Implementation plan for Floral Report Card: A National K-12 climate change education initiative

Linking the University of Washington Botanic Gardens to local schools and community through a network of climate change monitoring gardens

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Executive Summary

In the fall of 2009, the University of Washington Botanic Gardens (UWBG) partnered in the nationwide installation of a network of research gardens monitoring climate change. Through tracking the phenology (seasonal timing of plant life cycle events, such as first flower) of the garden plants, participant scientists hope to better understand the relationship between plants and climate. Plant phenology research has received an increasing amount of attention in the context of climate change, as studies have shown a general trend towards plant species flowering earlier in the spring season over the past century (Abu Asab et al. 2001;Fitter and Fitter 2002; Primack et al 2004; Defila and clot 2005; Menzel et al 2006). Phenological changes of vegetation can result in changes of fitness and function of both natural and agricultural systems, meaning these changes can have widespread ecologic, social, and economic implications for our society.

The study of plant phenology presents an ideal platform for public engagement, as anyone can observe and record a plant's first flower or first fruit with little training, and multiple observations across a myriad of locations are required to create useful datasets. As a result, regional and international flora and fauna phenology networks have incorporated citizen science into methods of valuable data collection.

In recognizing the opportunity that the climate change gardens present for youth engagement in the science of climate change, UWBG and project partners received a planning grant from the Institute of Museum and Library Services (IMLS) in 2009 to transform the network of research climate change gardens into a national K-12 climate change education initiative called Floral Report Card. Through the IMLS planning grant, collaborators developed a scaled partnership structure and five-year implementation plan to effectively integrate citizen science and existing technologies into school programs aiming to engage youth and increase science literacy. The funding period of the grant ended in October 2010, and the project is now in an interim state between planning and implementation phases, with implementation dependent on future funding sources.

In fulfillment of the final project requirement for the Masters of Environmental Horticulture program of the University of Washington, I worked as the Floral Report Card project coordinator for UWBG and facilitated the following:

- Coordination of the UWBG climate change garden installation
- Preliminary data collection of the UWBG climate change garden to identify best practices and establish species-specific protocols
- Recruitment of local K-12 educators interested in hosting a climate change garden at their school as pilot gardens
- Coordination of 3 school climate change garden site assessments and installations
- Creation of an implementation plan for the future UWBG FRC project coordinator
- Creation of a "*Getting Started Guide*" for pilot school educators to assist them in the interim period until a national FRC curriculum is developed

The purpose of this document is to provide logistical and conceptual guidance for future UWBG Floral Report Card project coordinators to use as the project transitions from planning to implementation. The document includes

- Project background
- Goals and objectives
- Descriptions of the UWBG and partner school garden installation
- Preliminary data collection protocols
- Learned lessons throughout garden installation process
- Suggested future actions for UWBG's continued participation in the Floral Report Card climate change garden network

I. **Project Overview**

Background

The Floral Report Card (FRC) project is a K-12 climate change education initiative designed by science and education experts from Chicago Botanic Garden (CBG) and partners from across the country. The project seeks to combine science education, garden research, and informal education resources into a climate change science curriculum through a network of gardens to be installed at universities, botanic gardens, and K-12 schools. Each garden is designed with seven plant species from different climatic zones that are biologically sensitive to changes of temperature. Through the observation of the timing of plant life cycle events, the gardens will collectively serve as ecological antennae of the effects of a changing climate on plant growth and survival. Data collected will also provide scientists with the ability to develop climate change models to help predict the impacts of climate change on plants.

In the fall of 2009, Chicago Botanic Garden (CBG) and partnering organizations began to install the replicated climate change gardens under the leadership of CBG. CBG acquired grant funding from the United States Botanic Garden, NASA, and the Institute of Museum and Library Services (IMLS) for the initial research garden installations at botanic gardens. The IMLS grant was awarded as a planning grant to CBG in collaboration with the State Botanical Garden of Georgia, Northwestern University, the University Corporation of Atmospheric Research, and the University of Washington. The purpose of the planning grant was to support the planning and development of logistics and curriculum for integrating the research climate change gardens into K-12 school programming, with the curriculum given the title of Floral Report Card. The planning grant supported the collaborative planning of all project partners over a one-year (10/2009-10/2010) period.

The overarching mission of the Floral Report Card project is to develop a model through which citizen science and existing technologies can effectively be integrated into school programs to engage youth, increase science literacy, and provide valuable data for researchers to understand the environmental impacts of climate change on ecosystems. The collaborative partnerships between formal and informal education institutions will enable educators to leverage resources and expertise in support of climate change education.

The FRC project is an offset of a successful public citizen science initiative called Project Budburst that was designed by Chicago Botanic Garden and members of the U.S. National Phenology Network (NPN). Launched in 2007, Project Budburst is an online educational and data entry program that engages citizen scientists of all ages in recording plant phenological observations on the project website http://budburst.org. The website provides information on the history and ecological importance of phenology, its link to climate change, materials for teachers and students, and a user friendly interface to upload and analyze data. FRC is a complimentary project to Budburst, and is intended to be the in-school, standardized version. While the project design of FRC is different from Budburst, certain components such as data collection protocols, phenophase definitions, and plant information will be adapted from Budburst materials. Materials and background information provided by the U.S. National Phenology Network, an umbrella organization for information on phenological research and a clearinghouse for historical data sets, will also be incorporated into FRC implementation materials.

Climate change represents one of the most pressing issues of the 21st century that will impact all aspects of natural and social systems, with implications that require interdisciplinary and informed management actions. The Floral Report Card project will provide valuable data and invaluable climate science education, and will support the framework of institutional connectivity that is necessary to support climate change mitigation and adaptation strategies.

Impact

The Floral Report Card (FRC) project has the potential to impact both museum and formal education communities while providing valuable scientific data for researchers to better understand the relationship between plants and climate.

One of the most empowering ways to increase science literacy is through direct involvement in scientific data collection. FRC will bring the engagement power of citizen science into K-12 classrooms through a curriculum designed by the professional development practice called lesson study.

An additional undercurrent driving the FRC project is the special need for science education improvement in cities across the nation. According to the most recent National Assessment of Education Progress (NAEP) in science (NAEP 2005), students in large cities perform significantly lower on the NAEP than in any other location in the country. The average NAEP score of a large city based student is 136 (out of 300) in comparison to an average of 146 in mid-size cities and a high of 155 in rural areas (IMLS planning grant application for Floral Report Card, 2009). Since almost one-third of our nation's youth live in large cities, this is of critical concern. Furthermore, while climate change represents one of the most pressing issues of the 21^{st} century, rarely is the science explicitly addressed in middle or high school science curriculum. A recent survey of middle and high school students conducted by the Yale Project on Climate Change Communication, *"American Teens' Knowledge of Climate Change"* (Leiserowitz et al., 2011), found that relatively few teens have an in depth understanding of climate change, with over fifty-four percent of teens in the study receiving a failing grade on their level of understanding. Only 27 percent said they have learned "a lot" about global warming or climate change from school curriculum. Additionally, 70 percent of teens said they would like to know more about global warming.

Science based museums can provide teachers with additional resources and support to effectively communicate scientific concepts as defined by national science standards and benchmarks. Many teachers do not have sufficient scientific knowledge or familiarity with emerging technologies to teach science effectively. This knowledge gap can be filled through program frameworks that foster partnerships between K-12 educators and science based museum resources of multiple scales.

Structure and Organization

Chicago Botanic Garden (CBG) has been the leading organization for the planning phase of the project. As the project management entity, CBG has guided project coordination, secured funding for the planning project phase (2009-2010), and submitted a proposal to IMLS in February 2011 for implementation funding. CBG has also taken the role as the propagating facility for all FRC gardens to date. In its implementation phase, CBG will act as the national FRC center for regional partnerships and will provide funding, technological, scientific, and organizational support as the leadership organization. Partnering botanic gardens and other participating organizations are projected to become regional FRC resource centers and will leverage their resources to provide educational and scientific support to local schools and community participants for their prospective regions.

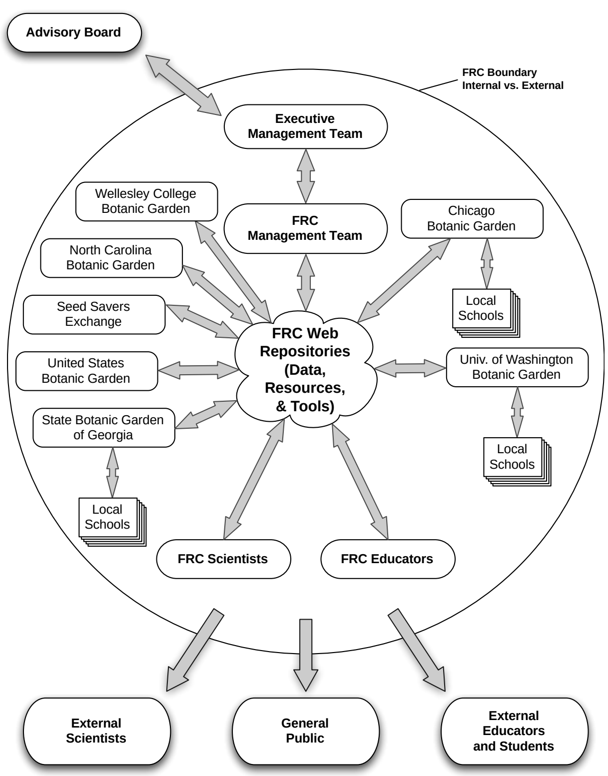

Figure 1. A diagram of the projected resource and information flow of the Floral Report Card project. Chicago Botanic Garden will act both as the national resource hub for regional botanic gardens and as its own regional source for participant schools in the Chicago area. This diagram was created by the technology committee during the 2009-2010 planning phase of the project.

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FRC regional resource centers

The first three years of implementation have been designated as pilot years, with the number of participating schools and regional resource centers limited to develop best practices. The following three botanic gardens will represent regional resource centers and support the installation of FRC gardens at K-12 schools of their region:

1. Chicago Botanic Garden
2. State Botanic Garden of Georgia at the University of Georgia
3. University of Washington Botanic Garden

While other project partners may install FRC gardens for data collection, they will not have the role of regional resource centers to support community and local K-12 school participation. After the initial three-year pilot testing period, additional gardens will be invited to participate. Gardens that have expressed interest include: the Vermont Institute of Natural Sciences, North Carolina Botanic Garden, the United States Botanic Garden, and the Denver Botanic Garden.

FRC K-12 schools

Recruitment in the three pilot sites (Illinois, Georgia, and Washington) focused on schools representing diverse ethnic, socio-economic, and regional differences were recruited from Illinois, Washington, and Georgia. Participating schools include:

Illinois
- Best Academy High School in Chicago
- Lane Technical High School, Chicago Prairie Crossing Charter School, Grayslake
- St. Martin de Porres High School, Waukegan
- Warren Township High School, Gurnee

Washington
- Ballard High School, Seattle
- Jane Addams School, Seattle
- Roosevelt High School, Seattle

Georgia
- Athens Montessori School in Athens
- Margaret Winn Holt Elementary School, Lawrenceville
- Statham Elementary School, Stratham

II. Role of UWBG

The University of Washington Botanic Gardens (UWBG) will function as a resource center for the Floral Report Card project for the Pacific Northwest region. UWBG will provide local K-12 schools and its surrounding community with project participation and implementation support. In addition, the climate change garden located at the Center for Urban Horticulture of UWBG will be the demonstration garden for prospective citizen scientists and for educators interested in hosting a climate change garden at their school. For project participants, UWBG will provide local climate change educational and scientific support. The educational and research components of FRC are in direct alignment with the mission of UWBG, to *sustain managed to natural ecosystems and the human spirit through plant research, display, and education*.

FRC will serve to further the UWBG mission several ways:

1. Provide an additional citizen science program that engages the local UWBG community in valuable plant research. UWBG currently hosts an award winning plant conservation program, the Washington Rare Plant & Conservation Program (Rare Care), which is driven through the dedicated work of volunteer citizen scientists. Other volunteer opportunities that UWBG offers includes data collection and support for the UWBG Otis Douglas Hyde Herbarium, opportunities to lead UWBG public and school programming, and landscape assistance to the UWBG gardening staff. FRC will compliment these engagement opportunities.
2. Provide a means for UWBG to extend its school programming resources to schools that may be unable to attend educational field trips to the Washington Park Arboretum.
3. Provide the UWBG community (schools and public) with a positive and meaningful way to participate in important plant research.

As per the FRC Memorandum of Understanding for participating schools (Appendix A) UWBG will provide:

- Program point person/contact
- Garden packages
- Support for garden design and installation
- Education framework and materials
- Lesson study professional development opportunities
- Curriculum implementation support
- Age appropriate data collection and maintenance protocols
- Training and instructional materials for garden installation and data collection

III. Project Goals & Objectives

The overarching mission of the Floral Report Card project is to develop a model through which citizen science and existing technologies can effectively be integrated into school programs to engage youth, increase science literacy, and provide valuable data for researchers to understand the environmental impacts of climate change on ecosystems.

One of the main tasks of the FRC planning phase was the identification of specific goals and objectives for each project component. This was achieved through the completion of a series of logic models outlined by project partners. Project partners identified three overarching goals and corresponding objectives of the project: education, research, and informal/formal education collaboration.

Goal 1: Education

To support the development of scientifically literate citizens who understand human impacts on the environment (specifically the impacts of climate change) and are prepared to act to mitigate their immediate and long term impacts.

> **Objective 1.1**: Teacher and student engagement in educational activities that integrate citizen science and field studies to support increased science content knowledge and scientific research skills.
>
> **Objective 1.2**: Teacher and student engagement in the exploration of the social, cultural, and economic impacts of climate change climate change.
>
> **Objective 1.3**: Leverage and expand a national network of education resources from botanic gardens and other informal education institutions participating in the Floral Report Card project. Each participating botanic garden will represent regional resource centers that provide horticultural materials, curriculum, in school implementation support, professional development, and scientific expertise.

Goal 2: Research

To use phenological data in combination with other climate and geo-science data to explore and understand the implications of climate change on plant life cycles and reproductive success.

> **Objective 2.1**: Provide useful, accurate, large scale phenology data to be used by students, teachers, and researchers nationwide in their efforts to understand the environmental impacts of climate change on ecosystems.

Goal 3: Formal/Informal Collaborations

To create and implement a sustainable, replicable model of informal/formal education collaboration that effectively brings museum resources into the classroom.

> **Objective 3.1**: Establish formal/informal educational partnerships that effectively provide resources and support to formal education institutions.
>
> **Objective 3.2**: Leverage and expand the national network of botanic gardens participating in the Floral Report Card project to create regional resource centers for schools and communities.
>
> **Objective 3.3**: Create a model that can be modified for use by other types of science-focused museums beyond botanic gardens.
>
> **Objective 3.4:** Create a cost and resource efficient model that can be integrated into existing museum operations and supported over the long term.

IV. Project Design

The FRC project is designed to function as a national plant phenology network that will serve the trifold purposes of education, generation of data that can be used in research, and as a replicable model to strengthen the partnership between the academic, informal education, and K-12 school communities. FRC differs from other phenology networks in that it contains a K-12 curricular component to be supported by scaled partnerships with museum and university resources. While other national and international phenology programs support educators by providing teaching materials for participation (e.g. Project Budburst, GLOBE) the FRC project will provide regional support through science museum partnerships to assist in curriculum and project adaptation.

Described below are the specific design goals, objectives, and supportive reasoning to show how each design goal and objective serves to fulfill the overarching project goals of education, research, and informal/formal collaboration.

Research design

Research Design Goal 1: Controlled Growing Conditions

Climate change gardens will be designed, installed, maintained, and monitored in ways that support the accurate collection of important phenological, morphological, ecological, and climate data.

> **Objective 1.1** Each garden contains seven genetically identical perennial plant species seed sourced from four different climatic regions of the U.S., USDA hardiness zones (4, 5, 6, 7). (For information regarding the exact seed source locations, contact Dr. Kayri Havens, see Appendix B).
>
> > **Purpose:** By creating a clonal phenology garden network, genetic variation amongst gardens is eliminated, and observed variation between the Floral Report Card gardens can be contributed to environmental factors. Changes in plant phenology can be due to three sources of variation: environmental factors, genetic factors, or a combination of both environmental and genetic factors. This is expressed in the following equation:

$$V=G+E+G*E$$

where V is the observed variation or a trait in a population, G is amount of variation in the trait due to genetic differences among individuals, and E is the amount of variation in the trait due to the influence of the environment (Haggerty and Maze, 2005). Controlling genetic variation in propagation allows each garden to contain genetically identical species, therefore environmental conditions such as temperature and precipitation that trigger phenological responses can be accurately measured.

Objective 1.2 Each garden will be maintained under comparable conditions in terms of human intervention on garden conditions.

> **Purpose:** Standard growing conditions in each of the gardens will ensure the collection of accurate data that diminishes bias from external non-climatic factors. Both individual (e.g. age) and environmental factors (weather and climate conditions, soil-conditions, water supply, diseases) influence plants. Only through standardized growing conditions and a well-documented account of the microclimate and environmental (climate and non-climatic) conditions of each site can accurate phenology data be collected.

This objective will be achieved for each FRC site through the following preparations:

- Each garden will contain a written and photographic record of the baseline conditions of the garden site (history of the site, physical characteristics)
- Soil testing is to be conducted at each site prior to planting
- Each garden will record all landscape and plant treatment practices (e.g., soil amendments, irrigation schedule, plant replacement)
- Each garden will have an on-site weather station to record for the environmental variables of site microclimates.
- Each garden will follow standard maintenance guidelines

Research Design Goal 2: Data Collection

The network of FRC gardens will provide useful, accurate, large-scale phenology data that can be used by researchers across the country in their efforts to understand the environmental impacts of climate change on ecosystems.

> **Objective:** Clear phenophase definitions, metrics, and data collection protocols were established for each FRC plant species. Written and illustrated data collection metrics will be provided to all project participants. The general guidelines are below. Individual FRC species protocols are located in section VIIII of this report, and have been provided to each of the pilot school gardens participating in preliminary data collection. These general guidelines are adapted from the Project Budburst guidelines and were created during the planning phase of the FRC project.
>
> > **Purpose:** One of the most important preconditions of obtaining comparable observation values is the exact definition of the phenological phases that are observed. Without standardization and consistency, phenology data is not useful.
> >
> > The following five phenophases are being observed for Floral Report Card:
> >
> > 1. First full leaf: When first leaves are completely unfolded from the bud.
> >
> > 2. First flower: When petals are open on individual flowers so that the stamens are visible. Flowers are to be considered "open" when the reproductive parts are visible between unfolded or open flower parts.
> >
> > 3. Full flower: When 95% of the flower clusters no longer have any unopened flowers. For individual flowers (*Aster*), full flower can be described when all disk and ray flowers appear to have opened.
> >
> > 4. First fruit: When the first fruits becoming fully ripe or seeds dropping naturally from the plant.
> >
> > 5. Leaf senescence: When 95-100% of the leaves have fallen.

Data collectors of FRC gardens will monitor the plants at least three times per week in the growing season to track plant phenophases. In the Pacific Northwest, the first phenophase “first full leaf” can occur in late February to early March. Some FRC species begin flowering in early spring, others in late summer. All project participants will refer to individual species data collection protocols. Once a phenophase is thought to be approaching as observed by plant growth characteristics (i.e. first flower), observations should be made daily to mark the exact phenophase date. Frequency of observations in between each phenophase (e.g. “first flowering” to “full flowering”) will depend on growth development of each individual FRC species.

Detailed accounts of plant health and garden conditions that may affect plant phenology will also be recorded. This information includes pest or pathogen occurrence, wind damage, or any other external conditions that may affect plant conditions. Once full-scale implementation funding is granted, data collection materials will be standardized and an interactive online database will be created for all FRC gardens. See “Preliminary data collection” in section VIII of this report for more details on record keeping of the UWBG climate change garden that includes data collections sheets.

Project participants will take a photograph of each marked phenophase. Participants will attempt to take phenophase photographs of individual plants from the same angle each time a picture is taken. This will support evidential and visual clarity of how the plants change through their annual life cycle stages.

The online database for FRC garden data has not yet been created, therefore all preliminary first-year data to be collected at the pilot FRC school gardens will be transferred onto excel sheets. For photograph storage, each teacher will receive a standardized computer folder pathway to save phenophase pictures collected during the first year of data collection. See “Information Management” in section VIIII of this report for more details.

Research Design goal 3: To answer specific research questions

Data collected will be used to enhance existing research projects and identify trends that lead to other research questions.

The following preliminary research questions have been identified during the planning project phase:

1. How does hardiness zone (both plant origin and zone of growth) affect phenology of cloned individuals?

2. Do latitudinal and longitudinal distances result in different phenological responses? How does scale of responses differ?

3. Do some types of species change phenologically more than others (i.e. do spring flowering taxa advance more rapidly than later flowering species)?

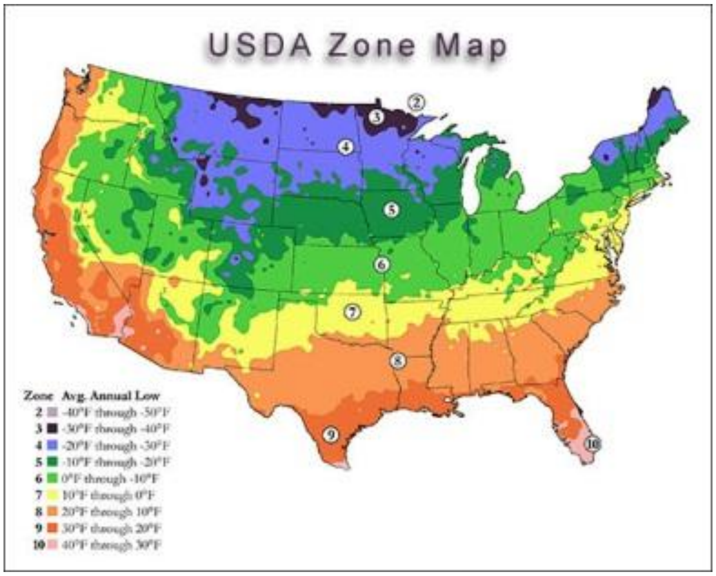
4. Is there evidence for ecological mismatches? (i.e. do non-“home” zone plants set less fruit?)

5. Do different species (early vs. late flowering) have different reaction norms?

6. Can we use the data to develop and test mathematical models for plant phenology, and apply the models for predicting the impacts of climate change on plant phenology in far into the future?

Objective 3.1 Each garden contains perennial flowering species native to different climatic regions of the United States. Some species bloom in early spring (early flowering species) and others later into the summer months of August and September (late flowering species).

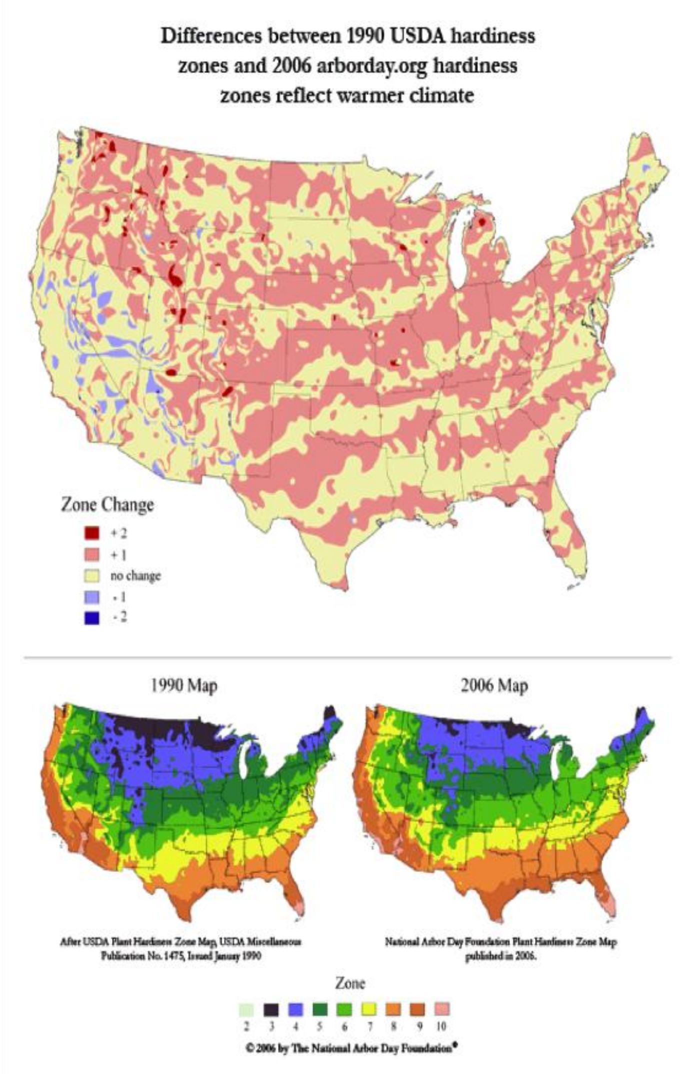
Purpose: By collecting the same plant species from different USDA hardiness zones, scientists will be able to better understand the relationship between phenological responses of plant growth and the environmental conditions of different climatic zones. This is useful information because as spring temperatures continue to increase due to the effects of anthropogenic climate change, plants that have physiologically adapted to colder regions will either have to shift their range, adapt in situ, or may experience population declines and range contractions. As stated in research design objective 1.1, each of the seven cloned plant species were seed sourced from four climatic regions of the U.S., USDA hardiness zones (4, 5, 6, 7). USDA hardiness zones are geographically defined areas that divide the U.S. and southern Canada into 11 areas based on a 10 degree Fahrenheit difference in the average annual minimum temperature, 0 being the coldest.



