

From the Ground Up

A Gardening and Native Plants Quarterly

Colorado State University Extension-Pueblo County

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KNOW YOUR NATIVES

PLAINS ZINNIA, A MULTI-SEASON PLANT FOR DRY GARDENS

by Warren Nolan, Colorado Master Gardener, 2008

Zinnia grandiflora is one of the few Latin plant names that is easy to remember; the name is poetic sounding and it describes the plant which it names perfectly...a grand plant. Commonly known as Plains, Desert, or Prairie Zinnia or even Paper Flower; *Zinnia grandiflora* is found all over southeastern Colorado. Its only prerequisite is sun, sun, and more sun. With its spectacular yellow flowers it is the bright prairie sun made incarnate as a plant.

Zinnia grandiflora has few, if any, drawbacks as a garden or landscape plant. It grows in every type of soil--even hot, dry clay--it blooms from late May through September, it is an attractive pollinator, and it spreads quickly. In fact, it can be a rather aggressive plant and in some circumstances, it can be a fight to keep it contained. This could be because, if *Zinnia grandiflora* is given even a modicum of extra water, it tends to become an insistent colonizer.

However, no other plant, in my garden, draws as much interest. People constantly stop and ask me what the beautiful yellow flower is that grows along the garden border where it softens and cools the hard edge of the hot sidewalk.

Interestingly, these questions show the disconnect between what people perceive as useful garden plants and as native prairie plants. How so? *Zinnia grandiflora* grows in vacant lots all over my developing Southside neighborhood and yet, it appears, that most people never connect the plant growing wild in vacant lots with the plant growing in my garden.

In the landscape *Zinnia grandiflora* has many uses: it can be utilized to brighten borders, it can be grown as a ground cover for difficult areas such as slopes and clay or shale barrens, and it can be incorporated into shortgrass meadow or natural prairie habitats. It almost goes without saying that *Zinnia grandiflora* is extraordinarily durable. It is deer and rabbit resistant, and it is extremely drought tolerant,



Left: Close up of flower. Photo courtesy of P. Alexander, hosted by USDA-NRCS PLANTS database.
Below: *Zinnia grandiflora* lines the sidewalk in the author's garden. Photo courtesy of R. Vigna.



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requiring only 6 to 8 inches per year. Many books and web sites warn that it will not tolerate too much water.

In 2014, Plant Select (www.plantselect.org) introduced *Zinnia grandiflora* "Gold on Blue" as one of their select plants "designed to thrive in the high plains and intermountain region." *Zinnia grandiflora* is, with some looking, available in the nursery trade, but its seed is reported to have a very low germination rate. I rescued my first plants from the top of a dirt pile that was the result of building a foundation for a new home in my neighborhood.

Please refer to the following Colorado State University Extension facts sheets for additional information: Xeriscaping Perennial and Annual Flowers: www.ext.colostate.edu/pubs/garden/07231.html and Native Herbaceous Perennials for Colorado Landscapes: www.ext.colostate.edu/pubs/garden/07242.html. 

The Outdoor Classroom Garden at the McClelland School

by Orla O'Callaghan, Colorado Master Gardener, 2005, Native Plant Master, 2009

The Outdoor Classroom Garden is a new and exciting garden created by Orla O'Callaghan and Liz Catt for the use and education of the children at The McClelland School, located at 415 E. Abriendo Avenue in Pueblo. Liz Catt initiated the project, and hopes it will be the first of many school educational gardens in Pueblo. She dreams of every school having a small pollinator garden to create a corridor for bees and other pollinators.

The site of the garden was selected as an open space on the Lake Avenue side of the campus that was quickly becoming more weeds than grass in the drought. Plans were drawn up and ground was broken in 2014. Weeds and grass were cleared, soil mounded into berms. Four raised beds were created around a forty-foot diameter circular classroom space. A sprinkler system was installed. Sandstone, generously donated by a parent, was placed on the sides of the raised beds. Patrick Hyatt, the now former Headmaster, built and placed log benches in the classroom space. Spring bulbs (species tulips, dwarf irises, and daffodils) and native seed were planted last autumn. Habitat Hero garden plant bundle from High Country Gardens was purchased and planted last fall.

This spring four Hackberry trees were planted inside the classroom circle to shade the children in the future. A Pinon Pine and the shrubs and trees in the Woodland border were also planted this April. The spring rains caused most of the native seeds to germinate. It was fun to watch them grow. Each visit to the garden lead to the discovery of new seedlings. The moisture and the cooler temperatures have resulted in a fabulous first growing season.

The Outdoor Classroom Garden consists of four themed, raised beds: a plains/prairie bed, a pollinator bed, a foothills/montane bed, and a wildlife bed. The goal is to create a curriculum which incorporates the garden into age specific lesson plans for most subject matters taught at the school. For example, the children can learn about botany, ethno-botany, eco-relationships, entomology, plant propagation, conduct measurements, do plein air painting, learn about native versus alien species of plants and the importance of



Photos of the educational gardens at McClelland School and students in the outdoor classroom courtesy of O. O'Callaghan.



