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Earth-Kind® Rose Trials – Identifying the World's Strongest, Most Beautiful Landscape Roses

Derald A. Harp[1]* · David Zlesak[2] · Gaye Hammond[3] · Steve George[4] · Wayne Mackay[5]

[1] Texas A&M University – Commerce, Dept. of Agricultural Sciences, P.O. Box 3011 Commerce, TX 75482 USA
[2] University of Minnesota Extension, 550 Bunker Lake Blvd. NW, Suite L-1, Andover, Minnesota 55304 USA
3Houston Rose Society, 5020 Montrose Blvd., 9th Floor, Houston, TX 77006 USA
[4]Texas A&M University, Dept. of Horticultural Sciences, Texas Agrilife Extension, 17360 Coit Road, Dallas, TX 75252 USA
[5]University of Florida, Mid-Florida Research and Education Center, 2725 S. Binion Rd., Apopka, FL 32703 USA

Corresponding author:* Derald_Harp@TAMU-Commerce.edu

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ABSTRACT

"Earth-Kind®" is the most prestigious horticulture designation bestowed by the Texas AgriLife Extension Service (part of the Texas A&M System). This designation is awarded based on multi-year scientific research studies, combined with extensive, regional field trials, conducted by or in collaboration with Texas A&M horticulturists. Only rose cultivars possessing an extremely high level of landscape performance, coupled with outstanding disease and insect tolerance and/or resistance may receive the designation. The Earth-Kind philosophy is based on the premise that it is possible to identify beautiful plants that tolerate harsh, low-maintenance environments without fertilizers, pesticides, and other agricultural chemicals along with a significant reduction in irrigation. This cutting edge, environmental effort is the most popular and fastest growing, research-based environmental university program of its kind in the U.S. and directly benefits all sectors of horticulture: growers, retailers, landscapers, and consumers. Earth-Kind rose research is underway in 25 states and four foreign countries, including Bermuda, Canada, India and New Zealand.

Keywords: disease resistance, *Diplocarpon rosae*, drought tolerance, environmental research, *Rosa*, soil management

INTRODUCTION

The rose is the most popular garden plant in the world as well as one of the most important commercial cut flowers (Horst 1995). Over 200 million roses are planted annually with a value of approximately $720 million in retail sales (Short *et al*. 1991). No other group of plants provides as wide a range of plant, flowering and blossom traits (Buck 1964a). They combine the best characteristics of annual bedding plants and perennials, but with a wealth of flower forms, colors and scents and plant forms and habits that few other plants can provide (Buck 1978). The public's demand for low maintenance,"environmentally-friendly" roses is growing as (a) more gardeners are becoming less willing to expose themselves and their families to pesticides, (b) city governments restrict landscape irrigation, (c) legislation restricts pesticide usage, and (d) the costs associated with commercial fertilizers and rose care products skyrocket (Zlesak 2006).

The Earth-Kind® environmental landscape management system applies to the entire landscape and was created by horticultural specialists in the Texas Agrilife Extension Service. It addresses, in a beautiful way, the four major horticultural challenges facing today's American homeowners and landscape professionals:

- Stewardship of precious water resources;
- The abuse and/or misuse of commercial fertilizers;
- The abuse and/or misuse of pesticides; and
- The need to keep natural resources (tree leaves and branches) in our landscapes and out of landfills, thereby making room for more non-recyclable waste.

Demand for improved cultivar performance

Today's gardeners face many new horticultural challenges and, as a result, have become more demanding of the plants they choose for inclusion in their landscapes. Drought and above normal temperatures have forced communities to limit irrigation during periods of severe plant stress. In response, homeowners in several states have proven to be mindful of water resource challenges and are prepared to make changes in their landscapes to accommodate limited water supplies (Israel *et al*. 1999; Spinti *et al*. 2004; Hurd *et al*. 2006). The term "xeriscape", (landscaping in ways that do not require supplemental irrigation) was first coined in Colorado in 1978 and is an important landscape movement in Texas (Welsh *et al*. 2000). Additionally in many areas, salt levels have increased due to a decrease in available ground water supplies, further limiting plant available water (PAW) (Brady *et al*. 2001). In addition to direct results of difficult environmental conditions, these stressors also increase susceptibility of rose cultivars to insect and disease pressure.

Horticulturists typically recommend supplemental irrigation, application of fertilizers, and spraying of the appropriate pesticide to improve plant performance or to correct inherent landscape problems. In the past, horticulturists and pathologists have routinely directed their research programs towards the development of control methods, rather than resistance mechanisms (Hagan *et al*. 1988). Unfortunately, when supplemental irrigation

is not always available, and in the face of increased costs for commercial synthetic fertilizers, consumers are showing a preference for more environmentally friendly landscape management techniques, eschewing the use of synthetic fungicides and pesticides.

For example, blackspot is a serious and often devastating disease of outdoor roses, caused by the fungus *Diplocarpon rosae* Wolf (Horne *et al*. 1988). It is the most serious disease problem of roses worldwide (Horst 1995; Rajapaska *et al*. 2001; Whitaker *et al*. 2007). Roses vary widely in their susceptibility, with popularly cultivated hybrid tea cultivars typically being the most susceptible (Jenkins 1955; Palmer *et al*. 1966). Control measures require repeated sprays with fungicides, often as frequently as once each week from the first flush of growth in the spring until the first hard frost in the fall (University of Illinois 1987; Reddy *et al*. 1992; Hagan *et al*. 2005). The repeated and prolific use of fungicides at this level not only increases the cost to the consumer, but can be potentially hazardous to the environment. It also places selection pressure on the pathogen and can lead to the development of acquired resistance to different chemistries and dynamic pathogen populations.

There has been a strong movement away from the use of roses as general garden plants in the United States during the last 80 years. In part, this can be attributed to the general level of culture required to keep roses healthy (Buck 1979). That consumers are making the shift to low maintenance roses and more environmentally responsible landscapes is illustrated in sales of the Knock Out® series of roses (the original cultivar in the series was introduced in 2000). "To date, Knock Out® and its siblings have sold between 10 million and 12 million plants in the states," says Steve Hutton, president of Conard-Pyle. "No other rose, not even 'Peace' which took the world by storm 60 years ago, has sold like that." (Virag 2007) (**Fig. 1**). Consumers have demonstrated a willingness to pay premium prices for cultivars that are resistant to common diseases. For instance, University of Tennessee developed a powdery mildew (*Microsphaera pulchra* Cook & Peck) resistant flowering dogwood tree (*Cornus florida* L.) that created a potential net nursery financial gain of $0.8 million (Gardner *et al*. 2004). Another important example is the work done identifying cultivars of American and non-American elm species that show resistance to Dutch Elm Disease (Santamore *et al*. 1995; Townsend *et al*. 2004). Current environmental and economic concerns behoove horticulture researchers to identify disease resistant and tolerant species and cultivars.