United States Department of Agriculture's (USDA) Hardiness Zone map. Last updated in 1990, this map is based on average annual minimum temperatures recorded throughout North America. Gardeners are able to determine which plants are suitable for their regional climate based on the "hardiness", or threshold of survival that is dictated by winter conditions.

By growing the same species of plants seed sourced from different hardiness zones, information can be collected regarding species fitness and reproductive success when grown in different climatic conditions. For example, by planting a *Penstemon digitalis* (foxglove beardtongue) specimen propagated from zone 4 seed collections, continuous and long term observations can provide insight to how it will respond to zone 6 climate conditions. This information is important because there is increasing evidence that climate change is causing plants to shift their geographic ranges resulting in range contractions and the extinction of some species (C. Parmesan, 2006, C. Parmesan & G.Yohe 2003).

In 2006, the Arbor Day Foundation created new hardiness zone maps that depicted a warming trend throughout many U.S. regions since 1990, the year that the most updated version of the USDA hardiness zone map was published. The figures below are based on 15 years of data (1990-2005) available from the National Oceanic and Atmospheric Administration's 5,000 National Climatic Data Center cooperative stations across the United States.



Hardiness zone maps developed by the Arbor Day Foundation, who extracted regional weather station climate data between 1990-2006 to show the shift of hardiness zones across the United States since 1990. These maps show how almost half of the United States has warmed at least one hardiness zone. These maps are publicly accessible and can be found on the organization's website, http://www.arborday.org.

Early and late flowering FRC species were chosen because studies have shown that there is a different response between the two types of plants to warmer temperatures. Plants that flower earlier in spring are showing a greater tendency to flower earlier than plants that grow later in the season (Bradley et al. 1999;Fitter and Fitter 2002; Dunne et al. 2003). This differential response to warmer temperatures may be attributable to the developmental limitation by temperature of plants early in the growing season. Plants that flower later in the season are more adapted to temperatures already exceeding optimal range, and flowering time may not be affected by temperature shifts.

Plant species list of Floral Report Card climate change gardens (listed from early to late flowering)

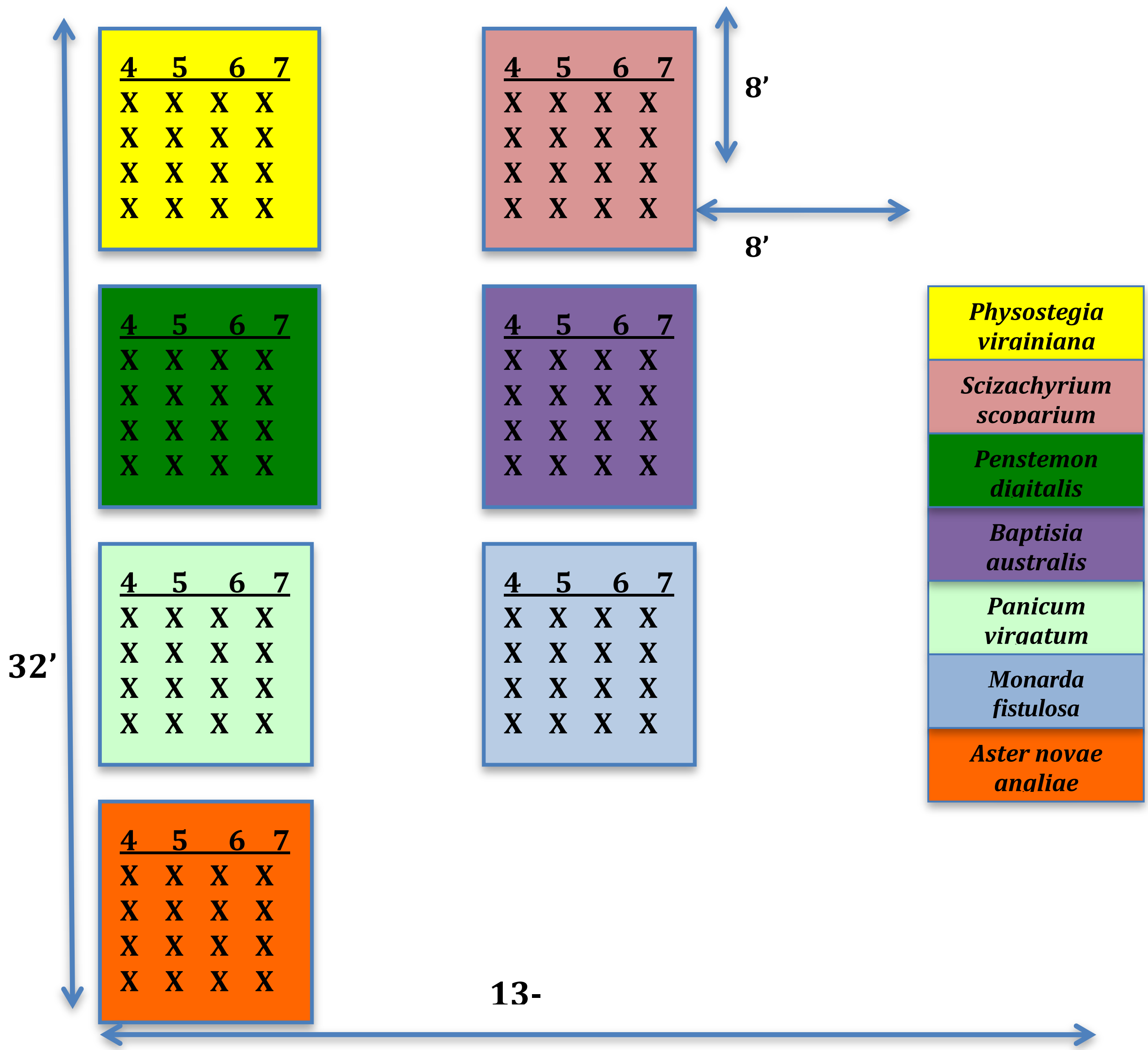
Plant Name	Zone	Family	Plant type	Height	Spread	Bloom time
Penstemon digitalis (foxglove beard tongue)	3-7	*Scrophulariaceae* (Figwort family)	Herbaceous perennial	3.5- 5 feet	1.5-2 feet	April-June
Baptisia australis (blue false indigo)	3-9	*Fabaceae* (Pea family)	Herbaceous perennial	3-4 feet	3-4 feet	May-June
**Syringa chilensis* (Chinese lilac)	3-7	*Oliaceae* (Olive family)	Ornamental Shrub	10-15 feet	10-15 feet	May - June
Physostegia virginiana (obedient plant)	2-9	*Lamiaceae* (Mint family)	Herbaceous perennial	1.5-2 feet	1.5-2 feet	June-September
Monarda fistulosa (bee balm)	4-8	*Lamiaceae* (Mint family)	Herbaceous perennial	2-4 feet	2-3 feet	July-September
Panicum virgatum (switchgrass)	5-9	*Poaceae* (Grass family)	Grass	3-6 feet	2-3 feet	July-February
Aster novae-angliae (New England aster)	4-8	*Asteraceae* (Sunflower family)	Herbaceous perennial	3-6 feet	2-3 feet	August-September
Schizachyrium scoparium (little blustem)	3-8	*Poaceae* (Grass family)	Grass	2-4 feet	1.5-2 feet	August-February

* *Data of Syringa chilensis phenology* is not a part of the original Floral Report Card garden design but is a part of an ongoing lilac phenology initiative of the U.S. National Phenology Network (USNPN). None of the Seattle school gardens as enough garden space to host the Chinese lilacs, but the UWBG garden at the Center for Urban Horticulture has 2 lilac plants. If future schools have enough garden space to include the Chinese lilacs they will be encouraged to do so and provided with the specimen through USNPN.

Other reasons for species selection:

- All species are long lived native species
- Species have a wide range of breeding systems and geographic range
- Species flowering time is initiated by temperature
- Each FRC plant can be easily cloned through propagation
- All FRC species are attractive in a garden setting.

Floral Report Card climate change garden design (General template)



Each garden contains 16 plants from each species, with species arranged in a simple block design. Within each block there are rows of 4 plants from each of the four hardiness zones. There are 112 plants in total for each site, excluding the optional planting of Chinese lilac (*Syringa chilensis)* in partnership with the U.S. National Phenology Network’s cloned lilac study. Design can be altered to suit individual site conditions. Ideally, each garden will have at least 415 square feet of space. Each plant requires about 2-3 ft. spacing. If a school garden has space for the USNPN Chinese lilac phenology study, an additional 16 square feet will be needed. Garden plots require full to partial sun.

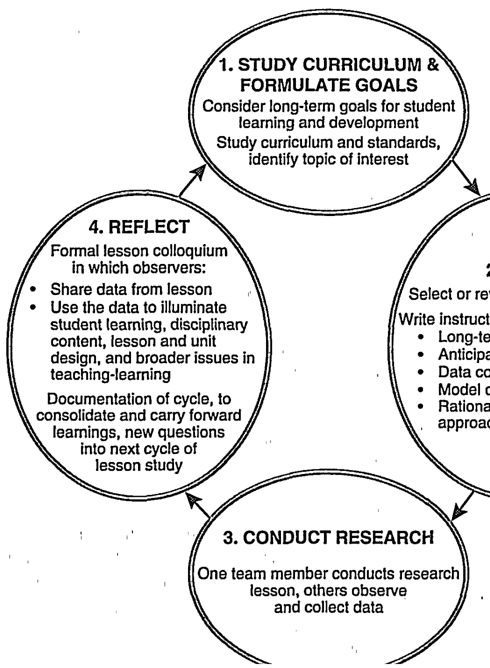
Education Design

Education Design Goal 1:

Develop an FRC curriculum that is universally accessible and contains model lessons that use principles of citizen science to foster science literacy and provides a multidisciplinary and interdisciplinary approach to teaching the science of climate change.

Objective 1.1: Model lessons will be created for use by teachers in a lesson study approach.

Purpose: Lesson study is a Japanese form of curriculum development for teachers that centers on the collaborative study experience of live classroom lessons. Through lesson study, teachers work together to design, present, tailor, and report on the effectiveness of their lessons based on anticipated and observed student learning. Curriculum development within a lesson study framework begins with a working group of teachers, from one to multiple schools, representing a variety of disciplines and grades working together through the following step by step process (Lewis, 2002).



Lewis et al 2006

1. Formulate long term goals for student learning development
2. Plan, conduct, and observe a teacher group designed “research lesson” to bring goals to life and support student content learning
3. Careful observation of student learning, engagement, and behavior during the research lesson

4. Through subsequent collaborative discussion and revision, the lesson is revised and implemented by the teachers of the working group.

The process of lesson study supports the type of interdisciplinary and collaborative approach that is necessary to holistically address a large scale global environmental issue such as climate change.

Education Design Goal 2:

To align lessons with grade level requirements that meet national and state science and social science standards. Science content will focus on earth systems science, plant science, research skills, and the scientific process. Social science content will emphasize the human impacts on the environment, and the social, economic, and cultural consequence of human action and inaction in the context of climate change.

Objective 2.1: American Association for the Advancement of Science (AAAS) Benchmarks for science literacy and AAAS Strand Maps will serve as guides to identify content and create model lesson appropriate for each grade band (4-6, 7-9, 10-12).

Purpose: The AAAS is an international non-profit organization dedicated to advancing science, and in 2009 published *Benchmarks for Science Literacy* as part of a project called Project 2061. Project 2061 is an initiative of the AAAS to help all Americans become literate in science, mathematics, and technology. *Benchmarks for Science Literacy* is the Project 2061 statement of the knowledge that all students should have in the topics of science, mathematics, and technology upon completion of grades 2, 5, 8, and 12. It provides educators with sequences of specific learning goals that they can use to design a core curriculum. (For more information on Project 2061, visit its website http://www.Project61.org)

Objective 2.2: Lesson study participants will create curricula aligned with their local standards and assessment.

Purpose: States have different standards and requirements for curricula and learning in K-12 education. For example, similar to the *Benchmarks for Science*

Literacy created by the AAAS (2009), the Washington State office of Superintendent Public instruction published the *Washington State Standards K-12 Science Learning Standards* (2009), which describes what all students are expected to know and be able to do at each grade of the WA educational system in the area of science. Regional resource centers of the FRC project will have to be knowledgeable of local standards to assist teachers with FRC curriculum alignment.

Education Design Goal 3:

To create curricula through the lesson study process that will engage students in active learning in the outdoor classroom provided by the FRC garden and inside the classroom through interactive online data analysis.

Objective 3.1: National and resource center partners will work with teachers in a lesson study context to develop curricula using the Understanding by Design approach. Understanding by Design is a framework for improving student achievement that focuses on student understanding. It emphasizes the teacher's role as a designer of student learning, by working within the standards-driven curriculum to help teachers clarify learning goals, implement assessments of student understanding, and create effective and engaging learning activities (Wiggins & McTighe, 2005). In addition, the National Research Council (NRC) Informal Learning Strands (2009), NRC Ready, Set, Science (2008), and AAAS Habits of Minds from Benchmarks will all ground the creation of the model lessons to be presented by teachers during the lesson study process.

Purpose: Students using the FRC curriculum will have increased knowledge of environmental science, understand the impacts of climate change on ecosystems, and be better able to use complex reasoning skills to understand scientific concepts.

Informal/formal collaboration design

Collaboration Design Goal 1:

To develop strong, long-term partnerships between schools, regional resource centers, and the national FRC center.

Objective 1.1: Foster collaboration between schools and resource centers to maintain FRC gardens

> **Purpose:** The National Academy of Science published a report in 2009 endorsing informal science experiences as a means to engage youth in science in ways that enhance and support school settings. The FRC gardens represent the opportunity for informal education institutions like botanic gardens to offer direct real-world research opportunities, hands-on activities, and experiences for both teachers and students that are not possible in the formal K-12 education system. Informal and collaborative education resources can offer educators the horticultural and academic support needed to incorporate the FRC garden into a science curriculum from a local perspective. In addition, museum resources can increase educator science content knowledge through supporting professional development experiences and a connection to current research.

Objective 1.2: Create flexible partnerships that capitalize upon the unique structure and resources of individual schools and gardens

> **Purpose:** The structure of a local-regional-national hub network allows for multi-scaled and multi-disciplinary partnerships that can become self-sustaining over time through the sharing of resources.

Objective 1.3: Develop teacher recruitment and retention strategies

> **Purpose:** Reliance on national grant funding sources is not practical; therefore, school FRC participants are expected to be able to implement FRC independently after 5 years. Teacher recruitment must be focused on those who are willing to take time to conduct lesson study lessons at their schools, and each participant signed contracts of expectations. See Appendix C for pilot school contracts signed by the contact teacher and principle of the pilot schools.

V. Project status

The Institute of Museum and Library Services (IMLS) planning grant supported the design of a project framework to support large scale implementation of the Floral Report Card project over the course of one year, 10/2009 through 10/2010. Chicago Botanic Garden has taken the lead on seeking future implementation funding sources, including an application for an IMLS Leadership Implementation Grant submitted in February 2011.

Moving forward, project partners will continue to collect data and refine protocols from the climate change gardens installed during the planning phase year. Further community and school engagement activities are dependent on future funding sources. Each pilot school garden installed in partnership with UWBG in the Spring of 2011 have been given the tools to begin using the gardens for climate change education and preliminary data collection in lieu of a national Floral Report Card curriculum.

Below is a detailed description of the activities completed during the 2009-2010 planning phase year, the installation and data collection practices of the UWBG climate change garden and school gardens, followed by recommendations to support the transition for UWBG to move forward into implementation project phases.

VI. Description of Planning Process

The three goals of the planning process within the 2009-2010 year as outlined in the original IMLS planning grant proposal were:

- To create detailed logic models that identifies inputs, goals, objectives, outputs and outcomes for all components of the project (see Appendix D).
- To create a 5-year implementation plan
- To identify and recruit key personnel and participants for implementation

Seven key project components of FRC were identified through collaborative discussion after the first November 2009 all partner meeting:

1. Climate change monitoring gardens
2. Floral Report Card curriculum and professional development
3. Technology
4. Research
5. Technology
6. Sustainability
7. Overall project goals and objectives

The logic models were created through a multi-stage process beginning in November 2009. One logic model was created for each project component. Each model contains a detailed listing of the overall component goals, objectives, short/mid outcomes (years 1-6), and longer-term impacts (years 7-10). Experts from each participating organization created the logic models through working in three separate committee groups (Education, Technology & Sustainability, and Science & Horticulture) that represented each of the seven project components. All project partners had continued access to the logic model drafts through a shared Google Groups website created by the Chicago Botanic Garden FRC project coordinators. UWBG utilized its scientific and botanical expertise in assisting with the completion of the research and horticulture logic models and timeline.

Similar to the logic models, the five-year implementation plan (see page 23) was created through working groups of the three different committees (Education, Technology & Sustainability, and Science & Horticulture committee). The plan includes a timeline of key checkpoints to achieve each of the project goals and objectives as outlined in the logic models. Years 1-3 have been designated as pilot years for project implementation to allow for formative and summative evaluation that will result in best practices for large-scale project implementation. SRI International has developed an evaluation plan draft. SRI International is an independent, nonprofit research institute that conducts research and development for government agencies, commercial businesses, foundations, and other organizations.

During the three pilot-phase years, each school participating in the project will run as a pilot and assist in the development and refinement of project components. After year 3, it is hoped that the pilot schools will have the ability to take full ownership of the program while maintaining long-term connections with the resource botanic garden hubs, allowing the botanic gardens to recruit more interested schools.

The recruitment of key personnel and participants for implementation included the establishment of an advisory board, a group of botanic gardens interested in participating, and recruitment of interested schools to participate as pilot gardens and represent diverse populations near each botanic garden. Each of the three planning goals was met during the 2009/2010 planning year.

Project Timeline: Developed in August 2010: Year 1 begins with implementation funding (earliest fall 2011)

Sustainability	Year 1												Year 2												Year 3												Year 4												Year 5											
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Completed pre funding																																																												
Create logo and branding campaign	X																																																											
School participation contract (3 year contract)	X																																																											
Identify Advisory Board	X																																																											
Identify Locations (initially 3: CBG, UGA, UW-Seattle)	X																																																											
Hub roles & responsibilities contract	X																																																											
Specify weather station and equipment	X																																																											
Identify a server and permanent host for FRC technoloy	**(See technology timeline)**																																																											
Partnership Development																																																												
Establish funded staff person at each center and each school				•	X																																																								
Provide on-site support to schools								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Maintain ongoing connections with participating schools																																					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Technology																																																												
Maintain proper functioning of technology resources	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Check and respond to "help desk" email	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Post and update technology "frequently asked question s	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X										X	X	X										X	X	X										X	X	X									
Update web resources annually (curricula, expert blogs, etc)													X	X	X										X	X	X										X	X	X										X	X	X									
Garden maintanance and data collection																																																												
Develop and refine models of long-term garden maintan	•	•	X																																																									
Refine data collection protocols based on research que s	•	•	•	X																																																								
Identify least expensive and most durable weather equi p	•	•	•	X																																																								
Ongoing Maintenance	**See In-School Sustainability below**																																																												
Curriculum and professional development																																																												
Ongoing lesson study for curric. rev. & prof. development		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
New annual curriculum themes, challenges & questions										•	•	•	X									•	•	•	X									•	•	•	X									•	•	•	X											
Regional workshops for teacher feedback													X												X												X												X											
National workshops for teacher feedback/PD														X	X											X	X											X	X											X	X									
In-School Sustainability																																																												
Resource Centers																																																												
Staffing up			X	X																																																								
Full integration into botanic garden operations					•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X																																			
School garden maintenance support													X	X	X										X	X	X										X	X	X										X	X	X									
Climate data collection/plan(s)							•	•	•	•	•	X	X	X	X	X	X					X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X					X	X	X
Phase 1 Schools 5 Implementation support plan																																																												
Years 1-2																																																												
2 days in-school support by garden staff	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																																				
summer garden maintenance support																								X	X	X	X																																	
Year 3																																																												
1 day in-school support by garden staff																									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Year 4-5																																																												

Sustainability	Year 1											
consultation upon request												
quarterly curriculum meetings (as part of lesson study public lessons)												
act as mentors for 1st/2nd year schools												
Phase 2 Schools												
Years 1-2												
2 days in-school support by garden staff												
summer garden maintenance support												
Year 3-4												
1 day in-school support by garden staff												
Year 5												
consultation upon request												
quarterly curriculum meetings												
Mentorship by experienced schools/teachers												
Informal Resource Integration												
National FRC Climate Change Resource Center												
Develop national curriculum framework	•	•	•	•	•	•	•	•	•	•	•	•
Develop & Support national/regional technology	•	•	•	•	•	•	•	•	•	•	X	Ongoing
Support Lesson Study initiatives		X	Ongoing									
Complete evaluation design	X	X										
Provide Regional evaluation instruments			X									
Complete national evaluations												
Disseminate results nationally (AAM, AERA, NSTA)												
Regional FRC Climate Change Resource Centers												
Hire/Train dedicated staff	X	X										
Develop region-specific resources	•	•	•	•	•	•	•	•	•	X		
Provide in school implementation support				•	•	•	•	•	•	•	•	•
Garden/MET station Installation & maintenance support	X	X	X								X	X
Provide educators with direct contact with researchers												
Disseminate results regionally (as appropriate)												
Evaluation												
Advisory Board Activities (X in person, • = skype)	X							•				
See Evaluation Plan for details												
Funding												
Explore web-based branding and marketing opportunities												
Find sponsors to provide grants to directly support teachers												
Develop/disseminate teacher grant writing instruction module												
Integrate FRC into botanic garden operations												

Sustainability	Year 2											
consultation upon request												
quarterly curriculum meetings (as part of lesson study public lessons)												
act as mentors for 1st/2nd year schools												
Phase 2 Schools												
Years 1-2												
2 days in-school support by garden staff												
summer garden maintenance support												X
Year 3-4												
1 day in-school support by garden staff												
Year 5												
consultation upon request												
quarterly curriculum meetings												
Mentorship by experienced schools/teachers												
Informal Resource Integration												
National FRC Climate Change Resource Center												
Develop national curriculum framework	•	X										
Develop & Support national/regional technology												
Support Lesson Study initiatives												
Complete evaluation design												
Provide Regional evaluation instruments		X	X									
Complete national evaluations	•	•	•	•	X							
Disseminate results nationally (AAM, AERA, NSTA)												
Regional FRC Climate Change Resource Centers												
Hire/Train dedicated staff												
Develop region-specific resources												
Provide in school implementation support				•	•	•	•	•	•	•	•	•
Garden/MET station Installation & maintenance support	X	X	X								X	X
Provide educators with direct contact with researchers		X	X									
Disseminate results regionally (as appropriate)												
Evaluation												
Advisory Board Activities (X in person, • = skype)		X						•				
See Evaluation Plan for details												
Funding												
Explore web-based branding and marketing opportunities												
Find sponsors to provide grants to directly support teachers												
Develop/disseminate teacher grant writing instruction module												
Integrate FRC into botanic garden operations								•	•	•	•	•

Sustainability	Year 3											
consultation upon request												
quarterly curriculum meetings (as part of lesson study public lessons)												
act as mentors for 1st/2nd year schools												
Phase 2 Schools												
Years 1-2												
2 days in-school support by garden staff	X	X	X	X	X	X	X	X	X	X	X	X
summer garden maintenance support	X	X	X									X
Year 3-4												
1 day in-school support by garden staff												
Year 5												
consultation upon request												
quarterly curriculum meetings												
Mentorship by experienced schools/teachers												
Informal Resource Integration												
National FRC Climate Change Resource Center												
Develop national curriculum framework												
Develop & Support national/regional technology												
Support Lesson Study initiatives												
Complete evaluation design												
Provide Regional evaluation instruments												
Complete national evaluations	•	•	•	X								
Disseminate results nationally (AAM, AERA, NSTA)										X	X	X
Regional FRC Climate Change Resource Centers												
Hire/Train dedicated staff												
Develop region-specific resources												
Provide in school implementation support				•	•	•	•	•	•	•	•	•
Garden/MET station Installation & maintenance support	X	X	X								X	X
Provide educators with direct contact with researchers		X	X									
Disseminate results regionally (as appropriate)	X	X	X									
Evaluation												
Advisory Board Activities (X in person, • = skype)		•										
See Evaluation Plan for details												
Funding												
Explore web-based branding and marketing opportunities								X	X	X	X	X
Find sponsors to provide grants to directly support teachers			X	X	X	X	X	X	X	X	X	X
Develop/disseminate teacher grant writing instruction module								X	X	X		
Integrate FRC into botanic garden operations	•	•	•	•	•	•	•	X				