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Landscape Design With Native Plants

Saturday, October 17, 9 a.m.-3 p.m.

Southeastern Colorado Water Conservancy District, 31717 E. United Ave, Pueblo

Sponsored by the Colorado Native Plant Society.

Tuition \$35.00. Register for this workshop at <http://conps.org/>.

Landscape Design With Native Plants instructor Jim Tolstrup is the Executive Director of the High Plains Environmental Center (HPEC) in Loveland, CO. Jim works to promote the conservation, restoration and landscape use of native plants.

Contact SECWCD or CSU Extension for more information.

Educational Classroom continued from page 2

controlling noxious weeds. Already the outdoor garden classroom was used by the kids to learn about farming. A parent brought in a chicken, a goat and a horse from her farm. The kids got to learn about these animals while enjoying a warm spring day.

The Pollinator Bed was created to educate the children about the importance of pollinators, and how we both depend on and effect the fate of these pollinators. Bees have been visiting this bed since early spring. Recently, four hummingbirds were fighting over the nectar in this garden. The Plains/Prairie bed is so lush in its first growing season that the hum of pollinators can be heard from outside the garden. The Montane/Foothills bed is shaded by mature trees. The kids can learn about biomes by comparing and contrasting the plants in the Prairie and Montane beds. The Wildlife Bed is still filling in. Wildlife visitors so far include many types of birds and at least one deer which may be why this bed is sparser than the others. This bed has plants that will be good for demonstrating eco-relationships between plants and animals. In the Shrub/Woodlands Border, regionally native trees and shrubs surround the garden beds to create a woodland habitat for the birds and as privacy screening. Because funding was tight at the time of purchase, we could only afford small trees and shrubs, and so it will be years before they grow big enough for their planned purposes.

For a list of the plants in these beds, please visit the CSU Extension-Pueblo County horticulture website at <http://pueblo.colostate.edu/hor/hort.shtml>.

Although the Outdoor Classroom Garden at McClelland is only in its first growing season, it is worth seeing, so come by and have a look. Maybe you will be inspired to create a school garden at another school. 🌱



Plants seen in the Plains/Prairie bed.
Above: *Ratibida columnifera*, Mexican hat. Left: *Cleome serrulata* Rocky Mountain Beeplant Below: *Glaucium graniflorum* Orange Horned poppy. All photos courtesy of O. O'Callaghan.



Seed collectors often process more seed than they need for the following year. If you have extra seed, please consider sharing with other Pueblo citizens through the All Pueblo Grows Seed Library at Rawlings Library. A drop site for dry seed has been set up under the card catalog that holds the collection on the second floor at Rawlings, or you can take donations to CSU Extension at 701 Court Street, Suite C. Please fill out the donation slip when you bring in seed so that the Colorado Master Gardeners know how to label the seed for distribution. Learn more about the seed library at <http://allpueblogrows.org/>.



Teaming with Microbes and Other Animals -The Natural Way to a Healthy Garden Environment

by Marge Vorndam, Colorado Master Gardener, 1997, and Native Plant Master, 2007

We think of gardening from our perspective of the plants that we desire to establish in our soils. But, there is an entire world of life that governs whether the plant we choose will thrive. We generally don't consider that fact when we plant seeds or transplant a vegetable or decorative forb into our gardens.

There are many "helper" organisms that contribute to healthy plant growth. Beside water and soil type in our garden, microorganisms and other creatures make plant growth possible. Without their roles in soil formation and maintenance of the environment, we wouldn't be successful gardeners. Understanding their lives and perpetuating their existence is imperative to soil structure and plant health.

Some of the organisms and their roles are listed below. Not all organisms of each type are necessarily a friendly garden inhabitant, but they all have parts to play in the garden food web. For instance, some fungi and bacteria parasitize plants and other soil critters, rather than helping plants grow...and prairie dogs, chipmunks and mice are not recommended as garden denizens (though they have much to do with prairie soil health)! But others of these organisms are crucial to soil fertility. Without their presence, plants could not grow.

The information below is taken from two excellent sources, recommended reading for the serious gardener:

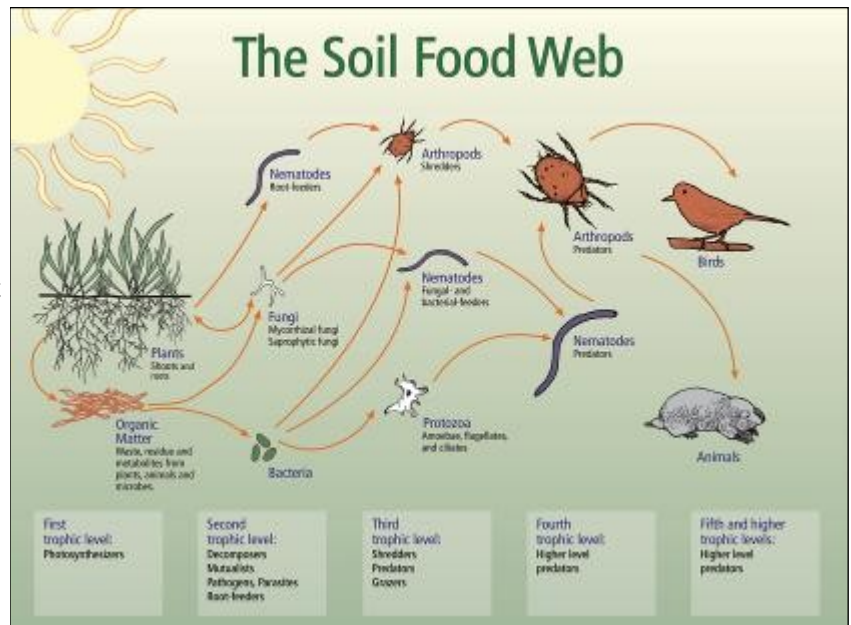
- Lowenfels, J. and W. Lewis. 2010. *Teaming with Microbes: The Organic Gardener's Guide to the Soil Food Web*, Revised Ed. Timber Press, Inc., Portland, OR
- Nardi, J. 2007. *Life in the Soil: A Guide for Naturalists and Gardeners*. The University of Chicago Press, Chicago, IL

Bacteria transform carbon, sulfur and nitrogen from air into usable components for plant use. They decompose complex organic soil constituents into simpler chemical minerals like potassium and phosphorus that can be taken up by plant roots, and create protective biofilms around roots that allow the plant to more efficiently absorb nutrient chemicals from the soil.

Fungi (an example of one type of fungi is a mushroom) break down rocks and sand particles to form minerals (soil fertilizers) and make these minerals available for plant uptake. Phosphorus scavenging by long fungi hyphae (hypha are the fungus equivalent to a plant root) brings this element from deep in the soil to the surface where plant roots can access it. This is one example of the myriad of beneficial uses that fungi have.

Protozoa are one-celled organisms that eat some bacteria and fungi, or form partnerships with other bacteria or fungi that aid in plant growth. They also function as decomposers by breaking down complex soil nutrients found in the bacteria that they eat into mineral forms that plants can take up.

Nematodes come in helpful and detrimental types. While we likely see them as small roundworms that harm roots, some also benefit plant growth—again via their predation on bacteria/fungi and in their role in breaking down more complex organic molecules into simple minerals. Nematodes also advantage bacterial colonization of new soil environments. As they move through soils, they carry bacteria to new soil areas on their skin.



Drawing courtesy of Natural Resource Conservation Service, <http://www.nrcs.usda>.



While not considered microorganisms, many animals also have supporting duties in a soil setting. They are part of the “soil food web.”

Earthworms form casts as they pass through soil. These casts are rich in calcium, nitrogen, potassium and phosphorous, all necessary for healthy plant growth. Their burrows help to aerate the soil, bringing oxygen to plant roots and the microorganisms that live there.

Arthropods such as spiders, pill bugs, centipedes, mites, scorpions and insects can function in beneficial ways. We are familiar with the pollinators, but many others of these organisms function in the garden soil food web. Most beneficial arthropods are “shredders”, breaking up larger organic particles to smaller particles that bacteria, fungi, etc., can further act on to make available for plant uptake. Others prey on garden pests, rendering their prey into small bits of organic material that eventually feed plants. Still others aid in soil aeration through burrowing activities.

Gastropods are represented by slugs and snails. While we don’t see their actions on our desirable plants as helpful at times, they, too, function as “shredders”, making decaying materials more available for processing into basic chemical nutrients by bacteria and fungi. They also spend around 80% of their lives underground, and help to aerate the soil in their travels via burrowing.

Reptiles, mammals and birds broadly keep garden critters under control. Some, such as mice, prairie dogs and chipmunks, turn the soil, bringing basic soil nutrient fertilizers to the surface through their digging actions, and help to redistribute the smaller organisms. Dung from these animals adds to the organic matter on which bacteria, etc., feed. The presence of birds, for instance, indicates that the garden environment is healthily stocked with earthworms and similar garden denizens.

What lessons can we take from all of this information? Being a good gardener also means that we must be good stewards of the microbe community that maintains the fertility of our gardens. While natural conditions do help to maintain the food web above, we can certainly support and enhance it through our own actions. “To increase microbial activity in a soil, one must make the environment optimal, or at least more favorable, in terms of aeration, moisture, and pH, and above all provide the organic substrates needed to fuel the population. The abundance of microbes in soil is directly proportional to the organic matter content.” says David Zuberer of Texas A&M in *Soil Microbiology Facts*, <http://organiclifestyles.tamu.edu/soil/microbeindex.html>. So, add those compost teas, composts, mulches and other organics, and the garden food web will make your gardening life much easier and more successful.

Our authors also recommend that gardeners give up the habit of rototilling or spading, and go with a “no till” approach to gardening. “Rototilling and excessive soil disturbance destroy or severely damage the soil food web...(among other drawbacks) by chopping up the miles of fungal hyphae that exist... Use a trowel, dowel or dibble to make discrete holes for plants and seeds.” This also prevents weed seeds in the soil that require light for germination from growing, and dramatically reduces erosion of that valuable topsoil.