The Earth-Kind program requires the support of researchers in biotechnology, molecular genetics, plant breeding, plant pathology, and entomology. In a typical breeding program, individual plants or genotypes are identified that exhibit a particular trait, such as drought tolerance, and pest or disease resistance. These unique individuals would be utilized in breeding and biotechnology programs as a genetic resource. Through the Earth-Kind program, the universities and communities involved provide this initial research and make available to plant breeders and others a long list of successful cultivars that possess adaptive traits across multiple environments. Also, once successful varieties are identified, basic research can be performed on these varieties to identify the specific morphological, physiological, or biochemical character that imparts these desired characteristics. As we broadly work across the various fields of science, the ultimate goal of identifying effective landscape plants can be realized. Once

known at the basic level, the traits identified that make Earth-Kind roses successful could also be transferred or utilized in other species, including ornamental, food, and fiber crops.

Low maintenance landscapes must be aesthetically pleasing

Over the past several years, virtually every state has developed programs that promote the use of native species adapted to local environmental conditions (Nelson 2003; Stack 2008). While many attractive native species have been identified, native species tolerant of local environmental conditions often lack the aesthetic qualities of their widely commercialized brethren. Unfortunately, the supposed hardiness and pest resistance of native species may not necessarily hold true, as that knowledge is often based on anecdotal and not scientific evidence. Scheiber *et al*. (2008) found that canopy size in non-irrigated plots declined similarly for eight introduced and eight native species in Florida. Similar results have been duplicated in other states and across numerous other species (Glenn *et al*. 1998; Stabler *et al*. 2000; Garcia-Navarro *et al*. 2004; Zollinger *et al*. 2006).

Many landscape professionals feel that the solution to today's landscape challenges with roses lie in the development of more disease resistant, drought and heat tolerant, winter hardy roses. However, the development of new rose cultivars can take 10 to 20 years to complete. Additionally, rose breeding is mainly carried out by amateurs or commercially by highly competitive companies whose genetic knowledge is often proprietary and unpublished (Gudin 1998, 2000; Australian Government 2005). For these reasons, researchers throughout the world now have a tremendous opportunity to develop or identify rose cultivars that are beautiful and highly adapted to regional environmental conditions. The goal of the Earth-Kind program is not to recreate the breeding programs of hybridizers around the world, but rather to identify those truly special cultivars that combine beauty with proven durability in the landscape.

Earth-Kind overview

The Earth-Kind philosophy is based on the premise that it is possible to identify beautiful plants that tolerate harsh, low-maintenance environments without fertilizers, pesticides, and other agricultural chemicals and with a significant reduction in irrigation. This cutting-edge environmental effort is the most popular and fastest growing, research-based environmental university program of its kind in the U.S., with testing of Earth-Kind roses currently underway in 25 states (from Alaska to Florida) and four foreign countries (Bermuda, Canada, India, and New Zealand). Six universities (Colorado State University, Iowa State University, Kansas State University, Louisiana State University, University of Minnesota, and the University of Nebraska) have joined Texas A&M in conducting peer-reviewed Earth-Kind rose research.

Earth-Kind systems are a revolutionary approach to landscape management suitable for almost any geographic region, climate zone, and soil type. Traditionally, gardeners have used peat moss and synthetic fertilizers to grow plants in areas where they are not adapted, protecting stressed plants from insects and disease through an arsenal of agricultural chemicals and from drought with an abundance of irrigation. These plantings suffer greatly when cities restrict landscape irrigation. While native landscapes may survive on limited irrigation, they often lack the aesthetic appeal of traditional gardens.

Organic landscapes limit the use of synthetic pesticides, but force gardeners to use expensive organic fertilizers and depend on often dubious concoctions for fertility and pest control. Organic management approaches are often supported only by anecdotal observations and frequently do not hold up to validation in controlled experiments (Grabowski *et al*. 2007). The Earth-Kind approach identifies aesthetically pleasing plants that combine the toughness and durability of well-adapted natives, environmentally friendly aspects of organic gardening, and techniques and recommendations based on university-based, peer-reviewed research.

Earth-Kind environmental soil management

Success in any gardening program is dependent on proper soil management, as improvements in the soil directly impact and enhance water and nutrient availability, as well as overall plant health and growth. The Earth-Kind principles of environmental soil management emulate natural environments for nutrient cycling. Leaves, branches, and other forms of organic matter fall to the ground and slowly decompose into humus, providing the required plant nutrients and improving soil tilth. In this natural environment, soil microflora flourish, increasing populations of beneficial fungi and mychorrizae and improving conditions in the root zone. In an Earth-Kind program, compost is incorporated only one time into the native soil to provide the essential elements needed for plant growth. An organic mulch is applied to the soil surface and replenished once or twice yearly to maintain a three inch thick layer. This mulch decomposes into humus and acts as a slow-release fertilizer. Harp *et al*. (2008) demonstrated this relationship, illustrating how separating the soil/mulch interface with synthetic weed barriers can decrease the transfer of nutrients from decomposing mulch into the root zone. Likewise, McBee *et al*. (2004) demonstrated how organic matter also contributes to improvements in soil porosity, drainage, aeration and plant available water.

Earth-Kind roses

No landscape species is better suited to serve as the flagship model crop for the Earth-Kind system than roses. The beauty of the species and its tremendous genetic diversity makes it an ideal candidate for refocused research. The genus *Rosa* is represented by over 100 species across four continents (Hortus 1976). Until recently, roses have been selected primarily on the basis of flower size, form, color, and, less frequently, fragrance. While the rose's popularity is exemplified by the number of products specifically developed for rose care in the landscape, many gardeners have shied away from roses, choosing to buy species with lower maintenance requirements (Buck 1979). Roses whose minimal maintenance requirements have been validated by peer-reviewed scientific research provide individuals with reliable alternatives for successful and productive landscapes.

Earth-Kind rose evaluation criteria

"Earth-Kind" is the most prestigious horticulture designation bestowed by the Texas AgriLife Extension Service. This designation is awarded based on multi-year scientific research studies, combined with extensive, regional field trials, conducted by or in collaboration with Texas A&M horticultural experts. Only rose cultivars possessing an extremely high level of landscape performance, coupled with outstanding disease and insect tolerance

and/or resistance may receive the designation.

Furthermore, roses will only be designated Earth-Kind if they meet several additional criteria. First, the rose must be attractive in both plant form and flower characteristics throughout the growing season. This beauty must be natural and not the result of manipulation, excessive fertilization, or heavy pruning. The Earth-Kind program recognizes, but does not evaluate differently between the various classes of roses, except for the evaluation of climbing roses. Climbers are not penalized for asymmetric plant habit because it is part of their nature as they mature in size. Besides this exception for plant habit, all roses, regardless of class, are evaluated by identical standards (**Table 1**).

