non-profit organization that provides services and support to high schools in Arkansas and across the country to implement innovative high schools that promote deeper understanding through project-based learning (PBL), a culture of learning responsibility, and a 1:1 student to computer ratio for self-directed learning. New Tech High Schools provide a unique and rigorous high school experience that prepares students with the knowledge and skills needed to succeed in college and in the careers of the “new economy”. The New Tech Network supports 120 total high schools in 18 states and Australia. There are ten New Tech High Schools located in Arkansas: Cross County High School, Lincoln High School, Arkadelphia High School, Dumas New Tech High School, El Dorado High School, Highland High School, Hope Academy of Science and Technology, Marked Tree High

School, Riverview High School, and Van Buren High School. Additional schools will be added each year over the next few years.

Link: <http://www.newtechnetwork.org/>

### **Project Lead the Way**

Project Lead the Way (PLTW) is the leading provider of rigorous and innovative Science, Technology, Engineering, and Mathematics (STEM) education curricular programs used in more than 4700 middle school and high schools across the United States and involves more than 400,000 students. The curriculum is standards-based, aligned with both Common Core and Next Generation Science Standards, and yet flexible and customizable so that schools and school districts can meet their curricular needs. Students in PLTW programs create, design, build, discover, collaborate and solve problems while applying what they learn in math and science. The hands-on, project-based engineering and biomedical sciences courses engage students on multiple levels, expose them to areas of study that they typically do not pursue and provide them the foundation and proven path to college and career success. The curriculum focuses on Technology (grades 6-8), Engineering (grades 9-12), and Biomedical Sciences (grades 9-12) and is founded in the fundamental problem-solving and critical-thinking skills taught in traditional career and technical education, but at the same time integrates national academic standards and STEM principles to create a model for 21<sup>st</sup> century learning. Arkansas Tech University is the university affiliate for PLTW in Arkansas. The teachers, selected by their school district, are required to attend and receive Core Training professional development at ATU before teaching any PLTW courses. There are currently 15 Gateway to Technology (middle school) programs, 30 Pre-Engineering programs (high School), and 5 Biomedical Sciences programs as of 2013 with more to be added in 2014 and successive years.

Link: <http://www.pltw.org/>

### **EAST Initiative**

The EAST Initiative is an Arkansas developed model that now is implemented in 6 states. EAST® (Environmental and Spatial Technology) is an educational model that uses community service and state-of-the-art equipment to facilitate learning that is student driven and project based. Facilitators guide students to work with their communities to identify problems and collaborate to find unique solutions using equipment including GIS/GPS mapping tools, architectural and CAD software, 3D animation suites, virtual reality development, etc. The unique learning environment of the EAST classroom is created by the students creating their own project-project based learning experience. Schools present their projects at the annual EAST Conference each year. There are approximately 200 EAST public schools across Arkansas and in Oklahoma, Iowa, Pennsylvania, Louisiana, and California.

Link: <http://www.eastinitiative.org/projectschools/>

### **EAST Core Schools**

EAST Core takes the developed EAST model of project based learning and applies best practices to core curricular areas, incorporating student-driven, collaborative, community projects into core classes for enhanced learning. The classes in the EAST Core are Biology, Geometry, Algebra II, Chemistry, Calculus, and Physics. EAST Core enhances high school core classes to strengthen the student's communication and problem solving skills while implementing high level technology skills. EAST Core curriculum prepares students with 21<sup>st</sup> century skills to work in the global economy. Five EAST core schools were initiated this past year with two additional to be added in 2013.

Link: <http://core.eastinitiative.org/>

## Resources and Professional Development Statewide

### Education Resource Centers (Arkansas Department of Education)

#### *Education Service Cooperatives*

The Education Service Cooperatives provide broad offerings of professional development throughout the state for Arkansas K-12 teachers. Fifteen cooperatives are strategically located around the state to service multiple counties and schools. Each cooperative reaches as few as 3 and as many as 9 Arkansas counties and as few as 10 and as many as 35 school districts. Cooperative personnel provide assistance in many areas including literacy, science, math, technology, gifted and talented, distance learning, early childhood, special education, dietetics, home school testing, etc.

Link: <http://www.arkansased.org/contact-us/education-service-cooperatives>

#### *Arkansas Network of Centers for STEM Education*

The Arkansas Network of STEM Centers provides regional hubs of STEM resources for teachers, administrators, students, and the public at 12 higher education institutions throughout the state. The STEM Centers are staffed by a director, a science specialist, and a math specialist to provide a variety of services and support for STEM education in the state. This model was initiated through an NSF SSTI grant (1993-99) setting up the Centers and adding math specialists. A US Department of Education Grant added the science specialists in 2003. The STEM Centers enrich the knowledge and teaching practices of teachers in STEM by linking higher education institutions, K-12 public schools, educational service cooperatives, and business. The Centers also work to keep the public informed and offer implementation assistance as it relates to trends in education.

Link: <http://www.arkansasstemcoalition.com/partners/arkansas-stem-centers/>

## Other Outreach Resources

### **STRIVE Program**

Project STRIVE is sponsored by the University of Arkansas at Little Rock. The Arkansas STRIVE program places middle, junior high, and senior high school science, math, and computer teachers into summer research positions with industries, businesses, government agencies, universities, research facilities, and nonprofit organizations. The purpose of the program is to provide teachers with hands-on, real-world research experiences that expand their scientific and technological knowledge. STRIVE is funded by a combination of funds from ADE and by ADHE through the No Child Left Behind grants.

### **Space Grant Consortium Outreach**

The BalloonSat and CricketSat outreach programs of the Arkansas Space Grant Consortium facilitate near space environmental experiments for high school students. The BalloonSat program flies weather balloons with small payloads to the edge of space and then recovers the payload using ham radios and real-time GPS transmissions. The CricketSat program allows students to build and fly a temperature sensor circuit for remote temperature sensing of the atmosphere as a function of altitude. The outreach activities introduce students to engineering principles in an engaging format. Four Arkansas higher education institutions (UALR, ASU, UCA, and UA) facilitate the BalloonSat and CricketSat programs.

Link: <http://www.arkballoons.com/index.html>

### **Arkansas STEM Coalition**

The Arkansas Science, Technology, Engineering and Math (STEM) Coalition is a statewide partnership of leaders from the corporate, education, government and community sectors which plan, encourage, coordinate and advocate policies, strategies, and programs supportive of excellence in science,

technology, engineering, and mathematics (STEM) teaching and learning in order to expand the economy of Arkansas and produce higher paying jobs.

Link: <http://www.arkansasstemcoalition.com/>

### **Arkansas ASSET Initiative (NSF) Outreach**

Advancing and Supporting Science, Engineering and Technology (ASSET) is a statewide program of the Arkansas Science & Technology Authority, funded under the NSF Experimental Program to Stimulate Competitive Research. ASSET Initiative Education, Outreach and Diversity goals center on providing quality professional development opportunities for STEM teachers and supporting novel and innovative programs designed to expand and strengthen Arkansas' STEM pipeline. ASSET's multi-university research projects (plant bioproduction, solar cell technology, and power electronics) set the tone for a diversity of STEM Education and Outreach opportunities tailored to meet the needs of Arkansans.

*Project-based Learning Kits and Mobile Resources*

Biotech-in-a-box (BTNB) and Power Box are fully developed, hands-on sets of classroom activities that provide equipment typically outside of a teacher's budget with instructions and protocols that ensure that both the equipment and experiments work in a grade appropriate manner in the classroom. The BTNB integrates current plant biotechnology techniques with topical issues in DNA analysis, biofuels, environmental and agricultural sustainability, and the Arkansas educational frameworks. The Power Box is designed to develop understanding regarding energy including: (1) the nature of energy; (2) how energy is generated, (3) how energy is used, and (4) renewable energy. Teachers receive professional development to equip them with the background and skills to effectively implement the BTNB and Power Box curriculum in their classrooms.

Links: BTNB - <http://www.plantpoweredproduction.com/education-outreach/>

Power Box - <http://www.victorcenter.com/education-outreach/>

The GREEN Mobile is a solar energy learning laboratory on wheels, designed to teach students about solar energy and encourage students to pursue STEM fields. The GREEN Mobile is particularly designed to reach rural areas of Arkansas to educate students and raise awareness of solar energy in Arkansas.

Link: <http://www.argreencenter.com/education-outreach/>

### *STEM Undergraduate Research Initiatives*

Undergraduate research opportunities are provided to Arkansas students each year through the ASSET STEM Student Undergraduate Research Fellowship Partnership. Undergraduates from across the state gain practical, hands-on experience guided by the top researchers in our state, in the research areas of the ASSET project. ASSET focuses on increasing female and under-represented participants in the project's three research centers by collaborating with the Arkansas Louis Stokes Alliance for Minority Participation (ARK-LSAMP) program to provide the Louis Stokes Alliance for Minority Participation Diversity Partnership. In collaboration with the University of Arkansas at Pine Bluff, lead institution for ARK-LSAMP, ASSET Initiative provides financial support for upper level students who have expressed interest in working in ASSET research.

### *Summer STEM Academies*

ASSET also provides Summer STEM Academies promote and fund summer academic programs for Arkansas high school students that provide real world learning experiences in a university environment and to enhance the student's STEM career choices. ASSET supports the development of summer academies and the training for faculty and staff to deliver summer academies. Summer academies, funded by the Winthrop Rockefeller Foundation and ASSET have occurred at many Arkansas institutions

of higher education over the past 7 years including ASU, UCA, UALR, UA, Mid-South College, Henderson State University and others.

Link: <http://www.asta.arkansas.gov/asset/Pages/default.aspx>

### **Arkansas Department of Higher Education SURF Program**

The Arkansas Department of Higher Education offers a competitive program that funds many summer research experiences for students at any 4-year institution across the state. The state funded program provides stipends, travel and supply costs to allow student to work in research opportunities in both STEM fields as well as non-STEM research. Each year students across the state compete for these awards in the fall and if awarded they participate with a mentor in laboratory projects in the spring and/or summer. Each year approximately 90 awards are made for meritorious student-proposed projects.

Link: [http://www.adhe.edu/divisions/financialaid/pages/fa\\_surf.aspx](http://www.adhe.edu/divisions/financialaid/pages/fa_surf.aspx)

### **University Summer STEM Academies**

Many universities offer summer educational experiences for high school students and in some cases, junior high and middle school. Some programs such as UA Engineering, UALR Engineering and Information Technology, ASU Arkansas Biosciences Institute, and UCA STEM are recruitment tools that offer enrichment and engagement experiences in engineering, science and/or mathematics. Other programs such as UAPB STEM Academy provides a summer of enrichment, tutoring and mentoring program for incoming STEM freshman to assure successful matriculation. UAMS has many diversely-focused programs such as the Summer Science Enrichment Program.

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## **Higher Education Institution Analysis**

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### **Technology, Infrastructure/Expertise and Research Support:**

There are various policy groups and support structure in place that advocate for expanded educational efforts and increased research capacity. Additionally, all of the seventeen campuses assessed in this study have established research clusters, many of which are quite significant on the larger research-focused campuses. All of this creates an environment that is conducive to expanding the statewide impact that universities play in moving Arkansas toward a 21st Century workplace.

**Accelerate Arkansas Goal:** Accelerate Arkansas is a statewide group of business and education leaders committed to building a competitive, knowledge-based economy in Arkansas with the goal of achieving parity in per capita income with the U.S. average by 2020. Once attained, approximately \$2.4 billion in additional tax revenue will be created for the state on an annual basis.

The Accelerate Arkansas Strategic Plan describes Accelerate Arkansas' recommendations for policy changes that will enable the state to build and accelerate its knowledge-based industries. The study entitled Arkansas' Knowledge Economy Initiatives: Analysis of Progress and Recommendations for the Future was recently released in cooperation with the Arkansas Economic Development Commission, Arkansas Science & Technology Authority, Arkansas State Chamber of Commerce, Arkansas Research Alliance, and Accelerate Arkansas. The study was conducted by the Battelle Institute, a nonprofit organization recognized as a global leader in science, technology, education, and commercial innovation.

**Arkansas Research Alliance:** The Arkansas Research Alliance is a nonprofit organization that accelerates Arkansas' ability to compete in a 21st century economy by focusing on university-based research.

Concentrating on statewide economic development, the ARA invests in university research and innovation that can incubate new businesses and create high-paying jobs in Arkansas. The ARA partners with economic development sources including:

- existing businesses,
- new business from the private sector and
- new business from university-based innovation.

The ARA was established to help achieve the first core strategy of Accelerate Arkansas: *Support job-creating research*. The ARA's focus is on university-based job creating research as an avenue to developing a knowledge-based economy in the state of Arkansas.

**Arkansas Biosciences Institute:** The Arkansas Biosciences Institute is a partnership of scientists from Arkansas Children's Hospital Research Institute, Arkansas State University, the University of Arkansas-Division of Agriculture, the University of Arkansas, Fayetteville, and the University of Arkansas for Medical Sciences.

Established by the Arkansas Tobacco Settlement Act of 2000, and with an annual budget of approximately \$10.5 million, the purpose of the Arkansas Biosciences Institute is to conduct:

- **Agricultural research** with medical implications;
- **Bioengineering research** that expands genetic knowledge and creates new potential applications in the agricultural-medical fields;
- **Tobacco-related research** that identifies and applies behavioral, diagnostic, and therapeutic knowledge to address the high level of tobacco-related illnesses in Arkansas;
- **Nutritional and other research** that is aimed at preventing and treating cancer, congenital and hereditary conditions, or other related conditions; and
- **Other areas of developing research** that are related or complementary to primary ABI-supported programs.

ABI's focus on agricultural and biomedical research expands the state's existing research base by leveraging ABI support to attract extramural funding to Arkansas. Since inception, ABI-supported scientists have attracted more than \$430 million in outside funding from the National Institutes of Health, the National Science Foundation, the US Department of Agriculture, and other agencies and foundations. This represents approximately \$3.32 dollars in outside funding for Arkansas for every one ABI dollar.

The Arkansas Biosciences Institute's long-term agricultural and biomedical research focus serves as a catalyst for increasing university-based research and laboratory-to-industry collaborations.

## **Cyberinfrastructure**

### **ARE-ON, HPC & super computers and MASS SPEC**

The Arkansas Research and Education Optical Network (ARE-ON) organization and its members comprise a community of thought leaders focused on collaborative learning and innovation through advanced networking, technology, and research in Arkansas. ARE-ON is a not-for-profit consortium of all public degree-granting institutions in Arkansas and other selected higher education organizations. ARE-ON provides a high-speed fiber optic backbone network throughout the state with 1Gb and 10Gb Ethernet connections to its members, affiliates, national research and education networks, regional optical networks, and commercial service providers. The network consists of approximately 1500 miles of long-haul fiber optic cable and about 40 miles of metro fiber in nine cities and four neighboring states. ARE-ON's extensive reach allows institutions to connect, collaborate, and innovate within the organization's core agendas: education, telemedicine, research, and emergency preparedness.

Major supercomputing resources exist in both Northwest Arkansas (University of Arkansas, UA) and Central Arkansas (University of Arkansas at Little Rock, UALR), and on a smaller scale at the Arkansas State University (ASU) in the northeast corner of the state, as well as at the University of Central Arkansas (UCA). An award to create facilities at UAPB was received in May from the Defense University Research Instrumentation Program (DURIP), a highly competitive award from the Army Research Office (ARO). The UA has available the Star of Arkansas, the Razor Cluster, GPU Nodes and Big Memory Node. The UALR HPC Cluster, Argon and Boron are relatively new, operational in the last three years and one year, respectively. ASU and UCA are very recent cluster developments.

The University of Arkansas Statewide Mass Spectrometry Facility is a state-of-the-art mass spectrometry resource established in 1999 through a combination of National Science Foundation and state funding. Its charge is to provide sophisticated mass spectrometry support for academic, government, and industrial researchers within Arkansas and nationally. This user facility opens to all researchers and has a multi-state reputation for exception analysis and research.

## Arkansas Universities

As a result of the natural resources, the economic impact of various existing industries, or emerging opportunities in areas of potential advanced technology industries, the state and our university campuses have made major investments in many areas of research to support the state's economy. Each of the state's universities (both 4-year and graduate institutions) have been analyzed for STEM educational efforts, cross-cutting or interdisciplinary/cluster research efforts, major equipment infrastructure, and unique or historic databases, collections or other resources suitable for research. The following is a summary of each institution listed alphabetically.

### Arkansas State University

#### **Unique STEM Education**

Arkansas State University has several unique outreach programs that are offered through the College of Sciences and Mathematics (CSM) and the Arkansas Biosciences Institute (ABI). The grant-funded programs for the College are coordinated through the Science-Mathematics Academic Resources and Tracking (SMART) Center. Amongst others, these include the Noyce Program, which seeks to increase the number of STEM secondary teachers, and the Experiential Learning Fellowships (ELF) Program, which has teams of students working on civic issues sent to them by local citizens and groups. Along with these, the College supports the Arkansas BalloonSAT Project that involves atmospheric researchers working with local school kids to launch high-altitude experiments developed by the kids. The College also supports the oldest science fair competition for middle and high school students in the state of Arkansas and annually sends competitors to the International Science and Engineering Fair. Through its educational outreach, ABI provides opportunities for students and parents to conduct hands-on experiments (ex. "Making Biodiesel", "DNA Extraction and DNA Electrophoresis") in the ABI research labs. The Institute also provides the attendees with educational tours of their lab facilities during these visits so that the public is more aware of the research that is being done.



**Figure 1: Biosciences outreach at Arkansas State University**

#### **Research Clusters**

Center for Efficient and Sustainable Use of Resources (CESUR)

CESUR research focuses on environmental sustainability by developing efficient and sustainable materials and energy conversion/storage practices. The center's construction materials development and testing expertise is leveraged to develop bio-based materials as well as materials recycled from the construction or paving industry, including collaboration with Jonesboro solid waste. In collaboration with Lexmark, they are also working to reduce energy and materials input in the printing process using nano- and micro-fabrication.

#### Ecotoxicology Research

The Ecotoxicology Research Facility at ASU is an EPA-certified laboratory for testing of whole effluent toxicity, nutrients, and total suspended solids (TSS). Non-point source pollution research includes in-stream sample collection and analyses for TSS and nutrients to identify and reduce agricultural and construction related contamination. A project in the Cache River basin identifies biological indices to predict wetland water quality and function. Researchers are collaborating with the ADEQ, USGS and the Arkansas Multi-Agency Wetland Planning team. Nanotoxicity research includes the study of aquatic uptake and food chain transfer of quantum dots which can contain toxic metals in the core of their layered structure.

#### Materials Science and Engineering

An interdisciplinary group of researchers from Engineering, Physics, and Chemistry works on developing innovative materials and sensors. Amongst the current work are studies of particle transport in semiconductors and the interaction between semiconductors and radiation.

#### Plant-based Protein Production

These teams focus on developing the technology to use plants as "factories" for production of complex human therapeutic proteins to treat cancer and other diseases, safer subunit vaccines and critical proteins for the veterinary and industrial sectors, and biofuels and biomass for energy use. Unique expertise exists in transgenic plants and hairy roots for bioproduction of therapeutic proteins and "specialized" (secondary) metabolites, protein processing and glycosylation, bioproduction of mucosally-delivered vaccines and vaccine adjuvants, and s technologies that make the production of cellulosic ethanol possible and affordable, including the creation of inexpensive enzymes.

#### Plant Metabolic Engineering

This research cluster focuses on such areas as plant metabolic engineering, Vitamin C metabolism, plant stress tolerance, phytoremediation, and enhancing plant production of key proteins and economically important chemicals. The teams focus on harnessing the power of plants to provide us with nutraceuticals, novel bio-active compounds for medicines and crop plants with enhanced nutritional and health benefits. Special expertise also exists in bioinformatics.

#### Neuroscience

Teams work on nicotine effects on stimulus properties, appetite and aversion effects, and effects on developing neonatal autonomic nervous system. Additionally, there is significant neuroscience expertise in neuronal development, mechanism of action of acetylcholinesterase, organophosphate pesticides and neurotoxicity, and structure-function relations in glycosylated neural proteins.

#### Marine Science

Researchers in this area are currently working on the effects of invasive species, oil spills, and aquatic parasites on marine ecosystems. Focus areas for the team are the Caribbean, the Gulf of Mexico, and the Western Pacific.

### Ornithology and Flying Mammals

This cluster studies local native species and the impact that various human activities have on them. Current research is on the effects of urbanization on bluebird populations, the effects of forest and game management on warblers and turkeys, and the causes and effects of white-nose syndrome in bats.

### Bioinformatics

Current research is on computational and mathematical model design, graphic and parameterized algorithm development, computational optimization, and applications in addressing challenging biological problems. This interdisciplinary team is working with researchers at a variety of medical colleges across the U.S.

### Molecular Innovations in Food Science

Researchers are designing cutting-edge molecular-based technologies for enhancing the quality and safety of the foods we grow and eat. Teams have expertise in designing molecular-based high throughput diagnostics for plant and food industries, rapid detection assays for pathogens in foods using nucleic acid probes and antibodies, and DNA microarray for detection and characterization of pathogens in foods and environments.

### **Unique Instrumentation**

LemnaTec (Plant Phenomics)  
Concentrated Solar Power Experimental Simulator  
Optical Contact Angle Analyzer  
EcoTox Facility Equipment  
High Performance Computing Cluster  
Three-color tunable picoseconds laser system

### **Databases**

Herbarium, Mollusks, and Herpetology Collections Plant Genetic Database

## Arkansas Tech University

### **Unique STEM Education**

The nuclear physics program at ATU is unique to the state of Arkansas and provides a firm theoretical foundation for persons employed or seeking employment in the nuclear power industry as well as the training needed to prepare for graduate studies in nuclear physics or nuclear engineering. The Master of Science in Health Informatics at ATU is a specialized program of study to serve the increasing workforce needs in the area of health information technology. The curriculum is designed to prepare graduates in the area of privacy and security of health care information, leadership and policy within the health care environment, as well as emerging concepts in health care information technology.



Figure 2: Fisheries and Wildlife field gear at Arkansas Tech University

ATU has a well-established engineering program which aligns closely with industry needs of Arkansas. Both the mechanical and electrical engineering programs at ATU have a hands-on approach that provides unique learning opportunities for undergraduate students. Interactive undergraduate teaching labs include the robotics lab, power systems lab, digital microprocessor lab, and the materials fabrication, testing, and characterization lab. As a result of the hands on learning approach, ATU students have been successful in obtaining internships with both state and national organizations such as Entergy, Arkansas Center for Space & Planetary Sciences, NASA, New Jersey Institute of Technology, and Oak Ridge National Laboratory to name a few.

Arkansas Tech University is the lead campus for Project Lead the Way, a secondary school program in pre-engineering and recently an expansion into biotechnology. Project Lead the Way expansion into more high schools is one of the components of the Governor's STEM Works Program.



**Figure 3: Research laboratory at Arkansas Tech University**

## **Research Clusters**

### Fisheries and Wildlife

Fish and wildlife research is a major research thrust at ATU and covers a wide range of research focused in Arkansas. Faculty research interests include:

- The ecology of non-game stream fish, especially movement and mortality responses to physical and chemical conditions
- Fisheries management, large river ecology, urban fisheries
- Freshwater fisheries management, propagation of commercial and rare species, biology of freshwater mussels, reproductive biology of fishes
- Avian ecology in forested ecosystems, influence of forest management on avian populations, ecology of brown-headed cowbirds, use of landsat imagery to model avian habitats.
- Small mammal population dynamics; management of game and non-game species; use of spatially explicit models to describe landscape-level population processes
- Waterfowl and wetlands ecology and management

### Ecology

Aquatic research teams focus on ecology of benthic macroinvertebrates, use of aquatic biota (fish, microinvertebrates, herptiles) to understand broad-scale geographical impacts of land uses, conservation of aquatic habitats, invertebrate life history adaptations to disturbance, and biogeography. This also includes sustainable use of natural resources, water scarcity, groundwater conservation, and invertebrate ecology and evolution, pycnogonid life histories. Other research focuses of population genetics and evolution of scorpions, in particular the population genetics of the bark scorpions. Populations of this scorpion encompass a large geographic range that includes western Arkansas.

### Renewable Energy Materials

Renewable energy materials are studied in association with the Arkansas Center for Energy, Natural Resources and Environmental Studies at ATU. This research includes the study of new, low-cost catalysts (biomimetic iron catalyst) for the production of hydrogen, and photocatalyst development for solar energy conversion. Other related expertise includes synthesis, characterization and application of

multifunctional magnetic nanoparticles, structural characterization of materials, and Raman spectroscopy theory.

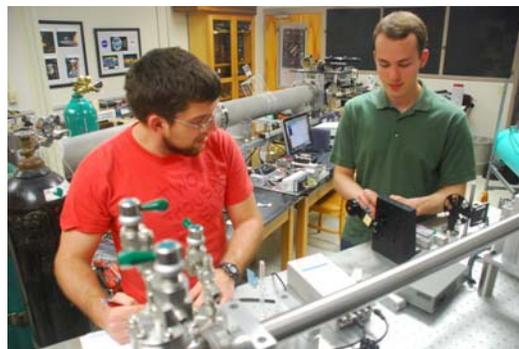
### **Unique Instrumentation**

Wide variety of Wildlife and Fisheries Equipment

### **Databases**

Zoology Collection

Herbarium



**Figure 4: Harding University students working in the Mars Simulation Laboratory**

## Harding University

### **Unique STEM Education**

Undergraduate students have unique opportunities to participate in various NASA sponsored aerospace projects and competitions around the country. Participation in these projects and competitions strengthens student's education in physics, chemistry, computer science, electrical engineering, and mechanical engineering. The projects and competitions include the Mars Spectrograph Project, the National Student Solar Spectrograph Competition, the RockSat-C competition, and the University Student Launch Initiative.

### **Research Clusters**

#### Aerospace

Aerospace research and instrumentation are very strong at Harding. Focal areas include:

- Rapid prototyping of hybrid rocket fuels (Collaboration with Marshall Space Flight Center, UALR)
- Developing a guidance scheme for a fleet of micro satellites (Collaboration with UA, UALR, Marshall Space Flight Center)
- Building an improved mobile robot for carrying science payloads on space missions (Collaboration with UAFS)
- Mars spectrometer Project (Collaboration with UALR)
- Atmospheric studies of lifetimes of pollutants in the atmosphere (Collaboration with UALR and Jet Propulsion Laboratory)

### **Unique Instrumentation**

Mars Simulation Laboratory: along path-length optical chamber with pressure and temperature controls for testing instrumentation and measuring spectra of gases. This instrumentation allows measurements to be made under low pressure and low temperatures like that of a Mars environment and can be used to create a variety of atmospheric conditions.

**Databases** Not applicable (NA)

## Henderson State University

### **Unique STEM Education**

Henderson State University hosts the Arkansas Undergraduate Research Conference every year in April that attracts undergraduate researchers from across the state to present their work.

A new Undergrad of Science Degree Program at HSU, Engineering Physics with concentration in electronics and electrical engineering, is set to begin in the fall 2013 term pending approvals. The program will be beneficial to the students and university as well as the surrounding community and industry.

The campus also has an excellent planetarium used for K-12 outreach and student training. The campus recently constructed the Simonson Biological Field Station on DeGray Lake for student ecology studies which have much potential for expanding research-based education.

### Research Clusters

#### Chemistry Research

Research includes the study of mercury levels in Arkansas (environmental research), drug synthesis, low volatility polymers, DNA synthesis, and antiviral nucleosides.

#### Physics Research

Research includes the study of low frequency radio-wave research, geophysics, seismology, hot springs discovery in Arkansas, astrophysics, aerodynamics, and theoretical research of atomic physics and particle interactions (using the EXCEED supercomputer).

#### Unique Instrumentation

NF Webscope (The NF Webscope is a fully automated telescope, located on a ranch in Silver City, New Mexico that queues requests from Arkansas researchers and students, captures images and sends the information back to Arkansas.)  
DeGray Lake - Simonson Biological Field Station

#### Databases

Moth Collection  
Rock and Mineral Collection (90 specimens)  
Mercury Concentrations in Arkansas

#### Hendrix College

##### Unique STEM Education

Green chemistry, the design of reactions to reduce or eliminate hazardous materials, is a focus in the undergraduate training on this campus. Hendrix College's faculty-developed green chemistry education materials are published in peer-reviewed journals, and implemented in the introductory course series of

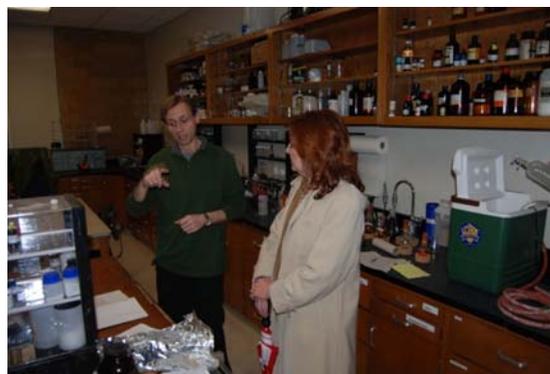


Figure 6: Chemistry Research Laboratory at Henderson State University



Figure 7: NF Webscope - Fully automated telescope, operated by Arkansas researchers and located in New Mexico



Figure 5: Green Chemistry laboratory at Hendrix College

General and Organic Chemistry for students to learn green chemistry methods and techniques. Green chemistry techniques are also put into practice at Hendrix through the faculty's basic research, which allows undergraduate researchers to apply green chemistry techniques.

## Research Clusters

### Biomedical Research

A loose association of researchers has interest in human applications including:

- Study of the biochemical mechanisms by which alcoholic beverages produce liver damage using cell fractions, cells, and experimental animals, with analytical, biological, and cellular chemical techniques.
- Research to understand the proteins that package DNA to create chromosomes, as well as the proteins that modify this packaging to ensure proper gene transcription using yeast as a model system to further our knowledge of basic aspects of human cell biology.
- Research to understand how extracellular growth factors and intrinsic patterns of transcription factor expression regulate neuronal progenitor cells in order to generate proper numbers and types of neurons during mammalian nervous system development.

### Environmental research

Environmental research at Hendrix College involves the sampling of water and soil near campus, water quality testing in the delta region of Arkansas, and the effects of natural aerosols on the earth system for a better understanding of how mineral aerosol influences bio-geochemistry, atmospheric chemistry, and climate.

### Robotics

Research interests in robotics include robots applications for border control, cooperative robots, and reactive control for mobile robots, sensor autonomy, and reactive control for mobile robots. These interests relate to specific areas of expertise including navigation, robot vision, machine learning, autonomous learning from sensor input, and software architectures.

### Zoology

Researchers study various mammalian and reptilian species. The chemical signals in secretions and excretions from threatened or endangered mammalian species (African elephant, Ring-tailed Lemur, Maned Wolf, etc.) are studied as well as snake species (coral snakes, copper heads, queen snakes), with a concentration by two researchers on the venom of certain species. Breathing muscles in cetaceans and guinea pigs are also studied.

