

RUTGERS

Institute of Earth, Ocean, and
Atmospheric Sciences

STRATEGIC PLAN 2018-2023

Strengthening and Integrating Rutgers Earth System Science
for Fundamental Understanding and Planetary Stewardship



EOAS
EXPLORATION. INTEGRATION. STEWARDSHIP.

Dear Colleagues:

Nearly a year ago, the Rutgers Earth system science community embarked upon its first integrated strategic planning process. This process engaged over five dozen faculty members from across six schools at Rutgers. The common message that emerged from the strategic planning committee meetings and town halls is that Rutgers is already a national leader in the Earth system sciences, but that, through the Institute of Earth, Ocean, and Atmospheric Sciences (EOAS), we can and must enhance our leadership by increasing collaboration and integration across relevant schools, departments, programs, and centers. Such integration is necessary both to maintain Rutgers' competitiveness and also to serve broader societal purposes: growing fundamental understanding of the past, present, and future of the Earth system, and leveraging this understanding to advance equitable civic stewardship of our regional and planetary environment.

This strategic planning document begins by discussing the planetary context, history, and accomplishments of EOAS to date, then presents the mission and vision of the Institute. It analyzes the strengths of the EOAS community, as well as the challenges we face both in general and by comparison to our peer institutions. Based on this analysis and the discussions during the strategic planning process, it presents a series of six goals and associated objectives that will strengthen the EOAS community's core program of exploration, enhance integration of Earth system science disciplines and programs, and link ongoing efforts to enhance our contributions to regional and global environmental stewardship. The Appendices provide an overview of many of the departments, centers, initiatives, and activities associated with EOAS; assess Rutgers Earth system sciences in comparison to peer institutions; describe the process that generated this plan; and highlight some opportunities for faculty hires identified in the course of the planning process.

We would like to thank the many members of the EOAS community who participated in the strategic planning committees (listed in Appendix III) and in the public review process. We would also like to thank the external participants in the planning committees and the public review process, including Don Boesch, Richard Duke, John Higgins, Larry Linden, Michael Oppenheimer, Frederik Simons, Michael Stein, and Jon Wilson. We would also like to thank Office of the Chancellor at Rutgers University-New Brunswick, the School of Environmental and Biological Sciences, and the School of Arts and Sciences for their core financial support for EOAS.

Over the next five years, we look forward to working with the EOAS community, the Rutgers community writ large, and our broader community of stakeholders in New Jersey and around the world to implement the vision laid out in these pages.

Sincerely,



Robert Kopp
Director



Lynne Trabachino
Associate Director

Table of Contents

- 1 Executive Summary**
- 4 Introduction**
- 6 Statement of Purpose**
- 7 Analysis**
- 10 Goals**
- 14 Appendix I: Affiliated Departments, Centers, Institutes and Activities**
- 18 Appendix II: Peers and Aspirant Peers**
- 23 Appendix III: Strategic Planning Process**
- 25 Appendix IV: Faculty Hiring**



EXECUTIVE SUMMARY

The modern era of human history is a planetary era. Addressing challenges like climate change, biodiversity loss, and the perturbation of global biogeochemical cycles requires an integrated program of Earth system science that advances both the fundamental scientific understanding of our home planet and also the knowledge and perspective needed for regional and planetary environmental stewardship. In order to address these needs, building upon the quarter-century history of the Rutgers Institute of Marine and Coastal Sciences, the Rutgers Institute of Earth, Ocean, and Atmospheric Sciences (EOAS) was created four years ago to link the Earth system science disciplines at Rutgers more tightly together.

EOAS today is a multidisciplinary, accomplished community of researchers that includes more than 100 faculty and staff across six schools. Our faculty ranks include numerous winners of national and international awards, and many of our researchers engage in policy and assessment processes at state, national, and international levels. EOAS scientists are global leaders in the study of climate and ecological risk, in integrated oceanic and atmospheric observation and prediction, and in polar research. They are pioneers in reconstructing past sea-level change and in piecing together the evolution on the protein nanomachines that power life. The EOAS community hosts a rich array of chemical and magnetic analytical facilities, and an extensive network of oceanographic, ecological, and atmospheric field stations. The community also has a long history of innovative education and outreach, including the country's first geology museum.

Developed through a process that engaged dozens of faculty members, this strategic plan is the first integrated strategic plan for the Earth system sciences at Rutgers University.

Mission and Vision

As an Institute, EOAS's mission is to cultivate a university-wide, interdisciplinary community for research, education, and public and policy engagement about the past, present and future of the Earth system, including the solid Earth, ocean, atmosphere, and biosphere, and humanity's dependence and impacts upon them.

Our vision is that, over the next decade, EOAS will strengthen Rutgers as a nationally leading public institution in research, education, and public and policy engagement that

1. advances the scientific understanding of the past, present and future of the Earth system and
2. builds the knowledge and perspective needed for equitable state, national and global stewardship of a healthy, sustainable and resilient planetary environment.

Key Impacts

EOAS scientists advance the scientific frontier of the study of how habitable planets form, give rise to the molecular machinery of life, co-evolve with the biosphere, and maintain conditions amenable to complex life. This fundamental research, together with associated educational and communications initiatives, nurtures the long-term, planetary-scale perspective and understanding of the relevant dynamics necessary for society to manage geological, climatic and ecological risks to populations, ecosystems, and economies.

EOAS also connects Earth system scientists with environmental social scientists, decision-makers, and regional stakeholders. Joining environmental history, observations, forecasts, and decision analysis, EOAS fosters integrated science and stewardship to help our region thrive economically while being more sustainable within environmental boundaries, more resilient to environmental shocks, and more flexibly adaptive to environmental change. From improving tomorrow's weather forecast to projecting the effects of sea level rise over the coming decades and centuries, EOAS uses science to enable society

to anticipate and prepare for the future. It is building the infrastructure needed to develop and pilot approaches for integrating Earth system science with decision-making to benefit communities, economies and ecosystems within urbanized land-coast-ocean environments, in our region and around the world.

Strengths and Challenges

The Rutgers Earth system science community has four key strengths that EOAS will build on to fulfill its mission.

A Broad and Deep Program of Exploration: The breadth and depth of our faculty's expertise are our central strengths. We have strong disciplinary expertise across the oceanographic, atmospheric, cryospheric, geological, geographic, hydrological, and ecological sciences.

A Tradition of Cross-Disciplinary and Cross-School Collegiality: The cross-disciplinary and cross-school collegiality of the Earth system science community at Rutgers–New Brunswick, as well as among the Earth system science, environmental social science, and environmental policy communities, has long been a strength.

Deep Regional Ties in a Heavily Urbanized, Environmentally Vulnerable State: Our deep ties within New Jersey, combined with our institutional history of collaboration among Earth system sciences, environmental social sciences, and environmental policy, make the EOAS community well-suited for developing an integrated understanding of our changing regional Earth system, and for leveraging this understanding to inform the civic stewardship of our corner of the planet.

Global Networks: Our faculty have global networks of collaborators and are actively engaged in a variety of international institutions. With New Jersey's path of urbanization now being followed around the world, these networks provide ideal pathways for leveraging lessons learned here to inform environmental stewardship in the planet's numerous rapidly urbanizing regions.

The Rutgers Earth system science community also presents EOAS with seven key challenges to fulfilling its mission.

Bridging Institutional Boundaries: The core Earth system science disciplinary programs at Rutgers–New Brunswick are split between two schools, the School of Environmental and Biological Sciences and the School of Arts and Sciences; fulfilling EOAS's mission requires involvement not only of these schools, but also of other schools at Rutgers–New Brunswick and of colleagues at Rutgers-Newark and Rutgers–Camden.

Overcoming Geographic Dispersion: Compared to our peers, the Rutgers–New Brunswick EOAS programs face an unusual degree of geographic dispersion, which leads to fewer spontaneous, creative interactions.

Expanding Student Support and Physical Infrastructure: Comparison to our aspirant and Big 10 peers indicates that, relative to the considerable research activity in the Earth system sciences at Rutgers–New Brunswick, these disciplines currently lag in terms of support for students and physical infrastructure.

Diversifying Funding Sources: Despite an ever-increasing need to address planetary environmental challenges, federal funding for Earth system sciences has been essentially flat in real terms since the mid-1990s, and the increasing polarization of public discourse around environmental topics is creating growing political risk for this funding.

Enhancing Visibility: It can be challenging for both Earth system scientists at Rutgers and also our external stakeholders to be aware of the breadth of ongoing activities and events at the university. Prospective and current students are likewise often unaware of the variety of available opportunities within the Earth system sciences.

