Campus-Community Partnership Proposal for a Restoration Teaching Garden
Trinity University and Mark Twain Middle School
San Antonio, Texas

Contents:

I. Project Description
II. Evaluation and Dissemination
III. Institutional Approval (Appendix I)
IV. Disclosure Statement
V. Tables
VI. Figures
VII. Photos
VIII. Appendix I

I. Project Description

Introduction - Project Goals and Objectives

Intense human land and resource use has resulted in major changes to virtually every ecosystem on the planet. In the United States, loss of intact ecosystems has driven research into their restoration to pre-European settlement conditions. Concomitant with this movement to restore habitats is an increased awareness of native species and the roles and interconnectedness of these species. It is now clear that this awareness is the key to the conservation and preservation of our native ecosystems. The primary goal of this project is to establish a teaching restoration garden at Mark Twain Middle School (MTMS) in San Antonio, Texas to enhance the science curriculum of this underprivileged, Latino-serving institution and increase student awareness of the natural history of the place in which they live and the intersection of Nature and Culture. Our garden will provide students a forum for education in biology, ecology, ecosystem and environmental science as well as issues of conservation biology, restoration ecology, farming and horticultural practices. To establish and maintain the garden we are forging a long-term campus-community partnership bringing together the expertise of faculty at Trinity University and teachers at MTMS. The teaching garden satisfies the goals of the ACS Campus-Community Partnership program in that it 1). facilitates community outreach for Trinity University faculty and students, 2). facilitates a long-term partnership between the a low-income, minority-dominated middle school and Trinity University's Biology Department, and 3). enhances community understanding of the natural world and how to act as responsible environmental citizens.

Project Description

Mark Twain Middle School

MTMS is part of the San Antonio Independent School District and services grades six through eight. The school has approximately 670 students and 41 teachers with a student to teacher ratio of 16.3. The school consists of 624 Hispanic students, or 93.13% of the student body. As a reflection of the socio-economic status of the students, more than half are eligible for the free lunch program (373/670).

MTMS is a very high profile school. It is located on a major thoroughfare (Figure 1, San Pedro Ave.) and has recently undergone a major renovation costing $18 million, which was paid for through a local school bond. Renovation of the school was done to preserve the original brick building and to add to it state-of-the-art classrooms, a new cafeteria, orchestra building, two gyms, state-of-the-art library and courtyard. The renovation sends a clear message to the students that education is a priority for adults in this part of San Antonio, and they respond.

Research Priorities of the Principle Investigator at Trinity University

Kelly Lyons is a faculty member in the Biology Department at Trinity University. Her research is focused at the intersection of the loss of biodiversity and invasive, pest species in natural ecosystems. Specifically, she investigates the role of plant community biodiversity in the maintenance of ecosystem functioning and the biotic and abiotic factors that determine establishment and spread of invasive plant species. She is currently researching the potential for species native to the Texas Hill Country to suppress invasive, pest species. The overall goal of this research is to provide guidance on management of Texas Hill Country grasslands to increase biodiversity and control invasive species. The teaching garden at MTMS will be used to complement this research agenda by providing information on the phenologies and growth forms of a large suite of native species. Information will also be collected on the abilities of the native species to suppress the invasive, pest species already present on the site.

The Site

The property on which MTMS resides includes a large drainage area for the three neighborhoods surrounding the school (see Photos 1 and 2). Flash flood events, which occur relatively frequently in this South Texas region, bring thousands of gallons of water through this drainage area. The school district and the city have struggled for years to control the water flow in this area. Recently, the city and the district collaborated to rebuild the drainage ditch along the east side of the school. In the ditch there are now several city drains as well as grassy areas both in the shade and full sun (Figure 1 & 2, photo 1). Through their efforts, the city and the school district have succeeded in controlling much of the flooding; however, standing water can be found in the lower sections of the drainage area even in the driest months of the year (Fig. 2, Area 4).

The science teachers at MTMS and Kelly Lyons of Trinity University have been given permission by the principal of the school to establish an experimental garden on the site (see attached letter, Appendix I). The total area measures approximately 1.25 hectares (3.08 acres). Through our garden we aim to capitalize on the open space that has been created by the new drainage channel (Fig. 1). In addition, the standing water in the lower areas will help us establish part of the garden in this very arid part of the U.S. The garden will also provide much needed erosion control for the sloped areas of the channel (Fig. 2, Area 4 & 5).

Fortunately for us, there are three previously established sources of water in the garden area. These will provide us with the irrigation needed to establish plants in areas 1, 2 and 3; however, we believe that due to the combined fall and spring rains and the use of drought tolerant species little irrigation will be required for this garden post initial germination and establishment.