Instead of depending on the addition of fertilizers and other harsh chemicals, consider using nature’s microbial helpers, creatively teamed up with other helpful animals and your addition of organics, as a way to be a more successful gardener. 🌱



Youth Opportunity: Have you thought about 4-H for your kids?

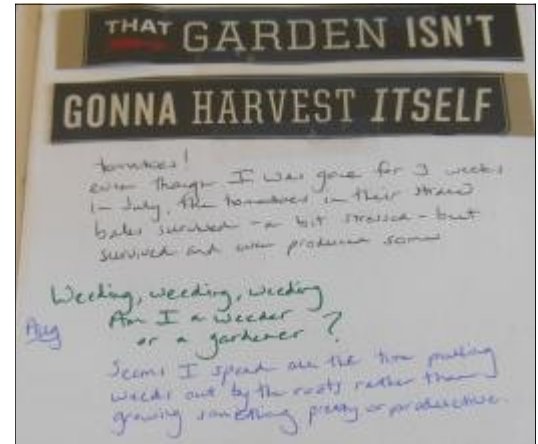
4-H offers over 50 projects ranging from cake decorating to woodworking, with dog, horse and livestock in between. Enrollment for the 2015-2106 year starts on October 15, 2015. For information about the Pueblo County 4-H program, call 719-583-6566 or write to Marnie Leinberger, 4-H Program Assistant at Leinberger@co.pueblo.co.us for an information packet. To learn about the statewide program, visit <http://www.colorado4h.org/>.



**ARE YOU A PHENOLOGIST?** by Maureen Van Ness, Colorado Master Gardener, 2015

Phenology is the study of plant and animal life cycles and events that recur periodically, such as migration or blossoming, and how they are influenced by climate and seasonal changes. Do you keep a garden journal? Did you know writing in your garden journal has a fancy name - phenology? Phenology goes beyond the basics of temperature highs and lows, weather, precipitation, or planting dates. Record leaf emergence, birds, insects visits, moon cycles, animal activity, blooms, fall color. Whenever you ask, "When did those beetles eat all my primroses last year?", you have a topic or event to watch for and write down this year. Phenology is about establishing a pattern, creating a yearly system by observation.

I like to balance the factual observations with an artistic note: cut garden photos you love out of magazines and tape them in your journal, collect quotes (a recent addition to mine is cut from a tough-girl clothing catalog, "That garden isn't gonna plant itself." I sketch out garden dreams in grid plans or drawings, or use a variety of ink colors. And honestly, I don't write in my journal every day. It's a goal, but not reality. I love to know, though, that when I do record events in my garden, I am a phenologist in-action.



In her book, *Founding Gardeners*, Andrea Wulf tells how George Washington, Thomas Jefferson, John Adams and James Madison each kept exact records of weather, plant varieties, plants that did well or did not, trees, design sketches, and notes on gardens they visited. They compared information and notes in order to learn, in order to improve their gardens and abilities as they worked to establish an independent country and independence through their gardens. Their observations reflected their understanding of the value of learning botany, meteorology, agriculture, and their love for observing and understanding nature.

While exploring information that my son needed for a school project, I found this at spaceplace.nasa.gov/science/en.

"Science is...

Observing the world.

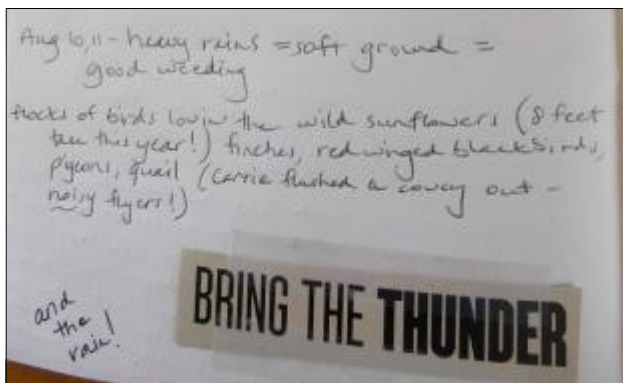
Watching and listening.

Observing and recording.

Science is curiosity in thoughtful action about the world and how it behaves."

The key word is observation. Watch. Listen. Record. Every day there is something to observe, to notice, as we watch our own yards and gardens. Become a phenologist.

If you are not into keeping lots of written notes, how about using a freebie calendar, like the one a



Journal entries courtesy of the author.


company gives out, and jot down one thing in each day's square. But you might discover how much fun this is and get carried away. Pay attention. Can you name the birds that visit your garden? Can you list unusual occurrences? Unique events? My one thing for today: "Weeding, again. Am I a weeder or a gardener? It seems like I spend all of my time pulling weeds out by the roots rather than growing something pretty or productive." Another day: "I love the color contrast of the deep gray clouds and the bright greens of rain washed plants. Those delightful rains that make the weeds grow."

