



State of the Natural Resource Ecology Laboratory at Colorado State University

November 2014

The Natural Resource Ecology Laboratory (NREL) is an innovative leader in the field of ecosystem science well-known for fostering a collaborative and enjoyable work environment for scientists who are passionate about discovery and application of knowledge. The NREL originated in 1968 with the Grassland Biome Project of the US International Biological Program (USIBP). George M. Van Dyne was the first director of both the biome project and of the NREL. His vision of systems ecology was responsible for establishing NREL's ongoing tradition of leadership in the development of systems ecology and ecosystem analysis, and the establishment of interdisciplinary, integrative, holistic, and team-oriented research. As the USIBP came to an end in the mid-1970s, NREL scientists opted to keep the enterprise together through grants and contracts, which to date, has proven to be successful.

The scope of research at NREL has evolved over the years, with the most recent and significant development occurring in 2011 with the formation of the Department of Ecosystem Science and Sustainability¹ (ESS). NREL welcomed several researchers from fields of ecological and watershed sciences through the establishment of ESS. The systems approach to research is a common thread throughout most NREL studies, which occur across a diversity of study sites, scales, and topics.

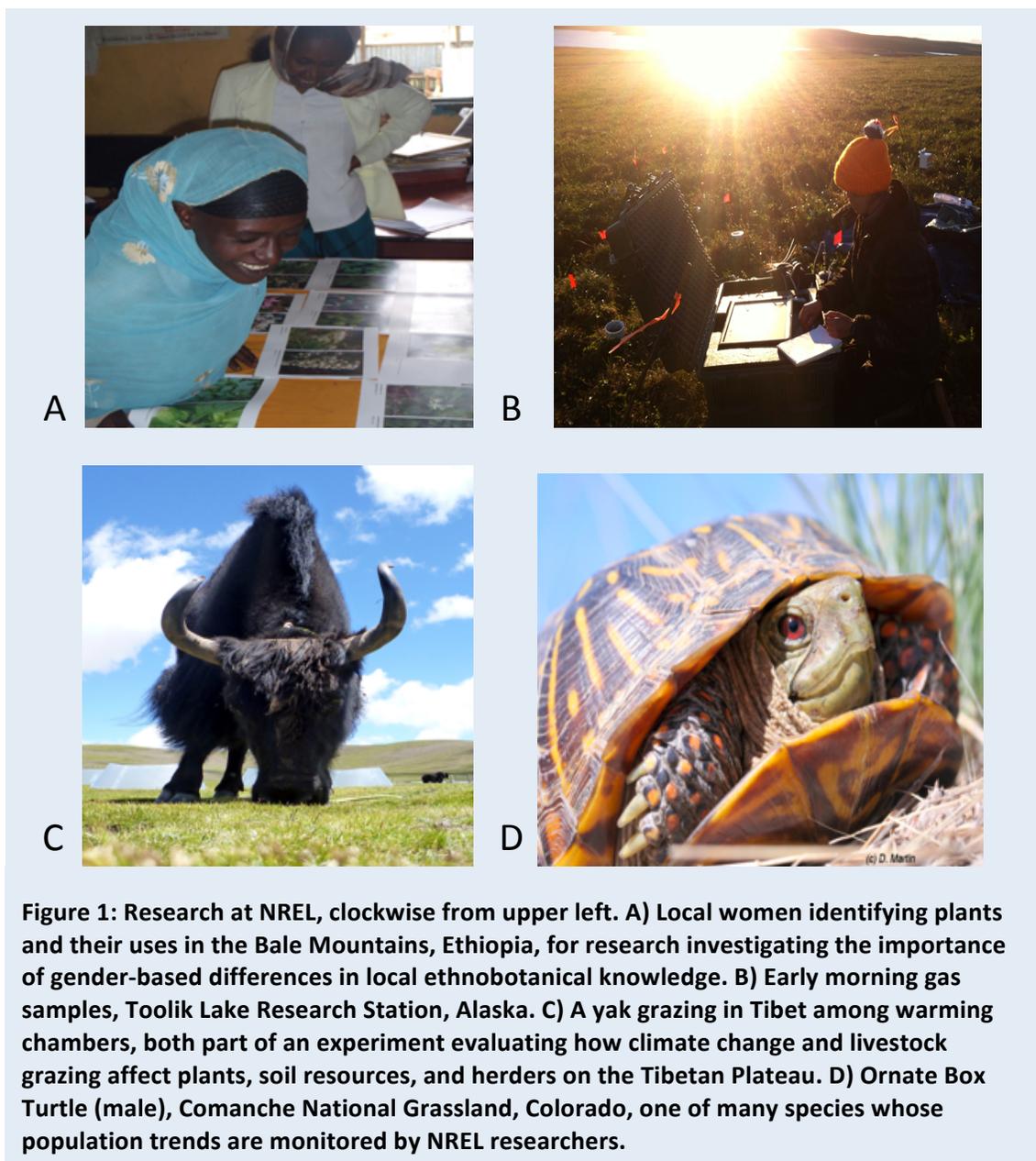
This document provides an overview of the current state of NREL, highlighting research, outreach, and educational activities, in addition to proposing future directions. The report serves as background material for the upcoming visit from our External Advisory Committee (EAC). The recommendations made by the EAC will inform a revision of the NREL Strategic Plan during the coming year.

