Meeting minutes

NCR-101 Committee for Controlled Environment Technology and Use
26th – 29th April, 2003
Guelph, ON, Canada

Attendants (listed in no particular order):
Chieri Kubuta (U. of Arizona), David Tremmel (Duke U.), Reg Quiring (Conviron), Rob Kerslake (CSIRO, Australia), A.J. Both (Rutgers U.), Erik Runkle (Michigan State U.), Desmond Mortley (Tuskegee U.), Keith Ingram (Crop Sci.), Henry Imberti (Percival Scientific), Rob Pauls (Enconair), Dave Wilson (EGC/NASA-Ames), Meriam Karlsson (U. of Alaska), Dick Gladon (Iowa State U.), Eugene Reiss (Rutgers U.), Robert Pollock (Southern Sun BioSystems), Dave Fleisher (Rutgers U.), Roy Young (Penn State U.), Peter Ling (Ohio State U.), Rich McAvoy (U. of Connecticut), Gianpaolo Bonaca (Southern Sun BioSystems), Mark Romer (McGill U. Phytotron), Tracy Dougher (Montana State U.), Cary Mitchell (Purdue U.), Ted Tibbitts (U. of Wisconsin), Wade Berry (UCLA), Allen Wright (Columbia U. Biosphere 2), Gary Gardner (U. of Minnesota), Alex Turkewitsch (Greenhouse Engineering), Mike Dixon (U. of Guelph), Bruce Bugbee (Utah State U.), David Brault (Conviron), Sharon Reid (Conviron), Marc van Iersel (U. of Georgia), Jonathan Frantz (Utah State U.), Steve Klassen (Utah State U.), Brent Shantz (Angstrom Engineering), Dave Flood (Argus Controls), Muhammad Iqbal (U. of Guelph), George Adamson (Ontario Scientific Inc.), Richard Vollebregt (Cravo Equipment Ltd), Daniel Schmoldt (USDA CSREES), Andrew Bass (Angstrom Engineering), Noel Folkard (Wood Bridge Foam), Ramesh Kanwar (Iowa State U.), Marc Theroux (Enconair), Mike Kolbe (EGC), Gary Stutte (NASA KSC), Neil Yorio (NASA KSC), A.O. Rule (EGC), Ray Wheeler (NASA KSC), Yang Yang (Ohio State U.), Christopher Sperk (EGC), Youbin Zheng (U. of Guelph), Tsuyoshi Okayama (Ohio State U.), Richard Worsfold (CRESTech), Robert W. Langhans (Cornell U.), Lou Albright (Cornell U.), Arthur Cameron (Michigan State U.)

Executive Committee
David Tremmel, Chair
Reg Quiring, Vice-Chair
Chieri Kubota, Secretary
A.J. Both, Past Chair

Call to order
Mike Dixon welcomed all the participants of the meeting. Dave Tremmel thanked Mike Dixon and Theresa Rondeau Vuk for organizing the meeting and introduced himself as the chair. The meeting was called to order at 9:15 a.m. at Peter Clark Hall, University of Guelph. The attendants took turns introducing themselves.

Minutes of the 2002 Meeting at Durham, NC.
Dave Tremmel thanked Reg Quiring for writing the minutes, then he asked if there were any questions on the minutes that were distributed to the NCR-101 member list a while ago. Since there were no questions, Alex Turkewitsch moved to approve the minutes, Roy Young seconded, and the motion was approved unanimously.

Administrative Advisor's Report
Ramesh Kanwar (Administrative Advisor of the NCR-101) expressed his thanks for all attending the meeting despite the SARS warnings.

2004 NCR-101 meeting in Australia Ramesh requested Dave Tremmel to have some time in the current meeting agenda to discuss strategy for approving the Australian meeting. Ramesh will write a letter to the Committee of Nine Experiment Station Directors, as he did for the UK meeting and he will also give a presentation at the Committee meeting to have the upcoming Australian meeting approved. He commented that for doing so, development of a good strategy is necessary.

Review at NCA-16 Committee (Agricultural Engineering Department heads/chairs) Ramesh gave an

oral review of activities of NCR-101 at the NCA-16. It has been evaluated as one of best multi-state committees under NCA-16.

Funding information Ramesh reviewed funding opportunities from many national agencies. USDA CSREES has six major areas: 1) Genomics, and future food and fiber production and quality, 2) Natural resources and environmental quality, 3) Human nutrition and food, organic farming, 4) Food safety, 5) Agriculture opportunity and rural prosperity (greenhouses, urban agriculture and greenhouse engineering), 6) Agricultural security (nanotechnology and nano sensors). NSF and NIH have bioengineering as a funding area. DOD also has funding toward sensor and instrumentation. EPA has funding for sensor technology toward biosecurity of water and biosensors. European Union provides 1 billion dollars to provide water systems in developing countries.

NIMMS database management system Ramesh introduced that there was a database available for experiment station directors (located at University of Wisconsin). All committees meeting minutes and activities are accessible through this database. Project proposals and renewal of 5 year projects should be submitted through the data management system. Ramesh is willing to share his ID and password with those who need or want to access the database.

Other comments Ramesh confirmed that alcohol served at dinner was not included in the registration but rather was sponsored by the growth chamber industry, since it is against the regulations for travel support from the Agricultural Experiment Stations. For the Australian meeting, Ramesh encouraged university faculty members to bring graduate students since it would be a great opportunity for graduate students to have an international experience.

Mike Dixon explained that actual cost for the Toronto meeting was $450.15 CDN per person while registration fee was $300.00 CDN. The difference was covered by sponsorships.

CSREES (USDA Cooperative State Research, Education and Extension Service) Report (APPENDIX I)

Dan Schmoldt, National Program Leader of Instrumentation and Sensors, reported that CSREES is interviewing candidates for a new horticulture national program leader position within CSREES.

NASA & USDA Having experience with both NASA and USDA, the new Deputy Undersecretary Rodney Brown is interested in interagency partnerships between NASA and USDA. A NASA/USDA working group has been formed with members from NASA's Office of Earth Sciences (OES) and National Program Leaders from USDA ARS and recently identified five focus areas: 1) Carbon management, 2) Invasive species, 3) Agricultural competitiveness, 4) Water management, and 5) Air quality. Under this interagency partnership, a new collaboration will involve USDA CSREES and ARS and the NASA Advanced Human Support Technology Program in NASA Office of Biological and Physical Research. Dr. Gus Koerner, Kennedy Space Center, will serve as an IPA at the CSREES offices in Washington DC during July-September 2003 and he will initiate a similar interagency working group that will establish a long term research and development agenda for collaboration contributing to life support technologies for space missions. Jointly supported funding opportunities are expected to develop relevant to science and technology for growing crops, recycling waste, recycling water and air, processing food, and converting crop residue into useful products.