In addition to the green areas that are available to us, there is a WPA historic building on the site that will be used by the students for data collection and journaling. We envision this building also as a retreat for the students where they can pursue their thoughts on Science and Nature outside of their typical classroom setting. The building will also be used to store tools and equipment for the garden and will provide a meeting location for the new Ecology Club.

Garden Design

The garden will have five areas (Fig. 2). Each area will be planted to serve 1). various portions of the curriculum through the academic year and 2). erosion control. Areas 2 and 5 are also designed to complement one another in their overlap of native species.

Area 1 is shaded by Texas Live Oaks (*Quercus fusiformis*) and is sorely in need of landscaping to establish vegetation on the bare soils (Fig. 1 & 2). Using students from the science classes, this area will be plugged with the natives Lindheimer's muhly grass (*Mulenbergia linheimeri*), Buffalograss (*Buchloe dactyloides)* and Pigeonberry (*Rivina humilis)*. Lindheimer’s muhly grass and Buffalograss are hardy, drought tolerant native grasses now widely planted in South Texas in horticultural settings. Therefore, after exposure to the species, students will see them growing in many public places and will be able to recognize it. Both species grow well in the shade of oaks, provide habitat for mammals and invertebrates and, once established, will require little irrigation. Pigeonberry is a hardy native forb used in horticulture. Its red berries are an excellent source of food for birds.

Area 2 will serve as a demonstration garden where annual and perennial native species used throughout the garden plus other select native species will be grown in a more formal, raised bed setting (Table 1). Raised beds will be constructed using methods developed by Urban Harvest, an organization dedicated to community teaching gardens in the Houston, Texas area (www.urbanharvest.org). These raised beds will allow students to explore the general morphological differences of the species and apply these principles to the basics of plant taxonomy.

Area 3 will be planted with both native and non-indigenous species that will appeal to the student senses (see examples in Table 1). Plants used as spices in cooking (e.g., sage, basil, oregano (Italian and Mexican)) and aromatherapy (e.g., lavender, lemon balm) will be emphasized. This garden will not only increase the student awareness of the uses of plants but will also bring them into contact with species from other parts of the world (e.g., lavender from the Mediterranean) that are now widely planted in south Texas and are becoming a large part of our local industry. We will also establish plants that serve no use to humans but have other features that appeal to the senses. For example, we will include strongly scented species that use secondary metabolites to ward off herbivores either directly or indirectly (e.g., Society garlic). Other herbivore defenses will be highlighted such as thorns, spines and urticating hairs (e.g., stinging nettle). Plants that cope with high light environments through white and grey reflective hairs on their leaves will also be included.

Area 4 is the lowest part of the ditch and, as such, is also the wettest. This area is generally too wet for students to use regularly so we will plant in this location a mixture of native species that do well in this climate and are suited for wetter habitats (Table 1). Our hope is that this mixture will beautify the area for the students and the local community and serve to stabilize the soils in the face of flash floods. We include Eastern gamagrass, a strongly rhizomatous native locally referred to as "riparian rebar." This species will serve to improve soil erosion in this area. We realize, however, that we run the risk of completely losing this planting should a large rain event occur before the species are well established.

Area 5 consists of approximately 48 degree sloped edges of the channel. This area will be used as an experimental garden to serve students at later stages in the curriculum. It will be seeded with mixtures of native species specifically designed to control erosion along stream and riparian corridors. Our aim is to establish an experiment in this area to address three scientific questions, although the list of possible questions is endless. We want to know 1). Do single-species plots control erosion and invasive species as well as three- and six-species plots?, 2). Which species and species combinations are the most effective for controlling previously established invasive species?, and 3). Which species and species combinations are the most effective for soil stabilization?

We will establish 81 plots consisting of single, three- and six-species combinations (Table 1) plus controls with no plantings. For the single-species plots, all six species used in the experiment will be grown alone. These plots will be established in four replicates (6 species x 3 replicates = 18 plots). We will also include three replicates of the three-species plots in all possible combinations of our six species (20 combinations x 3 replicates = 60 plots) and four replicates of the six species growing together (3 plots). Finally, we will include four plots in which nothing is planted to serve as a control. We expect to find that differences in number of species, species identity and species combinations will result in differences in invasive species and erosion control.

Concepts and Activities in the Garden - Curricula

In the state of Texas public school teachers are required to follow closely a set of guidelines for teaching. In the San Antonio Independent School District these guidelines are outlined in a document called the *Scope and Sequence*. Below we provide ideas for how the restoration teaching garden will be incorporated into the *Scope and Sequence* at each grade level. We first identify the general concept that is to be covered and then provide possible activities or experiments that would facilitate teaching of these concepts. The teachers of MTMS have also included in Appendix I examples of possible curricula utilizing the restoration garden.

6TH GRADE

Energy flow

1. Measure amounts of leaf litter in various parts of the garden and build hypotheses as to why some areas have more litter than others.
2. Decomposition study using various substrates. Students may compare, for example, the decomposition rates of evergreen and deciduous, thick and thin, smooth and hairy leaves.