¹ All faculty in the Department of Ecosystem Science and Sustainability are scientists at NREL.

Research at the Lab

The ecosystem approach practiced at the NREL provides a scientific framework for addressing research challenges surrounding the complex environmental problems that currently face society. The NREL has taken the initiative to develop programs and secure external funding to meet these challenges through interdisciplinary ecosystem research. Moreover, interdisciplinary research provides a basis for NREL scientists to build collaborations across fields of expertise at Colorado State University and other institutions both nationally and internationally (Figure 1).

The scientists at the NREL represent one of the most distinguished collections of ecosystem scientists in the world. The NREL consists of 34 core Research Scientists, 11 Postdoctoral Scientists (Postdoctoral Fellows or RSI), and 38 Affiliate Scientists, for a total of 69 active scientists. NREL Core and Affiliate Scientists



contribute to multidisciplinary intellectual interactions; lead or participate both nationally and internationally on complex, integrated research collaborations; and publish original results arising from an atmosphere of trust and collegiality. The collaborative research at NREL spans a range of topics, such as biological anthropology; carbon cycle science; nitrogen cycling; climate change; communities, women and diversity; ecosystem modeling; fire ecology and management; greenhouse gas emissions and mitigation; invasion ecology; pest risk analysis; land use and management; physical hydrology; aquatic ecology; population and community ecology; soil biochemistry; soil ecology; environmental microbiology; species distribution modeling; and tree physiology.

NREL scientists have been acknowledged for their research achievements, including winner of the Tyler Prize and member of the American Academy of Arts and Sciences, recipient of the “Champion of the Environment” award from the government of Mongolia, winners of prestigious Ecological Society of America awards, contributors to the Intergovernmental Panel on Climate Change which was awarded the 2007 Nobel Peace Prize, and among the most Highly Cited Researchers listed by Thompson Reuters. NREL scientists include Presidents and Fellows of professional research societies, Fulbright Scholars, and National Science Foundation program officers. NREL graduate students and young scientists have received NSF and USDA Graduate Fellowships, NSF Young Investigator, and Early Career Awards, in addition to recognition as University Distinguished Research and Teaching Scholars.

Funding

NREL relies on external grants and contracts to support research activities at the lab. NREL submitted 254 proposals during the last three years, averaging over 80 proposals per year, which is the highest number of submissions over the past decade and a half (**Figure 2**). This pattern partly reflects the increase in the number of scientists due to the development of the Department of ESS. In addition, the number of proposals submitted with lower budgets has increased over the past three years due to a decrease in available funds, and due to the number of awards given by traditional funding agencies, such as NSF and USDA. In general, NREL scientists are in a period of submitting more proposals for fewer dollars.

