PLANT SCIENCE RESEARCH CENTER YEARLY REPORT 2007-2008

On July 1, 2007, the Directorship of the Plant Science Research Center (PSRC) was passed to Scott Leisner, an associate professor in the Department of Biological Sciences. As part of his duties as Director, he is required to file yearly reports. This is the first such report describing the activities that occurred in the PSRC over the course Dr. Leisner's first year as PSRC Director from July 1, 2007 to June 30, 2008. This report is organized into 7 sections. The first section describes the composition of the PSRC, in terms of facilities, equipment, and personnel. The second section provides a history of the events occurring during the designated time period. The third section reports the accomplishments of the PSRC including the academic achievements its various members. The fourth section indicates the outreach work that the PSRC has engaged in during this time. The fifth section describes the PSRC budget and what the monies were used for. The sixth section describes the weaknesses of the PSRC. Finally, the seventh section provides information regarding the future plans for the PSRC. It is anticipated that the reports filed in successive years will not be as comprehensive as this one, which is the first of its kind.

I. COMPOSITION OF THE PSRC

The UT PSRC became operational in 1998 under the auspices of Dr. Stephen Goldman. The PSRC was designed to be a sophisticated facility allowing researchers to propagate and study plants. To permit this research, the PSRC was designed to contain a variety of growth facilities. In addition, the PSRC also possesses other laboratory equipment, to aid researchers in their work. Finally, the PSRC would not be functional if it were not for the personnel that use the facility. Below, the Plant Growth Facilities, Equipment, and Personnel are described.

I.A. PSRC Plant Growth Facilities

PSRC plant growth facilities refer to equipment for plant propagation. These include high quality research greenhouse and growth chamber facilities with advanced control systems. Since this is typically the limiting step for plant research, we have provided information below on the various plant propagation facilities contained within the PSRC.

I.A.1. Greenhouses

The PSRC currently contains 5 greenhouse modules that are used by researchers. The greenhouse modules are 20 feet by 30 feet providing 600 square feet of growth space per module for a total of 3000 square feet of growth space under glass. The greenhouse modules are computer controlled to regulate temperature, humidity, and light. Each module is an independent unit and with separate controls to for each module for regulating growth parameters. Temperature is controlled by convective heating, while cooling is accomplished via air flow over water-containing cooling pads and ejected out the other end of the greenhouse by exhaust fans. Supplemental light is also provided. Each module possesses its own water supply and drains as well.

I.A.2. Growth Room

The PSRC contains an EGC walk-in growth room (in WO 4276) containing 12 shelves and each shelf is 12 square feet for a total of 144 square feet of growth space. The growth room, made by EGC, permits more tightly controlled growth conditions for propagating plant material than a greenhouse. Hence the light quantity, photoperiod, temperature, and humidity can be tightly controlled. However, this growth room only permits one set of light, temperature, and humidity parameters to be used at one time.

I.A.3. Growth Chambers

To permit a wider range of growth parameters to be varied, yet controlled precisely, the PSRC currently houses 6 Conviron growth chambers. These chambers permit regulation of light quantity, photoperiod, temperature, humidity like the growth room, but since they are independent units, this permits greater flexibility in controlling conditions than a growth room. The one PGR15 that we have is the largest of the chambers. This chamber is good for growing larger plants under controlled conditions, or a large number of small plants. The internal growth space of the PGR15 is 15.85 square feet of growing space. The next chambers down in size in size are the E7/2s of

which, the PSRC owns 3. The E7/2s are split-level chambers that do not permit growing tall plants (like the PGR15) but do permit two different growth variables to be altered simultaneously. This permits additional flexibility when examining the effects of environmental conditions on plant growth. Each chamber possesses 8 square feet of growing space each for a total of 16 square feet per unit. Finally, the PSRC possesses 2 TC-16 growth chambers. These chambers are multi-level and each shelf provides 5 square feet of growth space and each unit contains 5 shelves for a total of 25 square feet. The TC-16s are used for growing plants in tissue culture.

I.B. PSRC Equipment

In addition to plant propagation space, other pieces of equipment are required for performing plant research. These include: centrifuges, a spectrophotometer, a scintillation counter, a laminar flow hood and other items. All items except the last two are covered by a service contract with the company Technical Alternatives.

I.B.1. Conventional Centrifuge

This piece of equipment is used for multiple purposes, from concentrating bacterial cells for DNA isolation to the purification of specific cell components. This machine allows separation of materials by placing them under centrifugal forces up to about 20,000 times the force of gravity (20,000 xg).

I.B.2. Ultracentrifuge

Like it's companion above, this piece of equipment has multiple purposes, from purifying DNA to the isolation of specific cellular organelles. While the above machine permits crude fractions to be prepared, this machine allows better separation of materials because it can place them under centrifugal forces up to about 150,000-200,000 xg.

I.B.3. Spectrophotometer

Another multifunctional piece of equipment. This device determines the amount of specific wavelengths of light that pass through a sample. This can then be used to determine the purity of the sample, the amounts of certain chemicals present, and if tied to time, can permit one to measure the activity of specific cellular catalysts called enzymes.

I.B. 4. Scintillation Counter

This piece of equipment permits the measurement of the amount of radioactivity within a specific sample. Since some techniques used in our laboratories use radioactive tracers to follow chemical reactions or examine the location of specific DNA sequences on a filter, we employ this device for measuring where the radioactivity is located.

I.B.5. Laminar Flow Hood

To work with plant tissue cultures, it is critical that they be kept sterile. The best way of accomplishing this is create a sterile environment and that is the purpose of the laminar flow hood.

I.B.6. Other Equipment

In addition to the large pieces of equipment mentioned above, the PSRC also contains other equipment such as: A gel documentation system, microscopes, a dual block PCR machine, an electroporator, ovens, an incubator a phosphorimager, a rocker table, a shakers, stir plates, and UV cross linker.

I.C. PSRC Personnel

The PSRC facilities and equipment described above are useful for plant research. However, the PSRC would not exist if not for the people who work there and use the facilities. PSRC personnel come from a variety of units including two Arts and Sciences Departments: Department of Biological Sciences, Department of Environmental Sciences, as well as the United States Department of Agriculture-Agricultural Research Service (USDA-ARS). The PSRC is also tended by a dedicated Greenhouse Manager. In addition to their own research, described below, each of the principal investigators for each unit is a member of the PSRC Advisory Committee, providing useful input and making decisions regarding growth space and other PSRC matters.

I.C.1. Department Of Biological Sciences

Two researchers from the Department of Biological Sciences are currently using PSRC facilities: Drs. Gray and Leisner.

I.C.1.a. Dr. John Gray

The research in Dr. Gray's laboratory is currently focused in two main areas. His first area of research examines regulomics in corn. An emerging theme in the regulation of gene expression is the identification of the regulatory networks in which transcription factors (TFs) participate. It is estimated that the number of TFs in maize could be up to 10% of the genome, representing more than 4000 proteins. As part of a long-term effort to investigate and understand grass regulatory networks, The Grass Transcription Factor ORFeome Project was initiated. The aim of this part of the project is to establish a collection of TF ORFs (open reading frames) that can be overexpressed for protein production. These proteins will be used to raise antiserum to be employed in developing chromatin-immunoprecipitation (ChIP) techniques aimed at TF target genes in the maize genome. In addition, information on grass TFs will be mined from databases and used to populate the GRASSIUS database. Thus far (in the first year of this project) over 75 novel Transcription factors have been cloned from corn and their over-expression has begun.

