

Policy and Usage Manual

Utah State University
Utah Agricultural Experiment Station
Research Greenhouse Complex



1410 N. 800 E.
Logan, UT 84341



Utah
Agricultural
Experiment
Station

Revision date: October 2009

Overview and Philosophy

Controlled environments have a storied history of use in plant biology. Rigorous control of the environment is essential in physics and chemistry laboratories, and it is similarly essential to solve the most challenging problems in plant biology.

Providing well-documented and precise control of the environment is a challenging task. The literature is replete with artifacts resulting from inadequate or incomplete control. Our goal is to help you achieve the control you need for your research objectives.

It is important that you know how the control systems work. We provide basic environmental control in all greenhouse sections and we are working to provide more sophisticated control as our funding allows. We can help you control lighting, temperature, humidity, and CO₂ concentration in addition to automated water and fertilization systems. We want this facility to be a model for Research Greenhouses across the nation. We look forward to working with you.

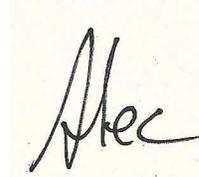


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Contact Information

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Bruce Bugbee	bruce.bugbee@usu.edu	435-797-2675 After hours 435-753-1238
Julie Chard	julie.chard@usu.edu	435-797-2605

Emergency Contacts

For any emergency call the **USU Police at 797-1939**. This includes security problems, fire, chemical emergencies, and medical emergencies.

For a mechanical systems failure (such as a broken water lines, no water, no electricity, no heat, no coolers functioning, broken glass overhead, etc.) first contact Alec Hay at 435-797-2600 or 435-232-2765 after hours.

If it is an emergency and you are unable to contact Alec, please contact the USU Police (435) 797-1939, who can then contact the required personnel with Facilities Maintenance.

General Information

The Utah Agricultural Experiment Station maintains the Research Greenhouse Complex for faculty with UAES research projects. The Research Greenhouse Complex is located to the north of the main campus. The physical address for UPS and Fed Ex deliveries is:

**USU Research Greenhouse Complex
1410 North 800 East
Logan, UT 84341**

Research Greenhouse Complex Facilities

- Twenty greenhouse sections
- Three walk-in coolers
- Two chemistry labs
- Twelve growth chambers
- Office space
- Nine storage sheds located north of the headhouse.

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Parking

Parking is located on the north side of the headhouse. Please park University vehicles along the north side of the lot, so that the spaces near the building are open for short-term parking. This is particularly important during the winter months, when the university trucks that are stored in our lot make snow removal difficult.

Alternate Transportation

We greatly encourage the use of alternate transportation whenever possible. The Aggie Shuttle "[8th East Express](#)" transports passengers from the Agriculture Systems Technology and Education (ASTE) building (just north of the Research Greenhouse Complex), to the Nelson Field house near the Student Center. It operates every 15 minutes from 7:00 am. until 5:00 pm. when school is in session.

The main campus is only a 6-minute bicycle ride or a 14-minute walk.

Telephone

There is a telephone in the main hallway of the headhouse: (435) 797-2605. This phone is shared by the graduate student office (Room 138), the growth chamber room (Room 140), and the chemical lab (Room 133). Please limit use of this line to brief, work-related calls since many people need to use this line. This line rolls over to voice mail in the graduate student office after four rings.

To dial off campus, dial 9, then the number. An access code is required for long distance calls. To dial on campus, dial 7, then the 4-digit extension.

Restrooms

Restrooms are located in the west hallway.

Fire Alarms

University regulations require that the building be vacated immediately when the fire alarm sounds. Once out of the building, please move to the lawn at the west end of the building so that we can do a head count to see that everyone has made it out safely.



Conducting Research at the Research Greenhouse Complex

The USU/UAES Research Greenhouse Complex is intended for plant and crop biology research.

Essential Considerations for Experimental Design

Designing a study for a greenhouse or other controlled environment typically involves unique modifications to achieve the desired experimental results. Submission of a “*Research Space Application*” form outlining your proposed project is necessary to enable the Research Greenhouse staff to prioritize requests and help users evaluate the options that are critical to effective controlled environment research.