Second, Earth-Kind roses must be durable, well-adapted plants capable of withstanding the local and regional environmental conditions. They must be growing on their own roots and not a product of grafting. Rootstock-scion interactions can affect vigor and other traits as well as plant longevity (Lindstrom and Kiplinger 1955; Buck 1964b; Mackay *et al*. 2008). Earth-Kind roses must be tolerant of the three primary soil textures (sands, loams, and clays), tolerant of high alkalinity and, once established, capable of surviving on the limited moisture and fertility provided by the native soil initially amended with compost and covered with organic mulch. In several trials across the state of Texas, many specimens in heavy clay soils have survived severe and prolonged drought with little or no supplemental irrigation. The use of synthetic and organic fertilizers is strictly forbidden in Earth-Kind trials. Candidate cultivars must have the ability to develop a healthy and aggressive root system with effective nutrient uptake and use efficiency for consistent, superior performance.

Finally, Earth-Kind roses must be tolerant of insects and disease. Since Earth-Kind rose trials last multiple years, each site has a minimum of 15 plants, and pesticides are not used, regional pests that affect roses tend to quickly invade Earth-Kind plantings and allow for differences in tolerance which impacts performance to be quickly evident. Varieties selected as Earth-Kind are tolerant of common rose insects, such as Western Flower Thrips (*Frankliniella occidentalis* Pergande), spider mites (*Tetranychus* spp.), and aphids (numerous species), and common rose diseases, such as blackspot and powdery mildew. It is important to use the term tolerant, as minimal pest and disease incidence can be expected in virtually any landscape plant during periods of heavy pressure. However, depending on the cultivar, Earth-Kind roses range from being only tolerant to being fully resistant, with the disease or pest damage being extremely limited in scope. One of the best known roses in the Earth-Kind program, Knock Out® (*Rosa* 'RADrazz'), has variations in the lipid component of the cuticle layer that account for its resistance to blackspot (*Diplocarpon rosae*) (Goodwin *et al*. 2007). Similarly resistant roses may share this characteristic, or have morphological variations in the leaflet surface (Reddy *et al*. 1992). It is understood that vigorous, healthy plants are less susceptible to insect and disease damage, so a good deal of the insect and disease tolerance and resistance can be attributed to prudent soil management under the Earth-Kind program that greatly reduces soil related plant stress. Currently there are 19 cultivars that have earned Earth-Kind status in the Southern US region out of over 115 evaluated (Mackay *et al*. 2008; **Table 2**) representing diverse flower and plant characteristics (**Fig. 2**).

It should be understood that, as currently implemented, the Earth-Kind designation recognizes tolerance of regional

environmental and soil conditions only. For example, a trial evaluating 20 rose cultivars is currently underway in Minnesota, Iowa, Nebraska, Kansas, Colorado, and Texas (**Table 3**). It would be perfectly reasonable to believe that cultivars recognized as Earth-Kind in Minnesota and Iowa may not be in Texas or Kansas as these states have very different climatic conditions. However, the researchers may be able to identify a cultivar that thrives across all the environments presented and merit Earth-Kind designation in multiple regions. This single rose variety could then be used as a source of genetic material for the improvement and development of current and new rose cultivars that will hopefully also have wide climatic adaptation.

Ultimately, the goal of Earth-Kind is to identify those cultivars that have the genetic potential to thrive in landscapes under normal cultural conditions. Extreme climatic events (heat wave, extreme cold, drought, etc…) and/or exposure to elevated disease and insect pressure is likely to overwhelm any genetic advantage these plants may possess. However, the identification of these traits through Earth-Kind protocols can provide plant breeders a focal point from which tolerance and resistance traits may be obtained. For example, chilli thrips (*Scirtothrips dorsalis* Hood) are becoming a serious threat to numerous ornamental, orchard, and field crops in the southern U.S. Chilli thrips are known to attack roses in India, therefore a program, like Earth-Kind, that was able to identify tolerance in India could provide valuable information to biotechnologists, plant breeders, and pest control operators in the U.S. This program would be further enhanced through international cooperators, as tolerant genotype(s) could be identified in areas known to be infested with the pest in question as it becomes established in other parts of the world.

OVERVIEW OF EVALUATION PROTOCOL

Cultivar selection

Candidate cultivars must undergo an extensive preliminary evaluation process before being entered into a regional Earth-Kind rose trial. Researchers consult numerous studies that have been conducted across the United States and Canada that evaluate roses according to their winter hardiness, disease incidence, and/or susceptibility to insect damage. Earth-Kind researchers also consult noted rosarians, looking to identify cultivar limitations prior to inclusion in an Earth-Kind trial. Roses that flower only in the spring and are not everblooming or recurrent and those that are hybrid rugosas at this point are being omitted from consideration. The public demands roses that have an extended season of flowering and hybrid rugosas are omitted due to their extreme sensitivity to iron chlorosis in alkaline soils. With the large quantities of cultivars being introduced annually, this preliminary screen of available knowledge helps to direct limited resources more efficiently towards roses that have a greater likelihood of being worthy of the Earth-Kind designation. Consulting various cultivar performance studies to pinpoint cultivars that merit inclusion provides further validation for the Earth-Kind program, supporting the recommendation of Earth-Kind varieties, even in other climatic regions.

Evolving evaluation models

The original and primary Earth-Kind model consists of two phases of rigorous testing: 1) a four-year, university-based research study

used to screen a large collection of cultivars, and 2) three-year, multiple site field trials over a wide geographic area to confirm cultivar performance of the best performing cultivars in phase one evaluation. A new model is being implemented for the Northern Earth-Kind Rose Trials (initiated in 2007 for landscape roses targeted for USDA Plant Cold Hardiness Zones 3 and 4). Due to the relatively limited number of cultivars with demonstrated cold hardiness in the far North, a smaller number of cultivars (20) were selected for this trial which is being accommodated simultaneously at several locations initially across the region (**Table 3**). This approach can help identify Earth-Kind worthy roses more quickly and is reasonable for this region with fewer cultivars with reputations as being cold hardy and pest tolerant in a typical landscape.

Earth-Kind research programs are not based on anecdotal evidence, but rather on randomized, replicated studies conducted with scientific rigor and honest evaluations. Care is taken to make them as free as possible of personal and commercial biases. Selection bias is avoided by excluding individuals and/or entities with a financial interest in any rose cultivar(s) as direct funding sources for the research studies. It is important to note that, while individuals and entities (i.e. nurseries) are excluded as direct funding sources, cultivars produced or promoted by these individuals are commonly included for evaluation purposes and donation of plant material is permissible. To date, primary funding for Earth-Kind Rose research has been provided through research grants from the Houston Rose Society and the Texas Nursery and Landscape Association. As other universities joined Earth-Kind research efforts, additional organizations within those states and regions are also contributing funding to support Earth-Kind research.