In addition to his work on transcription factors, Dr. Gray is also studying nutrient stress in plants. Nutrient-stressed plants exhibit internal changes prior to the display of visual symptoms (*e.g.*, "Hidden Hunger"). A USDA Specific Cooperative Agreement with two University of Toledo investigators (John Gray, Scott Heckathorn) investigates this phenomenon. The Gray lab is using genomic techniques to identify molecular markers of nutrient imbalance. Monitoring these markers will permit nutrient correction before plants show visual symptoms (and thus help avoid commercial losses). Earlier

work defined changing nutrient requirements during *Pelargonium* (geranium) growth and is being used to more carefully define nutrient regimes. In addition, novel genes whose expression is altered following boron (B) deficiency stress were identified in the model plant *Arabidopsis thaliana*. Over the past year, full-length genomic clones of these markers were isolated from *Arabidopsis* and from greenhouse geraniums. Some of these markers were induced significantly in response to B deficiency. One of these genes is a novel mitochondrial protein found only in plants, and current work is aimed at identifying its link to B metabolism. Dr. Gray also collaborates with other investigators to provide bioinformatical analysis. Dr. Gray's laboratory currently consists of a post-doc, 2 Ph.D. students and 8 undergraduate students and a technician.

I.C.1.b. Dr. Scott Leisner

Dr. Leisner is the current PSRC Director. The research performed by Dr. Leisner's laboratory mainly involves studying plant-virus interactions and the role of nutrition in these interactions. His laboratory is working on a variety of projects. First, his laboratory is studying the interactions among the various proteins of *Cauliflower mosaic virus* and their relationship to virus resistance in the model plant *Arabidopsis thaliana*. Second, a new virus (*Turnip ringspot virus*, TuRSV), discovered by Dr. Leisner's laboratory is being characterized. Third, the effects of silicon on viral infection are being studied in a variety of host plants. Fourth, the protein interactions of a pair of ornamental plant pathogens, *Pelargonium flower break virus* (PFBV) and *Pelargonium line pattern virus* (PLPV) are being elucidated. Fifth, PFBV and PLPV infection of *Arabidopsis thaliana* is being studied. Finally, Dr. Leisner's laboratory has cloned and is examining a *Pelargonium* gene implicated in virus resistance. Currently Dr. Leisner's laboratory consists of: 2 post-docs, 2 Ph.D. students, 1 undergraduate student and 1 technician.

I.C.2. Department Of Environmental Sciences

Three researchers from the Department of Environmental Sciences are currently using PSRC facilities: Drs. Dwyer, Heckathorn and Weintraub.

I.C.2.a. Dr. Daryl Dwyer

Dr. Dwyer's laboratory focuses on environmental remediation and restoration. Researchers in the Environmental Remediation and Restoration Laboratory (ERRL) primarily design methods to remediate contaminated sites and restore native habitat. Three major projects are currently underway. First, his laboratory is examining evapotranspiration covers to control leachate at older landfills. Next they are studying passive, plant-based treatment systems for arsenic-laden waters. Finally, his laboratory is examining wetlands for their ability to reduce the input of bacteria and nutrients to Maumee Bay. The facilities at the PSRC were used to grow and investigate the plants that are used in these projects. Currently, is laboratory is investigating 15 plant species for incorporation into landfill covers and seven plant species for the ability to take up arsenic. Dr. Dwyer's laboratory consists of 2 Ph.D. students, 2 M.S. students, 6 undergraduate students, and 3 technicians.

I.C.2.b. Dr. Scott Heckathorn

Dr. Heckathorn's research examines plant, and more recently algal, ecological physiology and biochemistry, stress physiology and stress proteins (especially heat-shock proteins, or HSPs), photosynthesis and respiration, and nutrient relations. Most of the current and recent research is focused on the following on-going projects: the effects of environmental controls associated with global climate change (e.g., CO_2, nitrogen, mean temperature) on tolerance and adaptations of plants to acute heat stress [with particular focus on photosynthesis and HSPs, plant productivity, and community composition]; the patterns, functional consequences, and causes of natural variation in protection of metabolism by small HSPs; micro-nutrient (especially boron) deficiency and toxicity effects on physiology and protein expression in plants; the causes of Microcystis cyanobacterial blooms in western Lake Erie; and the feasibility of using Lake Erie algae for bio-fuel production. Dr. Heckathorn's laboratory currently consists of a post-doc, a Ph.D. student and 2 MS students.

I.C.2.c. Dr. Michael Weintraub

Dr. Weintraub's research focuses on environmental disturbance. Global climate change, nutrient deposition, changes in plant community composition, increases in atmospheric CO2 concentrations, and other disturbances all have the potential to alter important ecosystem properties such as nutrient availability to both plants and soil microbes, soil organic matter (SOM) decomposition rates, and the quantity and quality of carbon (C) inputs to the soil. However, in many cases we don't understand the mechanisms underlying important ecosystem processes well enough to predict the effects of disturbances. In an effort to improve our understanding of how ecosystems function and predict their responses to disturbances, the goal of the Weintraub laboratory is to gain insight into the controls on soil nutrient dynamics and SOM decomposition by linking the ecology of soil microorganisms to ecosystem processes. Dr. Weintraub's laboratory currently consists of, a Ph.D. student and 3 MS students and an undergraduate student.

I.C.3. USDA-ARS

Three researchers from the USDA-ARS are currently using PSRC facilities: Drs. Frantz, Krause and Locke.

I.C.3.a. Dr. Jonathan Frantz

Dr. Frantz's research mainly focuses on plant nutrition. This year, the work performed at the PSRC included four experiments. First, the evaluation of *Pelargonium* species for susceptibility to phosphate stress. Second, the evaluation of *Pelargonium* species for susceptibility to boron stress. Third, a collaborative project with Dr. Scott Leisner and his laboratory that investigated the interactive effects of Si and Cu toxicity in zinnia. Finally, an examination of the reflectance of geranium and New Guinea impatiens in response to different rates of applied phosphate is being conducted. Dr Frantz's laboratory currently consists of 3 student workers and 3 technicians.