### **Unique Instrumentation**

Ring Laser Gyroscope (51 meter) for seismic analysis  
Access to the Thomas Jefferson National Accelerator Facility  
Animal Holding Facilities (unusual for size of school)

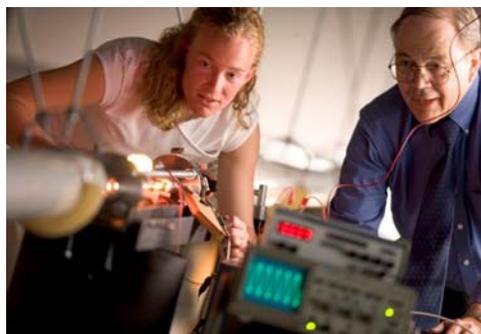


Figure 6: Ring Laser Gyroscope for seismic analysis at Hendrix College

## Databases (NA)

### John Brown University

#### **Unique STEM Education**

JBU offers a choice of three concentrations for the Undergrad of Science in Engineering degree, including a unique concentration in renewable energy. The Renewable Energy Concentration courses include a Practicum in Renewable Energy, Wind Energy, Solar Energy, and Bio-fuels and Biomass.

#### **Research Clusters**

##### Biomedical Research

Researchers study gene regulation of a gene (myelin proteolipid protein (PLP) gene) that is expressed in the central nervous system its association with neurodegenerative disorders, Q-fever and the intra-cellular parasite that causes it (Arkansas is a high incidence rate state with 1.0-4.9 cases per million persons), and medicinal chemistry to develop drugs that can interact with tuberculosis antigen for the discovery of anti-tuberculosis drugs.

##### Ecology

Stream Ecology research is conducted on a tributary of the Illinois River that runs through the JBU campus. Benthic micro-invertebrates from the stream are studied to assess water quality. Many undergraduate researchers are involved with this work. Additionally, one of the largest remaining populations of the endangered American burying beetle (ABB), located in Oklahoma, Arkansas, Kansas, and Texas is studied and the research is applied to assist with the conservation of this endangered species.

##### Renewable Energy

Research in renewable energy supports the Renewable Energy Concentration for the Undergrad of Science in Engineering. The research supports six undergraduate researchers and includes work in bio-fuels, fuel cells, and organic solar cells.

#### **Unique Instrumentation**

Stream Ecology equipment  
Springboard Biodiesel Processor

## Databases (NA)

### Lyon College

#### **Unique STEM Education**

The pre-engineering program at Lyon College has formal agreements with the University of Arkansas and Missouri University of Science and Technology for students to complete core math and science courses at Lyon College for 2-3 years and then transfer to complete an Undergrad of Science in Engineering. The low professor-student ratio at Lyon College allows for unique advising opportunities that provide excellent workforce development and has encouraged many students to pursue M.S. and Ph.D. STEM degrees at very high research universities (RU/VH) across the country.



Figure 7: Biomedical research laboratory at John Brown University

## Research Clusters

### Ecology

Researchers collect isolates of species from Arkansas caves for documentation and study. Many of these samples are previously undefined. This database of samples documents the status of a cave at the present time and may be useful for future research, especially as diseases spread in caves across the United States.

Researchers also collect samples for area lakes, rivers, and streams. Unique sampling equipment (deep stream pool plankton sampler; heavy vegetation bilge pump sampler) is designed by researchers and collected samples are characterized and documented.

### Biochemistry

Research to understand cellular response to toxins from food, drugs, and the environment is conducted on the model organism, *C. elegans*.

### **Unique Infrastructure**

AC Impedance Measurement System (Temp. Range: 70K - 400K; Freq. Range: 5 Hz to 13 MHz; primarily for characterization of ferroelectrics and glassy materials)

Biolistic Particle Delivery System (Bio-Rad)

Microinjection System; fluorescence dissecting microscope (*c. elegans* research)

### **Databases**

Local water database

Unique Cave species database

## Ouachita Baptist University

### **Unique STEM Education**

#### Howard Hughes Medical Institute – Science Education Alliance

The School of Natural Sciences at Ouachita Baptist University is a partner school in the Howard Hughes Medical Institute Science Education Alliance (SEA) which equips Ouachita to engage undergraduates in scientific research early in their college education. The program puts freshman students in a laboratory to isolate local soil-dwelling bacterial viruses, called phages, analyze the DNA sequence and use bioinformatics tools to analyze and annotate the genome. The School of Natural Sciences has seen significant improvement in the level of undergraduate research by students who began the Science Education Alliance program in their freshman year when they conduct degree required research as juniors and seniors.



Figure 8: *C. elegans* research laboratory at Lyon College



Figure 9: Phage Laboratory at Ouachita Baptist University

## Research Clusters

### Water Quality

The Ouachita Water Lab has a large database of water quality data from Arkansas rivers, streams and lakes going back 30+ year (including the Caddo River, Lake Ouachita, Cache River, Lake Chicot, Lake DeGray, Lake Greeson and other bodies of water in Arkansas). The water lab is certified by the Arkansas Department of Environmental Quality for water quality testing. Work in the lab is funded through local industry partners, and state and federal funding.

### Cancer Research

Cancer research at OBU is primarily funded through the INBRE program and much of the work is in collaboration with UAMS. The cancer lab is equipped with an incubator, a plate reader, and a tissue culture room and other support equipment. There are approximately 4 professors involved in cancer research at OBU.

### Computational Chemistry Center

The facility is primarily utilized as a research laboratory for molecular modeling with five students conducting research projects in the lab during the 2012-13 academic years. The CCC is also utilized by students in courses such as Physical Chemistry, Biochemistry, Advanced Chemical Calculations, and Experimental Techniques in Chemistry.

### **Unique Instrumentation**

Howard Hughes teaching lab, Computational Chemistry Center

### **Databases**

Arkansas Water Quality Database

## Southern Arkansas University

### **Unique STEM Education**

The Natural Resources Research Center (NRRC) provides unique undergraduate research opportunities to the College of Science and Technology students by facilitating research experiences in the NRRC through local businesses contracts. The NRRC currently has 6 funded positions for undergraduate researchers in the NRRC and plans to expand to 20 positions. The center recognizes its responsibility to aid in the training of scientists to meet the needs of the region. Experiences in the NRRC with SAU faculty and NRRC staff develop and train SAU students to become scientists to meet the high technology demands of Southern Arkansas industry. The NRRC is an Arkansas Department of Environmental Quality (ADEQ) certified laboratory.



Figure 10: Water quality research laboratory at Ouachita Baptist University



Figure 11: Researchers in the Natural Resources Research Center at Southern Arkansas University

## **Research Clusters**

### Analytical Chemistry

The Natural Resources Research Center (NRRC), opened in 2010, consists of seven separate laboratories and is thoroughly equipped with state-of-the-art analytical chemistry instrumentation to meet the needs of industries, public agencies, and private citizens. The NRRC analytic capacity and rapid turn-around on samples have strengthened its industry partnerships in South Arkansas. The researchers in this center provide unique analytical research capabilities for the College of Science and Technology. In addition, the NRRC can provide expertise and consulting in the areas of general research & development, quality control, analytical chemistry, nectar sampling, alternative energy & fuels, water, and soil chemistry.

### **Unique Instrumentation**

Extremely well equipped Natural Resource Research Center (NRRC) Equipment - high throughput chemical analysis.

### **Databases**

SAU Biodiversity Database- contains 3,323 specimens in total, not including mammals or birds, chiefly from Columbia County, Arkansas.

## University of Arkansas, Fayetteville

### **Unique STEM Education**

The Freshman Engineering Program (FEP) at the University of Arkansas, Fayetteville has greatly improved the retention rates in the College of Engineering by providing mentoring, tutoring, academic and career advising and an introduction to each engineering discipline to every incoming freshman engineering student. Students choose their discipline of engineering at the end of the first year of study, providing more time for the students to pick the discipline that aligns with their career goals. College of Engineering 2<sup>nd</sup>-year retention has increased from 61% (1998-2006) to 68% (2007-2011) with the implementation of the FEP.

### **Cluster Research**

#### Energy and the Environment

**Electronics Research:** Electronics research at the University of Arkansas, Fayetteville (UA) is focused on the challenges in energy including transportation, the smart grid, and energy exploration. Eight researchers in the College of Engineering and Fulbright College are directly involved in power electronics, integrated circuit design, 2-D materials, and optoelectronic device research for a broad range of energy applications. This research cluster includes world-class facilities in electronics packaging (**HiDEC**) and high power electronics testing (**NCREPT**), approximately 20 industry partners (**GRAPES**), and a high number of spin-off companies (>6) from the research.

**Environmental Research:** Environmental research for a sustainable future spans the colleges with research in many environmental subtopics including water, soil, atmospheric studies, geophysics, energy, oil and gas production and its effect on the environment, habitat alteration, environmental economics, and environmental policy. Water, a valuable Arkansas natural resource, is studied extensively. Water research topics include water quantity and quality, pollution (non-point source, broiler waste management), irrigation technologies, restoration, watershed management, ecological risk

assessment, remote sensing of water resources, membrane-based water treatment and purification, and the application of geospatial technologies (**CAST**) for water research are studied. Air pollution modeling of potential safety mishaps in chemical processing is a research strength, as well as life cycle assessment of carbon balance for food production. Soil research for responsible and sustainable farming practices support the agricultural strengths of the state.

**Renewable Energy:** Photovoltaic cell design, fabrication, and characterization are research strengths of a large group of both engineers and scientists and a number of start-up companies have spun off this research. Bio-fuel research is also an expertise of the campus and includes biomass production (lignocellulosic and algae) and post-harvest engineering, energy use at the farm level, bio-refineries, thermo-chemical conversion of biomass and byproducts, extraction of co-products, and conversion to bio-fuels. Researchers use state of the art tools for pretreating biomass, biomass hydrolysis, fuel production, surface characterization and analysis, simulations of sugar conversion mechanisms, slow speed wind modeling, and life-cycle assessment.

#### Supply Chain, Retail, & Transportation

A large group of researchers in Civil and Industrial Engineering and two research centers (with state, federal, and industry partners) the **Center for Excellence in Logistics and Distribution (CELDi)** and the **Mack-Blackwell Rural Transportation Center**, support the Supply Chain, Retail, and Transportation research cluster at UA. The cluster includes basic research in transport materials, soil, and water and applied research in traffic modeling, economic operations analysis of transportation systems, freight data analysis and modeling, multimodal network optimization, emergency logistics planning, and facility logistics (ex. healthcare logistics).

#### Nanotechnology Research

The cross-cutting nanotechnology research thrust at UA includes work in nanomaterials, nanolubricants, nanoscale surface engineering (self-cleaning, anti-reflection, antifogging, anti-wear), nanomechanics, nano-biotechnology, drug delivery systems, food safety electronics (biosensors), nanomanufacturing and self-assembly in many departments across the university, including, physics, biological sciences, chemistry, chemical engineering, civil engineering, mechanical engineering, biological engineering, electrical engineering, and food Science. Unique equipment and expertise at UA has led to the distribution of nano-scale samples, fabricated at UA, to researchers around the world.

The **University of Arkansas Institute for Nanoscience and Engineering** has 16 affiliated tenure-track faculty and is centered in the Nanoscale Material Science and Engineering building which houses state of the art equipment with multi-user labs and cleanrooms designed for nano fabrication and characterization. The Institute for Nanoscience and Engineering has won large federal grants to fund its projects, including a total of almost \$15 million over the past 10 years for the center itself, for graduate and undergraduate research and for education from kindergarten through 12th grade.

The advanced manufacturing sector in Arkansas (food science manufacturing, paper science manufacturing, aerospace, electrical products, agricultural chemicals, etc.) is targeted for growth by the AEDC. Research to support advanced manufacturing in Arkansas is available in the nanotechnology research thrust. The nanotechnology research thrust has already supported businesses development in Arkansas and can support the innovative, knowledge-based economy our state is targeting.

#### Food Science and Safety

Food Science and Safety research includes sustainable food systems (bio-sensing technology, food and bio-processing, bio-products utilization, microbial risk assessment, antimicrobial technologies, nano-biotechnology, bio/abio interfacing, phytochemical extraction, and bio-driven nanostructures); green technologies applied to food processing (replacement of energy intensive processes, utilization of co-products and by-products, minimization of waste products, engineered scale-up of optimized processes for commercialization); problems involving spoilage, fermentation, and safety of foods in collaboration with NCTR (bacterial pathogen detection and control on/in foods, viral food borne pathogens); awareness of nutritional quality of processed foods (identify, retain, and enhance bioactive components in processed foods); the role of important lipids in a healthy diet; protein and peptide chemistry; chemistry-based technology for new healthy ingredients (pro- and pre-biotics, bioactivities of nutraceutical natural extracts and food components, value-added use of industry by/co-products from rice, soybeans, and berries, edible films/coatings); sensory quality of foods; and rice product quality and value enhancement (collaboration with the National Rice Research Center).



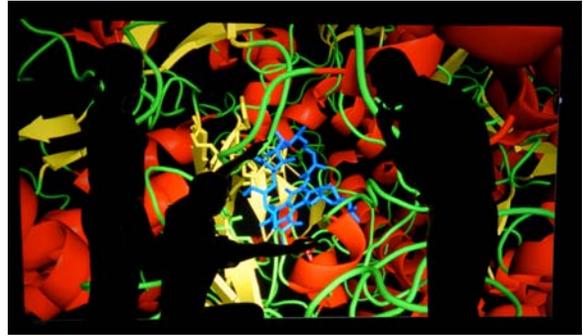
**Figure 12: Olfactory Laboratory in the food science research facility at the University of Arkansas, Fayetteville**

### Health

Cross-cutting health research at UA involves researchers from across the campus. The newly developed Department of Biomedical Engineering investigates prevention, diagnosis, and treatment of human health indications such as cardiovascular disease, cancer, diabetes, and influenza through technologies including high-resolution optical imaging, stem cell engineering, biomaterials-based delivery systems, tissue engineering, nanotechnology, and organ-on-a-chip. Computer scientists and engineers focus on new technologies for continuous monitoring and reporting of personal vital signs for the prevention and early detection of disease. Faculty with expertise in therapeutic discovery, design, expression, and detection study and produce biotherapeutics through a combination of chemical engineering, molecular biology, and systems biology. Industrial engineers focus on healthcare systems engineering for identifying and implementing healthcare supply chain and logistics innovations. Biophysics research includes single DNA and protein molecule detection and biomedical nanoscience. Health materials researchers are developing nano drug delivery applications for cancer, staph, and other diseases. Bioinformatics researchers use a computational approach for analyzing high through-put experimental data for health and other applications. Several health researchers study obesity in Arkansas and the role of foods in obesity/obesity prevention. A large project involving researchers at UA, Arkansas Children's Hospital Research Institute (ACHRI), Arkansas Children's Health Institute (ACHI), and UAMS studies the links between the food environment in Arkansas and the BMI of Arkansas children.

UA neuroscientists research the healthy human brain, biophysics of mental disorders, statistical and nonlinear physics of the brain, plasticity of the human brain cortex, and neural regulation in the avian brain for better understanding of avian reproductive system activation. An informal cognitive science group including researchers in physics, psychological science, psychology, music, and philosophy has formed at UA.

The **NIH NCRR Center for Protein Structure and Function** supports five multidisciplinary research projects involving over 20 faculty members in three different departments for the study of structures, functions and interactions of the thousands of proteins that are encoded within the genomes of humans, and human pathogens. The goals of the COBRE Center are to strengthen collaboration between investigators and allow them to develop promising new approaches to biomedical research in protein structure and function. High level users of the facility focus on protein structure, rational drug design, and molecular modeling.



**Figure 13: 3D Visualization of proteins at the Center for Protein Structure and Function at the University of Arkansas at Fayetteville**

### **Unique Infrastructure**

The U of A has a number of extremely well equipped core facilities and centers. Some function more as a resource while others provide both equipment resources and conduct independent research.

\*Arkansas High Performance Computing Center (The Razor Supercomputer in the AHPCC provides nearly 5,000 computing cores with 13.4 TB of memory and has a peak performance of approximately 73 TFlop/s.)

\*Center for Advanced Spatial Technologies (CAST) focuses on GIS, geospatial analysis and modeling, high density survey, enterprise spatial databases, remote sensing, digital photogrammetry, and geospatial data and model interoperability (*mentioned above in Environmental Research cluster*).

\*Arkansas Water Resources Center

\*Nanoscience Equipment (at the Nanotechnology Center and some at HiDEC) for Fabrication and Characterization at the nanoscale. Contains TEM, High Speed AFM and an Electron Optics Facility, a Materials Characterization Lab, Unique III-V-Bi MBE growth facility, and also a SiGeSn UHV-CVD system and the E-beam lithography in the HiDEC facility (*mentioned above in Nanotechnology cluster*).

\*Center for Protein Structure and Function - NMR Facility, 3D Visualization, State-of-the-art core facilities in NMR spectroscopy, X-ray crystallography, mass spectrometry, large-scale protein production, and high-throughput synthesis, photon confocal microscopy, Electron spin resonance (*mentioned above in Health cluster*)

\*Statewide Mass Spectrometry Facility: state-of-the-art mass spectrometry resource currently comprised of the High Performance Structural Mass Spectrometry Laboratory, located in Chemistry and Biochemistry and the Isotope Ratio Mass Spectrometry Laboratory, located in Biological Sciences.

\*University of Arkansas Stable Isotope Laboratory

\*X-ray Diffraction facilities

\*Food Sciences laboratories: Genome sequencing equipment, Sensory and Consumer Science Service Center (taste testing), Olfactory Lab, and Rice Research Lab

### **Databases**

Eumycetozoon Database (Searchable Database - <http://slimemold.uark.edu/databaseframe.htm>)

Arkansas Soil Database (Soil properties (by soil series) from every MLRA in Arkansas & >30 years of data)

Fulbright Museum (Extensive collections totaling some seven million objects in the fields of archeology, ethnography, geology, history, and zoology are developed and maintained by the staff).

## University of Arkansas at Fort Smith

### **Unique STEM Education**

The University of Arkansas at Fort Smith has established a state of the art lab for undergraduates to gain hands-on experience in the constructing, testing and optimization of renewable energy technologies. Classes such as “Generating Clean Electrons” teach students about cutting edge renewable energy technologies and hands on training programs certify students, through the Electronics Technology Association, to conduct energy audits. The manufacturing industry in the Fort Smith area provides internships to many STEM majors at UAFS. These companies include Exide Batteries, Baldor ABB, and SLW Automotive.

The UAFS engineering program has a long-standing electric car design project which teaches engineering students electrical and mechanical concepts, in a hands-on manner, which is a natural fit for UAFS. Approximately 75 total students have worked on the project over its lifetime, and Baldor ABB has been a strategic commercial sponsor for the project.

### **Research Clusters**

#### Ecology

Research focuses on exotic species in Arkansas and their impact on native species, impact of climate change on global biodiversity, avian ecology and distribution, and fish ecology and diversity in Red River oxbow lakes, and bacterial populations and the chemical composition of the water from different locations in Arkansas natural springs and associated pools.

#### Chemistry

Research in electrical properties of aggregated nanoparticle and organometallic synthesis and chelation studies.

### **Unique Instrumentation**

HPC Cluster with 184 cores for undergraduate research but primarily for teaching.

### **Databases**

Arkansas Fresh Water Fish collection/catalog



**Figure 14: Solar Energy conversion teaching module at University of Arkansas at Fort Smith**

## University of Arkansas at Little Rock

### **Unique STEM education**

UALR has a well established engineering program aligned with the industry needs in central Arkansas.

### **Research Clusters**

#### Bioinformatics

The research programs of the cluster members have significant domain overlaps as well as independent directions including algorithms for emotion analysis for early diagnosis of Autism Spectrum Disorders, neuroimaging data, to model, analyze and control genetic regulatory networks from an under-determined set of noisy and time-varying observations. Researchers apply text mining to identify facts about the timing of neurodevelopmental events, and analyze artificial neural networks to recognize

patterns in complex disease states that lead to diagnoses and recommended treatments. Others are using proteomics to investigate either intracellular signaling mechanisms in relation to environmental changes and disease states or the basics of aging. Metabolomics is being used to investigate how both genetic and environmental factors influence plant function.

### Aerospace Applications

The work in the area of Aerospace Applications is rather broad, but it can be broken down into research in the materials area, vibrations and active control, wind power and conceptual aircraft design. The materials research covers applications including coatings, nanostructured materials and composite materials. The coatings area includes de-icing as well as sensor development and applications. The vibration work involves measurement and control of engine vibrations, acoustic performance and active control with MEMS. The work in the area of wind power has been mainly in the manufacturing area for the composite blade construction, blade shape optimization, and energy conservation on large vehicles through active control of actuators. Conceptual design has been mainly applied to unmanned aerial vehicles and involves the configuration and shape optimization for specific mission profiles. Other areas on the information side include information and software dealing with large amounts of data and trying to distill for the decision process, swarm control of multiple remote UAVs, and data security and transmission.

### Advanced Materials

Materials science is large interdisciplinary cluster and covers materials science in various areas such as energy, medicine, biomaterials, polymers, agriculture, environment, information technology, and defense. Of significance is the nanotechnology research in the area of solar cells and transformative energy research using nanoplasmonic structures, nanowires, and nanostructured thin films for light trapping and enhancement of photo conversion in the solar cell. The materials synthesis methods include wet chemistry, physical vapor deposition, chemical vapor deposition, atomic layer deposition, and molecular beam epitaxy. The materials under investigation covers both III-V and II-VI compound semiconductors to be used as light absorber and active semiconductive layer, and shape memory alloy for plasmonic structures.

Another area of energy-related advanced materials research includes three major areas: organic/hybrid photovoltaic devices, catalysis, and hydrogen research using novel approaches for the development of organic photovoltaic devices. They are also investigating the optical/electrical/thermal properties of these polymeric materials when doped with various graphitic nanomaterials that include carbon nanotubes, graphene or fullerenes. They have also proposed a new solar cell architecture which is based upon n-silicon/graphitic materials (single and multi-walled carbon nanotubes, and graphene) and alternatively on developing an all Carbon solar cell by understanding how the graphitic materials can be processed such that will develop an either p or n type behavior. In another project they are developing novel non-precious metal complexes and polymers attached to carbonaceous materials (Graphene, multiwalled carbon nanotubes) which act as fuel cell cathode catalysts for oxygen reduction reaction. The purpose of this project is to decrease cost and increase power density. These composite materials can also be used as supercapacitors.

Another part of this cluster has specialized in the applications of nanostructured materials in renewable energy technologies including fuel cells, solar cells, batteries, and hydrogen storage utilizing a novel glancing angle deposition (GLAD) method to fabricate nanostructured materials of various kinds including metals, alloys, oxides, and semiconductors in a simple and cost-effective way as advanced electrode/active/functional materials for several alternative energy technologies. These nanostructured

electrodes have large effective surface area, small weight loadings, and simpler material compositions and will significantly improve the performance and power efficiency of energy devices, while at the same time lowering manufacturing costs.

Other novel research includes new technology for enhancement of plant productivity by application of nano-sized materials and collaborative efforts in nanomedicine with UAMS.

#### Energy, Environmental and Geotechnical

This is an emerging cluster of researchers focused on issues related to natural resources. Areas of interest include energy, the environment, and the application of geotechnical solutions for sustainable living on Earth. Research goals are to help society meet the energy, earth materials, and water resource needs of growing populations while reducing the impacts of resource extraction, infrastructure expansion, and waste production on the environment. Examples include research in atmospheric and environmental chemistry focused on the role that atmospheric aerosols play in climate; research in water quality on coal combustion residues and their fate and transport in the environment, research and educational training on central Arkansas ecosystems, water resources and source water protection; and research into the relationship between land subsidence and groundwater extraction from aquifers in eastern Arkansas.

#### Information, Computing and Security

The cluster is a eight-member group whose research falls into three broad categories: Social Computing and Organizational Dynamics, OYSTER Development, and Information Assurance and Security.

Social computing and organizational dynamics: studies the complex systems of humans and computers to better understand the induced socio-technical behavior and designs systems and developing models for enhancing knowledge creation, analyzing new types of interactions, and examining collective actions and their manifestations. Social computational systems is concerned with the study of social behavior and social context based on computational systems that deduce information from social behavior, perform scenario planning, and advance our understanding of behavior, patterns, and potential outcomes.

OYSTER Development: research thrust is to design and develop the tools and techniques that support entity identity information management (EIIM). Entity identity integrity is one of the basic tenets of data quality that applies to the representation of a given domain of real-world entities in an information system.

Information Assurance and Security Group: advances information assurance and security in both physical and cyber spheres. Current focus areas are on 1) cloud computing security, 2) wireless network security, 3) social network security, 4) internet security, 5) information security, and 6) physical surveillance system.

#### Optical and Wireless Information Networking

This is a large research group with significant expertise in wireless technologies. Major thrust Include:

- Applications of Artificial Magnetic Conductors in Flexible Wireless Systems
- Applications of Metamaterials in EMI/EMC Problems
- Mutual Coupling Reduction between Closely Spaced Antennas Using Novel Metasurfaces, Defected Ground Structures, and Planar Soft Electromagnetic Surfaces
- Carbon Nanotube-Based RF Antennas and Wireless Sensors
- OFDM Signaling Optimization

- Security of Wireless Communications
- Use of Wireless communication to support Smart Grid
- Global Optimization
- Wireless sensor networking
- Reliability, scalability, and security of energy-efficient wireless sensor networks
- Recovery in optical networks
  - Free space optical networking
  - 4G and next generation wireless optimization
  - Wireless services infrastructure for next generation wireless
  - Impact of social networking and social computing applications on wireless networks

### Robotics and Manufacturing

Research Cluster in Robotics and Embedded Systems thrusts include:

- Robotics rehabilitation: development of new robotic assistive technology to help people with disability, in particular disability due to aging.
- Robotics for space exploration: development of new instrument and computer vision technology for planetary exploration.
- Computer vision methods for improved autonomy of small robots: address the autonomy issue of small robot or robotic device which has limited computing resource and physical size. Our current effort is a solution based on a single vision sensor.
- Autonomous car: development of enabling technology for navigation of autonomous vehicle in urban environment and methods to coordinate multiple vehicles for reduction of traffic jam/accident and improvement of fuel economy.
- 3-D sensing technology for remote health care: development of new approach for remote health care that employs new 3-D imaging sensor(s) and other wearable sensors.
- Computer vision methods for objects and scene recognition from static images and video.
- Computer vision methods for activity recognition from video.

### Molecular Systems Biology and Biotechnology

Research in the Molecular Systems Biology and Biotechnology cluster is focused on using genomic and bioinformatic tools to understanding fundamental biological processes in plants, animals, and microorganisms and addressing critical problems in agriculture, energy, and biomedicine. Primary scientific objectives include:

- Develop plant transcriptome and metabolome profiles and utilize them for gene discovery and analysis of complex biosynthetic pathways as they function during development, and in response to environmental cues and biotic elicitors.
- Determine how plant metabolites function as signals to induce biotic defense pathways and examine the roles that secondary metabolites play in interactions with pathogens and herbivores.
- To utilize transgenic, cell-biology, and –omics approaches to delineate the post-transcriptional factors, such as cell endomembrane-based systems, source-sink relationships and oxidative status, which limit the stable accumulation of target products and biomass in plants.

### **Unique Infrastructure:**

The Center for Integrative Nanotechnology Sciences (CINS): CINS is both a user facility as well as a research facility that promotes a collaborative atmosphere and cross-disciplinary research, producing a

variety of innovative technologies in energy applications, nanostructural composite materials, and nanomedicine. The organization's three main areas of research are:

- High purity and high quality nanomaterials: carbon nanomaterials, graphene, and similar functionalized nanomaterials.
- Thin film deposition: anti-icing applications in aerospace, biocompatible coatings for medical implants, dust mitigation for a multitude of surfaces.
- Bionanotechnology, toxicology and nanomedicine: tissue engineering scaffolds for bone regeneration, cancer targeting and therapies, nanomaterials, and plant biology.

The center has state of the art instruments in the areas of electron microscopy, scanning probe microscopy, x-ray diffraction, and optical spectroscopy. CINS research has led to innovations in applications in organic solar panels, anticounterfeit sensors, conductive films, superhydrophobic and anti-icing applications, nanoelectronics, tissue scaffolds for bone generation, and targeting and destruction of cancer cells by nanoparticles.

The University of Arkansas at Little Rock also has the following equipment for advanced materials and nanotechnology research:

- Molecular Beam Epitaxy (MBE) & MOVCD System
- Atomic Layer Deposition System
- Thermo K-Alpha X-ray photoelectron spectroscopy System

UALR's new George W. Donaghey Emerging Analytics Center™ (EAC) is a world-class facility featuring "first of their kind in the world" advanced data visualization systems. It focuses on a broad agenda of data visualization research, building on UALR's College of Engineering and Information Technology (EIT) and College of Science (COS) faculty expertise --- which includes advanced data visualization, computer science, nanotechnology, engineering technology, construction, and systems engineering. UALR's College of Business (COB) faculty is also using the new facility for advanced business analytical data projects, and corporate and organizational partners are also engaged in a wide range of EAC activities. For more detailed information and an overview of the new center's technology resources (which includes the EmergiFLEX™, Mobile EmergiFLEX™, and Haption Haptic device for "touching" data) see <http://ualr.edu/emerginganalytics/facilities/>

The UALR Computational Research Center (CRC) specializes in adapting and providing services for diversity within the research community and has built a facility to serve and address the varied computational requirements of this environment; its strength lies in its platform diversity addressing big memory, large CPUs needs and multiple



Figure 15: The University of Arkansas at Little Rock Computational Research Center (CRC)

operating systems (Linux, Microsoft Windows, auto-parallelization). Argon is a traditional Rocks 5.4 cluster running CentOS 5.5 to achieve 5.45 Tflops (trillion floating point operations per second) theoretical peak performance, and is appropriate for situations where a problem can be split up

between numerous processors and where the researcher is comfortable with writing or modifying code to take advantage of parallel processing. Boron runs CentOS 6.2, has a high memory to CPU ratio, and is ideal for researchers who are not familiar with writing parallel code but still have the need for parallelization. Carbon cluster addresses the needs of the multitude of users who are bound to Microsoft platforms and applications. It is the first cluster of its kind within the Arkansas research community and provides a distinct flexibility to the CRC that sets us apart from other regional HPC facilities. Dubnium is an X9000 storage array available through both Ethernet and 40Gbps QDR Infiniband, and Erbium is a big memory machine by HP.

The Arkansas Earthquake Center has three missions: public education and community outreach, earthquake monitoring and data archiving, and scientific research. Currently it is the only educational institution in the state that conducts seismological research and is responsible for data collection and archiving using the Arkansas Seismic Observatory, which consists of 9 state of the art seismic stations installed throughout the state.

Other equipment in individual departments includes:

Microelectromechanical Systems Laboratory (MEMS)

Rock preparation and Mineral Separation laboratory

Unique and high-end Atmospheric testing facilities in Chemistry

Open Source OYSTER system

Digital Forensics Lab

CNC milling machine

State-of-the-art antenna testing with tapered anechoic chamber

MIMO wireless fabrication and testing laboratory

Four Pioneer robots, and one all-terrain robot (husky robot) equipped with state-of-art sensors, including 3 Flash LIDAR cameras, 5 LIDARs, 1 Fiber Optic Gyro, and a couple of MEMS Inertial Measurement Units.