Earth-Kind rose studies are currently underway at seven universities in the U.S. To ensure consistency, these trials are conducted according to a strict set of protocols. Site development begins with bed layout and must include sufficient space for four replicates of each cultivar with at least 2.5 m (8 feet) between plants in Southern and mid-America trials and at least 1.9 m (6 feet) in Northern trials (**Fig. 3**). A minimum of 15 cultivars are included in these initial studies. Experimental design is a randomized complete block design, with one specimen of each cultivar per block. There is flexibility in how the blocks are designed in order to best account for environmental variability across a site and to make the gardens accessible and aesthetically pleasing (**Fig. 4**). Soil preparation begins by killing and removing existing vegetation. Clean beds are tilled to a depth of 30 cm (12 inches). A layer of fully finished, plant-derived compost, 7.5 cm (3 inches) deep, is tilled into the native soil. The Earth-Kind protocol does not distinguish between forms of compost, although compost from local sources is recommended and manure is discouraged due to the greater potential for burn if not fully composted. Following planting, a minimum of 7.5 cm (3 inches) of organic mulch is applied to the soil surface. Again, a preference for mulch from local sources is noted and typically is chipped wood and bark mulch (**Fig. 3**). Water is supplied via drip irrigation as drip irrigation is a very efficient way to get water to the root zone. Compared to overhead irrigation for instance, drip irrigation can provide the same amount of moisture to plants with up to a 50% reduction in the water applied (Berstein and Francois 1973). Irrigation is provided freely during the first year of establishment, but only as-needed to prevent wilt during year two. During the final two years of the trial, irrigation should be applied only in the case of extreme and

abnormal drought. Earth-Kind site coordinators recognize that evaluations taken during weather that is atypical and unlikely to occur on a regular basis are not realistic and likely discriminate against selections that would survive normal conditions. No fertilizers or pesticides, including those labeled organic, are applied during the course of the four-year study. Roses are not pruned or deadheaded during the duration of the study with the exception of the removal of dead wood.

The evaluation process, other than survival, begins at bud break and continues through the first killing frost and occurs in year two through the duration of the study. The first year data is not taken to account for variation in starting plant material (i.e. initial plant size and logistics when plants can be acquired and planted) and to allow residual pesticides that may have been used during production to dissipate. For most of Texas, evaluations begin in April and end in November. These dates vary according the growing season of the evaluation site. Data collected include quantitative measures such as plant height, width (averaged across two measurements, perpendicular to each other), number and size of blossoms, and chlorophyll content using a SPAD 502 meter (Konica Minolta Sensing, Inc., Osaka, Japan). Leaf tissue analysis should be used to confirm plant nutrient status. Pressure bomb readings and gravimetric measures are used to quantify plant moisture status. Tensiometer readings, or other appropriate measures of soil water tension, should be used to quantify soil water tension at each recording interval. Qualitative measures include visual assessment of foliage coverage, foliage color, blossom coverage, growth form, disease incidence and pest activity, including notation of diseases or pests present (**Table 1**). Disease and pest data are collected by individuals trained in insect identification and plant pathology. Unidentifiable diseases and pests are sent to state plant pathologists and entomologists for identification purposes. Data is analyzed using SAS. Because of the repeated measures nature of the study, quantitative measures should be analyzed using Proc MIXED (Littell *et al*. 1998). For analysis of qualitative data, the Kruskal-Wallis statistic should be used. At the end of year four, the Earth-Kind research team meets to evaluate the performance of the cultivars tested. High performing cultivars are selected for inclusion in regional field trials.

The purpose of regional field trials is to determine if the trends observed in the university study also apply across a wider region, and differ from phase one trials only in number of cultivars and replications, duration of study, and post-trial data analysis. Field trials are conducted through multi-disciplinary partnerships between Extension agents, master gardener groups, rose societies, public gardens, and city governments. They tend to be located in publically visible spaces such as city parks and public gardens providing publicity for the program. Regional field trials feature those cultivars that have already proven to be successful performers in phase one. Cultivar selection is carefully monitored so that every cultivar is included in a similar number of field trials within the respective climatic zones. With the ongoing and dynamic evaluation process, not all cultivars being evaluated are in each site. However, the Earth-Kind winning rose in the South, Carefree Beauty™ (‘Bucbi’), is planted at all sites as a control because of its widespread zone adaptability (USDA Cold Hardiness Zone 4) and consistent performance in past trials. The minimum number of plants in a regional trial is 15, three plants of each of five cultivars. Soil preparation and plant maintenance in field trials are the same as for phase one studies. Cultivars in field trials receive supplemental

irrigation as needed for the first year of plant development, once per month during the summer of the second year, and then only in extreme drought in the final year. Likewise, field trial coordinators agree to never apply fertilizers or pesticides to the plants for the duration of the study. Currently regional field trials are underway at more than 40 sites across the United States encompassing USDA Plant Cold Hardiness Zones 4 to 10.

Through field trials in Odessa, TX, we have demonstrated that several roses designated Earth-Kind are tolerant of receiving drip irrigation water with high salinity. These saline-tolerant roses tend not to exhibit symptoms of chlorotic tissue normally found on other rose cultivars growing under these less than optimal conditions.

Earth-Kind outreach

One of the most important aspects of the Earth-Kind program is outreach and education geared towards the general public. For over a decade, Earth-Kind field trials have demonstrated the ability to produce high-quality landscape roses while reducing irrigation by potentially 70% or more (with the benefit of drip irrigation versus overhead irrigation and the use of mulch), eliminating fertilizers and pesticides, and reducing pruning, including the complete elimination of deadheading. Implementation of Earth-Kind principles with Earth-Kind plant materials allows for a very significant and measurable reduction of the introduction of pollutants into the environment, as well as a measurable reduction in maintenance costs to public gardens and city park departments. Gardeners and landscapers are enthusiastically receptive to these new techniques and plant materials that make their gardens more productive and much easier to maintain. The Earth-Kind program truly benefits all segments of the horticulture industry chain, from the grower to the final consumer (Rodda 2008).

Earth-Kind is advertised through:

- The Earth-Kind website (http://EarthKindRoses.tamu.edu);
- Aggie-Horticulture (http://aggie-horticulture.tamu.edu), Texas's repository for horticulture information; and
- Texas AgriLife Extension and other state Extension publications, field days, and public events.

Additionally, Earth-Kind educational publications are being distributed by more than 80 horticultural organizations across the United States. One of the strongest recent partnerships for dissemination of Earth-Kind rose research is the American Rose Society. They have featured articles on the progress of the Earth-Kind program in their magazine (*The American Rose*) distributed to ~30,000 members. Beginning in 2008 local rose society chapters can request regionally tailored Earth-Kind brochures designed to be distributed internally and externally to promote rose growing using Earth-Kind cultivars and methods. Preliminary reports from local societies indicate that there is a strong positive public response to Earth-Kind. The American Rose Society calendar for 2009 (used to promote rose growing and as a fundraiser for the society) is devoted to Earth-Kind and features Earth-Kind winning rose cultivars. In addition, commercial nurseries that are promoting Earth-Kind winning cultivars as such and in the context of education on Earth-Kind methodology are finding exponential increases in sales of those cultivars (Mark Chamblee, personal communication).

