“Vision without action is merely a dream. Action without vision just passes time. Vision with action changes the world.”...Joel Barker

“Greatness is not in where we stand, but in the direction we are moving.”...Oliver Wendell Holmes

Executive Summary

- Geosciences at UMass has a long-standing strong national reputation for excellence in graduate research and education
- Research and graduate education are organized into four concentrations: earth dynamics; global change; water; and geography, society and the environment
- We will continue to build on these strengths as a nimble department that can take advantage of emerging needs in graduate education and emerging trends in research opportunities
- Faculty hires (both tenure-stream and lecturer) are proposed for each concentration to continue our department’s position as a recognized leader in those fields as research and education needs evolve
- Graduate research and education in the Geosciences provides to the Commonwealth and the nation the next generation of thinkers and doers to address critical sustainability issues of such as climate change impacts, water resources, land-use change, non-renewable resources, and natural hazards
- Graduate education in Geosciences will continue as competitive program that incorporates a successful mix of research-intensive PhDs, thesis-track MS students, and non-thesis (fee-paying) pre-professional MS programs
- Strong university support for graduate education in the Geosciences is essential both to sustain our undergraduate teaching mission and to prepare our graduate students with strong scientific communication skills
- Geosciences graduate education will be central to the rigorous scientific preparation of students across the various graduate programs of the new School of Earth, Sustainability and the Environment (SESE)
1. The Vision – Future Research to Address Societal Needs

The world is experiencing ‘global environmental change’ at an unprecedented rate -- on land, in the oceans, and in the atmosphere. These changes are global, affecting all regions, from the tropics to the poles, and these changes impact not only the physical world around us, but societies around the globe. To anticipate and manage these changes, we need to understand Earth’s history, its processes, its hazards, its natural resources, and its diverse environments. At the same time it is important to recognize our human impact on the global system and to acknowledge the complexity of human social dynamics and relationships that shape and are part of these transformations.

In the Department of Geosciences, we explore Earth’s past and present and train students to think decades to centuries into the future. We use relevant and rigorous descriptive, analytical, and modeling tools to address the key environmental challenges that human society is facing today. We study environments and geologic systems, how these formed, how they changed in the past, how and why they are changing today, and the rates at which they are changing due to natural and human influences. As one department bridging the disciplines of geology and geography, we examine the inter-relationships between the environment and human societies, economies, and cultures.

The field of geosciences continues to expand and diversify, addressing the resource needs of a growing global economy while evaluating the present and future consequences of widespread human-induced environmental change. Reflecting this, the Department of Geosciences at UMass is highly visible and globally renowned in a number of geoscience sub-disciplines. New internationally visible public policy issues and research opportunities continue to arise (i.e., global warming, sea-level rise, water quality and availability, natural hazards, non-renewable natural resources, and limited energy), and UMass Geosciences researchers are at the forefront of tackling these. At the same time, new computational techniques, laboratory instrumentation and methods of data analysis have transformed many of the core Geoscience disciplines, particularly geochemistry, hydrology, sedimentology, biogeochemistry, paleoclimatology, isotope geology, geochronology, and spatial analysis and our faculty and graduate researchers reflect this transformation.

Our vision is to:

• Provide a deep and balanced background across these diverse subfields that are recognized strengths of Geosciences at UMass while also:
• Developing exciting cross college and campus wide levels of collaboration (e.g., School of Earth, Sustainability and the Environment; School of Public Policy, College of Engineering.)
• Steering our graduate research and education towards emerging career and research opportunities, reaching out to stakeholders and policy makers

The Department of Geosciences at present is organized around four research strengths, a scheme that emerged as a result of our 2013 AQAD review:

The Department of Geosciences today is organized around four research strengths.

(1) **Earth Dynamics** -- seeks to understand Earth’s tectonic system now and in the past, using the natural field laboratory and advanced quantitative analytical techniques to constrain complex geological processes, to understand natural hazards, and to use numerical models to test hypotheses. We have long had a strong international reputation in analytical petrology, tectonics, and geochemistry and have developed, and now operate the world’s most powerful electron microprobe to carry out cutting edge geological dating techniques.

(2) **Global Climate Change and Surficial Processes** -- is world renowned for paleoclimate and Quaternary research involving all aspects of the surficial Earth as a system. This specialty has been significantly enhanced in recent years to include biogeochemistry, stable isotopes, sediment geochemistry, coastal processes, geomorphology, and climate modeling on all times scales.

(3) **Water and the Environment** -- focuses on hydrogeology, water resources, water chemistry, ground water modeling, community needs and issues, and water politics and governance, while featuring strong connections with UMass Extension and the Massachusetts Geological Survey. Critical issues of sustainability, environmental quality, and decision-making lie at the interface of basic and applied, scientific and social-scientific, research.

(4) **Geography, Society and Environment** -- The field of geography is at the core and the cutting edge of intellectual and public engagement with sustainability, social justice, and the interface of science and society. Significant opportunities lie ahead in fields addressing sustainability, global change, natural hazards, human impacts on natural environments, and environmental policy and resource management.
We elaborate on our aspirations in these research clusters with the full inclusion of our home for the State Geologist and the future State Climatologist.

1.1 Earth Dynamics Group

The Earth Dynamics group seeks to understand our Earth’s dynamic tectonic and volcanic systems now and in the past. We use the natural field laboratory to constrain complex geologic processes and also use numerical and laboratory experiments and analyses to formulate and test hypotheses. We have a long-established strength in tectonics, petrology, and analytical geochemistry and now operate the world’s most powerful electron microprobe to carry out high-resolution analyses and cutting-edge dating techniques. Analog experimental laboratories around the world are looking to implement the quantitative innovations developed within our physical modeling lab. Our 3D numerical models of active tectonics have helped to define seismic hazards in southern California. Our X-ray fluorescence (XRF) laboratory provides precise analyses of major (those that make up >99% of a rock) and trace element abundances of every conceivable rock type for scientists and students throughout the U.S. We use these data to understand the origin of magmas and what happens to them in volcanoes and during volcanic eruptions. We explore the effects of volatiles emitted during volcanic eruptions on Earth’s past and future climate, and the effects of water and carbon dioxide trapped in minerals on the strength and behavior of rocks in our Fourier transform infrared spectroscopy laboratory. The seismology laboratory makes use of the Massachusetts Green High Performance Computing Center (MGHPCC) in order to simulate seismic wave propagation as one powerful and efficient way to understand the interior three-dimensional structure of the deep Earth. Energy needs for a sustainable society especially in fields of geothermal energy are key to expanding fields in the geosciences and we have demonstrated geothermal potential in Massachusetts.