New 1,200 ft<sup>2</sup> greenhouse facility located on the roof of the NanoTechnology Building

Biostat Photobioreactor for large scale liquid cultures

### **Databases**

Atmospheric chemistry and meteorology radiation database sampled at UALR Campus

Large Synthetic data sets (about 22,000 records)

Authorization to access student enrolment records for public schools in Arkansas

## **University of Arkansas at Monticello**

University of Arkansas System Division of Agriculture

Agricultural Experiment Station

### **Research Clusters**

Arkansas Forest Resources Center

Administered through the University of Arkansas System Division of Agriculture with faculty located on the University of Arkansas at Monticello campus

The Arkansas Forest Resources Center, a University of Arkansas Center of Excellence, has the mission of developing and delivering superior programs in research and extension that enhance and ensure the sustainability of forest-based natural resources. To support this mission, the Center brings together

interdisciplinary expertise from across the University System through the Arkansas Division of Agriculture to better serve the forest-based resource community. Research is administered through the Arkansas Agricultural Experiment Station, and extension and outreach activities are coordinated through the Arkansas Cooperative Extension Service. The Center is headquartered at the University of Arkansas at Monticello campus, but its programs range statewide. Major research program areas include:

- Forest Management
- Water Resources
- Riparian Management
- GIS/GPS/Remote Sensing
- Wildlife Management
- Wildland-Urban Interface Issues
- Bioenergy
- Ecosystem Services
- Natural Resources Economic & Social Issues

This research cluster has 10 primary faculty members with appointments in the Arkansas Agricultural Experiment Station and research occurs in both laboratory and field settings. Center scientists are currently:

- developing and evaluating best management practices for protection of water quality.
- evaluating impacts of cellulosic biomass production systems on select ecosystem services, such as carbon sequestration, water quality, and biodiversity.
- assessing biomass yields of a variety of different cellulosic feedstocks and determining the investment potential of cellulosic biomass production systems.
- developing, evaluating, and demonstrating appropriate management strategies and techniques to provide non-industrial private forest owners the necessary tools to sustainably manage their natural resources.
- evaluating and demonstrating habitat management strategies and techniques for conserving threatened and endangered species, and species of special concern.
- developing and delivering efficient and effective tools to assess and address impacts of wildland-urban interface expansion, such as fire risk and wildlife damage.
- delivering state-of-the-art information and training to natural resource management professionals.
- providing policy makers science-based information for making informed decisions on natural resource issues.
- educating youth and providing them opportunities to experience the natural resources of Arkansas.
- evaluating and demonstrating appropriate wildlife habitat and population management for both game and non-game species, including deer, elk, bear, songbirds, amphibians, quail, feral hogs, and others.



**Figure 16: Forestry Research at University of Arkansas at Monticello**

### **Unique Infrastructure**

The Arkansas Agricultural Experiment Station (AAES), the research component of the University of Arkansas Division of Agriculture, has about 13,400 acres of forested property located across the state.

AAES forests are located primarily at:  
Arkansas Agricultural Research and Extension Center, Fayetteville  
Southwest Research and Extension Center, Hope  
Livestock and Forestry Research Station, Batesville  
Pine Tree Research Station, Colt

## University of Arkansas at Monticello

### **Unique STEM Education** ***School of Forest Resources***

#### Forestry

UAM holds the distinction of having Arkansas's only accredited forestry program and ranks among the nation's leaders. The program's location in southern Arkansas, the heart of the state's forestry activity, allows students to rub elbows with professional foresters and land managers and learn firsthand what can't be experienced in any classroom. The program is accredited by the Society of American Foresters. Students are prepared to assume positions in both public and private forestry, and to succeed in graduate school.

The forestry program prepares students for a broad range of career opportunities involving the management, utilization or study of forest resources. Unlike coal, iron, oil and gas, forests hold a unique distinction as a renewable resource. Forests and the forest environment provide a diversity of valuable resources, including timber, water, wildlife, range, forage, recreation and wilderness. However, the management and protection of forests for a variety of products and services on a sustained basis require professional foresters who understand the complex ecological, economic and social issues facing natural resource management.

#### Wildlife Management

The wildlife management program is a professional program designed to give students a broad scientific background for management and perpetuation of wildlife resources. The curriculum emphasizes basic and applied sciences as well as communication skills and social sciences. This educational foundation serves students who plan to enter the wildlife profession directly, or those who plan to continue their education at the graduate level. Through appropriate selection of courses in consultation with his or her advisor, students can satisfy course work requirements for professional certification by The Wildlife Society.

#### Spatial Information Systems

The spatial information Systems program consists of two options: Geographic Information Systems (GIS) and Surveying. The GIS option prepares students to meet the growing demand for a geo-technology workforce. The program incorporates GIS, Global Positioning Systems (GPS), and remote sensing technology as well as critical general education and supportive requirements. The surveying option is the only 4-year surveying degree program available in the state. It also prepares students to meet the growing demand for a geo-technology workforce. The program provides students with the tools and education to take the state survey licensure exam and become a professional land surveyor.

#### Graduate Training in Forest Resources

The Master of Science in Forest Resources degree program offers emphasis areas in Forest Sciences, Spatial Sciences, or Wildlife Ecology and Management. Degree plans include a required core curriculum of 30 credit hours, inclusive of Research and Thesis hours. An approved thesis is also required for completion of the M.S. in Forest Resources degree. Students are required to define an appropriate problem for investigation; review relevant literature; develop a thesis proposal; collect, analyze, and interpret data; test hypotheses and draw conclusions; and write and defend a thesis. At the conclusion of the study and research program, a seminar and an oral comprehensive examination, including a thesis defense, is required of all graduate students for completion.

#### **Databases**

Coccoid Algae Collection

Herbarium

Water Quality Data on Ouachita River Watershed

### University of Arkansas at Pine Bluff

#### **Unique STEM education**

STEM Academy - UAPB has a unique NSF funded STEM program that targets STEM majors as entering freshmen and guides and mentors them until graduation. These students have broad opportunities for research and a significant number enter graduate schools across the country. UAPB also offers undergraduate degree program in Fisheries Biology (B.S.) to prepare students for careers in aquaculture and natural resources-related fields in Arkansas.



**Figure 17: The University of Arkansas at Pine Bluff warm water (fisheries) research system**

GREEN (alternative energy) Training Laboratory- A unique hands-on laboratory experience with topics including:

- Home Energy Savings Model System

- Wind Energy Conversion Training System

- Solar Power Conversion Training System

- Incandescent vs. Energy Saving Lightbulb Power Meter

NanoScience Training Laboratory- an undergraduate focused research laboratory, which offers students training in cutting-edge topics such as nano material characterization with equipment such as a raman microscope.

Computer Science Cybersecurity Research Laboratory – undergraduate, graduate focused research laboratory, with students taking part in cybersecurity research focused on intrusion detection in large-scale cyberinfrastructure systems cloud computing systems.

#### **Research Clusters**

### Advanced Materials Research

UAPB has a small cluster of researchers that have high-quality and unique equipment for materials characterization such as a state of the raman spectrometer systems.

### Data-Intensive Computing Research

UAPB has a unique community of researchers engaged in data-intensive computing research, particularly, data analytics, security informatics, and visualization applications. High-performance computing and visualization equipment such as the Apollo supercomputer support these research endeavors.

### Biotechnology Research

Another small cluster within the UAPB campus is focusing on drug development and modeling. Much of this is associated with INBRE, but also includes broader molecular biology research.

### Sweet Potato Research

Plant Science research is strong on the UAPB campus and the research and demonstration stations in Lonoke and Marianna. Eight sweet potato related research projects are underway at UAPB, including the mass multiplication of virus-free sweet potato through tissue culture and transcriptome analysis of genes involved in tuber formation through nextgen sequencing. The researchers provide extension support for the new and growing sweet potato industry in Arkansas to develop sustainable sweet potato production techniques. Other plant science research includes rice for potential biofuel production soil detoxification of arsenic using *Arabidopsis* genetic research. UAPB researchers have successfully down

### Aquaculture and Fisheries

The most significant cluster at UABP is Aquaculture/Fisheries (AQFI) Center of Excellence which is recognized as a leader in aquaculture/fisheries teaching, research and extension programs. It is the only comprehensive aquaculture program within the University of Arkansas System to support the state's \$167 million aquaculture industry and providing scientific support to the recreational fishing industry that has an economic impact of over \$440 million/yr in Arkansas.

The research cluster has wide-ranging research programs in aquaculture and natural fisheries conducted by faculty engaged with aquaculture and natural resource stakeholders to solve real-world problems. The research involves field study work and laboratory work analyzing for water quality, fish identification, food habitat, age, growth and nutrition and fish health studies.

\*AQFI has the 3rd largest warm water (fisheries) research system in the U.S. They provide comprehensive extension programs and services to Arkansas and other states to transfer newly developed techniques and research information into real-world practice. These include diagnostics services to identify fish diseases and water quality problems and to recommend treatments. They interact with the community through organized educational meetings, farm demonstrations, field days and provide fact sheets on important issues for county agents, fish farmers, farm pond owners, and natural resource managers.

### **Unique Instrumentation**

Aquaculture Experimental Ponds

Portable, educational SEM

Raman Spectrometer

90 mHZ NMR

**Databases N/A**

## University of Arkansas for Medical Sciences

### **Unique STEM Education**

UAMS is a unique graduate school program associated with the medical professional programs and has a strong emphasis on clinical applications.

The Translational Neuroscience Center has a program called Pediatric Physician Learning and Collaborative (Peds PLACE) program. Using Telemedicine conferencing, consultations follow the educational conferences and help form collaborative relationships, provide better care for rural and underserved populations, and lead to more organized transfers and referrals. A second program links nine existing Emergency Department sites with six new ones in a program called Emergency Department Physician Learning and Collaborative Education (EDs PLACE).

### **Research Clusters**

#### **Drug Discovery**

Medicinal chemistry, drug synthesis and natural products research at UAMS includes drug design and discovery in many areas, including anti-cancer drug design and synthesis, drug addiction related research, radiation protection, studies in prodrug and codrug design, drug metabolism, pharmacokinetics, and other areas of relevance to preclinical drug development. This research is cross-cutting, produces highly skilled PhD-level personnel in drug discovery techniques, and has the potential to spin-off and attract pharmaceutical and biotech companies who have an interest in new drug development to Arkansas.

#### **Human Behavior and Neuroscience**

The cluster includes research in all types of psychiatric illnesses, including drug use disorders, eating disorders, anxiety disorders, mood disorders, and psychotic disorders. Patient treatment in each illness enables the psychiatric research conducted at this institute to have ample access to the necessary psychiatric patient populations. Research also focuses on early childhood traumatic events (ranging from sexual or physical abuse to natural disasters and domestic violence) that can cause severe problems with the social, behavioral and psychological growth of a young child. The Brain Imaging Research Center (BIRC) is a brain imaging technology center of excellence providing cutting edge multimodal magnetic resonance imaging (MRI) acquisition, processing and analysis approaches to explore the neuroscience of human behavior in healthy and patient populations. The UAMS BIRC is a dedicated human neuroimaging research resource within the PRI. The research cluster is building a neuroimaging and detailed, anonymized patient information database.

#### **Neuroscience**

The Center for Translational Neuroscience research cluster has seven cores: Human Electrophysiology Core, Animal Electrophysiology Core, Image Analysis Core, Transcranial Magnetic Stimulation (TMS) Core, Molecular Biology Core, Behavioral Core and Telemedicine Core.

The Human Electrophysiology Core measures the effects of illness, lesion, drugs, etc. on different levels of the neuraxis in humans. The instrumentation available allows measurement of:

- arousal and assessment of brainstem-thalamus processes

- paired auditory stimuli to measure sensory gating, a process disturbed in a number of diseases
- reaction time to derive the prototypical measure of attention and thalamocortical processes.
- frontal lobe blood flow using near infrared spectroscopy

They have also established a satellite facility for spinal reflex testing in spinal cord injury and other patient populations.

**Animal Electrophysiology Core:** This Core includes the rodent equivalent of above allowing parallel human and animal studies, as well as animal reflex testing set-up facilities to allow parallel studies on humans and animal with spinal cord injury and other motor disorders.

**Image Analysis Core:** This Core has state of the art microscopy and voltage-sensitive dyes techniques for studying cell compartments such as single dendrites.

**Transcranial Magnetic Stimulation (TMS) Core:** This Core allows testing of TMS on a number of human conditions with older equipment used for parallel animal studies.

**Molecular Biology Core:** This Core includes a RT-PCR and multi-gene assay capacity, along with a state-of-the-art metabolic cage system.

**Behavioral Core:** The Core uses animals studies in locomotion, conditioned place preference, and prepulse inhibition.

**Telemedicine Core:** This Core includes real-time teleconferencing and diagnostic quality imaging equipment for 25 rural hospitals and a central Mediasite facility. (Peds PLACE and EDs PLACE above under education)

### **Medical Genetics**

Medical genetics reaches many different areas at UAMS, from research to clinical practice. Clinicians use genetic testing to understand and predict conditions (ocular diseases, myeloma, genetic disorders, downs syndrome, breast, ovarian and colon cancer, etc.). Researchers collect genetic information and link conditions to the causes and inheritance of genetic disorders. Genetic clinics and concentrations at UAMS include Adolescent and Medical Genetics Clinic, Down Syndrome Clinic, Cancer Genetics Clinic, Prenatal Genetics Clinic, Metabolic Genetics and Newborn Screening, and Pediatric genetics.

### **Myeloma Institute for Research and Therapy**

The objective of the research is to improve growth control of multiple myeloma by dissecting and exploiting the molecular and biological consequences of the multiple myeloma - microenvironment interaction. Translational research has been the core of the UAMS myeloma program, bridging basic science laboratory with developments in clinical care. Research areas goals include:

- genetic basis and clinical and biological behavior of myeloma
- Improving diagnostic capabilities
- risk factors and prognostic indicators with goal of individualizing each patient's treatment
- increase long-term remission and overall survival

This is a long-standing research effort and the MIRT has a large database of genetic and proteomic data for risk classification and prognostic indicators. An extensive cluster of expertise within this research team also exist identifying and developing therapeutic mechanisms (antibodies and targets for cell signaling pathways) to combat disease cells.

### **Infectious Disease**

Research in the Department of Microbiology and Immunology at the University of Arkansas for Medical Sciences is focused on addressing the emergence of unique viral variants capable of causing pandemic

outbreaks, and strains of bacteria that are resistant to all available antibiotics. The Center for Microbial Pathogenesis and Host Inflammatory Responses (CMPHIR) focuses on understanding the complex interaction between diverse microbial pathogens and their common human host, thereby laying the foundation for development of novel strategies to prevent and treat the growing threat of infectious disease. The Center has significant technical resources including the purchase of advanced instrumentation for genetic characterization of both pathogen and host, and detailed cellular characterization of the host response to infection.

### **Public Health**

Public health research topics at UAMS include cancer, diabetes, environmental/occupational health, minority health and health disparities, health systems, long-term care, obesity, and childhood obesity. Researchers in this cluster focus on molecular risk factors for disease, behavioral and social factors influencing disease, and disease prevention. Much of the cluster research involves field study work in conjunction with the Arkansas Department of Health and with data obtained through the Arkansas Department of Education. Molecular epidemiology studies are carried out in conjunction with the clinic within the College of Medicine.

### **Substance Addiction**

This research cluster has both basic research and commercial development of antibody-based medications for use in treating the neurological problems associated with drug abuse. The cluster researchers utilize molecular design, hybridoma technology, antibody engineering techniques, as well as studies of the effects of drug of abuse on brain function. Large scale production of antibodies as drugs is accomplished through the use of bioreactors, along with the development of the technology for the molecular and biological engineering of plant-derived antibodies. The overall goal of research is to develop new antibody-based medications to treat chronic and acute methamphetamine (METH) abuse. Research includes combining antibody therapy and nanotechnology to generate an adaptable range of anti-METH medications (dendribodies) that will have applicability to important therapeutic treatment (e.g., a short-acting medication for overdose and a long-acting, low volume of distribution medication needed for chronic treatment of addiction). In a second collaborative project with researchers in the UAMS Department Physiology and Biophysics, x-ray crystallography is used to determine the molecular structures of highest activity anti-METH antibodies in order to engineer a new generation of clinically relevant humanized antibodies with enhanced efficacy against METH.

### **Nanomedicine**

This research cluster is applying nanotechnology to comprehensive stroke research. The cluster is using “novel stroke therapy” employing nanoparticles in both delivery and drug efficacy. One approach is using the microbubble plus ultrasound (without tissue plasminogen activator method of clot lysis) has shown major advancement in thrombolysis, and has less bleeding risk. This has now made a first giant step towards human use with a human trial of ultrasound augmented thrombolysis at UAMS. A second area is a neuroprotective nano droplet, dodecafluoropentane emulsion (DDFPe). The perfluorocarbon liquid shifts to gas phase at 29 degrees Centigrade so can be given as a liquid IV suspension and then become a more active phase in circulation. There it transports a very large amount of Oxygen and delays the damage of ischemia in stroke for over one hour even without opening the occluded artery, acting as a neuroprotectant. The concept of combining these, an effective neuroprotectant and improved clot lysis, in a clinical application holds great promise.

### **Breast Cancer**

This cluster focuses on metastatic growth phase as a clinically broad target, and any treatment that limits metastases prior to their causing irreversible harm to the patient. The cluster works on adhesive and invasive processes with a broader spectrum of targets that might be required as tumor cells develop evasive strategies by down-modulating target molecule expression. One set of broad-spectrum targets are Tumor Associated Carbohydrate Antigens (TACA) expressed on a cancer cell surface. This cluster has developed carbohydrate mimetic peptides (CMP) that induce the immune system through broad-spectrum humoral and cellular responses targeting TACA that then inhibit tumor growth in preclinical studies. This novel approach induces immune responses against TACAs in humans and may prevent recurrence of cancer and in combination with other drugs, reduce or prevent metastatic spread. This research cluster uses computer-designed reverse engineering concepts and applies the structural properties of TACA reactive monoclonal antibodies for new immunization techniques.

### **Cardiovascular research**

Areas of cardiovascular research in this cluster include prevention of donor kidney injury and donor kidney quality assessment (mitochondria health); preventing heart attacks in women through early symptom recognition; blocking of oxidized LDL cholesterol receptors for cardiovascular disease therapy; the role of canonical transient receptor potential conduction of  $\text{Ca}^{2+}$  and  $\text{Na}^+$  in arterial contraction for the application of lowering blood pressure in hypertensive individuals; the role of blood platelets in tumor metastasis, rheumatoid arthritis, and severe sepsis; blood flow to the brain through cerebral arteries in patients on “beta blockers” using a novel scaffolding molecule; identification and preclinical evaluation of new therapeutic targets to treat sepsis-induced kidney injury; the use of microbubbles and ultrasound to lyse clots in stroke patients; personalized genomic approaches to optimize cardiovascular health in Arkansas; radiation induced heart disease; and therapeutic target identification for pulmonary hypertension.

### **Aging and Alzheimer’s research**

The research cluster at the Center on Aging focuses on the cell biology of Alzheimer's disease and dementia. The cluster investigates transcriptional regulation in neurons and uses insect models to study molecular basis for regulated gene activity, in response to gender, nutrition, aging and oxidative stress, for insight into human reproductive development, diseases of aging, including cardiac ischemia. They also have active research in neural protein degradation and signaling in Alzheimer's disease. This research also has implications for stem cell development in neurodegeneration and cancer. The cluster focus centers on the influence of neuroinflammatory cytokines, in particular interleukin-1, in the genesis and progression of neurodegenerative diseases such Alzheimer's disease, Downs syndrome, AIDS, and Parkinson’s disease.

### **Radiation Health research**

Division of Radiation Health focuses on studies of interactions between ionizing radiation and various normal tissues of the human body and on developing pharmaceutical interventions that can prevent the adverse effects of radiation in normal tissues. Research performed by this cluster will eventually help improve uncomplicated cancer cure rates, reduce the side effects of cancer therapy, and enhance the quality of life of cancer survivors. It may also contribute to improving the outcome in the event of a radiological or nuclear terrorism incident or accident. Studies of normal tissue radiation responses are complex and require broad, multidisciplinary expertise, not only in radiation biology, but also in the pathophysiology of specific organ systems, as well as in systems biology, cellular biology, and molecular biology of a variety of processes, for example, inflammation, cell proliferation, oxidative stress, connective tissue remodeling, neuroscience, and endothelial and vascular biology. The cluster is actively

investigating the mechanisms underlying the adverse effects of radiation on normal tissues and to developing pharmacological approaches such as Vitamin E components (new tocopherol and tocotrienol compositions) to reduce these effects.

### **Bone Health research**

The research cluster focuses on bone and muscle disease and encompasses any disease or treatment that causes debilitating bone problems. The UAMS Center for Osteoporosis and Metabolic Bone Diseases includes expertise in molecular and cellular biology, molecular genetics, the biology of bone as a tissue and the diagnosis and treatment of osteoporosis. The UAMS Center for Orthopedic Research includes basic research in breast cancer metastasis, skeletal phenotyping, distraction osteogenesis, osteomyelitis, and hormone action. Translational research encompasses cancer biomarkers, osteoporosis biomarkers, multiple myeloma, bone metastasis, and bone cancer. The Center for Orthopedic Research has a number of strains of transgenic and mutant mice generated or used at UAMS for this research as well as state-of-the-art instrumentation for bone research.

### **Unique instrumentation**

The Division of Radiation Health is equipped with state-of-the-art instruments for irradiation of experimental animals and cells, as well as for cellular and molecular biology research, including flow cytometry, cell sorting, cytogenetics, real-time PCR, thus providing capabilities for advanced cellular and molecular analyses of IR-induced tissue injury. The Stem Cell Analytic Core (SCAC) is also within this center and is capable of providing various basic and advanced analyses for stem cells and their derivatives.

**Biodosimetry Diagnostic Core:** Using ultrahigh-performance liquid chromatography-tandem mass spectrometry (UHPLC-MS/MS), this core offers high-throughput analytical services for determining diagnostic amino acids and their precursors or metabolic products. Available biomarkers include citrulline and tetrahydrobiopterin. Determination of other small molecules is possible, but fees will be assessed for the cost of method validation.

**Digital and Electron Microscopy Core:** Operates and maintains computer controlled microscope workstations ranging from light to electron microscopy. The core's faculty and staff provide advice, training and user support for equipment operation and sample preparation. Available equipment includes Zeiss LSM 510 Meta, AzioImager, and Axiovert S100TV microscopes and a FEI Tecnai F20 200keV electron microscope.

**Flow Cytometry Core:** Provides cell sorting as well as biomarker, cell cycle, cell proliferation, membrane potential and other analyses. Available instrumentation includes the FACS Aria with three lasers and detection of up to nine colors at one time and cell sorting of up to four populations at once. The FACSCalibur has four fluorescence detectors plus forward- and side-scatter detectors and is used for a variety of cell analyses. The core also offers protocol development advice and data analysis.

**Proteomics Core:** Provides the service of protein characterization by mass spectrometry. This includes identification of unknown proteins, quantitative comparison of proteins in biological samples, and mapping of post-translational protein modifications. Available instrumentation includes a Thermo Scientific LTQ Orbitrap Velos mass spectrometer with electron transfer dissociation capability (ETD), a Thermo Scientific LTQ XL Linear Ion Trap mass spectrometer with ETD, and a PerkinElmer SCIEX MALDI-PROTOF mass spectrometer capable of accurate mass measurements and sub-femtomole sensitivities.

**DNA Sequencing Core:** Makes DNA sequencing available to researchers so that they do not have to invest the funds and training of personnel to do it themselves. Available equipment includes the Operate 3100 Genetic Analyzer and supporting equipment (e.g., centrifuges, thermal cyclers, etc.). The core offers rapid turnaround and help with troubleshooting.

**Genomic Core:** Provides access to state-of-the-art instruments and information-intensive data for DNA, RNA and microarray analysis. The core specializes in pharmacogenomics, the influence of genes on an individual's response to medications. Available equipment includes the Agilent 2100 Bioanalyzer and Illumina iScan, BeadXpress, Cluster Station, and Genome Analyzer IIx systems. The core also uses a Tecan Robot for Illumina protocols and a Corbett Gene Extractor. Additional available equipment includes a SpectraMax Microplate Reader, Laser Capture Microdissection and Applied Biosystems 7900 Real-Time PCR.

**Crystallography Core:** Offers a full range of services to support the understanding of protein structure in the molecular basis of disease and in designing drugs or developing treatments. The core maintains a Rigaku RU-H3R rotating anode generator and Raxis IV++ image plate X-ray detector. This equipment is used to test the diffraction quality of a given protein crystal and collect the initial diffraction data. Higher resolution data collection is usually carried out at synchrotron facilities. The core has established access to beam-lines at Stanford Synchrotron Radiation Lightsource in Palo Alto, CA, and the Center for Advanced Microstructures and Devices at Louisiana State University in Baton Rouge, LA. The core processes diffraction data and determines and refines the structure of proteins of interest. For solving the structures, different techniques like molecular replacement, multiple isomorphous replacement, anomalous scattering, and multi-wavelength anomalous diffraction are employed. Various program packages such as CNS, CCP4, PHENIX, O and Coot are available on a workstation or Silicon Graphics 3D molecular graphics system.

**DNA Damage and Toxicology Core:** Provides expertise, equipment and facilities to perform DNA damage and toxicology studies related to toxic or hypoxic tissue/cell injury in drug development, diseases or aging. In addition to offering standard cytotoxicity assays including in vivo toxicology testing with approved IACUC protocol, the core can measure oxidative damage and quantify levels of apoptosis and necrosis in cells and tissues by using quantitative cytochemistry, immunocytochemistry techniques, and 3-D imaging.

**Experimental Pathology Core:** Offers centralized, comprehensive histological services. The laboratory director, consultants and technicians have extensive experience in routine histology and immunohistochemistry involving both human and animal tissues. The core offers veterinary pathology and a wide range of tissue analyses including Aperio digital slide scanning and image analysis.

**Skeletal Phenotyping Core:** Performs high-resolution skeletal imaging and analysis utilizing bone densitometry (DXA), peripheral quantitated computed tomography (pQCT) or microCT, and detailed histological analysis. Skeletons can be analyzed in vivo or ex vivo. When combined with histological evaluation, detailed insight into skeletal phenotype is obtained.

**Tissue Procurement Facility:** Offers a diverse, high-quality human biospecimen repository with appropriate patient protections, best practice collection methodologies, clinical data capture mechanisms and integrated information technology. The facility is designed to enhance diagnostic, preventive and therapeutic research efforts.

**Bioluminescent & Fluorescent Imaging Core:** Offers in vitro and in vivo biophotonic imaging services using bioluminescence and/or fluorescent molecules as reporters of gene or protein expression. The core maintains a Caliper Life Sciences IVIS 200 Imaging System, a highly sensitive CCD camera optimized for biophotonic imaging. The technology has applications in multiple research areas, including osteomyelitis, oncology, inflammation and metabolism. The core also offers protocol development and data analysis.

**Biotelemetry & Ultrasound Imaging Core:** Offers invasive and noninvasive monitoring of cardiovascular function and tumor research using small animal models. The core maintains environmentally controlled, individual rodent housing and 37 transmitters and 16 receiver stations for biotelemetry. The VisualSonic Vevo 2100 System is used for high-frequency, high-resolution digital imaging with linear array technology and color Doppler. This instrument provides frame rates in 2D up to 740 fps and superior resolution (30 micron) and image uniformity through the entire field of view. The core also offers assistance in experimental design, data interpretation and development of animal models.

**Skeletal Phenotyping Core:** Performs high-resolution skeletal imaging and analysis utilizing bone densitometry (DXA), peripheral quantitated computed tomography (pQCT) or microCT, and detailed histological analysis. Skeletons can be analyzed in vivo or ex vivo. When combined with histological evaluation, detailed insight into skeletal phenotype is obtained.

**Transgenic Mouse Core:** A state-of-the-art resource offering generation of transgenic mice via pronuclear microinjection of DNA constructs supplied by users. Microinjections are performed in embryos obtained from C57BL/6 or CB6F1 (a cross between BALB/c and C57BL/6) mice. Personnel are also available for consultation regarding DNA construct design and animal husbandry. The core consists of dedicated laboratory space with a microinjection suite, cryopreservation lab, and isolator rack animal wards.

**Brain Imaging Research Core:** This core is a resource to explore the neuroscience of human behavior in healthy and patient populations. Instrumentation includes a Philips Achieva 3T X-series MRI system housed in a custom-designed MRI facility. The short flared-bore magnet offers 50 cm field-of-view (FOV) imaging capability and Quasar dual gradient design with gradient magnitudes up to 80 mT/m and gradient switching speeds (slew rates) up to 200 mT/m/ms. The FreeWave data acquisition system features 32-channel architecture. The scanner room has three custom wave guides, in addition to the primary penetration panel, to permit the MR-shielded and nonferromagnetic application of visual stimulus projection, psychophysiological monitoring, and response acquisition devices. The adjacent control room permits constant visual and auditory contact with subjects in the scanner and contains the imaging control console and two additional computers to manage study stimulus and recording demands. A wide range of MR imaging sequences are available to support T1, T2, T2\*, diffusion tensor imaging, and magnetization transfer imaging.

**Clinical Research Services Core:** Facilitates clinical research by providing infrastructure for clinical investigators conducting human-based research; offering specialized facilities, equipment, personnel and advice. From pilot studies to multi-center trials, the core offers services to investigators who need skilled nursing support, specimen processing, dietary consultation from a registered dietitian, regulatory assistance, subject recruitment or data management.

## **Databases**

Multiple tissue banks

Genetic and proteomic databases in various clinical areas

## **University of Central Arkansas**

### **Unique STEM Education**

STEM Residential College

The STEM Residential College provides a unique living/learning experience for freshman STEM majors at UCA. The support of the STEM-faculty residence director, STEM-major residence assistants, and STEM peers creates a unique environment that fosters academic success and high freshman retention rates.

### **Research Clusters**

#### **Environmental Science**

Environmental Science research projects include the study of invasive Japanese Honeysuckle, bee communities in the Arkansas River Valley, the potential effects of natural gas development on headwater streams, resource ratio effects on stream detritus and detritivores, effects of rapid urbanization on ecosystem processes in wetlands within the Arkansas River Valley, status of invasive Northern Snakehead in Arkansas, upstream migration of Yellow-Phase American Eels (*Anguilla rostrata*) at Norrell Lock and Dam (Arkansas River Navigation System), occurrence of the Striped Mullet (*Mugil cephalus*) in the Lower Arkansas River, long-term study of fishes in Piney Creek in Arkansas, Alligator Gar status and life history, conservation status and threats to Grotto Sculpin (new species of cavefish in Missouri), effect of addition of wood to headwater streams in the Sylamore Ranger District (Arkansas), root endosymbioses in legumes and cereals, and corticosterone stress physiology in Ranid (frog) species, Chicken Turtle, and Red-eared Slider Turtle in Arkansas.