I.C.3.b. Dr. Charles Krause

Dr. Krause's research is in the area of plant pathology. However, being a research leader he also spends a great deal of time coordinating the efforts of laboratory scientists with stakeholders in the form of on-farm research. Cooperative field studies using 'on-farm' research along with rigorous laboratory studies by ATRU scientists have resulted in reductions of pesticide usage with potentially less negative impact on the environment and increased profitability. The vehicles for ATRU technology transfer activities are liaison committee meetings, 'Green Industry' trade show booths, participation in industry field days, pesticide spray night seminars all with all with "hands-on" opportunities for growers and research handouts. The above activities are accomplished with the close participation of Ohio State University Extension, Purdue University Extension and Michigan State University Extension. The stature obtained by the ATRU team is evidenced by frequent presentation requests by professional industry organizations that include: the Ohio State University Nursery and Floricultural Short Courses; OFA, CENTS trade shows; request to webcast ATRU research results by NPATA, and many others. Growers, stakeholders and other educators then realize the relevance of ARS Research and are able to provide feedback at appropriate times such as ARS National Program Workshops and other special events that require customer input of industry needs. Toledo Area stakeholder, Richard Bostdorff, participated in the USDA, ARS National Program Workshop in Florida on Crop Production and at a USDA, ARS Midwest Area seminar to show how USDA, ARS/PSRC Scientists work together with growers.

I.C.3.c. Dr. James Locke

Dr. Locke's research is focused on the fungal pathogens of ornamental plants. His latest project entails 3 major research foci. First, his laboratory is examining the potential interactions of plant nutrition with disease development. Second, they are testing the potential of silicon to serve a beneficial role in reducing biotic and abiotic stress on floricultural crops. Finally, his laboratory is engaged in the development of new and innovative approaches to reduce disease losses in greenhouse floricultural crop production. His laboratory has used the PSRC facilities for a variety of purposes, for example: to propagate and maintain test plant materials for various studies; to evaluate the uptake and accumulation potential of silicon in sixteen crops; to evaluate various delivery systems to supply silicon to selected "accumulator" species through root uptake utilizing varying silicon sources in the growing medium under greenhouse growing conditions; to evaluate the phosphorus x Pythium ultimum interaction on seed geranium; to carry out a Calibrachoa x pathogens x silicon study to determine interactions of this host with common greenhouse pathogens and silicon; and to study the stress response and disease severity of Pythium ultimum on impatiens under varying phosphorus regimens. His laboratory currently consists of a post doc and a technician.

I.C.4. Other Researchers

In addition to the personnel described above several other scientists are also using the PSRC facilities for a more limited period of time. Those researchers are listed below with a short description of what they are doing.

I.C.4.a. Tom Bridgeman. Dr. Bridgeman, of the Department of Environmental Sciences, is working in collaboration with Dr. Scott Heckathorn studying Lake Erie algae.

I.C.4.b. Hans Gottgens. Dr. Gottgens, of the Department of Environmental Sciences, is working on phytoremediation of soils by wetland plants.

I.C.5. Greenhouse Manager

In addition to the researchers, the PSRC also employs a full-time "Greenhouse Manager" to tend the facility. This person is, Vera Lynn Biltz. Ms. Biltz has a variety of duties. She is to insure the day-to-day functioning of the PSRC and work to accommodate the needs of the users. Her job requires her to adjust and run the control systems that operate the greenhouses and plant growth chambers and clean the facility. She carrys out basic maintenance on greenhouses, growth chambers, and other equipment associated with the PSRC where possible. In addition, she sprays plants for pests and pathogens on a regular basis, as well as develops an integrated pest management program. Finally, she processes space requests and keeps up her pesticide applicator's license.

II. EVENTS OCCURING IN THE PSRC 2007-2008

Below is a chronology of the events taking place in the UT PSRC over the past year. A short bit of what occurred before that is included for completeness, but it is in no way comprehensive.

1998 After many years of struggle, the persistence of Dr. Stephen Goldman pays off and the UT-PSRC opens with Dr. Goldman as it's first Director.

1/1/2007 Leadership of the PSRC is passed on to Dr. Constantine Theodosiou as the interim Director.

2/8/07 First meeting of the PSRC Advisory Committee.

2/15/07 First Greenhouse/Growth Chamber Space Request Forms are assembled.

2/19/07 First Greenhouse/Growth Chamber Space Request Forms are sent out to faculty.

2/26/07 First democratic space allocations are made

4/12/07 Second PSRC Advisory Committee meeting.

5/17/07 Requests for nomination of new PSRC Director

6/8/07 Rooms BO0125 and BO0130 are assigned to the PSRC.

7/1/07 Dr. Scott Leisner accepts Directorship of the PSRC.

8/1/07 Greenhouse manager position is approved and posted internally.

8/14/07 Third PSRC Advisory Committee meeting.

8/14/07 Committee composition for Greenhouse Manager search is approved.

10/22/07 Call for requests for greenhouse space to be assigned by PSRC Advisory Committee.

9/05/07 Fourth PSRC Advisory Committee meeting.

9/6/07 Greenhouse space assigned by PSRC Advisory Committee.

9/14/08 Greenhouse Manager search committee meets and identifies 4 candidates for interview.

9/19/07 Greenhouse manager applicants approved for interview.

9/26/08 PSRC subcommittee meeting to re-organize the PSRC website.

10/5/07 Greenhouse use policy for PSRC facilities approved by advisory committee.

10/22/07 A morning conference for Congresswoman Marcy Kaptur takes place.

10/24/07 Vera Lynn Biltz is hired as Greenhouse Manager.

11/11/07 Old PSRC Website inactivated and new one activated.

12/10/07 Fifth PSRC Advisory Committee meeting.

12/11/07 Computer training for PSRC greenhouse systems control.

12/13/08 A one page bulletin describing the new PSRC website is presented to the Maumee Valley Growers Association (MVGA). Drs. Jonathan Frantz and Scott Leisner also discuss how they will be presenting a series of talks on PSRC research over successive months to the MVGA. Dr. Frantz presents a talk on silicon uptake by ornamental plant species

1/10/08 Dr. Leisner presents a talk to the MVGA on the alleviating effects of silicon on copper toxicity.

1/22/08 Wiring is completed for PSRC centrifuges. WO 4217 is designated as a PSRC common equipment room.

1/30/08 Drs. Leisner and Frantz present talks to the Metro Detroit Flower Growers Association at their annual meeting on the research activities of the PSRC.

3/19/08 Dr. Leisner presents a talk describing PSRC research to the Farm Bureau.

4/10/08 Drs. Frantz/Dr. Locke present a talk to the MVGA on the alleviating effects of silicon on fungal infection.

4/14/08 First meeting of the Native Plant Working Group.

5/6/08 Sixth PSRC Advisory Committee meeting.

6/10/08 Second meeting of the Native Plant Working Group.

6/12/08 Dr. Leisner presents a talk to the MVGA on the alleviating effects of silicon on virus infection.

6/16/08 Manuscript by Drs. Li, Frantz and Leisner on the alleviating effects of

silicon on copper toxicity is accepted for publication by Journal of the American Society of Horticultural Science. This is the first manuscript accepted for publication from a collaboration between UT Department of Biological Sciences faculty and the USDA-ARS that was funded by a Specific Cooperative Agreement.

6/20/08 Dr. Leisner presents a talk describing PSRC research to Dr. Karl Ronn of Proctor and Gamble.

III. ACCOMPLISHMENTS OF THE PSRC

The PSRC has accomplished a great deal over the past year. For one thing, a rejuvenated image for the PSRC, catalyzed by more direct contact with and appeal to concerns of area growers has led to a better understanding of their problems and the PSRC has begun to adapt accordingly. With this in mind, the entire structure of the PSRC has been overhauled, a new employee has been hired and the faculty comprising the advisory committee have been very successful, both with respect to their publications (6 submitted, 12 accepted, and 23 manuscripts published) and funding (>$6,500,000.00). Below we describe these achievements.