Sustainability	Year 4											
consultation upon request												
quarterly curriculum meetings (as part of lesson study public lessons)												
act as mentors for 1st/2nd year schools	X	X	X	X	X	X	X	X	X	X	X	X
Phase 2 Schools												
Years 1-2												
2 days in-school support by garden staff	X	X	X	X	X	X	X	X	X	X	X	X
summer garden maintenance support	X	X	X									
Year 3-4												
1 day in-school support by garden staff												
Year 5												
consultation upon request												
quarterly curriculum meetings												
Mentorship by experienced schools/teachers												
Informal Resource Integration												
National FRC Climate Change Resource Center												
Develop national curriculum framework												
Develop & Support national/regional technology												
Support Lesson Study initiatives												
Complete evaluation design												
Provide Regional evaluation instruments												
Complete national evaluations	•	•	•	X								
Disseminate results nationally (AAM, AERA, NSTA)												
Regional FRC Climate Change Resource Centers												
Hire/Train dedicated staff												
Develop region-specific resources												
Provide in school implementation support				•	•	•	•	•	•	•	•	•
Garden/MET station Installation & maintenance support	X	X	X								X	X
Provide educators with direct contact with researchers		X	X									
Disseminate results regionally (as appropriate)	X	X	X									
Evaluation												
Advisory Board Activities (X in person, • = skype)		X										
See Evaluation Plan for details												
Funding												
Explore web-based branding and marketing opportunities	X	X	X	X	X	X	X	X	X	X	X	X
Find sponsors to provide grants to directly support teachers	X	X	X	X	X	X	X	X	X	X	X	X
Develop/disseminate teacher grant writing instruction module												
Integrate FRC into botanic garden operations												

Sustainability	Year 5											
consultation upon request	X	X	X	X	X	X	X	X	X	X	X	X
quarterly curriculum meetings (as part of lesson study public lessons)			X			X			X			X
act as mentors for 1st/2nd year schools	X	X	X	X	X	X	X	X	X	X	X	X
Phase 2 Schools												
Years 1-2												
2 days in-school support by garden staff												
summer garden maintenance support												
Year 3-4												
1 day in-school support by garden staff	X	X	X	X	X	X	X	X	X	X	X	X
Year 5												
consultation upon request	X	X	X	X	X	X	X	X	X	X	X	X
quarterly curriculum meetings			X			X			X			X
Mentorship by experienced schools/teachers												
Informal Resource Integration												
National FRC Climate Change Resource Center												
Develop national curriculum framework												
Develop & Support national/regional technology												
Support Lesson Study initiatives												
Complete evaluation design												
Provide Regional evaluation instruments												
Complete national evaluations								•	•	•	X	
Disseminate results nationally (AAM, AERA, NSTA)										X	X	X
Regional FRC Climate Change Resource Centers												
Hire/Train dedicated staff												
Develop region-specific resources												
Provide in school implementation support				•	•	•	•	•	•	•	•	•
Garden/MET station Installation & maintenance support	X	X	X									
Provide educators with direct contact with researchers		X	X									
Disseminate results regionally (as appropriate)	X	X	X									
Evaluation												
Advisory Board Activities (X in person, • = skype)	•								X			
See Evaluation Plan for details												
Funding												
Explore web-based branding and marketing opportunities	X	X	X	X	X	X	X	X	X	X	X	X
Find sponsors to provide grants to directly support teachers	X	X	X	X	X	X	X	X	X	X	X	X
Develop/disseminate teacher grant writing instruction module												
Integrate FRC into botanic garden operations												

National partner meetings & communication

- Face-Face Meeting Dates & Description:
    - November 18th-19th, 2010: Chicago Botanic Garden, Il

This was the first face-face meeting of all project partners. Dr. Soo-Hyung Kim attended as the representative of UWBG. Project partners discussed the overall educational, implementation, and scientific research goals of the Floral Report Card project. Program components were identified as follows:

1. Curriculum materials
2. Teacher professional development
3. Web-based resources
4. Climate change gardens
5. Garden-based climate change resource center network
6. Replicable structure for in-school implementation

Partner representatives were separated into groups according to expertise to outline logic models to clearly define the goals, objectives, impact, and activities associated with each project component.

The meeting agenda and a brainstorming document was created by the CBG program coordinator and posted to Floral Report Card Google Groups site. This document is available electronically on the UWBG shared dropbox, see "Information Management", in section XI for details.

- February 24th- 26th: Athens, GA

The purpose of the February meeting was to finalize project component logic models, address science & technology questions, prepare for student & teacher focus groups, develop an advisory board recruitment plan, and to brainstorm potential funding opportunities. Dr. Sarah Reichard attended from UWBG and assisted with the finalization of the research and garden logic models, refinement of research questions, and the creation of a supplies list for school garden installations.

A February meeting preparation guide and agenda was prepared and sent to the project partners via email by the CBG project coordinator. After the meeting completed logic model documents for each project component was also published and posted to Floral Report Card Google Groups site. See “Information Management”, in section XI for details on these documents.

- June 2nd- 4th Chicago Botanic Garden, Il

The purpose of the June meeting was to finalize and draft key elements for each of the six project components (education, curriculum, technology, sustainability, research, and horticulture). I represented UWBG at the meeting. Each project component was again discussed within designated committees at the meeting. UWBG partnered with Dr. Havens, Dr. Vitt, and Catherine Thomas from CBG in the Research & Horticulture committee. This meeting had the following goals:

- Review and alignment of key checkpoints for each project component
- Creation of draft timelines for all project components
- Review and presentation of teacher focus group comments
- Review and finalization of supplementary documents (data collection protocols, research questions, garden maintenance plan, content/enduring understandings, etc.)
- Identification of evaluation criteria for each project component

UWBG created a document in preparation for the June meeting, containing teacher focus group results, draft garden maintenance guidelines, and draft research collection protocols. The document is available electronically on the UWBG shared dropbox, see “Information Management”, in section XI for details.

- August 9-10th Chicago Botanic Garden, Il

August 2010 was the last face-to-face meeting of project partners. The goals of this meeting were to

- Finalize timelines for each project component
- Finalize and compile all appendices and supporting documents (data collection protocols, research questions, garden maintenance plan, content/enduring understandings, etc.)
- Report on advisory board member selection progress

The sustainability timeline on page 23 represents a compilation of all project timelines. Each timeline was created within a 5-year framework.

- Conference Calls
  - February 8th, 2010

Coordinated and led by Dr. Jennifer Schwarz from CBG, this conference call was held to ensure that each partnership organization was clear on the February face-face meeting expectations. I represented UWBG and disseminated the conference call minutes to UWBG associates via email. Dr. Sarah Reichard was delegated to be placed on the Research/Garden logic model committee to discuss data collection protocols and garden installation guidelines.

VII. UWBG climate change garden installation

Description of Planting & Installation

UWBG received its FRC plants from the Chicago Botanic Garden in the fall of 2009. Plants were re-potted from 6 inch to 1 gallon pots and were overwintered in the outdoor hoop houses of the UWBG Center for Urban Horticulture (CUH). Not all 114 plants were delivered due to propagation limitations at Chicago Botanic Garden. See the diagram on page 32 for plants not planted on the first day of planting.

The sixteen 6’ X 5’ raised wooden beds of the CUH climate change garden were not in use prior to planting. Due to the amount of weed material in the beds, in February of 2009 the soil was removed and replaced with new soil mix. Based on an initial field test, the new soil media is of a clay loam texture. See Appendix E for soil lab test results obtained from the University of Massachusetts Soil Plant and Tissue testing laboratory. In March 23rd, 2010, the plants were installed by several UWBG and CUH garden staff, including Washington Park Arboretum (WPA) horticulture staff supervisor David Zuckerman, CUH gardener Annie Bilotta and WPA Education Supervisor Patrick Mulligan. All plants were either in dormant or early vegetative stages. Since it was too early in the year to begin an automatic irrigation schedule, the transplants were watered manually using a trowel to detect soil moisture to each plant’s expected root zones. Manual watering is easily accessible through use of the quick coupling valve located in each of the two irrigation control boxes on site. The weather and soil were monitored and the plants were watered accordingly.

Image of the east two rows of
UWBG climate change garden beds
prior to planting. 3/9/2010.

Image of the east two rows of
UWBG climate change garden beds
4 months after planting. 7/28/2010.

Maintenance

During the week after the March 2010 plant installation, each bed was mulched with wood chips to conserve soil moisture and prevent weed establishment. Mulch will be replenished annually each spring and obtained from the supply available at the CUH. Open communication with the CUH gardening staff is imperative due to limited resources, and the CUH staff gardeners should be notified regarding resource needs for climate change garden maintenance. In the spring and summer, weeding should be done on a bi-weekly basis.

	Example maintenance calendar for UWBG climate change garden											
Task	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Cut back herbaceous perennials to ground (leave evergreen basal growth of *Penstemon digitalis*)												X
Weeding (as needed)		x	x	x	x	x	x	x	x	x	x	
Irrigation***				monitor	monitor	Follow weather patterns to begin automatic drip irrigation schedule	Monitor drip irrigation	Monitor drip irrigation, begin to reduce water schedule according to weather conditions	Monitor drip irrigation, set date for turning off automatic irrigation according to weather conditions			
Mulch replenishment				x								x

***The UWBG FRC project coordinator should work with the gardening staff of the UWBG to set up automatic irrigation schedules.

Irrigation

Prior to soil removal and plant installation, Dr. Soo Hyung Kim purchased drip line irrigation for each bed. The irrigation was installed by Brian K. Davis, the maintenance mechanic lead of irrigation for the University of Washington Facilities Services. Each of the sixteen beds has their own valve and there are two control boxes for the entire site. One control valve controls eight boxes (or one zone), and collectively emits 4 gallons of water per minute per zone (8 boxes per zone). Irrigation is controlled by two Hunter brand SVC's (smart valve controllers), one per control box. CUH gardener Annie Bilotta is trained in UW irrigation systems and has been the irrigation contact for the CUH climate change garden. In the event Ms. Bilotta was not available for assistance, WPA horticulture staff supervisor David Zuckerman was contacted.

The irrigation timers were activated on June 24th, 2009, to a watering schedule of Monday and Thursday mornings. Each zone received two hours of water from 7AM-9AM. The decision to start the timers was made by Annie Bilotta and based on weekly weather forecasts of the late spring/early summer season.

Brian Davis provided the following schedule as an example of a typical schedule, and stressed the importance of microclimate considerations and the need to monitor the soil moisture on site.

Example of a Typical Drip Irrigation Schedule

Days/wk.: 7 days/wk. for new plant starts, 3 days/wk. once established

Start times: 1 cycle in the early morning and possibly another cycle in the afternoon if necessary for shallow rooted new starts to offset any surface drying.

Run time: 20 minutes

Total run time per month

New plant starts w/ 1 cycle/day = 20 min * 1 cycle/day * 7 days/wk. * 4 wks./mo. = 560 min/mo. (or 9.33 hrs./mo.); or w/ 2 cycles/day = 1120 min/mo. (or 18.67 hrs.)

Established plants = 30 min * 1 cycle/day * 3 days/wk. * 4 wks.'/mo. = 360 min/mo. (or 6 hrs./mo. to warmer temperatures)

Total water per month

New plant starts w/ 1 cycle/day = 4.96 GPM/zone * 1 cycles/day * 20 min/cycle *7 days/wk. *4 wks./mo. = 2,777.6 gallons/month; or w/ 2 cycles/day = 5,555 gal/mo.

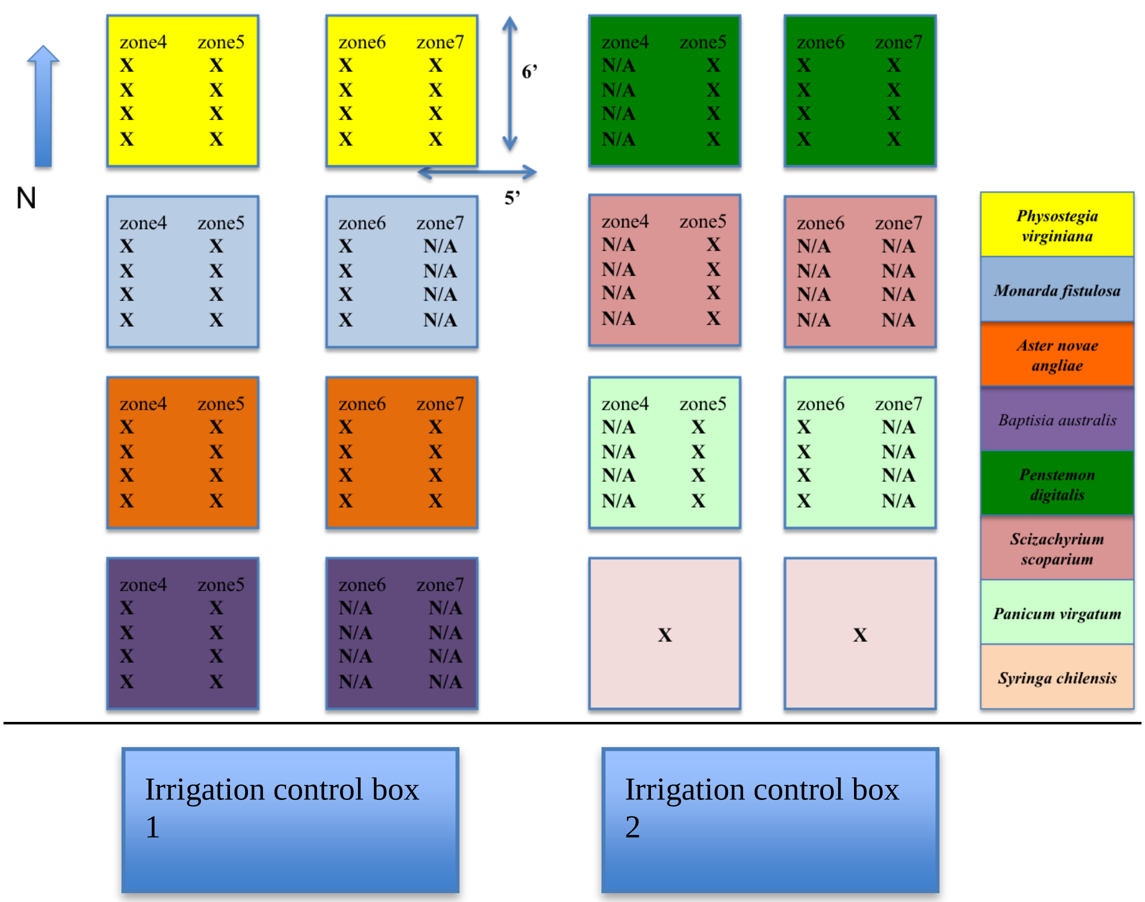
Established plants = 4.96 GPM/zone * 1 cycle * 30 min/cycle * 3 days/week * 4 wks./mo. = 1,785.6 gallons/month

The two-hour run time twice a week was sufficient throughout the climate change garden's first summer. However, in late August it was noted that the ground around the westernmost box (*Penstemon digitalis* zones 6 & 7) was saturated and standing water was observed in the west zone irrigation control box. Upon inspection by Brian Davis, it was concluded that the beds were being overwatered due to programming errors on the SVC controllers. Since garden data collectors did not observe this in July or during the first week of August, the overwatering is not believed to have occurred for a long enough period of time to cause plant damage.

Fertilization

Each box that was planted in March of 2009 was fertilized with a light application of APEX 16-6-11 (full spectrum slow-release) at rate of 3#/1000sq'.. CUH Gardener Annie Bilotta also assisted with setting the rate of fertilization.

UWBG Climate Change garden, March 23rd, 2010



In the above diagram, each “X” indicates a plant that was planted on March 23rd, 2010. “N/A” indicates that the plant was not received in the original order received by UWBG in the fall of 2009.

Plant Mortality and Replacement

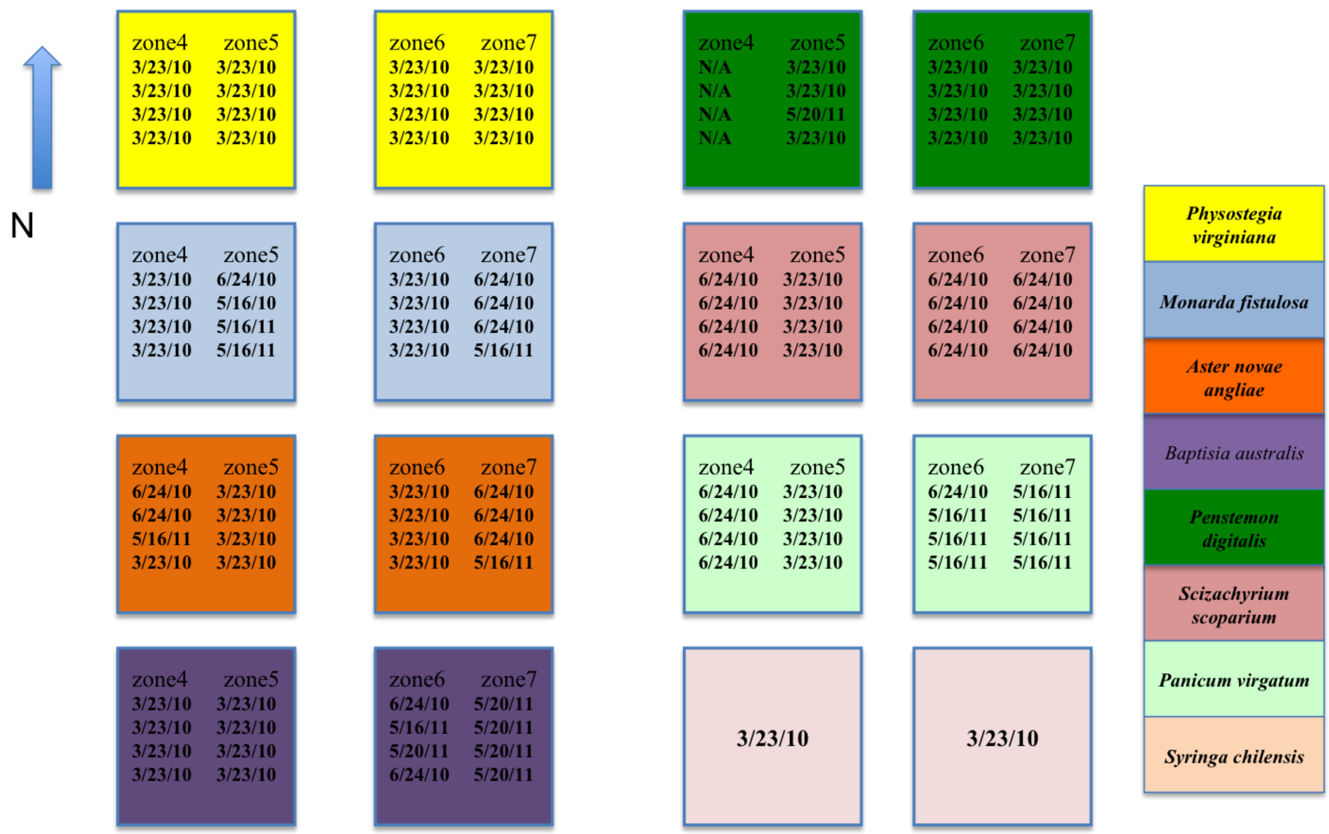
Over the course of the first and second growing season, there were three plant orders placed to Chicago Botanic Garden (CBG) to replace plants that either did not survive or were missing from the original fall 2010 order sent to UWBG. The three orders were placed in May 2010, April 2011, and May 2011. The April and May 2011 orders were to replace plants that did not survive the winter. As of May 2011, the only plants that have not been sent by CBG are zone 4 *Penstemon digitalis* (foxglove beardtongue). Each order was placed via email to Dr. Havens from Chicago Botanic Garden. The plants ordered in May 2010 were received by UWBG on June 2nd, 2010. Due to miscommunication, the plants were not watered for three days while in the CUH greenhouse (zone 3, bench 8A) and were therefore drought stressed. The health of the zones 6 and 7 *Baptisia australis* (wild blue false indigo) was most affected by this oversight. Dead stem and leaf material were removed from the 6-8 inch tall plants and the plants were monitored in the greenhouse until they were planted in the garden on June 24th, 2010. Half of the zone 6 *B.australis* and all of the zone 7 *B.australis* plants perished, likely due to the initial drought stress during its early stages of growth and subsequent inability to develop adequate root systems to over-winter in the garden beds. Interestingly, many of the same zones of plant species that needed replacement due to mortality in June 2010 also needed replacement in April 2011. This may indicate weak stocks of certain plant zones and should be monitored and compared with other gardens.

Plant	% Mortality between 9/2009-4/2010	% Mortality between 6/ 2010-4/2011
Zone 5 *Monarda fistulosa*	25%	75%
Zone 4 *Aster novae angliae*	50%	25%

Zone 7 *Aster novae angliae*	75%	25%
Zone 6 *Panicum virgatum*	25%	75%

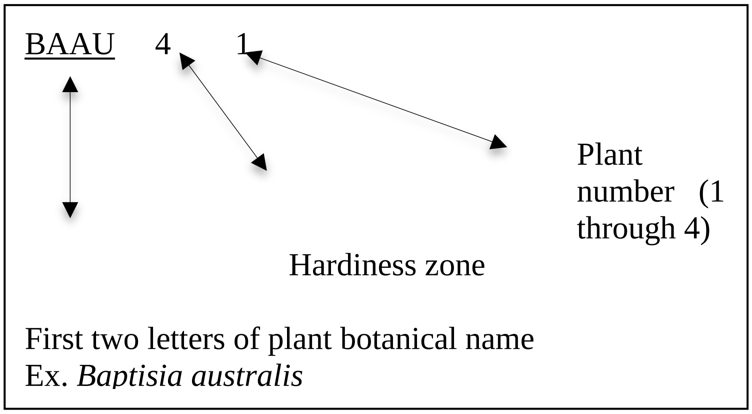
The diagram below shows the planting date of each plant. Plant mortality was due to either disease or winter stress. All plant observations and mortality records are also accessible in the UWBG_CCG excel workbook provided to Dr. Soo Hyung Kim and available on the Dropbox file sharing website (see report section VIIII, *Information Management* for more information).

UWBG climate change garden: planting dates

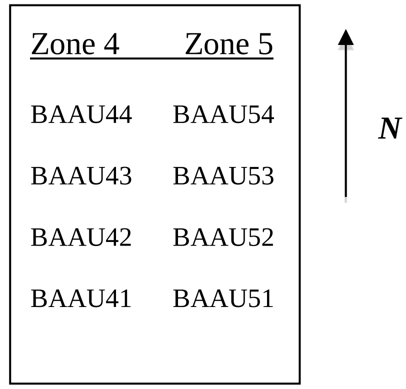


Preliminary data collection

For record keeping and phenology data collection of the UWBG climate change garden, each plant was given a code using the following technique:



Species bed



This plant coding technique will also be used for data collection of Seattle's FRC school gardens. Phenology data was collected during the 2010 growing season using protocols designed by Project Budburst (http://www.neoninc.org/budburst/) and the cloned lilac study of the U.S. National Phenology network (http://www.usanpn.org) for the two *Syringa chilensis* (Chinese lilac) specimen. Four phenophases were tracked for each species (excluding the *Syringa chilensis* data collection, which has a separate protocol available in Appendix F)

- First flower
- Full flower
- First fruit
- Leaf senescence

Upon initial plantings on March 23rd, 2010 and June 24th, 2010 all plants were past the phenophase of "first full leaf", therefore this phenophase was not tracked in the 2010 growing season. Data was collected through a shared weatherproof notebook using the following as a guideline:

Heading: Date
Name (of data collector)
Time:

Plant code	Height/#of stems or stalks	First flower	First fruit	Leaf senescence	Comments/Notes

Data collectors for the UWBG climate change garden for the 2010 growing season included myself, an undergraduate assistant between March and May 2010, and two high school interns between July and August 2010, and me. Data collection began on the first of April, and the plants were monitored three times a week. Once floral development was observed on any species, observations began daily, for the 2010 season was May 9th, 2010. Aside from a notebook or data collection sheet for recordings, each data collector was equipped with a digital camera, a printout of the general data collection protocols, a list of the garden species with brief backgrounds of species life traits and general phenology patterns, and a UWBG climate change garden plant code sheet for reference.