#### **Biomedical Research**

Biomedical Research at UCA involves more than 10 professors working in biochemistry, biophysics, and physiology. The research is funded primarily through the IDeA Networks of Biomedical Research Excellence (INBRE) and is in collaboration with researchers at the University of Arkansas for Medical Sciences and other national institutions. Biochemistry research at UCA includes the study of hypertension in post-menopausal women, the effect of vitamin A on immunity, wound healing in diabetic patients, and the association of changes in the structure of mitochondria to neurodegenerative diseases. A long-standing collaboration in biophysics research with UAMS researchers involves microgravity effects on cellular processes and physiology research in the Department of Mathematics involves spatial statistical modeling to analyze brain scan data for identification of specific areas of the brain affected by diseases.

#### **Neuroscience**

Neuroscience research at UCA is a collaboration between Physical Therapy, Communication Sciences and Disorders, Exercise Science and basic neuroscience researchers. Researchers at UCA, in collaboration with UALR, UAMS, and Cornell University, developed the Translating Time Project ([translatingtime.org](http://translatingtime.org)) to relate neurodevelopment data between non-human species and to humans with



**Figure 18: Environmental Science research at the University of Central Arkansas**

mathematical models that researchers around the world have used and cited. Other research in neuroscience at UCA includes functional brain mapping of armadillos, swallowing disorders research, the study of axonal and cellular degeneration mechanisms to find therapeutics for neurological disorders, and the study of Cognitive-Communication Disorders of Dementia.

### Informatics

Informatics research at UCA is conducted/facilitated by several faculty members in the Department of Computer Science, the Department of Health Sciences, and the Department of Mathematics. Concentrations in bioinformatics and health informatics include research in feedback control of molecular biological systems, medical image processing, and secure electronic health records transmission. An NSF funded Research Experience for Undergraduates (REU) at UCA in Health Information Technology attracts undergraduate researchers to UCA and encourages students to pursue graduate research in Computer Science.

### Ph.D. in Physical Therapy

The PhD in Physical Therapy at the University of Central Arkansas is designed to prepare students to become scholars and leaders in Physical Therapy. Graduates of this program will have the ability to make significant contributions to scholarship in physical therapy. Students in a PhD program are required to grasp complex intellectual issues in addition to the highly technical standards necessary for research and scholarship. Specific program objectives include the following:

- Skill to conduct original research, providing evidence of an understanding of research designs and the ability to formulate, plan methodologies, conduct data gathering (qualitatively and quantitatively), draw conclusions, and effectively communicate research findings;
- Commitment to engage in scholarship after graduation and to discover new knowledge and develop theoretical principles that advance the understanding of their chosen discipline;
- Breadth of knowledge of the discipline and the research literature;
- The ability to teach at beginning and advanced levels of instruction; and
- Leadership traits that guide the profession in identifying and resolving important questions and problems.



**Figure 19: Human Motion Analysis Laboratory at the University of Central Arkansas**

Research specialties within the Department of Physical Therapy are organized along four tracts – Adult Neurological, Spinal Cord Injury, Pediatrics, and Diabetes and Obesity research (see <http://uca.edu/pt/researchs/>). Whereas these areas represent general research specialties of the faculty; individual research projects are not limited to these areas. In most cases, faculty work directly with graduate and undergraduate students on research projects. Faculty may train and supervise students to work in their own research laboratories or they may supervise student-lead dissertation and honors theses. Both faculty and students are actively engaged in disseminating information to the public in the form of published manuscripts, chapters and textbooks. Additionally, faculty and students are actively engaged in seeking funds for research by submitting grant applications to a variety of regional, state and national agencies.

The following is a list of some of the faculty and student research projects currently underway in the Department of Physical Therapy: 1) using brain stimulation (i.e., transcranial direct current stimulation

(tDCS)) to augment gait recovery following stroke, 2) using tDCS experimentally to investigate human motor systems, 3) investigating therapeutic methods to reduce the pain and stress experienced by neonates in intensive care settings, 4) investigating methods of gait training for children with developmental delay, 5) examining the efficacy of prescribed exercise regimens for treating diabetes, 6) examining whether team based learning can enhance gross anatomy instruction and augment student learning, and 6) investigating whether and how electrical stimulation of the limbs can alter excitability of the cerebral cortex.

### **Unique Instrumentation**

Human Motion Analysis Laboratory uses four motion analysis cameras, floor mounted force plates, and motion analysis software to support a broad range of research projects involving human motion. Areas of research focus include rehabilitation of foot-drop, gait, strength and balance of senior citizens, athletes and individuals following stroke and head injury. The lab is used primarily by the Adult Neurological Research Group (ANRG) in the Department of Physical Therapy at UCA.

HPC cluster- Callisto Cluster (Research Computer Cluster)  
300MHz NMR Spectrometer , JEOL ECS-300 (Chemistry)  
Confocal Laser Scanning Microscope  
Micromass MALDI – TOF Mass Spectrometer

### **Databases**

University of Central Arkansas Herbarium

## National Center for Toxicological Research

### **Unique STEM Education**

#### Regulatory Science Training

NCTR provides opportunities for undergraduate and graduate students, postgraduate scientists, scientists from other countries, college/university faculty members, and others to obtain hands-on laboratory experience by working with experienced scientific researchers.

### **Research Clusters**

#### Biomarker Identification

Research discover and evaluate translational biomarkers of toxicity and disease using systems biology approaches in preclinical and clinical studies, and develop alternative models (e.g., stem cells) to assess toxicity and efficacy of FDA-regulated products. Together, these approaches will improve public health by providing new insights and assays in preclinical safety testing, disease detection, and patient management.

#### Bio-Imaging

##### Non-invasive Imaging

NCTR houses a Bioimaging Laboratory within its ALAAC-certified animal facilities to promote development of translational study designs that ease the transition of research laboratory discoveries to clinic application. In addition to the feature of translational study design, the non-invasive nature of the technologies improves experimental results as each animal serves as its own unique control, and they are repeatedly monitored through all phases of study design including dose administration, the course of lesion/toxicological event, and intervention protocol design. Featured instrumentation includes small-animal sized MRI/MRS and tandem microPET/CT platforms. Operation of the NCTR Bioimaging Laboratory is enhanced through cooperation with the nearby University of Arkansas for Medical Sciences cyclotron facilities that provide the short half-life radiochemicals required for this work. Initial work in this facility has featured comparisons of anatomical structure (MRI/MRS), biochemical function (microPET/CT) and traditional measures of pathology, which are utilized to anchor imaging data to accepted pathological assessments.

#### Computer-aided Imaging tools and protocols for Pathology Review

Accepted practices for regulatory decisions involving pathology include hands-on formal reading of slides, and consensus judgment of pathology working groups. This process is both expensive and often delayed because of difficulties in synchronizing the schedules of several consulting pathologists. The NCTR selected and then qualified methods for computer-aided digital review of pathology slides and distance evaluation by pathologists at different sites. In addition assuring identical technological color and resolution characteristic qualities for each pathologist protocols and computer technology permits multiple users to review the same image from off-site locations, and hold interactive discussions to achieve a consensus report in record saving times. The integrity and security of the study material is also enhanced by the single-site security protocol and minimal handling through the review process.

#### Nanotechnology

Through the Nanotechnology Core Facility, NCTR and the Arkansas Regional Laboratory (ARL) are working together to develop methodologies to detect nanoscale materials in biological samples of FDA-regulated products. The facilities are designed with a wide spectrum of workhorse instrumentation that assures accurate characterization of nanomaterials by size, shape, concentration, dispersion characteristics of dose materials for animal studies, dispersion for in vitro study design, etc. used in

toxicology studies The joint operation of the facility by NCTR (the primary research center of the FDA) and the ARL (one of 5 primary compliance laboratories of the FDA) provides the advantage of transferring or developing protocols for product quality and safety nanotechnology-based products in drugs, devices, biologics, cosmetics, and food within the regulatory responsibility of the FDA. The capabilities of this Core facility are both complimentary and augmented by the availability of research grade instrumentation located at the University of Arkansas at Little Rock and the University of Arkansas, Fayetteville.



Figure 20: Dale Bumpers National Rice Research Center

### Personalized Medicine and Systems Biology

The programs of Personalized Medicine and Systems Biology are organized around the strategic goal of the FDA to improve public health outcomes through individualized health care plans improving disease diagnosis, therapeutic regimens and nutritional assurance. Central to this effort is the development of biologic fingerprints (aka, “biomarkers”) that classify individuals into subpopulations that differ in their susceptibility to a particular disease or their response to a specific treatment. Classifications include genetics, sex, age, epigenetics, and life-style and environmental factors such as smoking and obesity. These studies are aided by NMR and mass spectrometry technologies and sciences (e.g., metabolomics, and proteomics) that evaluate whole blood, serum or urine for signature profiles of safety and efficacy of interventional protocols.

### Bioinformatics

The utilization of high- throughput technologies and data intensive evaluations created by arrays and digital imaging has created both a data storage overload and needs for advanced statistical evaluations. The Bioinformatics Program was developed to create solutions for issues of data storage and quality. The Program has provided the anchor base to test and reach consensus on the performance characteristics, visualization, and evaluation of these data rich technologies in the international arena. This program also investigates heuristic approaches to evaluate diverse data sources for detection of potential adverse treatment events, and data solutions for newer technologies (e.g. NexGen sequencing, etc.)

### **Unique Instrumentation**

#### High-Resolution MicroPET

NCTR’s high-resolution MicroPET installation has been completed and will be used in preclinical studies to evaluate the emergence and development of toxicity

#### Nanotechnology Core Facility

The Nanotechnology Core Facility supports nanotechnology toxicity studies, develops analytical tools to quantify nanomaterials in complex matrices, and develops procedures for characterizing nanomaterials in FDA-regulated products.

### **Databases**

## Dale Bumpers National Rice Research Center

### **Research Clusters**

#### Germplasm Evaluation and Enhancement

Research topics include germplasm regeneration and evaluation, genetic characterization of global rice germplasm, genetic improvement of grain yield and hybrid rice, physiological disease resistance (straighthead), arsenic content in rice grain, fungal disease resistance, and bran color control and new cultivar.

#### Molecular Genetics

The Molecular Genetics laboratory conducts genetic analysis of disease resistance for improvement of U.S. long grain germplasm. Current projects include mapping genes conferring sensitivity to the phytotoxin produced by *Rhizoctonia solani*, the causal agent of Sheath Blight, and identification of germplasm resistant to rice grain smuts and mapping the corresponding genes.

#### Molecular Plant Pathology

The Molecular Plant Pathology (MPP) program is assigned to identify the genetic and pathological tools and resources for rice breeding. The current focus of the MPP program is to study rice - *M. oryzae*, and rice - *R. solani* pathosystems, and to apply molecular techniques to identify sources of disease resistance, and to design strategies to accelerate incorporation of resistance genes into improved germplasm.

#### Molecular Biology

The Molecular Biology laboratory conducts research on the biology, genetics and molecular mechanisms of plant tolerance and response to insect, pathogen, cultural, and environmental stresses. Current projects include: factors influencing occurrence of straighthead; varietal response to stackburn; genetic basis of cold-sprouting; influence of poultry litter on plant growth; and non-destructive methods for carotenoid measurement.

#### Cytogenetics

Research projects include the identification of trisomic rice plants, the development of mapping populations from sheath blight resistant *Oryza* species, exploring the genetic basis of transgressive variation in rice, and the development of mapping populations between U.S. rice varieties and Wild *Oryza* species.

#### Weed Physiology

Researchers study weed suppressive rice cultivars and red rice hybrid control to increase crop yield.

#### Cereal Chemistry

The Cereal Quality Laboratory identifies factors affecting grain quality in conventional and specialty rices, including aroma and taste. The lab also conducts a trait discovery program to identify value-added grain traits for rice.

#### Rice Genetics and Breeding

The objectives of the rice genetics and breeding research program are to 1) Develop improved rice cultivars that are adapted for production in the Southern United States; 2) Develop novel genetic resources that can be used by the rice research community in breeding and to study the genomic location and genetic control of traits important to the rice industry; 3) Evaluate genetic resources for their resistance to diseases and physiological stresses; yield potential under diverse environments; and milling, cooking, processing and sensory qualities; and 4) Maintain, characterize, and distribute genetic resources to the rice research community through the Genetic Stocks Orzo (GSOR) collection.

## Unique Instrumentation

Genomics Core Facility

Performs DNA analyses for all projects at the Dale Bumpers National Rice Research Center as needed.

## Databases

Genetic Stocks - Oryza (GSOR) Collection

A genetic stock of rice seeds with unique genetic and agronomic traits has been archived. Total available accessions are 33,912. This genetic stock collection preserves materials that otherwise might be lost as researchers retire and/or grants terminate. Although model genetic stocks collections have been set up in tomatoes, maize, barley, and wheat in the U.S., such a collection was lacking for rice. Thus this collection fills that void, which has been recognized for at least a decade.

## Where We Want to Be

### Areas of research strength in Arkansas:

The review of the 17 public and private bachelor and advance degree conferring institutions document that a research promoting culture exists in all institutions, stronger on some campuses than others independent of size of the institution. Collectively the research on the 17 campuses can be collapsed into eight general areas with varying strength in human and physical infrastructure in these eight areas:

Drug industry – development/delivery/toxicity

- Biomedical & costs of drugs
- Antibody research
- Biotechnology – genetic information
- Plant produce human vaccines

Information Technology

- Transportation logistics
- Record keeping of medical records
- Information security
- Wireless sensors
- Data warehousing/data mining/retail data/ finance data
- IT support for mobile apps

Networking – increased efficiency – statewide & secure

- Convergence of broadcast/internet/paper
- Topography – delivery of internet – NW ARK
- Telemedicine
- Bioinformatics – medical and plant based

Agriculture

- Food safety & energy efficiency
- Inexpensive, nutritious feed ingredients / genetics
- Environmental impact/free renage/ growing meat in culture
- Diversification f the product/ climate change & food costs
- Rice & water usage/

- Weed killers & resistant weeds
  - Weather & climate change effect on crops & livestock/ fish kills
- Environmental Science
- Relationship to tourism/ biodiversity & genetic variability
  - Impact of drilling & new drilling technologies
  - Impact of drilling, mining, and agriculture on stream flow
- Energy & Alternative energy research
- Solar cell research
  - Biofuels research
- Materials Research
- Nanotechnology (all areas)
  - Metamaterials (all areas)
  - Practical applications of both above
- Mining & Geology
- Petroleum & Natural gas technology research
  - Seismology research – collaboration with Earthquake Center in Memphis
  - Mining research –Lignite & anthracite coal research

**Research Focus Areas.** After analyzing the multiple research areas of focus on the campuses, the infrastructure to support research broadly across the state’s six research clusters within the many campuses of Arkansas emerge as on-going research efforts and infrastructure for six collaborative research areas:

- **Advanced Materials**
- **Aerospace & Defense**
- **Agriculture, Food & Natural Resources**
- **Biomedical & Biotech**
- **Information Technology & Telecommunications**
- **Energy**

### **Economic cluster (applied opportunity)**

**Six economic cluster per IEA analysis.** The Institute for Economic Advancement was commissioned by U.S. Economic Development Administration (EDA) to analyze and identify the existing economic clusters, classify the clusters by level of innovation and research capabilities, analyze gaps between characteristics for innovative and noninnovative clusters, and develop strategies to assist existing clusters to increase innovation. IEA identified the following six clusters:

- Advanced materials
- Aerospace and Defense
- Agriculture, Food Processing and Packaging
- Forestry and Wood Products
- Biomedical and Biotech (Life Sciences)
- Information Technology and Telecommunications

The past ten years in Arkansas have been a time of progress in moving towards a knowledge-based economy. This change is visible in public policy, public and private sector action and is evidenced in a series of reports and evaluations by varied organizations including Milken [23], Battelle [24], and the upcoming UALR/IEA report on Regional Innovation Clusters in Arkansas. Important components of the change are the STEM Works initiative, linking changes in STEM education to economic advancement

and the 2009 policy changes [analyzed in the Battelle study] to encourage conversion of knowledge and university and industrial R & D into jobs. Federal programs, such as EPSCoR, have played a role, as has the newly formed Arkansas Research Alliance and state programs administered by ASTA. Both existing industry and startups have been affected. Programs such as the ARK utilize federal, state and private capital to recruit, inspire and advance start-ups in targeted application areas. The state has made targeted investments in research, such as the Nanotechnology Center at UALR, and providing "transferable" R&D tax credits to companies for investment in research. Industry has responded and more than doubled R&D on a per capita basis in the last five years (see Table 5), raising Arkansas to a rank of 37<sup>th</sup> among the states.

The Research Focus areas of the Science and Technology plan closely follow the Regional Industry Clusters found in Arkansas, and together support a set of Regional Innovation Clusters that combine geographic concentrations of interacting firms and industries with common needs for talent, technology and infrastructure with research partners, usually a university. The resulting innovation creates and transforms knowledge into new products, processes and services that meet market need. [*See Maps of research cluster and employment data from IEA study Appendix D.*]

Additionally, the Science Advisory Committee went through a brainstorming exercise before the IEA report was released. The exercise was designed to produce a list of industries employing STEM workers and to identify where opportunities for growth in many of these areas may exist. The industries identified can be related to five of the six areas identified as categories of research strength and significant infrastructure investment. The exception is advanced materials. While this is not a direct application of any of the industries that were part of the brainstorming exercise, it has indirect impact on several below and there are some younger, growing companies such as Nanomech and NN labs that directly utilize these research clusters.

**Opportunities: Arkansas has some unique opportunities based on the underlying technologies currently present in the state or emerging markets.**

Industries or organizations with high demand for skilled talent and potential R&D:

- Biomedical/Health Industry/NCTR
- Molex
- Wal-Mart-IT marketing on-line threat
- Dillard's – retail research
- Retail/logistics/food processing in NW Arkansas
- Data warehousing
- Telecom industry
- Connect Arkansas
- CTEH data collection
- Datafusion
- Photonics
- BEI
- SW Power Pool
- Arkansas Power Systems & Lasers
- SW Energy – oil & gas
- Alternative energy- windmills/turbines/solar panels
- Baxter/Mt Home – packaging of antibodies
- Biotechnology/environmental impact companies
- Nuclear power industry

- Falcon Jet & aerospace
- Defense industry

### **Analysis of employment and research clusters within the universities.**

Improving the ability of the state to fully participate in the knowledge-based 21st Century economy is vital to Arkansas. Understanding the existing research capabilities and working to upgrade them is an important step for three reasons:

- 1) Research in itself is an important part of the economy and wise choices must be made of areas of investment.
- 2) Research and Development in many areas are important to existing jobs and provide a path to preserving, increasing and advancing pay in these jobs.
- 3) Research is important to development of the IP that is the seed forming high-tech, high pay startup firms.

The Committee felt it important to define research clusters and to relate them to the present and future economy of the state. The first step was to look at the results of the survey of research efforts and group those efforts into clusters.

Six clusters emerged from thoughtful consideration of the research study as indicated earlier in Part II- Research Focus Areas. These include: **Aerospace and Defense, Energy, Advanced Materials, Agriculture, Food and Natural Resources, Biomedical and Biotech, and Information Technology and Telecommunications.**

Interestingly, a separate study by Accelerate Arkansas, working with the Institute for Economic Advancement (IEA) at the University of Arkansas- Little Rock, had focused on existing employment and grouped jobs into Innovation Clusters. The only differences in these two lists of clusters are:

- 1) Innovation Clusters split Agriculture, Food and Natural Resources into two clusters:
  - a. Agriculture and Food
  - b. Forestry
- 2) Innovations Clusters do not include Energy as a separate category.

The Committee felt that many research resources applied to Forestry as well as Food and Agriculture. Energy was included because it is a major research focus in the state and, with an industrial base in oil and gas and renewable, it is an area of growth in Arkansas.

The Accelerate Arkansas Innovation Clusters report focuses on trends and opportunities in these clusters. Since the Innovation Clusters closely parallel the Research Clusters, defined in the Science and Technology Plan, it was possible to use the base data prepared by the IEA to produce maps that relate employment to research efforts. The final maps were produced for the Committee by the Center for Spatial Technologies at the University of Arkansas, Fayetteville.

### **Structure of the Maps**

For each of the Research Areas there are three maps. The first map shows the research institutions in the state that have clusters of researchers working on topics within this area. This base map also shows the jobs in the corresponding cluster by county. Counties are shaded in 5 categories according to the number of jobs in the county in that cluster, with the lowest category being 50 or less and the highest 3,500 or more. This emphasizes the higher population counties.

Two companion maps relate the jobs in the cluster to the salaries in each county for this area of work. Shadings indicate the counties where pay in the cluster is below the state average per capita income (second map) and where the pay in the cluster is below the national per capita income.

### **Brief Discussion of the Maps by Cluster**

### **Aerospace and Defense**

This cluster is the largest employer of the six – with a total of 223,000 jobs. Jobs are distributed across the state with the highest number – 59,000 – in Pulaski County. A very broadly defined area of Central Arkansas, Northwest Arkansas, and the area around Craighead County stand out as centers of this cluster. The lowest employment is in the Ozarks, Ouachitas, and parts of the Delta.

The map shows the Space Grant Consortium as well as the research centers. The Arkansas Space Grant Consortium makes up a very specialized cluster, in that some universities may have very few total researchers active within the research area, but they participate in ASGC collaborative efforts. The low employment areas tend to lack either research centers or ASGC research.

The average salary for employees in this cluster within all counties is at or above the state average per capita income. Additionally, while the average of most of the jobs statewide in this cluster are out at or above the national per capita income, there are many counties with lesser employment where the pay is under the national per capita income.

### **Energy**

This cluster employs over 30,000 people statewide. Most counties have between 50 and 750 jobs, with six having less than 50 jobs. Pulaski County leads in employment in the cluster with 3,600 jobs, followed by Faulkner, Sebastian, White, Union and Pope. Oil and gas development accounts for part of this distribution. Wind energy accounts for some jobs.

The high employment counties have average pay above the state and national average per capita but most counties are below those values. In counties that have average salaries above per capita, there are 27,000 jobs in the cluster above the state average and 24,000 above the national average.

Universities in areas with greater employment that lack research in Energy include: UCA, SAU and UAM.

### **Advanced Materials**

This cluster employs over 35,000 people statewide. One third of the counties in the state - including many counties in the Ozarks, Ouachitas, and Delta have less than 50 workers in the cluster, several have zero. Most of the remaining counties have between 50 and 750 jobs. Pulaski County and Mississippi County each have around 4,500 workers in the cluster, followed by Benton, Washington, Sebastian, and Craighead.

Except in the counties with low reported employment the average pay in this cluster is above the state and national average per capita but most counties are below those values.

### **Agriculture, Food and Natural Resources**

This cluster employs over 88,000 people statewide and employment is spread across the state. Three counties have fewer than 50 employed. Washington, Benton, Sebastian and Jefferson counties lead with each having over 3,400 workers in the cluster. Eighteen counties have between 1,200 and 3,500 workers in the cluster.

The average of the jobs in the cluster (73,000 out of 88,000) is above the state average per capita most of the counties that are not in the top two categories have pay less than the national average. There are many institutions doing research in this area and two federal labs – the National Center for Toxicological Research and the Dale Bumpers National Rice Research Center. Forestry is in the cluster and although

the jobs are spread out in all counties research is centered on UAM, with some activities at other campuses.

### **Biomedical and Biotech**

This cluster is the second largest employer of the six – with a total of almost 98,000 jobs. Jobs are broadly distributed across the state with the highest number – 21,000 – in Pulaski County. Other counties with more than 3,500 jobs in the cluster are Washington, Sebastian, Craighead, Garland and Benton. Baxter almost makes this tier. A very broadly defined area of Central Arkansas, Northwest Arkansas, and occasional counties in other areas stand out as centers of this cluster.

Employment in this cluster pays below the state and national average in most of the smaller counties. The total jobs in counties that have average salaries above the state per capita is 86,000, so only 11,000 jobs are below that level, but only 56,000 jobs are above the national average. Twelve of the seventeen institutions report doing research in this cluster.

### **Information Technology and Telecommunications**

Although Arkansas is home to many firms based on Information Technology and Telecommunications, either as their core business or an essential element of the business, this cluster is the smallest employer of the six – with a total of 25,000 jobs. Jobs are not broadly distributed across the state. The three central counties of Pulaski, Faulkner and Jefferson have over half these jobs, with the highest number – 9,400 – in Pulaski County. Sebastian, Benton and Washington counties make up half the remaining jobs. Craighead County and Union County also employ significant numbers in this cluster. Almost all employment in this cluster pays above the state and national average per capita incomes. Many institutions do not report doing research in this cluster.

This cluster is necessary infrastructure for many other activities and the uneven distribution is a concern. The Delta, Ozarks and much of southern Arkansas (except Union County) show up as lacking both jobs and institutions reporting strengths in this area.

## Recommendations and Opportunities.

**Create a shared vision.** The Science Advisory Committee recognizes that the leadership and citizenry of the state need to understand the role that science and technology, research and development play in building the future of the state and increasing employment and per capita income. These advances require both innovation and creation of new enterprises and support for the existing economic sectors. The close relationship of the current research clusters and economic innovation clusters illustrate that this effort has begun.

**Collaborative efforts.** The Science Advisory Committee recognizes and encourages further use of collaborative efforts among universities and university researchers. In a small state such as Arkansas with limited resources, it is critical that universities look beyond their own boundaries and share infrastructure and expertise, if real innovative progress is to be made.

**Leverage better.** The Science Advisory Committee further reinforces that universities and the various research teams on university campuses must become more open and adept at leveraging resources. Open access to user facilities for key infrastructure rather than duplicating infrastructure on every campus is critical. Additionally, better efforts are needed to share information on available resources in order that research teams have a better working knowledge of where resources exist. Finally, university campuses and state agencies must work together to more fully implement programs that will benefit campuses and campus researchers.

**Investment needs.** A fund needs to be established and/or more funds made available to support key areas that lead to innovation including instrumentation, seed funds for transformative research, entrepreneurial training and support, seed capital for very early start-ups.

**Funding Opportunities.** A state fund needs to be developed to provide funds for critical infrastructure needs or high value equipment that support rapid advancement in science (not sustainability).

**STEM Workforce.** Arkansas must increase the number of educated youth selecting careers in Science and Technology and create an environment that entices students beyond our borders. Arkansas must build on STEM Works and take it to scale if we are to have a skilled population that meets future needs of the workforce (i.e. 80% of Arkansas jobs will require a 2-year degree).

**Push research that can lead to start-ups and strengthen existing enterprises.** Arkansas must foster an entrepreneurial education in all institutions. The Governors Cup competitions have increased the interest in this effort over the past few years. The number of SBIRs and STTRs is increasing and must be sustained. This is especially true on university campuses that have strong incubators and support for these efforts. In a 2012 Milken report, Arkansas is ranked 35<sup>th</sup> in the SBIRs/STTRs awarded per 10,000 business establishments between 2008-2010 and 30<sup>th</sup> in Phase II awards in that same category. In 2011, Arkansas companies were awarded twenty-three SBIRs, of which three were phase II awards. The majority were from start-up companies originating or partially supported with help from university incubators, but interestingly, one small start-up that is not affiliated with university support, Invotek, Inc., located in Alma, Arkansas, garnered four of those SBIRs/STTRs. The federal agencies issuing these awards to Arkansas companies included DOD (eight), DOE (one), NASA (three), NIH (five), NSD (two), HHS (three), USDA (two). In 2012, seventeen SBIRs/STTRs were awarded with four of these as Phase II. The distribution of federal agencies making these awards included: NIH (six), DOD (two), DOT (one), USDA (four), DOE (one), EPA (one), HHS (two). (See Table 2-4 in Appendix A.)

**Create an environment that will draw from all regions and retain our best and brightest.** Building a workforce of Arkansans with STEM skills is ineffective if there are no employment opportunities for these young people. Arkansas must create a culture that encourages STEM skills and supports this way of life with ample employment opportunities. The Governor's STEM Works Program is a major step in that direction and as it expands across our state will have major impact on STEM workforce proficiency and public attitudes toward 21<sup>st</sup> Century skills.

### **How do you support research?**

Toward these recommendations, it is our hope to enlist state government support in these efforts. Additionally, as noted in Table 5, industry R&D has doubled in the last 5 years. "In the past ten years R & D investment by Arkansas industry has more than doubled on a per capita basis and Arkansas is now 37<sup>th</sup> in rank and rising." In 5 more years will Arkansas industry be spending more? Arkansas state government needs to further campus-industry partnerships. In turn, issues which make such partnerships difficult need to be overcome, i.e. campuses need to relax the restrictions that can hamper intellectual property rights and industries need to work through publishing issues with campuses. Finally, state government support is more easily attained if research investments are approached strategically. Long, term strategies with economic impact factored in must be developed within the six research focal areas identified. By considering economic drivers for university research, campuses can build science/engineering platforms that will have long-term positive economic impact while simultaneously building stronger public support for research and adding to the state's economic fortunes.