III.A. Governance

On January 1, 2007, Dr. Constantine Theodosiou (Interim Director of the PSRC) instituted a democratic form of governance for the PSRC. This has been continued under the directorship of Dr. Scott Leisner. In the past, the PSRC was governed by one person. The PSRC is currently governed by a committee consisting of active plant science researchers located at UT. Each committee member has an equal voice in deciding allocation of resources. This ensures consensus is established at the start of any work. All committee members have been equally cooperative in sharing space as well as other PSRC resources. In addition, the committee has met regularly (6 times since January 1) to discuss and prioritize needs and requirements for their research. These changes have resulted in access of more plant science researchers to greenhouse space. Hence, the number of researchers from independent laboratories using the center is greater than it has ever been.

III.B. Collaboration

The new, transparent governance structure and implementation of an open access policy to allow the broadest possible access has led to an unprecedented level of collaboration among PSRC researchers. As things now stand, there are a group of scientists from a number of departments who have common interests and who now can gather around shared resources. Collaborations have appeared among faculty members of the same department (e.g., Drs. Gray and Leisner) among different departments (Drs. Gray and Heckathorn; Drs. Leisner and Weintraub) and among departments and the USDA-ARS personnel (e.g., Drs. Gray, Heckathorn, and Frantz; Drs. Heckathorn and Frantz; Drs. Dwyer and Frantz; and Drs. Leisner and Frantz). The collaboration between Drs. Heckathorn and Frantz have already borne fruit in the form of an accepted manuscript (Mishra, S.; Heckathorn, S., Barua, B. D.; Wang, D.; Joshi, P.; Hamilton, E.W.; and Frantz, J. The interactive effects of elevated CO_2 and ozone on leaf thermotolerance in field-grown (Glycine max) soybean (in press, Journal of Integrated Plant Biology, special issue on "global climate change")). Likewise, the collaboration of Drs. Frantz and Leisner has also resulted in an accepted manuscript (Li, J.; Frantz, J.; and Leisner, S., Alleviation of Copper Toxicity in *Arabidopsis thaliana* by Silicon Addition to Hydroponic Solutions (*in press*, Journal of the American Society of Horticultural Science). In addition, the collaboration of Drs. Dwyer and Frantz has also resulted in a publication (Rofkar, J., D. Dwyer, and J. Frantz. 2007. Arsenic Accumulation by Plant

Species Selected for Growth in Northwest Ohio. Comm. Soil Sci. Plant Analysis. 38:2505-2517). Other work is expected to result in additional manuscripts fairly soon. The collaborations have not been limited to PSRC members but also to interactions of those individuals with growers as described in Section IV.

The collaborations among PSRC members are not limited to research but also to the overall functioning of the center. For example, the forms for requesting greenhouse/growth chamber space were generated by Dr. John Gray, with the assistance of Dr. Constantine Theodosiou. The renovations to PSRC website were directed by Dr. Michael Weintraub. Numerous repairs to PSRC greenhouses, before the greenhouse manager was hired, were carried out by Dr. Jonathan Frantz. Other repairs were accomplished by the UT Plant Operations personnel, who have been extremely helpful. Other researchers have been very willing to share greenhouse space to help accommodate other researcher's work. So collaboration at multiple levels in the PSRC is now the rule.

III.C. Infrastructure Improvements

Changes, up-grades, repairs, and personnel all fall under this category.

III.C.1. User Fees

As mentioned in Section VI below, maintaining PSRC facilities is expensive. To help defray these costs, we have instituted a set of fees for greenhouse space. The fees are charged at a modest cost of $10 per bench per month.

III.C.2. Greenhouses

The PSRC greenhouses were not previously maintained appropriately. However, now they are being maintained and repaired on a regular basis. The computer control system has been up-graded to the most current version. PSRC personnel have also been trained on how to use and program it. Lights have been cleaned, along with fans and vents. The systems controlling each greenhouse module are continually monitored and repairs are called in when necessary. The Plant Operations people have been extremely helpful in assisting the PSRC with repairs. Hence, the greenhouses are functioning well.

III.C.3. Growth Chambers

Previously, the PSRC growth chambers were either partially functional or non-functional. However, at this time, all of the chambers have been repaired and are working as they should, except one. We anticipate repairs on this remaining chamber to be completed within a month or so. A schedule for preventive maintenance has been generated by the Greenhouse Manager and implemented. Hence, almost all of the growth chambers are functioning as they should.

III.C.4. PSRC Equipment

The PSRC possesses a number of important pieces of equipment. Previously, many of these were not used because they were not on service contracts to repair problems should they arise. Now, all of the major pieces of equipment have been repaired and are on service contracts to provide care should they break down.

III.C.5. PSRC Personnel

Over the past year, the PSRC has hired a dedicated Greenhouse Manager named Vera Lynn Biltz. Her description is listed above in Section I.C.5.

III.D. Education

Several items fall under education including the PSRC website, and the PSRC Symposium. These are described below. Presentations to growers, hand-outs and articles regarding research projects of interest to growers, etc. also occurred. While the interactions with growers are only mentioned in passing here, a more detailed description of what was done is given in Section IV below.

III.D.1. PSRC Website

The PSRC website has been completely upgraded from its previous form. The homepage for this website (http://www.utoledo.edu/as/psrc/home/aboutUs.html) now has a good deal of information regarding the people and the research taking place at the PSRC. The website contains several sections that describe our mission, provide information regarding the various members, and provide forms for requesting greenhouse and growth chamber space as well as the policies regulating their use. The research section contains descriptions of the work done by the investigators and one-page summaries, in case the reader does not have time to read the complete paper. The site also contains a special section called, "Growers Corner" which contains useful information for growers (described in Section IV.C.1).

III.D.2. USDA-UT Cooperative Project Meeting

On October 22, 2007, a meeting was held on the UT campus (Bowman-Oddy room 1045) to discuss the status of the USDA-UT cooperative project. The meeting consisted of a series of presentations given by various individuals, some of which were members of the PSRC. First, Dr. Frank Calzonetti gave a short introduction to the project. Next, Dr. Jonathan Frantz gave an overview of the USDA perspective. Next, Dr. Leisner gave a short overview of where the PSRC was and where it would be going. After that, Dr. Frantz gave a short presentation regarding how research was being translated into benefits for growers. Following that, Dr. Neil Reid gave a short presentation regarding the status of the Maumee Valley Grower's Association. Next came a presentation from Dr. Beth Fausey and Richard Bosdorf on the status of the ornamental plant industry. Finally, Dr. Calzonetti gave a concluding presentation regarding plant science.

III.E. PSRC Members' Individual Accomplishments

As reported above, the PSRC members are from a variety of departments and government institutions. Below are described the individual achievements and collaborative efforts in the form of manuscripts and grant funding contributed by PSRC members.