Root Environment

Container size

A wide range of sizes and shapes are used, from tall PVC columns to conventional pots. Smaller containers allow more replicates but may not be appropriate for bigger plants in longer-term studies. It is, however, possible to grow large plants in small containers if they are fertilized and watered properly. Drought stress studies benefit from a larger pot because it allows a slow, steady dry-down.



Media type

For standard plant cultivation we recommend soilless media with a 50/50 mix (by volume) of top-quality sphagnum peat and horticultural vermiculite. Many other ingredients (e.g. perlite and shredded bark) are used in commercial production to reduce the cost of the mix, but they reduce nutrient and water holding capacity, and we do not recommend their use for research studies, especially when reproducibility of results among replicate studies is important.

Field soils are rarely appropriate for plant growth in containers because they retain too much water. If media must closely match field soils, we recommend a 50/50 mix of sandy loam and sand to provide adequate root-zone aeration and to simulate field soils.

In studies requiring examination of the root system we recommend calcined (baked) clay as media, to facilitate removal from the root system. It can be difficult to remove other common media from root surfaces without losing the fine roots. There are several particle sizes available. If nutrient solutions are not being used in the study, an appropriate slow release granular fertilizer should be blended into the media prior to filling containers to ensure uniformity of distribution. We have extensively tested various brands of slow release fertilizer and can assist in fertilizer selection, if needed.

Water management

Achieving consistent and reproducible root-zone water potential is critical to research in controlled environments. We work with users to design and build automated drip irrigation systems that are appropriate for their studies. These systems often include irrigation with a dilute nutrient solution to provide a uniform root-zone environment from day to day and among replicate studies.

Foliar Environment

Temperature

The typical temperature set point is 25 °C day / 20 °C night. Higher or lower set points can be used when needed.

Radiation

Many sections have supplemental lighting from 1000-Watt high-pressure sodium lamps. These lamps are not available in all sections but they are critical to achieving acceptable rates of plant growth in the winter months.



Photoperiod is typically set for 16 hours day and 8 hours night. Some crops may require shorter day length for reproductive growth. This can be set in each section individually.

Air circulation

All sections are equipped with internal circulation fans to reduce plant diseases and to improve environmental uniformity.

Environmental monitoring and alarm systems

Temperature is monitored in all sections and displayed on a screen in the hallway. Data can be accessed through the internet at <http://129.123.115.139/> This system alerts staff to problems with temperature control, and all efforts are made to correct problems quickly to save valuable research.

The user fee covers the greenhouse infrastructure, which includes maintenance and control of temperature, supplemental lighting, and hydroponic nutrient delivery systems. It also includes access to laboratory space in the headhouse, limited office space for internet access, and basic research infrastructure including digital balances, digital photography station, leaf area meter, fume hood, Reverse Osmosis water, and short-term use of light, temperature, and humidity meters for spot-checking growing conditions.

The user fee does not cover modifications and supplemental control that are necessary for specific studies. Examples of these modifications include installation of additional

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supplemental lighting, control of humidity and CO₂, irrigation systems, mist systems, etc. ***The user fee does not include supplies for growing plants including containers, media, or fertilizers other than the standard greenhouse nutrient solution.***

We work with users that qualify for the subsidized fee to optimize the control systems necessary for their studies. We can provide an estimate of the cost to install any additional infrastructure needed for each study.

Eligible users

Greenhouse sections are rented to USU faculty or entities partnering in research with USU. The greenhouse is intended primarily for faculty with UAES funded research projects.

Space Allocation

USU Faculty with active UAES research projects have first priority for space.

There is great seasonal variation in demand for greenhouse space, with peak use during the winter months. Please notify us as early as possible of upcoming projects that will require greenhouse space so that we may make the best use of the available resources.

Charges

Researchers are charged substantially subsidized rental fees for all greenhouse facilities including: greenhouses, growth chambers, walk-in coolers, and storage sheds. The fees contribute to maintenance and repair of fan motors, glass, temperature control systems, and purchase of supplies, such as paper towels and soap at the sinks. Fees are subject to change by the Utah Agricultural Experiment Station and will gradually increase to reflect actual operating costs.