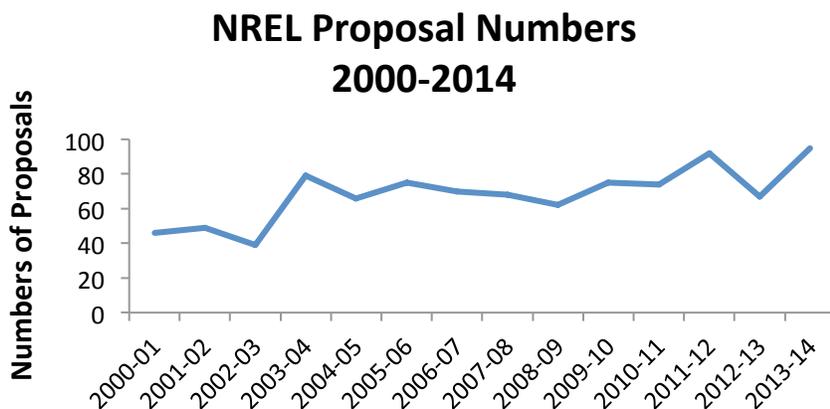


Figure 2: Total number of proposals submitted by NREL between 2000 and 2014.

NREL secured 207 awards and supplements² from external funding sources over the past three years, with a total funding of \$28.9 million. The current amount of funding dollars is similar to the levels from the early to mid-2000s, but has declined from the peak amounts reached in 2008 and 2009 (Figure 3). This decline in funding over the past 5 years may be associated with greater competition for grants from some of NREL’s traditional funding sources, such as NSF and NASA. The national economic downturn has also had an impact, as agencies develop funding plans to accommodate their limited research allocations.

NREL Awards -Dollar Amount 2000 - 2014

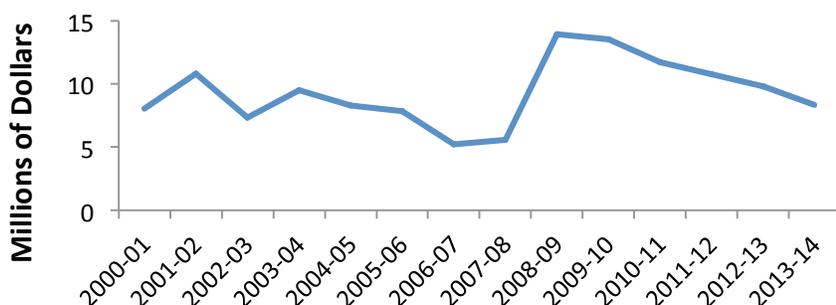


Figure 3: Total amount of awards to NREL in millions of dollars between 2000 and 2014.

Of the \$28.9 million of external funding to NREL, the total indirect cost recovered (IDC) by Colorado State University was \$5.3 million. Of the \$5.3 million, the average annual return of IDC to NREL has been \$474,000 per year, which is primarily allocated to fund the administrative support for the lab. The budget also includes occasional matching commitments by the College to NREL, but does not include the Director’s salary, which is supported through a separate funding source from the College.

Funding sources include grants and contracts from several federal agencies, state agencies, and subcontracts from other universities, with the largest amounts coming from the US Department of Agriculture, National Science Foundation, and US Geological Survey (Figure 4).

Funding Amounts by Source

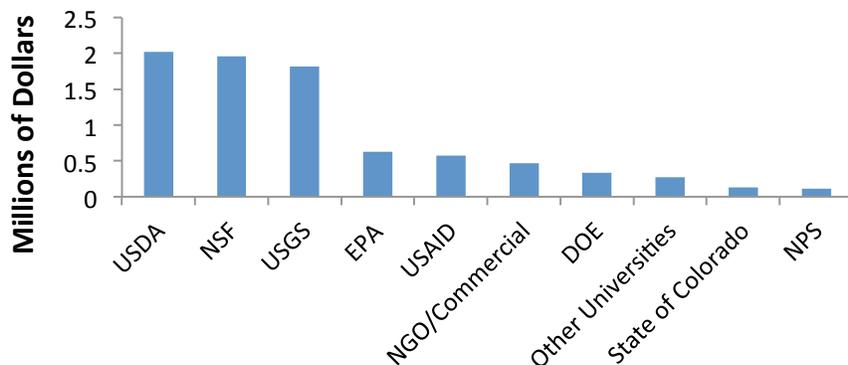


Figure 4: Funding dollars by source in millions of dollars for fiscal year 2013.