Recruiting and Retaining a New Generation of Faculty: Many of the core departments affiliated with EOAS are heavily weighted toward senior faculty members. Only about 10% of tenure-track faculty within EOAS are at the pre-tenure level, and many of our more senior faculty are likely to retire within the next decade.

Enhancing Diversity and Inclusion: The Earth system sciences, nationally and at Rutgers, have an inclusion problem. More senior faculty positions are disproportionately male, and minorities are under-represented at all ranks.

Strategic Goals

To build upon these strengths, address these challenges, and advance both fundamental scientific understanding of the Earth system and stewardship of the planetary environment, EOAS has identified six strategic goals for the next five years.

Strengthen the Rutgers Earth System Science Community of Practice: EOAS, as the institutional embodiment of our community, must create both physical and virtual spaces for exchanges and learning among members and foster a sense of communal identity. In so doing, it will create more opportunities for spontaneous, creative interactions that lead to new research, education, and engagement initiatives.

Enhance the Research Capacity of Core Disciplines: To sustain and build upon the strong tradition of globally recognized, collaborative research initiated by the Institute of Marine and Coastal Sciences, it is essential for EOAS to lead a coordinated effort to address issues related to student support, physical infrastructure, visibility, diversity, and inclusion.

Foster Interdisciplinary Research and Education: EOAS will foster clusters of cross-disciplinary learning, research and engagement in the Earth system sciences.

Strengthen External Engagement: EOAS will maintain a line of consistent communication with the public and effectively manage key relationships with external partners.

Pioneer Models of Planetary Stewardship: EOAS will facilitate the development and testing of frameworks for integrating academic expertise in Earth system science and environmental social sciences with environmental governance to advance equitable civic stewardship of the regional and planetary environment.

Foster a Diverse, Inclusive and Equitable Academic Climate: As a central unit and voice for the Earth system sciences at Rutgers, it is incumbent for EOAS to recognize, examine, and address seriously the existing imbalances within the academic community, and to lead an effort to improve the sense of validation and belonging felt by students, faculty, and staff.

Planetary Context

The solid Earth, the oceans, the atmosphere, and life have a complex, intertwined history: at some times, dominated by stabilizing feedbacks; at other times, scarred by catastrophes. Their interactions gave rise to the environmental conditions that permitted our species' evolution about 200 thousand years ago. Now, after millennia of agricultural civilization, humanity's role on our planet is rapidly changing: as a byproduct of the scientific and industrial revolutions that have brought about the wealthiest and most peaceful time in human history, there is almost nowhere on Earth's surface today—whether on land, in the oceans or in the air—that is untouched by our global civilization.

As the human population has exploded, we have claimed an ever-growing fraction of our planet's biological productivity and flooded the global nitrogen cycle. We have combined ecosystems that plate tectonics had sundered for tens of millions of years. We have altered our planet's atmosphere and oceans and shifted our climate from a gradually cooling trajectory to a rapidly warming one. In short, we have brought about a new geological epoch, the Anthropocene.

Earth system science and its allied fields – including, among others, atmospheric science, ecology, geology, geography, oceanography, and planetary science – study our home planet and the way its component systems behave and interact, the history of the Earth and of planets that have followed alternative developmental pathways, and the implications of these behaviors, interactions, and histories for our planet's future. Though the allied disciplines have long, rich, parallel histories of their own, reconstructing Earth's past and navigating Earth's future require an interdisciplinary, planetary perspective that cuts across divergent discourses and bureaucratic boundaries.

One of the greatest challenges of the Anthropocene is to employ our civilization's newfound knowledge and capabilities in a way that maintains and grows peace and prosperity, sustains the natural capital on which these depend, and manages the risks created by the way we live on the Earth. To tackle this challenge requires a vigorous, integrated program of Earth system science that links to environmental social sciences and environmental policy, informs civic literacy and planetary governance, and extends understanding of both our planet's intertwined natural systems and also human impacts upon them. Rutgers University, with a public mission grounded in New Jersey and global in extent, is taking a leadership role through the Institute of Earth, Ocean, and Atmospheric Sciences (EOAS).

Institute History

EOAS began with a solid footing in marine and coastal sciences. To unify these sciences at Rutgers, University President Edward Bloustein and Professor Fred Grassle inaugurated Rutgers Institute of Marine and Coastal Sciences (IMCS) twenty-nine years ago. The new Institute was launched with a building funded by the Port Authority of New York and New Jersey, which sought to create an authoritative, New Jersey voice on environmental and maritime issues. Professor Grassle served as director of IMCS through most of its first two decades, during which time it grew into one of the world's top oceanographic research institutions—ranked fourth globally in a 2011 Thomson Reuters assessment.

Recognizing that addressing the challenges of the twenty-first century required further integration of the Earth system sciences at Rutgers, in 2013 the faculty in IMCS and other Earth system science programs at Rutgers—New Brunswick proposed expanding the Institute to encompass the Earth system beyond the marine realm. With crucial leadership provided by Rutgers President Robert Barchi, IMCS Director Rich Lutz, and EOAS founding director Mark Miller, EOAS was inaugurated a year later.

EOAS Today is Multidisciplinary and Accomplished

EOAS links together a community of researchers that includes more than 100 faculty and staff across six schools, studying the Earth's interior, continents, oceans, cryosphere, atmosphere, and biosphere, their interactions and co-evolution through our planet's history, and humanity's dependence and impacts upon these systems. Our faculty include a laureate of the Tyler Prize for Environmental Achievement, 3 members of the National Academy of Sciences, 11 fellows of the American Association for the Advancement of Science, 3 American Geophysical Union fellows, 3 American Meteorological Society fellows, and 8 Geological Society of America fellows. They are engaged in national and international leadership through organizations and assessment processes like the National Climate Assessment, the Intergovernmental Panel on Climate Change, and the International Union for the Conservation of Nature. National Science Foundation statistics indicate that Rutgers–New Brunswick research in oceanography, geosciences, and atmospheric sciences involves over \$44 million/year in funding—about three times as much in proportion to total research funding as the average of our Big 10 peers, and third among the Big 10 schools in absolute dollar terms (see Appendix II on page 17).

Among the many world-class initiatives and facilities within the EOAS community are:

- Cutting-edge research and instruction on assessing and managing the risks that climate change and habitat change create for communities, economies, and ecosystems;
- One of the world's leading integrated oceanic and atmospheric observation and prediction systems;
- Active oceanographic, ecological and glaciological field programs in the Arctic and the Antarctic;
- Seminal research on the past, present, and future of sea level and coastal storm hazards on timescales from weeks to millions of years;
- One of the ten teams that comprise the NASA Astrobiology Institute, focused on the protein nanomachines that power life, their origins, and their co-evolution with the Earth system;
- An extensive suite of chemical and magnetic facilities for analyzing geological, biological and extraterrestrial samples;
- One of the four sediment-core repositories of the International Ocean Discovery Program; and
- A network of oceanographic, ecological, and atmospheric field stations that covers the state and extends as far as Borneo.

The EOAS community also has a long history of innovative public engagement, including the country's first geology museum and a series of trailblazing K-16 educational initiatives in ocean and polar science.

STATEMENT OF PURPOSE

Mission

EOAS fosters and enhances a university-wide, interdisciplinary community for research, education, and public and policy engagement about the past, present and future of the Earth system, including the solid Earth, ocean, atmosphere, and biosphere, and humanity's dependence and impacts upon them.

Vision

Over the next decade, EOAS will strengthen Rutgers as a nationally leading public institution in research, education, and public and policy engagement that

1. advances the scientific understanding of the past, present and future of the Earth system and
2. builds the knowledge and perspective needed for equitable state, national and global stewardship of a healthy, sustainable and resilient planetary environment.

Key Impacts

EOAS scientists advance the scientific frontier of the study of how habitable planets form, give rise to the molecular machinery of life, co-evolve with the biosphere, and maintain conditions amenable to complex life. This fundamental research, together with associated educational and communications initiatives, nurtures the long-term, planetary-scale perspective and understanding of the relevant dynamics necessary for society to manage geological, climatic and ecological risks to populations, ecosystems, and economies.