As the Earth-Kind message continues to grow, it is important to recognize that Earth-Kind, and its

accompanying logo, is a legal trademark of the Texas A&M University System. While no royalties are involved in use of the term and our goal is to expand the Earth-Kind system worldwide; the Texas A&M University System and the Earth-Kind team retains control over the trademark. People wishing to use the term must comply to the strict guidelines to maintain the purity of official Earth-Kind approved information.

Future prospects for Earth-Kind

The current goal of the Earth-Kind program is to see its expansion world-wide. In many communities, organic and traditional gardeners share different values and goals, frequently even becoming antagonistic towards each other. The Earth-Kind program provides horticulturists, scientists, gardeners, and landscapers a cohesive message that is easily recognized, understood, and implemented. By adopting the Earth-Kind program and operating under the Earth-Kind banner, researchers and rosarians need not develop and refine new testing methods, as the basic Earth-Kind protocols have proven to be successful regardless of climate, soil type, and other local variables. Regional variations can be incorporated as necessary. Earth-Kind provides a uniform testing procedure for university and regional field trials at a global level.

Defining what should constitute the extent of a region as more regions in the US and beyond are developed within the Earth-Kind program will be an important and ongoing consideration. Taking into account ranges in temperature, moisture, soil, and other critical factors impacting plant growth and performance will be imperative. US EPA Ecoregions could provide the framework for regional distinctions. However, this illustrates the challenge for this program. Currently the US EPA recognizes 84 Level III Ecoregions in the US (Griffith *et al.* 2004, Commission for Environmental Cooperation 1997). Texas alone has 13 ranging from the Chihuahuan Desert in far west Texas to the Coastal plain in southeast Texas (**Fig. 5**). Average annual rainfall may range from 200 mm or less in El Paso, while Beaumont may receive in excess of 1200 mm per year (Arnold 2008). At the same time, pan evaporation rates in El Paso may exceed precipitation rates by 1500 mm (Arnold 2008). Nonetheless, since 1998 the program has identified 19 roses that may be successfully grown using Earth-Kind recommendations throughout these varied regions.

As Earth-Kind moves world-wide, it is hoped that each participating country would use the Earth-Kind approach to identify and honor the strongest, most attractive roses from their own country. In so doing, each country would be developing its own national collection of beautiful Earth-Kind roses. These high-performance selections could be shared with other Earth-Kind researchers around the world to see how wide a region such cultivars are adapted. As the number of Earth-Kind researchers increase, a natural progression would be to convene a World Earth-Kind Conference to assemble a truly "World Collection of Earth-Kind Roses" where representatives from each country reports on, and shares propagation material of the top cultivars from their own trials. Through this uniform research mechanism, the hardiest specimens of *Rosa* germplasm can be identified, shared, and perpetually preserved.

The purpose of the Earth-Kind program is not one of exclusivity, but rather a single organizing entity that can provide a basic framework for individual research and creativity in the development of the hardiest and most beautiful landscape plants around the world. As additional researchers

contribute their expertise and trial data, the overall program will benefit. Unique expertise and resources can greatly benefit the growing research base. Although landscape performance in regional trials with local pest and climatic pressures is the key method by which regionally adapted cultivars are identified, laboratory or other assays to screen plants for tolerance or resistance to a particular pest or environmental stressor common to a region or across regions can be very useful. With the high volume of cultivars available to consider, challenging candidate cultivars with the most problematic factors for successful landscape performance in a region can help objectively pinpoint which to include in extensive field trials. In addition, if for some reason natural pest pressure or environmental extremes are atypical for a region during the trial, controlled resistance screens can help provide essential information that may not otherwise be possible.

For instance, blackspot is one of the most universal and devastating diseases of roses in the landscape. Three races of the pathogen (*Diplocarpon rosae*) causing blackspot collected from Eastern North America and characterized and preserved by the University of Minnesota Woody Plant Breeding Program are available to challenge roses and characterize their resistance (Whitaker *et al*. 2007). A grant provided by the University of Minnesota Garden Calendar Fund has allowed the 30 roses in the Earth-Kind National Brigade (phase two of trialing) (**Table 4**), the 20 Northern Earth-Kind trial roses (**Table 3**), and 17 Earth-Kind winners in the South (omitting 'La Marne' and 'Souvenir de St. Anne's' because they were designated Earth-Kind after the experiment started) (**Table 2**) to be surveyed for their resistance. Race specific and non-race specific resistance using detached leaf assays and these three races will be compared to a growing body of field data. If the lab tests prove predictive of field results, future Earth-Kind candidates can be characterized for resistance to these and potentially additionally identified and preserved races. University of Minnesota Earth-Kind collaborators have the expertise and resources to provide this service to the greater Earth-Kind team. Blackspot resistance/tolerance data can be coupled with other available performance data to help better pinpoint roses with Earth-Kind potential for inclusion in future trials.

There are multiple assays available to screen roses for resistance or tolerance to pathogens and abiotic factors and more that can be developed. Some assays that have been developed that may be useful in some regions include assessing the maximum cold tolerance of acclimated rose canes (Rajashekar *et al*. 1982) and screening for resistance to downy mildew (*Peronospora sparsa* Berk) using detached leaf assays (Schulz and Debener 2007). Additional areas of expertise and resources that support regional research under the broad Earth-Kind umbrella mission are most welcome to be proposed and considered.

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Table 1 Monthly rating scale used to evaluate Earth-Kind trial roses during the growing season in years two through four.

Rating	Foliage cover	Foliage color	Blossom coverage*	Growth habit	Disease	Pest
5	100% coverage	Dark green	90% or more	Symmetrical in all directions, branches consistent in size	No disease	No pest
4	90% coverage or more	Green, No chlorosis	75 to 90% coverage	Symmetrical in most directions, branches consistent in size	<10% of leaves or blossoms infected	<10% of leaves or blossoms with insect damage
3	75 to 90% coverage	Green, up to 25% of leaves chlorotic	50 to 75% coverage	Symmetrical in one direction only, one branch with irregular growth	10 to 25% of leaves or blossoms infected	10 – 25% of leaves or blossoms with insect damage
2	25 to 50% coverage	Lt. Green, 25 to 50% chlorotic	25 to 50% coverage	Asymmetrical growth, two or more branches with irregular growth	25 to 50% of leaves or blossoms infected	25 to 50% of leaves or blossoms with insect damage
1	<25% leaf coverage	Yellow, >50% chlorotic	<25% coverage	Inconsistent and irregular growth over entire plant	<50% of leaves or blossoms infected	<50% of leaves or blossoms with insect damage
0	Plant dead	Plant dead	Plant dead	Plant dead	Plant dead	Plant dead

*One point is added to blossom coverage for those cultivars with fragrant blooms.