It was decided by FRC project collaborators during the beginning of the planning process that each climate change garden required one growing season after installation to become established before accurate phenology data collection could begin. Therefore, data collected during the 2010 growing season served to identify best methods for creating species-specific phenology data collection protocols, and will not be included in the final dataset used for analysis. Photo monitoring and a recording of plant health served to provide reference points of the overall appearance, phenophase, and pest or pathogen damage of each plant species for observers collecting data. In addition, two high school students interned with the UWBG climate change garden and collected plant species phenology data between July and August of 2010. Their internship was through a partnership established by the UWBG Arboretum education supervisor Patrick Mulligan, between the UWBG and a summer youth program of the Pacific Science Center.

Due to the fact that an online database for national FRC garden data entry has not been created, all phenology data recorded was transferred to an excel sheet. Since the first year phenology data of the UWBG climate change garden served to provide a descriptive account for the creation of species-specific protocols, analytic research to identify cause-effect relationships between abiotic variables such as temperature and precipitation and plant phenophases was not conducted.

VIII. Species-specific data collection protocols

The general collection guidelines were adapted from guidelines provided to Project Budburst participants. I have created seven species-specific protocols using the experience of the 2010 growing season of the UWBG climate change garden. Species specific protocols designed by Dr. Kayri Havens from Chicago Botanic Garden and myself during the planning meeting in August are below, as well as a sample of "educator cards" that can be found in appendix I of this report.

General steps to guide data collection:

Step 1 Determine the phenophase to look for.

The following phenophases followed by their definitions are being observed for Floral Report Card

1. First full leaf- Report the date at which the first leaves are completely unfolded from the bud.

2. First flower- First flower can be described when petals are open on individual flowers so that the stamens are visible. If you see one open flower on the plant, mark plant to be in its first flower phenophase. Flowers are considered "open" when the reproductive parts are visible between unfolded or open flower parts.

3. Full flower- Full flower can be described as when 95% of the flower clusters no longer have any unopened flowers. For individual flower (*Aster*), full flower can be described when all disk and ray flowers appear to have opened.

4. First fruit- Report the date when you notice the first fruits becoming fully ripe or seeds dropping naturally from the plant.

5. Leaf senescence- 95-100% of the leaves have fallen

Step 2 Determine when and how often to observe plants.

Some species begin flowering in early spring, others in late summer. Refer to the individual species phenophase and data collection guides. Once spring approaches, observations should be made three times per week. Once a phenophase is thought to occur (i.e. first full leaf), observations should be made daily.

Step 3 Make detailed recordings of plant health and garden conditions that may affect plant phenology.

Step 4 Organize and input the data onto an excel sheet as provided into the garden kit. A photograph will be taken of each marked phenopohase using a digital camera Pictures of the plant will be taken from the same angle. This will allow observers to more clearly see how that particular plant has changed throughout its yearly life cycles.

Species-specific protocols

1. *Monarda fistulosa* (Bee-balm)

Background & Phenophase Identification

Many Native American groups used this member of the mint family for medicinal purposes, and some people still drink bergamot tea during cold and flu season. This plant is also the source of the antiseptic Thymol, used in some mouthwashes.

Some species begin flowering in early spring, others in late summer. *Monarda* will bloom in most climates between May and August. Observations should be made three times per week from early spring for first leaf. Once shoots become obvious observations should be made daily. After first leaf, it will be a couple of months until flowering. You can make observations less frequently until flower buds are visible, and then intensify to daily observations again.

1. First full leaf – *Monarda fistulosa* should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground. Shortly after emerging from the ground, the first leaf will open. When it is fully expanded, mark the date of this phenophase.

2. First flower – *Monarda* develops flowers at the end of most stems. The stems bear heads (botanically capitula) composed of several of purple-pink flowers, which open fairly simultaneously. "First flower" is when you see the first flower fully open.

While the photo to the left does not yet constitute first flower, once you observe the flower organs in developmental phases as shown, observations should begin daily.

3. Full flower – When at least 95% of flowers on all the flowering stems are open.

4. First fruit – The fruits of *Monarda fistulosa* are tiny nutlets found in the base of the dried flower heads. It is impossible to see them without dissecting the flower head, but they are mature when the flower head is brown and dry. When the first flowering head is 95% brown/dry, mark this phenophase. **Photo unavailable**

5. Leaf senescence – *Monarda leaves*/stems will turn colors in the fall, often first a yellow-brown and later brown and dry. When the plant is 95% brown and dry, mark this phenophase. **Photo unavailable**

2. *Penstemon digitalis* (foxglove beardtongue)

Background & Phenophase Identification

Penstemon means five stamens in Greek. Four of the stamens are fertile (make pollen) and one is sterile. The common name of beard tongue comes from the tuft of hairs on the sterile stamen resembling a beard.

Some species begin flowering in early spring, others in late summer. *Penstemon* will bloom in most climates between April and June. Observations should be made three times per week from mid-spring. Once flowering shoots become obvious and buds are visible, observations should be made daily.

1. First full leaf – *Penstemon digitalis* has a basal rosette of leaves, which are often evergreen and persist throughout the winter. Because of this, we will not be monitoring this phenophase for *Penstemon*.

Evergreen basal rosette of leaves of *Penstemon digitalis* (foxglove beardtongue).

2. First flower – *Penstemon* sends up several flowering stems of white flowers. The stems bear clusters of white flowers, known as a panicle, which mature over time. "First flower" is when you see the first flower fully open and shedding pollen.

This photograph shows buds beginning to burst for a *Penstemon digitalis* specimen. Once this has been observed, inspection of the plants needs to begin daily to obtain the exact date of first flower.

This photograph shows the first flowering phenophase of *Penstemon digitalis* (foxglove beardtongue). Although not all of the buds on the flowering stem are open, one flower is all it takes for the plant to be marked in its first flowering stage of development.

3. Full flower – when at least 95% of flowers on all the flowering stems are open. Since the flowers mature over time, some of the earliest opening flowers may have started to mature into fruit.

4. First fruit – The fruits of *Penstemon* are dry capsules. They are mature when they are completely brown and just starting to split open.

When the green fruits in this photograph of *Penstemon digitalis* (foxglove beardtongue) turns brown, this plant will be marked in its ripe fruit stage of development.

5. Leaf senescence - *Penstemon digitalis* leaves are often evergreen and persist throughout the winter. Because of this, we will not be monitoring this phenophase for *Penstemon*. (See photograph in step 1)

5. Physostegia virginiana (obedient plant)

Background & Phenophase Identification

Some species begin flowering in early spring, others in late summer. *Physostegia* will bloom in most climates between July and October. Observations should be made three times per week from mid-spring for first leaf. Once shoots become obvious observations should be made daily. After first leaf, it will be a number of months until flowering. You can make observations less frequently until flower buds are visible, then intensify to daily observations again.

1. First full leaf –*Physostegia virginiana* should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground. Shortly after emerging from the ground, the first leaf will open. When it is fully expanded, mark the date of this phenophase.

2. First flower – *Physostegia develops* flowers at the end of most stems. The stems bear spikes of numerous purple-pink flowers that open from the bottom up. "First flower" is when you see the first flower fully open.

The photograph on the left indicates that budburst is about to happen on a *Physostegia virginiana* specimen. Once this stage of floral organ development is observed, observations should intensify as the first flowering phenophase is about to be reached. The picture on the right depicts the first flowering phenophase.

3. Full flower – When at least 95% of flowers on all the flowering stems are open. Since the flowers mature over time, some of the earliest opening flowers may have started to mature into fruit. **Photo unavailable**

4. First fruit – The fruits of *Physostegia* are tiny nutlets found in the base of the old flowers. After pollination, the flower tube (corolla) will fall off, but the green sepals are retained. It is very hard to see the fruits, but they are mature when the base of the flower (sepals) surrounding them is brown and dry. When the first flower base is 95% brown/dry, mark this phenophase. **Photo unavailable**

5. Leaf senescence – *Physostegia leaves*/stems will turn color in the fall, often first a yellow-brown and later brown and dry. When the plant is 95% brown and dry, mark this phenophase. **Photo unavailable**

6. *Aster novae-angliae* (New England aster)

Background & Phenophase Identification

Some species begin flowering in early spring, others in late summer. *Aster* will bloom in most climates between August and November. Observations should be made three times per week from mid-spring for first leaf. Once shoots become obvious observations should be made daily. After first leaf, it will be a number of months until flowering. You can make observations less frequently until flower buds are visible, then intensify to daily observations again.

1. First full leaf –*Aster novae-angliae* should be cut back to the ground each winter.

In the spring, look for new green growth emerging from the ground. Shortly after emerging from the ground, the first leaf will open. When it is fully expanded, mark the date of this phenophase.

2. First flower – *Aster* develops flowers at the end of most stems. The flowers are aggregated into heads (capitula) composed of two kinds of flowers (ray florets and disk florets). The ray florets are around the perimeter have a strap-like "petal" that is purple. The disk florets in the center of the head are tiny, cylindrical and yellow.

This is an *Aster novae-angliae* that has begun floral organ development. Once this is observed, monitoring should begin daily to mark the phenophase of first flower.

The florets are mature when you first notice pollen being pushed out of the disk florets. Mark this as first flower.

3. Full flower – when at least 95% of flowers on all the flowering stems are open. Since the flowers mature over time, some of the earliest opening flowers may have started to mature into fruit. **Photo unavailable**

4. First fruit – The fruits of *Aster* are tiny achenes attached to fluffy, white hairs (pappus) held in the base of the old flower head, until carried away by the wind (like a dandelion). The fruits are mature when the base of the flower head surrounding them is brown and dry and white pappus is expanded. When the first flower head base is 95% brown/dry, mark this phenophase. **Photo unavailable**

5. Leaf senescence – *Aster* leaves/stems will turn color in the fall, often first a yellow-brown and later brown and dry. When the plant is 95% brown and dry, mark this phenophase. **Photo unavailable**

7. *Panicum virgatum* (switchgrass)

Background & Phenophase Identification

Some species begin flowering in early spring, others in late summer. *Panicum* will bloom in most climates between June to August. Observations should be made three times per week from late winter/early spring. Once shoots become obvious observations should be made daily. After first leaf, it will be a number of months until flowering. You can make observations less frequently until flower stalks are visible, then intensify to daily observations again.

1. First full leaf – *Panicum virgatum* should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground amidst the stubble of last year's growth. Shortly after emerging from the ground, the first leaf will lengthen and unroll. When it is fully expanded, mark the date of this phenophase.

Once new growth appears from *Panicum virgatum* (switchgrass) rootstock, observations should begin daily for first full (lengthened and unrolled) leaf.

First full extended leaf from *Panicum virgatum* (switchgrass). Mark this phenophase

2. First flower stalk – *Panicum* develops flowers at the end of most stems; grass flowers are quite small and non-descript. The stems bear clusters (botanically panicles) of green flowers which mature over time. "First flower" is when you see tiny yellow anthers dangling out of the first flower and shedding pollen.

3. Full flower – when at least 95% of flowers on all the flowering stems are shedding pollen. Since the flowers mature of time, some of the earliest opening flowers may have started to mature into fruit.

4. First fruit – The fruits of *Panicum* are grains, held within the green flower. They are mature when the flowering cluster turns from green to golden brown.

5. Leaf senescence – *Panicum* leaves/stems will turn color in the fall to yellow-brown. When the plant is 95% brown and dry, mark this phenophase.

Sample species protocols for educators:

For the full 7 species protocol card version of these cards, see appendix I

Floral Report Card

Baptisia australis: wild blue false indigo

This beautiful plant is an often used garden perennial and was named the 2010 perennial plant of the year by the Perennial Plant Association. Its common name refers to one use of the plant. Native Americans (Cherokee tribe) used the plant to create a blue dye, similar to the dye from the true indigo plant (*Indigofera tinctoria*). Its dried pea-like pods have been used for rattles for children and are popular in dried plant arrangements.

Baptisia australis

VIIII. Recruitment of interested educators & pilot schools

Email campaign & criteria for pilot school selection

FRC project collaborators limited the number of schools functioning as pilot school partnerships supported by each resource botanic garden hub during the project's planning stages of development. UWBG targeted three K-12 local schools to function as pilot school gardens. Starting in the winter of 2010, an email marketing campaign was conducted to local Seattle educators to gage interest. Educator email contacts from the UWBG Arboretum education staff was utilized, as well as contacts acquired through networking at local educator events.
The following is an introductory email sent to one of the three UWBG supported pilot school educators:

> Greetings,
>
> I hope this e-mail finds you well. I'm Allison McCarthy, a UW graduate student representing the University of Washington Botanic Gardens (UWBG). Ms. X gave me your information as she thought you might be interested in a nationwide climate change education initiative called **Floral Report Card,** which involves the installation of *Climate Change Gardens* onto school grounds for students to collect phenological data from.
>
> This year, UWBG has partnered with institutions nationwide in the installation of these *climate change gardens*. Each garden is planted with specially selected plants based on their sensitivity to temperature. Phenological data (i.e. first leaf out, first flower) will be collected and used by scientists to predict the effects of rising temperatures associated with climate change on plants.
>
> **In recognizing the potential for phenology data collection to be a tangible and hands-on way to understand climate change, the Floral Report Card Project was conceived to integrate these gardens into local school curriculum. The project is designed to engage students (grades 4-12) in climate change research through the installation of these Climate Change Gardens onto school grounds.** Students become the scientists, and will be able to collect data and input it into an interactive online database all on school property.
>
> Floral Report Card is currently in its planning stages of development. UWBG is looking to recruit local educators interested in hosting a climate change garden at their schools. Once UWBG identifies local partnerships, funding will be acquired to run a pilot program in which 3 partnership schools can have the gardens installed.
>
> If the Floral Report Card project seems like a good fit for your school and curriculum, please let me know!
>
> Thank you for your time and I hope to hear from you.

The developmental stage of Floral Report Card during pilot educator outreach and subsequent garden installment meant that standardized outreach or curriculum materials were not available and have yet to be developed to date. Additionally, the IMLS Planning Grant funding could only provide the three pilot schools with initial garden plant and weather station installment support and guidance from UWBG. Continued UWBG support as a regional resource is contingent on future funding sources. With these limitations in mind, the following criteria was placed on selecting the pilot school gardens:

1. Pilot school lead garden educators had to be teachers of science

   Reasoning: The FRC curriculum will be focused on increasing science literacy and engagement, specifically in the context of climate change education

2. Pilot school lead garden educators had to be flexible and adaptive

   Reasoning: Any project in its planning stages of development will require adaptive abilities of individual parties in terms of resource management and scheduling. For example, if the school climate change garden needed more than one scheduled class for installation, the educator needed to be able to schedule another class period devoted to planting

3. Garden space

   Reasoning: Each pilot school needed the appropriate amount of garden space, minimum requirement of 410 square feet of full to partial sun.

Educator Focus Groups

In the spring of 2010, each participating botanic garden was asked to host focus groups to K-12 educators to review the project components. Through educator feedback, project partners were able to identify local concerns and gage teacher interests and needs for program implementation. On May 13th and May 20th, 2010, two focus groups were conducted at the UWBG Center for Urban Horticulture. Teachers in attendance were representative of elementary, middle, and high schools from both public and private settings. Attendance turnout was 5 educators for May 13th and 3 for May 20th. Educators who were unable to attend were asked to submit written responses to questions (see Appendix G). The largest deterrent for educator involvement was the project's pilot status and lack of formal curriculum to provide with the installation of the garden.

Floral Report Card: Educator Focus Group Participants

Teacher	Subject Taught	Grade	School	Private/ Public	Contact
Cindy Jatul	Biology and Biotechnology	10-12	Roosevelt High School	Public	cyjatul@seattleschools.org
Robin Burn	6th grade- Physical Science 7th grade- Life Science	6-7	Northlake Middle School	Public	Robin_Burn @lkstevens.wednet.edu
Matthew Hutson	Science	7-8	Lakeside School 5-12	Private	Matt.Huston@lakesideschool.org
Patricia Lavelle	Retired teacher/ School garden volunteer	N/A	Jane Addams K-8	Public	lavelle@ w-link.net
Laurie Lenihan	Environmental Science and 9th grade Biology	9-12	Auburn Riverside High School	Public	llenihan@ auburn.wednet.edu
Julie Blystad	Science specialist		Bertschi school	Private	julieb@bertschi.org
Christine Benita	Science specialist/ Environmental Studies	K-8	Jane Addams K-8 school	Public	cabenita@seattleschools.org
Karen Lovick	Science	5	Immaculate Conception School (K-8)	Private	karen lovick@ic-olph.org
India Carlson*	Science, runs greenhouse on	10-12	Ballard High School	Public	ikcarlson@seattleschools.org

	school grounds				
Deborah Fullerton*	Science	6	Moorlandelementary	Public	dfullerton@nsd.org

The following is a list of concerns that the educators voiced about the Floral Report Card project during the educator focus groups.

Teacher concerns/ recommendations

Logistics

- Summer maintenance and data collection- this will be required, possible identification of an environmental after-school group/community group. Summer school participants not possible in a private school setting, likely a parent /community service group**. (A concern raised during both focus groups, teachers are generally not around summer months)**
- Request for UWBG FRC staff to help teachers identify garden sites at schools
- Mulch- how will mulch be acquired
- Soil- many sites will not have suitable soil or means of lawn removal, raised beds might be preferable
- Request for specific time-line of pilot and implementation phases of school garden installation.
- Provision of maintenance calendar template
- Identifying level of UWBG assistance
- Assist with teacher navigation within school districts (especially Seattle Public School District) to obtain garden approval

Curriculum

- Development of a student tour of the UWBG Center for Urban Horticulture greenhouses to present FRC and other research projects being done at UW of plant responses to climate change.
- Request for UWBG FRC staff to host a workshop of data collection technique/ website input for students at the school

1. It is preferable for lesson plans to be designed within FRC curriculum for teacher amendment as necessary (aligned to state standards), Inquiry-based, and STEM (science, technology, engineering, mathematics) oriented
2. Stress within curriculum how students are engaging in an active and present day research project as integral members of the scientific community

Professional Development

1. 2-day Professional Development preferences, teachers receive ~3 days per year for professional development. A Friday-Saturday recommended.

- Teacher training- dates and times of years suggested include summer for fall implementation and on the statewide in-service day for teachers in early October

Presentations and networking

Floral Report Card was first formally presented by UWBG on May 1st, 2010 during a weekend workshop for educators interested in incorporating climate change education into their school curriculum. The workshop was held at the Center for Urban Horticulture and while focused on a program entitled the "Cool School Challenge" of the Puget Sound Clean Air agency (www.coolschoolchallenge.org), the program coordinators hosted the workshops in collaboration with UWBG (see Appendix H for flier). Many organizations in Seattle are involved with both climate change based and school garden oriented programming that Floral Report Card can tap into and complement such as the Cool School Challenge.

In the summer of 2010, the UWBG Arboretum education supervisor, Patrick Mulligan, connected with a teen summer program called "Discovery Corps" hosted by the Pacific Science Center (PSC) in Seattle. WA. Discovery Corps is a program for high school students aged 14 and older that provides students with job and learning experience through volunteering 100 hours of service to the Pacific Science Center. During the 2010 Discovery Corps session, the PSC designed the program to have a climate change science focus and gave students the opportunity to work with local organizations to act as "mentors" in accepting high school students as assistants in various projects relating to climate change. UWBG was selected as a mentor organization and received two high school interns between July and August 2010 to volunteer 15 hours per week at the climate change garden. I trained the students in techniques of the plant phenology data collection as well as garden maintenance. These types of youth summer programs offer ideal platforms to recruit data collectors for the UWBG climate change garden and possibly the three school pilot gardens who need assistance in the collection of summer phenology data.

X. Pilot school descriptions & garden installations

Garden installation process

Once the pilot schools were selected, the following steps were taken in the garden installation process:

1. Site Assessment (conducted by UWBG FRC coordinator)
    a. Measurements
    b. Soil samples for testing
    c. Accessibility of irrigation
2. Site proposal written by UWBG FRC coordinator and submitted to educator for school district submission. Each site proposal is on the dropbox file sharing website, see “Information Management” section XI for more details.
    a. Garden design
    b. Timeline of proposed activities
    c. Needed supplies and tasks

** Note: Each pilot school in Seattle was required to gain permission to install a climate change garden. The proposal was written by UWBG to help aid the educator through the approval process. For the educator, this process began by first asking the principal, then the landscape crew, and finally an application for a Seattle Public School District “Self Help Program” approval.

3. Site preparation
    a. Pre-existing vegetation & sod removal (student & teacher assistance)
    b. Soil grading (student & teacher assistance)
    c. Mulch application (student & teacher assistance)
    d. Weather station installation*

*Note: I took the lead on assembling and installing two of the Seattle school weather stations and configured the consoles/receivers for each of the three schools. Two 4X4 cedar posts were cemented into the ground at each designated weather station site. This required assistance from either the teacher or a volunteer parent and permission from the principal and grounds crew. One of the lead school educators had the resources and assistance to install the weather station herself after assembly and configuration.

   e. Computer software installation (Teacher had technology staff person at each school install software)

4. Planting
   a. Soil grading & weeding (student & teacher assistance)
   b. Planting
   c. Mulch application (student & teacher assistance)

The memorandum of understanding that was signed by each principal outlined the following obligations of each pilot school should further implementation funding be granted.

1. Minimum 2 year participation
2. Minimum of 3 teachers participate in professional development activities
3. Maintain garden
4. Collect data throughout the growing season (including summer) including phenology, weather, and photographic data
5. Collaborate to develop and implement regional Floral Report Card curricula
6. Implement the Floral Report Card curriculum
7. Staff will attend public lessons of regional lesson study groups
8. Allow a minimum of 1 visit/quarter by project staff throughout the school year in addition to public lessons
9. Attend annual national lesson study workshops (paid travel & expenses for 4 teachers)
10. Collaborate with regional resource centers to integrate FRC into any existing communications, and marketing effort
11. Collect photographic documentation of school base implementation

Garden supply list

The list below represents a general supply list that each participating school garden may need to host a Floral Report Card garden. Since each individual pilot school connected with UWBG had varying amounts resources, not all of these supplies listed below were required for each pilot school in Seattle. The UWBG FRC project coordinator took the lead on ordering and creating these resources to each of the pilot school. See individual school descriptions for materials supplied.

- Gloves
- Weeding tools
- Receptacle for weeds
- Hoses and sprinklers
- Plant labels (112 labels per garden)
- Plant description, phenophases
- Data sheets
- Clipboards
- Digital camera and photo pole
- Weather station
    - Davis Instruments 6152 Wireless Vantage Pro2 Weather Station with Standard Radiation Shield,
    - Davis Instruments 6450 Solar Radiation Senor
    - Soil Moisture/Temperature Station for Vantage Pro2
    - Computer software (WeatherlinkIP) to enable educators to download data onto an easily accessible website for analysis
    - Vantage Pro2 Pole Mounting Kit,
    - Davis Instruments 6345 Wireless Leaf & Soil moisture sensors
- Plants
- Planting Plan
- Site prep information – sod/weed removal, spades, soil amendments depending on soil tests, mulch instructions, fencing if necessary (tools and horticultural advice for site prep supplied by UWBG)
- Soil test kit or instruction for where to send soil (soil test for each site was completed by the Soil and Plant Tissue Testing Laboratory of the University of Massachusetts at Amherst.)

Garden installations

1. Jane Addams

Address: **Jane Addams K-8**
11051 34th Ave NE, Seattle, WA 98125
(206) 252-4500

Teacher Contact: **Christine Benita**
Science specialist/Environmental Science teacher
Grades: K-8

School Description:

Opened in 2009, Jane Addams is a K-8 school with an environmental science focus. In being designated as an environmental science focused school, it implements a curriculum that teaches students to understand scientific concepts and methods and apply these skills to local and global environmental issues. The school also offers an integrated Spectrum program for advanced learners, bilingual services for English Language Learners (ELL), special education services, and a rich arts program. Jane Addams is the only school in the Seattle Public Schools district with a full time science specialist who is involved in planning science-related curriculum, securing grants for environmental science activities, and coordinating with teachers to organize science and environment-related field trips.

Student population:

Grades K-5	
Population	
Number of Students	198
Number of Teachers	23
Average class size	18
Demographics	
American Indian	4%
African America	18%
Chicano/Latino	14%
Asian	14%
White	51%
Free/Reduced Lunch	44%
English Language Learners	14%
Special Education	18%
Advanced Learning	3%

Grades 6-8	
Population	
Number of Students	147
Number of Teachers	23
Average class size	--
Demographics	
American Indian	5%
African America	22%
Chicano/Latino	10%
Asian	14%
White	50%
Free/Reduced Lunch	51%
English Language Learners	5%
Special Education	20%

Garden location: The climate change garden is within a fence enclosed area that is currently used as gardening space for the school. The area is full sun and was previously grass lawn.