Strategic Needs

Population increases worldwide means that we now have the greatest number of people ever vulnerable to geologic hazards. Geophysical approaches to understanding the structure of the crust are providing unprecedented insights into the behavior of active volcanoes and earthquakes that can help reduce the risks associated with these hazards. A new hire in crustal geophysics whose research has application to active tectonics will have tremendous benefit to researchers inside and outside of the department, the campus initiatives on sustainable development and to international understanding of earthquake, tsunami, and volcano hazards. The same imaging tools that geophysicists use to understand active volcanoes and earthquakes can also be used to assess hydrocarbon, geothermal, and mineral resources within the Earth. The sustainability of our limited resources depends on accurate characterization of subsurface hydrocarbon stores, geothermal systems, and mineral deposits. This geophysics hire may provide valuable insights to the energy and minerals industries in exchange for rich data sets that invigorate research, funding
opportunities to the university, and employment opportunities to students. The department’s existing expertise in micropaleontology, hydrogeology, rock mechanics, seismic tomography, igneous petrology, volcanology, geomorphology and environment geophysics will provide excellent opportunities for collaboration for a crustal geophysicists working on active tectonics and resources within the crust.

Geophysics is one of the most active areas of research and funding in the Geosciences. National Science Foundation, Department of Energy, Department of Defense, and the US Geological Survey all fund major geophysical projects. The new hire in crustal geophysics will bridge the research gap in Earth Dynamics in the Department, especially between the physical modeling lab and the seismology lab, and will fulfill our goal of establishing comprehensive undergraduate and graduate programs in solid Earth. Outside of the department, the research of a crustal geophysicist could translate into applications to increase the resiliency of our civil infrastructure to geologic hazards with input from earthquake, structural and mechanical engineers. Further cross-discipline interaction is likely with Physics, Astronomy, Computer Sciences, Environmental Conservation, and Geography (Natural Hazards).

Radiogenic isotope geochemistry is of paramount importance to all aspects of modern geoscience. Although founded in measuring the age of rocks, the fundamental use of radiogenic isotopes is to evaluate geochemical fractionation over geological time as a highly sensitive means to explore the most significant planetary- to nano-scale processes and the systems that influence their evolution. As a consequence, no facet of earth and planetary science has escaped isotopic scrutiny, from the timing of condensation and aggregation of the early solar system, to investigating the source and evolution of Earth’s crust and mantle, to quantifying recent weathering and the anthropogenic contamination of the Earth’s ecosystem. The UMass Geosciences Department is a national leader in the analysis and micro-analysis of rocks and minerals, isotopic analyses are increasingly essential for tracing Earth materials back to their origins in the interior of the Earth, and to predicting the effects of mountain-building and eruptive events into the future.

Hence, the Earth Dynamics research cluster is focused on a two-stage plan that will place UMass Geosciences in the very top group of solid Earth researchers and analytical facilities in the nation. The first goal is acquisition of a laser-ablation inductively coupled plasma mass spectrometer. This instrument will enable users to obtain trace element and rare earth element analyses of any spot on a mineral in-situ, and hence in the microstructural context in which the mineral grew. The power of such analyses would be difficult to overstate. A proposal for funding for the LA-ICP-MS could be submitted to the National Science Foundation in late, 2015. A future faculty member in isotope geochemistry would make use of this instrument, and would lead the effort to acquire a state-of-the-
art multi-collector LA-ICP-MS. This instrument will move UMass to a new elite level in geochemical analysis by permitting the analysis of any isotope of any element in the periodic table. The brightest frontier in the petrologic/geochemical world is the application of up-until-now exotic stable isotopes to geologic problems. The new instrument and the new faculty specialist, will dramatically enhance all of our existing research programs and moreover, will open many new research avenues from the timing of condensation and aggregation of the early solar system, to investigating the source and evolution of Earth’s crust and mantle, to quantifying recent weathering and the anthropogenic contamination of the Earth’s ecosystem.

The retirement of Professor Mike Rhodes within the next five years will impact the teaching, research, and analytical capabilities of the department in that Prof. Rhodes 1) teaches graduate-level courses in high-temperature geochemistry and volcanism, 2) conducts research on basaltic magmatic systems and the potential of Massachusetts granites to be tapped for geothermal energy, and 3) maintains the department X-ray fluorescence laboratory, which serves users on a national basis. The new hire in high-temperature radiogenic isotope geochemistry, who will oversee the inductively coupled plasma mass spectroscopy facility, will fulfill some of these roles, and will add the research power of analysis of trace elements and both traditional and newly-tapped isotopes to the analytical repertoire of the department. The Five College Geology Departments endorsed the continuation of a Five College Professorship if the hire was in this strategic area (Self Assessment Document, May 2015).

The recent downturn in federal funding for research has seen minimal impact within the Earth Dynamics group. We continue to secure grants from the National Science Foundation, US Geological Survey, American Chemical Society-Petroleum Research Fund, DOE, and the Southern California Earthquake Center, a joint USGS and NSF science center whose aim is to improve characterization of earthquake hazards in southern California. Our grants continue to support training of an excellent cadre of MS and PhD graduate students who land coveted positions within academia and industry. However, two of the most active and rising fields in the Geosciences have not been strengths in the Department: crustal geophysics and high temperature isotopic geochemistry. Our Solid Earth strategic plan includes the addition of these high-profile fields both to enhance the ability of existing faculty to secure funding and importantly, to open new income streams for future research.

