New Laboratory Complex
Department of Global Ecology
Carnegie Institution of Washington
Stanford, California

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1.0 Summary

The Carnegie Institution of Washington (CIW) is constructing laboratories, greenhouses, and associated facilities to house its new Department of Global Ecology. The buildings, located on the campus of Stanford University, will total approximately 11,000 square feet of research buildings, 3,000 square feet of storage and 3,000 square feet of greenhouses. Construction is scheduled for 2003.

The Department of Global Ecology will conduct basic research and training on large-scale interactions between ecological systems, the ocean, the solid earth, and the atmosphere. The facility described in this request for proposals will be the primary base of operations for the new Department, which will consist of 5-6 research groups, each with 6-12 people, plus an additional 2-4 support staff for a total population of up to 50. The research program and the construction will be integrated with the existing operations of the Department of Plant Biology of the Carnegie Institution of Washington at 260 Panama Street, Stanford, California.

We are developing a design that places a high priority on minimizing environmental impacts, while also maximizing occupant comfort and health. Design criteria will include the highest possible energy efficiency, an emphasis on the use of sustainable materials, and integrated energy production from photovolaics and/or wind. The project will also comply with the site and design guidelines of Stanford University.

The research activities of the Department of Global Ecology require offices, common spaces, areas for computer research, wet labs, dry labs, flexible space for equipment assembly, and storage. In addition, they require research greenhouses with capabilities for environmental control.

The architectural firm leading the design process is Esherick, Homsey, Dodge, and Davis, San Francisco, CA.

2: Project Overview

The project will develop the home for a new academic department. New construction will include space for seven classes of activities. These are (1) offices, conference areas, and administrative space, (2) computer research space, (3) wet laboratory space (4), flexible (dry) laboratory space, (5) storage, (6) research greenhouses, and (7) greenhouse support. The basic needs in each category are:

1) **Offices, conference areas, and administrative space**: The facility should have private offices for 6 faculty members, plus a few more private offices for visitors, emeritus faculty, and administrators. In addition, there should be shared offices for 30-40 students, post-doctoral associates, and other research staff. The office complex should include a conference room for up to 12 participants, plus informal conference areas for smaller groups. The facility should be as energy-efficient as possible, emphasizing natural ventilation and lighting.
2) **Computer research space**: Much of the research activity in the new department will be computer based. Approximately 1/3 of the researchers will work exclusively on computer-based research. The other 2/3 will make extensive use of computer-based research, in conjunction with field and laboratory studies. The computer research will involve a central cluster with many processors and hard disks. Most of the researchers will use ordinary PCs as terminals. With a few exceptions, the space designated as offices should be usable for computer research and vice versa. The space for the central cluster can be relatively small, but it will require substantial amounts of electrical power and climate control.
3) **Wet laboratory space**: The facility should have some traditional wet-laboratory space, designed for handling moderate amounts of chemicals and radioactive materials. To the extent possible, the wet labs will be shared among research groups. Much of the activity will be centered on relatively large instrument systems, each requiring several feet of bench or floor space. The wet labs will require fume hoods and environmental controls compatible with their use.
4) **Flexible (dry) laboratory space**: Much of the research will entail operations that do not require chemicals, fume-hoods, or radioactivity. This will include activities like sample processing (sorting, grinding, weighing) and some analytical operations (e.g. spectral reflectance of dry samples). In addition, this space will be used for developing and testing equipment and instrument systems that are deployed off site, in field sites, in the ocean, or in space. Because the uses of this space will change through time, the design should be as flexible as possible, with movable benches and partitions as well as overhead power distribution. The flexible laboratory space should be designed for the maximum energy efficiency consistent with maintaining appropriate working conditions.
5) **Storage**: Two kinds of storage will be unusually important for the research of the new department. One is the storage of samples, either dry or frozen. Much of the research will entail major sample collection efforts, followed by periods of intensive sample processing. In addition, some of the research will require archiving samples for later analysis. The second class of storage needs concerns instruments and other field equipment. The instruments used for intensive field

campaigns will spend much of the time in storage. The storage space should be designed for minimum building systems and environmental control.