Structure and function

1. Identify the four main plant organs, describe their structures and determine their functions.
2. Locate species that have unusual or specially adapted organs and features and provide hypotheses for their purpose.

Cell biology

1. Make cross-sections and longitudinal sections of plant organs in an attempt to view their cellular structures.
2. Collect water from the channel and identify some of the uni- and multi-cellular organisms

Response to external stimuli

Determine whether more birds use the channel as a water source in wet or dry times.

Food webs

Identify other species interacting with plants (herbivore, pollinators). Describe their activities.

7TH GRADE

Energy flow

1. Add nutrients to soils and measure changes in above ground biomass
2. Measure biomass differences pre- and post- rain events and at different times of the season.

Structure and function

1. Floral morphology
2. Compare floral traits of different species
3. Identification of the major plant families (e.g., *Lamiaceae, Fabaceae, Poaceae, Asteraceae*).

Response to external stimuli

1. Identify plants that are more susceptible to wilting. Identify conditions that cause wilting.
2. Identify plants that are completely stationary or are able to move.
3. Experiment with shade cloth to force plants to bend toward the light
4. Variability in species establishment based on the external environment.

Food webs

1. Identify the producers, consumers and decomposers.
2. Elucidate relationships among species through research.

Ecosystem science

Analyze erosion control ability of various species combinations (single, three and six species combinations). Measure the amount of litter versus soil in each plot.

8TH GRADE

Energy flow

1. Measure above and below ground biomass and reproductive output differences among plots treated with nutrients
2. Decomposition study using various substrates and abiotic environments. Students may compare, for example, the decomposition rates of evergreen and deciduous leaves in wet, dry, and fertilized areas of the garden.

Structure and function

1. Collection and preservation of plant specimen.
2. Identification of the major genera within plant families (e.g., *Lamiaceae, Fabaceae, Poaceae, Asteraceae*).

Response to external stimuli

1. Identify areas of garden with higher and lower biomass and plant cover. Construct hypotheses as to the driving factors behind patterns. Make soil measures to support observations.
2. Attempt to increase or decrease plant biomass or cover through alteration of the abiotic environment (addition of water or nutrients). Measure changes in plant responses.

Food webs

Herbivore and pollinator exclusion studies to determine the direct effect of pollination on fruit set (reproductive output).

Ecosystem science

1. Analyze effects of species diversity and species composition on above and below ground productivity.
2. Discuss experimental design, the need for replicates (environmental variability) and how to calculate and compare averages. Simple statistical analyses.

II. Evaluation and Dissemination

At the close of the school year a meeting will be held including all MTMS teachers involved in the project, student leaders from MTMS and Trinity faculty and students involved with the garden to discuss the success of the project. Assessment will be made of the following factors: 1. species chosen for the garden, 2. the theoretical focus of the garden and its use in the curriculum, 3. how the garden facilitated learning, 4. the use of the garden by courses outside the sciences, 5. future plans for contraction, expansion and/or reestablishment of the garden, 6. consideration of a produce garden, 7. reception of the garden by the community, 8. issues of vandalism or protection, and 9. sources of and proposals for future funding. Since this will be our first year is difficult to say if we will be able to provide a model for other schools in the area or other ACS schools; however, this is certainly our goal. The lessons learned from this first year of the garden will be documented and provided to ACS.

III. Institutional Approval (Appendix I) – Letter of support from Trinity University

IV. Disclosure Statement

The PI anticipates receiving no other support coinciding with the timetable of this proposal.

V. Tables

Table 1. Plant Species to be Used in Garden

Area	Common Name	Latin Name	planted as…
1	Understory landscaping		
	Lindheimer's mulhly grass	*Muhlenbergia lindheimeri*	plug
	Buffalograss	*Buchloe dactyloides*	plug
	Pigeonberry	*Rivina humilis*	seed
2	Texas Native Demonstration Garden		
	Forbs		
	American Basket Flower	*Centaurea americana*	seed
	Blackeyed Susan	*Rudbeckia hirta*	seed
	Clasping Coneflower	*Dracopis amplexicaulis*	seed
	Cutleaf Daisy	*Engelmannia pinnatifida*	seed
	Drummond Phlox	*Phlox drummondii*	seed
	Texas Foxglove	*Penstemon cobaea*	seed
	Greenthread	*Thelesperma filifolium*	seed
	Huisache daisy	*Amblyolepis setigera*	seed
	Indian Paintbrush	*Castilleja indivisa*	seed
	Mealy Blue Sage	*Salvia farinacea*	seed
	Pink Evening Primrose	*Oenothera speciosa*	seed
	Plains Coreopsis	*Coreopsis tinctoria*	seed
	Prairie Coneflower	*Ratibida columnifera*	seed
	Prairie Verbena	*Verbena bipinnatifida*	seed
	Purple Three Awn	*Aristida purpurea*	seed
	Scrambled Eggs	*Corydalis curvisiliqua*	seed
	Spiderwort	*Tradescantia occidentalis*	seed
	Standing Cypress	*Ipomopsis rubra*	seed
	Texas Blue Bonnet	*Lupinus texensis*	seed
	Texas Yellow Star	*Lindheimeri texana*	seed
	Winecup	*Callirhoe involucrata*	seed
	Grasses		
	Big Bluestem	*Andropogon gerardii*	seed
	Little Bluestem	*Schizachyrium scoparium*	seed
	Side Oats Grama	*Bouteloua curtipendula*	seed
	Silver Bluestem	*Bothriochloa laguroides*	seed
	Texas Winter Grass	*Nassella leucotricha*	seed
	Blue grama	*Bouteloua gracilis*	seed
	Buffalograss	*Buchloe dactyloides*	seed
	Sprangletop	*Leptochloa dubia*	seed