1.2 Global Climate Change and Surficial Processes Group

In her latest book, This Changes Everything, Naomi Klein notes, “if we continue on our current path of allowing emissions to rise year after year, climate change will change everything about our world”. This is not hyperbole, but a succinct statement of reality; human-induced climate change is a relentless global problem that is changing the natural environment as we know it, and this process
will have many detrimental effects on societies around the world. The Department of Geosciences is well-positioned to address these problems.

We have a world-class research program in paleoclimatology (past climate variations), and on the impact of climate on ecological systems and processes at the earth’s surface, organized around the Climate System Research Center (CSRC) and the Northeast Climate Science Center (NECSC). Our research in paleoclimatology, which provides the essential context and understanding of contemporary climate changes, is nationally and internationally recognized for excellence. The best metrics of our success are the number of high quality peer-reviewed publications of our faculty, post-docs and students, our record of financial support and the careers of our graduates. In all three metrics, we have been increasingly successful.

Geomorphology and Earth-surface dynamics are intrinsically linked to climate change and naturals hazards over timescales ranging from hours to millions of years. Recent hires in sedimentology, fluvial geomorphology, and coastal geology provide us with exciting new research areas that focus on a fundamental understanding about the resources, hazards and environments that shape both natural ecosystems and our human experience. Coupled with paleoclimatic studies, surface process studies are truly interdisciplinary research fields at the nexus in which physical, chemical, and biological processes interact to define the form and evolution of a landscape. Elucidating these interactions and feedbacks between topography, hydrology, climate, sedimentary deposition, and rock deformation provides ample directions for basic, investigator-driven research, while societal applications have emerged in studies of, for example, the interactions between erosion, landforms, and active faulting; non-uniform patterns of sea level rise following melting of polar ice sheets; the mechanisms of landscape-ecosystem co-evolution in human-impacted landscapes; sustainability of landscapes and their resiliency in the face of floods and climate change; and the preservation and management of coastal zone resources in the face of direct human impacts, climate change, and sea level rise. Computational analysis and or geospatial monitoring are considered important components of the work in this field.

• Members of the CSRC have published (as principal authors or co-authors) more than 25 high profile research papers in the most important scientific journals in the world over the last few years (Science, Nature, Nature Geosciences, Proceedings of the US National Academy of Sciences). This means that the climate research activities at the University are performing at the highest international level.
• In terms of financial support, we have attracted funding from NASA, the Department of Energy, NOAA, NSF and the Dept. of Interior. Major research projects include the Siberian Lake El’gygytgyn Project (led by Prof. Julie Brigham-Grette, a $10M NSF-supported international activity); the Antarctic ANDRILL project, a multi-million dollar project supported by the US and New Zealand NSF, (Prof. Robert DeConto, Co-PI), and the establishment of the
Northeast Climate Science Center, a $7.5M Dept. of Interior project, involving UMass as the lead institution and six other centers across the northeastern U.S. (Prof. Raymond Bradley, Co-PI).

- Our graduates have all gone on to successful careers in research, education and government (see: http://www.geo.umass.edu/climate/hall_of_fame.html)

**Strategic needs**

Notwithstanding the success of the current faculty, our fundamental expertise in climate system science (as distinct from paleoclimatology) is limited and not competitive nationally. To remedy this situation, we propose to hire 3 faculty members, with strengths in **climate dynamics**, **ocean dynamics** and **ice dynamics**. These are three critical areas that would clearly establish the Department as the national leader and consolidate the position of the climate/paleoclimate group at UMass as one of the strongest in North America. It is clear the issues of climate change, ice sheet collapse and sea-level rise, and ocean circulation changes are not going away, and will increasingly become vital areas of societal concern. A near-term strategy to acquire faculty in these areas would be a wise investment, with potentially large benefits. Furthermore, these positions offer the potential for rich interactions with existing faculty and future hires in Earth Dynamics (land-surface processes and hydrology – linking the atmosphere with the land surface, water resources, and the coastal ocean), and human dimensions of climate change and global sustainability.

The **Climate Dynamics position is critically important to our continued success in climate and paleoclimate**. This position will provide the foundation of a growing campus-wide interest in all aspects of water on a changing planet. The atmospheric component of the hydrological cycle, how it has changed in the past and how it might change in the future, is absolutely fundamental to the study of human dimensions of climate change – on a range of spatial scales from global to local. Currently no one on the UMass campus teaches courses in meteorology and modern climate dynamics. The campus desperately needs someone who can teach and develop a research program in meteorology and modern climatology (see justification below). This position is vital to our plans in quantitative paleoclimatology (proposed by DeConto et al.) and would form the foundation for student collaborations within CNS, Engineering, LARP, and Public Policy.

To complement an initial hire in Atmospheric Science/Climate Dynamics, two additional future hires in ocean and cryosphere science will fill critical gaps in the Amherst campus’ course offerings and environmental and sustainability research.

**Oceanography:** There is currently only one course offered in physical oceanography/geophysical fluid dynamics across the five colleges (taught by DeConto). The course is a cornerstone of the graduate climate program in Geosciences and is an elective for the Five College Marine and Coastal
Sciences program. However, considering the importance of the ocean in global climate and the local Massachusetts environment, this one-course limitation represents a critical underrepresentation of the vast and growing field of oceanography. Because of the role the oceans play in driving changes in the Atmosphere (from the bottom up), any future growth in atmospheric science in the Amherst campus should be complemented by equivalent growth in the area of ocean science, as has been common practice among our peer institutions.