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One advantage to writing it down is not having to keep all that information in our heads. Memory fades, and not just because we are getting older. We can go back and look up last year's event, or two years ago, or three years ago. Each of us has unique variations in our own garden - no reference book can be as precise as your own information from your own garden. When we jot down notes, it allows those brief moments and events that pass by blurred and quickly forgotten to become clear and vivid. The more familiar we are, the better we understand what our garden needs.

A garden journal is a series of phenological observations, a means to record what is going on in your garden. We make a vital connection that enables us to be a better gardener. So, now I don't just keep a garden journal. I am a phenologist, a scientific observer, one who watches, listens, and records the world in my garden and how it behaves. Sounds more intelligent anyway.

A phenology website, www.usanpn.org, encourages followers to keep a nature notebook of observations in their own yards and neighborhood. 

Upcoming Family and Consumer Classes



Fermenting -Wednesday, Sept. 23, 1:00-3:00 p.m. **OR** Wednesday, Sept. 23, 6:00-8:00 p.m., \$5.00 Fee.

Get Stronger, Live Longer– Progressive Weight Training for Beginners- For current times, locations, and registration information, contact CSU Extension at 719-583-6566. \$15.00 fee.

Rock Around the “Crock”-Tuesday, Dec. 1, 6:00-8:00 p.m. **OR** Wednesday, Dec. 2, 1:30-3:30 p.m., Fee \$10.00.

Gifts in a Jar-Monday, Dec. 7, 6:00-8:30 p.m., Fee \$10.00.

High Altitude Baking-Tuesday, Dec. 15, 1:30-3:30 p.m. **OR** 5:30-7:30 p.m., Fee \$10.00.

Smart Choice Health Insurance©-Wednesday, Oct. 14, 9:00-11:30 a.m.; **OR** Wednesday, Oct. 14, 5:30-8:00 p.m.; **OR** Thursday, Oct. 29, 5:30-8:30 p.m., Fee \$10.00. This CSU Extension-Pueblo County workshop will help you tackle the task of selecting health insurance coverage by explaining the process in plain language, outlining the differences in plans and highlighting the factors that may influence your decisions.

World Cultures through Food—Classes are all in the evening – starting at 5:30 p.m. and going until we finish eating! Fee \$20.00 per person.

September 18th **or** September 21st – Russian; October 16th **or** October 21st—U.S. Southern Cuisine
November 17th **or** November 20th—Swedish; December 11th **or** December 18th—Pennsylvania Dutch

To register, mail or bring payment to CSU Extension-Pueblo County, 701 Court St., Suite C, Pueblo, CO 81003. Please make checks payable to **Extension Program Fund**. Sorry no credit cards accepted.

Garden Tip: Don't move firewood!

The Colorado Department of Agriculture and the Colorado State Forest Service have issued warnings about moving firewood from Boulder. While the warning focuses on the Emerald Ash Borer, the movement of other types of wood can transmit insects and diseases.

From the recent bulletin: All ash wood, logs, debris and firewood is under quarantine within Boulder County and the City of Erie. If a tree infested with a pest dies, the tree is cut down and the logs often become 'firewood'. As firewood moves, so does the pest it contains. This is the single most common method of movement of invasive tree pests over long distances.

Ash nursery stock and firewood are not allowed to leave Boulder County and Erie (the quarantine area) unless under a special permit. Illegal movement of ash (live or dead) will result in penalties of up to \$1000 per violation.

For more information on EAB identification, reporting, management and planning, visit www.eab.colorado.com or call 888-248-5535.





INTERESTING INSECTS

PINE WILT DISEASE by Linda McMulkin, CSU Extension-Pueblo County

There is another threat to plant health in Colorado, and while the pest is not an insect or confirmed in Pueblo yet, I'm going to stretch the Interesting Insects idea to cover an animal that is impacting trees in the state. The animal of concern is a native round worm called pinewood nematode.

In Pueblo, we are used to hearing about insect pests that attack our native trees. Bark beetles and foliage defoliators have received a lot of coverage in the press and during tree care classes. But up to now, we have only mentioned the possibility of nematodes and Pine Wilt Disease as a threat to landscape trees. This summer, non-native Scots and Austrian pines in parts of Denver have died suddenly and the confirmed cause is Pine Wilt Disease.