It is our hope that when the S&T plan is revisited in 5 years, we will find our strategic vision has produced results and we will observe:

1. Many more STEM majors in K-12 classrooms through the continuation of UTEACH.
  2. Most students will have access to "hands-on" projects based learning, as pioneered in STEM Works and this experience will start in elementary school with trained elementary science specialists.
  3. More STEM-based entrepreneurship through SBIRs, STTRs and efforts such as accelerators, technology parks and programs to encourage and support entrepreneurship in students and working citizens.
  4. More industries with STEM employees and research as the source of new products and jobs.
  5. Greater collaboration with employers in the process of lifelong education, breaking down the silos of education and work. Employers and citizens in general will recognize and support the progress in education. Students will better understand why they need to learn STEM subject and entrepreneurship and there will be defined roles for employers in the educational process, including internships and other enrichment activities.
  6. Greater coverage of the state in STEM-related employment clusters.
  7. University outreach programs to offer courses at more locations and times and to offer extend STEM resources in research and development to a wider range of firms.
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#### APPENDIX A: Tables and Data from External Sources

**Table 1:** Percent Educational Attainment in Selected States, 2011.

	US Total	AL	AR	KS	KY	LA	MS	MO	OK	SC	TN	WV
Less than 9th grade	6.1	6.0	<b>6.5</b>	4.3	7.5	6.4	6.7	4.3	4.7	5.7	6.3	6.2
9th to 12th grade, no diploma	8.3	11.7	<b>10.4</b>	6.1	10.3	11.5	12.4	8.6	9.1	10.4	10.0	10.5
High school graduate (includes equivalency)	28.4	31.0	<b>35.1</b>	27.9	34.1	34.3	30.5	31.8	31.8	30.5	33.3	41.2
Some college, no degree	21.3	21.9	<b>22.3</b>	24.5	20.4	21.4	22.7	22.9	24.4	20.7	21.0	18.2
Associate's degree	7.6	7.2	<b>6.1</b>	7.3	6.8	5.0	8.0	6.9	6.8	8.5	6.1	6.1
Bachelor's degree	17.7	14.1	<b>13.0</b>	19.5	12.4	14.3	12.5	16.1	15.5	15.7	15.0	11.1
Graduate or professional degree	10.5	8.0	<b>6.5</b>	10.3	8.5	7.1	7.1	9.6	7.6	8.6	8.2	6.8
Percent high school graduate or higher	85.6	82.3	<b>83.1</b>	89.6	82.2	82.1	80.9	87.1	86.1	83.9	83.7	83.4
Percent bachelor's degree or higher	28.2	22.1	<b>19.5</b>	29.8	20.9	21.4	19.6	25.6	23.1	24.3	23.2	17.9
Total Population 25 years and over (million)	204.35	3.17	<b>1.92</b>	1.84	2.9	2.94	1.9	3.98	2.44	3.08	4.25	1.3

Source: Selected Social Characteristics in the United States: 2009-2011. 2009-2011 American Community Survey 3-Year Estimates

**Table 2:** Arkansas SBIR and STTR Awards Statistics (2002-2010)

	2002-2004		2004-2006		2008-2010		Arkansas Percentage Change (2002- 2010)	50 State Average Percentage Change (2002- 2010)	(Arkansas Percent Change) - (50 State Average Percent Change)
	AR State Rank	Statistic	AR State Rank	Statistic	AR State Rank	Statistic			
Average Annual Number of SBIR Awards per 100,000 People	45	0.56	34	0.67	31	0.79	41.07%	-21.30%	62.37%
Average Annual Number of STTR Awards per 10,000 Business Establishments (2008-2010)	42	0.26	20	0.76	22	0.76	192.31%	32.57%	159.74%
Average STTR Award Dollars per \$1 Million of GSP	42	5.4	11	25.83	24	15.82	192.96%	82.75%	110.21%
SBIR Awards per 10,000 Business Establishments, Phase I	35	2.14 (2004)	30	2.4 (2006)	35	2.3 (2010)	7.48%	7.49%	-0.02%
SBIR Awards per 10,000 Business Establishments, Phase II	32	1.07 (2004)	25	1.8 (2006)	30	1.23 (2010)	14.95%	-4.63%	19.59%

Source: Klowden K, Wolfe M. (2013). State Technology and Science Index 2012. Milken Institute. Accessed online April 23, 2013: <http://www.milkeninstitute.org/pdf/STSI2013.pdf>

**Table 3:** 2011 SBIR and STTR Grants in Arkansas

Year	Agency	Type	Phase	Company	City	Grant Number	Description
2011	DOD Air Force	SBIR	Phase 1	Space Photonics, Inc.	Fayetteville	FA8650-11-M-1107	Packaging Technique to Provide a Variety of Critical Anti-Tamper Safeguards
2011	DOD MDA	SBIR	Phase 1	Electronics International, Inc.	Fayetteville	W9113M-11-C-0033	Multi Module DC/DC Converter PMAD System For Optimal Energy Utilization
2011	DoD MDA	SBIR	Phase 1	Space Photonics, Inc.	Fayetteville	HQ0147-11-C-7608	EM Emanation Reduction Technique for FPGAs
2011	DOE	SBIR	Phase 1	Electronics International, Inc.	Fayetteville	n/a	Manufacturable High Voltage Power Module for Energy Storage Systems
2011	DOD NAVY	SBIR	Phase 1	Electronics International, Inc.	Fayetteville	N00167-11-P-0367	GaN power amplifier packaging for the transmit/receive modules
2011	DOD	NAVY	Phase 1	Electronics International, Inc.	Fayetteville	N00167-11-P-0367	GaN power amplifier packaging for transmit/receive modules
2011	NASA	SBIR	Phase 1	Nanomatronix, LLC	Fayetteville	11-1-A2.01-8229 GRC	Development of a Novel, Reactive Extrusion Process for Continuous Production of Long, Pure Carbon Nanotubes for Application in Lightweight Composite Materials
2011	NIH	SBIR	Phase 1	Invotek, Inc.	Alma	1R43AG039172-01A1	CAREGIVER TRAINING TO MAINTAIN DRESSING PERFORMANCE IN PERSONS WITH ALZHEIMER'S
2011	NIH	SBIR	Phase 2	Toxicity Diagnostics, LLC	Little Rock	2R42DK079387-03	ADDUCT DIPSTICK FOR DIAGNOSIS OF ACETAMINOPHEN TOXICITY
2011	NIH	SBIR	Phase 1	Invotek, Inc.	Alma	1R43HD063169-01A1	INTEGRATED EYE AND HEAD TRACKING FOR PEOPLE WITH SEVERE DISABILITIES
2011	NIH	SBIR	Phase 1	Ocean Nanotech, LLC	Springdale	1R43AI092962-01	QUANTUM DOT-BASED QUALITATIVE AND QUANTITATIVE MULTIPLEX STRIP TEST FOR MALARIA I
2011	NIH	SBIR	Phase 1	SFC Fluidics, LLC	Fayetteville	1R43NS076167-01	PORTABLE BRIAN INJURY BIOMARKER DETECTION SYSTEM WITH INTEGRATED MICRODIALYSIS PR
2011	NASA	SBIR	Phase 1	Ozark Integrated Circuits, Inc.	Fayetteville	X6.02-9582 MSFC	Wide-Temperature Radiation-Hardened Interface Chipsets Utilizing Delay-Insensitive Asynchronous Logic
2011	NASA	SBIR	Phase 1	Nanomatronix, LLC	Fayetteville	A2.01-8229 GRC	for Continuous Production of Long, Pure Carbon Nanotubes for Application in Lightweight Composite
2011	NSF	SBIR	Phase 1	AC Diagnostics, Inc	Fayetteville	1045736	Candidatus Liberibacter Species, Bacteria Associated with Citrus Huanglongbing
2011	NSF	SBIR	Phase 1	Ocean Nanotech, LLC	Springdale	1047352	Nanoparticle Enhanced Antibody Production
2011	HHS	STTR	Phase 2	Toxicity Diagnostics, LLC	Little Rock	2R42DK079387-03	Adduct Dipstick for Diagnosis of Acetaminophen Toxicity
2011	HHS	SBIR	Phase 1	Invotek, Inc	Alma	1R43HD063169-01A1	Integrated Eye and Head Tracking for People with Severe Disabilities
2011	HHS	SBIR	Phase 1	Invotek, Inc	Alma	1R43AG039172-01A1	Caregiver Training to Maintain Dressing Performance in Persons with Alzheimer's
2011	DoD Air Force	SBIR	Phase 1	Electronics International	Alma	FA8650-11-M-2165	Autonomous Wireless Sensor Networks in Aircraft Systems
2011	USDA	SBIR	Phase 2	Biostrategies, LLC	Jonesboro	2011-33610-31141	Plant Produced Porcine IL-12 Vaccine Adjuvant for Swine Flue and Other Viral Diseases
2011	USDA	SBIR	Phase 1	LLC dba Infinite Enzymes	Jonesboro	2011-33610-30459	Formulating New Cellulases For Diverse Markets: Defining QA Parameters
2011	DOD	SBIR	Phase 1	Space Photonics, Inc.	Fayetteville	W31P4Q-11-C-0161	XADUR - IP in untrusted fab environments
2011	HHS	SBIR	Phase 1	Ocean Nanotech, LLC	Springdale	1R43AI092962-01	Quantum Dot-based Qualitative and Quantitative Multiplex Strip Test for Malaria I
2011	HHS	SBIR	Phase 1	SFC Fluidics, LLC	Fayetteville	1R43NS076167-01	Portable Brian Injury Biomarket Detection System with Integrated Microdialysis PR
2011	DoD Air Force	SBIR	Phase 1	Aspire Solutions	Fayetteville	FA8117-11-C-0014	Improved Methodology for Engineering Repair Process

Source: Lee, T. "Arkansas SBIR / STTR Grant Awards". [Online] Arkansas Small Business and Technology Development Center. Updated January 16, 2013.

Available: <https://www.asbtdc.org/DocumentMaster.aspx?doc=2416>

**Table 4:** 2012 SBIR and STTR Grants in Arkansas

Year	Agency	Type	Phase	Company	City	Grant Number	Description
2012	NIH	SBIR	Phase 2	Invotek, Inc.	Alma	2R44HD059231-02	PLAYTALK' COMMUNICATION SOFTWARE FOR CHILDREN WITH COMPLEX COMMUNICATION NEEDS
2012	NIH	STTR	Phase 1	Ocean Nanotech, LLC	Springdale	1R42HL112518-01	Targeted Nanoparticles of Bismuth Organo Complexes for Spectral CT Imaging of COR
2012	DoD	SBIR	Phase 1	Aspire Solutions, Inc.	Fayetteville	FA8117-12-C-0020	Condition Based Maintenance: Planning and Implementation
2012	NIH	SBIR	Phase 1	Invotek, Inc.	Alma	1R43HD072649-01	On-screen Keyboard Access Method to Reduce Workload
2012	DoD	SBIR	Phase 1	Arkansas Power Electronics International	Fayetteville	FA9453-12-M-0326	Multi-Module, Scalable, High Power Density, Radiation-Hardened Power Converter Interface Systems for Space Rated Li-Ion Battery in Satellite Applications
2012	DOT	SBIR	Phase 1	Poly Adaptive LLC	Little Rock	DTRT57-12-C-10071	ElectroDynamic Shield for Prevention of Optical Surface Contamination
2012	USDA	SBIR	Phase 2	Sea Star International	Fayetteville	ARKW-2012-02129	Antimicrobial Combinations that Help Protect Against Salmonella spp. and L. Monocytogenes in Organic and Natural Poultry Products
2012	NIH	SBIR	Phase 1	AC Diagnostics, Inc.	Fayetteville	1R43OD012402-01	An Automated On-Site Detection System for Viral Pathogens of Biomedical Laboratories
2012	NIH	SBIR	Phase 1	Invotek, Inc	Alma	1R43DC012734-01	Effective Self-Expression for People with Severe Speech Disorders
2012	DOE	STTR	Phase 2	Power Electronics International,	Fayetteville		Design and Development of a Low Cost Manufacturable High Voltage Power Module for Energy Storage Systems
2012	NIH	SBIR	Phase 1	Technologies, Infinite Energy, LLC	West Fork		A Wheelchair Anti-Rollback Device
2012	USDA	SBIR	Phase 2	dba Infinite	Jonesboro		Formulating New Cellulases for Diverse Markets: Defining QA Parameters
2012	USDA	SBIR	Phase 1	Sea Star International	Fayetteville	2012-33610-19529	Production of a New Vaccine for Poultry to Prevent Salmonella
2012	USDA	SBIR	Phase 1	Agri Wind Turbines, LLC	Little Rock	2012-33610-19478	USING A MODIFIED GRAIN SILO TO POWER A VERTICAL AXIS WIND TURBINE
2012	EPA	SBIR	Phase 1	Synanomet, LLC	Little Rock	EPD12027	Novel Lignin-Based Magnetite Nanocomposites for Removal of Phosphate from Contaminated Waters
2012	HHS	SBIR	Phase 1	Invotek, Inc	Alma	1R43HD072649-01	On-screen Keyboard Access Method to Reduce Workload
2012	HHS	STTR	Phase 1	Biodetection Instruments,	Fayetteville	1R41AI100468-01	A Binary Probe-Based DNzyme Cascade for Rapid Detection of MRSA/MSSA

Source: Lee, T. "Arkansas SBIR / STTR Grant Awards". [Online] Arkansas Small Business and Technology Development Center. Updated January 16, 2013. Available: <https://www.asbtdc.org/DocumentMaster.aspx?doc=2416>

**Table 5:** Arkansas Industry R&D Dollars per Capita

Arkansas Industry R&D Dollars per Capita		
Year	AR State Rank	US\$ per Capita
2009	37	244.75
2007	46	119.76
2004	43	104.48

Source: Klowden K, Wolfe M. (2013). State Technology and Science Index 2012. Milken Institute. Accessed online April 23, 2013: <http://www.milkeninstitute.org/pdf/STSI2013.pdf>

## APPENDIX B: Infrastructure Tables

### Change to science infrastructure label

## Arkansas State University

### Special Research Equipment (up to 5 items)

Flow Cytometer, BD Biosciences, Model FACSCalibur

Cell Sorter, BD Biosciences, Model FACSAria

Bioimaging system, BD Biosciences, Model Pathway 855

Image Analyzer and Digital Phenotyper, LemnaTec, Model Scanalyzer HTS

Microscopy facilities [Electron Microscope, Jem-100cx Temscan;

Scanning Electron Microscope, TESCAN, Model Vega TS 5136 XM;

Upright Microscope (DIC, fluorescence, confocal), Nikon, Model E800;

Inverted Microscope (fluorescence), Nikon, Model TE2000u; Inverted

motorized Microscope (confocal), Zeiss, Model Axiovert 200M;

Upright Olympus Microscope Model BX51 w/Smiths Detection Model

illuminat IR]

### Other Research Infrastructure (up to 50 items)

Glasshouse (greenhouse) w/four independently programmable ambients

Plant Growth Facility w/Programmable Conviron chambers Models PGC20, ATC40, and ATC60

Animal Facility for small animal research, equipped w/cage housing and surgery room

ABI Bioinformatics Facility

Mass spectrometer with MassLynx, Waters Corp., Model Maldi Micro MX

HPLC-Mass spectrometer, ThermoScientific-DIONEX, UHPLC Ultimate 3000-LTQ XL

HPLC with PDA and Fluorescence detectors, DIONEX, Model Summit TLC analysis system, CAMAG, Linomat 5 sample applicator and TLC Scanner 3

Gas chromatograph w/flame ionization detector, Shimadzu, Model GC-2010

Perfusion Chromatography Workstation (Protein-HPLC), BioCAD, Model 700 E

Multiwell plate reader, Bio-tek, PowerWave XS

IRIS 1000 laser; with 4 DFB Diodes

Titration workstation, Radiometer Analytical, Model TitrLab TIM 854

Automated Electrophoresis System, Bio-Rad, Experion

Liquid handler, Eppendorf, epMotion 5075

Real-Time PCR detection systems, Bio-Rad, Model CFX384 and Model CFX96

Avance 300 NMR spectrometer

Automatic Nucleic Acids and Protein purification system, Promega, Model Maxwell 16

Thermal gravimetric analyzers (Seiko and TA Instruments Q500)

DNA and protein quantification spectrometers, Nanodrop, Model 1000 and Model 8000

96-well plate fluorescence spectrometer, BMG LabTech, Model PolarStar Optima

Dionex HPLC LPG 340

Laser, Surelite 1-10

Dionex ASE 350 100ML Bundled Package

Coherent SCANMATE Pro C400 & Frequency Counter

OPO Optimized for Narrow Linewidth Near-IR, Telescope, DFG Module to provide tuning

Powerlite DLS 8000: Oscillator/Amplifier, DS, DS-1, TS: Second and Third Harmonic Generators, Second and Third Harmonic Outputs, Fiber Optice Coupled Injection Seeder, and Beam access platform

Light Age Alexandrite Pulsed Seeded Ring Oscillator Pal Pro Laser System

Syst DL Pro 940 & SYST TA Pro-Custom Wavelength Complete System

Model WS-Ultimate/10MHz Wavelength Meter

Spectroscopic System, He Cooled cold head for Pb-salt detectors

5.2 um Tunable Laser Head - CW, mode-hop-free with Controller

Daylight Solutions 9.7 um CW Mode Hope Free Laser System

High Performance Counter Current Chromatograph, Dynamic Extractions, Model Spectrum

4.9um Tunable Laser System - CW, mode-hop-free

Tunable Laser Head, 7.5 micron CW Mode Hope Free

Differential Scanning Calorimetry, TA Instrments Q2000

Agilent Scanning ultraviolet-visible spectrometer

Shimadzu/Varian Gas chromatograph Mass Spectrometers

Shimadzu Inductively coupled plasma optical emission spectrometer

Varian graphite furnace atomic absorption spectrometer

Protein, Peptides and Nucleic Acids detection system, Bio-Rad, Model Bio-Plex

Micromass time of flight mass spectrometer

Nicolet FTIR spectrometers 90.125 cm<sup>-1</sup> and 0.5 cm<sup>-1</sup> resolution; 8700 GC/FT-IR Research Pkg0

MCL Picosecond OPA with 3 Channels, for ND: YAG Laser; Stand-Alone

SH Module with 3 Channels;MCL Picosecond OPO with 3 Channels;

Mode-Locked Picosecond Nd: YAG Laser

Array Detector Photodiode Pda-100

HEI-VAP Collegiate G1B 24/40-Rotary Evaporator (Roto-Vap)

## Arkansas Tech University

### Special Research Equipment (up to 5 items)

Electro-Fishing boats

### Other Research Infrastructure (up to 50 items)

Electro-fishing equipment

Fourier Transform Infra-red Spectrometer (FT-IR, Bruker)

X-ray Diffractometer (Leybold)

PCR machines

Tissue-culture equipment

GIS computer lab

16-inch reflecting telescope on Paramount ME+SBIGST9CCD detector

Metallograph rotating beam fatigue tester

Stress analysis XTR microscope

Rockwell hardness tester Charpy impact test machine

Digital Rockwell/Micro hardness tester Cantilever Flexor device

Universal tensile tester test machines

Metallograph stereo microscope with digital image acquisition /analysis

Low speed wind tunnel

HPGe detectors with shields

Gas flow proportional counter

Alpha/beta counting scanner

Digi bases for NaL detectors Fifty-five NIM modules

ADCAM and ACE ADC's Gamma Vision software

AmRay 1830T SEMAnatech VII Sputter Coating System

Thermo Noran X-ray detector Electronic analytical balance

IXRF X-ray analysis system Stereo light microscope

Keithley 197A digital multi-meter

Fluke 115 TRMS digital multi-meter

Leader LFG-1310 signal generator

HP 5314A Universal Frequency counter

Microkinetics express mill

Tetronic 3012B oscilloscope

EZ FG-8002 signal generator

## Harding University

### Special Research Equipment (up to 5 items)

Atmospheric Simulation Chamber

Diode Laser Spectroscopy Laboratory

Hybrid Rocket Motor Test Stand

Atmospheric Kinetics Laboratory

### Other Research Infrastructure (up to 50 Items)

Shimadzu LCMS 2020 Liquid Chromatograph

Shimadzu GCMS QP5000 Gas Chromatograph/Mass Spectrometer

PL 2300 Nitrogen Laser with Dye Laser

Shimadzu UV-2450 Ultraviolet Visible Spectrometer

Anasazi EFT-90 FTNMR Fourier Transform NMR

Shimadzu AA - 6650 Atomic Absorption Spectrometer

Aminco-Bowman Series 2 Luminescence Spectrometer

Shimadzu FTIR-8900 Fourier Transform Infrared Spectrometer

Perkin Elmer AutoIMAGE FTIR Microscope

Perkin Elmer Spectrum One FTIR Spectrometer

Cahn C-33 Microbalance

Microcal Scanning Calorimeter

High Vacuum Apparatus

Shimadzu GC-17A Gas Chromatograph with FID & ECD Detectors

Shimadzu 2010s Gas Chromatograph/Mass Spectrometer

## Henderson State University

### Unique Infrastructure (up to 5 items)

Simonson Biological Field Station (DeGray Lake)

Reynolds Science Center Planetarium

NF Webscope

Ground Penetrating Magnetometer

### Significant Infrastructure (up to 50 items)

CGEM 925 HD Computerized Telescope

CGEM 800 HD Computerized Telescope

CNC Machine

200 MHz NMR spectrometer

Gas Chromatograph w/ mass selective detector

High performance liquid chromatograph

Atomic absorption spectrophotometer, flame or graphic furnace atomizer

UV/Visible Spectrophotometer w/ biochemistry/kinetics package

Pasco Science Workshop Data Acquisition Systems (15)

Rigol DS1102E 100 MHz Digital Oscilloscope (5)

Meade 8 inch Telescope (4)

Fourier transform infrared spectrophotometer

Electrochemical analyzer

Mercury analyzer

UV Absorbance microplate reader

Refrigerated centrifuge

## Hendrix College

### Special Research Equipment (up to 5 items)

Research animal care facility

Robotics lab with robots based on FIRST and VEX platforms

400 MHz NMR spectrometer, JEOL ECS-400 with 24 position Autosampler – 2010

Cell culture room with laminar flow hoods (2), CO2 incubator (2), Nikon Eclipse TS100 microscope

### Other Research Infrastructure (up to 50 items)

Flow Cytometer (Accuri Cytometers, Inc)

Muscle Physiology system

Polymerase Chain Reaction (PCR) cycler (Antarus)

Zeiss Axioskop 40 microscope

Zeiss Axioskop 2 microscope

Microplate reader (Elisa)

Microwave reactor (MARS 6)

Two Linux-based computing clusters with workstations and servers.

Refrigerated high-speed centrifuge (Sorvall RC-28S)

Machine shop with mill, lathe, drill press, tapping station, band saw, grinding machine, and assorted hand tools

Microplate reader (Biotek Synergy 2), w/absorbance, fluorescence and chemiluminescence modes

Linux network managed independently by department, with 5 servers

FTIR spectrometer [3 (2 w/ATR)]

UV-visible spectrophotometer (3)

Atomic absorption Flame/Furnace spectrophotometer (Varian AA240 duo)

High Performance Liquid Chromatograph (HPLC) (3)

Ion Chromatograph (Dionex 1500) with AS40 autosampler

Gas Chromatograph-Mass Spectrometer

SpeedVac concentrator (Thermo Scientific)

Excimer laser (GAM Laser Inc., EX10/300) & Nd:YAG laser

Lab-built reflectron time-of-flight mass spectrometer with mass gate

Large ring laser interferometer for measuring rotational components of seismic waves, infrasound/ground coupling, convective storm generated infrasound

Nuclear physics lab with flexible NIM-based data acquisition system and various detectors

## John Brown University

### Special Research Equipment (up to 5 items)

Nuclear magnetic resonance spectrometer (Joel Eclipse +300MHz; Year Hold Oxford magnet)

HPLC (Hitachi Elite); diode array detector; diode pump

Atomic Absorption Spectrometer (Thermo Electron; Thermal Elemental S4 System)

Fourier Transform Infrared Spectrometer (Thermo Scientific Nicole iS5 ATR)

UV/Vis spectrometer (Agilent 8453)

### Other Research Infrastructure (up to 50 items)

Sorval Legend RT refrigerated tabletop centrifuge (and accessories)

Olympus Lumenera digital cameras (3) & microscope components (for attaching cameras)

Olympus phase contrast microscope (12)

Konica SRX-101A X-ray film processor with stand

Fixed angle rotor and two swinging-bucket rotors for ultracentrifuge

Shake incubator and shaker water bath

Liquid nitrogen-based cryogenic storage system; smaller Dewart flask for storing liquid nitrogen

Several room temp. microcentrifuge

Beckman Coulter DU530 UV/Vis spectrometer

UVP GelDoc-It 300 Imaging System with Software, transillumination and white light converter

CO2 incubators (1double stacked; 2 singles)

Inverted phase contrast microscope (Nikon, Olympus)

Luminometer

Gas Chromatograph Mass Spectrometer (Varian 3900 GC; Varian Saturn 2100T MS)

Semidry electroblotters (2)

Nikon Eclipse E400 epifluorescent microscope

Differential Scanning Calorimeter (TA Instruments DSC 2010)

Precision large-capacity refrigerated incubator, Model 30MR (with glass door)

Sorval refrigerated floor-model centrifuge with assorted fixed angle and swinging bucket rotos

Autoclave

Discovery 90 SE ultracentrifuge

SpeedVac concentrator, rotors, vacuum pump with refrigerated vapostrap (and accessories)

- 80 freezer; -150 freezer

Eppendorf 5417R refrigerated microcentrifuge with 301.5mL rotor

18.2 megaOhm water purification systems

BioTek microplate reader

Triathler combined benchtop liquid scintillation counter and luminometer

Class II biosafety cabinet (2)

Bio-Rad MyCycle Thermal cyclers (2)

Bio-Rad electroporation apparatus

DNA sequencing gel apparatus; vertical and horizontal gel apparatus; assorted powe supplies

Sonicator (with probes of various sizes)

Multi Potentiostat (Bioanalytical Systems)

## LYON COLLEGE (equipment List Unavailable)

### Ouachita Baptist University

#### Special Research Equipment(up to 5 items)

1 Mac Pro Server + 5 Mac Pro Workstations

1 Dell PowerEdge 2600 Server + 1 Dell Precision 650n workstation

#### Other Research Infrastructure (up to 50 items)

(2) 220 square foot tissue culture room (fully equipped)

Microplate reader w/ fluorescence, a dual injector and dual monochromators

Inverted fluorescence microscope with cooled CCD camera

Agilent Mx3005P real-time PCR instrument

Stratagene BioAnalyzer 2100 microfluids lab-on-a-chip instrument

Standard instrumentation for chemical analysis- NMR,IR,ICP,HPLC,AA

Sybyl-X molecular Modeling software from Tripos

**Southern Arkansas University**

**Special Research Equipment (up to 5 items)**

Shimadzu ICPE-9000 ICP with Autosampler and Vapor Generator (2)  
 Graphite Furnace Atomic Absorption Spectrophotometer

**Other Research Infrastructure (up to 50 items)**

Shimadzu TOC-VCSH Total Organic Carbon/Nitrogen Analyzer and Autosampler  
 Millipore Milli-Q Direct 8 Ultra High Purity Water System (Type I and Type III Output)  
 Shimadzu TGA-50 Thermogravimetric Analyzer  
 Shimadzu QP-2010S GC-MS with Autosampler  
 Thermo Nicolet IR200 FTIR with ATR Accessory  
 CEM MARS Microwave Digestion System  
 Thermo S4Flame AA  
 Flashpoint Instrument-Rapid Tester  
 Shimadzu EDX-720 energy dispersive X-Ray  
 Millipore Water System  
 Autoclave  
 - 80C Freezer  
 Anaerobic Growth Chamber  
 Centrifuges  
 CO2 Incubator  
 DNA-Analyser-1  
 Gel Imager  
 Growth Chamber  
 Lab Oven  
 EDX

Shimadzu Prominence HPLC with UV,RI detector, autosampler, MS-2020 Mass Spec  
 Varian EM-360 HHz MR with Anasazi upgrade , multinuclear, multi  
 Shimadzu UV-Vis 2450 UV-Vis Spectrophotometer  
 Ion Chromatograph-Autosampler  
 Varian Saturn 2000 GCMX including A Verian 3800 GC  
 Hewlett Packard 5890 Series II GC with ECD, FID, TCD Detectors  
 Nicolet IR Microscope  
 Auto Distiller  
 Incubator, BOD Incubator  
 Microscope w/camera  
 GC-MS  
 HPLC-MS  
 IC  
 Autoclave ICP  
 TGA  
 TOC/TN  
 GFAA  
 IR  
 UV-Vis

## University of Arkansas at Fayetteville

### Special Research Equipment (up to 5 items)

VICTER Power Box (4 Units)  
Razor Phase II - IBM iDataPlex system  
Razor Phase I - IBM iDataPlex system  
MacDonald Imagery Collection of five remotely sensed platforms  
Meteorite, rock and mineral collections  
Planetarium

### Other Research Infrastructure (up to 50 items)

Ultraflex II MALDI-TOF Mass Spectrometer  
Gas Chromatograph/Triple Quadrupole Mass Spectrometer  
Storm PhosphorImager  
StepOnePlus Real-Time PCR System  
Centrifugal Partitioning Chromatography  
ICS-5000 Capillary Reagent-Free Ion Chromatography System  
Quantum Efficiency Spectrometer  
JBX 5500FS Electron Beam Lithography System  
IR-VASE Spectroscopic Ellipsometer  
FEI Titan 80-300 Transmission Electron Microscope  
Eclipse 90i Confocal Microscope  
FEI Nova Nanolab 200 Dual-Beam Focused Ion Beam  
FEI XL-30 Environmental Scanning Electron Microscope  
Philips PW1830 Double System XRD and a Philips PW3040 X'Pert MRD High Resolution XRD  
Veeco Dimension 3100 Atomic Force Microscope  
High Temperature Conversion Elemental Analyzer (TC/EA)  
Elemental Analyzer (EA)  
Dual Inlet Mass Spectrometer  
Continuous Flow Mass Spectrometer  
GC-IRMS(EA)  
Agilent GC and Mass Spectrometer  
Bruker Reflex III MALDI-TOF  
Bruker Esquire-LC Ion Trap LC/MS  
IonSpec 9.4 Tesla Ultima Fourier Transform Mass Spectrometer  
Automated HPLC with analyte detection

Automated gas chromatograph  
ICP (Inductive Coupled Plasma) mass spectrometer  
Bomb calorimeter  
Automated Nitrogen/protein/carbon analyzer  
High Density Electronics Assembly Lab  
High Density Electronics Low-temperature Co-fired Ceramics Lab  
Li6400XT Portable Photosynthesis System  
Adaptis A1000 Growth Chamber  
X-ray diffractometer  
Perkin Elmer 433A peptide synthesizer  
Perkin Elmer protein sequencer  
Typhoon 8600 variable mode laser imager  
LAS 100 colled CCD Luminescent imager  
AKTA Explorer Air FPLC  
Optech ILRIS-3D scan unit  
AR High Performance Computing Center (4,985 cores)  
Water protein HPLC systems with diode array detectors  
Botany Greenhouse (13000 sq ft)  
Mullins Library: Special Collections  
Mullins Library: Electronic Journals (56,021)  
Physics Library  
Chemistry Library  
Glass shop  
Machine shop  
Ground-based radar interferometer  
MTS load frame

## University of Arkansas at Fort Smith

### Special Research Equipment (up to 5 items)

HPC cluster  
Student-Constructed Electric Vehicle (Geo Metro)  
Renewable Energy Laboratory

### Other Research Infrastructure (up to 50 items)

(2) Gas Chromatograph (Gow-Mag)  
UV-Vis Spectrophotometer (Thermo-Scientific)  
Atomic Absorption Spectrophotometer (Buck)

(2) IR Spectrophotometer (Thermo Scientific)  
Shimadzu HPLC  
(10) Visible Spectrophotometer (Thermo-Scientific)

University of Arkansas at Little Rock

Special Research Equipment (up to 5 items)

Transmission Electron Microscope JEOL JEM 2100F
Emerging Analytics Center
Molecular Beam Epitaxy (MBE) & MOVCD System
Atomic Layer Deposition System
Thermo K-Alpha X-ray photoelectron spectroscopy System

Other Research Infrastructure (up to 50 items)

Bruker D8-Discover (XRD)
JEOL 7000F SEM
Horiba Jobin Yvon LabRam 800 (Raman Spectrometer)
Micromeritics Surface Area Analyser ASAP-2020
Shimadzu UV/Vis/NIR Spectrometer UV-3600
Veeco Dimension 3100 AFM
Jeol 400 MHz multinuclear NMR instrument
Magnetron Sputtering Deposition System with GLAD capability
Electron-Beam (E-Beam) Evaporation System with GLAD capability
Metal-Organic Chemical Vapor Deposition (MOCVD) System
Plasma Etcher
Terra Universal Modular Cleanroom (1000)
Manual Probe Stations (Hot/Cold Stage)
UV-Vis-NIR spectrometers
FT-IR and Pico-Fox XRF spectrometers
Low energy HP-Ge gamma counter
Multi-angle Absorption Photometer -MAAP
Aethalometer (2 and 7 wavelength) black carbon measuring instruments
Gas Chromatography Mass Spectrometer (GC/MS; GC/MSD)
UV-A and UV-B detectors
DOC and TOC instrumentation (Shimadzu)
7 wavelength Multi-filter rotating shadow band radiometers
GC luminol detection systems (nitrogen dioxide, peroxyacetyl nitrate)
Long-path gas cells and tunable diode laser system
Nicolet Magna IR 500 spectrometer with ATR capabilities

Fluorescence and Emission spectrophotometer
Brüker Electron Paramagnetic Resonance Instrument
Concrete Mixing Equipment
Concrete (Fresh) Materials Testing Equipment
Hardened Concrete Testing Equipment
Concrete Curing Equipment
Hydrogen Storage and Gas Absorption/Desorption Measurement System
Battery Test Set-Up
Nanosphere Lithography Setup
TGA/DSC
Instron tensile test machine with environmental chamber
PVD system
Photoluminescence spectroscopy
Atomic Absorption Instrument
Low-temperature/ time resolved PL system
High energy/power laser ablation system
Doubly Vibrationally Enhanced (DOVE) Four Wave Mixing Spectroscopy
BASI electrochemistry Equipment
Polarimeter
Three electrode probe electrochemical analyzer(chronopotentiometry, etc.)
Perkin Elmer Model 3840 Diode Array Spectrometer
Shimadzu Gel Permeation Chromatography instrument
Mobile Devices (tablets, cell phones, motes) from Digital Forensics Lab
UALR Computational Research Center

## University of Arkansas at Monticello

### Special Research Equipment (up to 5 items)

BartZ Btc-2 minirhizotron camera system

Synergy calorimeter

Li-Cor LI-6400XT portable photosynthesis system

FLIR T620 Thermal Infrared Imager

Mitsubishi IR-M700 Thermal Imaging System

### Other Research Infrastructure (up to 50 items)

Spectroradiometer

Windendro tree ring scanner

Isco portable sequential sampler

Conviron A1000 growth chamber

Thermo Scientific MOD818 plant growth chamber

Ion Chromatograph

Shimadzu combustion analyzer

Shimadzu autosampler

Tuttnauer autoclave sterilizer

Eppendorf vacufuge concentrator

Lachat QuikChem flow analysis system

Li-Cor LI-8100 LEEF Climate Change package

Li-Cor datalogger

Li-Cor area meter

Decsgon Devices leaf porometer system

TreeTop III video probe

Leica microtometer

Products Group Portable Ultrasound

TMI chip classifier

Giddings 3pt mount coring & drill

PP600A Pellet mill

Wisconsin electrical oven

Compact track loader, blade & grapple

Sandpiper Technologies 10-mile wireless video system

Scientemp Corp. ultra cold countertop freezer

Nyle lumber drying system

Wood-mizer sawmill

Wisconsin forced air lab oven

Tinius Olsen wood shear tool

Tinius Olsen static bending testing tool

Mavco programable vacuum extractor

Fabtec beam compressor

Gilson modular hydropneumatic elutria

Gilson heavy duty 835 rpm mill

2 walk in coolers

## University of Arkansas at Pine Bluff

### Special Research Equipment (up to 5 items)

- (1) Anasazi 90 MHz FT NMR With H1 and C13 accessories, and COSY, NOSEY, HETCOR, DEPT, T1/2, and Kinetic Capabilities
- (2) Shimadzu HPLC with both Isocratic and Gradient Modes in Normal and Reverse Columns, and with Multiple Sample Handling Capabilities.
- (3) Scanning Electron Microscope, Phenom G2 Pro & Pro Suite Specification: Magnification range 20 – 45,000x
- (4) Raman Spectroscopy by Horiba, Labram HR Evolution Specification: Optimized for 200-2500nm, with two
- (5) Closed Cycle Refrigerated Cryogenic System with liquid Helium cooling, with Horiba Spectrometer

### Significant Infrastructure (up to 50 items)

Barnstead Nanpure Ultrapure Water System

### Other Research Infrastructure (up to 50 Items)

Taylor\_Wharton Liquid Nitrogen Storage  
Sonic Dismembrator  
Laminar Flow Hood  
Air Compressor Treadelight  
Shandon Linistain  
Scanmaker 3600 Microtek  
Flow Through System 2.5 gal tank  
Dolphin Water Pump  
Carbon Water Filter  
Tageluo Water Sand Filter  
TBS Water Floatation System (water bath histo)  
Surgipath Microtome  
Labconco Purifier PCR Hood  
Thermofisher FT - IR-works with neat samples, solid or liquid, no need of sample preparation.