² This estimate includes awards for the 254 submissions, in addition to smaller award submissions and supplements for existing grants or contracts.

Communicating Our Science

Over the past three years, NREL scientists produced a total of 330 peer-review journal publications, averaging between 65 and 85 per year (Figure 5). The scientists have also contributed numerous book chapters as well as several full book publications. NREL scientists have an exceptionally distinguished record of publications printed in some of the world's premier journals, such as *Science*, *Nature*, *Proceedings of the National Academies of Science*, *Bioscience*, *Ecology*, and *Ecology Letters*, covering their research in general science, the environment, and ecology.

Several scientists have made significant contributions through book publications, including "*Soil Biology and Biochemistry*," by Eldor Paul, "*Measuring Plant Diversity*," by Tom Stohlgren, "*Energetic Food Webs: A study of real and model ecosystems*" by John Moore, "*Rocky Mountain Futures*" by Jill Baron, and "*Sustaining Biodiversity and Ecosystem Services in Soils and Sediments*," by Diana Wall. Our scientists have an exceptional record with respect to total publication numbers and citations, with several members and the unit as a whole ranking in the top 1% of scholars for disciplines within the environment and ecology. H-indices average 26 for NREL scientists, with a range from 5 to over 70.

In addition to journal publications, NREL communicates science to the global community through our website (<http://www.nrel.colostate.edu/>), presenting the NREL vision of interdisciplinary research, and our recently launched internet-based publishing platform – EcoPress. EcoPress was originally funded by successive NREL development grants with a main purpose of highlighting NREL science and scientists through non-traditional communication outlets integrated with social media (Figure 6). Run by successive teams of graduate student editors, EcoPress creates a dynamic and engaging online presence for NREL, provides valuable opportunities for graduate student professional development and creative public engagement, and has the capacity to support additional science communication opportunities by engagement with NREL alumni and integration with more traditional NREL online content.

This platform has become a diverse science communication outlet for NREL scientists. Authors include the breadth of the NREL community, from graduate students to research associates and primary investigators. Their contributions reflect the depth of NREL science from publication summaries, commentary, and opinions, to innovative presentations of scientific ideas.

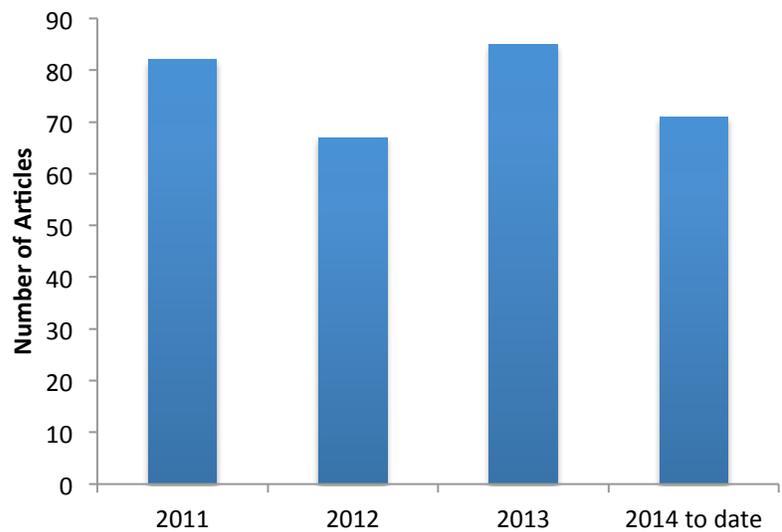


Figure 5: Number of journal publication by year.