Cryosphere Science: The polar and alpine regions contain most the Earth's fresh water. Recent changes in Arctic sea ice and snow cover have been linked with the increasing severity of New England winters and California's drought, and the loss of Greenland and Antarctic Ice are likely to soon become the primary drivers of sea level rise with important impacts on global (and Massachusetts) coastlines and cities. Expanding in this field would complement existing expertise in polar climate, ice sheet modeling, sea level research, and glacial geology, and would tap into a rapidly expanding field within the geosciences. In addition to hires in atmosphere and ocean science, expanding in this area would fully round out the Geosciences climate program (covering every major component of the Earth’s climate system), making us more competitive with our primary peer institutions and departments (e.g., Colorado, Penn State, Wisconsin, Oregon, Arizona).

In sum, the present lack of atmosphere, ocean, and cryosphere science on the Amherst campus represents an important deficiency, but it also represents a fantastic opportunity for growth and to expand on the existing, national, and international reputation of Climate System Research Center already established within the Department of Geosciences. Complementary connections with Engineering, the School for Public Policy, the Northeast Climate Science Center, the Massachusetts Geological Survey, and the pending Office of the State Climatologist make growth in these areas especially timely.

1.3 Water and the Environment Group

A principal goal of this group is to research basic and applied problems in water resources to enable citizens and organizations to make choices that ensure sustainable economic development, enduring environmental quality, and cultural resource preservation for the people, businesses, and governments of Massachusetts and the world beyond. The disciplines within the Department of Geosciences and across the campus naturally address issues of sustainability and human impact on the environment. Climatic extremes are affecting the hydrologic cycle around the globe, with dire consequences for water availability in ever-increasing areas of the planet.

Water is the medium that connects geological, chemical, physical, and biological processes on Earth's surface and in shallow, subsurface environments, and is central to human interactions with those processes. Research that links our
outstanding foundation faculty (and the Massachusetts Geological Survey) in groundwater and surface water resources with aqueous geochemistry is critical to the future of our department. Our faculty conduct research that encompasses basic questions and problems, such as the rates and magnitudes of water-rock interaction, mineral precipitation and dissolution, and reactive transport in porous media. Faculty in this group also work in applied areas, including contaminant transport and remediation, point-source and non-point-source ground water pollution, and baselines and modification of waters associated with industrial activities such as hydraulic fracturing or “fracking”, to train undergraduate and graduate students in service to stakeholders. As such, there is strong potential for growth in fee-paying MS student education in this field, and our 1-yr Hydrogeology MS program capitalizes on this.

Understanding the controls on the chemical composition of natural and unnatural surface and ground waters is the main focus of aqueous geochemistry. Chemical signatures (e.g., solutes and isotopes) are unraveled by aqueous geochemists to recover important information about the quantity and quality of water reserves, their history of interactions with their surroundings, and the nature of processes acting within Earth’s Critical Zone. Our ability to assess the suitability of waters (quantity and quality) for human and ecosystem use is reliant on the chemical signatures of those waters in time and space. With the forthcoming visibility and research strength in aqueous geochemistry at UMass, we will take advantage of regional, national, and international initiatives in water research to train the next generation of water scientists in service to the Commonwealth.

Our search for an aqueous geochemist will begin in the Fall 2015 (approval spring 2015). This scientist will sit in a unique position on campus. The Department of Geosciences is a singular location within the University that has the academic capability to lead research in the field of the geochemistry of natural waters. No other departmental home could yield the basic research, instrumentation, and curriculum that an Aqueous Geochemist housed in Geosciences will provide. The position provides important depth to the Water and Environment Group, and ensures a sustainable 5th-year professional Master’s Program, in addition to contributing to fundamental basic research areas. Moreover, the position is also specifically intended to complement research in and develop synergies with Environmental Conservation, Civil and Environmental Engineering, UMass-Amherst Extension, Center for Agriculture Food and the Environment, the Water Resources Research Center, and the Massachusetts Geological Survey.

Strategic needs
In a report titled “Challenges and Opportunities in the Hydrologic Sciences” (NRC, 2012) the National Research Council specifically identifies the interface between hydrologic processes and land surface dynamics as a critical research area. For example “Many challenging research questions arise when exploring how
topography, vegetation (and their animal ecosystems), and the hydrologic processes that connect them may co-organize over geomorphic time scales.” These include questions involving how topography, terrestrial and aquatic ecosystems, and the hydrologic processes that connect them, may co-organize over geomorphic time scales. For instance, in the area of fluvial geomorphology, hydrologic cycles respond to changing climate conditions, and these in turn yield new morphological conditions and non-stationary processes. Where these three disciplines intersect, three of our departmental strengths also intersect: Global Climate Change and Surficial Processes; Water and the Environment; and Geography, Society and Environment Group. A future hire in the area of fluvial geomorphology would complement existing departmental strengths and bolster our students’ toolboxes as they face increasingly complex and nested environmental problems.

1.4 Geography, Society and Environment Group

The field of geography has a strong intellectual history of public engagement with sustainability, social justice, and the interface of science and society. Building geography within the Geosciences at UMass should be central to the University’s efforts to renew the promise of the public university and develop a School of Earth, Environment and Sustainability. UMass Geography has a strong history of community and international research, engagement, and advocacy. Our current faculty are few in number but are highly active in conservation, sustainability, and social justice research, and advocacy in our region and internationally, and they maintain active research in political ecology, political geography, urban geography, and Geographic Information Science and Technology (GIS). Community engagement informs both research and teaching in geography, through which the geography program makes significant contributions to campus global diversity and environmental studies education through both general education program courses and other courses which draw a high percentage of non-majors from diverse campus departments.

Geography graduate research at UMass contributes to the University’s efforts to become a destination of choice for environmental, sustainability, and international studies. In 2012, the geography program embarked upon an intensive effort to build and re-center around environmental and sustainability themes. While the program has been successful in establishing a campus-wide network of 20 affiliate faculty, we need to rebuild our core strength in geography faculty with fundable research programs. The program can best be rebuilt through strategic tenure system and lecturer hires that complement the strengths of our existing core and affiliate faculty.