FY 2003 Budget The final budget for CSREES for FY 2003 is $1.12 billion dollars, which include an increase in the National Research Initiative (NRI) of $47 million dollars (total of $167 million dollars). Four new program areas in NRI to complement the increase in funding are: 1) Genetics, 2) Air quality, 3) Obesity, and 4) Animal and plant biosecurity.

FY 2004 Budget The budget of $1.015 billion dollars was sent to the Congress. The NRI's authorizing legislation had identified six priority research areas, which were funded as individual line items in each

appropriation bill. The agency is now re-evaluating and re-organizing its NRI grant programs, and the six issue areas were identified last fall as constituting the new NRI "look", beginning with this fall's NRI RFA: 1) Agricultural security, 2) Human nutrition and food science, 3) food safety, 4) Genomics, 5) Natural resources and environmental quality, and 6) Rural communities and prosperity.

NCR-101 2004 meeting Dan Schmoldt, Ramesh Kanwar and David Tremmel submitted in February a proposal to CSREES for supplemental travel funding for the upcoming NCR-101 meeting in Australia. At one time, this funding opportunity was considered likely to have funding of $35,000 for a three year budget cycle (2002-2004). However, there are concerns relating to conflicts with Congressional support of agriculture experiment stations and issues relating to the recent budgetary problems of many agriculture experiment stations. The CSREES funding is still expected but possibly a smaller amount (around $10,000). Dan Schmoldt suggested that a good strategy and justification are necessary to convince the agency to provide funding. There are several other funding agencies including NSF, USDA NRI, NASA, and OECD (Organization of Economic Cooperative Development). We might be able to come up with several, but small funding sources to put together. Dan Schmoldt commented that we have to be careful how we do it.

Gary Gardner asked if it was easier for CSREES to justify funding, if we consider the Australian meeting as a public meeting held in conjunction with NCR-101. Dan Schmoldt answered that what Gary suggested was exactly the current strategy to get funding from various agencies.

Bruce Bugbee asked if individual experimental station directors can choose who to support. Dan Schmoldt answered it would be supplemental funding to provide each experimental station representative with a differential between the expenses for a regular meeting (approximately $1,000) and the Australian meeting (approximately $2000). Ramesh Kanwar explained that NCR-101 includes22 agricultural experiment stations and therefore the total amount to be raised would be $22,000. Dan Schmoldt mentioned that a $10,000 was still available from CSREES. Ramesh Kanwar mentioned that NSF had opportunities to support $25,000 to $30,000 as long as the majority recipients were US citizens.

Mike Dixon asked about considering funding for other university researchers, graduate students and industry representatives, which were outside of the support of the agriculture experiment station. Dan Schmoldt explained that other funding organizations such as OECD could possibly support guest speakers and it was his intention to form a subcommittee for possible procedures on applications for available funding.

ASHS CE (Growth Chamber and Controlled Environments) Working Group Meeting Report
Chieri Kubota summarized the ASHS CE working group meeting held on April 25th just before the NCR-101 meeting. Chieri explained that the CE working group was willing to share information with NCR-101 and expected more interaction between the two groups. Several ASHS events supported by CE working group were planned, such as a colloquium on "Bio-Derived Energy Sources for Protected Horticulture**".** CE working group supported another colloquium held during the International Horticultural Congress in August, 2002, namely "Mission to Mars", organized by Gary Stutte. A book of proceedings is expected as a volume of Acta Horticulturae.

NCR-101 Website Update
Mark Romer reported the past year's membership update, including a few additions and deletions (Appendix II). The E-mail list has worked well with few bounced emails. This year, significant updates and improvements were made to the website (http://www.ncr101.duke.edu/). Updates included revised URLs of members and addition of award information. In the history section, a list of past meeting locations and the names of past committee chairs will be included. In the activities section, a link was made with the instrument package operation organized at Utah State University. Measurement standards and reporting guidelines published in Biotronics (vol. 29, 9-16, 2000) are now

available on the NCR-101 website.

Dave Tremmel brought up the issue of losing the NCR-101 website host, associated with Duke Phytotron's closure (after 2004). Dave asked that anyone who can host and maintain the website would contact him. Dave stated that McGill University could host the website temporality but a new, more permanent host should be sought.

Instrument package report

Bruce Bugbee stated that it was relatively quiet year for the instrument package due to a transition of different instruments (from calibration instruments to more novel instruments). One new introduction is a spectroradiometer. This spectroradiometer has the capability of measuring a wider range of wavebands starting from UV to IR range. Bruce also explained various applications of this instrument, such as diagnosis of plant stress status. Rental for the quantum sensor calibration package including the spectroradiometer (small package) cost $300 and $450 for the large instrument package (including the remainder of the calibration sensors). Circulation of packages works best for a month at a time, which limits their use to 12 organizations per year. These packages can be rented by the traditional experimental station members, but also by other members, including the growth chamber industry. Ted Tibbitts asked if there is any demand for long wave radiation measurement. Bruce replied that the demand is less and sensors are large and require greater care during shipping and handling. Account of the instrument package is shown below.

NCR-101 Instrument account (April 2002 to April 2003)

Beginning balance			$1,115.18
Expenses			
	6 award plaques	$ - 598.50	
	Balance in Account		$ 516.60
Payment pending		$ +300.00	
Total			**$ 816.60**

Guidelines of measuring and reporting growth chamber environments

A.J. Both distributed a draft handout of "minimum guidelines" (Appendix III), a condensed version of the guidelines published by the ASAE and in Biotronics. These minimum guidelines will be widely distributed among growth chamber users, manufacturers, and journal editors. An international committee formed at the NCR-101 meeting in the UK has worked on developing these minimum guidelines. Once it is determined to be published, several versions are planned to be tailored towards (1) Europe, (2) NZ/AU, and (3) North America. A.J. Both asked for feedback regarding this draft, since the guidelines are expected to be published in the next couple of months.

Ted Tibbitts explained the background of this project. The creation of minimum guidelines was decided at the meeting in UK, followed by Dr. Lynton Incoll's review report that no major journals were following the NCR-101 guidelines exactly. The international committee was immediately formed, consisting of 15 people from several countries, chaired by Ted Tibbitts, to develop minimum guidelines. Ted addressed several issues to discuss.