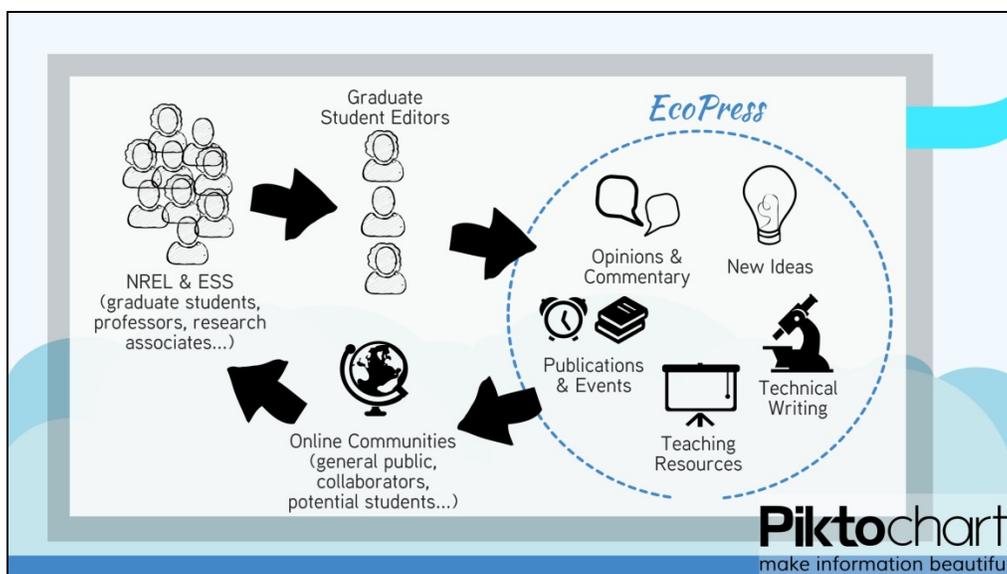


Figure 6: The EcoPress approach to science communication

Broadening Our Impact through Outreach and Mentoring

Citizens and decision makers from Colorado and beyond learn about their environments from a wide variety of lectures and events in which NREL scientists participate. With two RAPID grants, NREL scientists work closely with Fort Collins, Larimer County, and State officials to understand and mitigate the combined effects of the devastating 2012-13 fires and floods. Science-manager partnerships between NREL scientists and the Department of Agriculture, USDA Forest Service, and Department of Interior are strong in the fields of carbon accounting, forest and range management and conservation, air quality policy, and adaptation to global change. NREL scientists are involved with National Climate Assessments and the IPCC, and support US government reporting of greenhouse gas emissions to the United Nations. NREL also hosts a NASA DEVELOP center in collaboration with the U.S. Geological Survey. This center fosters interdisciplinary research where undergraduate and graduate students receive training and hands-on experience working with scientists and natural resource managers utilizing NASA Earth Observatory technologies to address community concerns and public policy issues. NREL’s global reach to the governments of Mongolia, Kenya, and Ethiopia influence how socio-environmental decisions are made at the highest levels. Moreover, NREL has helped shape global research collaborations, such as International Geosphere-Biosphere Programme, Diversitas, and International Human Dimension Programme, and will be fundamental to the new Future Earth.

Our engagement extends to the public through invited seminars, testimony to state and national offices, and by developing close working relationships with professional societies (especially with the Ecological Society of America, American Geophysical Union, and others) and with various Non-Governmental Organizations, such as The Nature Conservancy, Environmental Defense Fund, and National Wildlife Federation. NREL scientists are frequently interviewed by the media, including appearances on the local public radio station, KUNC.

Our education activities have a broad reach from training the next generation of scientists to improving environmental literacy. NREL scientists mentor outstanding graduate students, and during the past three years, 28 students have graduated from the Graduate Degree Program in Ecology, 10 from the Watershed Science program, and another 4 from other programs. NREL has launched students into successful careers in research, education, and public service.

The knowledge gained in our research is shared among many user-communities, which extend from K-12 education throughout northern Colorado, to State and Federal agencies, and to governmental and non-governmental organizations worldwide to improve environmental literacy. NREL scientists have developed a Summer Soils Institute to provide opportunities for teachers to learn how to study soils through lectures, field visits, and laboratory experience. Short courses have also been developed and offered on other topics associated with research at NREL, such as application of the DayCent simulation model, species niche modeling, and greenhouse gas emission accounting.

NREL has blended its talents and working ethos even more fully into the central mission and goals of the University to support ESS. For example, ESS is offering a two-semester course for undergraduate students entitled “Research Skills for Ecosystem Science”, which was developed through a NREL project (Figure 7). The course enhances student research experience through instruction and active learning activities about scientific methods. The first semester consists of a series of classes on a range of topics, including forming hypotheses, experimental design, finding and reading literature, and analyzing data, which are led by two to four NREL scientists. During the second semester, students are paired with NREL scientists to complete a small research project and present their findings during a poster session that is open to the public. NREL scientists are also contributing to new online courses offered through ESS, “African Dryland Ecosystems and Societies” and “Critical Thinking in Ecosystem Science”.