Area to be covered: 576 square feet

Site preparation: Cardboard & mulch application over entire area to kill sod and prevent re-growth

Soil amendment: N/A Native soils (See appendix E for soil test results)

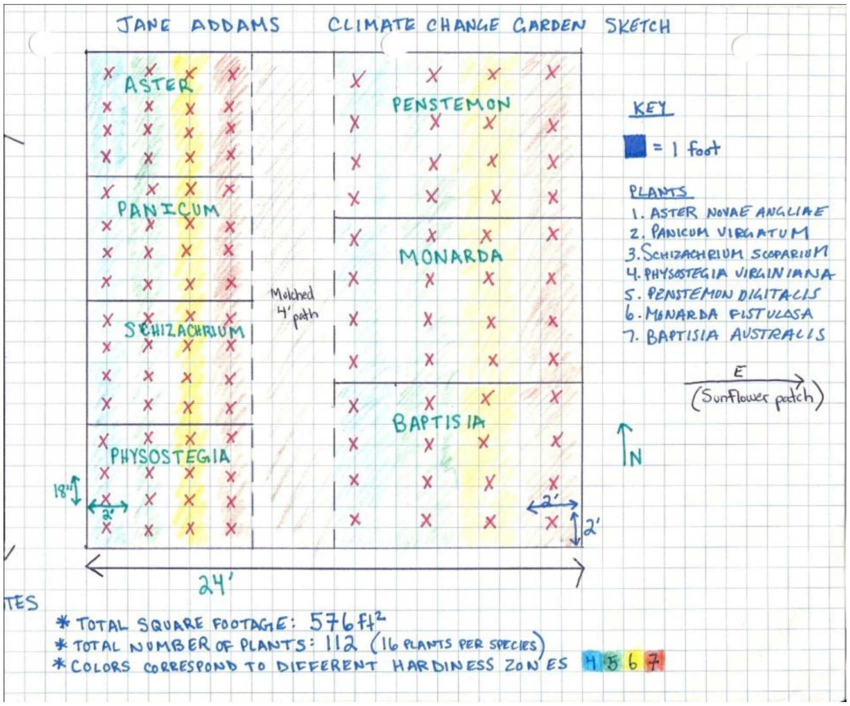
Above: Photo of the Jane Addams K-8 school garden location. The picture was taken facing north direction. The garden will be situated between an existing butterfly garden to the west and a native plant flowerbed to the east.

Above: Model created for the garden site proposal to Jane Addams using Google SketchUp model application. Model not drawn to scale.

Garden site preparation:

As an alternative to using power equipment such as a rototiller to remove the grass lawn, in January 2011 students of Jane Addams assisted in the laying down of cardboard over the garden location. Mulch was then applied on top of the stacked cardboard.

Planting plan:



Plant codes for data collection

ASNO44	ASNO54	ASNO64	ASNO74
ASNO43	ASNO53	ASNO63	ASNO73
ASNO42	ASNO52	ASNO62	ASNO72
ASNO41	ASNO51	ASNO61	ASNO71

PAVI44	PAVI54	PAVI64	PAVI74
PAVI43	PAVI53	PAVI63	PAVI73
PAVI42	PAVI52	PAVI62	PAVI72
PAVI41	PAVI51	PAVI61	PAVI71

BAAU44	BAAU54	BAAU64	BAAU74
BAAU43	BAAU53	BAAU63	BAAU73
BAAU42	BAAU52	BAAU62	BAAU72
BAAU41	BAAU51	BAAU61	BAAU71

PHVI44	PHVI54	PHVI64	PHVI74
PHVI43	PHVI53	PHVI63	PHVI73
PHVI42	PHVI52	PHVI62	PHVI72
PHVI41	PHVI51	PHVI61	PHVI71

MOFI44	MOFI54	MOFI64	MOFI74
MOFI43	MOFI53	MOFI63	MOFI73
MOFI42	MOFI52	MOFI62	MOFI72
MOFI41	MOFI51	MOFI61	MOFI71

PEDI44	PEDI54	PEDI64	PEDI74
PEDI43	PEDI53	PEDI63	PEDI73
PEDI42	PEDI52	PEDI62	PEDI72
PEDI41	PEDI51	PEDI61	PEDI71

SCSC44	SCSC54	SCSC64	SCSC74
SCSC43	SCSC53	SCSC63	SCSC73
SCSC42	SCSC52	SCSC62	SCSC72
SCSC41	SCSC51	SCSC61	SCSC71

Garden maintenance:

Jane Addams has a very strong volunteer base to assist with garden maintenance during the summer months. Science educator and school science specialist Christine Benita has taken the lead in outlining a maintenance and preliminary data collection schedule using this volunteer base.

Garden Installation:

Students from the environmental science class at Jane Addams (approximately 17 students) assisted in the planting of the climate change garden over the course of 3 class periods, which totaled about 2.5 hours of student and teacher time. All of the plants were installed by May 26th, 2011. During each class period, students were separated into three groups, one planting group, one mulching group, and one weeding group. I took the lead on laying out each of the plants prior to the start of planting using flags as markers to assist the students in proper placement. Before plant installation, students tasked with planting were given a demonstration on how to properly plant. All of the plants were watered in using the hose supplied to the school through the FRC school garden budget.

2. Ballard High School

Address: **1418 NW 65th St**
Seattle, Washington 98117
(206) 252-1000

Teacher Contact: India Carlson
Science Teacher & Greenhouse manager
Grades: 10 -12
ikcarlson@seattleschools.org

School description:

Ballard High School (BHS) has over 1600 students in grades 9-12, and is the oldest continuously operating high school in the city of Seattle. Students have the opportunity to join unique programs such as video production, Academy of Finance, Maritime Academy, Biotech Academy, and BHS is of the few high schools in Seattle to offer Botany and Environmental Horticulture as science courses to students. BHS is also well-known for having a very supportive community with a strong PTSA, booster clubs, and its own Ballard Foundation.

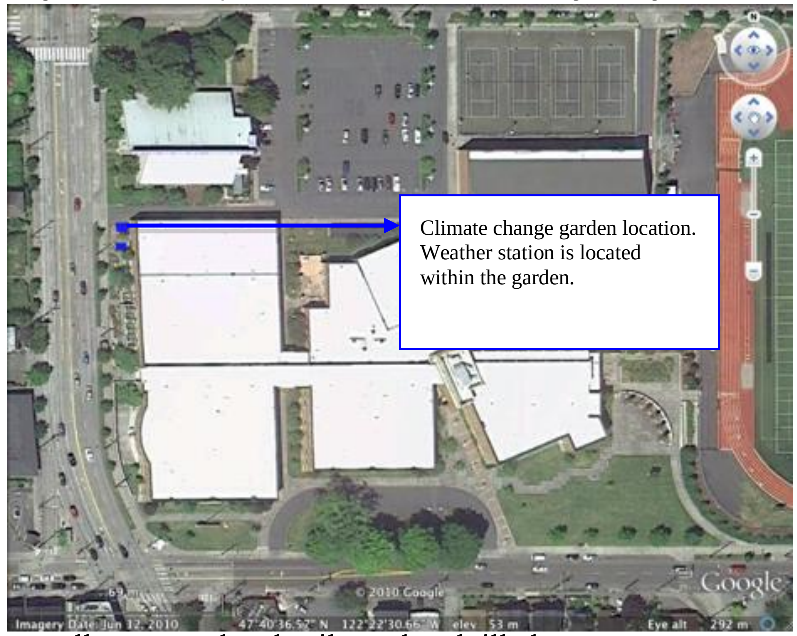
Student population:

Grades 9-12	
Population	
Number of Students	1,632
Number of Teachers	89
Average class size	27
Demographics: Data as of October 1, 2009*	
American Indian	3%
African America	8%
Chicano/Latino	11%
Asian	11%
White	67%
Free/Reduced Lunch	24%
English Language Learners	6%
Special Education	11%

*** Data available within school reports that are published annually on the Seattle Public School District's website, http://district.seattleschools.org**

Garden Location

The garden at Ballard is located next to the greenhouse adjacent to the school building along 15th Ave NW. The area is fenced in, flat, and is west facing. There will be two garden plots separated by a blue atlas cedar tree that is approximately 25' in height. The western facing aspect of the garden will provide partial sun, with shade influences from the building shadow and cedar tree.



Area to be covered: 333 square feet

Site Preparation: Sod and plants were manually removed and soil was hand tilled.

Soil amendment: N/A Native soils (see Appendix E for soil test results)

Garden site preparation

All English ivy (*Hedera helix*) along the wall of the school building was removed to garden planting.

This first plot will cover an area of 224.75 square feet, and will contain 80 plants.

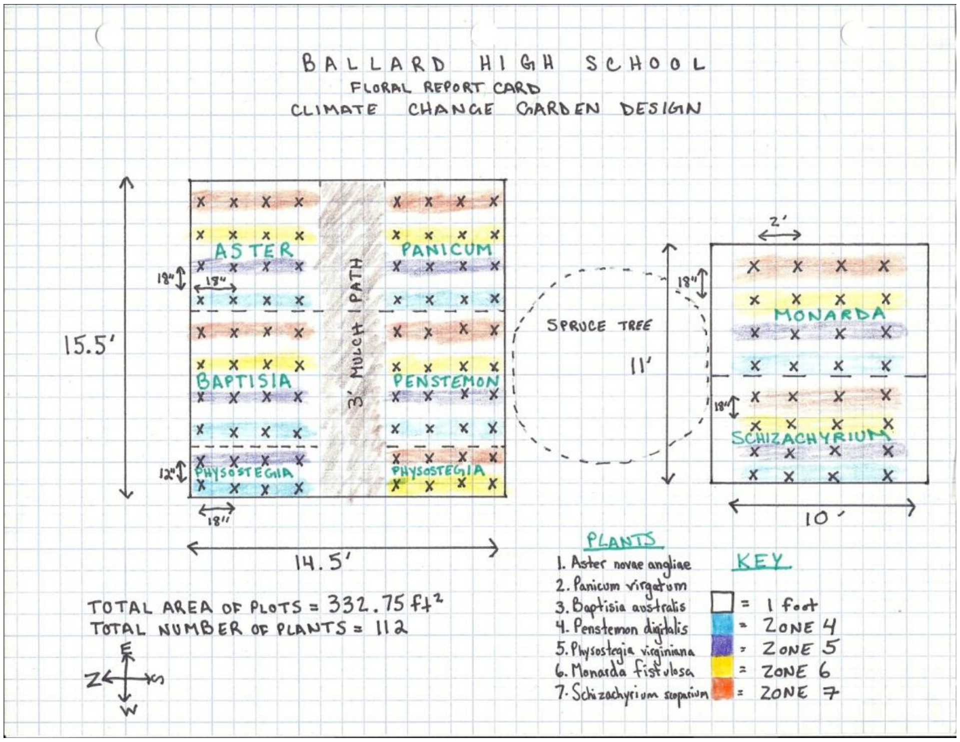
This is the second plot adjacent to the other side of the cedar tree and will cover an area of 100 square feet and will contain 32 plants. Existing plants as circled in the picture were removed in order to make space for the second garden plot.

After the sod was removed and soil tilled and graded, 2-3 inches of mulch was spread by students across the two garden plot areas. Mulch was obtained free of charge by a local arborist from Treemendous tree service (http://www.treemendoustree.com).

Plot 1 (North side of cedar tree) post mulching.

Plot 2 (South side of cedar tree) post mulching.

Planting Plan



Plant codes for data collection

ASNO71	ASNO72	ASNO73	ASNO74	PAVI71	PAVI72	PAVI73	PAVI74
ASNO61	ASNO62	ASNO63	ASNO64	PAVI61	PAVI62	PAVI63	PAVI64
ASNO51	ASNO52	ASNO53	ASNO54	PAVI51	PAVI52	PAVI53	PAVI54
ASNO41	ASNO42	ASNO43	ASNO44	PAVI41	PAVI42	PAVI43	PAVI44
BAAU71	BAAU72	BAAU73	BAAU74	PEDI71	PEDI72	PEDI73	PEDI74
BAAU61	BAAU62	BAAU63	BAAU64	PEDI61	PEDI62	PEDI63	PEDI64
BAAU51	BAAU52	BAAU53	BAAU54	PEDI51	PEDI52	PEDI53	PEDI54
BAAU41	BAAU42	BAAU43	BAAU44	PEDI41	PEDI42	PEDI43	PEDI44
PHVI51	PHVI52	PHVI53	PHVI54	PHVI71	PHVI72	PHVI73	PHVI74
PHVI41	PHVI42	PHVI43	PHVI44	PHVI61	PHVI62	PHVI63	PHVI64

MOFI71	MOFI72	MOFI73	MOFI74
MOFI61	MOFI62	MOFI63	MOFI64
MOFI51	MOFI52	MOFI53	MOFI54
MOFI41	MOFI42	MOFI43	MOFI44
SCSC71	SCSC72	SCSC73	SCSC74
SCSC61	SCSC62	SCSC63	SCSC64
SCSC51	SCSC52	SCSC53	SCSC54
SCSC41	SCSC42	SCSC43	SCSC44

Garden Installation

Photo of all plant placements prior to planting

Over the course of three class periods students assisted with the climate change garden installation on May 24th, 2011. It took a total of three class periods (approximately 3 hours) to prepare the soil and plant. The soil was prepared through grading and mulch clearing. I laid out each plant according to proper spacing prior to student installation. Each class of students (approximately 20 each) was split in to two groups. One weeding group and one planting group. Before plant installation, students of the planting group were given a demonstration on how to properly plant. All of the plants were watered and re-mulched post planting.

Photo of students preparing the soil and removing English ivy (*Hedera helix*)

Supply List for Ballard High School		
Item	**Quantity**	**Cost**
Soaker hose (100ft)	2	29.98
plant tags (copper)	112	7.96
Garden stakes (40 per bag)	1	5
Digital camera	1	100
TOTAL		142.94

3. Roosevelt High School

Address: **1410 NE 66th St**
Seattle, Washington 98115
(206) 252-4810

Teacher Contact: Cynthia Jatul
Science Teacher: Biology & Biotechnology
Grades: 10-12
cyjatul@seattleschools.org

School description:

With over 1700 students, Roosevelt High School hosts a vigorous academic program with highlights that include a wide variety of Advanced Placement courses offered in core academic areas, and a nationally recognized program in the arts and drama. Roosevelt's student body is reflective of the diversity of Seattle, and includes almost 10 percent English Language Learners. Twenty-one percent of Roosevelt's students qualify for free or reduced lunch. Academically, Roosevelt students perform well beyond the state average. In 2007, Roosevelt students were the top scorers on the WASL amongst Seattle Schools with 92.7 % meeting standard on the Reading WASL, 76.3% meeting standard on the Math WASL, and 94.4 % meeting standard on the Writing WASL.

Grades 9-12	
Population	
Number of Students	1,653
Number of Teachers	89
Average class size	27
Demographics: Data as of October 1, 2009	
American Indian	1%
African America	10%
Chicano/Latino	8%
Asian	20%
White	62%
Free/Reduced Lunch	21%
English Language Learners	7%
Special Education	9%

Garden location

Unlike Ballard High School and Jane Addams, Roosevelt High School did not have dedicated gardening space. Lead educator Ms. Jatul had to seek approval from both the principal and grounds crew for gardening space. After several site requests, the one site given permission for the climate change garden is located on a sloped green space located in front of the school in between two cement staircases along a south facing cement wall. The gardening conditions are less than idea as the heat from the surrounding surface and the site's sloped conditions will have strong microclimate influence on plant growth. Furthermore, because the garden site is located at the building's main entrance, the weather station could not be placed directly in the garden space as a safety precaution to thwart vandalism. The station was instead placed approximately 500 feet from the site in a landscaped patch that is not utilized by students.

Area to be covered: 503 square feet

Site Preparation: Sod and plants were manually removed and soil was hand tilled.

Soil amendment: N/A Native soils. Entire site was mulched.

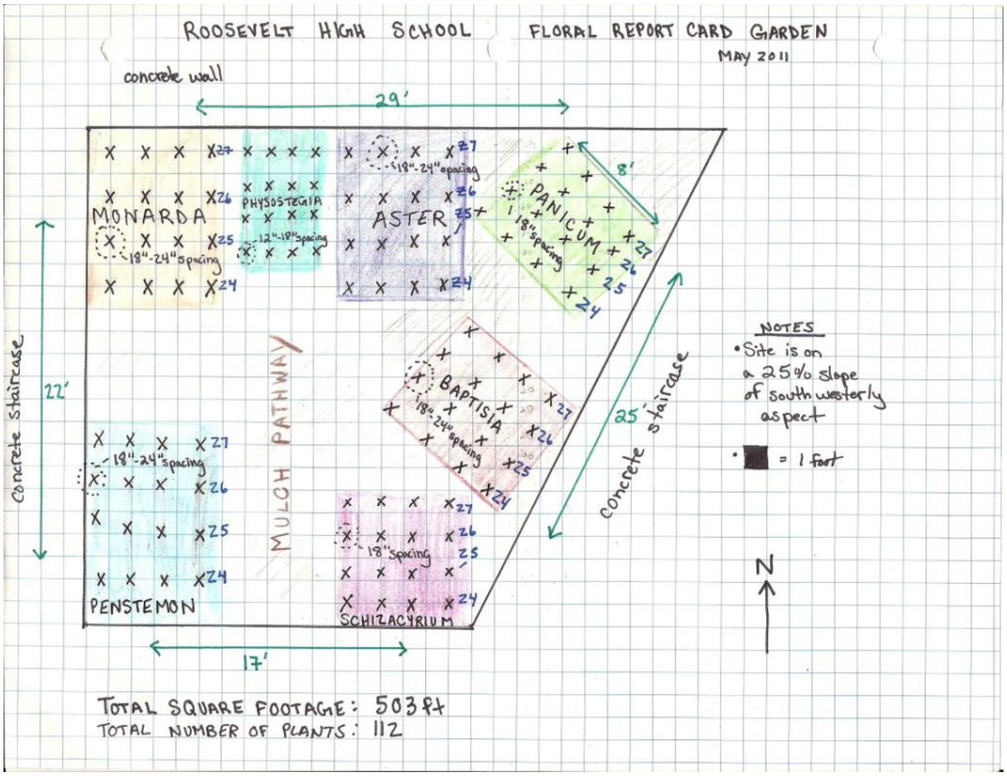
Garden site preparation: All plants and sod were manually removed with the help of students who were able to earn extra credit after school over the course of 3 days. Students spent approximately 6 hours assisting in the removal of the preexisting vegetation. All waste was transported to Pacific Topsoils, a landscape service company in Seattle that allows the public to drop-off yard waste for a small fee.

After the sod was removed and soil tilled and graded, 2-3 inches of mulch was spread across the entire area. Mulch was obtained free of charge by a local arborist from Treemendous tree service (http://www.treemendoustree.com).

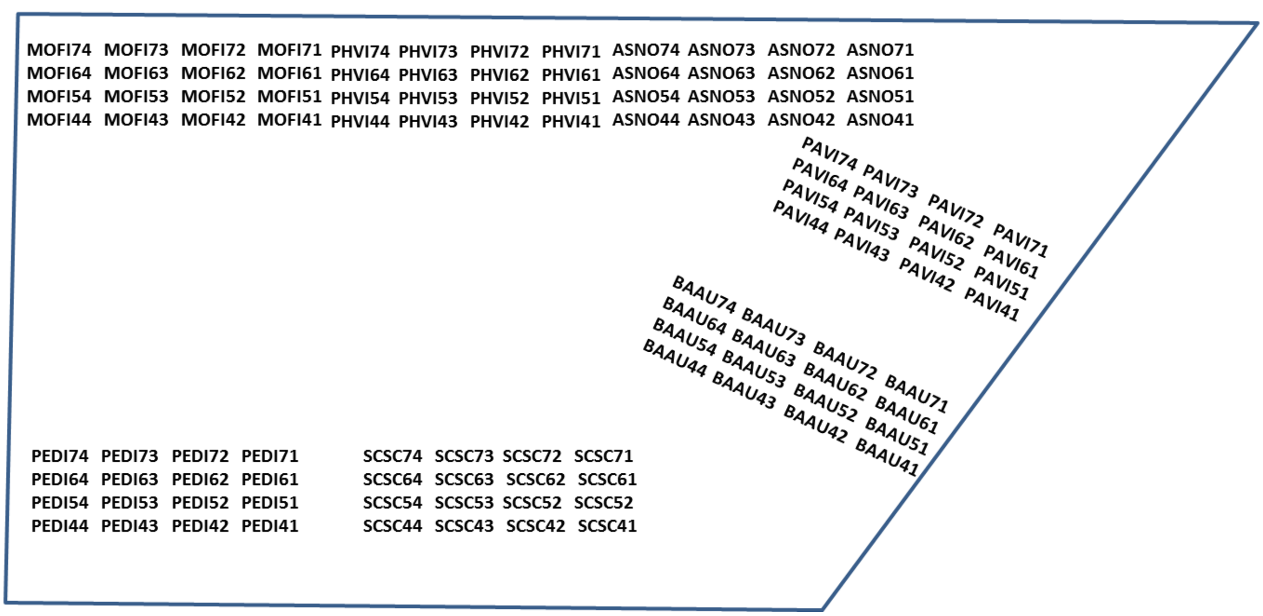
Planting date for Roosevelt High School is scheduled for June 2nd through 4th, 2011.

Supply List for Roosevelt High School		
Item	**Quantity**	**Cost**
Hose	1	36.98
Water wand	1	12.97
Weeding tools (4 piece set) (2 trowels, 1 weeder, 1 cultivator in each set)	6	59.88
plant tags (copper)	112	7.96
tool box	1	163.16
gloves	30	120
4 X 4 post	1	9.63
60 lb cement (1 bag)	1	2.98
shovel	1	7.98
rake	1	9.98
bucket	1	2.78
Clipboards	30	60
Camera	1	100
TOTAL		594.3

Planting plan



Plant codes for data collection



XI. Information Management

UWBG FRC Garden

Data Management

Phenology Data

Plant phenology data will be recorded as per the species-specific data collection protocols. Data collection can be done through a student internship orchestrated by the UWBG program principal investigator, Dr. Soo-Hyung Kim, or the UWBG FRC project coordinator can outreach through local community venues to recruit citizen scientists. Until a formal online data management system is created, data can be recorded manually via a shared notebook and inputted into an online excel sheet. Data collectors can use the established plant coding technique to record the phenophase of each plant. A template data excel sheet has been provided to Dr. Soo-Hyung Kim. All data collection inquiries should be direct to Dr. Soo-Hyung Kim.

Weather Data

Weather data can be obtained from the weather station located at the UWBG Center for Urban Horticulture. The UWBG FRC garden data collector can upload data monthly and process it according to research needs. Dr. Soo-Hyung Kim can be contacted for weather station data access. Weather data that has been processed should be stored within the same workbook of the plant phonological recordings for the corresponding year. Data to be processed includes temperature, precipitation, wind, and solar radiation.

Photographic Data

Until an online database is established, photographs of each plant phenophase can be organized through photo sharing websites. Websites such as “Photobucket”, “Snapfish” or “Shutterfly” allow image files to be uploaded and organized within folders. Each growing season will result in a total of 660 pictures for the phenophase tracking of the seven species, as each plant will require a total of 5 photographs of each tracked phenophase (first leaf; first flower; full flower;

first fruit; leaf senescence) with the exception of *Penstemon digitalis* (bearded fox tongue) which only has 4 phenophases to track due to its basal evergreen growth eliminating the "first leaf" phenophase from analysis. Each photograph should be titled using the plant codes used in phenophase data collection followed by the phenophase codes and the date phenophase observed in a XX_XX format.

<u>Phenophase codes for photo documentation</u>

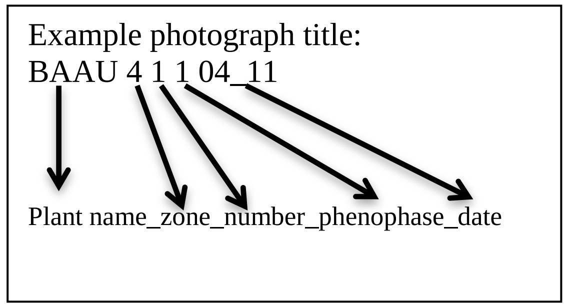
1: first leaf

2: first flower

3: full flower

4: first fruit

5: leaf senescence



I have established a profile on the photo-sharing site "Photobucket" for the next UWBG FRC data collector to use in lieu of a national Floral Report Card online database.

Website: http://photobucket.com/

Username: UWBG_FRC

Password: floralreportcard

Until a mounting post for a digital camera is purchased for the UWBG FRC garden, data collectors should practice the technique of repeat digital photography by taking pictures from the same angle each time the photograph is taken.