Table 2 The 19 Earth-Kind roses designated for the Southern region of the US.

Cultivar[a]	Horticultural class	Year of introduction
Souvenir de St. Anne's	Bourbon	1950
Ducher	China	1869
Mutabilis	China	<1894
Spice	China	unknown
Climbing Pinkie	Climbing polyantha	1952
Else Poulsen	Floribunda	1924
New Dawn	Large flowered climber	1930
Caldwell Pink	Polyantha	unknown
La Marne	Polyantha	1915
Marie Daly	Polyantha	unknown
Perle d'Or	Polyantha	1884
The Fairy	Polyantha	1932
Belinda's Dream	Shrub	1992
Bucbi (Carefree Beauty™)	Shrub	1977
RADrazz (Knock Out®)	Shrub	1999
Sea Foam	Shrub	1964
Duchesse de Brabant	Tea	1857
Georgetown Tea	Tea	unknown
Mme. Antoine Mari	Tea	1901

[a] Trademark or exhibition name, if different from cultivar name, is listed in parenthesis.

Table 3 The twenty rose cultivars included in the current Northern Earth-Kind Rose Trials.

Cultivar[a]	Horticultural class	Year of introduction
Radbrite (Brite Eyes)	Large flowered climber	2006
RADramblin (Ramblin' Red)	Large flowered climber	2001
John Cabot	Hybrid kordesii	1978
John Davis	Hybrid kordesii	1986
Quadra	Hybrid kordesii	1994
William Baffin	Hybrid kordesii	1983
Alexander Mackenzie	Shrub	1985
BAIine (Yellow Submarine)	Shrub	2004
BAIlena (Lena)	Shrub	2007
BAIole (Ole)	Shrub	2007
BAIore (Polar Joy)	Shrub	2004
BAIset (Sunrise Sunset)	Shrub	2004
BAIsven (Sven)	Shrub	2007
Bucbi (Carefree Beauty)	Shrub	1977
Frontenac	Shrub	1992
George Vancouver	Shrub	1994
Morden Blush	Shrub	1988
Prairie Joy	Shrub	1990
Seafoam	Shrub	1964
Summer Wind	Shrub	1975

[a] Trademark or exhibition name, if different from cultivar name, is listed in parenthesis.

Table 4 Earth-Kind Brigade roses being trialed in the mid US.

Cultivar[a]	Horticultural class	Year of introduction
MACdub (Dublin Bay)	Climbing floribunda	1975
Chuckles	Floribunda	1958
Penelope	Hybrid musk	1924
KORtersen (Rosarium Uetersen)	Large flowered climber	1977
New Dawn	Large flowered climber	1930
The Fairy	Polyantha	1932
Amiga Mia	Shrub	1978
April Moon	Shrub	1984
Barn Dance	Shrub	1975
Belinda's Dream	Shrub	1992
Bucbi (Carefree Beauty™)	Shrub	1977
Country Dancer	Shrub	1973
Earth Song	Shrub	1975
Flora Dora	Shrub	unknown
Folksinger	Shrub	1985
MEIpitac (Carefree Wonder™)	Shrub	1990
Pearlie Mae	Shrub	1981
Polonaise	Shrub	1984
Prairie Breeze	Shrub	1978
Prairie Harvest	Shrub	1985
Prairie Princess	Shrub	1972
Princess Verona	Shrub	1984
Quietness	Shrub	2003
Radcon (Pink Knock Out®)	Shrub	2005
RADrazz (Knock Out®)	Shrub	1999
Radyod (Blushing Knock Out®)	Shrub	2004
Sea Foam	Shrub	1964
Square Dancer	Shrub	1972
Summer Wind	Shrub	1975
Winter Sunset	Shrub	1997

[a] Trademark or exhibition name, if different from cultivar name, is listed in parenthesis.