The geography program’s highest priority is for tenure system research faculty in human geography in the areas of sustainability and environmental studies and policy. Tenure system hires are critical to developing our MS degree program and becoming a destination of choice for graduate students. These
proposed tenure track hires build on our current strengths in environmentally-focused human geography and include:

(1) Sustainability and international development,
(2) Human dimensions of global environmental change
(3) Environmental governance/climate policy and implementation, and
(4) Natural hazards and climate change (impacts, mitigation, and adaptation)
(5) Lecturer in GIST
(6) Lecturer in Human Geography

We now have the opportunity to strengthen our program through well-targeted hires in current cutting-edge geographical research in these areas. This kind of geographical research and teaching is now being advocated and offered by sustainability programs in the U.S. and U.K. and identified as a priority by a wide range of organizations, from the National Academy of Sciences to Future Earth. These hires will provide core expertise, research opportunities, and teaching to a future School of Earth, Sustainability, and Environment.

Position descriptions:

**Tenure system position 1: Sustainability and International Development**
Human geographer with research and teaching specialization in sustainability and sustainable development, particularly in relation to climate change adaptation and mitigation in the global South (Latin America, Asia, Africa). Ability to teach on both US and global South/"developing world" green economy and sustainable development contexts is desired. Areas of research interest may include sustainability and sustainable development discourses, policies and planning and implementation at international, national, regional, and local scales with emphasis on food systems, food security, and environmentally-sustainable land use/marine practices; low carbon energy; and/or climate change mitigation and adaptation. Synergies desirable with existing faculty research and teaching on biodiversity conservation, water management, and urban development. GIS skills and use in research and teaching are valued for this position.

**Tenure system position 2: Human Dimensions of Global Environmental Change**
Human geographer with research and teaching specialization in coupled human-environmental systems and dynamics of change at local and regional scale. Expertise desirable in areas such as analysis of societal impacts on environment, ecosystems, and natural resources; monitoring and assessment of environmental change, conservation, and sustainability initiatives; or changing social-ecological systems dynamics associated with climate and other global environmental change. GIS skills and use in research and teaching are important for this position.

**Tenure system position 3: Environmental governance/climate policy and implementation**
Human geographer with research and teaching specialization in global and comparative international governance of physical and biological earth systems with particular reference to climate change adaptation or mitigation policies and programs. We seek a colleague who work on one or more of the following themes: international governance actors, mechanisms, policies, and programs concerned with climate change mitigation and adaptation; international biodiversity, forest, or marine conservation with emphasis on climate change related policies and programs; green economies and sustainable development.

**Tenure system position 4: Natural Hazards and Climate Change Impacts**
Human geographer with research and teaching specialization in climate change related natural hazards and responses. Areas of possible research interest include socio-economic and geographical variations, inequalities, and dynamics in vulnerability/risk; resilience, and adaptation; prevention and mitigation policies and planning; socio-ecological coping mechanisms and capacities; human impacts and responses to climate change-associated natural hazards such as sea level rise, severe storms, desertification, environmentally-associated diseases; environmental refugees; resource scarcity and land degradation associated conflicts. GIS skills and use in research and teaching are valued for this position, as is international experience.

**Geography lecturer 1**
GIST: geographic information science and technology, including GIS, remote sensing, and computer cartography (joint proposal with the Department of Environmental Conservation). **Spatial data analysis** (or **Geographic Information Science**) is a rapidly expanding field with applications across nearly all disciplines in applied science, engineering, land-use planning, and social science. Providing a strong curriculum and research environment in GIS is now critical for student career preparation, for future funding opportunities, and for visibility on issues of national interest and policy. Geographical Information Science as a discipline within our department is well positioned to contribute to campus inter-disciplinary environmental science and sustainability studies (Department of Environmental Conservation, ECo). A proposed joint lecturer position with ECo is a first step in further strengthening the GIST component of the Geography program, which, with a single faculty member now responsible for both GIS and remote sensing, lags far behind the standards of Research I universities.

**Geography lecturer 2: Human Geographer**
We propose to hire a full-time lecturer in human geography with primary responsibility for teaching general education/foundation courses in introductory human geography and world regional geography. This teaching will contribute directly to campus initiatives in sustainability and internationalization. Providing these foundational and gen-ed courses more frequently will strengthen our geography degree programs, contribute to the general education program, and contribute to campus-wide efforts to shorten the time-to-degree for
undergraduate students. It will significantly enhance the geography degree program, moreover, by enabling our small number of tenure system geography faculty to devote more time to providing advanced undergraduate and graduate courses. We anticipate that the overall expansion of the geography curriculum will help us to maintain the steady growth in the number of geography majors that we have experienced in the past few years. Our efforts to increase geography’s campus presence and contributions will be greatly advanced by hiring a lecturer in human geography. While it will not fulfill our needs for additional tenure-system, research-active faculty, particularly in the areas of sustainability, human dimensions of global environmental change, environmental governance, and natural hazards, this teaching position will increase the ability of our current human geography faculty to provide more teaching in political ecology, environmental geography and policy, and urban change.

The proposed tenure system geographers and lecturer positions are extremely cost-effective by CNS standards. Future hires in GIST will also be cost effective in that they will share GIST laboratory and teaching laboratory space with our current faculty.

1.5 Interfacing with the Massachusetts Geological Survey

The Massachusetts Geological Survey, lead by Dr. Stephen Mabee, provides a valued connection in the Department between applied research and outreach to communities and stakeholders within the Commonwealth. Survey staff collaborate with many professors within the Department on a number of research activities and interact with other faculty here at the University as well as other academic institutions and State and Federal agencies. The Survey provides an additional source of funding to the University and provides opportunities for students to do field research or gain experience as practicing Earth science professionals.

The mission of the Massachusetts Geological Survey as stipulated in MGL Ch.21A, Section 7B is to:

- Conduct research on the land, mineral, and water resources of the state;
- Coordinate and facilitate research and communication among various agencies, researchers and stakeholders;
- Collect, compile, analyze and preserve data pertaining to the geologic environment;
- Disseminate the findings of such research to the public through maps, reports, and other publications;
- Advise all other branches of state and local government, concerning the geologic character of the state and its implications for both economic and scientific needs in conjunction with all existing and future environmental factors relating to the geology of the state;
- Identify and mitigate potential threats to public health and safety and to land, mineral, and water resources of the state;
• Educate the public about threats to drinking water, geohazards in the state, and potential impacts of major storms and rising sea level through the website and outreach activities.