6) **Research greenhouses**: The greenhouses will be designed to meet two goals. The first is providing a large amount area with modest environmental control. A second set of uses will require more elaborate environmental controls, with different parts of the greenhouse complex maintained at different levels of temperature or CO_2 concentration. The greenhouses will be used by the existing Department of Plant Biology as well as the new Department of Global Ecology.
7) **Greenhouse support**: This facility will be used for sterilizing soil, potting plants, storing greenhouse chemicals, etc. It should be attached to the greenhouses.

Site Plan and Existing Facilities

The new facilities will be located on a 7.3 acre site at 260 Panama Street, Stanford, CA (Figure 1). The site has been the home of the Department of Plant Biology since 1928 and is leased by the Carnegie Institution of Washington from Stanford University. The current lease is effective until 2037; the planning process should assume the facility is permanent. The current buildings on the site include a combination of one and two-story structures including a total of approximately 39,000 gsf. Existing facilities include a two-story office building, two clusters of one-story laboratory buildings, an engineered metal building that houses shop and storage facilities, plus small buildings for a seminar room, a garage, and greenhouse support. In addition, the site has nine small greenhouses and parking lots with approximately 75 spaces.

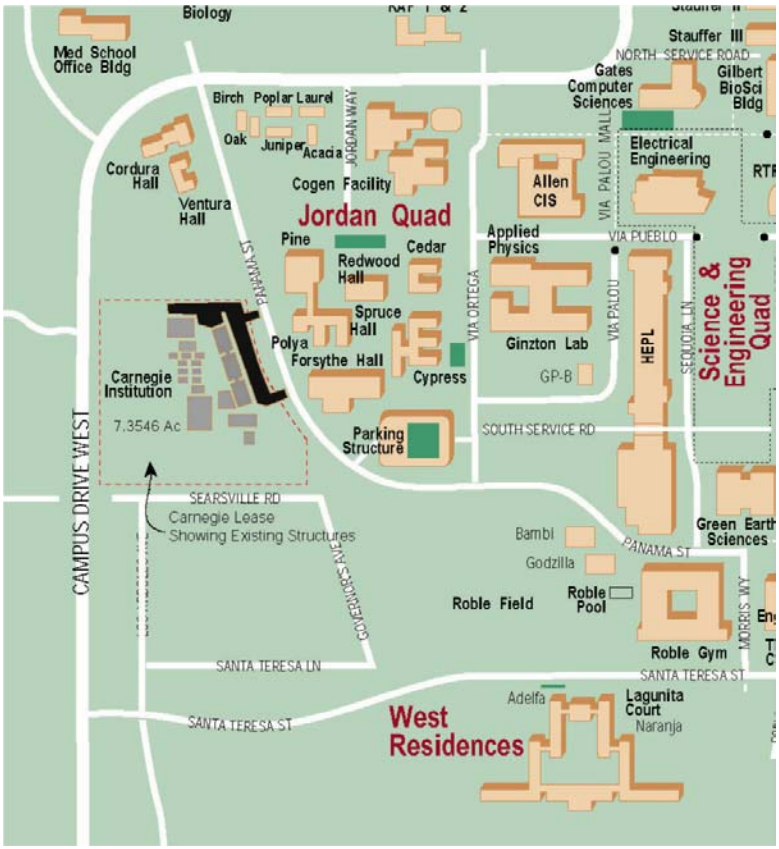

Figure 1: Part of the Stanford campus, showing the location of the Carnegie Institution of Washington. Existing buildings are shown in gray. Parking is black.

Much of the site has been used for experimental gardens. Recently, the emphasis on research using experimental gardens has decreased, but we wish to protect the option for future studies using open fields on the site.