3	Sense Garden		
	Lavender	*Lavendula spp.*	sapling
	Sage	*Salvia greggii, among others*	sapling
	Bay laurel	*Laurus nobilis*	sapling
	Rosemary	*Rosmarinus officinalis*	sapling
	Mexican Oregano	*Lippia graveolens*	sapling
	Italian Oregano	*Origanum vulgare*	sapling
	Stinging Nettle	*Urtica dioica*	sapling
	Society Garlic	*Tulbaghia violacea*	sapling
	Mint	*Mentha spicata*	sapling
	Jasmine	*Jasminum sp.*	sapling
	Rootbeer Plant	*Piper auritum*	sapling
	Lamb's Ears	*Stachys byzantina*	sapling
	Spicebush	*Lindera benzoin*	sapling
	Lilac Chaste Tree	*Vitex agnus-castus*	sapling
	Rice Paper Plant	*Tetrapanax papyrifer*	sapling
	Jewelweed	*Impatiens sp.*	sapling
4	Experiment: Single, triple and six-species combinatons		
	Big Bluestem	*Andropogon gerardii*	seed
	Eastern Gamagrass	*Tripsacum dactyloides*	seed
	Green Sprangletop	*Leptochloa dubia*	seed
	Switchgrass	*Panicum virgatum*	seed
	Black-eyed Susan	*Rudbeckia hirta*	seed
	Pink Evening Primrose	*Oenothera speciosa*	seed
5	Erosion control using two mixtures from Native American Seed Company		
	Drainfield Mix (excluding non-natives)		
	Big Bluestem	*Andropogon gerardii*	seed
	Eastern Gamagrass	*Tripsacum dactyloides*	seed
	Green Sprangletop	*Leptochloa dubia*	seed
	Prairie Wildrye	*Elymus canadensis*	seed
	Switchgrass	*Panicum virgatum*	seed
	Wetland Fringe Mix		
	Clasping Coneflower	*Dracopis amplexicaulis*	seed
	Cutleaf Daisy	*Engelmannia pinnatifida*	seed
	Scarlet Sage	*Salvia coccinea*	seed
	Plains Coreopsis	*Coreopsis tinctoria*	seed
	Illinois Bundleflower	*Desmanthus illinoensis*	seed
	Black-eyed Susan	*Rudbeckia hirta*	seed
	Pink Evening Primrose	*Oenothera speciosa*	seed
	Maximilian Sunflower	*Helianthus maximiliani*	seed
	Obedient Plant	*Physostegia intermedia*	seed
	Pitcher Sage	*Salvia azurea*	seed

All seeds will be purchased through Native American Seed Company, Junction, Texas

Table 2. Budget

item	cost	matching	amount needed	source of matching
Trinity University student stipend[1]	560		560	
cinder blocks[2]	200		200	
shovels (x3)	60		60	
dibble x 2[3]	100	100	0	Trinity University Lyons' lab
dolly[4]	50	50	0	MTMS teacher
wheelbarrow[4]	40	40	0	Trinity University Lyons' lab
gloves (20 pairs)	40	40	0	MTMS
writing utensils and paper	100	100	0	MTMS
clippers[5]	40	40	0	MTMS
aircraft cable[6]	100		100	
miscellaneous hardware	50		50	
signage and photo monitoring[7]	150		150	
picnic table[8]	100	100	0	MTMS
weather station[9]	250	250	0	
wooden identification markers	40		40	
landscaping soil[10]	180		180	
seed[11]	540		540	
plugs[12]	250		250	
plants[13]	160		160	
labor[14]	800	800	0	MTMS students, Trinity and Lyons' lab
Totals	3810	720	**2290**	**Request from ACS = $2290**

Justifications:

1 - 70 hours x $8.00/hour = $560

2 - cinder block for raised beds

3 - dibbles for plug planting

4 - dolly for moving cinder blocks, wheelbarrow for moving soil

5 - seasonal prunning

6 - to mark experimental plots

7 - Due to the fact that this will be a high profile garden, we feel it is imperative to provide interpretation to the community to explain what the garden is, its use and what can be found in there. In addition, the garden will be established in a intercity area where there is occassional vandalism. We aim to provide interpretive signage to emphasize to the community the importance of the garden to the education of our children in hopes of inparting a sense of ownership of the project. We will also establish photo monitoring posts to document the progress of the garden and for documentation for future funding potential.