EOAS also connects Earth system scientists with environmental social scientists, decision-makers, and regional stakeholders. Joining environmental history, observations, forecasts, and decision analysis, EOAS fosters integrated science and stewardship to help our region thrive economically while being more sustainable within environmental boundaries, more resilient to environmental shocks, and more flexibly adaptive to environmental change. From improving tomorrow's weather forecast to projecting the effects of sea level rise over the coming decades and centuries, EOAS uses science to enable society to anticipate and prepare for the future. It is building the infrastructure needed to develop and pilot approaches for integrating Earth system science with decision-making to benefit communities, economies and ecosystems within urbanized land-coast-ocean environments, in our region and around the world.

Rutgers' position as a public center of collaborative excellence in Earth system science research, education, and engagement rests upon three pillars: exploration, integration, and stewardship. This strategic plan focuses EOAS on activities that support and enhance excellence in these key areas and that mitigate challenges to them.

Strengths

A Broad and Deep Program of Exploration: At the core of the EOAS community is a program of exploration, focused on the hydrosphere, cryosphere, geosphere, atmosphere and biosphere of our home planet and its neighbors, as well as their evolution over time. The breadth and depth of our faculty's expertise are our central strengths. Our more than one hundred faculty members explore a wide swath of the Earth system – from the poles to the tropics, from Earth's core and deep ocean ecosystems to its polar ice sheets and stratosphere. Their research spans from the earliest days of the solar system to the coming centuries of climate and ecological change. We have strong disciplinary expertise across the oceanographic, atmospheric, cryospheric, geological, geographic, hydrological, and ecological sciences. EOAS's role is to help sustain and grow research capacity within and across these disciplines.

A Tradition of Cross-Disciplinary and Cross-School Collegiality: To understand our planet, we must comprehend not just its different components, but their history and how they interact to give rise to the complex dynamics of the Earth system. The cross-disciplinary and cross-school collegiality of the Earth system science community at Rutgers–New Brunswick, as well as among the Earth system science, environmental social science, and environmental policy communities, has long been a strength. Building upon this strength requires an institutional commitment. EOAS's role is to catalyze research, education, and engagement that integrates disciplinary perspectives and builds new interdisciplinary and transdisciplinary perspectives across school and geographic boundaries.

Deep Regional Ties in a Heavily Urbanized, Environmentally Vulnerable State: One driver of EOAS's mission is an ethic of planetary stewardship. As New Jersey's state university and land-grant university, Rutgers has a special responsibility toward our home state, which is currently experiencing rapid climatic and ecological change. Our deep ties within the state, combined with our institutional history of collaboration among Earth system sciences, environmental social sciences, and environmental policy, make the EOAS community well-suited for tracking the regional effects of environmental change, developing an integrated understanding of our changing regional Earth system, and leveraging observations and scientific knowledge to inform the civic stewardship of our corner of the planet. EOAS's role is as a hub for research, education, public engagement, and policy engagement related to this regional stewardship mission.

Global Networks: EOAS's stewardship mission is not limited to our state alone. New Jersey's path of urbanization is now being followed around the world, and the lessons learned here can inform the planet's numerous rapidly urbanizing regions. Our faculty have global networks of collaborators and are actively engaged in a variety of international institutions. Leveraging both our strong New Jersey roots and our global networks, EOAS's role is to facilitate the development and testing of frameworks for integrating Earth system science, environmental social sciences, and environmental governance to advance sustainability, resilience, and planetary health in a rapidly urbanizing world.

Challenges

Bridging Institutional Boundaries: The core Earth system science disciplinary programs at Rutgers—New Brunswick are split between two schools, the School of Environmental and Biological Sciences and the School of Arts and Sciences; fulfilling EOAS's mission requires involvement not only of these schools, but also of other schools at Rutgers—New Brunswick and of colleagues at Rutgers—Newark and Rutgers—Camden. In the Responsibility Centered Management budgeting system, these institutional boundaries have the potential to be more substantial barriers than they have been in the past, as they lead collaborative research and teaching projects to involve substantial negotiations about the allocation of revenue and costs across decanal units. The role of Chancellor-reporting Institutes like EOAS is to foster community, catalyze projects, and provide a dynamic, flexible structure for collaboration across school boundaries.

Overcoming Geographic Dispersion: Compared to our peers, the Rutgers—New Brunswick EOAS programs face an unusual degree of geographic dispersion, with more than three miles and the Raritan River separating the departments of Earth and Planetary Sciences and Geography from the departments of Marine and Coastal Sciences, Ecology, Evolution, and Natural Resources, and Environmental Sciences. This geographic dispersion leads to fewer spontaneous, creative interactions than occur at many peer institutions. The general feeling within the EOAS community is that the long-term co-location of the EOAS core programs at Rutgers—New Brunswick would be advantageous. In the near term, EOAS's role is to foster a strong sense of community despite this dispersion.

Expanding Student Support and Physical Infrastructure: Comparison to our aspirant and Big 10 peers (Appendix II) indicates that, relative to the considerable research activity in the Earth system sciences at Rutgers—New Brunswick, these disciplines currently lag in terms of support for students and physical infrastructure. To bring the ratio of doctorates earned to research expenditures up to the Big 10 average would require a tripling of student support. To bring the ratio of space to research expenditures up to levels comparable to those at aspirant peers and consistent with current levels of research, the Earth system sciences at Rutgers are in need of a 30%-150% physical expansion. EOAS's role is as a voice for Rutgers Earth system science programs and their resource needs.

Diversifying Funding Sources: Despite an ever-increasing need to address crucial planetary environmental challenges, federal funding for the Earth system sciences has been essentially flat in real terms since the mid-1990s.¹ In addition, the increasing polarization of public discourse around environmental topics is creating growing political risk for this funding. Thus, it is crucial that the Earth system science community develop a broad, diverse base of funding that is not excessively reliant on any single source. EOAS's role is to develop and sustain relationships with external stakeholders who can assist individual investigators and the Institute as a whole in diversifying funding sources.

Enhancing Visibility: One of consequences of the institutional dispersion of the Earth system sciences at Rutgers is limited coordination in internal and external communications. It can be challenging for both Earth system scientists at Rutgers and also our external stakeholders to be aware of the breadth of ongoing activities and events at the university. Prospective and current students are likewise often unaware of the variety of available opportunities within the Earth system sciences. This limited visibility hinders growth and advancement of Rutgers' Earth system science programs. EOAS's role is to facilitate internal communications and serve as a unifying hub for external engagement.

¹ American Association for the Advancement of Science (2017). Environmental Science Research Funding, 1978-2015. www.aaas.org/page/research-science-and-engineering-discipline. Accessed May 1, 2018.

Recruiting and Retaining a New Generation of Faculty: A healthy academic program requires a balance of junior and senior faculty, and thus sustained efforts to recruit and retain promising young faculty. However, many of the core departments affiliated with EOAS are heavily weighted toward senior faculty. Only about 10% of tenure-track faculty within EOAS are at the pre-tenure level, and many of our more senior faculty are likely to retire within the next decade. This turnover presents a challenge, but also an opportunity to bring in new, diverse talent, focused in a manner that advances the vision of this strategic plan. EOAS's role is to work with departments, deans, and university leadership to help manage this turnover.

Enhancing Diversity and Inclusion: Science advances further and faster when it welcomes all talents, and developing viable strategies for planetary stewardship requires the richness of perspectives that comes from engaging individuals reflecting our species' full diversity of backgrounds and experiences. Yet the Earth system sciences, nationally and at Rutgers, have an inclusion problem. Within the Earth system sciences nationally, according to NSF statistics for 2014, underrepresented minorities constitute just 10% of graduate students, compared to 15% for science graduate students generally, and 23% for the population of New Jersey as a whole. Nationally, about half of graduate students in the Earth system sciences are female, as are about half the junior tenure-track faculty within EOAS at Rutgers; yet just 15% of tenured faculty are female. EOAS's role is to encourage the development of an inclusive academic climate that supports equity and diversity.

Goal 1: Strengthen the Rutgers Earth System Science Community of Practice

Rationale: The EOAS community is a community of practice, knit together not just by association but by intersecting problems of interest and by both overlapping and complementary methodologies. Successful communities of practice are dynamic, driven by the interests and goals of their members; they create opportunities for dialog both internally and externally; and they provide learning opportunities to and are perceived as valuable by participants engaged a variety of levels of intensity. EOAS, as the institutional embodiment of our community, must create both physical and virtual spaces for exchanges and learning among members and foster a sense of communal identity. In so doing, it creates more opportunities for spontaneous, creative interactions that lead to new research, education, and engagement initiatives. Compared to peer institutions, deliberate effort to create these spaces and this identity is especially important at Rutgers because the Earth system science community at Rutgers is spread broadly both geographically and across decanal units.