Background & outreach materials

Background and outreach materials for the FRC project are stored on a Dropbox file sharing website. During the 2009-2010 planning phase, the folder shared on the Dropbox website, *"FRC"*, was accessible to Dr. Soo-Hyung Kim, UWBG education supervisor Patrick Mulligan, and myself as the FRC project coordinator.

School Gardens

Data Management

Phenology data

Since each pilot school garden was not planted until late May of 2011, phenology data will not be useful until the spring of 2012 because the plants require a one year establishment period. In the event that a Floral Report Card national online database has not been created by the spring of 2012, each pilot school educator has been given electronic copies of data collection sheets and a template excel sheet to record preliminary plant phenology data. Pilot school educators can save these excel files on their school computers.

Photography data

Until an online database is established for the Floral Report Card gardens, photographs of each plant phenophase can be organized through photo sharing websites or onto desktop computers. Websites such as “Photobucket, “Snapfish” or “Shutterfly” allow image files to be uploaded and organized within folders. Each growing season will result in a total of 660 pictures for the phenophase tracking of the seven species, as each plant will require a total of 5 photographs of each tracked phenophase (first leaf; first flower; full flower; first fruit; leaf senescence) with the exception of *Penstemon digitalis* (bearded fox tongue) which only has 4 phenophases to track due to its basal evergreen growth eliminating the “first leaf” phenophase from analysis. Each photograph should be titled using the plant codes used in phenophase data collection followed by the phenophase codes and the date phenophase observed in a XX_XX format.

<u>Phenophase codes for photo documentation</u>

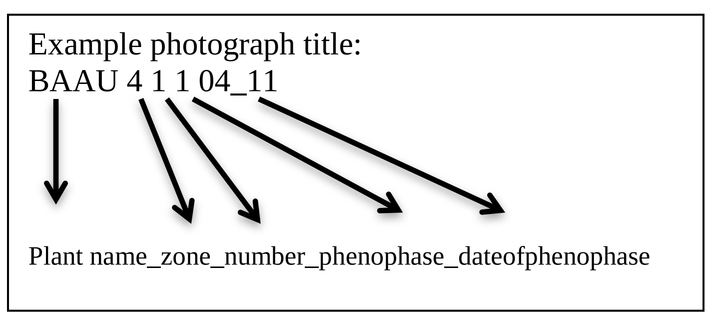
1: first leaf

2: first flower

3: full flower

4: first fruit

5: leaf senescence



Each teacher can decide between establishing a file sharing website and creating a file pathway on their school computers for photograph storage. It is suggested for teachers to use the file sharing websites so students can upload photographic records independently in the classroom.

Each school has access to or has received a digital camera as part of the pilot school climate change garden package. After the first preliminary year of data collection, the pilot school educators can assess the best means for photo monitoring using a class of students. Each teacher is encouraged to have the students practice the technique of repeat digital photography by taking phenophase pictures from the same angle each time the photograph is taken.

Weather Data

Each school has received a Davis Instruments Vantage Pro2 wireless weather station with an integrated suite that includes a console/receiver, rain collector, temperature and humidity sensors an anemometer, and solar panel. At a future date, soil moisture and leaf evaporation sensors will also be provided to each school. Electronic components are housed in a weather-resistant shelter. Each school also received weather Davis Instruments 6555 WeatherLinkIP computer software that posts weather data collected from the Vantage Pro2 station directly to the internet. Educators will only be tasked with plugging the data logger that came with the software into the back of the console and a cable/DSL router connection to the internet. Using the WeatherLinkIP software, educators will be able to create publicly accessible websites to see their data live. More information about the weather station and equipment purchased for each school garden can be found on the Davis Instruments website, http://www.davisnet.com.

XII. Total cost of school garden installations

The cost below represents the approximate total cost of the materials, supplies, and equipment of the three Seattle school garden installations. This cost does not include staff time or car rental rates for traveling to/from each school.

TOTAL SCHOOL GARDEN INSTALLATION COST: MATERIALS, SUPPLIES, EQUIPMENT		
Item	**Quantity**	**Cost**
Weather Station		
(all componenets included)	**3**	**2000**
Garden Supplies		
Hose	2	73.96
Soaker Hose	4	64
Water wand	2	25.94
Weeding tools (4 piece set)	11	109.78
(2 trowels, 1 weeder, 1 cultivator in each set)		
plant tags (copper) (1 bag=10 tags)	30	119.4
tool box	2	326.32
gloves	40	160
4 X 4 post	2	19.96
60 lb cement (1 bag)	2	5.96
shovel	1	7.98
Garden stakes (2 bags)	2	10
rake	1	9.98
bucket	1	2.78
Clipboards	60	120
Camera	2	200
TOTAL		3256.06

XIII. Moving forward

The majority of the direct cost of the Floral Report Card project was in the materials and supplies for the garden installations. Over the next three years, little additional direct costs should be associated with the pilot school gardens aside from plant replacement, staff time and vehicle rental charges.

If FRC implementation funding is granted in the fall of 2011, UWBG will receive resources to hire a program coordinator who will work directly with the three pilot school gardens over the next three years through Floral Report Card curriculum development and K-12 data collection protocol refinement.

If the IMLS funding is not granted, UWBG can begin to seek sources of funding that will be dependent on the direction that UWBG wishes to implement the FRC project independently of the national climate change garden education initiative. One way to integrate the FRC garden project into existing UWBG programming is through the project's incorporation into the UWBG Garden-based Restoration & Outreach Workgroups (G.R.O.W.) program for high school students. The G.R.O.W. program aims at strengthening the relationship between youth and the environment by funding environmentally themed projects at schools. High school students are first taken on field trips to the UW campus where they are given project ideas and guidance. The students then apply for a "mini-grant" for the project of their design. This type of empowerment is what citizen science fosters, and a phenology garden option for a G.R.O.W school is in alignment with the G.R.O.W program mission and activities. Alternatively, the UWBG can also seek funding to turn the CUH climate change garden into an interpretive garden that includes signage to encourage public engagement. Ways to implement this idea include

1. Adding permanent signage to the site that invites public participants to collect garden data. Public patrons frequently walk past the garden beds en route to the UBNA trail, and can be drawn to the site through appropriate signage
2. Advertising CUH climate change garden on the UWBG website and other appropriate sources and providing the opportunity to conduct citizen science

X. Recommendations

While the national Floral Report Card project is in an interim state between planning and large-scale implementation, there are several actions that the University of Washington Botanic Gardens is advised to take so that the organization can:

a) Make a smooth transition into the FRC implementation phase
b) Ensure long-term program sustainability

A chart of prioritized recommendations for UWBG to consider through the next phase of development is belo. It is in UWBG's best interest to act upon these recommendations as funding permits for the purposes of continued data collection of the installed climate change gardens and community relations.

The highest priority actions for UWBG to consider in order of importance include:

1. **Establishment of UWBG FRC project coordinator position**
2. **Identification of local funding opportunities to sustain UWBG involvement independent of the national Floral Report Card education initiative**
3. **Integration of FRC into existing UWBG school and public programming**
4. **Identification of prospective organizational partnerships**

The most important action is the recruitment of a project coordinator for the 2011-2012 year. While this position is contingent on future funding, it would be ideal for the coordinator to have a start date that coincides with the beginning of the 2011-2012 school year (fall quarter).

The following duties/responsibilities are expected for the future UWBG FRC project coordinator:

a. Coordinate the garden maintenance activities of the UWBG FRC climate change garden
b. Coordinate the data collection activities of the UWBG FRC climate change garden

c. Create interpretive and outreach materials to establish the UWBG climate change garden as a public engagement tool to attract interested project participants and citizen scientists in climate change garden data collection
d. Act as the contact person for the three local pilot schools and provide support through national Floral Report Card program implementation as needed
e. Work with UWBG personnel to identify local, regional, and national funding sources

These responsibilities can be shared through recruitment of student interns and citizen science participants. Upon hire, the FRC project coordinator should focus on community outreach to engage citizen scientists in becoming involved with the UWBG garden, and assume the role as the pilot school contact for FRC information and resources. Outreach will increase awareness, which will in turn provide the publicity that can create funding opportunities for UWBG. Starting in the fall of 2011, pilot schools will need an in-school visit by the UWBG FRC coordinator to introduce the project to participating classes and demonstrate the data collection protocols. The educators will also need assistance in testing the accuracy of their weather station data over the summer season, and will immediately need notice of national FRC funding status.

Recommendation	Action by	Justification	Outcomes	Priority
1. Establish a UWBG FRC project coordinator position	UWBG FRC P.I.'s, Dr. Soo-Hyung Kim and Dr. Sarah Reichard	A dedicated UWBG staff person is needed to coordinate UWBG FRC garden maintenance & data collection, community outreach, and pilot school garden support	Data collection of the UWBG FRC garden; UWBG FRC garden upkeep; Provision of contact person for pilot school educators; Facilitation of community outreach	High
2. Integrate FRC into existing UWBG school and public programs	FRC project coordinator in collaboration with UWBG Arboretum education department	FRC can be a complimentary program to UWBG's existing school and citizen science initiatives. This can allow UWBG to apply for funding independent of the national education initiative, use existing contacts and resources, and extend its reach to schools and community	Integration of FRC into UWBG school programming	High
3. Identify local funding opportunities to sustain UWBG involvement independent of the national Floral Report Card education initiative	FRC project coordinator in collaboration with UWBG fundraising personnel	With independent funding resources, UWBG can have the flexibility to design and expand the existing FRC project according to local interests, needs and resources.	Funding to support UWBG FRC climate change garden and school gardens independently.	High

4. Identify prospective organizational partnerships	FRC project coordinator	With the goals of increasing youth science literacy, climate change education, citizen science inclusion, and the school garden component makes FRC in alignment with the missions of other organizations. Partnerships will allow for effective outreach and program implementation	Partner workshops, recruitment of citizen scientists, means of public engagement through partnerships	High
5. Create a webpage within UWBG website to show UWBG FRC garden data and activities	FRC project coordinator in collaboration with UWBG website development	This will allow the public and pilot FRC garden schools to view UWBG phenology data and garden activities. Phenophase pictures can be posted, and public engagement opportunities can be presented.	Increase public awareness of UWBG activities, resource for pilot school gardens to make comparisons, and a means to archive data in lieu of a national Floral Report Card online database	Medium
6. Host a ‘ Seattle school garden’ conference at the Center for Urban Horticulture as a means for schools to share information and resources	FRC project coordinator	This can allow Seattle educators to share resources and experiences about the use of school area for gardening space.	Educator connectivity, UWBG awareness, and garden resource exchange	Medium

7. Connect with graduate students of UW Climate Impacts Group and explore possibility of PNW climate change workshops for educators held at UWBG	FRC project coordinator	UW CIG can present to local primary and secondary school educators about climate change impacts specific to the Pacific Northwest region		Medium
8. Explore the possibility of in-house propagation of FRC garden species	FRC project coordinator	In-house propagation is favorable as it will allow garden installation scheduling in favor of educator availability and local climate conditions	Provide UWBG with the flexibility to plant partner Floral Report Card gardens according to its own resources and local climate	Medium
9. Explore project extension to campus-wide UWBG phenology network initiative using the campus cherry trees	FRC project coordinator in collaboration with UWBG education department	The cherry blossom trees of the UW campus draw many visitors annually. These observations can be posted onto the UWBG FRC climate change garden webpage. This will attract campus citizen scientists and increase awareness of UWBG activities.	Valuable data collection, increased awareness on main UW campus of UWBG activities, an additional UWBG citizen science initiative which may increase funding opportunities for UWBG	Low

APPENDICES

Appendix A
<u>Memorandum of Understanding for Regional Resource Centers</u>

1) 1 Full time committed staff (grant funded through CBG)
2) Coordinate volunteers as necessary for regional implementation
3) Minimum 5 year participation
4) Provide each school with an in-school program introduction and training
5) Provide support for school FRC garden maintenance
6) Provide support to schools to implement curriculum implementation
7) Staff attend public lessons of lesson study groups
8) Minimum of 1 visit/quarter throughout school year in additional to public lessons
9) Maintain regular contact with participating schools and teachers.
10) Attend annual national lesson study workshops years 1-3 (paid travel & expenses for coordinator)
11) Commitment from non-funded, horticulture and research staff to serve as research resources and education support (2% time).
12) Authoring and/or contributing to scientific publications.
13) Regional resource centers integrate FRC into existing communications, and marketing efforts. They will collaborate with national marketing efforts through CBG. Communicate regional impacts of climate change.
14) Maintain, collect and submit data on on-site FRC gardens.
15) Customize FRC educational resources for your region. Develop regional ecosystem educational resources for schools.
16) Maintain regional garden help/support email address or FRC participants
17) Recruit four schools for initial participation year
18) Recruit three additional schools in year 3
19) Photographic documentation of school-based implementation when possible

<u>CBG will provide</u>

1) Funding for one full time staff person over 5 year period
2) Technology infrastructure and support
3) Plants (initial sets)
4) Educational framework and materials
5) Age appropriate data collection and maintenance protocols
6) Garden packages (plants, weather station, signage, how-to guides, soil testing, soil recommendations)
7) Training and instructional materials for garden installation and data collection
8) Funding for required travel (lesson study, meetings, conferences etc.)\
9) Garden signage, interpretive materials
10) Program management/leadership
11) Program point person/contact
12) Site preparation costs (soil testing/amendment)
13) Acknowledgement of all contributing parties on publications.

Appendix B
Floral Report Card – Project partner contact information

University of Washington Botanic Gardens

Principal Investigator of UWBG FRC
Soo-Hyung Kim, PhD
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Co-Principal Investigator of UWBG FRC
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Annemarie Bilotta,
Gardener
Center for Urban Horticulture
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anniebp@u.washington.edu

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Maintenance Mechanic Lead - Irrigation
University of Washington Facilities Services
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Chicago Botanic Garden (CBG)

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Chicago Botanic Garden
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Kayri Havens, PhD
Director of Plan Science and Conservation

Chicago Botanic Garden
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jault@chicagobotanic.org

Becky Barak
Chicago Botanic Garden
Climate Change Education Project Coordinator
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Meaningful Science Consortium/Northwestern University:

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University Corporation for Atmospheric Research (UCAR)

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University Corporation for Atmospheric Research
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dward@ucar.edu

State Botanic Garden of Georgia/University of Georgia

James Affolter, PhD
Director of Research,
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North Carolina Botanical Garden

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919.962.6939Peter.white@unc.edu

State Botanical Garden of Georgia

Anne Shenk
Education Director
University of Georgia
706.542.6158

Appendix C

Floral Report Card Memorandum of Understanding for Participating Schools

Requirements for Participating Schools

1) Minimum 2 year participation

2) Minimum of 3 teachers participate in professional development activities

3) Maintain garden

4) Collect data throughout growing season (including summer) including phenology, weather and photographic data

5) Collaborate to develop and implement regional Floral Report Card curricula

6) Implement the Floral Report Card regional curriculum in your school

7) Staff will attend public lessons of regional lesson study groups

8) Allow a minimum of 1 visit/quarter by project staff throughout school year in additional to public lessons

9) Attend annual national lesson study workshops (paid travel & expenses for 4 teachers)

10) Collaborate with regional resource centers to integrate FRC into any existing communications, and marketing efforts.

11) Collect photographic documentation of school-based implementation

As a participating school, we understand that we will receive the following materials and support from the Regional Resource Center and the Chicago Botanic Garden for a minimum two year period:

Regional Resource Center will provide:

1) Program point person/contact
2) Garden packages (plants, meteorological station, signage, how-to guides, soil testing, soil recommendations)

3) Support for garden design and installation
4) Educational framework and materials
5) Lesson Study professional development opportunities
6) Curriculum implementation support
7) Age appropriate data collection and maintenance protocols
8) Training and instructional materials for garden installation and data collection

National Center (Chicago Botanic Garden) will provide:
1) Technology infrastructure and support
2) Funding for required travel (lesson study, meetings, conferences etc.)
3) Garden signage, interpretive materials
4) Program management/leadership
5) Site preparation costs (soil testing/amendment)
6) Acknowledgement of all contributing parties on publications.

This contract can be dissolved upon the agreement of both parties with 90 days notice. Should it be dissolved, the school agrees to return the Meteorological station to the Regional Resource Center.

Signed
Date: Date:
Principal Signature Regional Resource Center Signature
Print Name Print Name
Resource Center Location
Date: January 20, 2011

Dr. Jennifer Schwarz Ballard
for the Chicago Botanic Garden

Appendix D

Logic model for Floral Report Card Project

Overall Project Goals	Objectives	Short/Mid Outcomes (1-6 yrs)	Impacts (7-10 ys)	Outputs/ Activities
Education Support he development of scientifically and environmentally literate citizens who are prepared intellectually and socially to understand human impacts on the environment (specifically climate change) and act to mitigate their immediate and long term impacts on the environment.	• Engage teachers and students in educational activities that integrate citizen science and field studies to support increased science content knowledge and scientific research skills. • Engage teachers and students in exploration of the social, cultural, and economic impacts of climate and climate change. • Leverage and expand the existing national network of botanic gardens participating in the Floral Report Card research project to create regional resource centers for schools and communities that provide ***horticultural materials, curriculum, in-school implementation support, professional development, and scientific expertise.***	• Increased students', teachers', and communities' awareness of and content knowledge in botany, ecosystems, and the impacts of climate change. • Increased students' scientific research skills through participation in fieldwork and citizen science. • Increased understanding of the global social, cultural, and economic impacts of climate change and the ability of humans to mitigate those impacts.		• Curriculum, professional development and resources that use Floral Report Card gardens to teach about botany, ecosystems, climate and the impacts of climate change on the environment.
Research Explore and understand the implications of climate change for plant populations, biodiversity, and endangered and invasive species using phenological data in combination with other climate and geo-science data	• Provide useful, accurate, large scale phenology data that can be used by researchers across the country in their efforts to understand the environmental impacts of climate change on ecosystems.	• Research opportunities, structures, and protocols that enable citizen scientists to collect accurate and useable scientific data. • Data collection processes that ensure data accuracy and comparability • Data sets that are relevant to real, identified, research goals.	• Robust, accurate, precise and useful data collected using common research protocol formatted and ready for integration into regional and national data bases for scientific use.	• Phenological data sets for the species in the floral report card gardens.

Formal/Informal Collaborations
Create and implement sustainable, scalable, replicable model of informal/formal education collaborations that brings museum resources effectively into the classroom.
	• *Scalable:*
	    ○ Develop and test a "resource hub network" model and identify best practices for the establishment of formal/informal education partnerships that effectively provide resources and support to formal education institutions
	    ○ Leverage and expand the existing national network of botanic gardens participating in the Floral Report Card research project to create regional resource centers for schools and communities.
	• *Replicable:* Create a model that can be modified for use by other types of science-focused museums beyond botanic gardens.
	• *Sustainable:* Create a cost and resource efficient model which can be integrated into existing museum operations and supported over the long term.
		• Formative and summative evaluation resulting in best practices for large-scale implementation.
		• Pilot program is tested and refined in preparation for expansion to additional schools and botanic gardens.
		• Six regional botanic garden resource centers are established, each of which implements the pilot program with 1-3 schools.
		• Engage school communities across the country in citizen science and climate change research using Floral Report Card gardens
			• National network of botanic garden resource centers that offer a replicable model of successful and sustainable collaboration and resource sharing with formal education institutions.
			• Maintain relevance and responsiveness to societal, scientific, botanic garden and school needs
			• Self supporting (integrated into botanic garden operations)
			• Dissemination targeted at research, education, museum audiences.
				• National network of botanic garden resource centers that provide ***horticultural materials, curriculum, in-school implementation support, professional development, and scientific expertise*** to schools.

Appendix E

Soil test results for UWBG climate change garden

SOIL ANALYSIS REPORT FOR PERENNIALS 05/26/10

SOIL AND PLANT TISSUE TESTING LAB
WEST EXPERIMENT STATION
UNIVERSITY OF MASSACHUSETTS
AMHERST, MA 01003

LAB NUMBER: S100524-111
BAG NUMBER: 93426

SOIL WEIGHT: 5.81 g/5cc
CROP: FLW

ALLISON MCCARTHY
2020 MINOR AVE E APT5
SEATTLE, WA 98102

COMMENTS: MCCARTHY.ALI@GMAIL.COM

SAMPLE ID: PHENOLOGY GARDEN

RECOMMENDATIONS FOR PERENNIAL HERBS AND FLOWERS:

SOIL PH ADJUSTMENT:

pH ADJUSTMENT FOR PERENNIAL HERBS AND FLOWERS

Soil pH is in the desired range. No adjustment required.
To allow co-planting of perennials with acid loving shrubs we have supplied recommendations to adjust pH to 6.0.

FERTILIZER:

The organic matter in this soil is lower than desired for most herbaceous perennials. Consider plants adapted to poorer soils or improve humus content with good finished compost.

* Potassium level is extremely high in this soil. DO NOT add additional K at this time.

Contact the soil lab to discuss these results.

MICRONUTRIENT		PPM	SOIL RANGE	MICRONUTRIENT		PPM	SOIL RANGE
Boron	(B)	0.5	0.1-2.0	Copper	(Cu)	0.2	0.3-8.0
Manganese	(Mn)	24.0	3 - 20	Iron	(Fe)	11.8	1.0- 40
Zinc	(Zn)	2.1	0.1- 70	Sulfur	(S)	26.8	1.0- 40

SOIL pH 6.7 NITROGEN: NO3-N = 27 ppm
BUFFER pH 6.8 ORGANIC MATTER: 6.5 % (Desirable range 4-10%)

NUTRIENT LEVELS:		PPM	Low Medium High Very High
Phosphorus	(P)	6	XXXXXXXXXX
Potassium	(K)	782	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Calcium	(Ca)	1337	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Magnesium	(Mg)	220	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

CATION EXCH CAP
10.6 Meq/100g

PERCENT BASE SATURATION
K=16.3 Mg=14.7 Ca=54.3

MICRONUTRIENT LEVELS
ALL NORMAL

EXTRACTABLE ALUMINUM: 31 ppm (Soil range: 10-250 ppm)

The lead level in this soil is low.

VISIT www.umass.edu/plsoils/soiltest FOR FURTHER INFORMATION ON SOIL TESTING AT UMASS.
TO CONTACT THE LAB: EMAIL soiltest@psis.umass.edu PHONE (413-545-2311).

Soil test results for Jane Addams K-8

SOIL AND PLANT TISSUE TESTING LAB
WEST EXPERIMENT STATION
UNIVERSITY OF MASSACHUSETTS
AMHERST, MA 01003

LAB NUMBER: S101104-303
BAG NUMBER: 96648

SOIL WEIGHT: 4.78 g/5cc
CROP: FLOWERS/HERBS

ALLISON MCCARTHY
2020 MINOR AVENUE EAST
SEATTLE, WA 98102

COMMENTS: MCCARTHY.ALI@GMAIL.COM

SAMPLE ID: JANE_ADAMS

RECOMMENDATIONS FOR PERENNIAL HERBS AND FLOWERS:

SOIL PH ADJUSTMENT:

pH ADJUSTMENT FOR PERENNIAL HERBS AND FLOWERS

Soil pH is low. For new plantings you may incorporate ground limestone at 8 cups per cubic yard of soil.
For established plantings lightly topdress with no more than 7 cups/100 sq ft of ground limestone. Retest next year.

FERTILIZER:

The organic matter in this soil is adequate for many herbaceous perennials. The level should be increased for plants requiring humus-rich conditions.

NEW BED PREPARATION: In early spring incorporate 1 part peat moss into 2 parts soil along with 7 cups 5-10-5 fertilizer per cubic yard of soil.
ESTABLISHED BEDS: In early spring and early June sidedress 2.5 cups 5-10-5 fertilizer per 100 square feet, taking care not to damage foliage and water afterward.

MICRONUTRIENT		PPM	SOIL_RANGE	MICRONUTRIENT		PPM	SOIL_RANGE
Boron	(B)	0.2	0.1-2.0	Copper	(Cu)	0.4	0.3-8.0
Manganese	(Mn)	2.1	3 - 20	Iron	(Fe)	35.3	1.0- 40
Zinc	(Zn)	3.9	0.1- 70	Sulfur	(S)	17.1	1.0- 40

SOIL pH 5.6
BUFFER pH 6.1

NITROGEN: NO3-N = 3 ppm
ORGANIC MATTER: 8.4 % (Desirable range 4-10%)

NUTRIENT_LEVELS:		PPM	Low___Medium___High___Very High
Phosphorus	(P)	2	XXX
Potassium	(K)	55	XXXXXXXXXXXXX
Calcium	(Ca)	918	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Magnesium	(Mg)	141	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

CATION EXCH CAP
16.7 Meq/100g

PERCENT BASE SATURATION
K= 0.9 Mg= 7.3 Ca=29.0

MICRONUTRIENT LEVELS
ALL NORMAL

EXTRACTABLE ALUMINUM: 68 ppm (Soil range: 10-250 ppm)

The lead level in this soil is low.