Tissue Tek Dispensing Console  
Tissue Tek Thermal Console  
Tissue Tek Vacuum Infiltration Processor  
Molecular Devices Vmax Spectrophotometer  
Stratagene Joule Box System  
Olympus SZX 12 Dissecting Microscope  
Fisher Marathon 6K Centrifuge  
Blue M Incubator  
Tuttnauer 2540E Autoclave  
Eppendorf Centrifuge 5417R  
DNA Sequencer  
Tissue Tek Cryo Console

## University of Arkansas For Medical Sciences

Special Research Equipment (up to 5 items)

Numerous Core facilities

### Core Facility Equipment

Biosimetry Diagnostic Core -ultrahigh-performance liquid chromatography-tandem mass spectrometry (UHPLC-MS/MS)

Digital and Electron Microscopy Core ( Zeiss LSM 510 Meta, Aziolmager, Axiovert S100TV microscopes and a FEI Tecnai F20 200keV electron microscope)

Flow Cytometry Core ( FACSaria with three lasers)

Proteomics Core (Thermo Scientific LTQ Orbitrap Velos mass spectrometer with electron transfer dissociation capability (EDT), a Thermo Scientific LTQ XL Linear Ion Trap mass spectrometer with ETD, and a PerkinElmer SCIEX MALDI-prOTOF mass spectrometer)

DNA Sequencing Core (Operate 3100 Genetic Analyzer)

Genomic Core (Agilent 2100 Bioanalyzer and Illumina iScan, BeadXpress, Cluster Station, and Genome Analyzer IIx systems, Tecan Robot for Illumina protocols, Corbett Gene Extractor, SpectraMax Microplate Reader, Laser Capture Microdissection, Applied Biosystems 7900 Real-Time PCR)

Digital and Electron Microscopy Core (Zeiss LSM 510 Meta, Aziolmager, and Axiovert S100TV microscopes and FEI Tecnai F20 200keV electron microscope)

Experimental Pathology Core (Taperio digital slide scanning)

Skeletal Phenotyping Core (bone densitometry (DXA), peripheral quantitated computed tomography (pQCT) or microCT)

Bioluminescent & Fluorescent Imaging Core (The core maintains a Caliper Life Sciences IVIS 200 Imaging System, a highly sensitive CCD camera optimized for biophotonic imaging.)

Biotelemetry & Ultrasound Imaging Core ( VisualSonic Vevo 2100 System )

Molecular Imaging Core ( 7 Tm Magnetic Resonance Imager (MRI), MicroPET (Positron Emission Tomography))

Brain Imaging Research Core (Philips Achieva 3T X-series MRI system)

Molecular Imaging Core Provides comprehensive services for noninvasive imaging with a 7 Tm Magnetic Resonance Imager (MRI) and a MicroPET (Positron Emission Tomography).

## University of Central Arkansas

### Special Research Equipment (up to 5 items)

Human Motion Analysis Laboratory

Beckman Coulter Cell Lab Quanta SC Flow Cytometer

Confocal Microscope

Supercritical Fluid Extractor

Micromass MALDI-TOF Mass Spectrometer

### Other Research Infrastructure (up to 50 items)

Osmometer Vapor Pressure Wescor Inc 5130B

Microtome Rotary, American Optical 820

Rotavapor Brinkman Instruments R110

Transmittance/Reflectance Scanning Densitometer Model 1650

Spectrophotometer UV-Vis Beckman Du-40

Microscope Compound Binocular Olympus CH-2

Scholander Bomb PMS Instruments 610

Microscope Stereoscope Olympus SZ w Camera Attachment

Fotodyne DNA Transilluminator Analytical 3-3100

Centrifuge Micro 5415C

Living Stream Tank Frigid Units Inc LSW-900

Leaf Area Meter Portable CID Inc CI-202

Electrofisher Gas Powered Smith-Root, Inc 15-C POW

Thermal Cycler Programmable Thermal Cntl MJ Research PTC 100

Microscope Stereo Leica MZ6 w Moticam 1000

Microscope Compound Binocular Olympus BX40F-3 w Polarization

Microscope Inverted Phase Contrast Olympus IX70

Microscope Compound Binocular Wild Leitz M400

Uv Crosslinker SpectroLinker XL-1000

Osmometer Vapor Pressure Wescor 5500

Microscope Dual Observation Olympus CH3-DO

Sequi-Gen GT System

Vibratome 1000 Plus Sectioning System

Spectrophotometer Smart Speck Plus Bio Rad

Plant Growth Chambers Conviron E15

Microscope Inverted Phase Contrast Cambridge Instruments

GIS Laboratory

Sorvall RC 6+ centrifuge

Plasma Oxidation Apparatus

Selected Ion Drift Cell Reactor Triple Quad

Vapor Deposition Apparatus

JEOL NMR Spectrometer

Nicolet IR Spectrometers

Varian GC Mass Spectrometer

Adv Analyt Inst EPR Spectrometer

Perkin Elmer Luminescence Spectrophotometer

Plasma Oxidation Apparatus

Selected Ion Drift Cell Reactor Triple Quad

Microwave Synthesizer

Beckman Centrifuge

Supercritical Fluid Extractor

Callisto HPC Cluster

Digital Spectrum Analyzers and Waveform Generators

Low Frequency Thermo-Acoustic Resonator

Portable anechoic chamber

ASPEX Scanning Electron Microscope

Meade 14-inch aperture LX200R GPS telescope

Physics Education Research Observational facility

Patch Clamp facility

Biodex isokinetic dynamometer

Terason diagnostic ultrasound unit

GAITRite portable walkway and platform system

Parvo Medics Metabolic Cart

Physical Accoustics Research Laboratory

**APPENDIX C: Arkansas Colleges and Universities STEM Statistics**

Institution	Total Enrollment (Fall 2011)							Bachelor Degrees Conferred (2011-2012)				
	Total Enrollment	Female (%)	Male (%)	Underrepresented Minority* (%)	In-state (%)	Out-of-state (%)	Foreign (%)	Total Bachelor Degrees Conferred	Bachelor STEM <sup>1</sup> Degrees (%)	Bachelor STEM <sup>1</sup> Degree Underrepresented Minority (%)	Bachelor STEM <sup>1</sup> Degree Female (%)	Bachelor STEM <sup>1</sup> Degree Male (%)
Arkansas State University	13900	61	39	18	77	17	6	1687	32	10	60	40
Arkansas Tech University	10464	55	45	12	94	4	2	1185	28	13	52	48
Harding University	7056	53	47	8	25	71	4	875	16	0	37	62.7
Henderson State University	3774	56	44	26	86	13	1	514	19	14	47	53
Hendrix College	1426	58	42	8	47	50	3	309	32	6	51	49
John Brown University	2454	56	44	8	30	61	9	453	11	10	45	55
Lyon College	600	54	47	10	80	19	1	100	28	4	54	46
Ouachita Baptist University	1594	53	47	10	53	45	2	314	17	0	50	50
Southern Arkansas University	3382	58	42	35	74	23	3	406	18	16	47	53
University of Arkansas at Fayetteville	23199	49	51	11	61	38	1	3130	29	10	46	54
University of Arkansas at Fort Smith	7606	58	42	15	92	8	0	627	11	32	36	64
University of Arkansas at Little Rock	13068	60	40	29	93	4	3	1236	28	27	51	49
University of Arkansas at Monticello	3920	60	40	36	87	13	0	370	23	15	52	48
University of Arkansas at Pine Bluff	3188	57	43	95	55	44	1	461	24	92	51	49
University of Arkansas for Medical Sciences	2819	79	21	13								
University of Central Arkansas	11163	57	43	20	89	8	3	1554	37	17	66	34

\* American Indian or Alaska Native, Black or African American, Hispanic/Latino, Native Hawaiian or other Pacific Islander

<sup>1</sup>STEM Degrees include STEM Programs/Majors, Health Related Programs/Majors, and STEM Education Programs/Majors, as defined by the institution. Estimations indicated with "est."

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Arkansas State University	
<b>Undergrad</b>	
BAS Applied Science - STEM	
BSA Agricultural Business - STEM	36
BSA Agricultural Studies - STEM	
BSA Animal Science - STEM	11
BSA Plant Science - STEM	5
BS Technology - STEM	15
BSCE Civil Engineering - STEM	5
BSEE Electrical Engineering - STEM	6
BSEN Engineering - STEM	19
BSME Mechanical Engineering - STEM	8
BS Clinical Laboratory Science - HEALTH RELATED	14
BS Communication Disorders - HEALTH RELATED	0
BSRS Radiologic Sciences - HEALTH RELATED	55
BSN Nursing - HEALTH RELATED	140
BS Biological Sciences- STEM	54
BS Wildlife Ecology & Management - STEM	9
BSE Biology Education - STEM EDUCATORS	3
BA Chemistry - STEM	31(including total BA and BS)

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
BS Chemistry - STEM	31(including total BA and BS)
BS Forensic Science - STEM	1
BS Physics - STEM	1
BSE Chemistry Education - STEM EDUCATORS	3
BA Computer Science - STEM	12(including total BA and BS)
BS Computer Science - STEM	12 (including total BA and BS)
BS Mathematics - STEM	14
BSE Mathematics Education - STEM EDUCATORS	8
<b>Graduate</b>	
MS Vocational Technical Administration - STEM	3
MSA Agriculture - STEM	32
MEM Engineering Management - STEM	20
MCD Communication Disorders - HEALTH RELATED	49
DPT Physical Therapy - HEALTH RELATED	84
MPT Physical Therapy - HEALTH RELATED	1
MS Health Sciences - HEALTH RELATED	23
MSN Nurse Anesthesia - HEALTH RELATED	94
MSN Nursing - HEALTH RELATED	108
MSW Social Work - HEALTH RELATED	81
MA Biological Sciences - STEM	3
MS Biology - STEM	30
PSM Biotechnology - STEM	2
MS Chemistry - STEM	12
MSE Chemistry Education - STEM EDUCATORS	2
MS Computer Science - STEM	51
MS Environmental Science - STEM	7
PHD Environmental Science - STEM	23
MS Mathematics - STEM	18
MSE Mathematics Education - STEM EDUCATORS	6
PHD Molecular Biosciences - STEM	15
Arkansas Tech University	
<b>Undergrad</b>	
Fisheries and Wildlife Biology	19
Computer Science	5
Information Technology	18
Information Systems	5
Mathematics (Teaching)	6
Physical Science and Earth Science (Teaching)	1
Life Science and Earth Science (Teaching)	4

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Electrical Engineering	16
Engineering Physics	2
Mechanical Engineering	47
Biology	31
Mathematics	10
Physical Science	1
Chemistry	9
Geology	8
Physics	1
Nuclear Physics	0
Health Information Management	14
Medical Technology	0
Nursing	129
<b>Graduate</b>	
Fisheries and Wildlife Science	10
Information Technology	52
Master of Engineering	4
Health Informatics	20
Nursing	21
Harding University	
<b>Undergrad</b>	
Biochem and Molecular Biology	25
Biochemistry	2
Biology	17
Chemistry	3
Computer Engineering	4
Computer Science	20
Electrical Engineering	5
Mathematics	2
Mechanical Engineering	8
Medical Technology	2
Psychology	54
<b>Graduate</b>	
Pharmacy	0
Henderson State University	
<b>Undergrad</b>	
Aviation	21
Biology	28

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Chemistry	3
Computer Science	4
Mathematics	3
Medical Technology	0
Nursing	20
Physics	8
Radiography (New degree)	0
Hendrix College	
<b>Undergrad</b>	
Biochemistry/Molecular Biology	17
Biology	43
Chemical Physics	2
Chemistry	12
Computer Science	4
Environmental Studies	11
Mathematics	2
Physics	8
John Brown University	
<b>Undergrad</b>	
Engineering	15
Biology	17
Biochemistry	3
Mathematics, General	1
Sports Medicine	5
Chemistry	1
Construction Management	9
Lyon College	
<b>Undergrad</b>	
Biology	14
Chemistry	0
Mathematics	10
Computer Science	4
Ouachita Baptist University	
<b>Undergrad</b>	
Computer Science	3
Computer Software Engineering	1

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Biology	32
Mathematics	4
Chemistry	8
Professional Chemistry	2
Physics	4
<b>Southern Arkansas University</b>	
<b>Undergrad</b>	
Computer & Information Sciences, General	2
Agricultural Teacher Education	6
Mathematics Teacher Education	0
Science Teacher Education/General Science Teacher Education	0
Chemistry Teacher Education	0
Industrial Technology/Technician	4
Biology/Biological Sciences, General	26
Mathematics, General	2
Biological & Physical Sciences	2
Chemistry, General	10
Physics, Other	5
Registered Nursing/Registered Nurse	18
<b>Graduate</b>	
Computer Science	3
Library Media	16
<b>University of Arkansas, Fayetteville</b>	
<b>Undergrad</b>	
Agricultural Education, Communication, And Technology, BSA	23
Animal Science, BSA	36
Poultry Science, BSA	12
Food Science, BSA	14
Crop Management (Crop Science), BSA	6
Environmental Soil And Water Science, BSA	22
Computer Science, BA	6
Computer Science, BS	26
Biological Engineering, BSBE	25
Chemical Engineering, BSChE	29
Civil Engineering, BSCE	55
Computer Engineering, BSCmpE	17

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Electrical Engineering, BSEE	29
Mechanical Engineering, BSME	88
Industrial Engineering, BSIE	41
Biology, BA	28
Biology, BS	135
Mathematics, BA	12
Mathematics, BS	13
Chemistry, BA	8
Chemistry, BS	37
Earth Science, BS	5
Geology, BS	19
Physics, BA	5
Physics, BS	23
Communication Disorders, BSE	63
Community Health Promotion (Public Health), BSE	30
Nursing, BSN	94
<b>Graduate</b>	
Animal Science, MS	11
Animal Science, PHD	1
Poultry Science, MS	5
Poultry Science, PHD	4
Food Science, MS	10
Food Science, PHD	3
Crop, Soil And Environmental Sciences, MS	10
Crop, Soil And Environmental Sciences, PHD	4
Horticulture, MS	5
Computer Science, MS	8
Computer Science, PHD	2
Educational Technology, MED	9
Educational Program Evaluation, PMC	1
Educational Statistics & Research Methods, PHD	2
Educational Statistics And Research Methods, PMC	3
Engineering, MSE	4
Engineering, PHD	17
Biological Engineering, MSBE	2
Biomedical Engineering, MSBME	1
Chemical Engineering, MSChE	3
Civil Engineering, MSCE	9
Computer Engineering, MSCmpE	2
Electrical Engineering, MSEE	22

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Mechanical Engineering, MSME	16
Industrial Engineering, MSIE	13
Operations Management, MSOM	254
Biology, MS	2
Biology, PHD	3
Plant Pathology, MS	3
Plant Science, PHD	1
Cell And Molecular Biology, MS	5
Cell And Molecular Biology, PHD	9
Entomology, MS	3
Mathematics, MS	7
Mathematics, PHD	5
Statistics, MS	8
Space And Planetary Sciences, MS	1
Space And Planetary Sciences, PHD	2
Chemistry, MS	2
Chemistry, PHD	7
Geology, MS	5
Environmental Dynamics, PHD	6
Physics, MS	3
Physics, PHD	1
Microelectronics-Photonics, MS	9
Microelectronics-Photonics, PHD	3
Communication Disorders, MS	25
Community Health Promotion, MS	7
Community Health Promotion, PHD	5
Rehabilitation, MS	13
Rehabilitation, PHD	3
Nursing, MSN	4
University of Arkansas at Fort Smith	
<b>Undergrad</b>	
Biology	28
Biology (Teacher Licensure)	1
Chemistry	2
Chemistry (Teacher Licensure)	0
Computer Science	33
Database Management	
Networking	
Programming	

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Web Developer	
Electrical Engineering	
Mechanical Engineering	
Mathematics	1
Mathematics (Teacher Licensure)	0
Animation Technology	7
University of Arkansas at Little Rock	
<b>Undergrad</b>	
Biology - BS	53
Chemistry - BA	4
Chemistry - BS	5
Computer Science - BS	17
Construction Management - BS	37
Electronics and Computer Engineering Technology - BS	4
Engineering Technology (Mechanical) - BS	10
Environmental Health - BS	1
Geology - BS	11
Health Sciences - BS	74
Information Science - BS	15
Mathematics - BA	4
Mathematics - BS	6
Nursing Completion Program - BSN	73
Physics - BS	1
Systems Engineering - BS	36
<b>Graduate</b>	
Applied Science - MS	27
Applied Science - PHD	8
Applied Statistics - GC	4
Bioinformatics - MS	5
Bioinformatics - PHD	1
Biology - MS	9
Chemistry - MA	2
Chemistry - MS	1
Communicating Sciences and Disorders - PHD	2
Computer and Information Science - MS	3
Engineering Science and Systems - PHD	7
Geospatial Technology - GC	3
Health Sciences - MS	9
Information Quality - GC	22

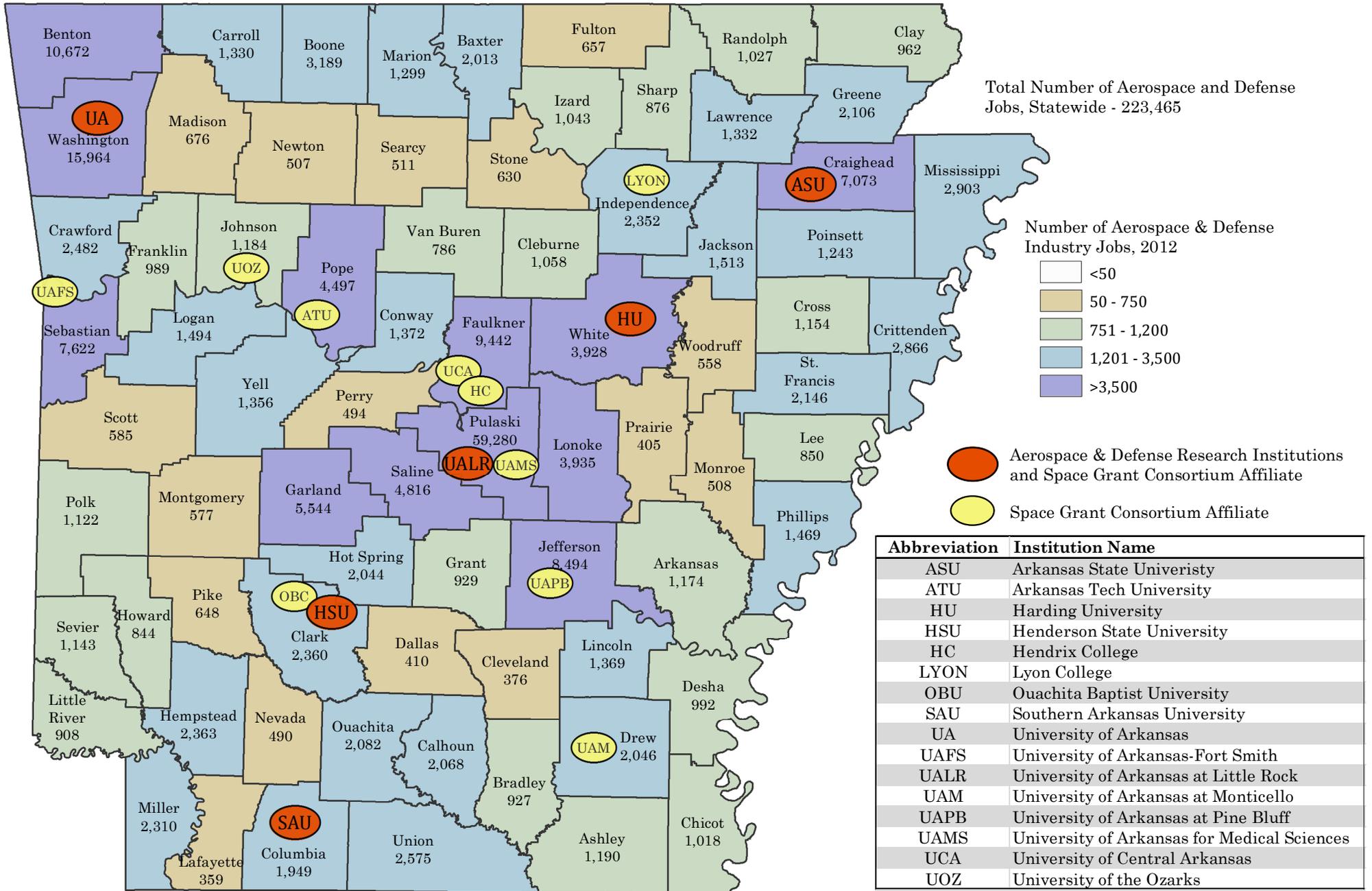
STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
Information Quality - MS	9
Integrated Computing - PHD	18
Integrated Sciences and Mathematics - MS	1
Learning Systems Technology - MED	17
Mathematical Sciences - MS	6
Systems Engineering - GC	1
Systems Engineering - MS	8
Technology Innovation - GC	2
University of Arkansas at Monticello	
<b>Undergrad</b>	
Wildlife Management	8
Spatial Information Systems	5
Biology	18
Mathematics	8
Natural Science	12
Chemistry	3
Computer Information Systems	15
Forestry	5
Agriculture - subplans 01.0901 (Animal Sci) & 01.1101 (Soil & Plant Sci)	11
<b>Graduate</b>	
Forest Resources	6
University of Arkansas at Pine Bluff	
<b>Undergrad</b>	
Agriculture Sciences	14
Computer Science	7
Fisheries Biology	1
Computer Science	11
Industrial Technology	30
Biology	32
Mathematics	2
Chemistry	10
Physics	3
<b>Graduate</b>	
Aquaculture & Fisheries, M.S.	7
Agricultural Regulations, M.S.	5
Mathematics, M.Ed.**	1
Science, M.Ed.**	1

STEM Programs/Majors	Number of Degrees Conferred (2011-2012)
University of Central Arkansas	
<b>Undergrad</b>	
BS-Environmental Science/Studies	16
BS-Computer Science	16
BS-Nutrition	40
BS-Biology	86
BS-Mathematics	18
BS-General Science	5
BS-Chemistry	13
BS-Physics	9
BBA-Management Information Systems	31
BS-Speech Pathology	38
BS-Nuclear Medicine Technology	3
BS-Radiologic Technology	18
BS-Athletic Training	12
BS-Medical Technology	2
BS-Addiction Studies	28
BS-Health Education	51
BSN-Nursing	76
BS-Health Sciences	107
<b>Graduate</b>	
MA-Mathematics Education	8
MS-Applied Computing	14
MS-Biology	33
MS-Applied Mathematics	13
MS-Health Sciences	34
MS-Health Systems	2
MS-Occupational Therapy	47
MS-Speech Language Pathology	102
MSN-Nursing	153
PHD-Physical Therapy	8
DPT-Physical Therapy	164
PHD-Communication Sciences and Disorders	8
PMC-Adult Nurse Practitioner	1
PMC-Family Nurse Practitioner	1

## APPENDIX D: Maps of research clusters vs. industry employment

# Aerospace and Defense

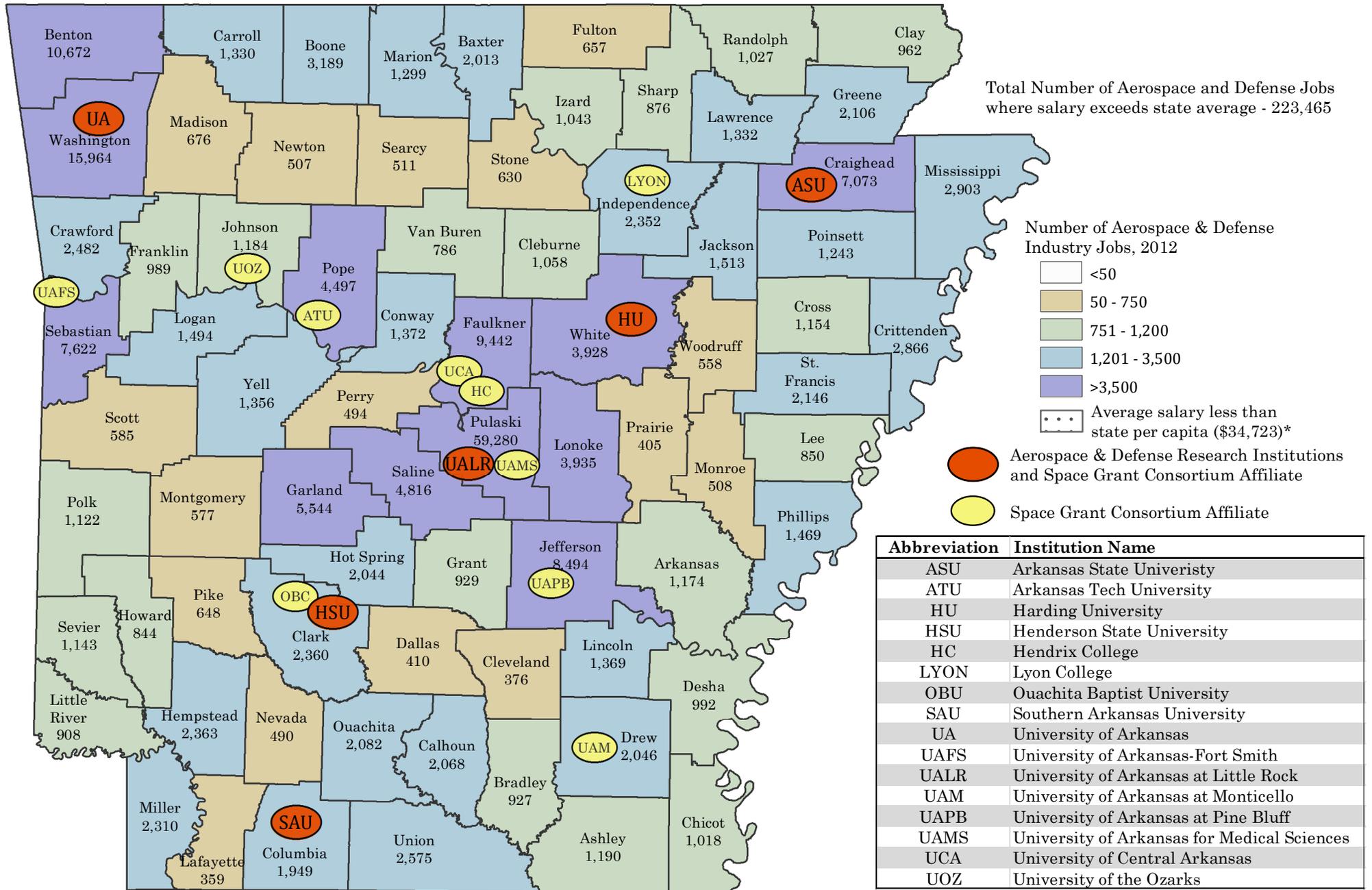
## Location of Higher Education Research and Distribution of Employment