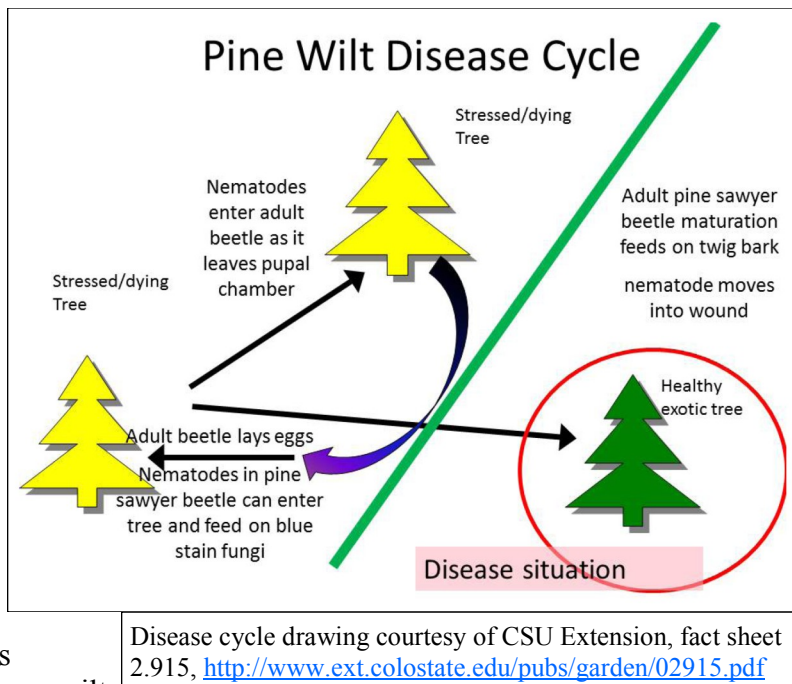
Native pines, spruce and fir have evolved with the pinewood nematode, which feeds on bluestain fungus within the tree. The trees are resistant to damage from the nematodes and the infestation does not kill the native trees. But native conifers have been heavily infested by wood boring insects in recent years and the adults that emerge from infested trees can carry nematodes to non-native pines such as Scots, Austrian, and Mugo.

When introduced to non-native pines, the behavior of the nematode changes and it infests the vascular tissues, inhibiting the movement of water to the needles. While infection and colonization begins early in the growing season, observable symptoms generally appear as the weather warms. Needles turn gray-green, then brown. In the case of Scots pine, the entire tree is affected and death occurs rapidly. In Austrian pines, wilt may become visible a few branches at a time and death is prolonged.

Death in local landscape pines can be caused by drought, temperature fluctuations such as we had in November last year, insect infestations, girdling roots, damage to the bark and roots, or a combination of stresses. But if you lose a Scots or Austrian pine suddenly, please consider sending a sample to one of the diagnostic labs in Colorado for analysis for pinewood nematodes. Samples of cut wood, one from the trunk and one from a branch, cut near the trunk) is recommended. The trunk sample should be a pie-shaped wedge about one-inch thick. The 2-3-inch diameter section of branch, 6-inches long, is recommended for this evaluation. Samples should be sent to the CSU Extension lab in Jefferson County or on the CSU campus in Fort Collins. You can find instructions and addresses in fact sheet 7.246 at <http://www.ext.colostate.edu/pubs/garden/07246.html>.

One of the most important tools in controlling the spread of pinewood nematodes and pine wilt disease is to remove all above ground parts of a dead tree and destroy the wood by chipping, burning or burying. This must be done early in the year before adult borers emerge.

For additional information about pinewood nematodes and pine wilt disease, see CSU Extension fact sheet 2.915. For paper copies of CSU Extension fact sheets, call or visit your local Extension office.



Subscribe to this quarterly horticulture newsletter by contacting Carolyn at 583-6574.
Available in paper and electronic formats.





WICKED WEEDS

YELLOW FLAG IRIS (*Iris pseudacorus* L.)

by Mary Knorr, Colorado Master Gardener, 2009, and Colorado Native Plant Master, 2009

When I was at the Denver Botanic Gardens, I noticed an informational sign alerting the public to the invasive perennial, Yellow Flag Iris (*Iris pseudacorus* L.). The sign sparked my curiosity, because it's the only iris that's considered invasive.


Some of the common names of *Iris pseudacorus* are Paleyellow Iris, Water Flag, and Yellow Water Iris. The plant is characterized by yellow flowers with three sepals that curve backward and three petals that point upward. There are brownish-purple stripes on the petals. Unlike other iris, Yellow Flag Iris doesn't have hair on the sepals. The sword-like leaves fold and clasp the stem at the base, in a fan-like configuration. They can grow three and four-feet tall.

When I was researching *Iris pseudacorus*, one website said it was native to North America (not so). The plant was widely introduced into the United States and Canada during the mid-1800s as an ornamental garden/pond plant from its native homeland of Western Europe, Western Asia and North Africa. Its native habitats include river low-lands, pond borders, marshes, swamps and ditches. Planting this species was encouraged as it stabilized stream and pond banks.

In many states, Yellow Flag Iris has escaped into riparian habitats, displacing native plants and wildlife. Currently, it can be found in every US state **except** Colorado, North Dakota, Arizona, and Hawaii. It is dispersed by rhizomes (during flooding) and the seeds, which have an airspace that allows them to float, can be distributed in water or on the wind. The rhizomes and seeds will sprout, even after being burned!

Yellow Flag Iris is also known for its ability to collect heavy metals from sewage effluence. The plant is toxic to grazing animals and humans due to a resin in its leaves and stalks that is very irritating.

Unfortunately, it's still sold in American garden centers and on the internet. Colorado Gardeners have an additional Wicked Weed to watch out for, Yellow Flag Iris!