Objectives:

1. Create more frequent opportunities for faculty, staff, postdocs, and students across the Earth system sciences to interact socially by coordinating new community building events and providing support to make existing departmental events open to the broader EOAS community.
2. Design and develop a new website and other internal communication media as central resources for Earth system science news, events, and information at Rutgers.
3. Develop and support training programs that bring together students, postdocs, and faculty from different disciplines around shared problems and/or shared methods, such as statistics and informatics, the design and operation of observing tools and platforms, Earth system modeling, and science communications.
4. Develop and maintain an inventory of existing Earth system science instrumentation and data resources at Rutgers.
5. Establish a Distinguished Visiting Fellows program to bring scientists who can help catalyze cross-disciplinary communication and collaboration to campus for extended visits.

Goal 2: Enhance the Research Capacity of Core Disciplines

Rationale: Research capacity is a critical factor enabling continued excellence in exploration and a crucial prerequisite for excellence in integration and stewardship. The research capacity of Earth system science disciplines at Rutgers is challenged by needs related to student support, physical infrastructure, visibility, diversity and inclusion. To sustain and build upon the strong tradition of globally recognized, collaborative research initiated by the Institute of Marine and Coastal Sciences, it is essential for EOAS to lead a coordinated effort to address these issues.

Objectives:

1. Support and promote the efforts of core disciplines to enhance the visibility of Earth system science research to university leadership.
2. Work with the Office of Advanced Research Computing to promote the use of Rutgers' considerable high-performance computing resources within the EOAS community.
3. Work with university and school leadership to develop a long-term strategy to resolve geographic, physical infrastructure, and student support challenges within EOAS, as well as faculty recruitment and retention.

Goal 3: Foster Interdisciplinary Research and Education

Rationale: Cross-disciplinary integration is needed to address a wide range of topics in Earth system science, from the cycling of biologically and climatically important gases on timescales from minutes to millions of years, to the ecological forces and feedbacks that have controlled biodiversity in the past and can guide conservation efforts today, to the dynamic processes governing the transfer of material and energy across environmental interfaces, such as the coastal zone, that sit at the intersection of various components of the Earth system. Cross-disciplinary educational programs are often key not just to producing new cross-disciplinary thinkers, but also to catalyzing creative interactions among more established scientists. Potential new cross-disciplinary learning clusters include planetary origins and evolution, the co-evolution of the geosphere and biosphere, integrated Earth system modeling, polar and tropical studies, and biodiversity trends and conservation.

Objectives:

1. Work with deans and departments to facilitate hires of new faculty who cross disciplines, including coordinated hires in cross-disciplinary clusters.
2. Provide seed funding to innovative, faculty team-generated interdisciplinary research, education, and engagement projects with the potential to lead to broader initiatives. The portfolio of investments should include a significant fraction of “venture capital” for activities that are high risk and high potential reward.
3. Support workshops to generate creative new ideas for integrative research, teaching, and engagement initiatives. Opportunities identified by the strategic planning process included polar climate change, land-use change across scales, catastrophic environmental risks and potential Earth system surprises, and the interplay between sea-level and climate change over geologic time.
4. Undertake a cross-program curriculum review to identify opportunities for restructuring courses and establishing cross-disciplinary short courses or new graduate certificate programs in areas of methodological or thematic overlap and alignment across programs.
5. Explore opportunities to develop professional masters and/or certificate programs related to Geoscience Education, Laboratory Management, Marine Environmental Management, and Biodiversity Conservation.
6. Explore opportunities for cross-disciplinary five-year joint bachelors and masters that produce graduates with interdisciplinary perspectives and a valuable job-market credential.
7. Work with the Aresty Research Center to develop opportunities for undergraduates to participate in interdisciplinary research in the Earth system sciences.
8. Encourage and promote efforts by the core Earth system science departments to establish interdepartmental majors or minors in areas such as environmental geology and interdisciplinary Earth system science.
9. Establish EOAS as a nationally and globally recognized leader in interdisciplinary research and education through the dissemination of successful models to other institutions.

Goal 4: Enhance External Engagement

Rationale: To carry out its mission of fostering a university-wide, interdisciplinary community for research, education, and public and policy engagement, EOAS must maintain a line of consistent communication with the public and effectively manage key partnerships. As part of its management of key partnerships, it must work to assist the Rutgers Earth system science community in diversifying funding.

Objectives:

1. Support, promote, and coordinate among education and outreach activities to facilitate communication of EOAS research broadly to New Jersey communities and the general public.
2. Support, promote, and coordinate among efforts by EOAS members to enhance the visibility of Earth system science research to state and national policy makers.
3. Coordinate with the Rutgers Office of Public and Media Relations to enhance external communications.
4. Establish a living list of ongoing field activities within the Earth system sciences at Rutgers, with a focus on opportunities to engage journalists and potential donors as participants.
5. Establish an External Advisory Board to seek advice and garner assistance regarding promoting the disciplinary and cross-disciplinary work of EOAS, strengthening stakeholder relationships, and expanding development.
6. Work with the Rutgers Foundation to seek funding for interdisciplinary initiatives on Earth system science and on planetary stewardship.
7. Convene an annual meeting to promote and communicate the research activities of EOAS.

Goal 5: Pioneer Models of Planetary Stewardship

Rationale: A core part of EOAS's mission is to facilitate the development and testing of frameworks for integrating academic expertise in Earth system science with environmental social sciences and policy to inform current and emerging models of environmental governance, with the aim of advancing equitable civic stewardship of the regional and planetary environment.

Diverse, heavily urbanized, with abundant legacies of heavy industry, and intimately interfaced to an ocean that both threatens settlements and provides food, energy, and transportation resources—New Jersey and the broader mid-Atlantic region have long grappled with, yet still face, environmental challenges and opportunities that are increasingly common around the world. Approaches to environmental stewardship developed in New Jersey and the broader mid-Atlantic region therefore have potential applications in urbanized land-coast-ocean environments across the planet. The region is thus a valuable 'living laboratory' for environmental stewardship.

The EOAS community is rich in resources that can be brought to bear to study the past, present and future of our region as a coupled natural-human system and lay the groundwork for long-term environmental management. More broadly, the Rutgers community has deep expertise in crucial aspects of process design, such as politics and conflict resolution. The Institute will work to tie these resources together into a coordinated framework for integrating the science and the stewardship of the Earth system.

One key early opportunity is the development of a common regional Earth system data portal, built upon existing platforms such as the Mid-Atlantic Regional Association Coastal Ocean Observation System and the Mid-Atlantic Ocean Data Portal. Such a data portal would link together not just coastal ocean observations, but also observations of geologic, atmospheric, climatic, and estuarine systems.

Extending the model of the Coastal Climate Risk and Resilience (C2R2) initiative, EOAS can develop frameworks for learning and engagement that brings Rutgers expertise to bear on real-world problems in our region and prepare students for work across sectors. A clinical environmental program, for example, could share with C2R2 some core courses on transdisciplinary research and communications with stakeholders and expand C2R2's studio course model – in which students spend a semester addressing a real problem brought to the program by real stakeholders – into other areas of environmental management. Building off the launch of the Center for Fisheries and Ocean Sustainability, marine environmental management and sustainability provides a natural initial target for this expansion.

The goal of EOAS's efforts to advance integrated Earth system science and stewardship is not simply to improve regional environmental stewardship, but to use our region to test frameworks that can inform efforts around the world. Thus, we will work with Rutgers Global and other partners at the university to support faculty engagement and leadership in the institutions of global environmental governance.

Objectives:

1. Scope the establishment of a coordinated regional framework for integrating Earth system science and stewardship.
2. Work with the Bloustein School, the Eagleton Institute, and the Department of Landscape Architecture to provide internship and fellowship opportunities that engage Rutgers students, postdocs and faculty in environmental decision-making.
3. Through C2R2, the Center for Fisheries and Ocean Sustainability, the Rutgers Raritan River Consortium, the New Jersey Climate Adaptation Alliance, and other Rutgers-based initiatives with regional stakeholder networks, engage stakeholders in scientifically informed dialogues to help resolve conflicting uses of environmental resources.
4. Seek sustainable funding for key existing related initiatives, including C2R2 and the Center for Fisheries and Ocean Sustainability.
5. Expand the C2R2 model to establish a series of clinical environmental programs.
6. Facilitate faculty engagement and leadership in global institutions like the Intergovernmental Panel on Climate Change and the International Union for the Conservation of Nature.