Some of the specific benefits of the State Geological Survey to the University are that it: 1) provides access to funding only available to state geological surveys; 2) provides a source of revenue to the University and funds students; and, 3) increases visibility and brand recognition for the University of Massachusetts as well as foster additional connections to other federal and state entities (eg., USGS, DCR, DEP, MassGIS, MADOT, NPS, FEMA)

**Strategic Needs**
One area that needs investment and would benefit undergraduate and graduate educational experiences is the development of two internship programs. One internship would provide money to fund a student or two to work with the Massachusetts Geological Survey staff on various projects including geologic mapping. There are many field projects and research questions that the Survey cannot always spend adequate time researching. These could be addressed through an internship and developed into senior undergraduate theses or Master’s projects.

The second need is to develop dedicated, annual internships with one or two companies that would take the top candidate(s) in the Department and give them an opportunity to gain experience in a professional organization. Two companies that might be willing to discuss this possibility are AECOM and Golder Associates. Graduate school and internship opportunities with the Survey or an outside organization would give these students a competitive advantage.

### 1.6 Interfacing with eventual State Climatologist Office (OMSC)

Weather directly and indirectly affects production and consumption decision making in every economic sector of the United States at all temporal and spatial scales. One recent study estimated that Massachusetts has a high sensitivity to weather variability, as a function of state gross domestic product. An active OMSC in Massachusetts will benefit stakeholders throughout the Commonwealth as trust-based relationships develop between the Office and decision makers in various economic sectors.

The University proposed the development of an Office of the Massachusetts State Climatologist (OMSC) be established at the University of Massachusetts, Amherst. The position is currently on hold for hiring due to budget constraints emplaced by Governor Baker. Yet the position was advertised and a search initiated. Once hiring freezes are removed, the role of the OMSC will be:

- To facilitate and enhance the collection, dissemination and use of climate data and information for the Commonwealth;
- To monitor and assess climatic conditions and impacts in the
Commonwealth to further the economic efficiency and general welfare of public and private institutions and individuals in the state;
• To engage in outreach by working closely with stakeholders in the Commonwealth, interacting with state and local media and public education efforts.

This Office would complement, and benefit from the presence of the Department of Interior Northeast Climate Science Center at the University, which focuses on climate change and climate impacts across the entire northeastern quadrant of the United States (from Minnesota to Missouri, and Virginia to Maine). The OMSC will work synergistically with NOAA agencies and the DOI Northeast Climate Science Center in studying the effects of climate change on ecosystems, wildlife, water and other resources in the region. By centralizing and disseminating timely climate information, the OMSC will also help the UMass Extension mission (see below) and the Massachusetts Geological Survey. Graduate opportunities working with the State Climatologist is a natural synergy within the Department and the School for Earth Sustainability and the Environment.

1.7 Interfacing with UMass Extension and the Center for Agriculture, Food and the Environment

UMass Extension has the unique capability of bringing UMass Amherst’s depth and breadth of knowledge and its academic resources to bear in identifying and solving problems. Our research and teaching programs link different departments and facilitate mutually beneficial collaborations between the University and external organizations, individuals, and businesses, making a vital contribution to the public to educational experiences and to research opportunities.

While Geosciences has not traditionally been a department with Extension Faculty, research within all four focus areas within the Geosciences is of crucial importance to the identification, understanding, and prediction for a broad array of environmental hazards, and UMass Extension faculty within Geosciences can help form and strengthen the links that disseminate this research to the broader community and Commonwealth. Geosciences broadly can help promote the UMass Extension mission to: (i) improve the health, well-being and security of youth, families, and communities (ii) strengthen agriculture and food systems, (iii) provide crucial information and advice in support of water resource management in the Commonwealth, and (iv) educate the public on mitigation and adaptation measures.

Geosciences is an active partner and collaborator with the UMass Center for Agriculture Food and the Environment and it’s primary functions, including: (i) Research, (ii) Integrated-Research-and-Extension, (iii) Organizational and Community Services, and (iv) Public Liaison.
2.0 Summary Realizing the Vision

Enhancing our value as a destination of choice that expands our strengths include faculty hires over time as follows:

Immediate hiring needs:
1. **Aqueous Geochemistry** -- interfacing with all of the research areas in the department with important synergies campus wide, including graduate programs like the 5th year masters program in hydrogeology and water related fields.
2. **Climate Dynamics** -- bringing atmospheric science to three of the 4 research areas and for the first time to campus bridging programs in CNS and engineering
3. Split hire with the Department of Environmental Conservation for a **GIS Lecturer** to develop and sustain both certificate program and revenue generating 5th year masters program.
4. Radiogenic isotope geochemistry – providing synergies across the earth dynamics group

Longer-term hiring as outlined in text above:
5. Crustal geophysics
6. Natural hazards and climate change
7. Ocean and Ice dynamics
8. Environmental governance/climate policy and implementation

Space – Critical Needs and Timely Opportunity

Perhaps the single most critical obstacle to growth in the Department of Geosciences is space for modern modeling and analytical research, space for innovative hands-on Earth Science teaching, and space for student research and interaction. Every growth area in the Department of Geosciences, even on the shortest time scale, is severely limited by space constraints. One short-term opportunity exists to put the Department on the road to the future. As researchers and laboratories in the Department of Biology shift to renovated space in Morrill IV, released space in Morrill II and Morrill II is perfectly situated to satisfy some of the most critical needs while also furthering some of the immediate growth areas in CNS and the proposed School of Earth, Environment, and Sustainability. These include, new teaching and research space for GIS and new space for the State Geologist and Climatologist and new analytical and modeling space for students. Renovated space in Morrill III combined with renovated backfill space currently in the Department can facilitate our next step toward the upper tier of Geosciences research/teaching institutions.