III.E.1. Department Of Biological Sciences

Two researchers from the Department of Biological Sciences are currently using PSRC facilities: Drs. Gray and Leisner.

III.E.1.a. Dr. John Gray

Manuscripts

Smith, K.A., Komuniecki, R.W., Ghedin, E., Spiro, D. and **J. Gray.** 2007. Genes encoding putative biogenic amine receptors in the parasitic nematode *Brugia malayi*". Invertebrate Neuroscience 7: 227-244.

Wragg, R.T. Hapiak, V., Miller, S.B., Harris, G.P., **Gray, J.,** Komuniecki, P.R., and R.W. Komuniecki. 2007. Tyramine and octopamine independently inhibit serotonin-stimulated aversive behaviors in *Caenorhabditis elegans* through two novel amine receptors. Journal of Neuroscience 27: 13402-13412.

Bartsch S, Monnet J, Selbach K, Quigley F, **Gray J**, von Wettstein D, Reinbothe S, and C. Reinbothe C. 2008. Three thioredoxin targets in the inner envelope membrane of chloroplasts function in protein import and chlorophyll metabolism. Proc. Natl. Acad. Sci. U.S. A. 105: 4933-8.

Grant Funding

National Science Foundation Plant Genome Research Program (PGRP), Grotewold, E., Gray, J. and Dauluri R., $2,600,000. TRPGR--The Grass Regulome Initiative: Integrating control of gene expression and agronomic traits across the grasses. 2007-2010.

U.S. Dept. of Agriculture, Gray, J. and Heckathorn, S.A., $637,973. Biomonitoring of nutritional and environmental stress in plants. 2004-2009.

Ohio Plant Biotechnology Consortium, Gray, J. and Grotewold, E., $80,000. Identification of carbohydrate and phenolic metabolism regulatory genes in corn. 2007-2008.

III.E.1.b. Dr. Scott Leisner

Manuscripts

Rajakaruna, P., Khandekar, S., Meulia, T., and **S.M. Leisner**. 2007. Identification and host relations of Turnip ringspot virus, a novel comovirus from Ohio. Plant Disease 91: 1212-1220.

Li, J., Frantz, J., and **S. Leisner**. Alleviation of Copper Toxicity in *Arabidopsis thaliana* by Silicon Addition to Hydroponic Solutions. *Accepted 6/16/08*, Journal of the American Society of Horticultural Science.

Hapiak, M., Li., Y., Agama, K., Swade, S., Okenka, G., Falk, J., Khandekar, S., Raikhy, G., Anderson, A., Pollock, J., Zellner, W., Schoelz, J., and **S. M. Leisner**. *Cauliflower mosaic virus* gene VI product N-terminus contains regions involved in resistance-breakage, self-association and interactions with movement protein. *Submitted* to Virus Research.

Grant Funding

U.S. Dept. of Agriculture, Leisner, S.M., $289,905. Examination of factors influencing virus disease in floriculture crops. 2007-2008.

III.E.2. Department Of Environmental Sciences

Three researchers from the Department of Environmental Sciences are currently using PSRC facilities: Drs. Dwyer, Heckathorn and Weintraub.

III.E.2.a. Dr. Daryl Dwyer

Manuscripts

Chowdhury, R., Defne A., and **D.F. Dwyer**. 2008. Preliminary studies for designing a wetland for arsenic treatment. Submitted to *Groundwater Modeling, Management, and Contamination*.

Barnswell, K. D. and **D.F. Dwyer**. 2007. Vegetation survey of an inactive municipal solid waste landfill: implications for restoration and leachate control. Submitted to the *Journal of Environmental Engineering*.

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National Resources Conservation Service, Dwyer, D. $120,03868. Stream Gage Installation. 2007-2010.

US Dept. of Agriculture, Dwyer, D., $721,853. Phytoremediation Plant Research. 2006-2009.

III.E.2.b. Dr. Scott Heckathorn

Manuscripts

Spijkerman, E., Barua, D., Gerloff-Elias, A., Kern, J., Gaedke, U., and **S**. **Heckathorn.**

2007. Stress responses and metal tolerance of *Chlamydomonas acidophila* in metal-enriched lake water and artificial medium. Extremophiles 11:551-562.

Zhu, B., Mayer, C., **Heckathorn S.,** and L.G. Rudstam 2007. Can dreissenid attachment and biodeposition affect submerged macrophyte growth? Journal of Aquatic Plant Management 45:71-76.

Wang, D., **Heckathorn, S.**, Barua, D., Joshi, P., Hamilton, E.W., and J. LaCroix. 2008. Effects of elevated CO_2 on the tolerance of photosynthesis to acute heat stress in C3, C4, and CAM species. American Journal of Botany 95:165-176.

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Mishra, S., **Heckathorn, S.**, Barua, D., Wang, D., Joshi, P., Hamilton, E.W., and J. Frantz. The interactive effects of elevated CO_2 and ozone on leaf thermotolerance in field-grown (Glycine max) soybean. (*in press*, Journal of Integrated Plant Biology, special issue on "global climate change").

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III.E.2.c. Dr. Michael Weintraub

Manuscripts

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effects of tree rhizodeposition on soil exoenzyme activity, dissolved organic carbon, and nutrient availability in a subalpine forest ecosystem. Oecologia DOI: 10.1007/s00442-007-0804-1.

Grandy, A.S., Neff, J.C., and **M.N. Weintraub.** 2007. Carbon Structure and Enzyme Activities in Alpine and Forest Ecosystems. Soil Biology and Biochemistry DOI: 10.1016/j.soilbio.2007.05.009

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Sinsabaugh, R.L., Lauber, C.L., **Weintraub, M.N.**, Ahmed, B., Allison, S.D., Crenshaw, C., Contosta, A.R., Cusack, D., Frey, S., Gallo, M.E., Gartner, T.B., Hobbie, S.E., Holland, K., Keeler, B.L., Powers, J.S., Stursova, M., Vesbach, C., Waldrop, M.P., Wallenstein, M.D., Zak, D.R., and L. Zeglin. *in review*. Stoichiometry of soil enzyme activity at global scale. Ecology Letters.

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Grant Funding

National Science Foundation International Polar Year Program, Schimel, J.P., Reardon K., Wallenstein M., Weintraub M.N., $904,623. Microbial winter survival physiology: a driver on microbial community composition and carbon cycling. 2007-2010.

University of Toledo Center for Teaching and Learning Summer Teaching Fellowship, (Lawrence, P.L., Weintraub, M.N., Czajkowski, K., $8,950. 2008.

III.E.3. USDA-ARS

Three researchers from the USDA-ARS are currently using PSRC facilities: Drs.

Frantz, Krause and Locke.

III.E.3.a. Dr. Jonathan Frantz

Manuscripts

Frantz, J.M., Locke, J.C., Datnoff, L., Omer, M., Widrig, A., Sturtz, D., Horst, L., and C.R. Krause. Detection, distribution, and quantification of silicon in floricultural crops utilizing three distinct analytical methods. Comm. Soil Sci. Plant Analysis. *Accepted 8-31-07.*

Frantz, J., Locke, J., and D. Pitchay. 2007. Improving Growth of Calibrachoa in Hanging Flower Pouches. HortTechnology 17:199-204.