Goal 6: Foster a Diverse, Inclusive and Equitable Academic Climate

Rationale: Diversity, inclusion, and equity are critical to both the long-term success of Earth system science as a discipline and to the application of Earth system science to environmental stewardship. As a central unit and voice for the Earth system sciences at Rutgers, it is incumbent for EOAS to recognize, examine, and address seriously the existing imbalances within the academic community, and to lead an effort to ensure a sense of validation, belonging, and personal safety is felt by students, postdocs, staff, and faculty.

Objectives:

1. Ensure EOAS's organizational decision-making processes embrace a broad range of backgrounds and perspectives.
2. Facilitate cross-program mentorship to support faculty and students from underrepresented populations and to foster an environment conducive to faculty retention.
3. Support and enhance outreach programs that provide opportunities to improve intercultural competence and engage with underserved communities.
4. Establish a diversity committee that will work with the Rutgers Office of Diversity and Inclusion to discuss strategies and identify further actions EOAS could implement to address issues of inclusion, diversity, and intercultural engagement.
5. Establish an EOAS awards program to recognize faculty, staff, and students whose activities, ideas, or accomplishments significantly advance EOAS's strategic goals.

Affiliated Departments

EOAS's program is centered in five core departments at Rutgers—New Brunswick: Earth and Planetary Sciences; Ecology, Evolution, and Natural Resources; Environmental Sciences; Geography; and Marine and Coastal Sciences. Our faculty members share a common interest in EOAS's mission and come from a variety of schools and departments at Rutgers, including:

School of Environmental and Biological Sciences

- Biochemistry and Microbiology
- Ecology, Evolution, and Natural Resources
- Environmental Sciences
- Human Ecology
- Landscape Architecture
- Marine and Coastal Sciences
- Plant Biology

School of Arts and Sciences

- Anthropology
- Earth and Planetary Sciences
- Geography

School of Engineering Department of Civil and Environmental Engineering

Bloustein School of Planning and Public Policy

New Jersey Agricultural Experiment Station

Rutgers—Newark College of Arts and Sciences

- Biological Sciences
- Earth and Environmental Sciences

Rutgers—Camden Department of Biology

Affiliated Centers, Institutes, and Activities

One of EOAS's flagship activities is the **Coastal Climate Risk and Resilience (C2R2)** initiative launched in 2016 with support from a five-year NSF Research Traineeship grant. C2R2's graduate program prepares students in the natural sciences, social sciences, engineering and urban planning to work with one another and stakeholders to address the challenge of assessing climate risk and building resilience in coastal communities and ecosystems. C2R2's first cohort of five students began in January 2017 and worked in fall 2017 with the town of Union Beach to develop a resilience plan. Its second cohort of thirteen students began in September 2017. C2R2 is managed by EOAS in partnership with the Bloustein School of Planning & Public Policy and the School of Engineering. For more information: c2r2.rutgers.edu.

The **Rutgers Center for Ocean Observing Leadership (RU COOL)** integrates across interdisciplinary research, education and outreach using one of the world's leading operational ocean observing systems. The Operations Center maintains a sustained coastal ocean observatory that provides real-time ocean data to the research and education groups and also serves as the training ground for Operational Oceanography students. It links together satellite data, CODAR (Coastal Ocean Dynamics Applications Radar), a network of underwater gliders, and mesoscale meteorological modeling. In addition to advancing basic research, its work supports applications including hurricane forecasting, offshore wind, coastal water quality, sediment transport, fisheries, and search and rescue. RU COOL serves as the

operational headquarters for MARACOOS (the Mid-Atlantic Regional Association Coastal Ocean Observing System), which covers the region from Cape Cod, MA to Cape Hatteras, NC. RU COOL is working with the Graduate Program in Oceanography to launch a new M.S. degree in Operational Oceanography. For more information: rucool.marine.rutgers.edu.

The new **Center for Fisheries and Ocean Sustainability** addresses the challenges of managing fisheries and aquaculture and conserving biodiversity. New Jersey is one of the most important fishery states in the US, with the second-largest recreational fishery, after Florida. With competing impacts and demands from climate change, invasive species, habitat loss, and additional uses like marine wind and shipping, studying and managing fisheries and aquaculture in New Jersey requires a coordinated interdisciplinary approach and has the potential to serve as a model for efforts nationwide. The Center for Fisheries and Ocean Sustainability will bring academic scientists, commercial and recreational fishers, state and federal partners, and conservation groups together to tackle major research challenges and educate the next generation of interdisciplinary fishery scientists. For more information: fisheries.rutgers.edu.

The **Grant F. Walton Center for Remote Sensing and Spatial Analysis (CRSSA)** advances the development and application of geospatial information science and technology (remote sensing, geographic information systems, global positioning systems, computer simulation modeling) to address issues in the built and natural environment both locally and globally. Its objective is to bring the best information to bear in place-based decision-making with the broader goal of promoting sound land, coastal and marine planning, natural resource and agricultural management. CRSSA's web resources include MARCO (the Mid-Atlantic Ocean Data Portal) and NJ Flood Mapper. For more information: crssa.rutgers.edu.

A cornerstone of EOAS's new **astrobiology initiative**, the ENIGMA (Evolution of Nanomachines in Geospheres and Microbial Ancestors) team within the NASA Astrobiology Institute studies how proteins evolved to become the catalysts of life on Earth, allowing chemical energy to be converted into biological energy. The team is studying how protein 'nanomachines' developed before the origins of life, how evolution within early microbes fostered increasingly sophisticated nanomachine structures, and how these nanomachines co-evolved with the solid Earth, ocean, and atmosphere over geologic time.

Based in the Department of Anthropology, the **Center for Human Evolutionary Studies** advances the discovery, teaching, and public dissemination of knowledge on the origin, evolution, and biological and ecological bases of human behavior. For more information: ches.rutgers.edu.

The **Center for Urban Environmental Sustainability (CUES)** brings the knowledge available through Rutgers out into the "real-world" to address environmental challenges that New Jersey faces. A collaboration between the departments of Landscape Architecture and Environmental Sciences, CUES works to combine science, engineering, and design expertise to address urban environmental issues. CUES provides expertise and research related to environmental and natural resources, human and ecosystem health, and community development. Through collaborations with faculty and students, CUES also provides educational opportunities for Rutgers students interested in environmental sustainability. For more information: cues.rutgers.edu.

The **Climate Impact Lab** is a path-breaking academic-private sector collaboration involving more than 20 climate scientists, economists, computational experts, researchers, analysts, and students from Rutgers; the University of California, Berkeley; the University of Chicago; and Rhodium Group. Its work on the economic risks of climate change to the United States has been widely recognized. It has been used in analyses by the Office of Management Budget, the Congressional Budget Office, and the Government Accountability Office. It recently partnered with the US Climate Alliance (a bipartisan coalition of 17 governors, including that of New Jersey) to advance work on the use of the global Social Cost of Carbon Dioxide in crafting climate change policy. For more information: impactlab.org.

The **Office of the New Jersey State Climatologist**, headed by EOAS faculty member David Robinson, serves as the State focal point for activities pertaining to the climate of New Jersey. It collects and archives climate data, maintains an active research program pertaining to New Jersey climate and, through various outreach programs, provides climate education and information to the citizens of New Jersey. EOAS is also home to one of the leading candidates to be New Jersey's first *State Oceanographer*, a position established by the state legislature in 2016. The State Oceanographer will provide advice and assistance to the State government on issues involving the ocean, serve as a member of the New Jersey Coastal and Ocean Protection Council, and report on developments in the state in ocean observation, research, and prediction. For more information: climate.rutgers.edu.

EOAS faculty, students, and staff are active participants in the **Rutgers Raritan River Consortium (R3C)**. R3C is a collaborative effort at Rutgers–New Brunswick that recognizes the critical value of the Raritan and its environs to the social, economic and ecological integrity of the region that Rutgers calls home. Its mission is to utilize Rutgers' proximity to the Raritan to inform university-based education, research and scholarship and to apply our efforts, in collaboration with Raritan partners, to advance improvements in regional planning, policy and decision-making that positively affect the ecology and economy of the Raritan region. For more information: raritan.rutgers.edu.

The **Rutgers-IODP (International Ocean Discovery Program) Core Repository** archives and distributes cores samples to investigators throughout the world. Funded by NSF, the Department of Earth & Planetary Sciences, and the School of Arts and Sciences, the Repository collections focus on cores from the Mid-Atlantic US coastal plain and the Newark Basin in central NJ and include world-class records of the Cretaceous-Paleogene boundary ("death of the dinosaurs"), the Paleocene-Eocene Thermal Maximum, and Newark Basin astronomically-paced lake cycles. For more information: eps.rutgers.edu/centers-institutes/rutgers-core-repository.