1) Use of PAR (photosynthetically active radiation) instead of PPF (photosynthetic photon flux) or PPFD (photosynthetic photon flux density).
2) Emphasis on the use of VPD (vapor pressure deficit)
3) Eliminating the requirement of reporting CO_2 concentration, air velocity and EC (electrical conductivity) but encouraging reporting if data is available.
4) Inclusion of daily integral for PAR (mol m^{-2} d^{-1})

Gary Gardner pointed out that reporting daily integral only was not enough and both daily integral and PAR (instantaneous values) should be required. He also pointed out that manufacturer information on light sources should be included. After discussion on the necessity of incorporating such information into the guidelines, Rob Kerslake reminded us that it was supposed to be “minimum guidelines” and we should avoid including too much information. Bruce Bugbee mentioned that, although he thought using PAR with □mol m^{-2} s^{-1} was acceptable, many people used PAR with the unit of W m^{-2}, while PPF and PPFD were in units of □mol m^{-2} s^{-1}. Keith Ingram commented that if research was toward water relation, rather than CO_2 assimilation, then the total energy should be reported using the unit of W m^{-2}. Roy Young suggested to clearly indicate the unit to use with PAR by adding another footnote to the table. A question was made by Peter Ling as to whether we should include the energy unit used for water relation studies, but Ted Tibbitts considered that it would be an expansion beyond the purpose of minimum guidelines. A question was raised if the guidelines should include greenhouse or if two separate lists for greenhouse and growth chambers was more appropriate. Mark Romer suggested, although the mandate made at the UK meeting was for growth chambers, it would be worth considering the creation of separate guidelines for greenhouse, instead of starting over again for creating greenhouse guidelines after completing the guidelines for growth chambers.

Gary Gardner suggested reporting on watering should include whether tap water or DI water was used. Then the discussion moved to using VPD as a measure to report the potential for plant transpiration.

Mark Romer asked if any manufacturers have instruments providing readouts of VPD, and a Priva representative mentioned that their company did this. The importance of knowing VPD was emphasized by Dick Gladon and Mike Dixon, while some opposed it as a “minimum guideline” since it can be too complicated and since VPD sometimes includes leaf temperature in the calculation. There was some confusion about the definition of VPD: “the difference between saturated vapor pressure at the air temperature and the current vapor pressure of the air”, or “the difference between saturated vapor pressure at the leaf temperature and the current vapor pressure of the air”.

A comment was made on the definition of “average” to report, either spatial average or time average. Ted Tibbitts explained that this also led to discussion among committee members but consensus was not yet reached. Peter Ling suggested that it should be time average since information on spatial average could be accommodated by growth chamber properties. Allen Wright suggested providing the definition of average in another footnote.

Keith Ingram commented that “concept of independent measure” was missing in the guidelines and he emphasized the need of measurements independent from control of the system, since sensors used for chamber control were not always calibrated accurately. Gary Gardner commented that it was a different issue than reporting guidelines. Peter Ling suggested that a statement should be included about sensor calibration. Ted Tibbitts commented that it could be included in the introduction rather than tabulated in the guidelines per se. Alex Turkewitsch noted that the guidelines were very good and acceptable as it is.

Ted Tibbitts brought up another issue as to whether chamber specifications (such as model, manufacture, size, presence/absence of barrier and air flow direction) should be included, indicating that some UK people were against the inclusion. Currently the committee is leaning toward including minimum information, such as barrier and air flow direction as indicated in the draft guidelines. Gary Gardner mentioned that identification of chamber model and manufacture would suffice. Reg Quiring commented that conditions inside growth chambers were the result of growth chamber equipment, and it would be helpful to include such available information but that other direct measurements such as radiation and air velocity were more important information.

Comments were made by Wade Berry that, under “nutrition”, solid media should be reported on a dry mass base, not only elemental nutrients but also form of nutrient (e.g., nitrate or ammonia as nitrogen source) should be reported, and that liquid culture should include volume so that amount of salts could be determined. A.J. Both added that another thing discussed by the committee members was whether to include the form of aeration for liquid culture. Wade Berry commented that information on whether or not the liquid was aerated would be sufficient, but the form of aeration would not be necessary as minimum guidelines.

Concern over sampling location for CO_2 concentration creating shade over the canopy was expressed (Peter Ling), but comments were made that the effect would vary depending on sensor type. Gary Stutte expressed concern about the variability of ambient CO_2 concentration and asked if we should require reporting CO_2 concentration. A.J. Both explained that reporting CO_2 concentration would be too complicated for average users of minimum guidelines, and also that such a mandate would require growth chambers to have the capability of CO_2 measurement while most chambers did not have such capability.

A.J. Both explained that other concerns related to the guidelines included means and costs of publication, sponsorship, the addition of logos and pictures to the documents and asked for any comments or suggestions.

Richard Vollebregt recommended measuring surface temperature in addition to air temperature, because the amount of radiation coming from the light source is a significant consideration for transpiration rates. Ted Tibbitts stated that a similar discussion was made years ago at NCR-101 and suggestion were made to have the capability to measure surface temperature using a black body sensor, but Ted considered it too complicated for minimum guidelines. A question was made as to who are the “average” users that will use the minimum guidelines.

A.J. Both would feedback the comments made at this meeting to the international committee, and finalize the guidelines in the next couple of months. Regarding the number of copies to be printed, A.J. explained that the committee had not made any decisions. Initial idea was distribution as a handout at scientific meetings or among institutions. Possibility of publication in scientific journals was not known. Publication at a website of organizations (ASHS or NCR-101) was suggested.

Revision of plant growth chamber handbook

At the 2002 meeting, a decision was made to start working on updating the growth chamber handbook (eds. R.W. Langhans and T.W. Tibbitts) published in 1997 and a committee was formed (Marc van Iersel, Corinne Rutzke, and A.J. Both). A.J. Both explained that the committee surveyed original authors’ willingness to be involved in revision and update process (Appendix IV). Most original authors indicated a willingness to be involved in the revision process. A.J. mentioned that the next step would be finding potential authors for chapters that do not have original authors willing to work on the update. A.J. Both said that Keith Ingram would like to discuss another option of publishing a similar book on Controlled Environments.