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The Ohio State University, Frantz, J. $5,000. Diagnosing Lettuce Deficiency Symptoms in Five Commonly Grown Lettuce Cultivars. 2008

III.E.3.b. Dr. Charles Krause

Manuscripts

Zhu, H., Frantz, J., Derksen, R.C., and **C.R. Krause**, 2007. Investigation of Drainage and

Plant Growth from Nursery Container Substrate. Appl. Eng. Agri. 23:289-297.

Palumbo, R., Hong, Q., Craig, R., Locke, J.C., **Krause, C.R.**, Tay, D., and G. Wang, 2007. Target Region Amplification Polymorphism (TRAP) as a Tool for Detecting GeneticVariation in the Genus Pelargonium. HortScience. 42:1118-1123.

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Krause, C.R. 2007. What's IR-4 Done For Me Lately? OFA Bulletin. No. 905:29-30.

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III.E.3.c. Dr. James Locke

Manuscripts

Locke, J., Omer, M., Frantz, J., Widrig, A., Zellner, W., Leisner, S., and C. Krause, 2008. Potential for the use of silicon to alleviate disease stresses in floricultural crop production. Phytopathology 98:S93.

Omer, M., **Locke, J.,** Frantz, J., and C. Krause, 2008. The influence of phosphorus concentration on the development of Pythium root rot disease of seedling geranium. Phytopathology 98:S116.

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IV. PSRC OUTREACH WORK

The PSRC has engaged in work with the stakeholder community. This work has taken many forms (described below) that are grouped together into 4 major categories: Groups; Educational Events; Educational Resources; and Direct Research With Specific Growers. These collaborations are described below. Other collaborations not listed here have also been done.

IV.A. Groups

The PSRC has been actively engaged with two major groups of stakeholders, the Maumee Valley Grower's Association (MVGA) and the Toledo Native Plant Working Group (NPWG).

IV.A.1. Maumee Valley Grower's Association (MVGA)

Drs. Frantz, Krause, Leisner, and Locke have been active participants in the monthly meetings of the MVGA. As taken from their website, "The Maumee Valley Growers is a not-for-profit association of regional growers who are committed to sustaining and growing the local economy. Through a collaborative process of sharing resources and knowledge, we identify solutions to commonly shared problems." The PSRC members are typically on the agenda for the monthly MVGA meetings.

IV.A.2. The Toledo Native Plant Working Group (NPWG)

Michael Weintraub, a member of the PSRC Advisory Committee was instrumental in the creation of the Toledo NPWG. The purpose of the NPWG is to facilitate partnerships between growers and stakeholders in order to conserve and promote native plants to producers and consumers. This working group also involved many other local and regional entities. The NPWG meets bi-monthly to discuss various issues confronting stakeholders that grow, promote, and sell native plants. In addition to Dr. Weintraub, Drs. Frantz, Heckathorn, Leisner, and Locke have also actively participated in these meetings.

IV.B. Educational Events

The research performed at the PSRC is not very useful to stakeholders unless it can be delivered to the people who need it. Therefore, the PSRC members have carried out a variety of educational activities for local stakeholders, to inform them of the active research occurring at the PSRC and other work that could directly benefit them. This has taken the form of presentations at MVGA and Metro Detroit Flower Grower's Association (MDFGA) meetings.

IV.B.1. MVGA Meetings

Approximately once each month, the MVGA meets to discuss the issues facing the industry. During each meeting, Drs. Frantz, Krause, Leisner, and Locke provide information of use to the growers. Drs. Frantz, Leisner, and Locke have also given short

presentations on their research summarizing their work in an area of grower interest. Presentations given include the analysis of silicon uptake by various ornamental plant species as well as the ability of silicon to alleviate copper toxicity, fungal attack and viral infection.

IV.B.2. Metro Detroit Flower Grower's Association (MDFGA) Annual Meeting.

At least once a year the MDFGA holds a symposium concerning factors influencing the ornamental crop industry. This symposium often includes Ohio growers as well as those from Michigan. This year, Drs. Frantz and Leisner gave presentations on the benefits and risks of silicon fertilization of various plant species.

IV.C. Educational Resources

To disseminate information more efficiently, in addition to presentations, the PSRC members have been active in assembling and releasing information that would be of interest to stakeholders. This information takes many forms: the PSRC Website has been enhanced, handouts for the presentations that given at the MVGA meetings have been assembled, PSRC members have contributed to the Resource news letter and finally, the USDA Personnel have generated a computer program to benefit stakeholders called Virtual Grower.

IV.C.1. The PSRC Website.

The PSRC website has been completely re-done. An important new portion of the website is a special section just for stakeholders called "Growers Corner." Growers corner contains a number of categories containing useful information for growers such as environmental factors influencing plant growth, information to assist in making greenhouses more efficient, manuscripts describing how certain plant growth parameters are measured, specific items pertaining to the nursery industry, how growers can better use nutrition to assist plant propagation, issues related to pathogens and pests, and finally, a series of outside resources. The outside resources contain information for providing appropriate plant nutrition, contact information for diagnostic laboratories to test for pathogens and nutrient problems, etc. Hence, the PSRC now provides versatile information for growers.

IV.C.2. MVGA one-pagers.

Each time one of the PSRC members has presented a talk to the MVGA on their research, they have also provided a one-page handout summarizing the work discussed during the meeting. This provides the growers with information they can directly take with them from each meeting.

IV.C.3. The *Resource* Newsletter.

Once a month, the Agricultural Business Enhancement Center releases a newsletter containing information of use to stakeholders. Several of the members of the PSRC have contributed to the newsletter again to provide the growers with the most current information.

IV.C.4. Virtual Grower

A major educational resource contributed by the USDA-ARS personnel, that are members of the PSRC, is a user-friendly, free, computer program called "Virtual Grower." This program permits growers to model their greenhouses with the goal of energy savings and other benefits. This program can also help growers to choose various parameters should they desire to construct a new greenhouse, such as shape of greenhouse, the type of glass, the slope of the roof, etc. This computer program also benefits growers world-wide, being that it has been down-loaded by individuals on all continents except Antarctica and is down-loaded at a rate of approximately 3 times per day. This program probably has saved growers approximately $300,000.00 over the time it has been operational.

IV.D. Direct Research With Specific Growers

The research conducted at the PSRC is important for the local growers and plant science, in general. However, it is also important to apply this work to the problems that local growers face today. With this in mind, we have begun several collaborations, described below.

IV.D.1. Testing Local Grower's Plant Materials

Although his is not a diagnostics lab, Dr. Leisner's laboratory did test plants for two local growers. This was relatively simple since Dr. Leisner's lab already had all of the materials to test these plants for the viruses the plants were thought to have. One grower was contacted to obtain some virus-free *Pelargonium* varieties. However the majority of the plants tested were virus infected and the grower was informed of this. The second grower had a greenhouse full of *Cyclamen* that he thought were infected with *Tomato spotted wilt virus* (TSWV). These plants were tested for TSWV and they came up negative. Later, the grower sent his samples off to a professional diagnostic lab and found that the plant symptoms were actually due to a fungal infection rather than a virus.