8 - Table will be used for data collection, journaling and art projects.

9 - Will be placed on the roof of the school to complement data collected on phenologies of the plants in the garden as well as activities of other inhabitants of the garden such as invertebrates and soil microbes.

10 - To be purchased from GardenVille, San Antonio, TX. We anticipate a need of 5 yards of soil at $30/yard plus $30 for delivery. This totals 5 X $30 + 30 = $180.

11 - We anticipate seeding approximately 36 species singly by seed and estimate needing approximately .25lb/species at an average cost of $14.00/species. This totals 36 x $14 = $476. In addition, we will need approximately 2 lbs. of both the Drainfield and Wetland Fringe mixes at an average of $10/lb. This totals 4 lbs x $10 = $40. The total cost for seed with shipping is estimated at $476 + $40 + $20 (shipping) = ~$540.

12 - We will need 250 plugs of both grass species (M. lindheimeri and B. dactyloides.) for a total of 500 plugs at an estimated cost of $.50 per plug for a total of 500 x $.50 = $250

13 - We intend to plant 16 sapling shrubs at an average cost of $10/plant. Total cost is 16 x $10 = $160.

14 - We estimate a need for 100 human hours for constructing raised beds, purchasing seed, plugs and plants, seeding, planting and irrigation establishment at a cost of $8/hour (8 X $100 = $800). We will save in cost of labor by using volunteer students from Trinity University and incorporating planting into the school curriculum.

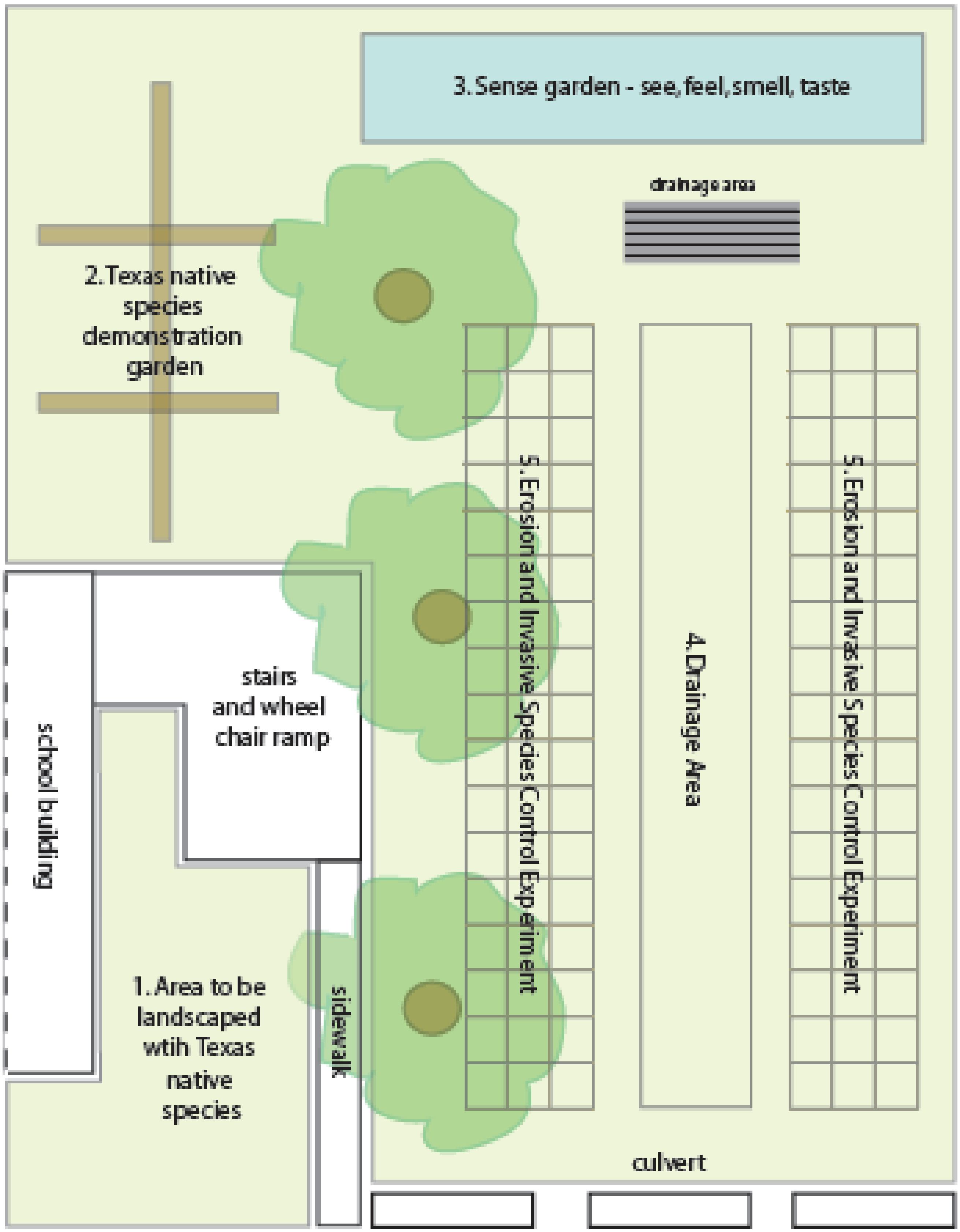
Table 3. General Timeline for September 2006 to May 2007