For more than 15 years Rutgers has hosted the myroms.org User Portal for the **Regional Ocean Modeling System (ROMS)** and convened international ROMS User Workshops in 9 countries to support the global community comprising over 5000 registered users. As the central repository of the ROMS system, Rutgers has been a leader in the open sourcing of integrated earth system component models for biogeochemistry, ecosystems, geomorphology, bio-optics, water quality, acoustics, and maritime energy. For more information: myroms.org.

EOAS works closely with the **Rutgers Climate Institute**, which links together Rutgers researchers addressing the natural science, social science, medical, policy, and humanistic aspects of climate change. It has produced influential reports, including the annual New Jersey State of the Climate report and a recent report on climate change mitigation options for New Jersey. It hosts the secretariat of the **New Jersey Climate Adaptation Alliance**, an innovative stakeholder network which draws upon expertise coordinated out of Rutgers to inform climate adaptation planning across the state. For more information: climatechange.rutgers.edu and njadapt.rutgers.edu.

EOAS also collaborates with the **Rutgers Energy Institute**, which fosters fundamental scientific research applied scientific research, and policy research to develop sustainable energy production compatible with economic growth and environmental vitality. Two notable areas of mutual interest are offshore wind energy and carbon storage. For more information: rei.rutgers.edu.

The **Newark Environmental Sustainability Institute** works with partners including the City of Newark, Newark Science and Sustainability and the New Jersey Highlands Coalition to advance urban sustainability in the greater Newark region.

EPS and DMCS are home to an extensive set of **analytical facilities** for inorganic, isotope and magnetic analysis of geological and biological samples. This includes a broad range in mass spectrometers, including a multiple collector inductively coupled mass spectrometer (MC-ICP-MS) for the precise analysis of elemental isotope ratios. The most recent addition is a laser ablation system that can be coupled to both the single collector ICP-MS and the complementary mass spectrometry MC-ICP-MS for spatial analysis of solid samples at high resolution. Efforts are also underway to update analytical facilities in Marine and Coastal Sciences.

EOAS is closely tied to Rutgers' **network of field stations** within New Jersey. These include the Rutgers Marine Field Station in Tuckerton, the Pinelands Field Station, and the Haskin Shellfish Research Laboratory. The Jacques Cousteau National Estuarine Research Reserve plays a key role in the C2R2 initiative. The Rutgers Photochemical Assessment Monitoring (PAM) Site measures air pollutants and meteorological variables. Rutgers is also a partner in the Science and Resilience Institute at Jamaica Bay, which produces integrated knowledge that increases biodiversity, well-being, and adaptive capacity in coastal communities and waters surrounding Jamaica Bay and New York City. Rutgers is also a partner in the Tuanan Orangutan Research Station in Borneo, which studies wild orangutan behavior and the effects of habitat degradation.

Founded in 1872 by Professor George H. Cook, the **Rutgers Geology Museum** is the oldest geology museum in the United States. Its exhibits showcase the natural history of New Jersey, focusing on geology, paleontology, and anthropology. It hosts a wide range of outreach activities that engage approximately ten thousand visitors from across the region each year. For more information: geologymuseum.rutgers.edu.

Identification of Aspirant Peers

The National Science Foundation's Higher Education R&D (HERD) Survey collects data on R&D expenditures at US colleges and universities by field of research. The nearest disciplinary grouping within the HERD data to the scope of EOAS is that of "geosciences, atmospheric sciences, and ocean sciences." Accordingly, to identify Rutgers–New Brunswick's peers and aspirant peers with respect to these disciplines, we examined total research expenditures in these fields in the most recent (FY 2016) statistics².

Many of these institutions have schools, colleges, or institutes that are roughly comparable to EOAS in scope. Others may provide interdisciplinary groupings for some but not all of the Earth system sciences. We attempted to identify the integrative organization at each institution that most closely resembled EOAS in scope; these organizations are listed in Table II.1 (located on page 19).

Those closest in scope to EOAS, as assessed by the inclusion of geological sciences, atmospheric sciences, oceanography, and ecology (at least in marine environments) and in order of total research funding in these fields, are:

- **UCSD Scripps Institution of Oceanography**
- **University of Washington College of the Environment**
- **University of Hawaii School of Ocean and Earth Science and Technology**
- Columbia University Lamont-Doherty Earth Observatory
- University of New Hampshire Institute for the Study of Earth, Oceans, and Space
- Oregon State University College of Earth, Ocean, and Atmospheric Sciences

Focusing only on the public institutions, we have therefore identified three aspirant peers (highlighted in bold in the above list) for Rutgers with respect to the scope of EOAS.

² National Center for Science and Engineering Statistics (2017). *Higher Education Research and Development Survey, Fiscal Year 2016*. ncesdata.nsf.gov/herd/2016. Accessed March 2, 2018.

Comparison to Peers

In addition to the statistics on research expenditures, we examined the most recent statistics on physical space (FY 2015) and earned doctorates (2016)^{3,4}. Where we calculate ratios of expenditures to physical space, we use FY 2015 statistics on research expenditures.

Comparing Rutgers–New Brunswick statistics to those of our aspirant peers and those of our Big 10 peers indicates that the Earth system sciences at Rutgers–New Brunswick are significantly under-resourced in terms of physical space and student support.

Across US academic institutions, geosciences/ocean sciences/atmospheric sciences average 4% of assignable area and 5% of research expenditures. At Rutgers, they are 2% of assignable area and 7% of research expenditures. To bring the ratio of physical space to research expenditures up to levels comparable to those at aspirant peers and consistent with current levels of research, Earth system sciences at Rutgers–New Brunswick are in need of a 30%-150% expansion (Figure II.2 on page 20).

Among Big 10 institutions, Rutgers–New Brunswick ranks last in the ratio of geosciences/atmosphere/ocean science doctorates earned to related research expenditures (Figures II.3, II.4, located on page 21). Among all Big 10 institutions in 2016, the average ratio was 0.6 doctorates earned per million dollars research expenditures; at Rutgers–New Brunswick, the ratio was 0.2 doctorates earned per million dollars. This low ratio points to the need for a considerable expansion of student support.

³ National Center for Science and Engineering Statistics (2017). *Science and Engineering Research Facilities, Fiscal Year 2015*. ncesdata.nsf.gov/datatables/facilities/2015. Accessed March 2, 2018.

⁴ National Center for Science and Engineering Statistics (2018). *2016 Doctorate Recipients from U.S. Universities*. [nsf.gov/statistics/2018/nsf18304](https://ncesdata.nsf.gov/statistics/2018/nsf18304). Accessed March 2, 2018.

Table II.1
Peer Institutions, Ranked by Research Expenditures in Geosciences, Atmospheric Sciences, and Ocean Sciences

Rank	Institution	EOAS Analog
1	University of California, San Diego ¹	Scripps Institute of Oceanography
2	Woods Hole Oceanographic Institution ²	Woods Hole Oceanographic Institution
3	University of Colorado, Boulder	(no unifying body across disciplines)
4	University of Washington, Seattle ¹	College of the Environment
5	Texas A&M University	College of Geosciences
6	University of Hawaii, Manoa ¹	School of Ocean and Earth Science and Technology
7	Columbia University	Lamont-Doherty Earth Observatory
8	University of Texas, Austin	Jackson School of Geosciences
9	University of Alaska, Fairbanks	Geophysical Institute
10	University of Miami	Rosenstiel School of Marine & Atmospheric Sciences
11	University of New Hampshire	Institute for the Study of Earth, Oceans, and Space
12	University of Wisconsin – Madison	Nelson Institute for Environmental Studies
13	Massachusetts Institute of Technology	Department of Earth, Atmospheric and Planetary Sciences
14	University of Maryland, College Park	Earth System Science Interdisciplinary Center
15	University of Maryland, Center for Environmental Science ²	Center for Environmental Science
16	Oregon State University	College of Earth, Ocean, and Atmospheric Sciences
17	University of Oklahoma, Norman	College of Atmospheric & Geographic Sciences
18	Rutgers University – New Brunswick	Institute of Earth, Ocean, and Atmospheric Sciences
19	Arizona State University	School of Earth & Space Exploration
20	University of Rhode Island	Graduate School of Oceanography and College of the Environment and Life Sciences

¹ Aspirant peers.