IV.D.2. Silicon Fertilization And Zinnia

During one of the presentations to the MVGA given by the PSRC members (Dr. Leisner), the speaker was approached by a local grower. Later, the grower and Dr. Leisner had a private meeting where they discussed and then began a greenhouse study to examine the effects of silicon fertilization on *Zinnia*. Under certain conditions in this grower's greenhouse, the *Zinnia* he was growing would become infected with mildew. Since the PSRC members had previously mentioned, during a MVGA meeting, that silicon fertilization could protect plants against mildew, Dr. Leisner and the grower decided to test this idea in the grower's greenhouse. These studies are currently on-going.

V. PSRC BUDGET EXPENDITURES

Running the PSRC is a costly business. Perhaps the most important and most expensive part of the budget is the salary for an excellent greenhouse manager. The other funds were for communication, room repair, parts, service and pesticides. Below is a list of the costs used by the PSRC this past year. Note, there may be a few items that this budget has missed.

V.A. Salary For Greenhouse Manager

These costs were used to pay the salary of the greenhouse manager:

Salary so far: $28,594.00 Fringe Benefits so far: $10,241.00

Total Cost: $38,835.00

V.B. Communication

These costs were used to pay for a poster describing the PSRC.

10/20/07 **Cost: $56.00** UT Audio-Visual

V.C. Room Repair

These costs were used to pay for the repair for the installment of a flange on the door separating WO4223 from WO4217.

4/24/08 **Cost: $85.00** Tanner Supply Co.

V.D. Parts For Repairs

These costs were used to pay for the parts necessary to repair the PSRC greenhouses and growth chambers.

Date	Cost	Company
1/9/08	Cost: $138.55	Grainger
1/17/08	Cost: $528.58	Conviron
1/30/08	Cost: $3,221.41	Conviron
2/21/08	Cost: $370.00	Gem
2/27/08	Cost: $6.00	Dollar General
3/3/08	Cost: $16.10	Graybar Electric
3/28/08	Cost: $13.76	Bayer Hardware
4/2/08	Cost: $19.99	Hewlett Packard
4/24/08	Cost: $166.56	Grainger
5/16/08	Cost: $271.93	Conviron
5/28/08	Cost: $3.39	Bayer Hardware
5/29/08	Cost: $74.98	Carter Lumber
6/9/08	Cost: $150.00	Lowes
6/24/08	Cost: $2,540.00	Hortimax
6/24/08	Cost: $61.76	Bayer Hardware
6/24/08	Cost: $29.40	Lowes
6/30/08	Cost: $1,540.00	Hydro-garden
Total Cost:	**$9,152.41**	

V.E. Service Costs

These are the costs to pay for the repairs done by non-UT personnel.

Date	Cost	Company
12/10/07	Cost: $1,200.00	Hortimax
5/6/08	Cost: $487.50	M & M
6/24/08	Cost: $600.00	Hortimax
6/24/08	Cost: $393.75	M & M
Total Cost:	**$2,681.25**	

V.F. Pesticide Costs

These are the costs to pay for the pesticides used to control problems in PSRC greenhouses and growth chambers.

Date	Cost	Company
11/30/07	Cost: $70.17	Waldo
1/9/08	Cost: $42.68	Waldo
2/27/08	Cost: $162.43	Waldo
3/5/08	Cost: $60.33	Waldo
3/14/08	Cost: $72.53	BGH
5/8/08	Cost: $10.95	BGH
Total Cost:	**$419.09**	

V.G. Service Contracts

These are the costs to pay for repairs of PSRC equipment if it should break down.

Date	Cost	Company
4/24/08	Cost: $1,375.00	Technical Alternatives
4/24/08	Cost: $1,350.00	Technical Alternatives
4/24/08	Cost: $150.00	Technical Alternatives
4/24/08	Cost: $1,600.00	Technical Alternatives
4/24/08	Cost: $900.00	Technical Alternatives
4/24/08	Cost: $250.00	Technical Alternatives
Total Cost:	**$5,625.00**	

V.H. Total Costs

Taken together, the total costs for the PSRC over the past year (as of June 30) are:

Total Salaries and Fringe Benefits:	$38,835.00
Total Other Costs:	$18,017.75
Sum Total:	**$56,853.75**

VI. WEAKNESSES OF THE PSRC

The major weaknesses of the PSRC revolve around funding, expansion, and outreach. Each is described below.

VI. A. Funding

Funding is needed for three specific areas for the PSRC. The first is for maintenance and supplies to keep the center functional. The second is for discretionary funds to permit immediate grower concerns to be addressed quickly. Finally, an account and a mechanism needs to be set up to permit growers, companies, etc. to donate funds to help the PSRC. Given the number of researchers using the PSRC and the size of grants for plant science, it is unlikely that the PSRC will ever be completely self-sufficient. It is possible to defray some of these costs in grant proposals by charging of "greenhouse fees" but even federal agencies will only permit a limited amount of this. What this means is that it will be necessary for the University to assist with the costs listed below.

VI.A.1. Maintenance Funding.

As is obvious from Section V of this report, maintenance costs for the PSRC are significant. The PSRC is a sophisticated entity and the more sophisticated equipment becomes, the more likely it is to break down. That, in addition to the fact that some of the equipment was in a state of dis-repair and obsolescence means that many pieces of equipment currently in the PSRC needed to be repaired or up-graded. For example, the electrical systems in each of the greenhouse modules need to be up-graded to a newer version. We have begun to effect these repairs. It is also assumed that the Plant Operations staff can repair many of these items as they usually do an excellent job. However, certain items, such as pesticides must be purchased on a regular basis and their application cannot be done by the Plant Operations staff. Likewise, the PSRC owns several pieces of equipment that need to be on service contracts that cannot be repaired by Plant Operations staff.

VI.A.2. Discretionary Funding

Ornamental crop growers face a number of problems, some of which the PSRC can help with. If one of the PSRC researchers were to submit a grant proposal covering a grower problem under normal conditions, it could take several years to obtain funding. By then, the grower may be out of business. However, if the PSRC were to have a small pool of money that it could use to fund pilot projects, this would provide useful information to growers more rapidly. In addition, such work could provide preliminary data for larger more detailed studies to be conducted later.

VI.A.3. Donations

As mentioned above, funding is needed for maintaining the PSRC. To help defray these costs, it would be helpful if external entities could easily donate funds to the PSRC. Hence, it will become necessary to set up an account for this.

VI.B. Expansion

In order to plan for the future it will be necessary to expand PSRC facilities. The major expansion that would be most helpful would be an increase in greenhouse space. In addition, it would be advantageous if the PSRC growth chambers were positioned in a central location that would permit easy access to the PSRC members. These contingencies are listed below.