3.0. Graduate Education
Graduate education in the Department of Geosciences at UMass includes a Ph.D. program and M.S. programs in Geosciences and Geography. Much of the discussion that follows related to the Geosciences PhD and MS programs; the Geography MS program is discussed separately at the end of this section.

The geosciences have typically been a field in which employment opportunities are diverse and abundant with a Masters level of education. This is particularly true for field-oriented subfields which have been strengths at UMass. One part of our graduate program has traditionally addressed the need for MS degrees that lead to employment outside of academia. Further, until recently a large proportion of students who ultimately pursue an academic or research career acquire a M.S. on route. Consequently, geosciences graduate programs, and the UMass program in particular, have tended to have a large proportion of M.S. students, typically a 2:1 ratio of MS to PhD students. However, this ratio is changing and will continue to change in the future, for two distinct reasons. First, the faculty of the Department of Geosciences made a careful and conscientious decision to increase the admission of PhD students, and in the process to emphasize the research-oriented PhD program. As resources (TA and RA) to support graduate students are limited, this is by necessity resulted in a reduction in MS students. There has been a concerted effort to recruit and accept more PhD students while simultaneously being more selective in our acceptance of MS applicants. Second, with fewer TA resources being provided to support our undergraduate teaching mission and provide graduate student stipends, the department relies ever more heavily on funded research grants for graduate student support. As the duration of a typical Geosciences research grant is three years, while PhD student time-to-degree is five years or more, the Geosciences graduate program increasingly awards the limited TA support we have available to 1st- or 2nd-year PhD students, who subsequently move on to RA support for the remainder of their graduate career with us.

At present (Spring 2015), the Geosciences graduate program has 22 active MS students in Geosciences, 11 MS students in Geography, 7 in the MS/PhD, and 33 in the PhD program. Since 2004, the Geosciences MS program averages 32 applicants each year, of whom on average 60% are accepted and 20% enroll in the program. The Geosciences PhD program averages 34 applicants each year, of whom 48% are accepted and 18% enroll in the program. The yield (percent of accepted applicants who enroll) averages 33% for the Geosciences MS program and 38% for the PhD program over the past 10 years. Thus for the past 10 years, we have an entering class of graduate students made of 6-7 MS students and 6-7 PhD students.

3.1 Geosciences PhD Programs into the Future

The Department of Geosciences has consciously moved to increase strength in the expanding fields of geochemistry and Earth modeling while maintaining
strength in paleoclimatology, sedimentology, structural geology, petrology, and tectonics. This change has brought a change in the profile of graduate research in the department, with increasing numbers of graduate students carrying out experimental, modeling, or analytically intensive dissertation research.

**Vision:** The Department of Geosciences is dedicated to providing a realistic and relevant, research-oriented PhD experience in which students gain the experience and training necessary to transition into an academic or research career. Toward this end, we emphasize student training and participation in grant writing, multiple publications en route to the PhD rather than the more traditional long dissertations. And we strive to provide practical teaching experiences, commonly teaching an introductory course under the guidance of a faculty mentor. PhD students have had significant success in securing academic positions, post-doctoral fellowships, and research positions in industry.

PhD students in the Department of Geosciences have tended to take 5 or more years to complete their degrees, in some cases because of the added time involved with fieldwork in distant locations. One goal is to reduce the time to degree to 4-5 years without MS, and 3-4 years for candidates with a M.S. degree. Our PhD program enrolls an average of 6-7 incoming students each year. Given the normal time-to-degree in Geosciences, this corresponds to most faculty advising 1-2 PhD students at any given time. There is some capacity for growth in our PhD program in terms of faculty advising commitments, but we are also severely constrained in both graduate student support and physical space requirements for graduate student offices and lab/research facilities. As such, Geosciences anticipates only modest growth in the size of our PhD program in coming years. Any vision for growth in our program can only be realized by a commitment from the University for increased space and increased graduate student support (particularly TA support to maintain and strengthen our undergraduate teaching mission, and to provide teaching opportunities for our graduate students). Most of the faculty in the department have research funding of some kind to support the graduate program but success rates for grants continue to drop below 10% and are extremely competitive.

**Proposed School of Earth, Sustainability and the Environment (SESE)**

The Department of Geosciences anticipates playing the lead role in development of a graduate program within the proposed School of Earth, Sustainability and the Environment (SESE). This school will bring together faculty from the departments of Environmental Conservation, Geosciences, and the Stockbridge School of Agriculture. The original proposal for this school, crafted primarily by faculty from the Department of Environmental Conservation, focused exclusively on undergraduate education. Geosciences on the other hand, understands this school as an exciting opportunity to additionally promote visibility and strengths in research and graduate education. As such, we will spearhead plans to ensure that graduate education be an integral component of this school in the future,
with MS and PhD programs in Environmental Conservation, Environmental Geology, Climate Science, Geoscience and other related disciplines. Within this framework, we will leverage our existing 1-yr MS degree in Hydrogeology (a fee-paying MS) with additional fee-paying 1-yr MS and certificate programs in Environmental Geology, GIS Science, and a 5th-year MS program in Geology.

Support: We tend to get a large number of high-quality applications and there is generally room in the program for additional students. However, financial support has been the main limiting factor in attracting the highest quality students into the PhD Program. In particular, the duration of guaranteed support is a key reason why we have lost high-quality accepted PhD applicants to other programs. In short, while our peer institutions offer 4 or even 5 years of support, until recently we have only offered 2. The most common model of grant support funding in the Geosciences is “one grant, one project, one student, three years”, i.e. funding by national agencies in the Geosciences does not traditionally have a model of large, sustaining and renewed grants that can support multiple graduate students spread over many years and several related projects. Incoming PhD students supported on a research grant commonly find themselves without guaranteed support following the end of the research grant, and entering into a newly funded project in the final year or two of their PhD does not fit well with completing dissertation research. Additionally, many incoming PhD students require 1-2 years of training (graduate-level courses, research methods, professional skills) before they are prepared to engage in their PhD research, during which time PhD students may not be ready to contribute to and be supported by a research grant. Geosciences programs at other institutions supplement PhD student funding beyond the typical 3-year grant duration by offering students 4- or even 5-years of guaranteed support, initially as TAs, followed by a transition to an RA on a research grant. To be competitive with offers from our peer departments at other institutions, the UMass Geosciences Department is now using TA support to supplement offers to high-quality graduate students with a guarantee of 4 years of support, but this further depletes our potential to make TA offers to other students.