² WHOI and UMD Center for Environmental Science are not degree-granting institutions yet run degree programs in partnership with MIT and with other UMD campuses, respectively.

Figure II.1
2016 Research expenditures in geosciences, ocean sciences, and atmospheric sciences at Top 20 US institutions and at Big 10 institutions.

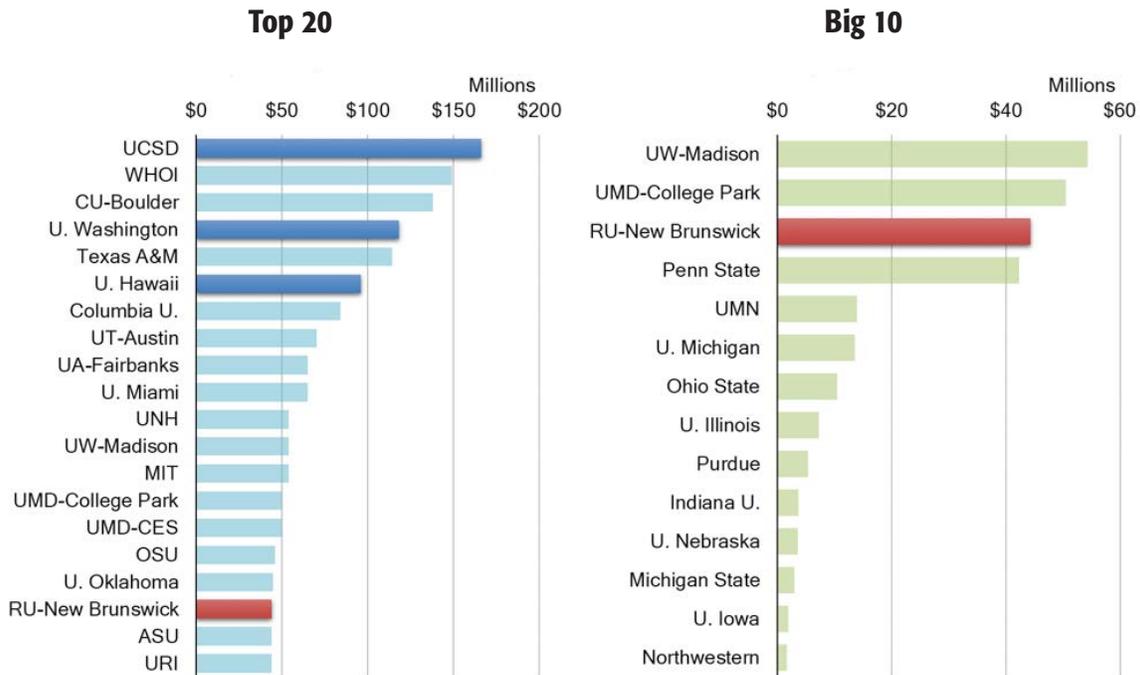


Figure II.2
2015 Ratio of space to research expenditures in geosciences, ocean sciences, and atmospheric sciences at Top 20 US institutions and at Big 10 institutions.

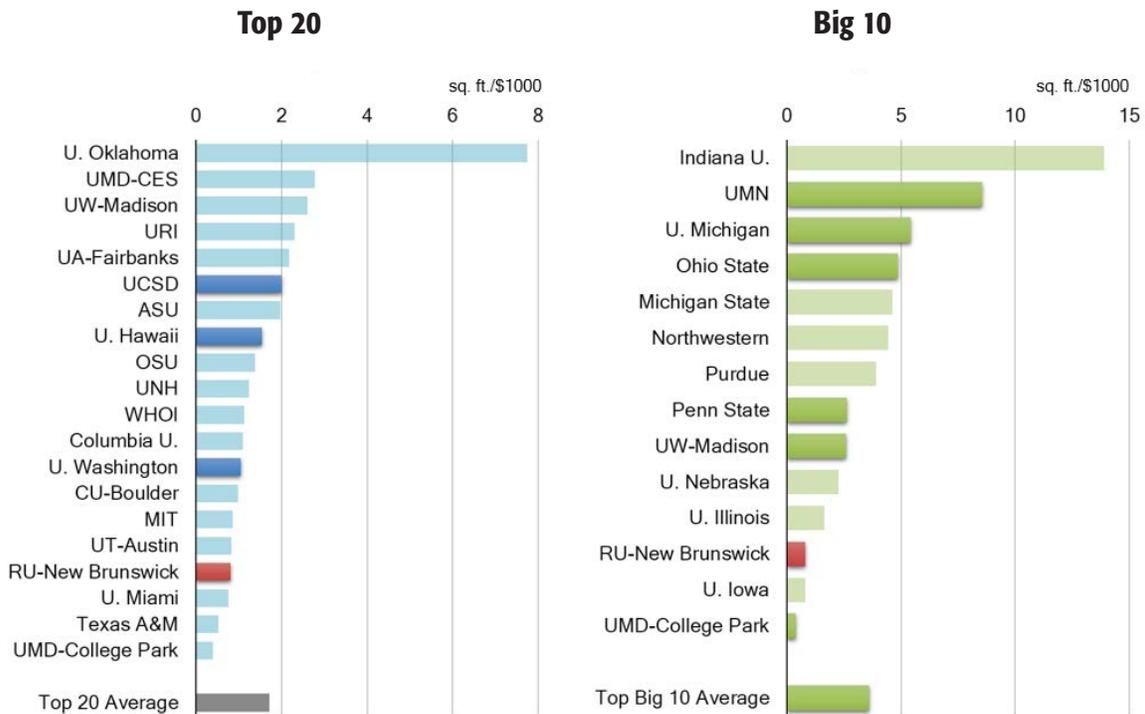


Figure II.3
2016 Number of earned doctorates in geosciences, and atmospheric sciences at Top 20 US institutions and a Big 10 institutions.

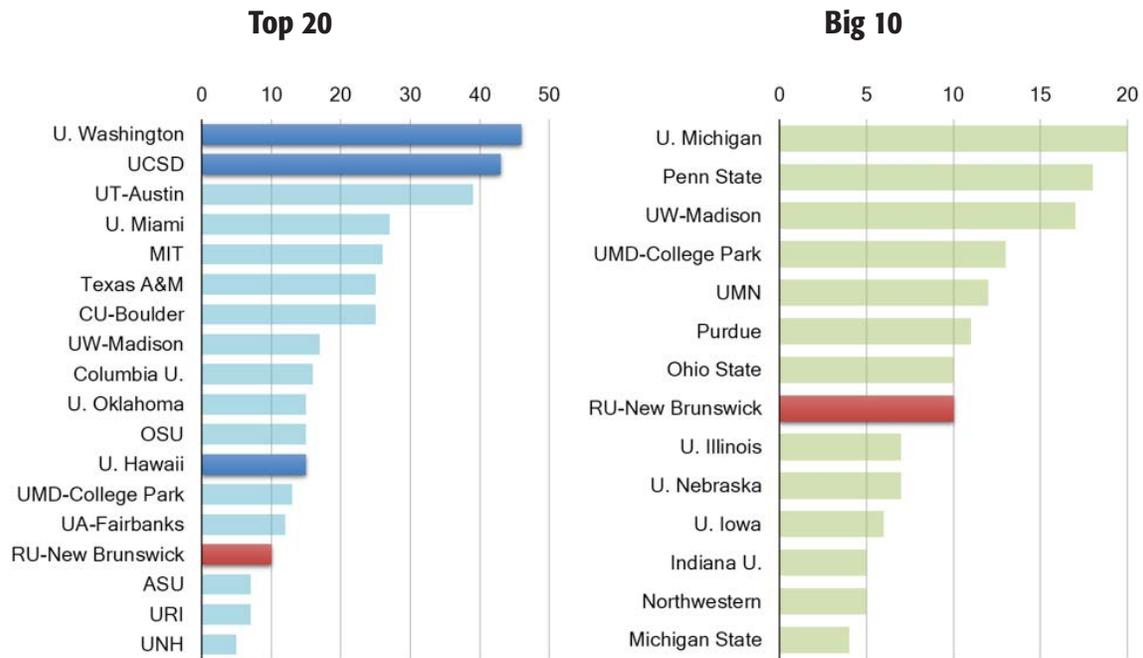
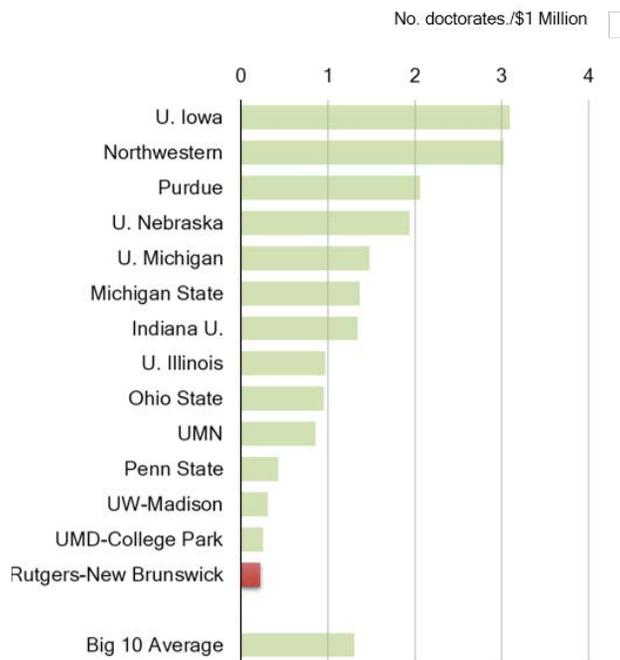