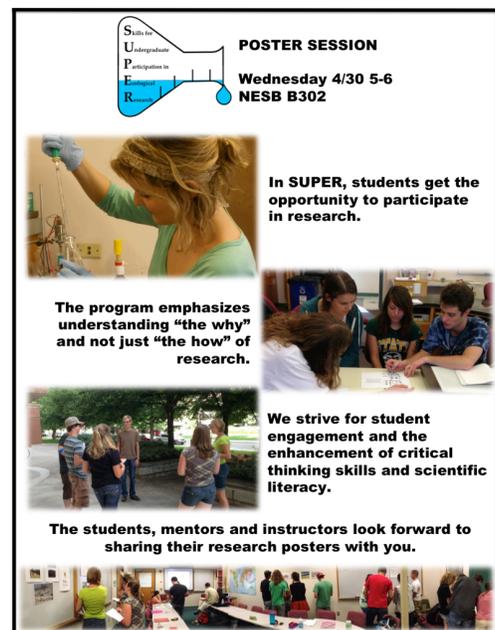


Figure 7: NREL's SUPER mentoring program at work.

Making NREL Work: Administrative Structure and Logistical Support

NREL is a multi-college research center within the Warner College of Natural Resources, and employs over 100 people per year in various job classes. Today, NREL Research Scientists, through their competitive grant funding, support and house a professional support staff of approximately 45 research associates, 8 full- and part-time administrative staff, 29 graduate students, and numerous undergraduate research assistants. Visiting scientists and students take an active part in the lab, even though they are funded through other sources.

The Director of NREL oversees the lab and also serves as the Head of ESS. The Director is advised by the NREL Executive Committee, made up of approximately 10 members representing the diversity of NREL

Research Scientists. The Director and the Executive Committee meet monthly to review and suggest changes to operations at NREL.

The NREL has four main administrative areas, pre-award, post-award, EcoCore laboratory support, and information technology support. Each area has an individual in charge, and these leaders work together to ensure that the lab runs smoothly.

The pre-award team works with scientists to complete all proposal submissions. The team reviews the funding request and ensures that all proposals are in compliance with the funding opportunity. The NREL is in a unique position within CSU because the Office of Sponsored Programs has given the Assistant Director authority to submit proposals. The post-award team works with the scientists to implement each of their projects and ensures compliance with all regulations and guidelines set forth by the sponsor. This team is responsible for assisting scientists as they navigate CSU procedures while completing their research in a timely and efficient manner.

EcoCore is our analytical laboratory facility ([Figure 8, http://ecocore.nrel.colostate.edu/](http://ecocore.nrel.colostate.edu/)), and a CSU core facility, with support staff that maintains the lab and equipment to ensure research can be completed in a timely manner. EcoCore is working towards the goal of being a self-sustaining entity that pays for staff, consumables, and equipment through a University approved billing model. EcoCore is at the forefront of providing analytical procedures and equipment that are needed to address key scientific questions in ecosystem science.



Figure 8: The EcoCore facility provides students and researchers valuable hands-on experience with the instruments, and assists CSU faculty in facilitating labs for isotope-related classes and workshops.

The Information Technology support staff facilitates NREL research through various desktop computing systems, as well as server design and maintenance for network computing. NREL research often utilizes large datasets (

) that have specific IT requirements. The IT team designs, builds, and maintains these systems in-house.