Other major features of the site include a major electric powerline across the Southern end and a large storm sewer running South to North. The distribution points for electricity, gas, phones, sewer, and emergency power are scattered across the site.

The existing buildings will continue to be occupied by the Department of Plant Biology. The new facilities should enable efficient interactions between the existing activities and the activities of the new Department of Global Ecology. The interactions will be scientific as well as operational. It is important to facilitate a free flow of people and ideas between the two departments, and it is also important to provide efficient access to shared personnel and facilities. The key personnel supporting both departments will be staff for administration and facilities management. Spaces used by people in both departments will include the seminar room, libraries, greenhouses, and storage facilities.

The current facility includes 9 small greenhouses that we will upgrade as part of the overall project. The age, efficiency, and organization of the greenhouse complex makes it likely that the best option will entail replacements greenhouses, perhaps on a different part of the current campus.

3: Sustainable, Low-impact, High-efficiency Buildings

This project should strive for buildings with minimal environmental footprints, for three reasons. First, for researchers dedicated to understanding the way the world works, it is clear that human impacts pose major threats to a sustainable future. One way to manage these threats is through creative design of the places where we work. Second, Carnegie's support for research and infrastructure operations comes from the same pool of resources. Any actions that can be taken now to manage future operating costs will pay large dividends in the future. Third, this project can serve as an example, encouraging other parts of the Stanford community, as well as other institutions, to look seriously at options for "green" buildings.

Some of our motivations for emphasizing "green" design are purely practical, and others are largely philosophical. Our goal in selecting features is to make the practical and philosophical considerations work together. It is important to have the buildings make a statement, but the statement must be that it is not necessary to sacrifice economy, comfort, worker efficiency, or beauty for low environmental impact.

We would like to consider a broad range of technologies and materials. The suite of candidates should include, but is not limited to:

1) Natural ventilation (where consistent with the building code requirements)

2) Passive solar design (for natural illumination, minimum heating in summer, and maximum heating in winter)
3) Sustainable, low impact, building materials (from sustainably harvested wood through ash-filled concrete and straw)
4) Environmentally friendly building materials (low VOC paint)
5) Passive and active energy storage (including cold and hot water)
6) High-efficiency building systems (HVAC, lighting)
7) Photovoltaics
8) Co-generation with fuel cells or a microturbine
9) Building location with an emphasis on preserving local environmental values

4: Context

Carnegie Institution of Washington

The Carnegie Institution of Washington was founded in 1902, with a charge from Andrew Carnegie that it advance basic science for the betterment of mankind. Its explicit goal was to augment the efforts of the nation's universities and not to compete with them. Currently, Carnegie has 5 academic departments. The Geophysical Laboratory and the Department of Terrestrial Magnetism are located in Washington, DC. The Department of Embryology is located on the campus of John's Hopkins University in Baltimore, and the Observatories are located in Pasadena. The Department of Plant Biology has been located at its current site on the Stanford Campus since 1928 (Figure 2). The new Department of Global Ecology will be inaugurated in 2002.

The Institution is led by its President, Maxine Singer, and its Board of Trustees, chaired by Thomas Urban. The Director of Administration and Finance is John Lively. The Director of the Department of Plant Biology is Christopher Somerville.

The scientific enterprise of the Carnegie Institution operates with funding from its endowment, plus grants from government agencies and other foundations.

Figure 2: The main building of the Carnegie Department of Plant Biology, at the time of its completion in 1929.