Source: EMSI

# Aerospace and Defense

## Location of Higher Education Research and Distribution of Employment

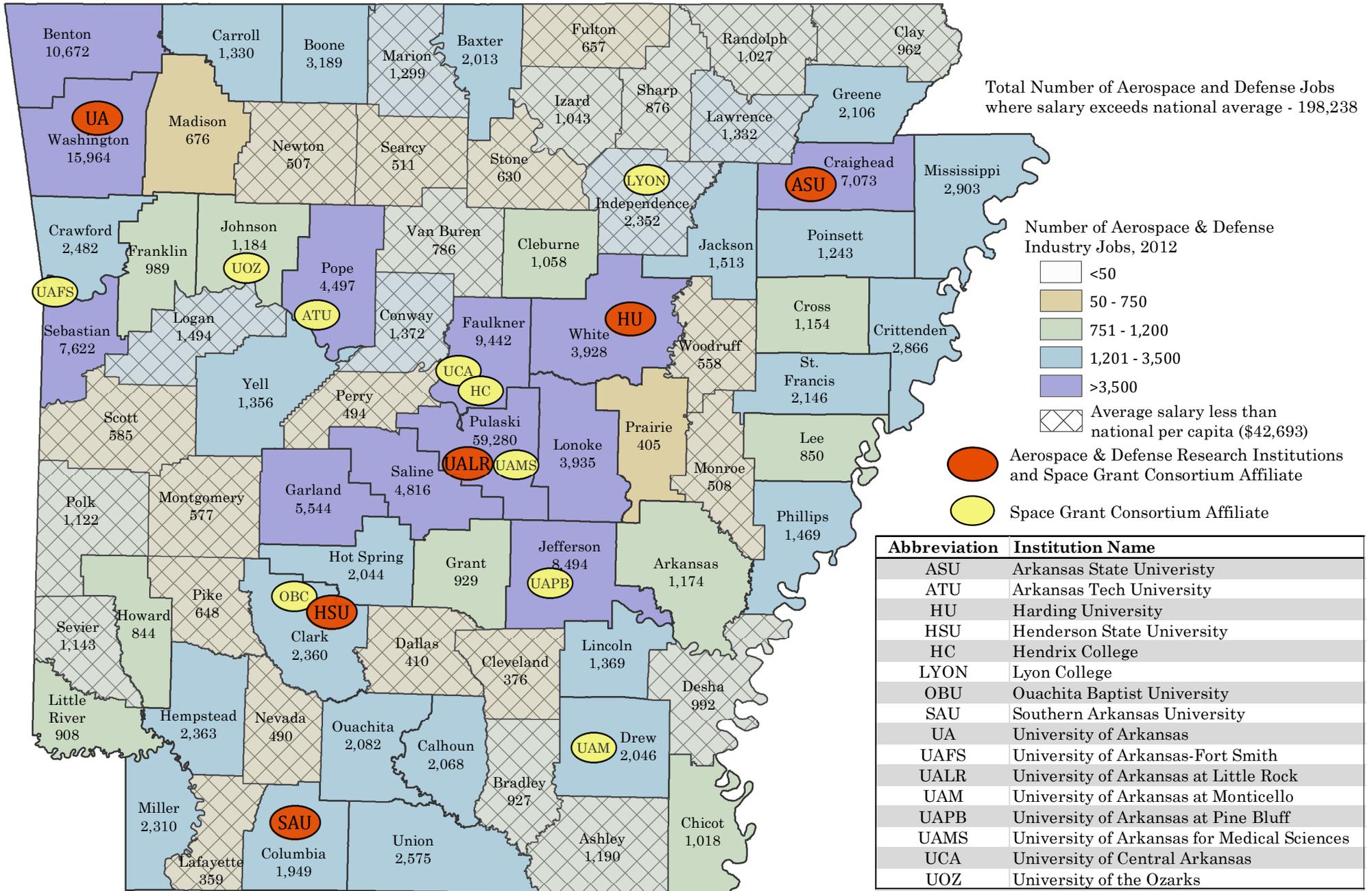


Source: EMSI, U.S. Bureau of Economic Analysis

\*All counties in this category average above state per capita personal income. Center for Advanced Spatial Technologies Tuesday, October 22, 2013

# Aerospace and Defense

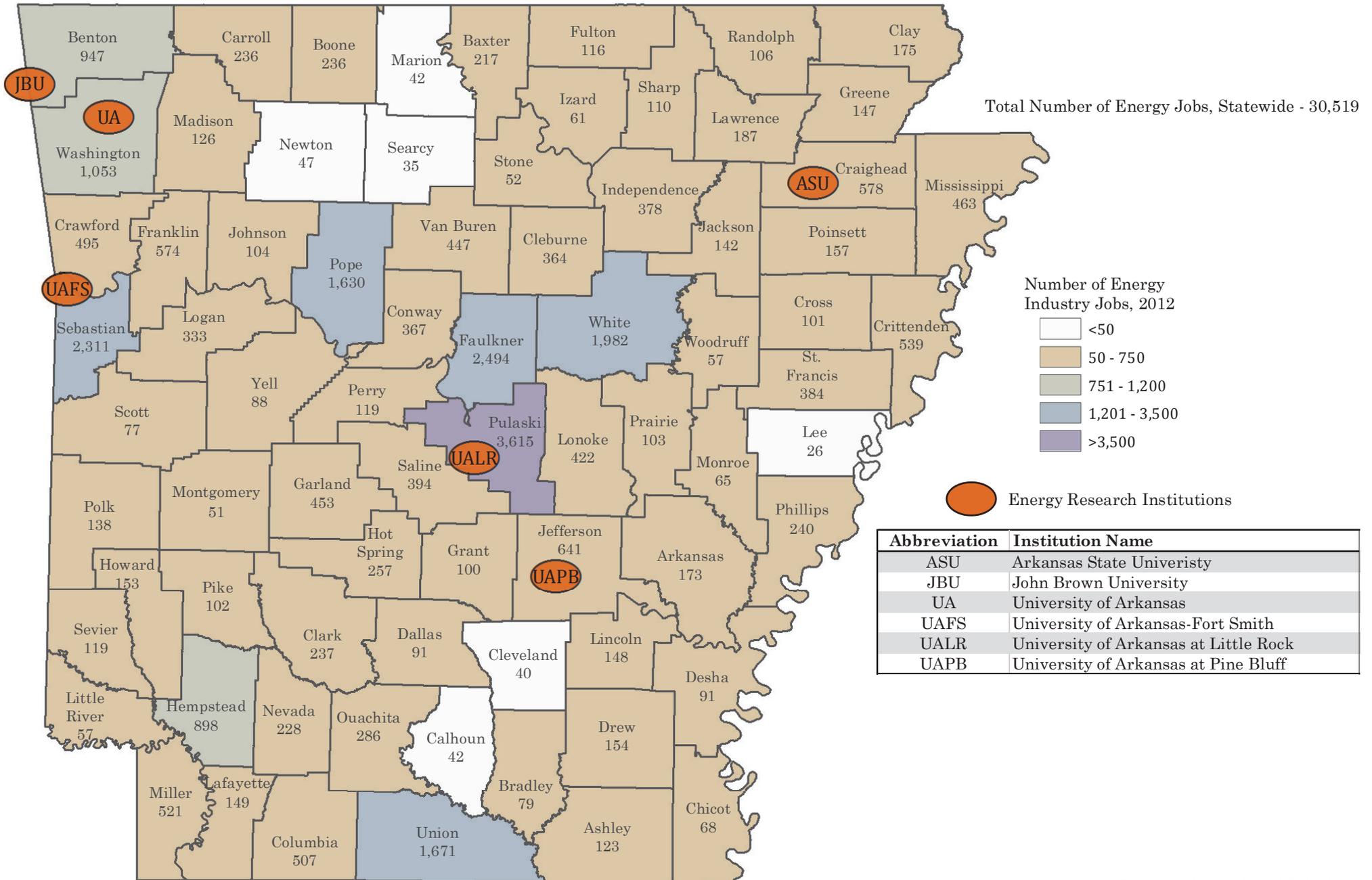
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Energy

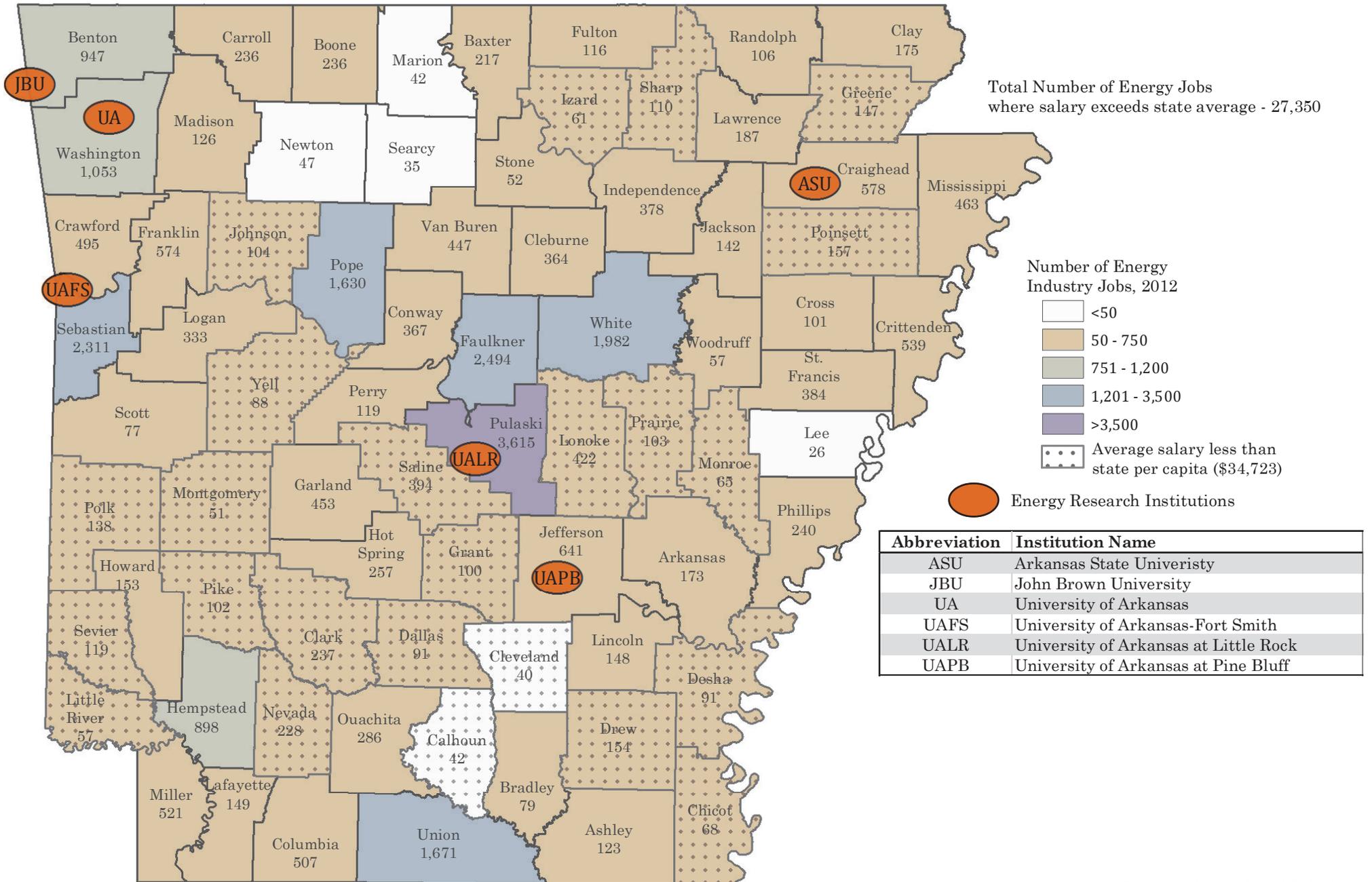
## Location of Higher Education Research and Distribution of Employment



Source: EMSI

# Energy

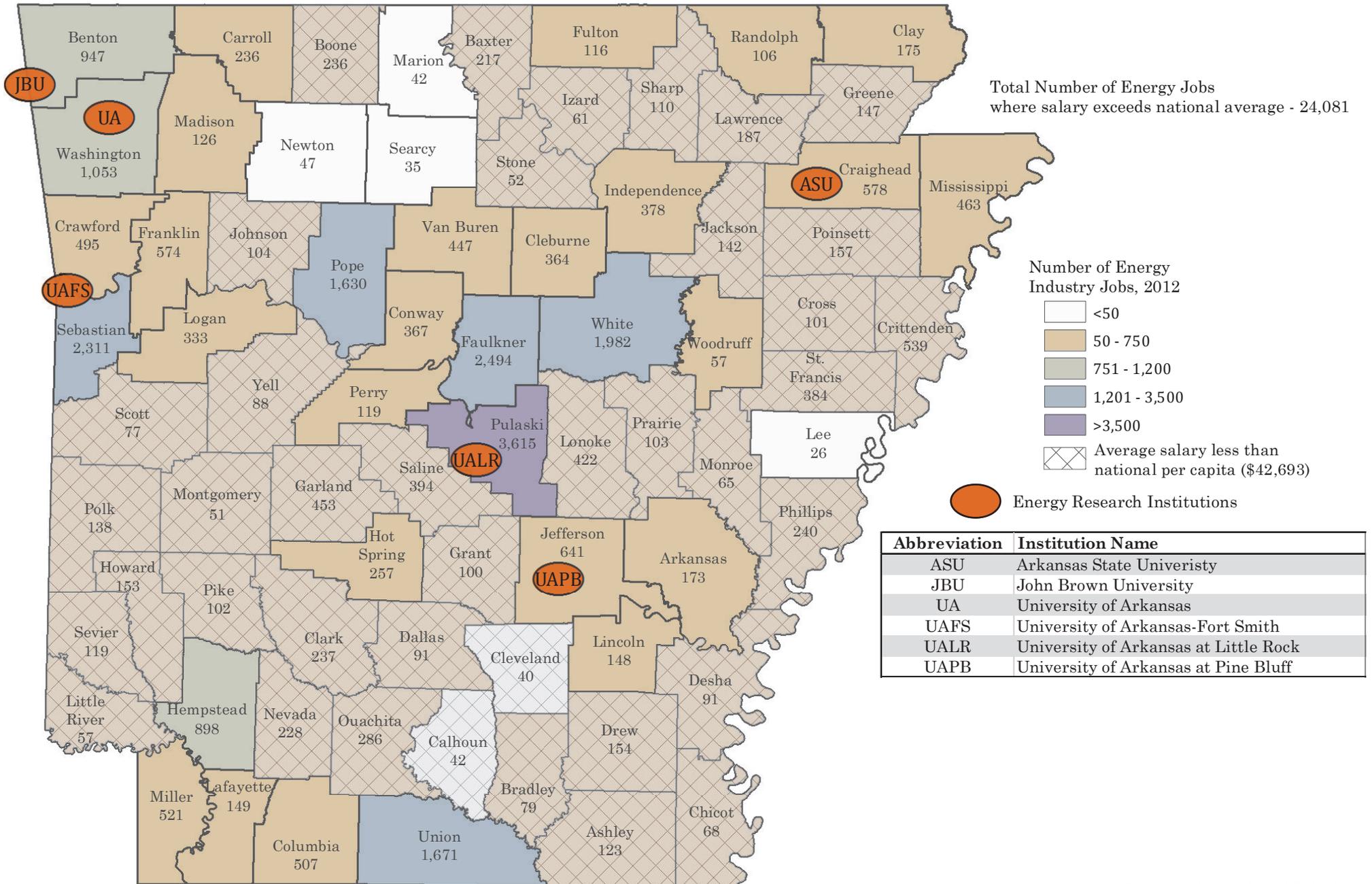
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Energy

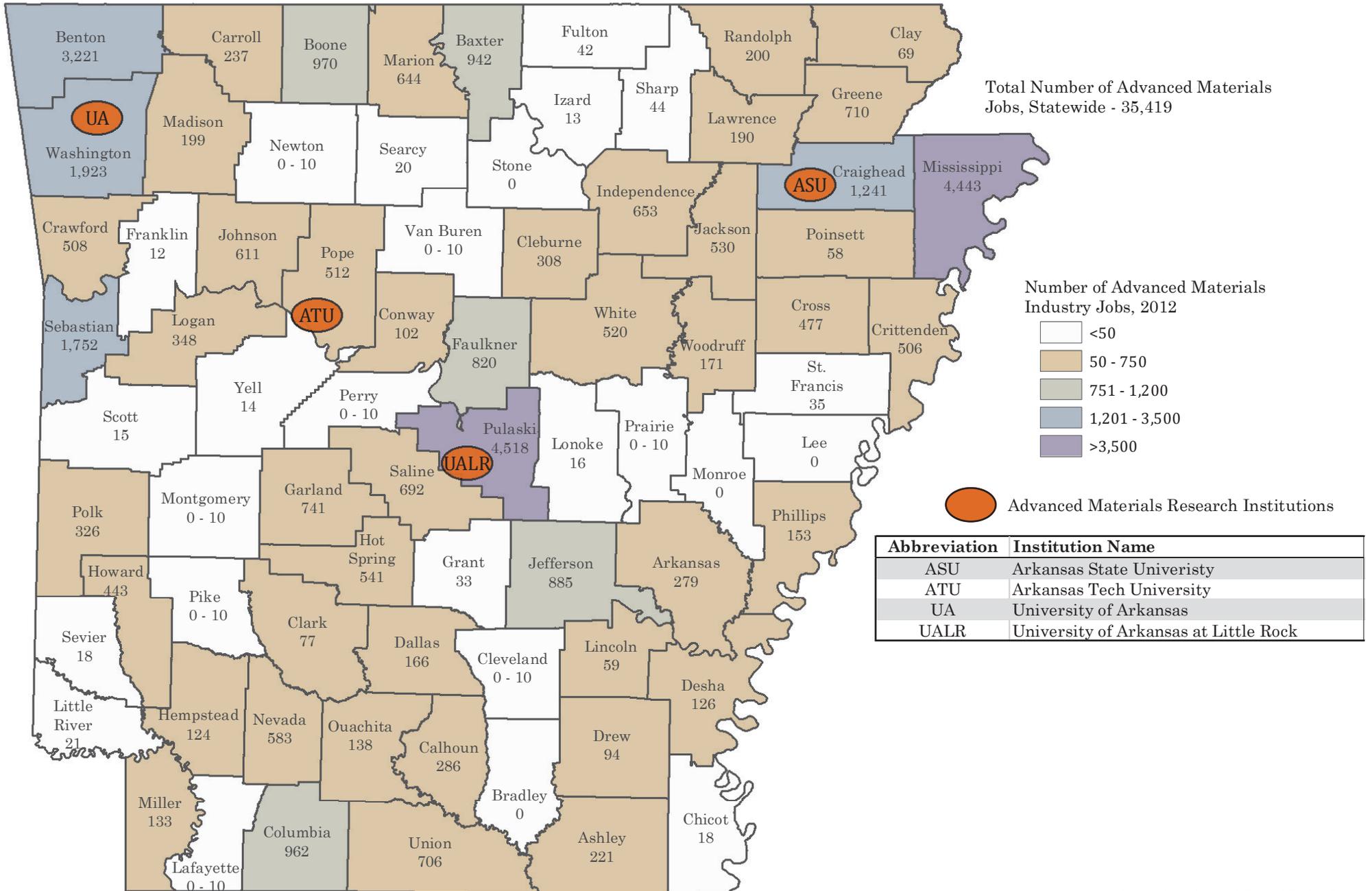
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Advanced Materials

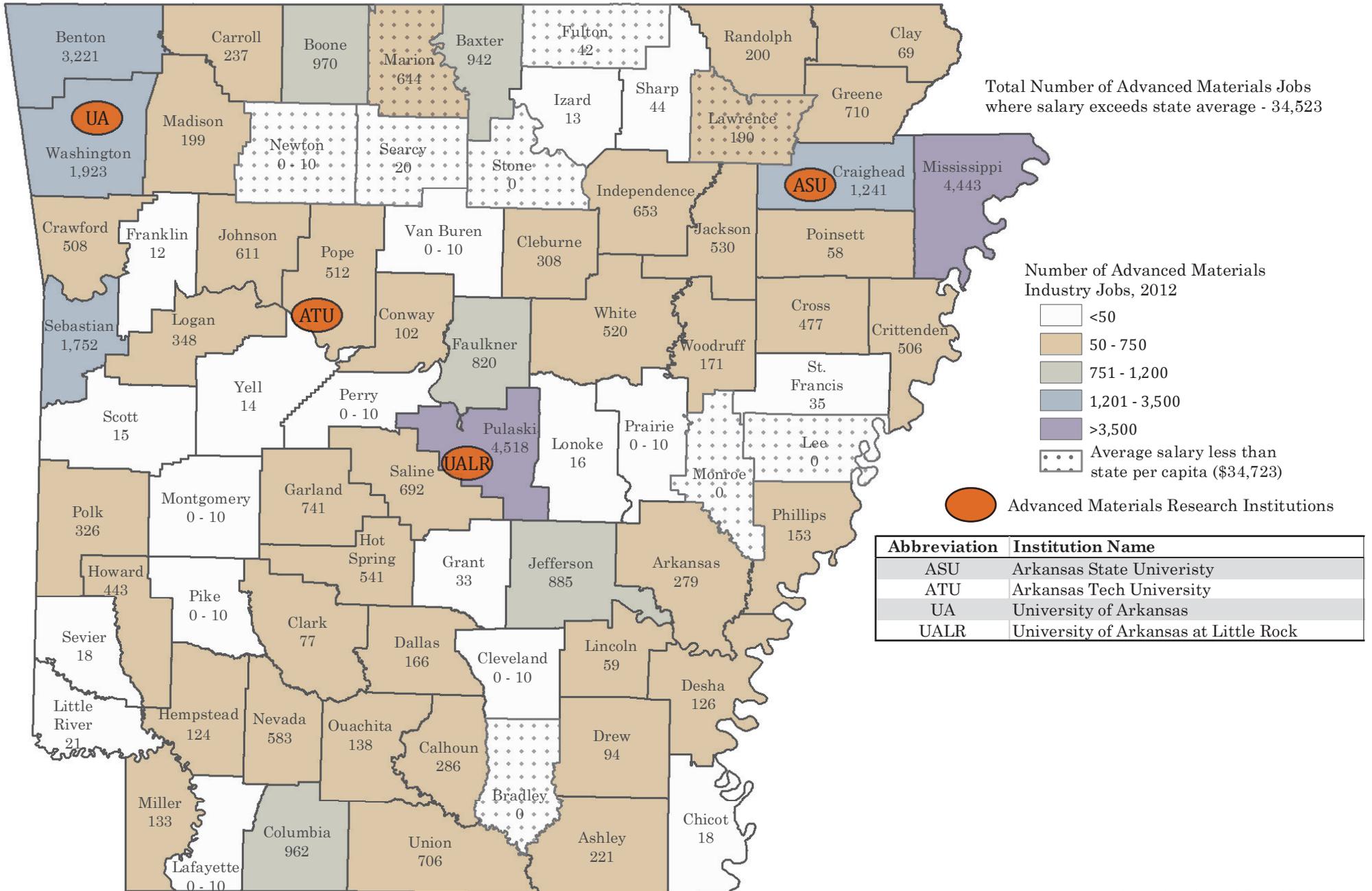
## Location of Higher Education Research and Distribution of Employment



Source: EMSI

# Advanced Materials

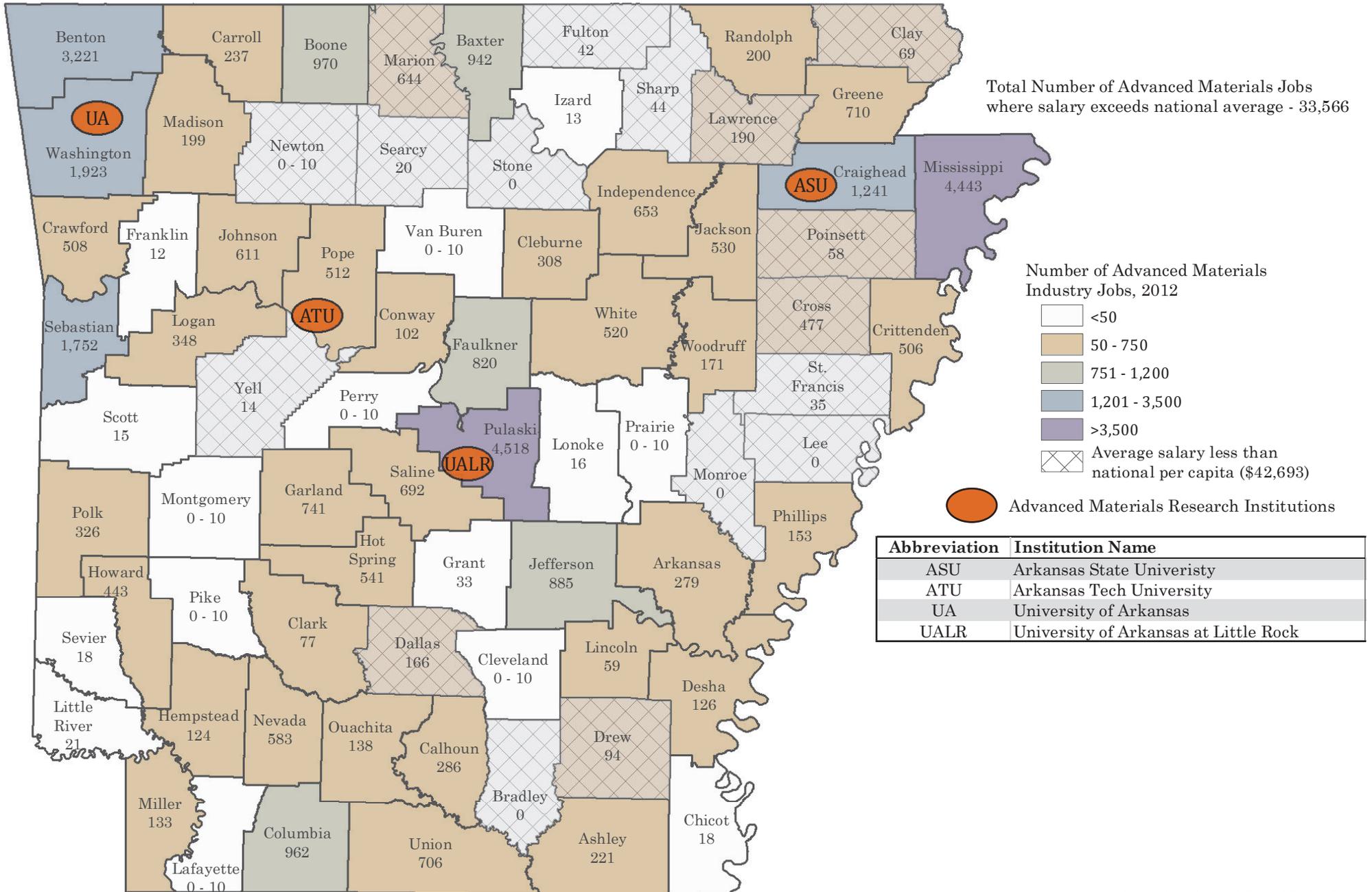
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Advanced Materials

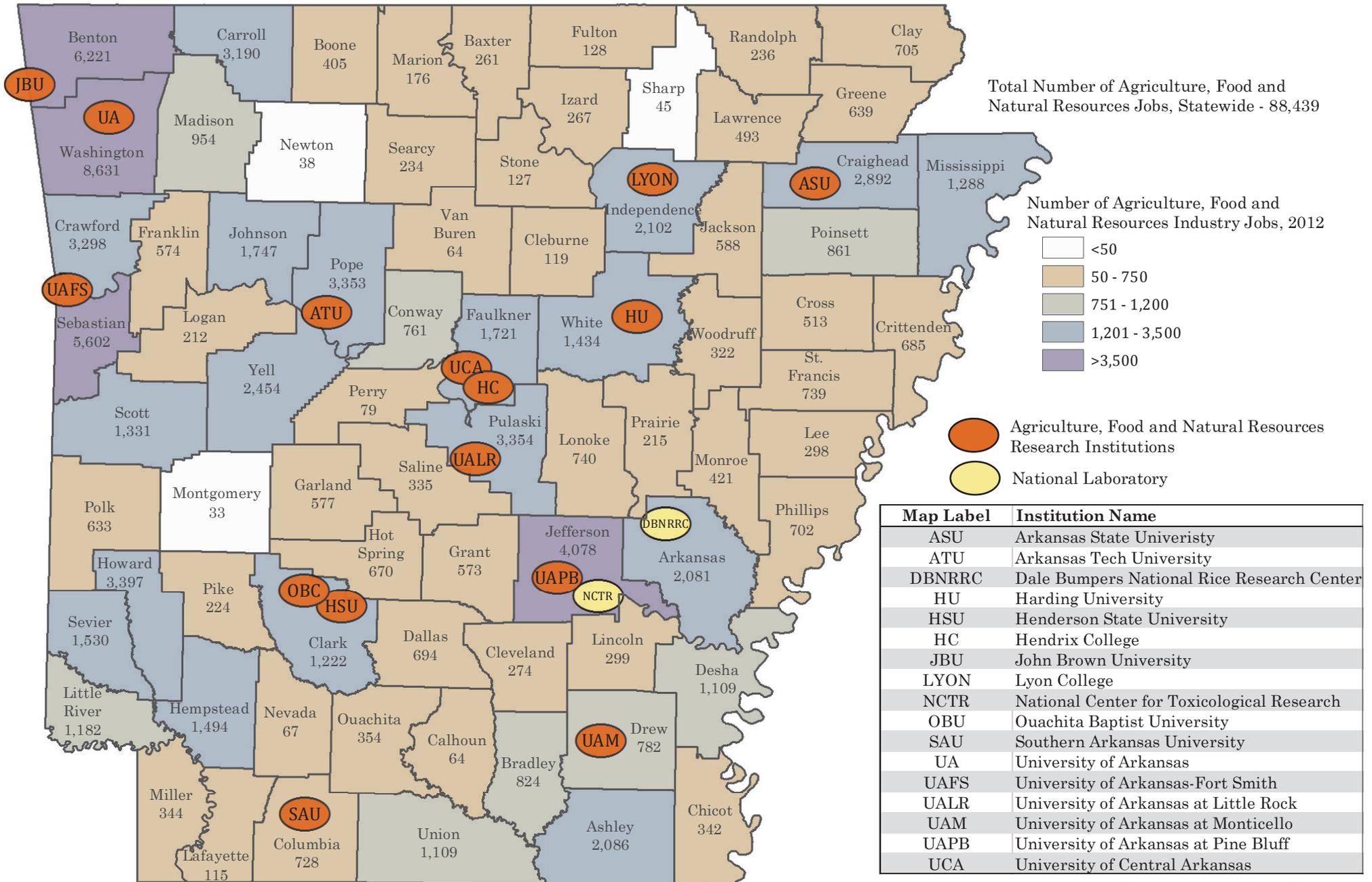
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Agriculture, Food and Natural Resources