The Department of Geoscience has a strong record of soliciting external funding to support graduate education. The majority of our graduate students (50-65% each year) are supported by RA appointments, while each year only 8-10 receive TA support out of a population of 60-70 students. Approximately 10% of our students hold fellowships or external support, while a small number receive no support at all (typically students in a final semester finishing their writing after grant support has expired).

The Department is extremely nervous about the suggestion of decreasing the number of TAs but increasing the level of support. The idea of admitting fewer students but funding them better simply is not reasonable for a graduate program of our size. Although there are times when our offers are not competitive, in general, the amount of support in terms of annual stipend has not discouraged
students from coming to UMass. Rather, it is the duration of guaranteed support that has most affected our enrollment yield. Decreasing the number of TAs would simply decrease the number of graduate students in our already small program that is highly strained to adequately support our undergraduate teaching responsibilities. An alternative is to try to use alumni support to bolster the grad support package; not to entirely endow student fellowships, but to make student offers more competitive.

3.2 The Geosciences Masters Programs in the Future

The Department of Geosciences has always had a large and diverse cadre of M.S. students. Both our MS and PhD programs have a strong focus on preparing students for careers outside of R1 universities, in part because there are many opportunities for employment in Geosciences outside of faculty positions at research universities. Our MS program is especially strong in this non-academia preparation, and we plan to continue this strength. Many of our former M.S. students are currently employed at all levels in environmental consulting, mineral exploration, petroleum exploration, and other industries. In recent years, we have also seen strong growth in post-graduation employment for our MS students in fields related to water resources, environmental geology, and resource conservation, working in industry, for governmental agencies and for NGOs. We perceive this as a crucial service need that the department fulfills in the Commonwealth, and we plan to continue this. We are moving towards increasing our numbers of fee-paying MS students in a new School of ESE, especially in subdisciplines and on non-thesis MS projects that are more pre-professional than academic. At the same time, we recognize that approximately half of our MS students enter our program as preparation towards a subsequent PhD degree. For those students, we plan to maintain a program of strong, academic research theses completed in 2-3 years. A growing number of these students (~11%) continue on at UMass for their PhD.

For many subdisciplines of the geosciences, it would be difficult to sustain a fee-paying MS program. In part this is because demand for MS degrees is not uniformly high across all of the geosciences, in part this is because some of these subdisciplines are found mainly within academia, and most critically, competing programs at our peer institutions largely provide support for their MS students. However, several subfields with significant employment opportunities have a strong potential for pay-as-you-go, fifth-year M.S. programs. We have recently established a one-year intensive M.S. program in hydrogeology and also in geography, and we are moving to establish a 5th Year MSc program in Geographic Information Systems (GIS). These have the potential to provide needed funds and also to provide a service to students and businesses.

3.3. The Geography MS program in the future
The Geography MS program attracts graduate students wishing to pursue studies in our current faculty specialties - political ecology, political geography, urban geography, and Geographic Information Science and Technology (GIS). Students earning MS degrees in geography are well-qualified for a wide range of occupations in government agencies, NGOs, and private business, or further graduate study at the PhD level. Alumni of the UMass geography M.S. program have had great success finding relevant and successful jobs which make use of their skills and are working in a wide range of agencies and businesses, from the U.S. Census Bureau to the City of Portland, Oregon, from a housing agency in Holyoke to the Pioneer Valley Planning Commission, and from a Boston-based investment bank to the Holyoke electric company. Those who have continued on to PhD programs in geography have found faculty positions in recent years at the University of Maryland, the University of Texas, the University of Delaware, Southern Connecticut State University, Worcester State University and Westfield State University.

In 2012, after a careful self-evaluation, the geography program made a decision to build an effective and competitive undergraduate geography program at UMass centered on environmental issues, policy and sustainability, while limiting graduate admissions. Yet, we aim to build research programs at the graduate level in areas that represent the intersection of Geosciences in the future. We plan to strengthen program in economic geography, international development and natural hazards (lost through faculty retirements and death), and expand our faculty strengths in the areas of sustainability, human dimensions of global environmental change, and environmental/climate governance, policy and implementation.

Growth in our MS program and becoming a destination of choice for graduate students in geography will require an emphasis on our shared geoscience program that uniquely combines earth system thinking with the social dimensions of earth and environmental change. We do not expect to compete with peer institutions who average 18 tenure system geography faculty and offer full geography curricula, facilities, and program activities. Rather, investment is long overdue in Geography at UMass, due to campus initiatives that would strongly benefit from Geography’s contributions to environmental, sustainability, and international studies as well as public policy.

4. Office Staffing Needs

The faculty in Geosciences cannot function without adequate professional and classified staff for human resource management, grant and budget management, planning, purchasing, and travel, among other essential duties. We are currently down by 1.5 FTEs but have plans for replacing these positions in the urgent future. Looking out over the next year or two, the retirement of our accountant and business manager will provide an opportunity to restructure department operations. New business models and “RCM” will require us to invest in a new
business manager with perhaps MBA qualifications and an accountant specifically trained for the new protocols. Moreover, one of our staff could become an assistant to the faculty advisors, acting as a coordinator of overall department advising while also assisting with outreach, event planning, and other department duties. Plans for joint positions related to a new School of Earth Sustainability and the Environment might also include staffing a recruiting and career center with shared support within CNS. The department office cannot tolerate further decrease in our current staff (4.5 FTEs).