month	Area	grade level(s)	Activity
August	all	none	establish photo monitoring posts (x4)
September	2	none	construct raised beds
	4	none	establish experimental plots with aircraft cable and rebar
	2, 4	all	establish native species demonstration and experimental garden
	5	all	establish seed erosion control area
	1	all	plant plugs
	3	all	plant shrubs
	all	all	student orientation
October	all	all	monitor establishment
	all	all	journaling, experiments and data collection
November - April	all	all	journaling, experiments and data collection
May	all	all	garden farewell
	all	all	assessment of effectiveness of garden
	all	all	planning for replanting in fall 2007

VI. Figures

Figure 1. Overview of Area for Restoration Garden and Teaching Facilities

Figure 2. Plans for Restoration Teaching Garden



VII. Photos

Photo #1

Photo #2

VIII. Appendix I
Contents

1. Letter of Support from Diane Smith, Trinity University Associate Vice President of Academic Affairs - Institutional Approval
2. Letter of Support from Monica C. Garcia, MTMS principal (forthcoming)
3. Letter of Support from Chanda Day, 8th grade teacher
4. Example of 6th Grade Lesson Plan
5. Example of 8th Grade Lesson Plan

1. Letter of Support from Diane Smith, Trinity University Associate Vice President of Academic Affairs - Institutional Approval

TRINITY UNIVERSITY

OFFICE OF THE VICE PRESIDENT FOR ACADEMIC AFFAIRS & DEAN OF THE FACULTY

ONE TRINITY PLACE
SAN ANTONIO, TX 78212-7200
www.trinity.edu

(210) 999-8201 voice
(210) 999-8234 fax

Date: June 27, 2006

Re: Campus-Community Partnership Grant Proposal by Dr. Kelly Lyons

Dear Dr. Rossmann,

I have reviewed and approved the final proposal and budget that Dr. Kelly Lyons has prepared for her submission to the ACS Campus-Community Partnership Grant Program. This project will provide wonderful educational opportunities for students of the Mark Twain School, a local middle school. Trinity University and the Mark Twin School have forged a partnership for educational and service programs, and this proposed project is ideally suited for this partnership. Please let me know if you need additional information.

Sincerely,

Diane R. Smith
Associate Vice President for Academic Affairs
dsmith@trinity.edu
(210) 999-7656

2. Letter of Support from Monica C. Garcia, MTMS principal (forthcoming)

3. Letter of Support from Chanda Day, 8th grade teacher

TWAIN LETTERHEAD

July 26, 2006

To Whom It May Concern:

It is an honor to support and work on a project that brings students and scientists together. This project distributes scientific literacy beyond the formal education venue. The possible gardening, periodic field study, mathematics and technological aspect of this project broaden the inquiry appeal.

There are many implications of having a growing base of knowledge being developed from the data driven research. I can foresee this project becoming a model for students to work on year after year as citizen scientists. This focus means that the foundation of student understanding of ecological systems will emerge from interested investigators such as themselves.

Sincerely yours,

Chanda Day
Eighth Grade Science
Mark Twain Middle School

Appendix 1 - Example of 6^{th} Grade Lesson Plan

Joy Tuxhorn 6^{th} Grade
Schedule Over 2-3 Days
How are ecosystems studied?

1. Unit: Ecosystems
    a. In this unit students will be answering the questions:
        i. How are ecosystems studied? (What do ecologists do?)
        ii. What are the components that make up an ecosystem?
        iii. How do these component systems work together in the ecosystem?
        iv. What are some ways humans are impacting natural ecosystems?