Greenhouses, coolers, and storage sheds may be rented by multiple users, with the monthly rent divided among them.

Rates for entities partnering in research with USU are set by agreement with the Utah Agricultural Experiment Station.

Rental Rates for USU Researchers (Current September, 2009)

One Greenhouse Section.....	\$ 125.00 / month
Walk-in cooler space (by area used).....	\$ 25.00 - \$100.00 / month
One Storage Shed (100 ft ²).....	\$ 25.00 / month

Space in the Research Greenhouse Complex is rented in one-month increments. The Utah Agricultural Experiment Station reserves the right to reassign the greenhouse space based on UAES research priorities.

The monthly rate will change to reflect the cost of greenhouse upkeep as the price of materials and labor changes.

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Payment

Each user of facilities at the Research Greenhouse will provide a Banner Index number to Alec prior to occupying any area. This account will be charged for the appropriate rent each month.

Termination of Rental

Please provide at least 30 days notice to terminate the rental of any greenhouse section, cooler, or storage shed to Alec. Failure to do so may result in a charge of the regular monthly rate for that space.



Greenhouse Policies

Security

Security is a concern at all research facilities. The two main security concerns are prevention of theft and the protection of controversial research, such as work with genetically modified organisms. To help prevent theft, please return tools and instruments to their proper location when finished, and avoid leaving items out in the hallways or outdoors. To protect your own research work and that of colleagues, it is necessary for greenhouse users to be aware of their surroundings. Please take notice of the people that you see on the premises.

The keypad locks on the four main headhouse doors will open after the first valid code is entered on weekdays after 8:00 a.m. and will remain open until 6:00 p.m. All Research Greenhouse users must have a door code issued by Alec in order to access the headhouse after hours or on weekends. Codes are issued to each individual user and are recorded by the locks when used. The codes help us track greenhouse use and possibly to investigate missing equipment or other problems. ***Please keep your code confidential.*** Do not share it with anyone else unless it is a legitimate emergency.

If persons who work for you have a door code and are no longer in your employ or working on your project, please let Alec know so that their codes can be removed from the keypad locks.

Storage

The rental of greenhouse space does *not* include storage of items in the hallways, headhouse, or on the grounds surrounding the greenhouses. If a small amount of temporary storage is needed, see Alec about designating some of the shelf space in the main hallway of the headhouse. This area must be kept neat and labeled with the user's name and phone number. The bench tops and counter tops are not to be used for storage.

Storage of materials inside the greenhouse sections should be kept to a minimum. Items piled under the benches make weed control difficult and interfere with the circulation of heat from the radiators that are located around the perimeter of the section under the benches. Items stored on top of benches are a waste of growing space, can block air circulation, and make maintenance of the exhaust fans difficult.

Storage and use of chemicals, pesticides and all hazardous materials must comply with all Utah State University, State, and Federal regulations. Chemical inventories, all paperwork, and proper disposal are the responsibility of the greenhouse user.

Watering

Users are responsible for watering their plants. The greenhouse staff can be of assistance in designing an automated irrigation system to reduce the amount of time spent in keeping plants properly irrigated, though final responsibility for proper watering rests with the greenhouse user.

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Pest Control

It is the responsibility of each user to control insects, disease, and weeds in their section. Any application of a pesticide is to be done by or under the supervision of a person with a current Utah pesticide applicator's license and according to label rates and directions. The section treated shall be marked clearly with a sign indicating the pesticide used, the time at which re-entry is safe, and the name and phone number of the applicator.

Pest populations left uncontrolled by users may result in the removal of plants.

Expendable Materials

The greenhouse budget, funded in part by user fees, provides for a small amount of potting materials (pots, soil, amendments, etc.). There are often used pots available for general use. If additional materials are needed, researchers should make arrangements to purchase their own supplies. See Alec for assistance in sourcing and obtaining supplies.

Environmental Controls

Most greenhouse sections are independently controlled, with three-stage cooling and separate day / night set points. Mistakes made in setting these controls can cause damage to plants and greenhouse systems. Please contact Alec for a quick demonstration on the operation of this system. The four greenhouses in the 115 section have simple thermostats in each section.