Figure II.4
2016 Ratio of earned doctorates to reasearch expenditures in geosciences, ocean sciences, and atmospheric sciences at Big 10 institutions.



APPENDIX III: STRATEGIC PLANNING PROCESS METHODOLOGY

Over the course of summer and fall 2017, six faculty committees met to assess resources, challenges, and opportunities facing EOAS. Five committees were structured around five strategic themes, identified based on an initial assessment of cross-cutting strengths in the EOAS community:

- **Planetary habitability:** Understanding the factors that drive the evolution of planetary habitability
- **Earth system history:** Reconstructing past states of the Earth system and using these reconstructions to test, challenge, and advance our understanding of Earth system dynamics
- **Earth observations and forecasting:** Observing the Earth system and forecasting Earth system dynamics on operational timescales
- **Earth system risks:** Assessing and managing Earth system risks on decadal and centennial timescales- including but not limited to risks to climate and ecological risks within coastal and marine systems, urban systems, and food systems
- **Polar change:** Understanding past, present, and future dynamics of the cryosphere and of climatic, ecological, and human systems of Earth's polar regions

A sixth committee, which also had an immediate operational mission, addressed graduate education with a goal of improving coordination among EOAS's affiliated graduate programs, with a focus on both making an impact on admissions and recruitment in the current academic year and driving forward with tighter integration in years to come.

Reports and town hall meetings held by these committees served as the primary source of information about existing strengths and new initiatives. Findings from these committees, along with additional background information, were synthesized into a draft strategic plan by the EOAS Leadership Team. The leadership team then sought feedback on this draft from the EOAS Faculty Advisory Committee and the chairs of the strategic planning committee, and revised accordingly. The revised plan was shared with the EOAS community and the general public during an extended public review process. The 180 comments from 40 respondents were then evaluated by the EOAS Strategic Planning Synthesis Committee and used to produce the final plan.

Strategic Planning Committee Membership

EOAS Strategic Planning Synthesis Committee

Robert Kopp, EOAS Director
Lynne Trabachino,
EOAS Associate Director
Ken Eng, EOAS
Senior Administrative Assistant
Carrie Ferraro,
C2R2 Associate Director
Rebecca Jordan, Human Ecology
Christina Kaunzinger,
EOAS Assistant Director
Ken Miller, EPS
Xenia Morin, Plant Biology
Lily Young, DES

EOAS Faculty Advisory Committee

Carl Swisher, EPS Chair
Henry John-Alder, DEENR Chair
Tony Broccoli, DES Chair
Robin Leichenko, Geography Chair
Oscar Schofield, DMCS Chair

Graduate Program Coordination Committee

Ken Miller, EPS (co-chair)
Bob Chant, DMCS (co-chair)
Ben Lintner,
Atmospheric Sciences GPD
Olaf Jensen,
Ecology and Evolution GPD
Laura Schneider, Geography GPD
Jim Wright,
Geological Sciences GPD
John Wilkin, Oceanography GPD;
succeeded by Yair Rosenthal,
Oceanography GPD
Daniel Gimenez,
Environmental Sciences GPD
Gerben Zylstra,
Microbial Biology GPD

Planetary Habitability Committee

Juliane Gross, EPS (co-chair)
Nathan Yee, DES/EPS (co-chair)
Tamar Barkay,
Biochemistry and Microbiology
Paul Falkowski, EPS/DMCS/RBS
Greg Herzog, Chemistry
Saurabh Jha, Physics
Charles Keeton, Physics
John Reinfelder, DES
Sonia Tikoo, EPS
Costa Vetriani,
Biochemistry and Microbiology

Earth System History Committee

Ying Fan Reinfelder,
DES/EPS (co-chair)
Silke Severmann, DMCS (co-chair)
Lauren Adamo, Geology Museum
Marie-Pierre Aubry, EPS
Debashish Bhattacharya,
Biochemistry and Microbiology
Dan Cabanes, Anthropology
Paul Falkowski, EPS/DMCS/RBS
Craig Feibel, Anthropology/EPS
Linda Godfrey, EPS
Ken Miller, EPS
Yair Rosenthal, DMCS
Jill Van Tongeren, EPS
John Higgins, Princeton Geosciences
Jon Wilson, Haverford Biology

Earth Observations and Forecasting Committee

Josh Kohut, DMCS (co-chair)
Ben Lintner, DES (co-chair)
Jie Gong,
Civil and Environmental Engineering
Rick Lathrop, DEENR
Vadim Levin, EPS
Daphne Munroe, DMCS
John Reinfelder, DES

David Robinson, Geography
Karina Schäfer,
Rutgers-Newark
Biological Sciences
Laura Schneider, Geography
Erin Vogel, Anthropology
John Wilkin, DMCS
Frederik Simons,
Princeton Geosciences
Shantenu Jha,
Electrical and Computer Engineering

Earth System Risks Committee

Enrique Curchitser, DES (co-chair)
Olaf Jensen, DMCS (co-chair)
Clint Andrews, Bloustein/C2R2
Carrie Ferraro,
C2R2/Rutgers Raritan River Initiative
George Guo,
Civil and Environmental Engineering
Jeanne Herb, Bloustein/C2R2
Marjorie Kaplan, RCI
Christina Kaunzinger,
Landscape Architecture
Kevin Lyons, RBS/REI
Cymie Payne, Human Ecology
Rachael Shwom,
Human Ecology/REI
Rachael Winfree, DEENR

Polar Change Committee

Asa Rennermalm,
Geography (co-chair)
Rob Sherrell, DMCS (co-chair)
Enrique Curchitser, DES
Jennifer Francis, DMCS
Max Häggblom,
Biochemistry and Microbiology
Lee Kerkhof, DMCS
James Miller, DMCS
David Robinson, Geography
Grace Saba, DMCS
Hal Salzman, Bloustein
Oscar Schofield, DMCS

APPENDIX IV: FACULTY HIRING

The strategic planning committees encouraged the hiring of colleagues with expertise at the interface of different components of and perspectives on the Earth system to serve as catalyst tying together different departmental programs. The newly launched search for a Henry Rutgers Chair in Earth, Ocean, and Atmospheric Sciences provides an immediate opportunity to advance this objective.

The specific faculty hiring priorities proposed by the strategic planning committees can be broadly classified into four clusters:

Planetary origins and evolution cluster

- Exoplanet research
- Experimental petrology
- Remote sensing
- Planetary atmospheres
- Planetary geomorphology
- Early Earth geobiology

Earth system instrumentation, statistics, informatics, and modeling cluster

- Design, control, and optimization of observation systems
- Ecological and environmental big data
- Integrated modeling of the geosphere and Earth surface
- Paleo-Earth system modeling
- Polar regions observing systems

Coastal zone and boundary layer cluster

- Boundary layer meteorology, oceanography, and hydrology
- Polar ocean-ice-atmosphere observations or modeling
- Quantitative coastal geomorphology
- Sea-level reconstruction

Polar research cluster

- Polar regions observing systems (also Earth system instrumentation cluster)
- Sea ice dynamics
- Polar terrestrial processes
- Ice sheet modeling (also Earth system modeling cluster)
- Physical oceanography at the ocean-ice interface (also coastal zone/boundary layer cluster)
- Polar marine biology at high trophic levels (also coastal zone/boundary layer cluster)