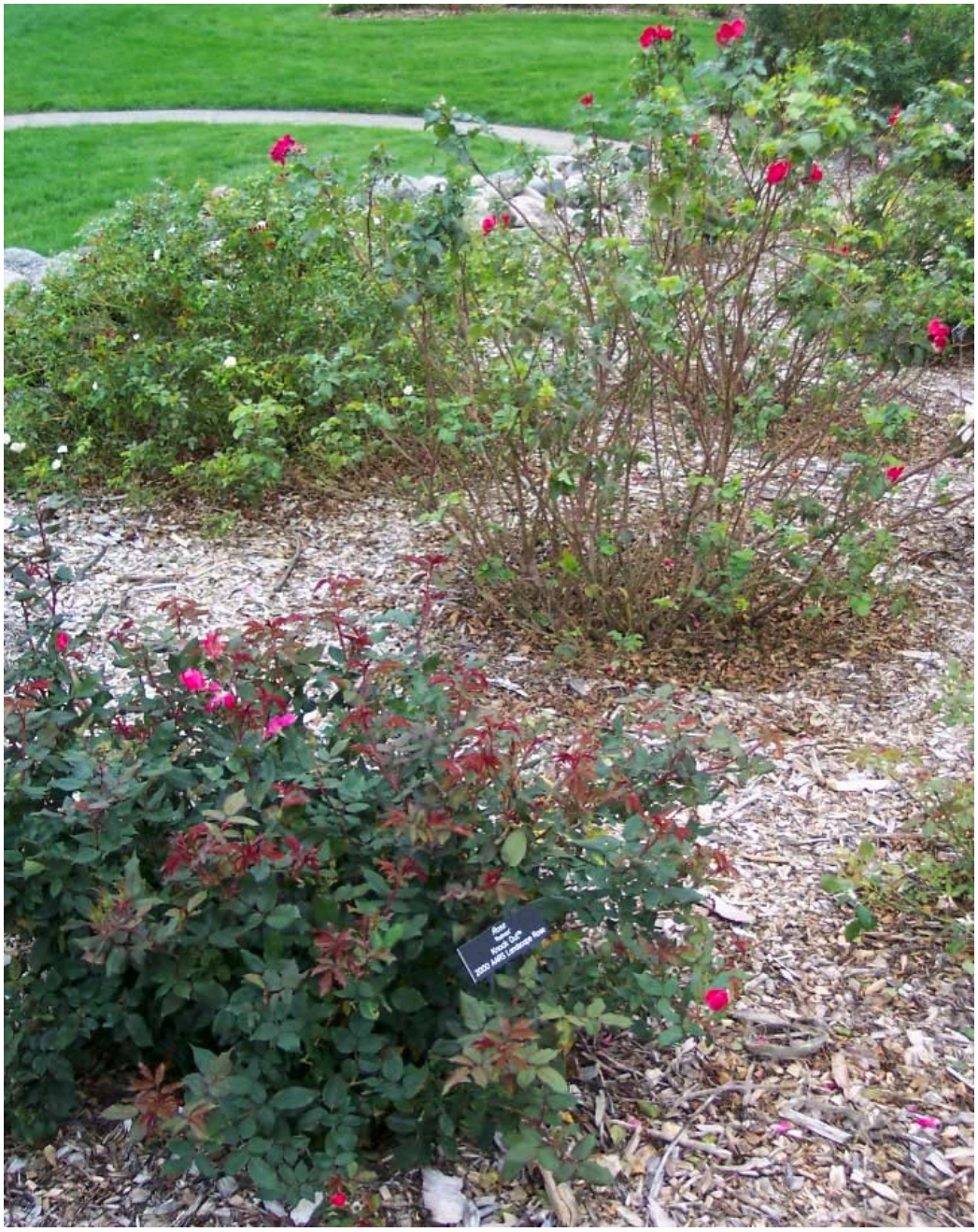

Fig. 1 The EarthKind™ winning rose for the Southern US region, 'RADrazz' (=Knock Out®; foreground), has demonstrated consistently superior resistance to black spot and other diseases and contributes to the reason it is one of the most widely sold rose cultivars in history.

Fig. 2 EarthKind™ winning roses in the Southern US region: 'Belinda's Dream' (A), 'Bucbi' (=Carefree Beauty™) (B), 'Caldwell Pink' (C), 'Climbing Pinkie' (D), 'Ducher' (E), 'Else Poulsen' (F), 'Duchesse de Brabant' (G), 'Georgetown Tea' (H), 'La Marne' (I), 'Mme. Antoine Marie' (J), 'RADrazz' (=Knock Out®) (K), 'Marie Daly' (L), 'Mutabilis' (M), 'New Dawn' (N), 'Perle d'Or' (O), 'Seafoam' (P), 'Souvenir de St. Anne's' (Q), 'Spice' (R), and 'The Fairy' (S).

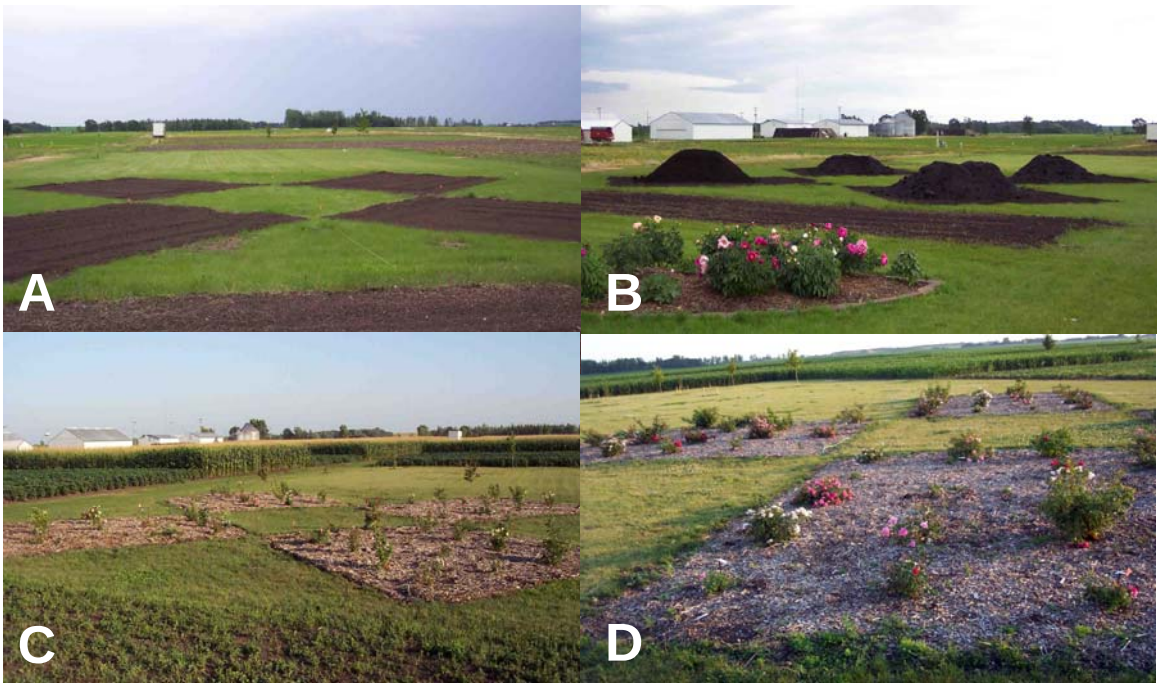

Fig. 3 Planting of the first Northern EarthKind™ rose trial at the University of Minnesota Outreach, Research, and Education (UMore) Park in Rosemount, Minnesota. Grass was removed from beds (A) and plant derived compost was obtained (B) and incorporated. The four beds served as blocks with one of each of the 20 cultivars randomized and planted (June 2007) per block (C) and mulched with a 7.6cm layer of wood chips. Well established plants are blooming during the second growing season (July 2008) (D); the growing season when monthly performance data is first taken.