Mechanical failures routinely occur in control systems, fan motors, water pumps, etc. ***Regular monitoring of your section for proper operation is a must.*** Familiarity with the control systems may help you identify problems before they threaten the survival of research plants. Users are encouraged to monitor the conditions in their greenhouse section closely. Greenhouse temperatures and other pertinent data may be viewed remotely on the USU Research Greenhouse webpage, <http://129.123.115.139/>

Individual users are responsible for ensuring that special treatments, such as supplemental lighting or chemical application do not interfere with other nearby research projects.

Clean up

Clean up, soil disposal and storage of materials are the responsibility of the greenhouse user. Keep in mind that USU janitors clean only the hallway and restrooms in the headhouse. Maintain your section by cleaning out unused materials and emptying the trash on a regular basis. Keep the section weeded to help suppress insect and disease problems, and to maintain a professional appearance. Do not store materials under the greenhouse benches as they will interfere with air circulation and effectiveness of the heating system, as well as making weed control difficult.

- Empty trashcans into the brown dumpster next to shed #9 in the parking lot. Please recycle paper, plastic, or aluminum in the bins located in the central hallway of the headhouse. Place cardboard in the recycle bin located in the green "lean-to" shed north of the building.

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- All growing media, root balls, and plant material not prohibited from being disposed of in the open should be disposed of in the compost bins north of the headhouse. They are the two eastern bins in the row of concrete bins on the north side of the parking lot (not covered).
- Do not dispose of hazardous wastes in the trashcans or the dumpster. Please fill out a hazardous materials pickup request online at <http://www.ehs.usu.edu/>. This includes leftover or old pesticides and used HPS lamps (mercury).
- If greenhouse sections or storage areas are not maintained in a clean and professional manner, they may be cleaned up at Alec's discretion and the cost of cleanup charged to the users of that area or section.

Labeling

Label all plants, pots, bags of media or equipment not inside your greenhouse section in a conspicuous manner with the name of the researcher and a contact phone number. Materials not identified to a researcher risk being discarded.

Reporting Mechanical Problems

Report all repairs that need to be made on the Research Greenhouse Complex to Alec or his assistants. Do not report them directly to the USU Facilities Maintenance Department, unless it is an emergency as specified under "Emergency Procedures" at the beginning of this manual. Alec will determine which items require Facilities Maintenance and which can be repaired by greenhouse personnel. If non-emergency items are called in directly to Facilities Maintenance without notifying Alec, the reporting party may be required to pay for the repairs from their own funds.

Visitors

Because this is a research facility, some restrictions apply:

- Individual visitors must be accompanied by a sponsoring greenhouse user at all times.
- Group tours must be scheduled in advance with Alec to avoid conflicts with research, which is our primary mission.
- The greenhouses are not a suitable site for children.

Prohibited Activities

- Use of any tobacco products is prohibited at all times within all greenhouse facilities because of the threat of tobacco mosaic virus.
- The greenhouses are a University facility and must abide by all University rules and regulations.
- No skateboards or roller-blades are permitted in the greenhouses.

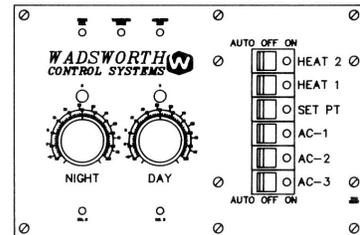
Greenhouse Systems

Wadsworth Environmental Controls

Greenhouse sections in the 117 and 119 wings have Wadsworth automated environmental controls providing three-stage cooling, heating, and an independent day / night set point for very precise temperature control. The control panel for each section is located in the main hallway of the headhouse. Please see Alec with any questions or for information on setting the controls for your section.

Hanging in the center of each section is a yellow sensor box, with temperature and light sensors wired to the controller in the main hallway. A photocell in the sensor box is what switches between the day and night set points.

The control panel in the hallway has knobs for the day and night temperature set point. A red lamp shows which set point is currently in use. A series of toggle switches on the right side control the heating and cooling equipment. **These switches should always be in the "AUTO" position.** A lamp by each switch indicates which functions are active.