Keith Ingram proposed to edit a Book on Controlled Environment Systems for Agriculture (Appendix V), as an integrated activity incorporating diverse groups working in controlled environments (NCR-101, Crop Science, and others). This project idea originated several years ago, when Keith Ingram was asked by the editor of Crop Science journal to help develop guidelines for controlled environments. Keith contacted and distributed draft guidelines among some members of NCR-101, being aware of NCR-101’s activities. This eventually emerged into interest in publishing a book on guidelines for using controlled environments. The major difference between this proposed book and NCR-101’s plant growth chamber handbook is that the book will cover all controlled environment systems such as greenhouses and SPAR units and it would include chapters on insect pests and diseases in controlled environment. The authors listed in the book proposal (Appendix V) are only

suggestions and there are no commitments at this point. Since there would be many duplications between the two publications, discussion was opened on whether we should combine the two and publish them as one integrated version or publish two separate publications as originally planned.

Gary Gardner asked what would be the price of the book. But it was not known at this point. Bruce Bugbee suggested asking for potential support from Crop Science Society, but Keith Ingram was concerned about the society's recent moratorium for special publications due to financial concerns. Keith thought if the market was guaranteed, they might be interested. Ted Tibbitts pointed that an advantage of publishing the guidelines as a book was the availability at libraries worldwide, while a handbook was not. However, Ted Tibbitts also noted that price for a (hardcover) book would limit its use, which would be a drawback of publishing a book. Keith Ingram added that the final number to print would determine the price per copy. Mike Dixon suggested publishing it as a CD since it would cost only $1 to produce. Keith Ingram noted that, despite the available technology, many people still preferred to have hardcopy as a reference. Mike Dixon emphasized that the accessibility was the key, and books of $80 to $100 would have less accessibility due to their high price. Marc van Iersel commented that a CD may not be accommodating to all libraries. Bruce Bugbee suggested checking with agronomy society and offered his potential assistance to approach to the society. If they publish the book, they would sell it at low price and advertise as well, therefore making it more accessible to more people. Bruce added that having the publication as a book made it more accessible for readers to use as a reference.

Keith Ingram asked again if we should publish both book and handbook. Wade Berry stated that it would be dependent on the prices since if the total price of a set was expensive, no one would buy both. Dave Tremmel suggested that the handbook could be published as a CD (with a very reasonable price) and thereby the book can be published as a book even if it costs $100. Gary Gardner mentioned that the handbook should be recognized as one of the best external achievements of NCR-101. Ted Tibbitts asked if it is problematic to publish the same information (such as "radiation") in both book and handbook. Ramash Kanwar stated that books were copyrighted. Ted Tibbitts considered that it would be best if the two can merge into one.

Peter Ling asked whether chapters on greenhouses in the proposed book would cover both commercial and research greenhouses. Peter stated that commercial production greenhouses had different issues from research greenhouses. Keith Ingram mentioned that potential readers interest would have to be investigated, to determine if production greenhouse should be included or not. Dave Tremmel mentioned that since the proposed book would have a much broader scope, it would be "reprinting" what has been developed within NCR-101, and that it would be a much easier approach to have NCR-101's growth chamber handbook contents as a portion of the broader scope of the book, in order to solve the copyright problem. Ray Wheeler commented that publishing a revised NCR-101 handbook would provide opportunities for younger and new members to be authors in the revised version, but the proposed book would be a bigger community with new people, as a tradeoff. Mark Romer commented that going beyond growth chambers, to the much wider scope of greenhouse environmental control, would be challenging, since defining minimum standards and guidelines for the narrow scope of growth chambers has already been challenging. Gray Gardner stated that there was a clear need for a similar kind of book focusing on the greenhouse area, which may be a good opportunity and therefore, it would be easier if we continue with the revision and have it published jointly with crop science. There will be assistance from experimental stations for publication cost. That also will make the book available to libraries, because it would be an agronomy society book. Gary Gardner also suggested publishing a greenhouse book eventually or simultaneously.

Keith Ingram asked for suggestions on directions from this point. Dave Tremmel asked if we should go forward with the handbook. Marc emphasized that the NCR-101 handbook was very different from what was proposed for the book and therefore we should go forward with the handbook focusing on growth chamber users. No opposition or further comments were made. Since the motion of going

forward with the handbook revision was already made in the 2002 meeting, a particular motion to confirm this decision was not needed. Ted Tibbitts and A.J. Both encouraged new authors to volunteer to help write a revision of the handbook.

2004 meeting in Australia

Rob Kerslake presented the proposed conference dates (March 14-17) and tentative programs for the 2004 meeting in Australia (Appendix VI). The optional dates are in September but March is more favorable for UK people. Rob Kerslake made a short presentation, introducing new construction at CSRIO and its facilities, where the meeting will be held. Then Rob Kerslake explained the scientific programs including "controlled environment for molecular biology and gene expression", and "what we can/can't do with CE". Time for poster sessions is allocated on Monday and Wednesday. The conference format is more formal, as it was during the UK meeting. The meeting starts Sunday evening and a post meeting tour starts on Wednesday afternoon, immediately following the concluding morning session. The 2.5 day tour will be optional, visiting the northern area of Brisbane, including visits to rainforests, a winery and a horticultural research station specializing tropical crops, then coming back to Brisbane on Friday afternoon. Trade exhibitions are also planned. A.J. asked if there was any promotion to attract more attendants from Asian countries, since having Asian participants was one expectation with an Australian meeting. Rob already contacted and will be further contacting groups in India, Phillipines, and Japan. Mark Romer suggested considering sharing Phytotron experiences in controlled environment for molecular biology and gene expression.

Funding for supporting travel to 2004 meeting in Australia

Dan Schmoldt explained that a tentative funding strategy was proposed during a meeting with the executive committee members of NCR-101 during the lunch hour. The conference title or theme "Advances in Controlled environments for Sciences and Technology" was proposed for funding purposes. Other items to emphasize in the proposal will be that the conference has broader international audiences. The expected attendance is 100 in total including 40 to 60 attendees from North America. Scientific sessions include poster and paper presentations, the abstracts of which should be reviewed in advance. Publication of a proceeding will be considered. One potential publication source is Computer & Electronics in Agriculture, which is a peer reviewed journal and it would be more appropriate if proceedings are published as peer reviewed.

Dan Schmoldt continued and explained the proposed "funding committee" along with potential funding sources as shown below.