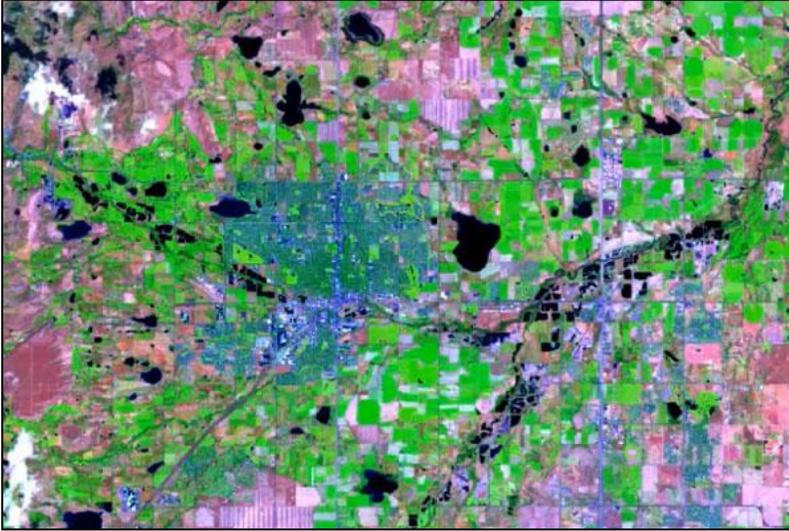


Figure 9: Screenshot of an image of Longmont, CO, from a video showing 28 years of change in Northern Colorado as seen from Landsat 5. The video was created by Dr. Randall Boone, NREL.

Proposing Future Directions

NREL is in the midst of an exciting time of change and challenge. Throughout its 46-year history, its overarching goal has been to bring scientific knowledge to bear on issues of global and regional environmental concern with collaborative ecosystem-level inquiry that encourages specialists and systems-level thinkers alike to place their research into broad contexts. NREL has been very successful at securing external funds to meet this goal.

With increasingly competitive grant programs, NREL must evolve to remain at the forefront of our field. NREL will need a range of scientific expertise to address emerging scientific questions and environmental challenges facing society, while also being true to its history of interdisciplinary, integrative, holistic, and team-oriented research. NREL must also be flexible to allow the interests of the talented scientific staff to influence the overall direction of the lab, as well as enhancing our value to CSU, our colleagues, and other stakeholders.

As NREL considers revisions to its Strategic Plan, the following objectives have been highlighted as ways to create continuity and move the lab forward, ensuring the continued success of NREL.

- **Scientific Advancement.** Continue pushing the frontiers of science, improve our ability to retain and recruit scientific talent, create an incubator model to develop new research ideas, and actively seek funding to maintain the research enterprise.
 - NREL will continue pushing the frontiers of science and advancing our understanding of ecosystems, watersheds, and other areas of research focus at the lab. Advancing our knowledge and expertise will enhance our regional-to-global perspectives of the biological and physical processes that drive these systems, while also facilitating our ability to provide solutions for pressing societal problems.

- Develop mechanisms to recruit and retain scientific talent in order to maintain and further enhance the expertise of the scientific staff. Anticipate retirements and develop plans to ensure continuity of our historic areas of expertise, while also expanding into new areas.
 - NREL will institutionalize the practice of identifying new scientific questions and opportunities to address environmental challenges that the lab is well suited to lead. To achieve this goal, NREL is proposing to adopt an incubator model for new research ideas by facilitating small conferences that produce manuscripts, white papers, and proposals.
 - To maintain the research enterprise, NREL will continue to actively seek funding through federal and state government agencies, but will also actively explore other opportunities for funding as they arise.
- Research Support. Enhance data management capabilities and strengthen EcoCore.
 - Continue to develop informatics analysis services. Explore the creation of a data management hub, including valuable data archives from past projects, network services, data portals, the CSU Libraries digital repository, and other information services. We are especially interested in staying at the forefront of data sharing and open access movements that are revolutionizing how science is disseminated and communicated.
 - Continue to develop EcoCore as a self-sustaining facility at CSU, with the primary goal of providing the most advanced analytical tools, expertise, and training to facilitate cutting-edge research.
 - Marketing and Branding. NREL has casually promoted itself around loose self-organized groups of scientists with common research interests. Moving forward, NREL will highlight our research expertise as it relates to grand environmental challenges and other key topics of scientific exploration. NREL research is multi-faceted and dynamic, and our marketing should reflect the breadth of this research and its relevance to the scientific community and society. Marketing efforts will focus on dissemination of information through our website and building on the nascent efforts with social media through EcoPress.

The proposed future directions are an initial set of ideas that will be further discussed, added to, and refined through discussions with the NREL External Advisory Committee as NREL undertakes a revision to the strategic plan for the lab.