2. Lesson: Scientific Drawing/Diagramming
    a. It has been observed that students are lacking in this skill.
    b. Detailed observation is a muscle that needs exercising
    c. Students feel that drawing pictures is not a serious part of science.
    d. Particular lesson is good for ESL and SpecEd because of building on more visual skills

3. Objectives:
    a. Students will be able to create a list of criteria for a "good" scientific diagram. (Comprehension)
    b. Students will be able to evaluate "good" and "bad" scientific diagrams. (Evaluation)
    c. Students will be able to create own example of a "good" scientific diagram. (Application/Synthesis)

4. TEKS: 6.1a; 6.2be; 6.3c

5. Materials:
    a. Teacher
        i. Laptop
        ii. Projector
        iii. Power Point of examples of good and bad scientific diagramming
        iv. Roll of white butcher paper or large pieces of paper
    b. Student
        i. Interactive notebook
        ii. Colored pencils
        iii. Plastic sample container
        iv. Ruler
    c. School
        i. Access to outdoors
        ii. Garden

6. Warm-up
    a. Students will be shown a scientific diagram of an animal that they would probably not be familiar with.
    b. Students will have 5 minutes to write down all the information that they get about the animal.
    c. Class then discusses and teacher lists information on the board.
    d. Discuss how the students were able to gather so much information.

7. Introduction:
    a. Teacher and class will discuss the importance of proper scientific diagramming.
    b. Teacher will show an example of a "good" scientific diagram
        i. Large, neat, and clear depiction- colored neatly
        ii. Scale is shown
        iii. Notation is made of important structures
    c. Teacher will ask students to make note in their notebooks about the qualities of the diagram
    d. Teacher will show an example of a "bad" scientific diagram
    e. Teacher will ask students to make note in their notebooks about the qualities of the diagram
    f. Teacher will pose the question: Which of these is better and why?
    g. Students will answer question in notebooks and then class will discuss- Teacher will write/project student responses on board.

8. Guided Practice
    a. Activity 1: Criteria
        i. A 1-2-4 formatted activity
        ii. Students will be asked to individually come up with a list of criteria a diagram must meet in order for it to be "good"
        iii. Students will then discuss in pairs and then come up with another list together.
        iv. Then 2 pairs will form a group of four to compile information and create the final list of criteria on a large piece of butcher/white paper.
        v. Each group will present their list to the class and a class consensus will be made and written into the students' notebooks.
    b. Activity 2: Evaluation
        i. Teacher will show a PowerPoint made of several slide depicting "good" and "bad" diagrams.
        ii. Students will be using the list of criteria
        iii. After each slide students will evaluate the diagram
            1. If the diagram is "good" they will explain why
            2. If the diagram is "bad" they will explain why and what needs to be done to fix it.

    iv. Afterward the PowerPoint will be shown again and class will discuss their evaluations.

9. Independent Practice
    a. Students will be taken outside- to the garden
    b. The students will be asked to walk around and observe
    c. The students will then be asked to remove a small sample from the garden and place it in their plastic sample container.
    d. Students will then go back to the classroom with their sample and make a "good" scientific diagram.
    e. Student will then exchange papers with a partner and the class will then be taken back down to the garden.
    f. The students will then be asked to find where/from what each person took their sample from.
    g. Their partner will tell them if they got it correct or not.
    h. The students will then evaluate each other's diagrams using the criteria and make suggestions for improvement if necessary.
    i. Students can then exchange papers with others and repeat- getting more feedback.

10. Closure
    a. Students will write a reflective piece in their notebook on what they have learned and the importance of their new skill.
    b. Students can share out with the class if desired.

11. Assessment/Evaluation
    a. Teacher will be able to assess student understanding by observation of class during discussion.
    b. Teacher will be able to assess student work throughout the guided practice.
    c. Teacher will be able to assess student understanding through the sharing in the 1-2-4 activity
    d. Teacher will be able to evaluate students understanding by collecting students notebooks.
    e. Teacher will be able to evaluate student work by collecting diagrams and feedback from the garden sample activity.

12. Feedback
    a. Peer feedback is built into garden sample activity
    b. Teacher feedback provided by handing back notebooks with grades/notes
    c. Teacher feedback provided by handing back diagrams from garden activity
    d. Self feedback provided by reflection at the closure of the lesson.

Appendix 1 - Example of 8th Grade Lesson Plan

Possible format for native grass study adapted from ***Science Scope***
July 2006, p. 42-46 The Nature of Science and Art, **Debby Chessin and Mary Jane Zander**

Activity 1—History of nature printing and plant taxonomy.

Procedure

Using the websites listed, answer the questions below.

- Science at a Distance, Classification—www.brooklyn.cuny.edu/bc/ahp/CLAS/CLAS.Linn.html
- Swedish Museum of Natural History, Carl Linnaeus—www.nrm.se/fbo/hist/linnaeus/linnaeus.html.en
- The Franklin Institute, Families—sln.fi.edu/tfi/units/life/classify/classify.html

Common characteristics of science and art.