Department of Global Ecology

The Department of Global Ecology, Carnegie's first new department in more than 80 years, was approved by the Board of Trustees in May 2001, for inauguration July 1, 2002. The goal of the department is to advance the understanding of the earth as an integrated system. Global ecology is a new field, building on explosive developments in a number of technologies to address fundamental questions about large-scale ecological processes and the requirements for preserving a sustainable biosphere. The field's foundation is in biology, in understanding the mechanisms that control the growth, distribution, and function of plants, animals, and microorganisms. It then extends this information in space, and integrates it with information from other disciplines, including oceanography, atmospheric science, and geology, as well as the social sciences. The tools of global ecology range from laboratory-scale biochemical studies through analyses of global-scale satellite data sets. Core techniques include molecular biology, remote sensing with earth-observing satellites, analyses of atmospheric composition, and extensive application of computer models. Some of the experimental studies will be conducted in the laboratory, but many will be conducted at remote field sites. Some of the experiments will be based on ocean going ships, in airplanes, or on satellites in space. Much of the work of the department will concern developing new techniques for large-scale measurements and interpreting data from remote sensors.

The department's agenda is unique, but it is not isolated. Vital interactions with a number of organizations will be vital for the department's success. First, the department will be closely associated with the Carnegie Department of Plant Biology, with which it will share a campus. The intellectual core of the interaction will concern the application of molecular techniques (many developed at Plant Biology) to ecological problems, including questions about biological diversity and its maintenance. Second, the department will work closely with several units at Stanford University. Carnegie faculty have a long history of active involvement in training Stanford undergraduates and graduate students. In addition, collaborations with Stanford faculty will provide links to disciplines not represented in the Department of Global Ecology. Collaborations with geologists, oceanographers, atmospheric scientists, and engineers will be as critical as links to Stanford's exceptional biologists and biogeochemists. In addition, we anticipate collaborations with a range of social scientists, including economists, lawyers, and faculty in business and education. Third, the department will be part of an international network of institutes and projects that collect and analyze global-scale data. Effective integration in this network will entail extensive travel by the department's personnel, as well as frequent visitors from other locations.

Department of Plant Biology

The Department of Plant Biology conducts basic research on plant growth and function. Its staff of approximately 100 includes faculty, students, post-doctoral associates, and other researchers. The operations of the department focus on laboratory and computer-based research. Research greenhouses and indoor growth rooms are critical for the department's operations.

Stanford University

All of the new construction on the Stanford campus is managed for consistency with its General Use Permit, approved by Santa Clara County in November, 2000. The Carnegie project falls within the area designated as "Campus Center" in the General Use Permit, and it was included in the Capital Plan released May 7, 2001, by the Stanford Provost, John Etchemendy.

5: Design Considerations

Our goal with this project is developing a home from which the Department of Global Ecology can be successful. We wish to develop a research environment that is efficient, flexible, and pleasant. In addition, the home for the department should help establish its identity as a major initiative for the Carnegie Institution of Washington and an important component of the research and training capabilities in the Stanford community.

Research in the Department of Global Ecology will focus on studying the interconnections among parts of the earth system. We explicitly recognize that a laboratory complex interacts with the larger environment, and the new facilities should emphasize these interactions in two central ways. First, the buildings should have the minimal environmental impacts consistent with fulfilling the research mission. The design should be based on building materials with minimal impacts on the environment as well as features that minimize the inputs of energy and water required to operate the facility. Second, the facility should make a strong statement about its commitment to sustainable, low-impact, energy-efficient construction.

The facility should be designed to provide space for 6 research groups. Each research group will include 6 to 12 people. The planning target for the total personnel associated with the facility should be 50.

The faculty of the new department will include three members of the existing Department of Plant Biology (Greg, Asner, Joe Berry and Chris Field) and additional scientists to be appointed in the future. The planning process needs to account for the fact that the facility will need to accommodate researchers who are not yet appointed.

Global ecology research has space and facilities requirements that place a high priority on flexibility. Key features of the facilities requirements will be similar across

all of the research groups in the new department. Others will be unique to each research group. The features that are common across groups include:

1) **Space requirements that are specific to each project**: In contrast to many kinds of laboratory research, where it is practical to assign each researcher a standard amount of bench space, the space requirements for researchers in global ecology are highly variable. Some projects will require small amounts of space over long times. Others will require large amounts of space for short times. Some projects require high standards of management for chemicals or radioactivity. Others require only a roof.