VISIT www.umass.edu/soiltest FOR FURTHER INFORMATION ON SOIL TESTING AT UMASS.

Soil test results for Ballard High School

SAMPLE ID: BALLARD_A

RECOMMENDATIONS FOR PERENNIAL HERBS AND FLOWERS:

SOIL PH ADJUSTMENT:

pH ADJUSTMENT FOR PERENNIAL HERBS AND FLOWERS

Soil pH is too high if plants are in beds containing acid loving shrubs. Otherwise pH is acceptable. If coplanted with ericaceous shrubs and ground covers acidify soil by incorporating sulfur at 6 to 8 cups per 100 square feet into the top 7 inches of soil. For established plantings you may topdress soil with sulfur at 3 to 4 cups/100 sq ft and maintain an acidic organic mulch. such as pine needles.

FERTILIZER:

* Potassium level is extremely high in this soil. DO NOT add additional K at this time.

Contact the soil lab to discuss these results.

MICRONUTRIENT		PPM	SOIL RANGE	MICRONUTRIENT		PPM	SOIL RANGE
Boron	(B)	0.5	0.1-2.0	Copper	(Cu)	0.2	0.3-8.0
Manganese	(Mn)	5.0	3 - 20	Iron	(Fe)	3.8	1.0- 40
Zinc	(Zn)	4.3	0.1- 70	Sulfur	(S)	81.3	1.0- 40

SOIL pH 7.3 NITROGEN: NO3-N = 8 ppm
BUFFER pH 7.2 ORGANIC MATTER: 10.6 % (Desirable range 4-10%)

NUTRIENT LEVELS:		PPM	Low Medium High Very High
Phosphorus	(P)	17	XXXXXXXXXXXXXXXXXXXXXXXXXXX
Potassium	(K)	654	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Calcium	(Ca)	4859	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Magnesium	(Mg)	209	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

CATION EXCH CAP	PERCENT BASE SATURATION	MICRONUTRIENT LEVELS
25.8 Meq/100g	K= 6.1 Mg= 6.2 Ca=87.8	ALL NORMAL

EXTRACTABLE ALUMINUM: 7 ppm (Soil range: 10-250 ppm)

The lead level in this soil is low.

VISIT www.umass.edu/soiltest FOR FURTHER INFORMATION ON SOIL TESTING AT UMASS.

Lilacs

Appendix F

Breaking leaf buds
In at least 3 locations on the plant, a breaking leaf bud is visible. A leaf bud is considered "breaking" once the widest part of the newly emerging leaf has grown beyond the ends of its opening winter bud scales, but before it has fully emerged to expose the leaf stalk (petiole) or leaf base. The leaf is distinguished by its prominent midrib and veins. *(This phenophase was previously called "First leaf".)*

All leaf buds broken
For the whole plant, the widest part of a new leaf has emerged from virtually all (95-100%) of the actively growing leaf buds. *(This phenophase was previously called "Full leaf out".)*

Open flowers
For the whole plant, at least half (50%) of the flower clusters have at least one open fresh flower. The lilac flower cluster is a grouping of many, small individual flowers. *(This phenophase was previously called "First bloom".)*

Full flowering
For the whole plant, virtually all (95-100%) of the flower clusters no longer have any unopened flowers, but many of the flowers are still fresh and have not withered. *(This phenophase was previously called "Full bloom".)*

End of flowering
For the whole plant, virtually all (95-100%) of the flowers have withered or dried up and the floral display has ended. *(This phenophase was previously called "Last bloom".)*

There are no intensity measures for lilacs.

Please see the species profile page for complete information about the phenophases for each species.

Plant Phenophase Datasheet

nature's notebook

Directions: Fill in the date in the top row and circle the appropriate letter in the column below.

y (phenophase is occurring);
n (phenophase is not occurring);
? (not certain if the phenophase is occurring).

Do not circle anything if you did not check for the phenophase. In the adjacent blank, write in the appropriate measure of intensity or abundance for this phenophase (see left-hand column for details).

Species: ______
Plant Nickname: ______
Site: ______
Year: ______
Observer: ______

Do you see...?	Date:	Date:	Date:	Date:	Date:
Breaking leaf buds	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
All leaf buds broken	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Open flowers	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Full flowering	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
End of flowering	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Check when data entered online:	☐	☐	☐	☐	☐

Comments:

Do you see...?	Date:	Date:	Date:	Date:	Date:
Breaking leaf buds	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
All leaf buds broken	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Open flowers	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Full flowering	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
End of flowering	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Check when data entered online:	☐	☐	☐	☐	☐

Comments:

Appendix G
Educator Responses to Focus Group Questions via Email

Educator: India Carlson
School: Ballard High School (public)
Grades: 10-12
Subject: Science

Logistics
Who are the key players in your school/community that would need to be on board for Floral Report Card (FRC) to be a part of your school?
The self –help SPS person Gretchen DeDecker, the principal
Does your school have the green space necessary for planting a FRC garden?
Yes
Do you believe your school/classroom has the technology resources needed to support FRC (eg: computers with internet access for data submission and data analysis, and communication with other schools, etc.)?
Yes
Do you think your school has the time and resources to meet the data collection requirements of FRC, including visiting the gardens once a week (?) to make observation, even during the summer months?
Yes
Do you think your school has the time and resources to meet the garden maintenance requirements of FRC, including watering the gardens during the first year, and weeding the garden, even during the summer months?
Yes, I have dedicated group of students who help with the school garden

Curriculum
Do you think your students would be excited about Floral Report Card?
Yes
What instructional model to you use at your school? (eg: Understanding by Design)?
Mostly guided Inquiry based science but I would like more project oriented curriculum
How flexible is your school in terms of altering or adding to the curriculum? In my plant classes very flexible
Do you think FRC could fit into your school's curriculum – either though a class, or through an after school club?
Yes
What content is covered in each grade that may be related to the goals of FRC?
I teach Botany and Horticulture- so plant biology, transfer of energy in biological systems, climate and human activity and plants, etc.
How willing are you to take an active role in bringing FRC to your school, and sustaining the program once it is here.
Very willing- can't wait
If we provided educational resources relating to the FRC garden, what resources would you be most likely to use?

Printable or websites

Professional Development

When would be a good time for a professional development workshop on the FRC (week long? 2 day?)

August or Early October

What type of continuing education/professional development does your school require or encourage?

I have attended a series of Professional teachers of Science workshops, in-house tech training, and outside workshops

How much time is spent over the course of the year on professional development?

At least 40 hours

How much, and what types of professional development support does your school provide over the school year?

We have structured PLC's and data teams

In-school vs. distance support *(not sure what this means) –

Mostly in School

What are the make or break aspects of the project? What would make you very or not at all interested in the project? What are the most compelling/appealing aspects of the project?

I am most interested in having real –time data that students can see and then have an opportunity to use in their own investigations. Just collecting data that we never know what happens to it would be boring. Students are willing to take on big projects if they feel they are doing "real science," and the FRC seems like a chance to do just that.

Appendix H

You are invited to a

Cool School Challenge Training Workshop

with a Special Focus on Climate Change and Plants

9:00 a.m. - 3:00 p.m. | Saturday, May 1st, 2010

University of Washington Center for Urban Horticulture

3501 NE 41st Street, Seattle, WA 98105

Are you are a 3rd-12th grade teacher interested in actively engaging your students in one of the most timely topics of the century? If so, we invite you to a FREE workshop focusing on the connection between climate change and plants. The **LEARN, TEACH, ACT** sequence below will give you a taste of what to expect:

LEARN – What is the connection between climate change and plants? If you're a teacher interested in educating your students about the causes, impacts and potential solutions of climate change then plants deserve a starring role in your curriculum! Join environmental educators from the ***University of Washington Botanic Gardens*** to learn about "climate change gardens" and how the age-old study of phenology can be used to engage your students in hands-on science learning.

TEACH – How do you incorporate the topic of climate change into your curriculum? If you're looking for additional resources to lay the foundation for understanding some of the forces behind climate change and its connection to numerous social, economic, and environmental factors, let ***Facing the Future*** walk you through their ***climate change curriculum*** and other great resources.

ACT – How do you take action in your school? Learn about the ***Cool School Challenge***, become a "Challenge Coach," and help your students reduce their environmental impact, mitigate their individual "carbon footprint" and lead their school through the same process. The *Cool School Challenge* **engages students, teachers and school districts** in a school-wide initiative **to reduce the school's carbon dioxide (CO_2) emissions** by 2,000 pounds or more per classroom, per school year. Implement the *Challenge* and empower your students to become leaders, take action, and make a difference! The program can be administered by any teacher interested in becoming a "Challenge Coach," and is especially suited for science and math teachers and ASB leaders.

SPACE IS LIMITED TO THE FIRST 15 TEACHERS!

Please register online by April 23rd at:
www.coolschoolchallenge.org/workshop-schedule.aspx

For more information, contact Kimberley Cline at info@coolschoolchallenge.org

Washington Science Teachers Association Clock Hours will be available. Please bring a totally waste free lunch and your own reusable mug. We'll provide light snacks, coffee and tea and will have recycling and composting bins on hand to help minimize trash. Visit www.coolschoolchallenge.org for more information.

University of Washington Botanic Gardens – Plants for Life | pscleanair.org – Puget Sound Clean Air Agency | Facing the Future

Appendix I: Getting Started Guide for Teachers (DRAFT):

(Page 106-126)

Appendix I

Implementation plan for Floral Report Card: A National K-12 climate change education initiative

Linking the University of Washington Botanic Gardens to local schools and community through a network of climate change monitoring gardens

Written by Allison McCarthy
University of Washington Botanic Gardens

May 28th, 2011

Use of this guide

This guide was created as a project implementation tool for the three Seattle school educators who have partnered with the University of Washington Botanic Gardens as pilot schools of the Floral Report Card project (FRC). FRC is presently in an interim stage of development between its planning phase that was completed in 2010 and implementation. More detailed information about the project's background and planning phase activities are provided in an Implementation Plan that was written for the University of Washington Botanic Gardens.

An Institute of Museum and Library Services National Leadership implementation grant was submitted in February 2011 by Chicago Botanic Garden (CBG), which has led all logistical and fundraising activities for the project. CBG and partner botanic gardens are expected to be notified of the grant's status by the summer of 2011. The recommendations of this document are subject to change as standardized FRC curriculum, materials, and protocols are developed in collaboration with national project partners during the project's implementation phase.

Participant teachers have the flexibility to incorporate preliminary data collection of the garden as appropriate, from teaching the scientific method in a biology class to the skill of digital photography in an art class. As funding becomes available to establish a separate FRC internet database, all data collected will be inputted by students to excel for analysis.

The following is included in the guide

1. Teacher FAQ
2. Maintenance calendar & guidelines
3. Data collection protocols
4. Copy of a relevant plant phenology lesson plan
5. Phenology resources
6. Journal article by Mote et al (2010), "Future climate of the Pacific Northwest" that provides a summary of the expected impacts of climate change for the Pacific Northwest region.

The following descriptions of the project background and goals are abbreviated versions. Educators should refer to the corresponding Implementation Plan written for the University of Washington Botanic Gardens for more detailed descriptions.

Background & Description of the Floral Report Card Project

The Floral Report Card (FRC) is a national climate change research and education project initiated by Chicago Botanic Garden. The project involves the installation of a network of "climate change gardens" that will create a nationwide ecological antenna to monitor the effects of a changing climate on plant growth and survival. In conjunction with partnering regional resource centers (including universities and botanical gardens), students' grades K-12 will record climate data and a standard set of phenological events from their school climate change gardens, such as first day of flowering and fruiting. This data will be inputted into an interactive online database and used to help predict the impacts of climate change on plants and the important services they provide to people and wildlife.

FRC allows students to become the scientists and provides a unique hands-on learning experience that integrates science and technology into school programming. By focusing on one of the most urgent contemporary issues—the impact of climate change on plants— the FRC project will provide students with an active means of engagement to a seemingly intangible and overwhelming topic such as climate change. Despite the massive impacts climate change will have on plants (and people), education resources that address plant science and climate change are largely absent from available sources.

In the fall of 2009, Chicago Botanic Garden received planning grant funding from USBG (United States Botanic Gardens), NASA, and the Institute of Museum and Library Services (IMLS) to develop a pilot program for project design and implementation on a national scale. The IMLS grant has provided the funds to assess the viability of installing and collecting useful data from climate change gardens through interdisciplinary collaboration from both formal and informal education institutions. The grant has also supported the development of curricula frameworks and technology for pilot program schools, teachers, and students. In addition, a 5-year climate education implementation plan for Floral Report Card has been established.

Floral Report Card Project Goals

Aside from the useful data that is to be collected from the gardens and the unique means of youth engagement in the science of climate change, **the goal of FRC is to implement, study, and improve a sustainable STEM professional development model.** FRC curricula will be designed to improve teaching practice in environmental science through the observation of student learning by utilizing a Japan based professional development method called "Lesson Study". **Simultaneously, FRC will promote the integration of climate science and secondary education by bringing research sites (monitoring gardens) to schools and connecting educators with researchers and regionally based climate change science curricula.**

Floral Report Card Project Expected Outcomes

1) Professional science teaching communities with increased capacity to teach climate science;

2) A national network of climate education resource centers that support authentic school-based climate research

3) Expansion of technical capacity for data sharing, researcher/teacher collaboration, and educational resource development.

Teacher FAQ

❖ **Project support questions**

- **When will I be notified if the Floral Report Card project has received implementation funding?**

In February of 2011, Chicago Botanic Garden and project partners submitted an application to the Institute of Museum and Library Services for implementation. Notification of grant status is expected to be received by UWBG over the summer of 2011. You should hear from a representative from the UWBG by the beginning of the school year if implementation funding has been granted.

- **In the event the Floral Report Card project does not receive large scale implementation funding next year, should I continue to collect phenology data from the garden?**

Yes! UWBG will continue to collect data from its own climate change garden, and data can continue to be collected on an individual site basis with the availability of each garden to share data electronically. Simple climate and phenology data comparisons can be made between each of the climate change gardens across the nation using the publicly accessible weather data on each school's WeatherlinkIP online website, and a file sharing site can be used to share phenology data excel sheets.

- **Should I collect phenology data of the garden plants over the summer of 2011?**

If you have the resources, yes! During the first year of plant establishment, all data collected from the garden is considered preliminary. If you have the resources to start collecting data using the protocols provided, do so in order to develop best practices. In the beginning of the school year, many of the Floral Report Card species will be in their full flowering phenophase (e.g. *Aster novae-angliae*, *Monarda fistulosa*, *Physostegia virginiana*, and *Schizachyrium scoparium*). There will still be time to record the "first fruit" and "leaf senescence" phenophase with your students. You can begin to trial data collection with your classes to develop best organizational patterns and identify best practices of data collection.

- **Who can I contact from UWBG with questions?**

A dedicated staff person from UWBG to work with each of the project schools is contingent on future implementation funding. In the event funding is not received by the start of the 2011-2012 school year, pilot school educators can still contact the UWBG Floral Report Card project P.I., Dr. Soo-Hyung Kim, with horticultural or program status questions. You can also contact the national program P.I. from Chicago Botanic Garden, Dr. Jennifer Schwarz. See contact sheet attached.

❖ **Horticultural Questions**

1. **Over the summer of 2011, it appears that some of the plants have died: what should I do?**

All plants from the Floral Report Card project were received through Chicago Botanic Garden. If you have been notified by the beginning of the 2011-2012 school year from a UWBG representative that implementation funding has been received, you should notify the UWBG FRC program coordinator.

2. **Some of the plants appear to have pest or disease damage, what should I do?**

Make detailed recordings of all observed plant damaged onto the notes/comments section of your phenology data excel sheet. Pests and diseases are expected for some of the plants, and since the project partners want to limit the amount of external influence on plant growth, the best course of action is to avoid chemical use and make detailed recordings of plant health.

3. **Where can I obtain mulch?**

Mulch can be obtained from local arborists in your area. Make sure that you request "clean" chips, and that you leave yourself at least 3 weeks of lead time between calling the arborist and scheduling a mulch drop off date. You will need to tell the arborist how much you need (each garden should have a steady supply of 2-3 inch mulch coverage) and where to drop off chips on your site.

- **Curriculum Questions**

1. **Where can I receive plant phenology resources as the Floral Report Card curriculum is being developed?**

Below are links to two excellent websites that provide an abundance of plant phenology resources. Also attached is a phenology lesson plan providing a synopsis of the importance of phenology and tools to conduct an in-class lesson.

- Project Budburst: http://neoninc.org/budburst/

The Floral Report Card project is an in-school and standardized version of a successful citizen science initiative using public observations to collect valuable plant phenology data called Project Budburst. Floral Report Card curriculum and materials are being modeled from Project Budburst, which makes this website your first resource for lesson planning materials as the FRC curriculum is being developed. Project Budburst is a national citizen science campaign involving a network of people across the United States who monitors plants as the seasons change. Like Floral Report Card, it is designed to engage the public in the collection of important ecological data based phenophases. Project BudBurst's website includes easy-to-use materials for teachers and student groups.

- U.S. National Phenology Network: http://www.usanpn.org

The USA National Phenology Network (USA-NPN) monitors the influence of climate on the phenology of plants, animals, and landscapes in partnership with a multitude of partners. Through education and outreach, NPN supports programming that encourages people to observe phenological events and provides a place for people to enter, store, and share observations. It is comprised of many partners including federal, state and local agencies, universities, colleges and schools, non-governmental organizations, citizen volunteers, and many others. On its website, there is a useful “Educator Clearinghouse” resource that houses educational materials (lesson plans, activity guides, syllabuses, project design plans), to provide educators with resources on phenology.

2. **Where can I find information on climate change education information relevant to the Pacific Northwest region?**

While there is an abundance of resources available for educators regarding climate change education materials, for climate information specific to the Pacific Northwest region, a valuable resource is the website of the University of Washington’s Climate Impacts Group (CIG), http://cses.washington.edu/cig/. **CIG** is an internationally recognized interdisciplinary research group studying the impacts of natural climate variability and global climate change. Research at the CIG considers climate impacts at spatial scales ranging from local communities to the entire western U.S. region, with most work focused on the Pacific Northwest (PNW). The CIG engages in climate science in the public interest, working to understand the consequences of climate variability and climate change for the US Pacific Northwest (PNW).

Another website that provides an “Educator clearinghouse” type service listing an array of different curriculum and materials for educators in climate change education can be found here: http://www.climate.org/resources/educational/teacher-sites.html as published by the Climate Institute. The Climate Institute is a non-profit U.S. organization that works to integrate active research with public engagement for the benefit of climate change adaptation and mitigation strategies for public policy and effective science communication.

Garden maintenance guidelines

Water

- Watering schedule should be staggered (i.e. Monday-Wed-Fri) to encourage first year plant establishment. During second growing season, only water when necessary (soil is dry to the touch 3-4 inches deep). **In Pacific Northwest, summer is going to be the most important time to remember to water garden.**
- Soil should be checked weekly and watered if the soil is dry 3 or 4 inches deep.
- A common rule of thumb for perennials is that they grow well with 1 inch of water per week from natural rainfall or from irrigation.
- Water should be done slowly and deeply rather than frequently and shallowly to encourage deep rooting systems.
- Water should target the soil and root systems of the plants as opposed to the plant foliage (leaves/flowers) to decrease plant susceptibility to pathogens.

Mulch

- Mulch is beneficial for the garden because it controls weeds, conserves moisture, moderates soil temperature and prevents soil compaction and runoff after rain. Bark mulch is very good and should be used instead of plastic or landscape material.
- Spread a 2-inch layer of mulch over weed-free ground in the spring. Organic mulches can be layered on the garden every spring.
- Avoid mulching around the crown of the plant because mulch holds moisture and plants tend to rot if the crown stays wet.

Staking

- Some FRC plants (*Physostegia*, *Penstemon*, and *Baptsia*) may require staking for erectness and to prevent flopping over after strong winds or rain. Depictions of staking techniques using gathered materials (i.e. branches) recommended.

Weeding

- During spring season, weeding should be done weekly by students. Not all students will be necessary. Designation of a rotating "weeding team" of 5-6 students can complete task. Other students can collect phenological or weather data during class period.

General data collection protocols

Step 1 Determine the phenophase to look for.

The following phenophases followed by their definitions are being observed for Floral Report Card

1. **First full leaf-** Report the date at which the first leaves are completely unfolded from the bud.

2. **First flower-** First flower can be described when petals are open on individual flowers so that the stamens are visible. If you see one open flower on the plant, mark plant to be in its first flower phenophase. Flowers are considered "open" when the reproductive parts are visible between unfolded or open flower parts.

3. **Full flower-** Full flower can be described as when 95% of the flower clusters no longer have any unopened flowers. For individual flower (*Aster*), full flower can be described when all disk and ray flowers appear to have opened.

4. **First fruit-** Report the date when you notice the first fruits becoming fully ripe or seeds dropping naturally from the plant.

5. **Leaf senescence-** 95-100% of the leaves have fallen

Step 2 Determine when and how often to observe plants. Some species begin flowering in early spring, others in late summer. Refer to the individual species phenophase and data collection guides. Once spring approaches, observations should be made three times per week. If the plant is observed to be changing phenophase, observation should begin daily.

Step 3 Make detailed recordings of plant health and garden conditions that may affect plant phenology.

Step 4 Organize and input the data onto an excel sheet

A photograph will be taken of each marked phenopohase using a digital camera Pictures of the plant will be taken from the same angle. This will allow observers to more clearly see how that particular plant has changed throughout its yearly life cycles.

Data Management (during first year of plant establishment)

Phenology data

Since each pilot school garden was not planted until late May of 2011, phenology data will not be useful until the spring of 2012 because the plants require a one year establishment period. In the event that a Floral Report Card national online database has not been created by the spring of 2012, each educator has been given electronic copies of data collection sheets and a template excel sheet to record preliminary plant phenology data. Pilot school educators can save these excel files on their school computers.

Plant coding:

Below are the garden sketches and corresponding plant codes for each school garden. Each plant has also received a tag with the plant coding inscribed onto the tagging.

Species-specific data collection protocols

See the template below for species-specific data collection protocols that can be printed as cards for easy use in the field. These cards will be completed and standardized at a future date.

Floral Report Card

Baptisia australis: wild blue false indigo

This beautiful plant is a popular garden perennial and was named the 2010 perennial plant of the year by the Perennial Plant Association. Its common name refers to one use of the plant. Native Americans used the plant to create a blue dye, similar to the dye from the true indigo plant (*Indigofera tinctoria*).
Its dried pea-like pods have been used for rattles for children and are popular in dried plant arrangements.

Baptisia

First full leaf

Baptisia australis should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground. The stalks will look a little like asparagus at first. Shortly after emerging from the ground, the first leaf will open. When it is fully expanded, mark the date of this phenophase.

Baptisia

First flower

Baptisia australis develops flowers at the end of most stems. The stems bear spikes (botanically racemes) of blue flowers, which mature over time from the bottom to the top. "First flower" is when you see the first flower fully open.

Baptisia

Full flower

Baptisia australis develops flowers at the end of most stems. The stems bear spikes (botanically racemes) of blue flowers, which mature over time from the bottom to the top.

First fruit

The fruits of *Baptisia australis* are dry legumes (like an inflated pea pod). They are mature when they are completely brown/black.

This is *Baptisia australis* (wild blue false indigo) almost in its ripe fruit phenophase of development. The legumes or pea pods are not considered ripe until they are black in color and about to split open.

Baptisia

Leaf senescence

Baptisia leaves/stems will turn color in the fall, often first a yellowing brown and later almost black. When the plant is 95% brown/black and dry, mark this phenophase.

Floral Report Card

Aster novae angliae: New England aster

Some species begin flowering in early spring, others in late summer. *Aster* will bloom in most climates between August and November. Observations should be made three times per week from mid-spring for first leaf. Once shoots become obvious observations should be made daily. After first leaf, it will be a number of months until flowering. You can make observations less frequently until flower buds are visible, then intensify to daily observations again.

Aster novae-

Aster novae-

First full leaf

In the spring, look for new green growth emerging from the ground. Shortly after emerging from the ground, the first leaf will open. When it is fully expanded, mark the date of this phenophase.

First flower

Aster develops flowers at the end of most stems. The flowers are aggregated into heads (capitula) composed of two kinds of flowers (ray florets and disk florets). The ray florets around the perimeter have a stripe like "petal" that is purple.

Aster novae-

This is an *Aster novae–angliae* that has begun floral organ development. Once this is observed, monitoring should begin daily

The florets are mature when you first notice pollen being pushed out of the disk florets. Mark this as first flower.