Indicators are on at each switch under the following conditions:

- HEAT 2 – Not used.
- HEAT 1 – All heat in the section is on.
- SET PT – The temperature set at the controller has been reached.
- AC-1 – Low Fan is on. Depending upon the greenhouse this could mean
 - a) one of two fans is on, or
 - b) both fans are on at low speed.
- AC-2 – Water pump is supplying water to the cooling pads.
- AC-3 – High Fan is on. Both fans are on at high speed.

The roof vents in the greenhouse hallways open automatically in response to the section having the highest demand for airflow. Please keep the doors to the greenhouse hallway closed to avoid pulling air from the headhouse. Keep the door to each section closed because cooling efficiency is reduced when air is diverted around the cooling pads.

Automated Watering and Fertilization System

Regular irrigation and fertilization are critical for optimum plant growth. Some sections at the Research Greenhouse have drip irrigation systems that are connected to a fertilizer proportioner. These drip systems, along with several spigots within the greenhouses, dispense a complete and dilute nutrient solution. Because the growing media used in most of our research is soilless media, fertilization and proper irrigation are critical.

The fertilizer in the concentrate tanks is ~ 200X. Do not use the concentrate straight from the tank! It must be diluted by passing through the proportioner. Ask for a

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demonstration if you are unfamiliar with this equipment. The dilute fertilizer is complete and is the equivalent of $\frac{1}{4}$ strength Hoagland's solution. It is designed for daily watering of plants without fertilizer burn. The most up to-date fertilizer analysis is posted by the proportioners.

If you are interested in setting up an automated watering or nutrient delivery system for your section, Alec can help in locating the needed equipment and planning an irrigation system. Greenhouse staff can also help with the installation of equipment for a charge.

Automated Light Control

Supplemental lighting significantly improves plant growth, particularly during the winter season. Lamps at the Research Greenhouse Complex are 1000-Watt high-pressure sodium, which have excellent efficiency.

Every greenhouse section has a timer that controls outlets designated for lighting. These outlets and their associated wiring and circuit breakers have been sized properly to handle the load from the 1000-W lamps. Do not modify the plugs on the lamps, or use adapters or extension cords to plug additional lamps into other outlets, as this creates a fire hazard. Please ask Alec if you need to add more lamps.



Since 1000-W lamps produce a lot of heat, supplemental lighting makes cooling the greenhouse more difficult, and causes premature failure of fan motors and water pumps. To combat these problems, and to help conserve energy, an automated light control system has been installed for the entire complex. A PPF sensor mounted on the roof of section 119A reports light intensity to a datalogger in the main hallway. The datalogger is programmed with a light threshold level, typically $\approx 1000 \mu\text{mol}/\text{m}^2/\text{sec}^{-1}$. When natural light surpasses this level, the lamps are turned off. When natural light falls below this threshold, the lights are turned on again. There is a 15-minute delay built in to prevent damage to the lamps from rapid cycling.

The timer in each greenhouse determines the photoperiod for that section. A gray box next to the timer controls whether or not the automated light sensor system is controlling that section or not. The switch may be in one of three positions:

- **Auto.** When the switch is in the "Auto" position, the lights are controlled by the sensor and datalogger.
- **Hand.** When in the "Hand" position, the lights are on with no control by the datalogger or the timer.
- **Off.** In the "Off" position, the lights are off and not controlled by either the timer or datalogger.

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See Alec with any questions about supplemental lighting, photoperiod, or threshold light levels for the greenhouses.

Greenhouse Shading

When increasing outdoor temperatures make it difficult to maintain cool temperatures in the greenhouses, shade paint is applied to the **roof only** of greenhouse sections. Paint applied to the sides of greenhouses is ineffective and presents a security concern due to poor visibility.

Additional Cooling for Greenhouse Sections

Cooling at the Research Greenhouses is accomplished by a “pad and fan” cooling system in all sections. Some sections have been outfitted with misting fans to add still more humidity. These are connected to the building’s Reverse Osmosis water supply to avoid the deposition of salts in the greenhouse. Mist fans are commercially available, very quiet, and may be controlled by a humidistat to a range of humidity levels. The cost of the unit varies from \$350.00 to \$450.00 depending upon the size of fan and the controls desired.