Funding sources	**PIs**	**Target $$$**
USDA CSREES	R. Kanwar	10K
USDA NRI	C. Kubota and R. Kanwar	10K
NSF	R. Kanwar and C. Kubota	25K
OECD	R. Kerslake	10K – 25K
Other agencies (NASA, DOE)	R. Wheeler	?
Industry support	?	?
Australian support	R. Kerslake	?

To survey the number of potential attendees from North America and their needs for extra funding to support travel to Australia, a survey sheet was circulated among the attendants. 37 people indicated their interest in attending the Australian meeting and among 37, 13 indicated potential full funding available within his/her institution and 20 indicated a partial funding (30 – 50%) and 4 indicated no funding.

Dan Schmoldt commented that they would pursue these fund-raising activities very quickly, especially with NSF. Dan Schmoldt asked for any feedback within the next few months. Dave Tremmel asked if

someone wants to make a motion to approve the funding committee (Dave Tremmel, Reg Quiring, Chieri Kubota, Dan Schmoldt, Ramash Kanwar and Ray Wheeler). Gary Gardner moved and Ted Tibbitts seconded the motion. Motion was approved unanimously.

Dave Tremmel asked if we should be prepared with a backup plan (in case Australian meeting does not happen). Dick Gladon made a motion that the 2004 meeting would be canceled if NCR-101 meeting does not go to Australia. Bruce amended the motion such that the 2004 meeting would be at Biosphere 2 in Arizona if not in Australia, as we agreed in the 2002 meeting in NC. Mark Romer seconded the amended motion and the motion was approved unanimously.

Dave Tremmel asked if any other institutions were interested in hosting future NCR-101 meetings. Kennedy Space Center and The Ohio State University expressed interest. It was confirmed, as agreed in the previous year, that Arizona would host the 2005 meeting if the 2004 meeting was held in Australia.

New Business

Nomination of new secretary
Dave Fleisher was nominated by the current executive committee as next year's secretary for the NCR-101. Dave Fleisher agreed that he was willing to serve as a secretary. Dave Tremmel asked if there were any other nominations from the floor but no nominations were made. Roy Young made motion to approve Dave Fleisher as a new secretary from 2004 meeting and Peter Ling seconded. The motion was approved unanimously.

Dave Tremmel asked for a motion to adjourn the meeting. Mark Romer moved and Gary Gardner seconded. The meeting was adjourned at 3 PM.

Station Report
20 oral reports were made as shown below (in no particular order).

CRESTech (Richard Worsfold), Utah State University (Bruce Bugbee), University of Georgia (Marc Van Iersel), Duke University National Phytotron (Dave Tremmel), Rutgers University (Dave Fleisher), University of Connecticut (Rich McAvoy), Michigan State (Eric Runckle), University of Arizona (Chieri Kubota), Kennedy Space Center (Neil Yorio), Pennsylvania State University (Roy Young), Conviron (Reg Quiring), Conviron (Dave Brault), Ohio State University (Peter Ling), A.O. Rule (EGC), Allen Wright (Biosphere 2), Purdue University (Cary Mitchell), University of Wisconsin (Ted Tibbitts), Crop Science (Keith Ingram), University of Guelph (Micheal Stasiak)

Student poster competition
During the meeting, all attendants had the opportunity to evaluate students posters and select the two best posters among 7 entries. Best poster awards were presented to Yang Yang (The Ohio State University) and Jamie Doran (University of Guelph), each awarded with a check for $250.00 CDN.

Respectfully submitted,

Chieri Kubota
NCR-101 Secretary

Cooperative State Research, Education, and Extension Service -- Update

New Horticulture NPL Position

Earlier this year, CSREES requested applications for a new Horticulture National Program Leader (NPL) position within the agency. That announcement closed some time ago, and one candidate was interviewed. Another candidate has cancelled his interview. No agency decision has been made on how it will proceed at this point, but things should be resolved within the next month.

NASA & USDA

Over the past 40+ years, NASA near-Earth space missions have resulted in a substantial base of data-collection and delivery systems and a variety of modelling and decision-support capabilities. Many of these NASA products can have a direct benefit to USDA interests. A NASA/USDA interagency working group was formed early in 2002 to explore a closer partnership—jointly chaired by the Deputy Under Secretary for REE (Rodney Brown) and the Asst. Associate Administrator for the Office of Earth Sciences (OES) in NASA (Ron Birk). This group, containing members from NASA's OES along with NPLs from ARS and CSREES, is developing a 10-year roadmap to apply OES data products and models to improve decision support systems for agricultural management and policy (including natural resources and forestry). To date, the partners have identified five broad focus areas within the mandates of USDA for which USDA-NASA OES cooperation may lead to strengthening of decision support systems:

- Carbon Management
- Invasive Species
- Agricultural Competitiveness
- Water Management
- Air Quality

With this interagency partnership currently underway, NASA and USDA are embarking on a brand new relationship. This new collaboration will involve CSREES and ARS (in USDA) and the Advanced Human Support Technology Program in NASA's Office of Biological and Physical Research. Many of the needs for extended stays in space involve nutrition, food safety and quality, air quality, water quality, cropping systems, waste management, and bio-based materials and processing—things with which USDA has experience. Dr. Gus Koerner, Kennedy Space Center, has accepted an IPA position at our offices in DC during July-September 2003. During his brief tenure, Dr. Koerner's primary duty will be to initiate a similar interagency working group that will, over time, establish a long-term research and development agenda for agency collaboration contributing to human support technologies for space missions. To facilitate agenda development, we will likely convene a national workshop similar to what was done in the OES collaboration. Such a workshop would examine the current state of science and technology at USDA and NASA, and identify where gaps exist. At some point down the road, then, it is expected that this agenda will lead to jointly supported funding opportunities to develop the relevant science and technology for: growing crops, recycling waste, recycling water and air, processing food, and converting crop residue into useful products.

The Budget is in…for FY 2003 that is

In mid-February, the Congress passed and the President signed the 2003 Omnibus Appropriations Bill that provides funds for federal discretionary programs covering 11 of the 13 regular appropriation bills that were still unfunded. The CSREES budget for FY 2003 is $1.120B, which is an increase over the previous year's appropriation. This appropriation included an increase to the National Research Initiative

(NRI) of approx. $47M—putting that program at $167M, which is short of the President's $240M request. A supplemental RFA for FY 2003 has been drafted and will be on the street soon. Four new program areas in the NRI will receive the bulk of supplemental funding:

- Genomics—one program for bovine genome sequencing and one for functional genomics of agriculturally important organisms,
- Air quality—to develop emission data for agriculture, forestry, and rangeland production practices
- Obesity—to link basic nutrition research, applied social science research, and food production factors, and
- Animal and plant biosecurity—to establish collaborations for animal and plant diseases and pests of high economic impact.