The Montana State University Extension published a "Biology, Ecology and Management of Yellowflag Iris" brochure, number EB0203, May 2011. It's online at <http://store.msuextension.org/publications/AgandNaturalResources/EB0203.pdf> 



Photos courtesy of J.S. Peterson and Jeff McMullian, USDA-NRCS PLANTS Database, <http://plants.usda.gov/java/>

Garden Tip: Overwintering Mint

Mint is often grown in containers to control its aggressive nature. If you have a favorite mint, you can overwinter the pot and have a jump start on growth next spring. After the plants go dormant, cut back to soil level. You can bring the pots into the garage or other sheltered location, protect the roots outdoors by piling mulch or straw around the pots, or heal the pots into your garden soil. Don't forget to water the pots periodically to keep the roots hydrated.



The Nitrogen Cycle and How Micro-organisms Make it Possible

by Ed Roland, Native Plant Master, 2011

Nitrogen (N on the periodic table of elements) is essential to life on earth. It's key to the structure of our DNA and the proteins that make up our bodies and brains.

The same goes for plants and crops. Nitrogen is the limiting reactant in photosynthesis . . . so, generally speaking, the more nitrogen there is in the system, the more food that can be grown on the same plot of soil (with other inputs, like water and sun, being equal).

Yet, even though nitrogen is the fourth most common element on the planet and makes up 78% of our atmosphere, and about the same percentage of the air we breath -- it is, in a way, in short supply.

This is because, like oxygen and some other gases, nitrogen travels through space in pairs of atoms, indicated as N_2 . Atoms can have single, double or triple bonds between them, and the more bonds the more difficult they are to separate. Atmospheric oxygen, which also travels in pairs as O_2 , has only two bonds, so it can easily (at least compared to nitrogen) separate to react with other chemicals (think rust and fire). With three bonds, N_2 is held together so strongly it is essentially inert. So, what we breath in, we also breath out with no effect on our physiology.

However, when it comes to the plant world, things are different. Nitrogen from the atmosphere is indirectly available to plants by the processes of "nitrogen fixing": the splitting apart of N_2 into single atoms of N that can react to become ingredients in many, many essential biological processes.

Step One in the Nitrogen Cycle, **Nitrogen Fixing**, can happen two ways:

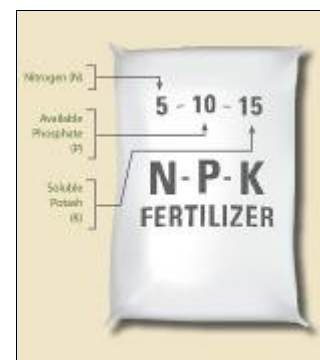
1. By meeting their own metabolic needs, some soil bacteria convert atmospheric N_2 to ammonium (NH_4^+) and ammonia (NH_3). One important group of nitrogen fixing bacteria, called rhizobia, live in nodules on the roots of legumes and on the roots of some woody plants, such as alders. Some cyanobacteria in aquatic systems can also fix nitrogen. Some of these nitrogen-fixing species form symbiotic relationships with the plants they "service," in effect trading free nitrogen for nutrients supplied by their hosts.

These processes are so pervasive that bacteria are -- far and above any other source -- the primary facilitators for making nitrogen available to the rest of the biosphere, including us.

2. The triple bond in atmospheric N_2 can also be separated in an environment of intense heat and pressure. In nature, lightning has the power to "blow apart" N_2 , producing nitric oxide (NO). Other combustion reactions that produce NO take place in car engines and fossil fuel power plants.

Even more significant is the production of commercial synthetic (vs. organic) fertilizers, which fixes nitrogen in a high pressure, high temperature industrial operation called the "Haber Process." In brief, this process takes nitrogen from the air and combines it with hydrogen from natural gas to produce ammonia (NH_3). The Haber Process, developed in Germany before WWI, has given farmers the ability to directly "inject" pressurized anhydrous ammonia into otherwise N-depleted soils to dramatically increase the world food supply.

This ammonia is also processed to create salts of nitrogen compounds -- eg., urea ($CO(NH_2)_2$)*, ammonium nitrate (NH_4NO_3), and ammonium sulfate ($(NH_4)_2SO_4$) -- that homeowners spread on their lawns and vegetable gardens. This is done for convenience (hard pellets are easy to apply), but also because these various forms of N compounds have different rates of release and conversion by soil microbes, and also vary in how they affect soil pH with long term use.



The 3 numbers on the front of a fertilizer bag indicate the percentage of nitrogen, phosphate, and potash in the bag. The back of the bag will detail the nitrogen compounds. For more information on fertilizers and calculating application rates, see Colorado Master Gardener GardenNotes #232: Understanding Fertilizers and #233: Calculating Fertilizer Rates at <http://www.cmg.colostate.edu/gardennotes.shtml#soils>.

* Note that urea rapidly hydrolyzes to ammonia, which is a volatile gas. To avoid loss of nitrogen, this fertilizer must be immediately "watered in" after application.