2) **Strongly phased requirements for research space**: Much of the research in global ecology has space needs that vary strongly in time. A typical trajectory for a project includes an initial pulse of assay and instrument development, a second pulse of instrument manufacture, a long period where data are gathered in the field, followed by a phase of massive sample preparation and analysis. In addition, the work is often highly seasonal, with intensive fieldwork during a relatively short field season, followed by a period of intensive lab work. Because many researchers focus on a single part of the world, it is uncommon for the projects in a single lab to combine in a way that levels these pulses. Across the department, there will still be pulses, but the number of projects and the number of regions under study will help damp the variations.

3) **Wet-laboratory space**: Some of the assays widely used in global ecology require wet labs with fume hoods. For example, Kjeldahl digestions require extended refluxing in hot sulfuric acid, sometimes with a mercuric chloride catalyst. Pigment extractions typically require organic solvents. Some common assays require small amounts of phenol or acetonitrile. Assays with radioactive reagents are less common than in the past, though several important tests still use ^{14}C, ^{32}P, or ^{3}H. Some of the major instrument systems (e.g. HPLC) generate waste streams containing hazardous chemicals.

   Other lab operations require wet labs but use no hazardous substances. Examples of this kind of operations include washing soil from roots and extracting nutrients from soils. An oceanographer with a laboratory program would require facilities for seawater management and analysis.

   Some of the wet-lab operations will utilize instruments that are installed permanently or semi-permanently. In at least some of the cases, the management of the environment (ventilation of waste management) might be designed as part of the instrument system rather than part of the building system.

   The wet-lab space should be available to all of the research groups in the department. It could be broken into several small labs managed by separate groups, but it could also be mostly or entirely common space. In the future, the importance of wet-lab assays is likely to decrease but not disappear.

4) **Permanent, major instrument systems**: Much of the research is based on data from major instruments, ranging from mass spectrometers to HPLCs. Most of these require permanent or semi permanent installations. Some sit on the floor but an increasing fraction sit on lab benches. Most take a significant mount of bench space and work best when they are not too crowded. Many of these instruments require gas cylinders, venting, water cooling, or management of a stream of chemical wastes.

   The major instrumentation can be organized into one or a few instrument clusters. Clustering should be configured to provide efficient access by researchers, good access to support systems, and convenient management by an instrument specialist who oversees several instruments. The instrument clusters should be compatible with a system for integrated data collection, quality control, and maintenance records.

5) **Flexible space**: Many of the research activities in global ecology will require space that could be better described as manufacturing than laboratory facilities. Operations in this kind of space will range from equipment developing and testing to sorting and drying large harvests of plant material. None of the activities that utilize this kind of space will be permanent. Assembling of a large piece of equipment might require more than a year. Sorting a harvest or calibrating a field instrument might require a few days.

   For instrument assembly, we will need large, open spaces with fork-lift access. Benches and partitions may be useful for some projects, but they should not be permanent. Instruments to be assembled in this space generally will not require special lighting or air filtering. Some of the projects will entail assembling large numbers of similar units. Some aspects of instrument development and testing may entail test units containing large quantities of soil or water.

   The flexible space should also be available for research operations that do not require the full range of laboratory support. Examples include sieving soil, sorting plants to species, separating leaves from stems, and grinding plants and soils. Other operations that should be possible in this kind of space include measuring the spectral reflectance of dry materials (duplicating satellite measurements), or measuring plant carbon balance. For all these activities, it is important that the space is easy to configure, but it is not necessary to have precise control of temperature or air circulation.

   Currently, Carnegie has one manufactured metal building that is used for storage, growth chambers, and the machine shop. It is likely that a similar building could meet the new needs for flexible research space.