Headhouse Infrastructure

Laboratory

There is a chemistry laboratory in the headhouse (Rm. 133) featuring precision electronic balances, reverse osmosis (deionized) water, and a fume hood. ***Those using this lab should complete the USU Lab Safety course, taught by the USU Environmental Health and Safety Department, <http://www.ehs.usu.edu/>.***

- This is a working lab. It is critical that users keep this area clean.
- The fume hood is not to be used as a storage space.
- The chemicals and supplies in this lab were purchased by the USU Crop Physiology Laboratory, and are not for general use without permission.
- The electronic balances in the laboratory are precision instruments, and have been calibrated in their present location. They are not to be moved from their current position. There is a moveable scale available by arrangement.

Growth Chamber Room

Room 140 houses several environmental growth chambers which are maintained by the USU Crop Physiology Laboratory. Growth chamber space, when available, may be rented by USU faculty or entities partnering in research with USU.

Room 140 also houses a hydroponic solution mixing station which is maintained by the USU Crop Physiology Laboratory. Researchers renting space at the Research Greenhouse Complex may be granted access to the hydroponic solution mixing station by arrangement.

Workshop

The Crop Physiology Laboratory maintains a workshop (Rm. 131) in the headhouse, with basic hand tools and some power tools. The tools are not for general use, and are not to be taken out of the shop without permission. Supplies in this workshop are property of the USU Crop Physiology Laboratory. Ask permission before making use of items found in the workshop.

Users should be aware that power tools are dangerous and are used at their own risk. The greenhouse staff is neither qualified nor authorized to instruct anyone in the use of power tools. If needed, get help from a qualified instructor. Once you're done using the workshop, please return the favor by cleaning up any mess you've made and returning tools to their proper locations.

Graduate Student Office

Room 138 in the headhouse serves as an office for graduate students, and to provide occasional computer access to guest users. Computer accounts must be approved by Alec, Bruce, or Julie. Those not on the permanent staff of the greenhouse or pursuing advanced degrees will be provided with a guest account. The computers are not to be used for any work unrelated to research being done at the Research Greenhouse Complex.

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Photocopier

A photocopier which is owned and maintained by the Plants, Soils, and Climate Department is available in Laboratory 142. A user code is required for this machine. If you have a user code for the copiers in the PSC department on campus, that code will work here as well.

Photography Area

Outside of Room 138 is a photography area. Lights, a tripod, and black backgrounds are available to aid in the photographic documentation of experiments. The background is to be rolled up, out of harm's way after every use. The black velour cover on the table must remain clean. Do not put dirty or wet pots on the velour.

Practice Environmental Awareness

Learn to “feel” the environment of each room so that you recognize a problem when one exists (e.g. coolers not operating, vent stuck open or closed, heat not functioning or heat on at wrong time, etc.). Are the lights on at the correct time? Bring any problems to Alec's attention.



Utah State University Campus



Building Index

Code	Name
G-3	Agribusiness
K-3	Agricultural Science (Elmer George Peterson)
K-4	AgriLife
K-5	AgriLife Apartments
F-2	AgriLife Plaza
K-6	AgriLife Plaza
K-7	AgriLife Plaza
K-8	AgriLife Plaza
K-9	AgriLife Plaza
K-10	AgriLife Plaza
K-11	AgriLife Plaza
K-12	AgriLife Plaza
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K-100	AgriLife Plaza

G-4	MAC
L-3	HSS
L-2	HSS
L-1	HSS
L-4	HSS
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L-7	HSS
L-8	HSS
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L-49	HSS
L-50	HSS