Additionally, there are several small amounts of funding provided for inter-agency programs in: the President's Nanotechnology Initiative, the President's Global Climate Change Initiative, and NASA/USDA Geospatial Extension positions.

FY 2004 President's Budget

The FY 2004 budget that the President has sent to the Congress contains a request of $1.015B for CSREES. This number is $12M below the FY 2003 request. Note: the FY 2004 request is substantially below the FY 2003 appropriation because the President's budget does not include Congressional earmarks, which represent about 1/6 of the agency budget. In the FY 2004 budget, there is a request for $200M for the NRI, which is $40M below the FY 2003 request. Keep in mind that the FY 2003 budget request was submitted to OMB by USDA prior to 9/11. It has taken some time for the full ramifications of those events to affect budget reductions and reallocations.

The NRI's authorizing legislation (ca. 1965) identified six priority research areas. These have remained largely intact to this day because, until recently, those areas were funded as individual line items in each appropriation bill. Partially at the request of the REE Under Secretary, the agency is now re-evaluating and re-organizing its NRI grants programs. Based on what agency leadership expects will be marketable to USDA and OMB, the following six issue areas were identified last fall as constituting the new NRI "look":

- Agricultural Security
- Human Nutrition and Food Science
- Food Safety
- Genomics
- Natural Resources and Environmental Quality
- Rural Communities and Prosperity

Beginning with this fall's RFA, the NRI's grant offerings will be organized around these six issues. Many of the current NRI grant programs will remain (only reorganized), a few new ones may be added, and the programs appearing in this spring's supplemental RFA will carry over to FY 2004. In addition to future NRI funding increases, the long-term agenda for the NRI is fewer grant programs with greater individual funding support. This will also carry over into awards with fewer grant awards of larger award sizes.

Daniel L. Schmoldt

National Program Leader,
Instrumentation and Sensors

Appendix II: NCR101 membership update summary

NCR101 Membership Summary …… March 2003
Mark Romer, *List Curator*

Membership Number ..... April 2002 132
2003 132

- Additions.....7
- Deletions 7
- Net Gain(Loss) 0

Membership Composition	Institutions	Members
• Phytotrons & Controlled Environment Facilities	13	19
• University Departments, Agr. Exp. Stations	41	64
• Government Organizations & Contractors	14	18
• Industry Representatives	22	30
• Other		1

Total Number of Institutions **90**
Total Number of Members **132**

New Institutions 2002-3

Australia
School of Wine and Food Science, Charles Sturt University

Canada
DeCloet Greenhouse Manufacturing Ltd.

USA
Dept. of Agricultural & Biosystems Engineering, Iowa State University
Department of Plant Biology & Pathology, Rutgers University
USDA – Alternate Crops and Systems Laboratory, Beltsville
Matsushita Electric Works
Southern Sun Biosystems
CDH Energy

ADDITIONAL CONSIDERATIONS

Introduction

Conditions in controlled environment plant growth rooms and chambers (CE units) should be reported in detail for comparison of results and duplication of experiments. The included guidelines table, along with the notes below, will help meet these aims, indicating a required, minimum amount of information that should be reported. They may also highlight parameters that could be important, but that investigators may not be measuring.

Radiation

- Output of all electric radiation sources decreases with hours of operation. Typical 1500 mA fluorescent lamps emit 70% of original irradiance after 6000 hours (~1 year at 16 hours/day). Fluorescent lamp output may drop 20% after the first five months of use.
- Irradiance varies significantly across the growing area in most CE units.
- Vertical radiation gradients occur in all growth chambers, depending on chamber size, lamp type, lamp distribution, and luminaire shape.
- Artificial light spectra generally differ from that of the sun. Unnatural red to far red light ratios may affect morphogenesis in some plants and photomorphogenic effects should be considered when interpreting results.

Temperature

- Differences may exist between the temperatures of the air and plant, especially under high radiation loads.
- Older on-off control systems can result in as much as ± 5°C variation from set point temperature.
- A vertical temperature gradient occurs in most CE units, depending on airflow rates and other factors.

Atmospheric moisture

- Air humidity affects plants in CE units both directly (transpiration and gas exchange effects) and indirectly (plant's energy balance and physical and biological environment).
- Heating and cooling cycles lasting only 1 to 3 minutes can change absolute humidity by 1 to 2%, altering relative humidity by 20 to 40%.
- Air humidity is a challenging parameter to monitor, but is critical to plant water relations and infection by foliar pathogens. Relative humidity (RH) is acceptable for reporting humidity until CE units can control vapor pressure deficit (VPD), or portable instruments are available to measure and display VPD.

Carbon Dioxide

- Carbon dioxide (CO_2) is probably the least controlled environmental parameter in CE studies. Unfortunately, too little or too much CO_2 is hard to detect until plants start to show specific symptoms.
- Small variations in CO_2 can affect plant growth and development significantly. People in or around CE units, and even greenhouses, can increase CO_2 , as may motor vehicles, heating systems, and other nearby sources that produce CO_2.
- Few CE units manufactured today have CO_2 control or monitoring equipment installed as a standard feature. However, most do have some degree of ventilation or air exchange, and good air exchange can moderate CO_2 build-up or depletion.
- Even if a CE unit is well ventilated, it is important to remember that the surrounding area with which it exchanges air should also be well ventilated.

Experimental Design Issues

- Ideally, a single CE unit should be treated as a single replicate. True replication requires using multiple CE units, or repeating treatments in each unit with time, both expensive and time consuming options.
- Regular transfer of plants between CE units may be an alternative to avoid direct confounding of effects of an imposed environment with that of a CE unit.
- Repeating experiments in a CE unit with poorly controlled or monitored environmental parameters may lead to erroneous assumptions about treatment conditions and resulting data.

Reporting Example

A plant experiment was conducted in a 3 by 4 m growth room equipped with cool white fluorescent lamps mounted behind a plexiglass barrier, and a horizontal airflow distribution system using sufficient outdoor make-up air to provide ambient CO_2 conditions inside the room. The room air temperature was maintained at 25/20 (±2) °C during the light/dark period. The light intensity at the top of the canopy was maintained at 400 (±10) µmol m^{-2} s^{-1} during the 12-hour photoperiod. The relative humidity in the room was maintained within a range of 60-80%. The plants were hand watered daily with a freshly prepared nutrient solution. The pH and EC of the nutrient solution were maintained at 6 and 0.12 S m^{-1}, respectively. The plants were grown in 10 cm diameter pots filled with a peat-vermiculite (2:1 volume ratio) mixture.