6) **Storage**: Global Ecology will need facilities for storing samples and for storing field equipment. Sample storage will facilitate staging for intensive pulses of

analysis as well as allow archiving important materials. Most of the samples can be stored dry. The storage facility should provide the possibility for freezer storage, including one or more –80 freezers. Most of the sample storage can be in bins or boxes organized by project. The building needs to provide only simple shelf units in a space with minimal environmental control (but with effective protection from pests).

Equipment storage will provide a home for apparatus used in the field. Most of the field instruments are in shipping cases, and the storage facility can be a series of simple racks. The instrument storage requires little or no environmental control.

It may be possible to combine the flexible research space and the storage in a single building.

7) **Research greenhouses**: The research greenhouses will serve fundamentally different purposes for researchers in Plant Biology and Global Ecology. At this point, we anticipate that use of the greenhouse space will be approximately 2/3 Plant Biology and 1/3 Global Ecology. For Plant Biology, the main requirement is for efficient places for growing and maintaining large numbers of plants. Temperature and light will need to be controlled to keep them within the acceptable range. For Global Ecology, the greenhouses will be used as experimental tools for examining the responses of plants or microorganisms exposed to well-controlled differences in environment. Environmental factors that might be manipulated in an experiment include CO_2 concentrations, levels of atmospheric pollutants, level of UV-B, temperature, light, water, and availability of mineral nutrients.

   We will probably use commercial greenhouses, designed and constructed by a greenhouse company. The structures themselves will require little input from the project architects, but there will be input for site selection, utilities, etc.

   Future research may require growth chambers, essentially large refrigerators with lights. Space for growth chambers could be incorporated in the building for greenhouse support, or it could be incorporated in the storage facility.

8) **Computers and communications**: All of the research groups will make heavy use of computers. The department's computer facilities will include a multi-processor cluster for large calculations, as well as a large number of PCs. In general, there will be a computer at every location where a person is working. We will examine options for dedicated machines versus portables that are moved from place to place within the department. To save space and power, we plan to avoid CRT displays (traditional video monitors). Effective networking is crucial. We will examine options for wireless as well as wired networks.

One of the distinctive features of this global ecology research is that most people do not work at consistent locations. This makes it challenging to provide a useful phone system and enhances the value of wireless systems.

The global agenda of global ecology places a high priority on effective collaborations. We anticipate a steady stream of visitors, in residence from a few weeks to a year or more, who need to be effectively incorporated in the work of the department. In addition, we need to insure good communications with collaborators both on and off site, placing an emphasis on conference facilities, capabilities for video conferencing, and informal gathering spots.

Though we have not yet made final decisions on future appointments, future appointments may include an oceanographer, a molecular ecologist, an atmospheric scientist, and a biogeographer. Each of these fields is so diverse that it is not possible to specify particular instruments or laboratory systems that will be needed. It is likely, however, that programs in these areas will have demands for flexibility similar to those of the existing programs. In addition, they are likely to require additional dedicated instrument systems. To accommodate a range of possible future directions, we hope to leave some space undeveloped while also maximizing the flexibility of the space that is finished.

Support staff

Much of the support staff will be shared with the Department of Plant Biology. In general, support staff should be distributed between the new and the existing buildings in a way that maximizes efficiency. There should be at least one administrative staff member located in the new building to provide reception, receiving, etc. In addition, it might be appropriate to locate one financial administrator in the new complex. The new department will probably also require one additional position for grounds and facilities. It is unlikely that the administrative staff housed in the new buildings will number more than 3.

Shared facilities

We hope to realize substantial benefits through sharing facilities between Global Ecology and Plant Biology. Shared facilities will include several that already exist: the seminar room, the library, the receiving dock, and the machine shop. The addition of the new department should be managed to enhance the attractiveness of the campus grounds. New shared facilities developed as part of this project will include the greenhouses and the computer cluster. In addition, we will continue to evaluate the research directions and space needs in both Global Ecology and Plant Biology to take advantage of future opportunities.