- Both disciplines are based on observation, experimentation, and traditional models.
- Both disciplines recognize that problem solving requires a willingness to come up with and reexamine theory.
- Both disciplines encourage reflection, assessment, and openness to change.
- Both disciplines respect historical tradition.

Questions

1. What kinds of things do botanists study?
2. How did Linnaeus become interested in the study of plants and what abilities and qualities did Linnaeus have that helped him become a renowned scientist?
3. Historically, have scientists always agreed with the way that Linnaeus grouped plants? Explain. Do modern scientists? Explain.
4. Describe some ways that plants are classified, starting with the broadest category.
5. Research and describe current plant classification.

What is the unique binomial name Linnaeus suggested for an individual of a species? What is an example?

Through this activity, the students will gain a historical perspective of how nature printing was an early way to record the shape of leaves for collections. Students will research information about the history of nature printing, taxonomy, and Carl Linnaeus using selected websites to answer a set of guided questions.

Each group will research one question and facilitate a whole-group discussion of all the questions. Students may complete their research at home. Students will be encouraged to think about the importance of being able to classify objects according to similar features. Whole class discussion on Linnaeus's characteristics, as well as his classification system and how it works.

Activity 2—Observe and record nature.

Materials

- meter sticks
- compass and/or GPS
- journals and pencils
- tempera paints
- sponge brushes

Observe

1. Find a unique spot outside with your small group. Measure a square meter and draw it to scale in your science journal. Describe the location in as much detail as possible (e.g., top or bottom of a hill? shady or sunny spot?). Use your compass to indicate North, South, East, and West and if available, use a GPS unit to record latitude, longitude, and elevation. Sketch the living and nonliving components in your square. Bring one leaf specimen back to the classroom with you.

Record

2. Make nature prints by brushing paint on the underside of your leaf. This simulates the action of blackening the leaf with candle soot. Place the painted leaf between two pieces of paper and rub gently until the paint creates a perfect image of the leaf on the page. Work in pairs to apply paint and transfer the print. Clean up with soap and water.

3. Make entries in your journal that describe the size, shape, color, texture, smell, margin, vein patterns, and location and environment in which they were found. This may be repeated with each different type of leaf by using new pages for each print and journal entry.

Extend

1. Explore similarities and differences among your group's leaves and develop your own hierarchical ordering system. Back in the classroom, share your system with the class.

2. Explore the scientific binomial system using the website The Franklin Institute, Families—
sln.fi.edu/tfi/units/life/classify/classify.html.

Activity 3—Plant structures and functions

Materials

- crayons
- 8½ x 11 inch paper
- construction paper
- books and other references

Procedure

1. Sketch the leaf specimen. Next, think about the role of the leaf in terms of the whole plant. What are the functions of plant roots, stems, veins, and leaves? Consider the factors of temperature, light, water, air, and nutrients.
2. What specialized structures of plants protect them from adverse conditions? Consider conditions such as weather, insect pests, or other dangers to survival. Draw and describe.

Groups research plant adaptations for survival in different biomes and prepare a report for the class. Each person will choose a plant part and biome to research. Follow the links to plant adaptations on the Biomes of the World website www.mbgnet.net for information on this topic.

In each group, each student chooses a different plant structure and a biome to research. Information is recorded in the Cornell Notes format in their Science Journals. Groups come together to share information with each other and with the class. Research may be completed as homework.

Activity 4—Nature of art.

Materials

- crayons
- tempera paints, slightly diluted to watery consistency
- sponge brushes
- heavy paper

Observe

1. Carefully observe the shape of a leaf. Notice whether it has radial symmetry, asymmetry, or bilateral symmetry. Also notice any characteristic features,
   such as rounded or sharp edges, or how the vein pattern is designed to
   feed the plant.

Draw

1. On a piece of construction or heavy paper, draw the outside shape of the leaf including characteristic features. Find differences in shape between leaves with vein patterns that are symmetrical and those that have radial or asymmetrical structure. Observe the outside contours of the form and note the importance of the space outside the leaf as well as the space within the leaf in creating the overall contour of the shape.
2. Look at details and characteristics of emerging growth (i.e., how leaves join the stem, smaller veining patterns, and developing buds or leaves).

Overlap some leaves to create depth. Vary their size and direction of placement to create interest.
Group leaders display the final products in the designated areas

National Science Education Standards

Content Standard C: Life Science

- The characteristics of an organism
- Life cycles of organisms
- Organisms and environments

Content Standard G: History and Nature of Science

- Science as a human endeavor
- History of science
- Nature of science

Reference: SAISD Science, grades 6 - 8 TEKS Alignment For The Garden