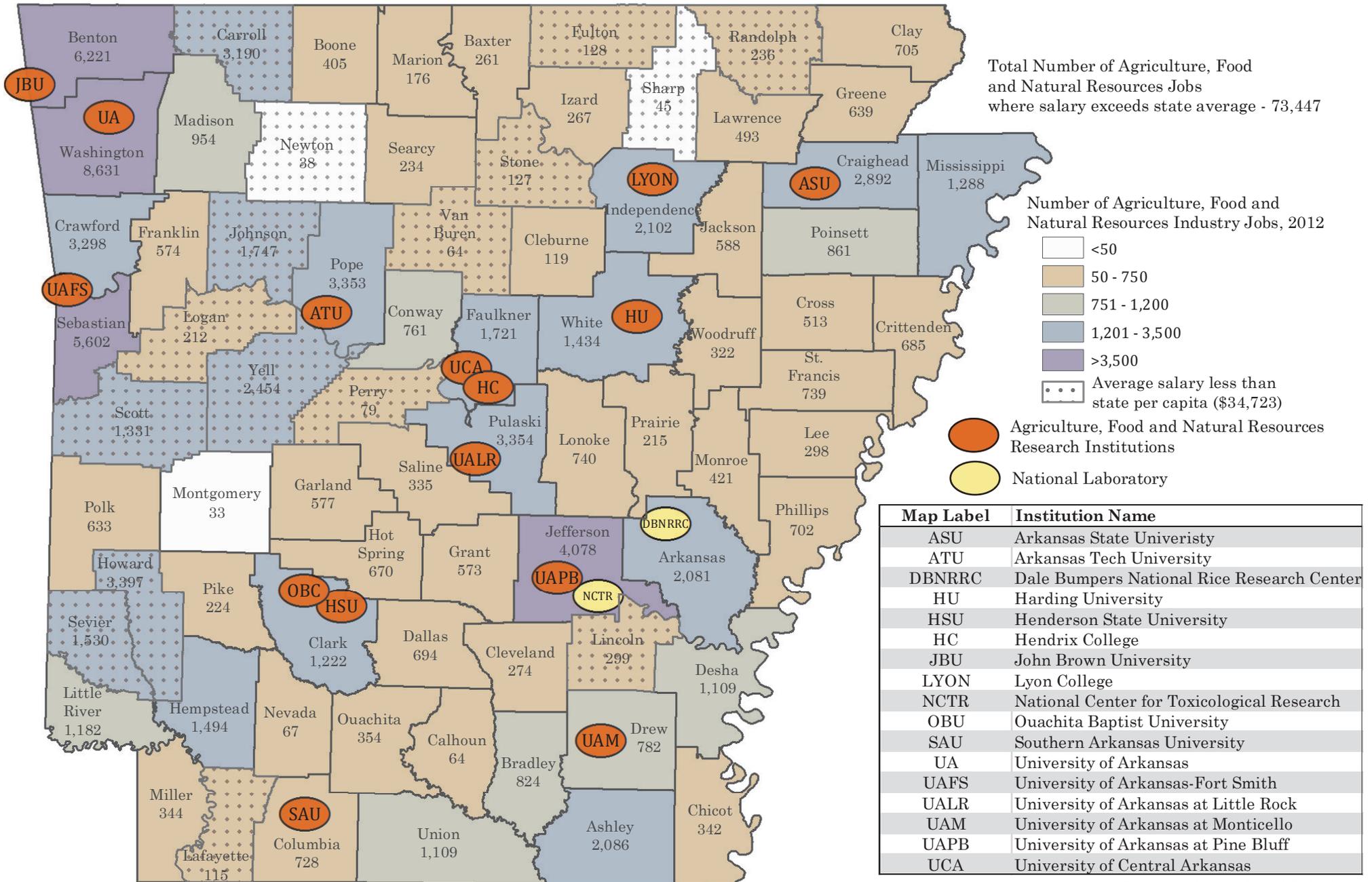
## Location of Higher Education Research and Distribution of Employment



Source: EMSI

# Agriculture, Food and Natural Resources

## Location of Higher Education Research and Distribution of Employment

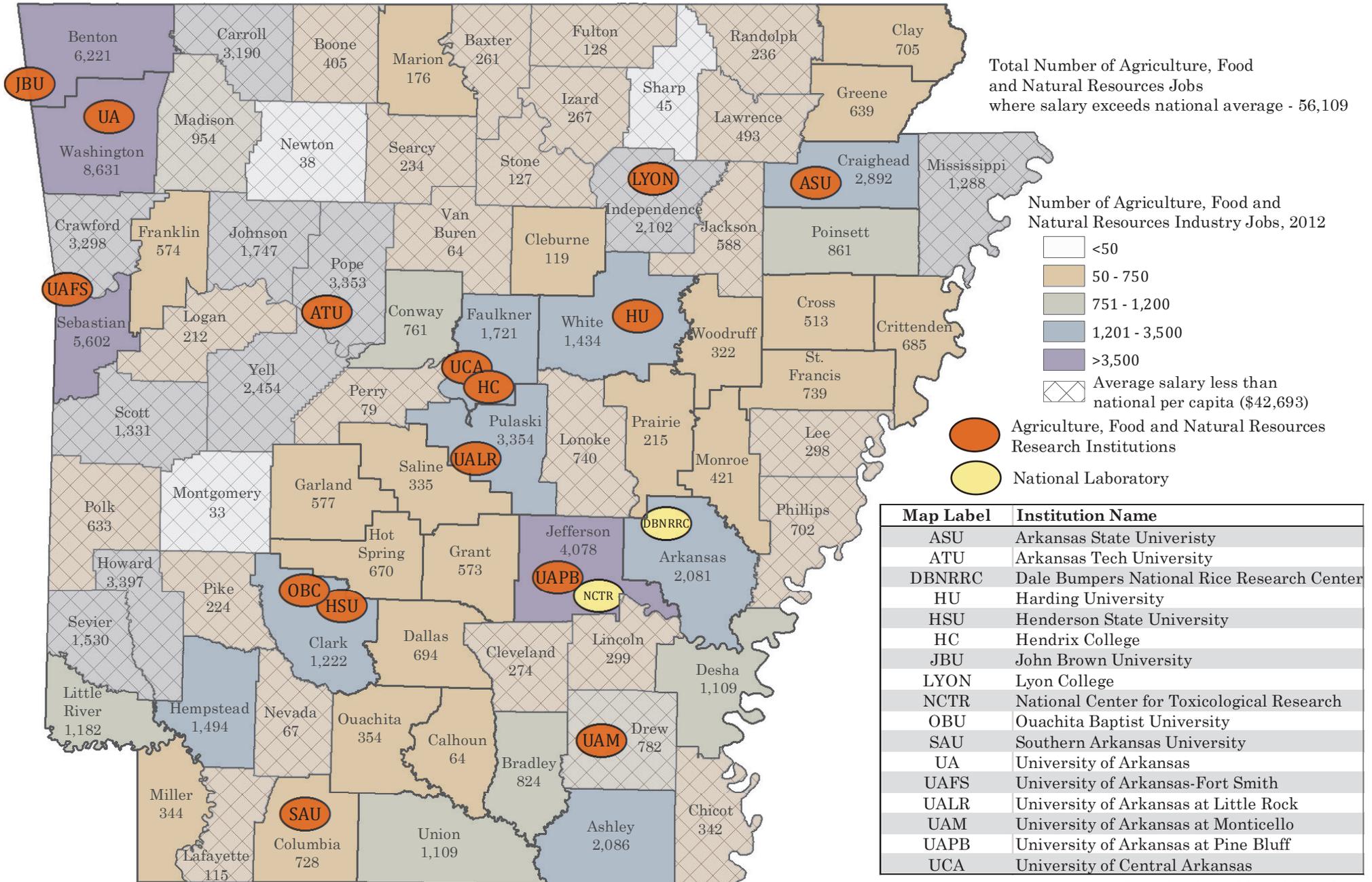


Source: EMSI, U.S. Bureau of Economic Analysis

Center for Advanced Spatial Technologies  
Wednesday, September 11, 2013

# Agriculture, Food and Natural Resources

## Location of Higher Education Research and Distribution of Employment

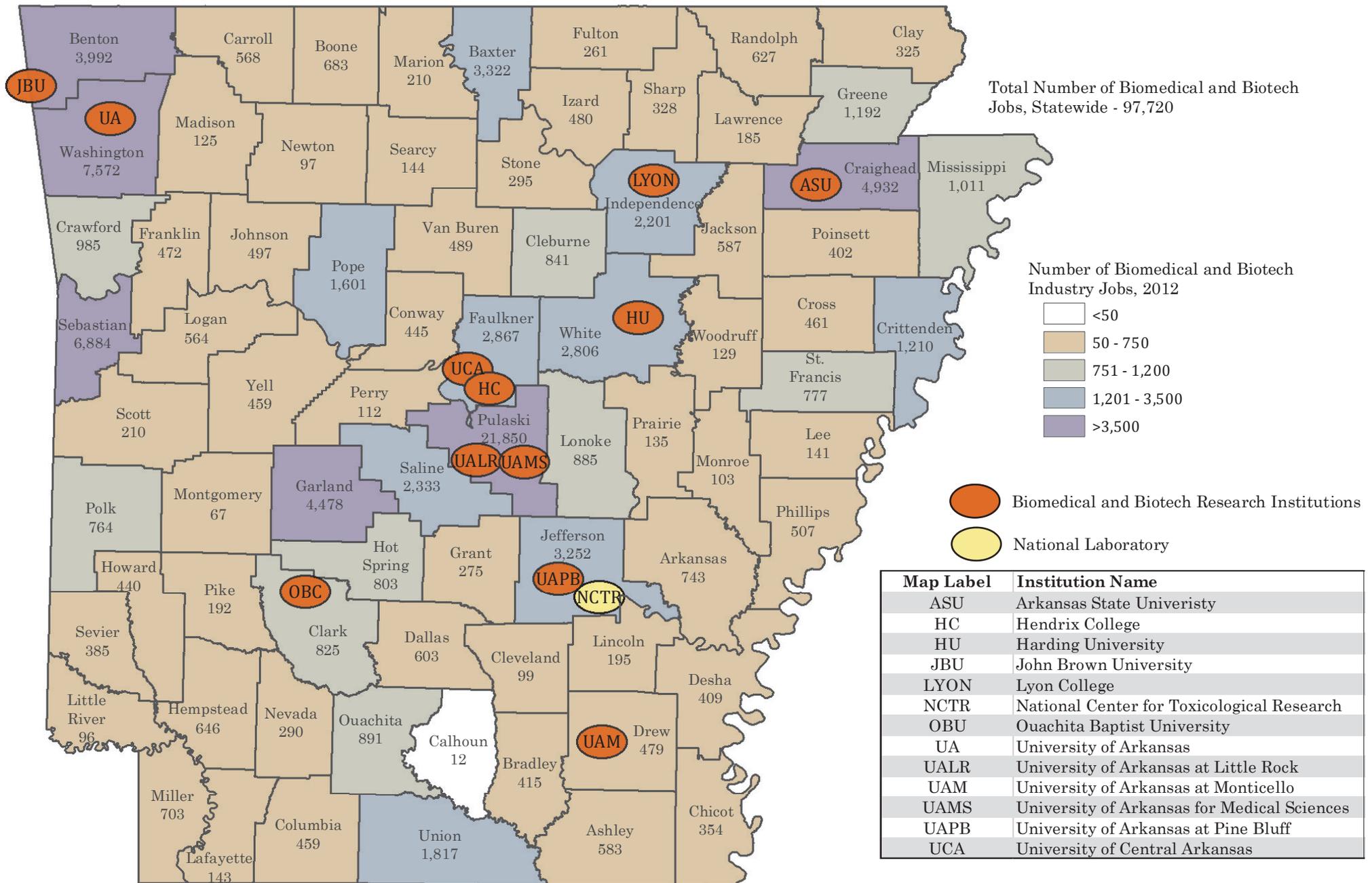


Source: EMSI, U.S. Bureau of Economic Analysis

Center for Advanced Spatial Technologies  
Wednesday, September 11, 2013

# Biomedical and Biotech

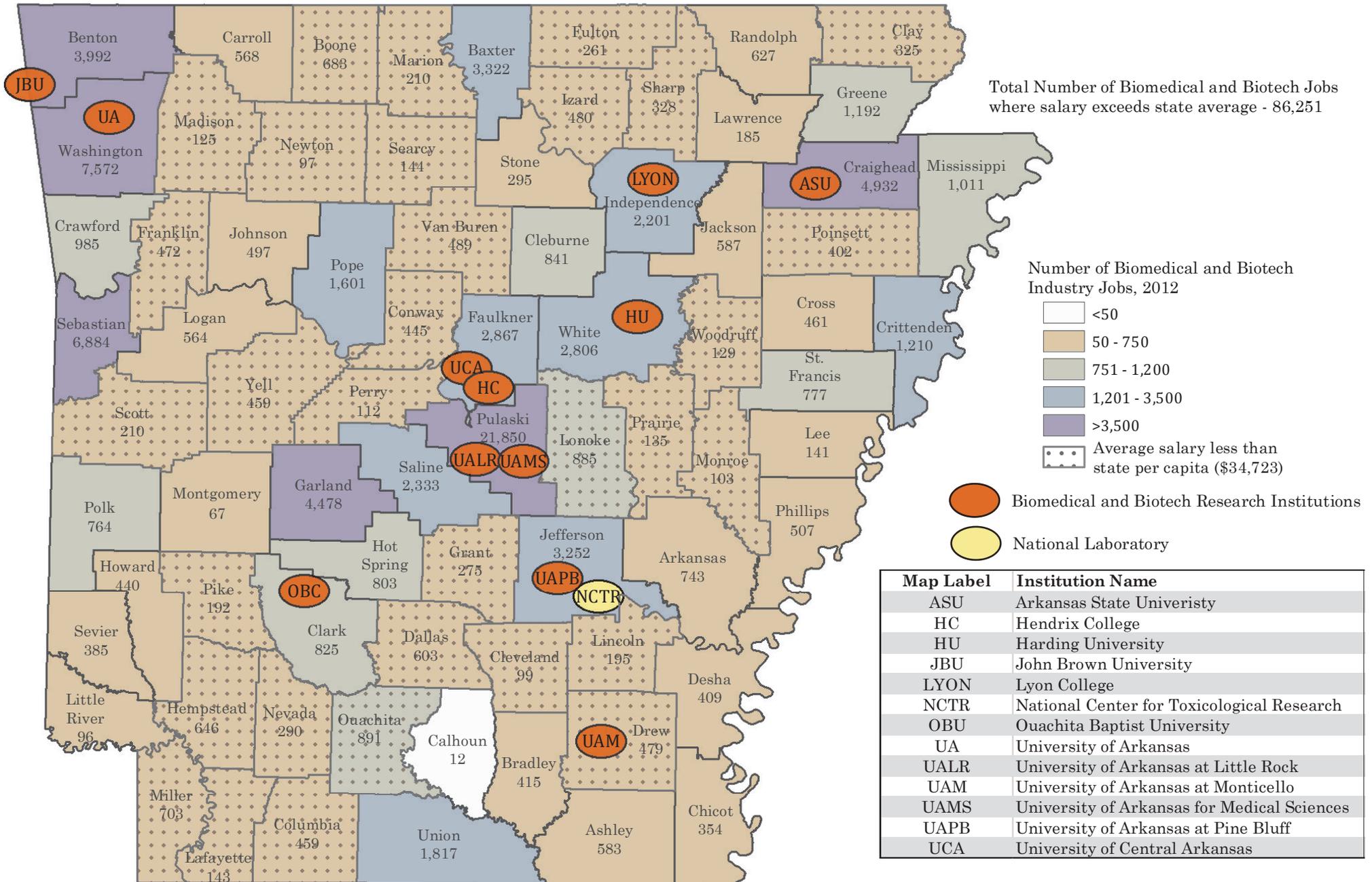
## Location of Higher Education Research and Distribution of Employment



Source: EMSI

# Biomedical and Biotech

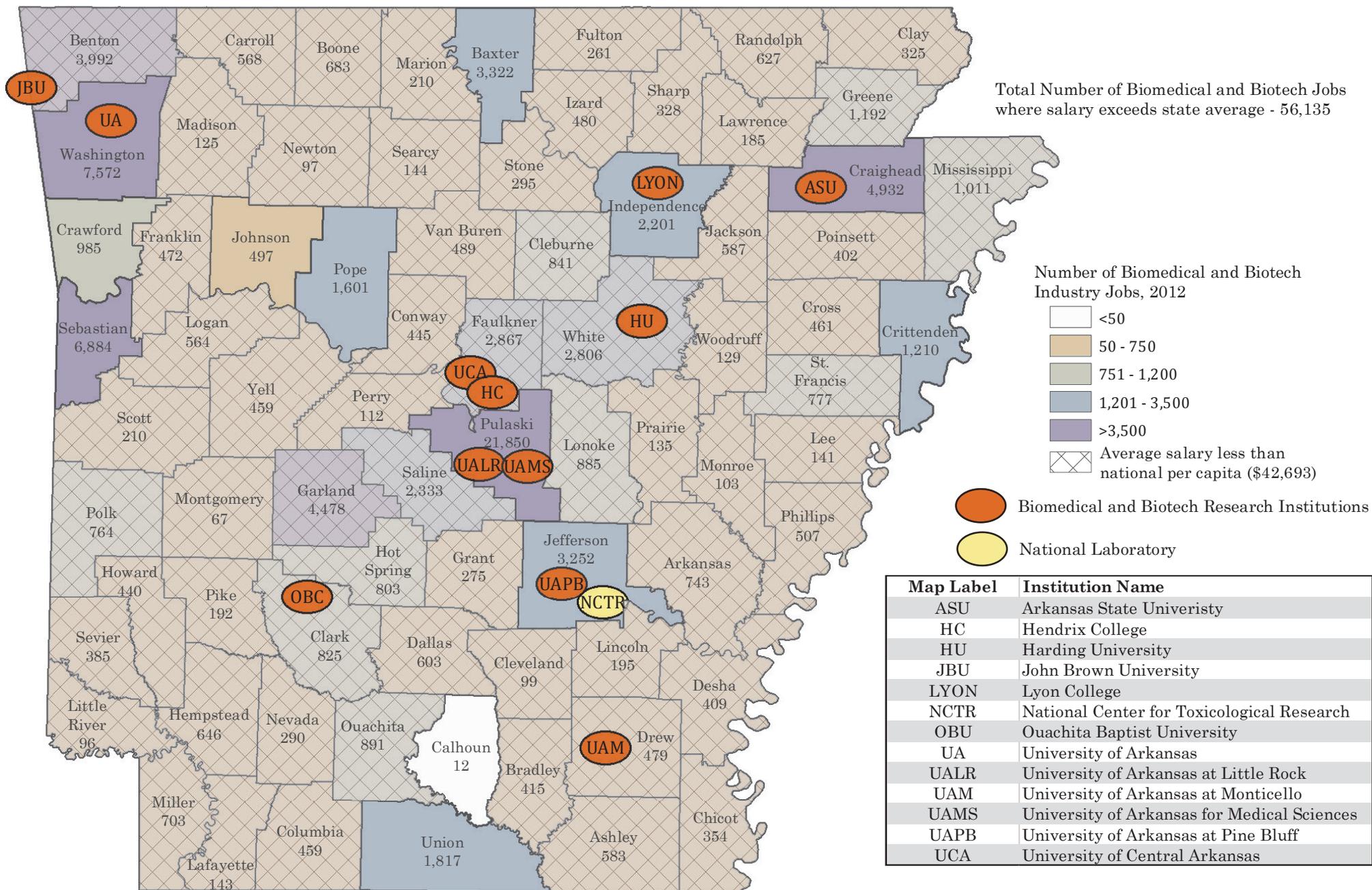
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Biomedical and Biotech

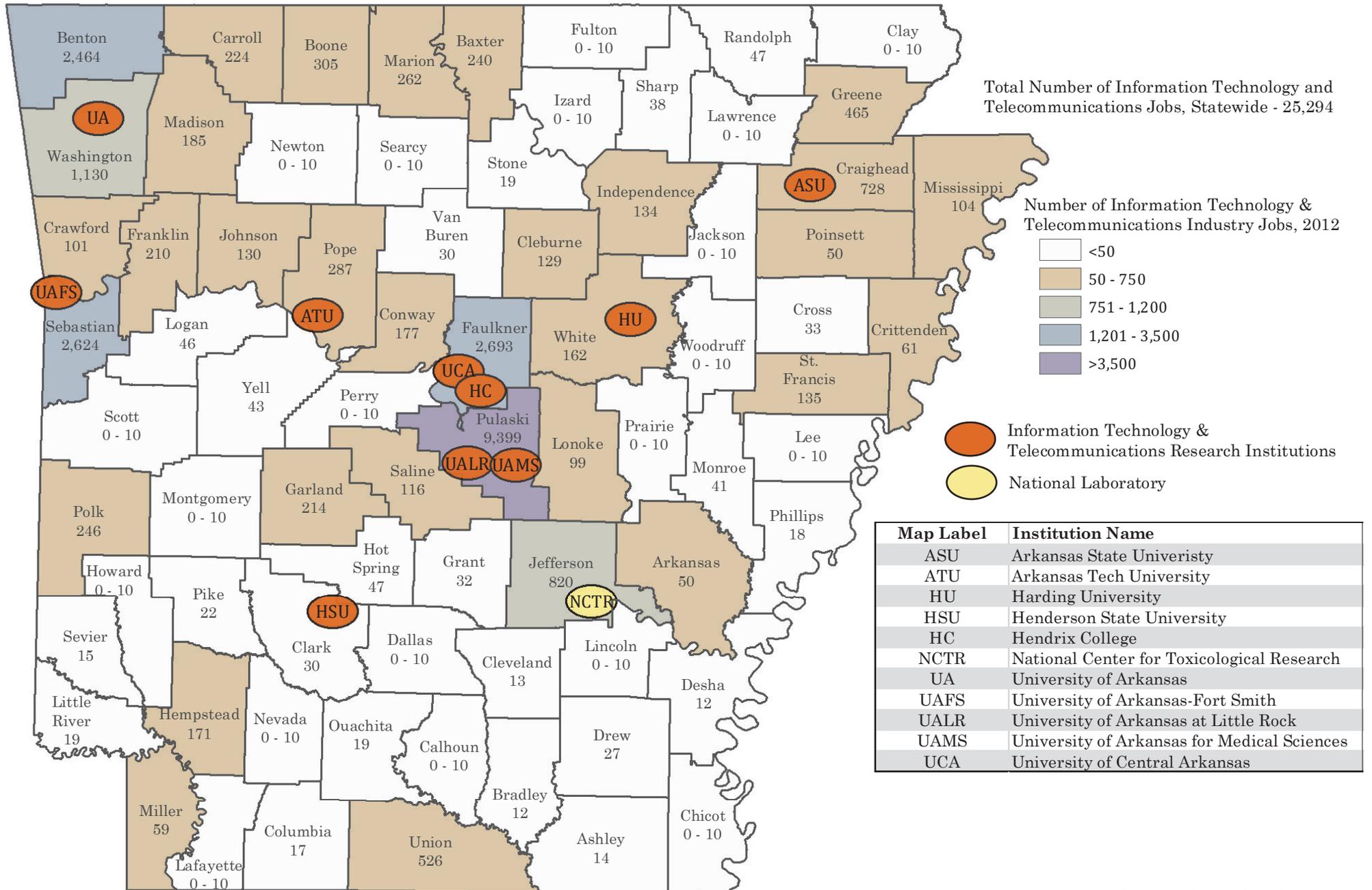
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Information Technology & Telecommunications

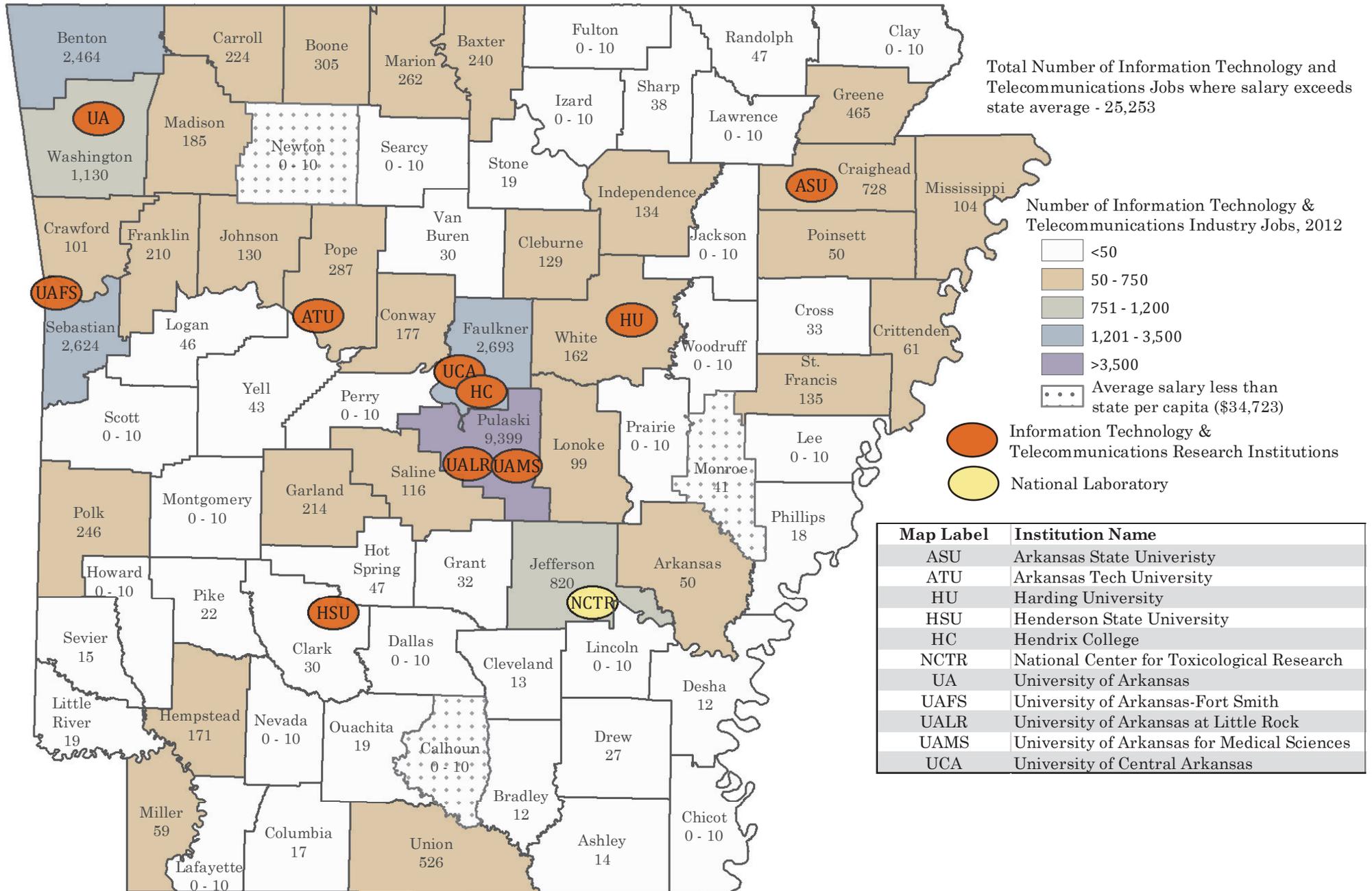
## Location of Higher Education Research and Distribution of Employment



Source: EMSI

# Information Technology & Telecommunications

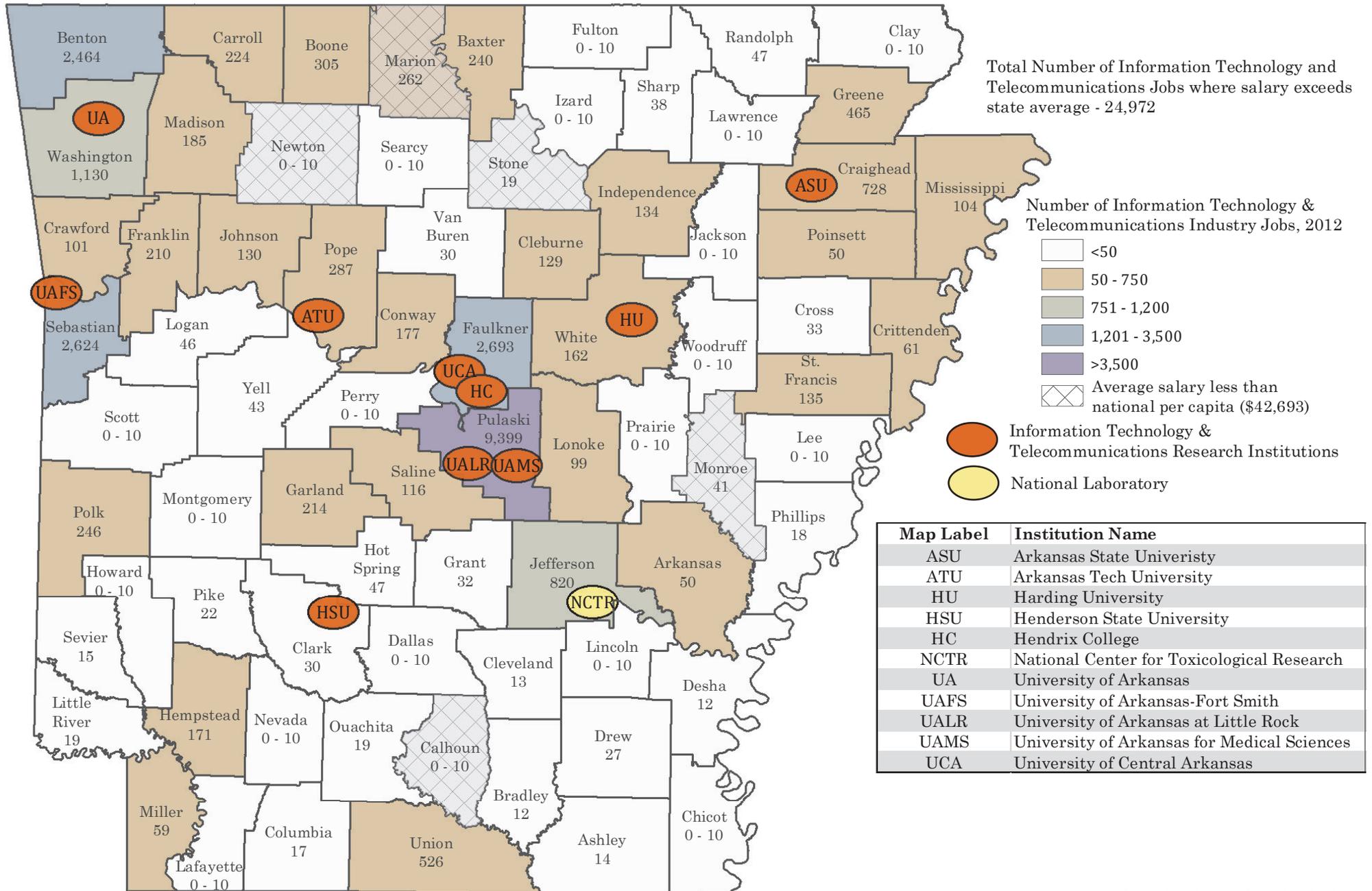
## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

# Information Technology & Telecommunications

## Location of Higher Education Research and Distribution of Employment



Source: EMSI, U.S. Bureau of Economic Analysis

**APPENDIX E: Institution Contacts**

Institution	Contact	Email
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	Linda Williams, MS	LDWilliams@uams.edu
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	Stephen Addison, PhD	SAddison@uca.edu
National Center for Toxicological Research	Thomas Flammang, PhD	Thomas.Flammang@fda.hhs.gov