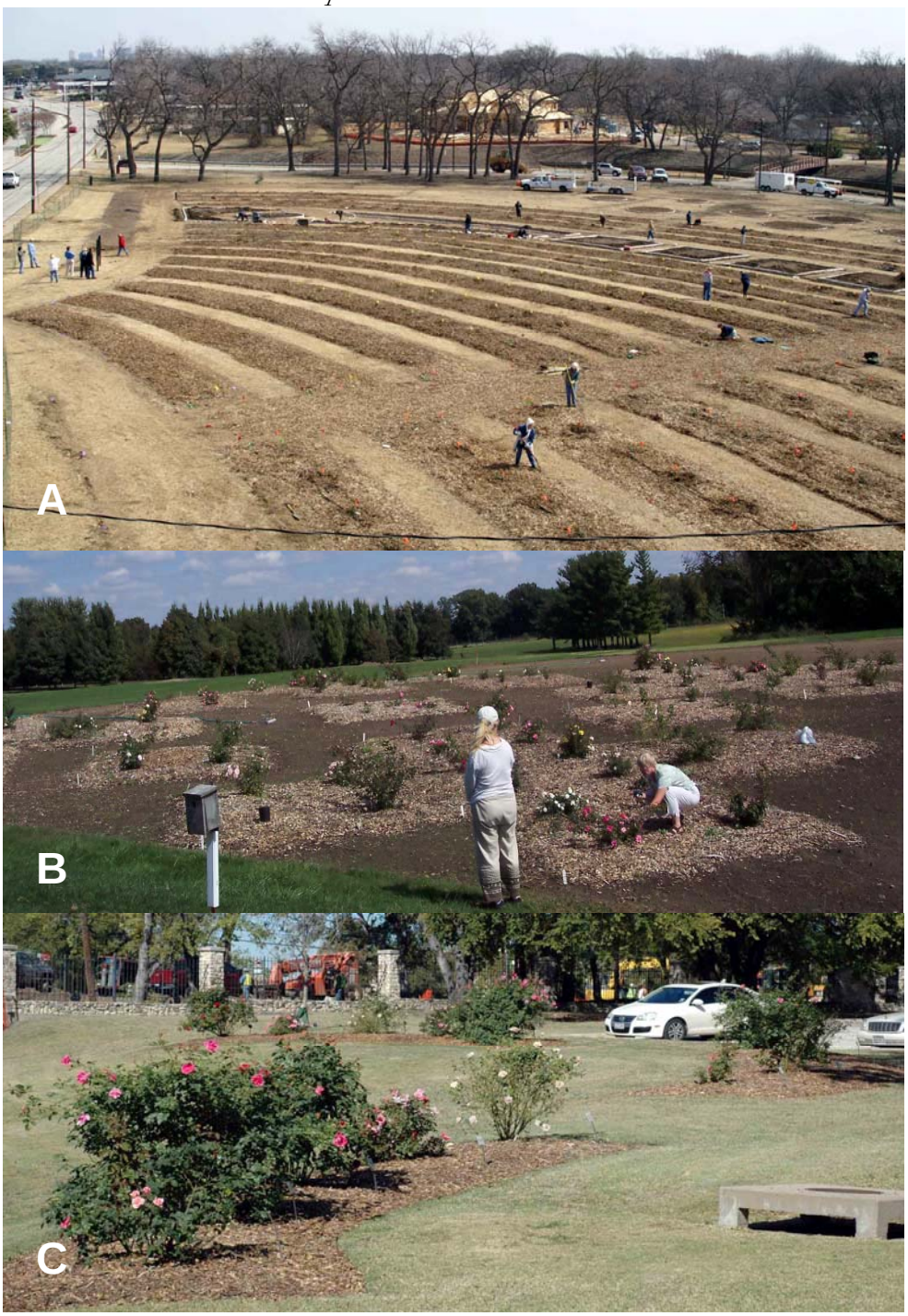

Fig. 4 Layout of blocks is flexible to provide sites the necessary freedom to arrange them to best account for environmental variability and to be aesthetically pleasing. In 2008 a new phase one trial in the Southern US region was planted at Gussie Field Watterworth Park in Farmers Branch, Texas in concentric arches large enough to accommodate 100 cultivars (A). Also in 2008, a Northern EarthKind™ trial site was planted using cross and square shaped beds (crosses contain the test roses and squares contain additional roses not part of the trial) at the Horticultural Research Station in Ames, Iowa (B). A minimum-sized phase two trial site consists of five cultivars replicated three times, and this site (collaboratively sponsored by the Dallas County Master Gardeners and Farmers Branch Parks and Recreation in Farmers Branch, Texas) consists of three blocks arranged in a serpentine design (C).

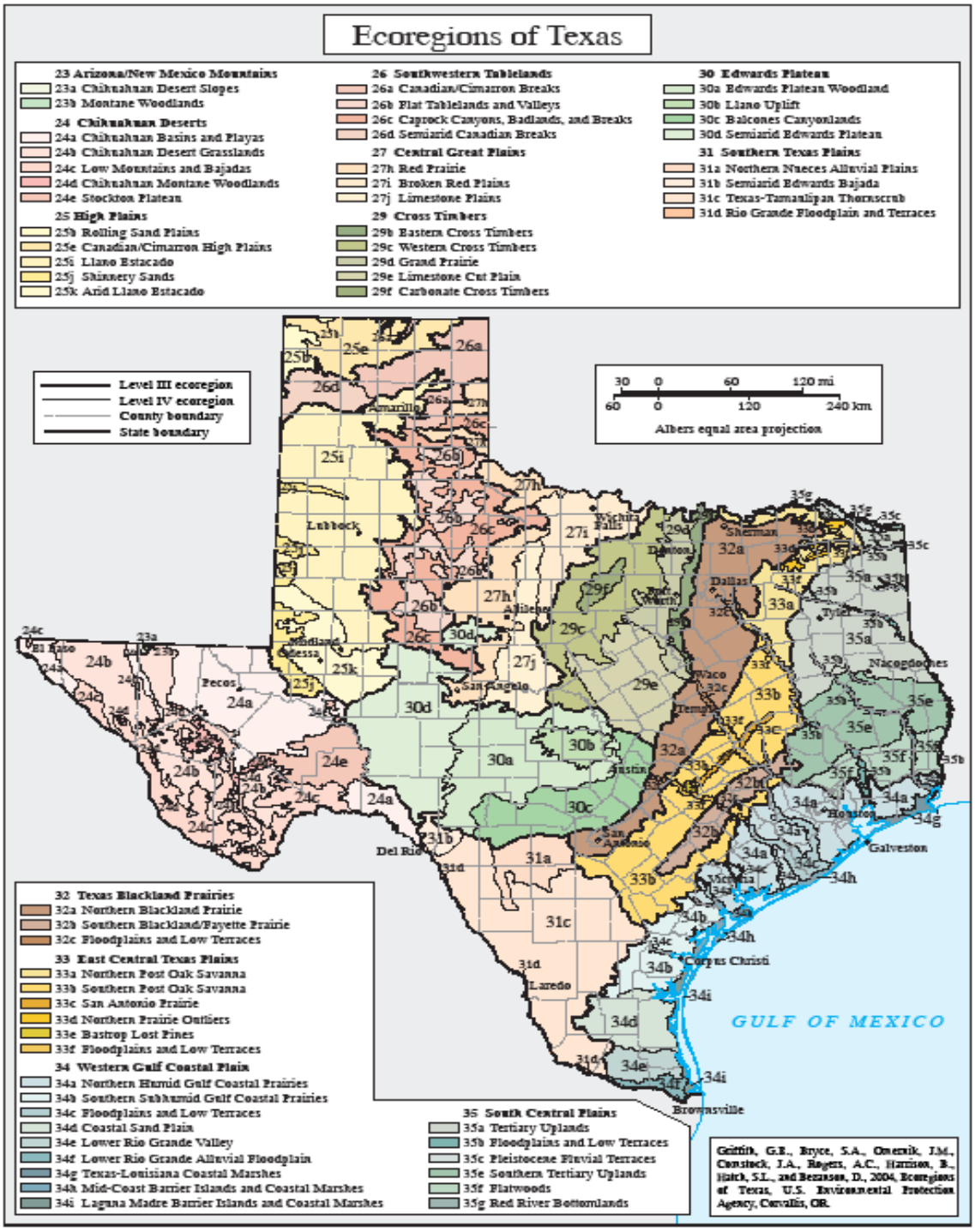

Fig. 5 Level III Ecoregion Map of Texas. (From Griffith *et al.*2004)