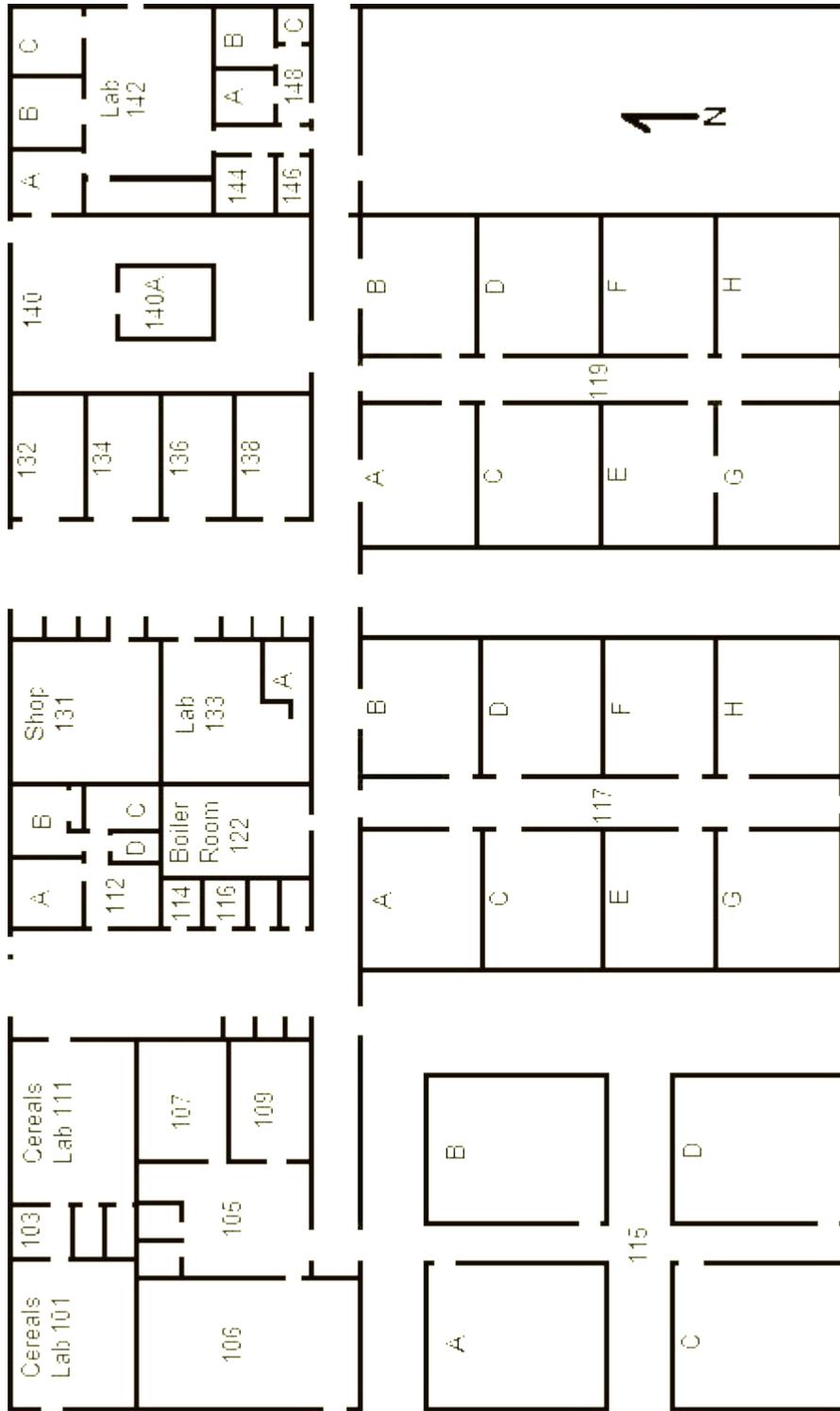
C-3	SOFTT
C-2	STOR
C-1	SIAMT
C-4	TSC
C-5	TSC
C-6	TSC
C-7	TSC
C-8	TSC
C-9	TSC
C-10	TSC
C-11	TSC
C-12	TSC
C-13	TSC
C-14	TSC
C-15	TSC
C-16	TSC
C-17	TSC
C-18	TSC
C-19	TSC
C-20	TSC
C-21	TSC
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C-29	TSC
C-30	TSC
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C-32	TSC
C-33	TSC
C-34	TSC
C-35	TSC
C-36	TSC
C-37	TSC
C-38	TSC
C-39	TSC
C-40	TSC

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Map of Research Greenhouse Complex



Research Greenhouse Aerial Photograph



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PI Signature

Date

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