International Controlled Environment Guidelines Committee

MINIMUM GUIDELINES FOR MEASURING AND REPORTING ENVIRONMENTAL PARAMETERS FOR EXPERIMENTS ON PLANTS IN GROWTH ROOMS AND CHAMBERS

Sponsored by and published for the UK Controlled Environment User's Group, the North American Committee on Controlled Environment Technology and Use (NCR-101), and the Australian Controlled Environment Working Group

Minimum Guidelines for Measuring and Reporting Environmental Parameters for Experiments on Plants in Growth Rooms or Chambers

International Committee on Controlled Environment Guidelines

Parameter	Units [a]	Measurements		Measurements
		Where to take	When to take	What to report
Radiation				
Photosynthetically active radiation (PAR) [b]	□mol m^{-2} s^{-1}	Top of plant canopy in center of growing area	At start, and every 2 weeks of each experiment	Average and range. Radiation source and type of instrument/sensor
and				
Photoperiod	h			Duration of light and dark periods
Temperature				
Air	°C	Top of plant canopy in center of growing area	Daily during each light and dark period, at least 1 h after light/dark change	Average and range Type of instrument/sensor
Liquid culture		Within solution under plants		
Atmospheric moisture				
Water vapor pressure deficit (VPD)	kPa	Top of plant canopy in center of growing area	Daily during each light and dark period, at least 1 h after light/dark change	Average and range Type of instrument/sensor
or				
Relative humidity (RH)	%			
Carbon dioxide [c]	µmol mol^{-1}	Top of plant canopy	At least hourly	Average and range
Air velocity [c]	m s^{-1}	At one or more representative canopy locations	At least once during experiment	Average and range
Watering	Litre (L)		Daily	Frequency of watering and amount of water added
pH				
Soil media and liquid culture	pH		Daily before pH correction	Average and range
Electrical conductivity (EC) [c]	S m^{-1}		Daily, or before EC correction	Average and range
Substrate			At start of each experiment	Type of soil and amendments, components of soilless substrate, container dimensions
Nutrition				
Solid media	mol kg^{-1}		Indicate schedule for replenishment and/or supplementation	Nutrients added to soil media
Liquid culture	mmol L^{-1}			Nutrient concentration in liquid additions and solution culture. Form of aeration if any
Room or chamber properties				Specifications: manufacturer, model, and floor area
Barrier				Indicate if present, and the composition
Air flow				Indicate whether up, down or horizontal

[a] Report in other multiples or sub-multiples of indicated units if more convenient.

[b] Referred to as photosynthetically active radiation (PAR: 400-700 nm) for general usage and described as photosynthetic photon flux density (PPFD) by many journals, professional societies, and manufacturers of quantum sensors.

[c] This parameter should be reported if records are available and always when it is a variable under investigation. Consult the detailed guidelines published as ANSI/ASAE Engineering Practice EP411.4 (2002) Guidelines for measuring and reporting environmental parameters for plant experiments in growth chambers for more information. ASAE, 2950 Niles Road., St. Joseph, MI 49085-9659, USA.

Plant Growth Chamber Handbook, 1997

underlined = contacted; bold and underlined = willingness to work on an update; in parantheses = willingness to play a minor role (e.g., review)

Chapter 1	Radiation (**John Sager**), (**Craig McFarlane**) John.Sager-1@kmail.ksc.nasa.gov
Chapter 2	Temperature **Peter Hicklenton**, Royal D. Heins hicklentonp@agr.gc.ca
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Chapter 4	Carbon Dioxide (**Mary Peet**), Don Krizek mpeet@unity.ncsu.edu
Chapter 5	Air Contaminants **Ted Tibbitts** twt@facstaff.wisc.edu
Chapter 6	Air Movement Jack Downs, Don Krizek dkrizek@asrr.arsusda.gov
Chapter 7	Plant Culture in Solid Media **Art Spomer**, **Wade Berry**, Ted Tibbitts l-spomer@uiuc.edu
Chapter 8	Plant Culture in Hydroponics **Wade Berry**, Sharon Knight wberry@biology.ucla.edu
Chapter 9	Plant Physiological Disorders **Robert Morrow**, **Ray Wheeler** Raymond.Wheeler-1@kmail.ksc.nasa.gov
Chapter 10	Pests and Diseases John Sanderson, Ken Horst jps3@cornell.edu
Chapter 11	Special Use Chambers (**Craig McFarlane**), **Robert Morrow**, Doug Ormrod,, Steve Schwartzkoff mcfarlane.craig@epa.gov
Chapter 12	Chamber Maintenance (**Bob Langhans**), Ted Tibbitts rwl2@cornell.edu
Chapter 13	Experimental Design Allen Hammer, Doug Hopper pah@hort.purdue.edu
Chapter 14	Writing Chamber Specifications William Wade (deceased), William Bailey, Herschel Klueter **Reg Quiring**
Chapter 15	Guidelines for Measurement and Reporting of Environmental Conditions Don. Krizek, John Sager, Ted Tibbitts dkrizek@asrr.arsusda.gov
Appendix	Crop Growth Requirements Doug Hopper, **Gary Stutte**, Ann McCormack, Dan Barta, Royal Heins, John Erwin, Ted Tibbitts StuttGW@kscems.ksc.nasa.gov

Book Proposal

Controlled Environment Systems for Agriculture

Suggested: Keith T. Ingram, Ted W. Tibbitts, A.J. Both
(Note: All names of editors and authors are suggestions only.)

Description

A broad range of research facilities falls under the category of controlled environment systems, the most important of which growth chambers, open top chambers, gradient tunnel systems, green houses, and soil-plant-atmosphere research (SPAR) chambers. Phytotrons, biotrons, and envirotrons are research facilities that generally include several such controlled environment systems.

If properly designed and managed, controlled environment research facilities offer great potential to enhance our understanding of how biological systems respond to their environment, including environments that do not currently exist on earth. Research conducted in controlled environments can help us predict the effects of global climate changes, predict zones of adaptation for new crops and varieties, and provide a mechanistic basis for simulation models. The challenge is assuring that controlled environment systems are designed and managed so that they provide the intended environmental conditions – a challenge that many controlled environment systems fail to meet.