Full flower

When at least 95% of flowers on all the flowering stems are open. Since the flowers mature some of the earliest opening flowers may have started to mature into fruit.

First fruit

The fruits of Aster are tiny achenes attached to fluffy, white hairs (pappus) held in the base of the old flower head, until carried away by the wind (like a dandelion).
The fruits are mature when the base of the flower head surrounding them is brown and dry and white pappus is expanded. When the first flower head base is 95% brown/dry, mark this phenophase.

Leaf senescence

Aster leaves/stems will turn color in the fall, often first a yellow-brown and later brown and dry. When the plant is 95% brown and dry, mark this phenophase.

Floral Report Card

Penstemon digitalis: foxglove beardtongue

Penstemon means five stamens in Greek. Four of the stamens are fertile (make pollen) and one is sterile. The common name of beard tongue comes from the tuft of hairs on the sterile stamen resembling a beard.

Some species begin flowering in early spring, others in late summer. *Penstemon* will bloom in most cli- mates between April and June. Observations should be made three times per week from mid-spring. Once flowering shoots become obvious and buds are visi- ble, observations should be made daily.

Penstemon

First full leaf

Penstemon digitalis has a basal rosette of leaves, which are often evergreen and persist throughout the winter. Because of this, we will not be monitoring this phenophase for *Penstemon*.

The picture to the left shows the evergreen basal rosette of leaves of *Penstemon digitalis.* (foxglove beardtongue).

First flower

Penstemon sends up several flowering stems of white flowers. The stems bear clusters of white flowers, known as a panicle, which mature over time.

"First flower" is when you see the first flower fully open and shedding pollen.

Penstemon

Full flower

When at least 95% of flowers on all the flowering stems are open, mark the phenophase as full flower. Since the flowers mature over time, some of the earliest opening flowers may have started to mature into fruit.

First fruit

The fruits of *Penstemon* are dry capsules. They are mature when they are completely brown and just starting to split open.

Leaf senescence

Penstemon digitalis leaves are often evergreen and persist throughout the winter. Because of this, we will not be monitoring this phenophase for *Penstemon*.

Penstemon

Floral Report Card

Physostegia virginiana: obedient plant

Some species begin flowering in early spring, others in late summer. *Physostegia* will bloom in most climates between July and October. Observations should be made three times per week from mid-spring for first leaf. Once shoots become obvious observations should be made daily. After first leaf, it will be a number of months until flowering. You can make observations less frequently until flower buds are visible, then intensify to daily observations again.

Physostegia

First full leaf

Physostegia virginiana should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground. Shortly after emerging from the ground, the first leaf will open. When it is fully expanded, mark the date of this phenophase.

Physostegia

First flower

Physostegia develops flowers at the end of most stems.
"First flower" is when you see the first flower fully open.

Full flower

The full flowering phenophase occurs when at least 95% of flowers on all the flowering stems are open. Since the flowers mature of time, some of the earliest opening flowers may have started to mature into fruit.

First fruit

The fruits of *Physostegia* are tiny nutlets found in the base of the old flowers. After pollination, the flower tube (corolla) will fall off, but the green sepals are retained.

When the first flower base is 95% brown/dry, mark this phenophase.

Physostegia

Leaf senescence

Physostegia leaves/stems will turn color in the fall, often first a yellow-brown and later brown and dry. When the plant is 95% brown and dry, mark this phenophase.

Physostegia

Floral Report Card

Monarda fistulosa: bee-balm

Many Native American groups used this member of the mint family for medicinal purposes, and some people still drink bergamot tea during cold and flu season. This plant is also the source of the antiseptic Thymol, used in some mouthwashes.

Some species begin flowering in early spring, others in late summer. *Monarda* will bloom in most climates be- tween May and August. Observations should be made three times per week from early spring for first leaf. Once shoots become obvious observations should be made daily. After first leaf, it will be a couple of months until flowering. You can make observations less frequently until flower buds are visible, and then intensify to daily observations again.

Monarda

First full leaf

Monarda fistulosa should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground. Shortly after emerging from the ground, the first leaf will open. When it is fully expanded, mark the date of this phenophase.

Monarda

First flower

Once you observe the flower organs in developmental phases, as shown, observations should begin daily.

Full flower

When at least 95% of flowers on all the flowering stems are open, mark this phenophase.

Monarda

First fruit

The fruits of *Monarda fistulosa* are tiny nutlets found in the base of the dried flower heads. It is impossible to see them without dissecting the flower head, but they are mature when the flower head is brown and dry. When the first flowering head is 95% brown/dry, mark this phenophase.

Leaf senescence

Monarda leaves/stems will turn colors in the fall, often first a yellow-brown and later brown and dry. When the plant is 95% brown and dry, mark this phenophase.

Monarda

Floral Report Card

Panicum virgatum (switchgrass)

Some species begin flowering in early spring, others in late summer. *Panicum* will bloom in most climates be- tween June to August. Observations should be made three times per week from late winter/early spring.
Once shoots become obvious observations should be made daily. After first leaf, it will be a number of months until flowering. You can make observations less frequently until flower stalks are visible, then intensify to daily observations again.

Panicum

First full leaf

Panicum virgatum should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground amidst the stubble of last year's growth. Shortly after emerging from the ground, the first leaf will lengthen and unroll. When it is fully expanded, mark the date of this phenophase.

New emergent growth

First full leaf

First flower stalk

Panicum develops flowers at the end of most stems, grass flowers are quite small and non- descript. The stems bear clusters (botanically panicles) of green flowers which mature over time.
"First flower" is when you see tiny yellow anthers dangling out of the first flower and shedding pollen.

Full flower

When at least 95% of flowers on all the flowering stems are shedding pollen mark this phenophase.

Panicum

First fruit

The fruits of *Panicum* are grains, held within the green flower. They are mature when the flowering cluster turns from green to golden brown.

Leaf senescence

Panicum leaves/stems will turn color in the fall to yellow- brown. When the plant is 95% brown and dry, mark this phenophase.

Panicum

Floral Report Card

Schizachyrium scoparium (little bluestem)

Some species begin flowering in early spring, others in late summer. *Schizachyrium* will bloom in most climates between July to October. Observations should be made three times per week from late winter/early spring. Once shoots become obvious, observations should be made daily. After first leaf, it will be a number of months until flowering. You can make observations less frequently until flower stalks are visible, then intensify to daily observations again.

Schizachyrium

First full leaf

Schizachyrium scoparium should be cut back to the ground each winter. In the spring, look for new green growth emerging from the ground amidst the stubble of last year's growth. Shortly after emerging from the ground, the first leaf will lengthen and unroll. When it is fully expanded, mark the date of this phenophase.

Schizachyrium

First flower

Schizachyrium develops flowers at the end of most stems; grass flowers are quite small and non-descript. The stems bear clusters (botanically panicles) of green flowers which mature over time. "First flower" is when you see tiny yellow anthers dangling out of the first flower and shedding pollen.

Full flower

When at least 95% of flowers on all the flowering stems are shedding pollen. Since the flowers mature of time, some of the earliest opening flowers may have started to mature into fruit.

First fruit

The fruits of *Schizachyrium* are grains, held within the green flower. They are mature when the flowering cluster turns from green to golden brown and fluffy white hairs attached to seed are visible.

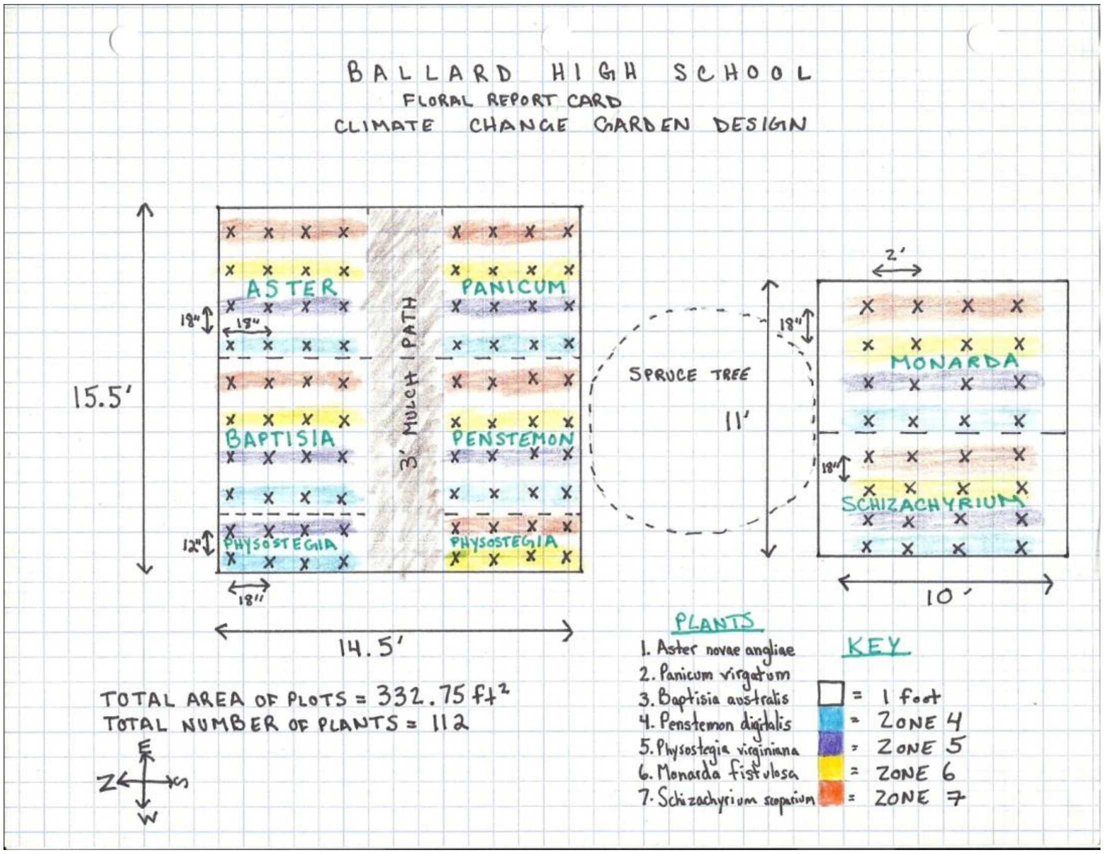
Schizachyrium

Leaf senescence

Schizachyrium leaves/stems will turn color in the fall to yellow-brown.
When the plant is 95% brown and dry, mark this phenophase.

Schizachyrium

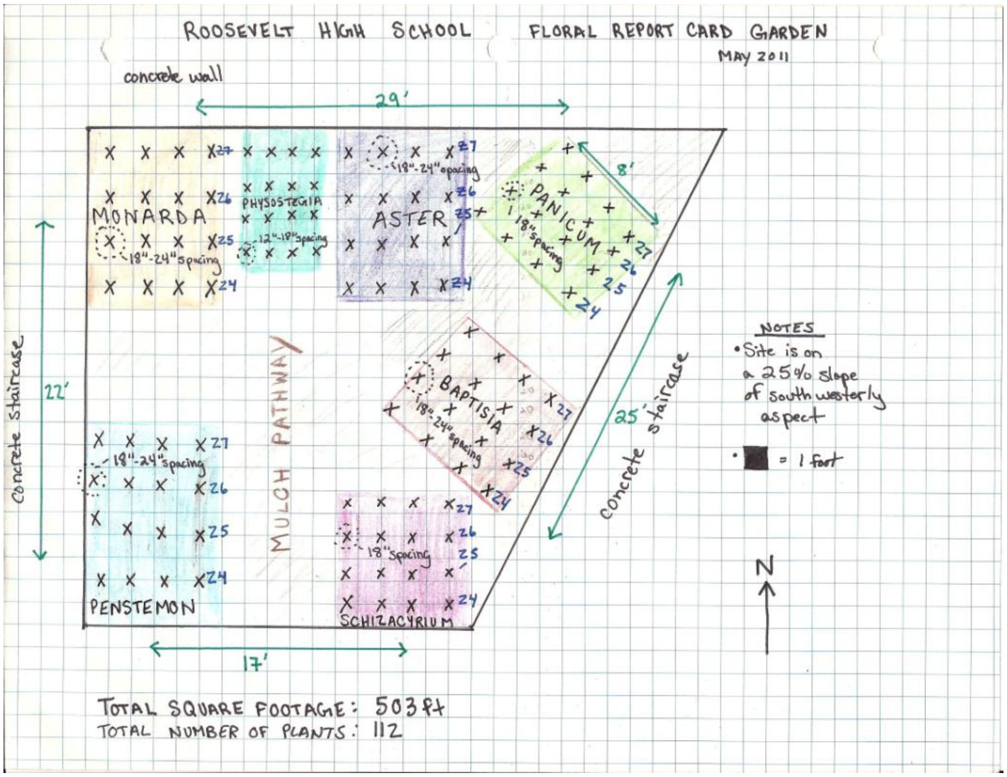
Garden design & plant coding sheet for Ballard High School

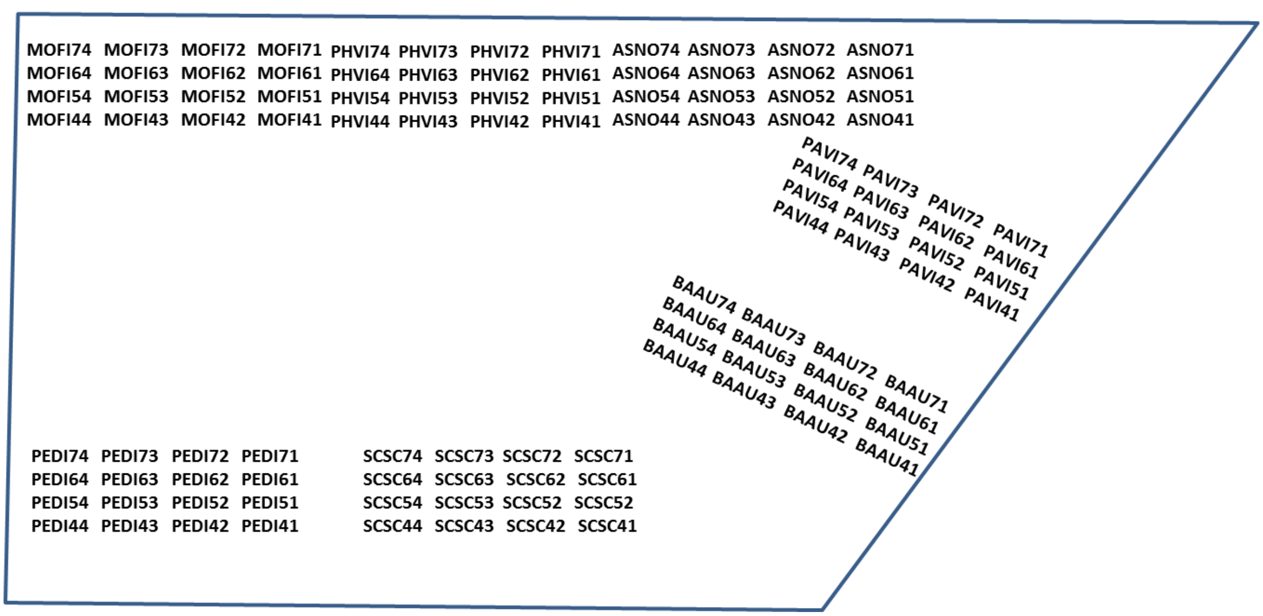


ASNO71	ASNO72	ASNO73	ASNO74	PAVI71	PAVI72	PAVI73	PAVI74
ASNO61	ASNO62	ASNO63	ASNO64	PAVI61	PAVI62	PAVI63	PAVI64
ASNO51	ASNO52	ASNO53	ASNO54	PAVI51	PAVI52	PAVI53	PAVI54
ASNO41	ASNO42	ASNO43	ASNO44	PAVI41	PAVI42	PAVI43	PAVI44
BAAU71	BAAU72	BAAU73	BAAU74	PEDI71	PEDI72	PEDI73	PEDI74
BAAU61	BAAU62	BAAU63	BAAU64	PEDI61	PEDI62	PEDI63	PEDI64
BAAU51	BAAU52	BAAU53	BAAU54	PEDI51	PEDI52	PEDI53	PEDI54
BAAU41	BAAU42	BAAU43	BAAU44	PEDI41	PEDI42	PEDI43	PEDI44
PHVI51	PHVI52	PHVI53	PHVI54	PHVI71	PHVI72	PHVI73	PHVI74
PHVI41	PHVI42	PHVI43	PHVI44	PHVI61	PHVI62	PHVI63	PHVI64

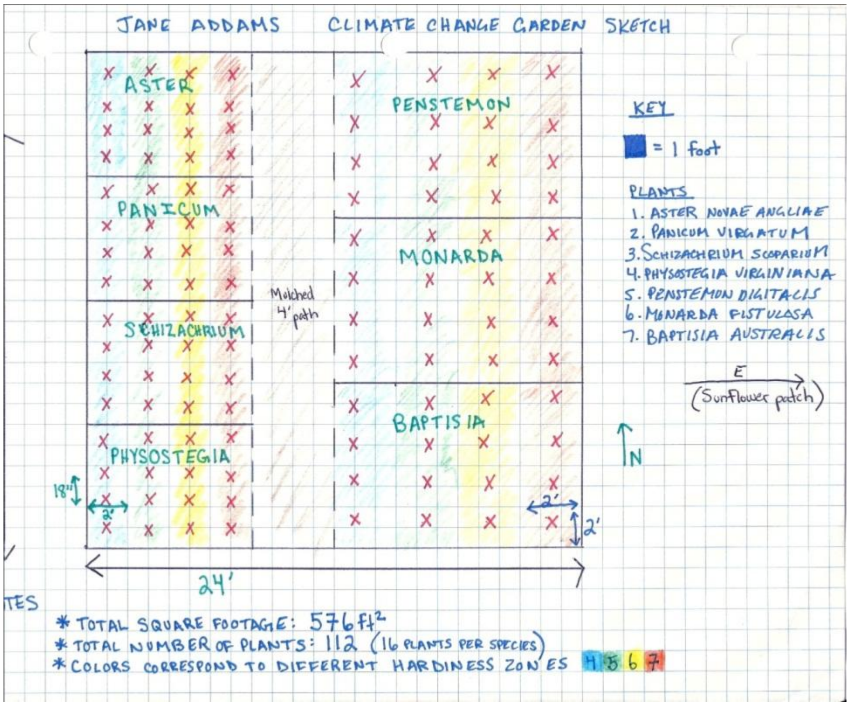
MOFI71	MOFI72	MOFI73	MOFI74
MOFI61	MOFI62	MOFI63	MOFI64
MOFI51	MOFI52	MOFI53	MOFI54
MOFI41	MOFI42	MOFI43	MOFI44
SCSC71	SCSC72	SCSC73	SCSC74
SCSC61	SCSC62	SCSC63	SCSC64
SCSC51	SCSC52	SCSC53	SCSC54
SCSC41	SCSC42	SCSC43	SCSC44

Garden design & plant coding sheet for Roosevelt High School





Garden design & plant coding sheet for Jane Addams K-8



ASNO44 ASNO54 ASNO64 ASNO74
ASNO43 ASNO53 ASNO63 ASNO73
ASNO42 ASNO52 ASNO62 ASNO72
ASNO41 ASNO51 ASNO61 ASNO71

MOFI44 MOFI54 MOFI64 MOFI74
MOFI43 MOFI53 MOFI63 MOFI73
MOFI42 MOFI52 MOFI62 MOFI72
MOFI41 MOFI51 MOFI61 MOFI71

PAVI44 PAVI54 PAVI64 PAVI74
PAVI43 PAVI53 PAVI63 PAVI73
PAVI42 PAVI52 PAVI62 PAVI72
PAVI41 PAVI51 PAVI61 PAVI71

PEDI44 PEDI54 PEDI64 PEDI74
PEDI43 PEDI53 PEDI63 PEDI73
PEDI42 PEDI52 PEDI62 PEDI72
PEDI41 PEDI51 PEDI61 PEDI71

BAAU44 BAAU54 BAAU64 BAAU74
BAAU43 BAAU53 BAAU63 BAAU73
BAAU42 BAAU52 BAAU62 BAAU72
BAAU41 BAAU51 BAAU61 BAAU71

SCSC44 SCSC54 SCSC64 SCSC74
SCSC43 SCSC53 SCSC63 SCSC73
SCSC42 SCSC52 SCSC62 SCSC72
SCSC41 SCSC51 SCSC61 SCSC71

PHVI44 PHVI54 PHVI64 PHVI74
PHVI43 PHVI53 PHVI63 PHVI73
PHVI42 PHVI52 PHVI62 PHVI72
PHVI41 PHVI51 PHVI61 PHVI71

Photography data

Until an online database is established for the Floral Report Card gardens, photographs of each plant phenophase can be organized through photo sharing websites or onto desktop computers. Websites such as “Photobucket, “Snapfish” or “Shutterfly” allow image files to be uploaded and organized within folders.

Each growing season will result in a total of 660 pictures for the phenophase tracking of the seven species, as each plant will require a total of 5 photographs of each tracked phenophase (first leaf; first flower; full flower; first fruit; leaf senescence) with the exception of *Penstemon digitalis* (bearded fox tongue) which only has 4 phenophases to track due to its basal evergreen growth eliminating the “first leaf” phenophase from analysis. Each photograph should be titled using the plant codes used in phenophase data collection followed by the phenophase codes and the date phenophase observed in a XX_XX format.

Phenophase codes for photo documentation

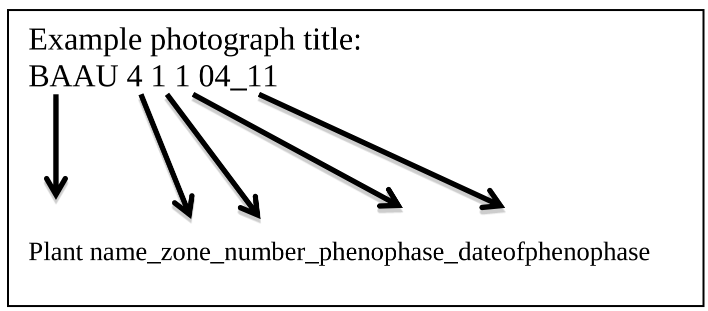
1: first leaf

2: first flower

3: full flower

4: first fruit

5: leaf senescence



Each teacher can decide between establishing a file sharing website and creating a file pathway on their school computers for photograph storage. It is suggested for teachers to use the file sharing websites so students can upload photographic records independently in the classroom.

After the first preliminary year of data collection, the pilot school educators can assess the best means for photo monitoring using a class of students. Each teacher is encouraged to have the students practice the technique of repeat digital photography by taking phenophase pictures from the same angle each time the photograph is taken.

Weather Data

Each school has received a Davis Instruments Vantage Pro2 wireless weather station with an integrated suite that includes a console/receiver, rain collector, temperature and humidity sensors an anemometer, and solar panel. At a future date, soil moisture and leaf evaporation sensors will also be provided. Electronic components are housed in a weather-resistant shelter. Each school also received weather Davis Instruments 6555 WeatherLinkIP computer software that posts weather data collected from the Vantage Pro2 station directly to the internet. Educators will only be tasked with plugging the data logger that came with the software into the back of the console and a cable/DSL router connection to the internet. Using the WeatherLinkIP software, educators will be able to create publicly accessible websites to see their data live. More information about the weather station and equipment can be found on, http://www.davisnet.com.

The Davis Instruments website provides all FAQ and troubleshooting materials for educators to refer to with problems or questions concerning the weather station.

Snapshot of template excel sheet for school garden data collection

Floral Report Card
Plant phenology data

Directions: Use this sheet to organize preliminary phenology data. Insert the date of each phenophase observed using a xx/xx/xx format. Each plant is tagged in your Floral Report Card Garden with the following code.

Name of school:

Method of data entry :

Describe the general method of data entry you are using at your school. (For example, who has access to this excel sheet, how is information being transferred by student observations).

Plant	First leaf	First flower	Full Flower	First Fruit	Leaf Senescence	Comments
BAAU41						
BAAU42						
BAAU43						
BAAU44						
BAAU51						
BAAU52						
BAAU53						
BAAU54						
BAAU61						
BAAU62						

Phenology data collection sheet

FILL OUT ONE SHEET FOR EACH PLANT YOU OBSERVE

Name: ____________________________ **Date:** ____________________________

School site: ____

Plant code: Refer to the tag in front of each plant for plant code ______________________

Phenophase observations: Phenophase definitions are slightly different for each plant. Refer to species-specific data collection protocols.

Phenophase that occurred	Month	Day	NOTES

FL= first leaf FFR=first fruit
FF= first flower LS= leaf senescence
FULLF = full flower

DON'T FORGET TO TAKE A PICTURE OF EACH PHENOPHASE YOU OBSERVE!
INPUT ALL DATA ONTO CLIMATE CHANGE GARDEN EXCEL SHEET

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