VI.B.1. Greenhouses

Currently, the PSRC almost has adequate space for the people using the facility. However, as collaborations develop among the PSRC researchers and with local growers, it is likely that some expansion of the facility will be needed. Likewise, as departments grow and additional plant scientists join the University, they will also need growth space. The expansion of greenhouse facilities would permit us to more effectively attract strong plant science faculty to the University of Toledo. However, there are currently no plans for expansion of the facility. The PSRC greenhouses are located on one side of the 4th floor of Wolfe Hall. Interestingly, the other side of the roof (opposite the greenhouses) was prepared for the construction of additional greenhouses, but they were never erected. While shading issues limit the amount of useful space on that side of the roof, it is likely that 3 additional glass houses could be built in that area. That would increase the PSRC greenhouse capacity by 60%.

VI.B.2. Growth Chambers

In addition, the PSRC growth chambers need to be re-located from Wolfe Hall 4276 to Wolfe Hall 4225. This will provide lab space for Dr. Daryl Dwyer in Environmental Sciences and provide a central location for all of the PSRC growth chambers. For this to be accomplished, the chambers in WO 4276 (which will become Daryl's lab) would need to be disconnected from the water and electrical systems that they are currently connected to and connected to electrical and water systems in WO 4225. The electrical and water systems of WO 4225 would need to be added to accommodate the chambers. Physical transport from one location to the other is not a problem since the chambers are all on wheels and they are only being moved to another portion of the same floor. One other item that needs to be moved from WO 4276 is a laminar flow hood. Finally, it is unclear if the cooling capacity of WO 4225 is sufficient to accommodate the 5 additional chambers, but to accomplish this, the cooling unit from WO 4276 could possibly be moved to WO 4225 to provide extra capacity.

VI C. Visibility/Outreach

To assist in the functions of the PSRC and to increase public awareness, it is important to increase our visibility. At the same time, it would be advantageous if the ties between the growers were strengthened. This means, that it would be helpful if more members of the PSRC attended MVGA meetings to see if their research overlaps with grower problems. In addition, it would also be a good idea if the PSRC would hold a symposium for researchers discuss what they are currently working on with the growers.

VII. FUTURE PLANS FOR THE PSRC

The University of Toledo is located within an area rich in agriculture. In addition, a large portion of the ornamental plant industry is concentrated within this area. With the changes and improvements that have occurred during the past year, the future of plant science in general on the UT campus and the PSRC, in particular, is bright indeed. As the PSRC's scientists make new discoveries and their interactions with growers are strengthened, we believe that plant science will grow here. To achieve the goal enhancing plant science on the UT campus, we make the recommendations, divided into four areas described below.

VII.A. Faculty

As should be obvious from Section III, plant scientists are productive in the PSRC environment. With the resources of the PSRC becoming available in a functional state, it is expected that research previously incapable of being performed, can now be done. This will lead to increased success for plant scientists and will provide an important contribution to the visibility of the PSRC as described below. In addition, it is likely that further collaborations will develop among the PSRC researchers as well as with outside scientists. This will also enhance research productivity in the form of additional publications and grant funding.

Hiring additional faculty with a research interest in plant science would expand the productivity of the PSRC and this will be a major focus for the future. These faculty could engage in their own research and with the core of researchers already present, it is likely that the new scientists could become productive faster. New plant scientists could also engage in collaborative research. If hiring is done in a targeted fashion, the new faculty could fill in the gaps in PSRC research areas permitting more effective collaborations to be developed. Hence, additional plant science faculty would lead to additional notoriety for the PSRC and permit new collaborations to be developed. Such collaborations could lead to increased funding for the researchers involved, the PSRC, and the University. The increase in faculty and their dedication to plant science would make the University of Toledo attractive for recruiting additional scientists. Such a situation could permit the establishment of a plant science discipline on campus. This could take the form of a specialization in the Biological Sciences or Environmental Sciences major.

VII.B. Visibility

In order to increase funding for the center, it is critical that the PSRC increase its visibility. Part of that will be accomplished by the research output described in Section VII.A. Other ways of increasing visibility are to tie the PSRC to various University events. For example, the PSRC would like to conduct a plant sale connected with either the beginning of the semester or homecoming. In addition, it would be useful for the PSRC to tie in with other types of outreach. This will help increase the awareness of the of the Toledo area to the PSRC. Of course, the connections between the PSRC and the

MVGA will be strengthened and as PSRC researchers aid growers in various projects, this will also increase their awareness of the PSRC. The presentation of PSRC research to larger groups would also help to increase PSRC visibility. Finally, the PSRC plans to approach companies in the plant research area to inform them of PSRC activities. As a first step, a brochure describing the PSRC is under production.

VII.C. Infrastructure

As mentioned above, additional faculty will require increased plant growth space. To permit expansion, it is suggested that the University develop the side of the Wolfe Hall roof opposite the current greenhouses into usable space. As mentioned previously (Section VI.B.1), this portion of the roof is already sealed and prepared for greenhouses. Although it would not be possible to install 5 greenhouses on this portion of the roof as on the other side, due to shading issues. However 3 greenhouses could be put in and this would increase space by 60%. Such an arrangement would also benefit the USDA-ARS researchers. This is because they could use some of that new space in Wolfe Hall on campus, instead having to travel to the greenhouses at the Toledo Botanical Gardens.

The remaining roof space could be developed into a head house/dirty lab area where samples could be prepared prior to analysis. Because we do not have a head house/dirty lab, we need to carry out sample preparation in the greenhouses. This will be a problem in the future because using greenhouse space for sample preparation reduces already limited greenhouse space. However a central sample preparation facility would be of great use. This would also be a place to store soil and other items so they are in a more secure place than in the Wolfe Hall hallway.

VII.D. USDA Involvement

A large part of the success of the PSRC and its researchers has been the involvement of US Department of Agriculture-Agricultural Research Service (USDA-ARS). The USDA-ARS has been ***EXTREMELY*** helpful with research as well as the establishment and development of the PSRC. As mentioned above, it would also be very helpful if additional plant science researchers could be brought on board. These researchers could engage in their own and in collaborative research, expanding the plant science base at the University of Toledo. However, to bring in plant scientists and provide work-space for them is a challenge. Laboratory space on campus for UT Departments is limited. Because greenhouse space is also almost at capacity and would be greatly taxed by the inclusion of the necessary personnel to grow plant science on the UT campus, it would be extremely advantageous if the USDA would consider the construction of a new building.

It would be best if the proposed USDA building were situated on the UT main campus to permit efficient access of USDA-ARS plant scientists to facilities and to other researchers. It is important to note that a good deal of collaborative science is done among researchers that can easily communicate with each other. Therefore, the location of researchers is a key to their productivity. Such a building would also be helpful for

education/outreach work, as growers could visit the site and see first-hand the type of work plant scientists are performing. Rather than seeking a room within a campus building, there would be a dedicated ***building*** for growers to visit, making the research easier for them to access.

Since the ornamental plant industry is an important part of the Northwest Ohio Economy, we would suggest that a major area of research for the hypothetical new building would be floriculture. The focus on the ornamental plant industry by such an entity along with the current PSRC would provide a strong base for floriculture research and could turn the University of Toledo into a major research center. While many institutes focusing on food crops exist throughout the US, few specialize in the study of ornamental crops. This could put the University of Toledo on the map as a major site for ornamental crop research. Such an arrangement could benefit the USDA, the growers and the University of Toledo.