The objectives of this book are: 1) to summarize the physical and mechanical bases for environmental controls; 2) to identify common pitfalls of environmental controls; and 3) to describe a framework that scientists can use to assure the quality of research they conduct in controlled environment systems. This framework shall also help reviewers, administrators, and granting agencies to evaluate the quality of completed or proposed research. Readers will gain an understanding of both how controlled environment systems operate and how they can monitor and report environmental controls.

While the engineering literature describes many environmental control systems in great detail, most of this literature omits the biological requirements of experimental subjects. This book aims to link environmental control systems with the specific needs for plant systems.

There are several groups working in a poorly coordinated effort to establish guidelines for conducting and reporting research in controlled environments. These groups include NCR-101, a USDA-sponsored working group that includes mostly horticultural scientists, a sub-committee of *Crop Science*, and an informal international coalition of scientists that are concerned about the quality of research conducted in controlled environment systems. This book is unique in that it aims to draw together representatives from these diverse groups to reach a broad-based agreement where none currently exists.

Table of Contents

Davis, EGC)
Avoiding overheating under high light intensities (Ian Warrington, New Zealand Phytotron)
Optimum lighting for day length extension vs. plant growth
Problems encountered when interpreting results of experiments conducted under low light conditions

Chapter 6: Carbon dioxide, Hartwell Allen, 25 pages
Carbon dioxide effects on plant growth and development
Sources of carbon dioxide (commercial compressed gas vs. methane) (Bugbee)
Choosing the best carbon dioxide analyzer (Ian Flitcroft, Georgia Envirotron)
Systems for carbon dioxide removal (Dave Tremmel, Duke University)
Common pitfalls in monitoring and controlling carbon dioxide

Chapter 7: Research design for controlled environment systems, Jeff Baker, USDA-ARS, 25 pages
Balancing needs for replication with logistics
Regression vs. analysis of variance
Unbalanced designs for controlled environment research
Index plants
Linking experimental designs with research objectives

Chapter 8: Systems that integrate control of multiple environmental variables, Joshua Dyan, 25 pages
Temperature and humidity (Reg Quiring)
Ventilation and temperature
Radiation and carbon dioxide (Hartwell Allen, Bruce Bugbee)
Radiation, temperature, ventilation, humidity, and nutrients (Dietmar Schwarz, Institute for Vegetable and Horticultural Crops)

Chapter 9: Managing insect pests and diseases in CES, 25 pages
Prevention of infestation and infection
Common insect pests in CES and their control
Common diseases in CES and their control
Using CES to contain biohazards

Chapter 10: Quality assessment framework for controlled environment research, KT Ingram, 25 pages
Quality assurance plans – definition, scope, and value (Dave Olszyk, AJ Both, Lynton Incoll)
Recommended minima for monitoring and controlling environmental variables
Recommendations for reporting environmental controls (A.J. Both)
Using the internet for real-time quality assurance

Approximate total length:	250 pages
Artwork:	40 to 50 line graphs and diagrams using Excel or Powerpoint No photographs

Review

To assure that information in this book is of the highest quality, we propose to have two experts review each chapter for scientific content and accuracy. The challenge with any reviewed book is to maintain a timely publication schedule. In order to achieve timely reviews, we should try to tap both the *Crop Science* and NCR-101 pools of potential reviewers.

Market

The primary audience for this journal is scientists and graduate students that conduct research in controlled environment systems. This group includes members from several scientific societies, particularly those in the areas of plant physiology, agronomic and horticultural sciences, and agricultural engineering.

Secondary audiences for this book might include: 1) administrators and donor representatives charged with evaluating controlled environment research and research proposals; 2) undergraduate and graduate students in agronomic and horticultural sciences; and 3) designers and managers of commercial controlled environment production facilities.

Competing Books

The book that would most directly compete with the proposed book is *Plant Growth Chamber Handbook*, published in1997 by the Iowa Agricultural and Home Economics Experiment Station, authored by the North Central Regional committee NC-101 on Controlled Environment Technology and Use, with RW Langhans and TW Tibbits as co-editors. According to TW Tibbitts, this book is not widely marketed and there is no intention to update or reprint it.

The NCR-101 group published another related book edited by TW Tibbits, based on the proceedings of an International Workshop held in 1994 on *Lighting in Controlled Environments*. Though it contains excellent information, both the distribution and availability of this book are highly limited.

The American Society of Engineering Standards also publishes highly technical recommendations for control and monitoring of greenhouses and growth chambers. These publications tend to focus on physical factors with little or no input from biological scientists; hence many biological scientists do not consult these standards.

2004

International Controlled Environment Meeting

Queensland Bioscience Precinct (QBP)
University of Queensland Campus

14-17 March

BRISBANE
AUSTRALIA

CONTROLLED ENVIRONMENTS – THE POWER TO MANUPILATE

SUNDAY 14 March

17:00 – 20:00	Registration/Mixer/Welcome

MONDAY 15 March

09:30 – 10:00	Opening Address
10:00 – 10:30	Session 1 Showcasing technology Australasia/Pacific Rim
10:30 – 11:00	Morning Tea
11:00 – 12:30	Session 2 Showcasing technology Australasia/Pacific Rim cont.
12:30 – 13:30	Lunch
13:30 – 16:30	Tour of QBP and CEF Posters
16:30 – 17:30	Session 3 What Controlled Environments can/can't do technically
17:30 – 19:30	Business Meeting – NCR-101/CEUG
19:30 – 22:30	BBQ Dinner (on campus)

TUESDAY 16 March

09:00 – 10:30	Session 4 Advances in plant science from the space program
10:30 – 11:00	Morning Tea
11:00 – 12:30	Session 5 Science showcasing manipulating environments and plant processes
12:30 – 13:30	Lunch
13:30 – 15:30	Session 6 Science showcasing manipulating environments and plant processes cont.
15:30 – 16:00	Afternoon Tea
16:00 – 17:30	Session 7 Manipulating genes in Controlled Environments
17:30 -	Transport to Australian Woolshed for conference dinner
22:30 -	Transport to hotels

Wednesday 17 March

09:00 – 10:30	Talks on selected posters (10 min presentations/5 min discussion)
10:30 – 11:00	Morning Tea
11:00 – 11:45	Open Forum – Is there still power in controlled environments? Chair – Dennis Greer
11:45 – 12:30	Closing Address
12:30 – 13:30	Lunch
13:30	Sunshine Coast tour departs