Continued on page 11



It's estimated that the Haber Process, i.e., industrialized conversion of N_2 to ammonia and other fertilizers, is now responsible for 13% of total nitrogen fixation on earth.¹ In essence, this represents a huge distortion of the natural Nitrogen Cycle over just a few decades. In contrast, organic fertilizers are simply naturally occurring plant materials which have been composted and/or digested by herbivores to produce manures, etc. They make their natural N compounds available to be slowly "recycled" by soil microbes. This slow release of N and other nutrients is primarily what distinguishes organic fertilizers from synthetics -- once applied, the chemical and biological processes are the same.

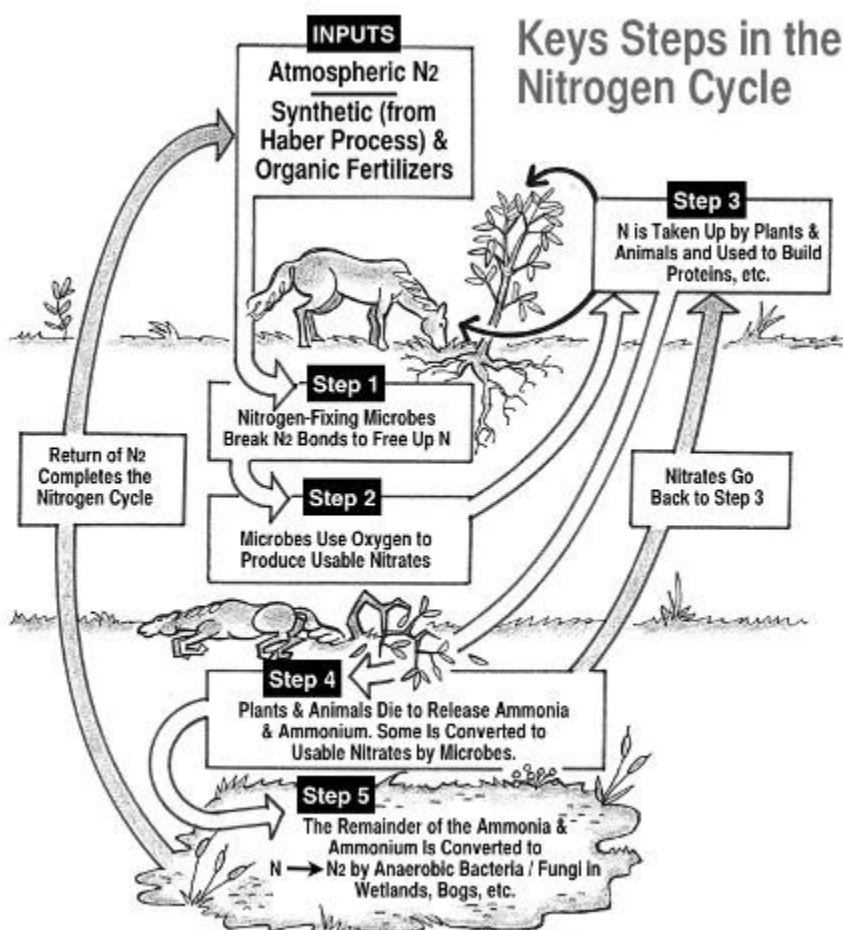
Step Two is **Nitrification**: Soil bacteria combine ammonia (NH_3) and ammonium (NH_4^+) with oxygen to form a nitrate (NO_3^-), the most usable form of nitrogen for most plants. As you can see from its chemical symbol, nitrate is a negatively-charged molecule (or ion), and since most soils also have a slight negative charge, nitrates are slightly repelled by soil particles and can leach or migrate from soils if not quickly utilized by plants. This is why over-application of fertilizers -- by agriculture, golf courses and homeowners -- leads directly to eutrophic pollution of our watersheds.

Also, note that oxygen is necessary for the formation of a nitrate. This explains why soils that are depleted of oxygen by over-watering can literally starve a plant to death by shutting down its primary source of nitrogen. (While it's true plants make their own food from light energy, N is essential to that process.)

Step Three in the Nitrogen Cycle is **Assimilation**: Nitrogen is made available by the micro-biome in the soil and "taken up" by plants through their roots to be incorporated into their biological processes and tissues (mostly proteins). This N is then passed on to us and other animals when we eat these plants, or eat food animals that have fed on plants, and then assimilated into our own proteins, nucleic acids, etc.

In **Step Four**, **Decomposition**, plants and animals inevitably die and decay to release their N back into the soil as ammonia and ammonium. Some biologists put organic fertilization, such as with composts and manures, in this step because they feed plants through decomposition vs. a direct application of raw chemicals. Again, as in Step Two, microbes and some fungi use oxygen to convert these molecules to the nitrate that plants can use. Also, nitrates gain a negative charge as before and are subject to leaching and polluting.

Finally, **Step Five** is **Denitrification**: This process returns free N to the atmosphere where it once again bonds to create N_2 gas and completes the Nitrogen Cycle. This is also a bacterial-driven process, but takes place in oxygen poor (anaerobic) water-logged soils, saturated sediments, bogs and wetlands. Wetlands are particularly critical to this process since it's estimated that over half of all denitrification takes place in these ecosystems.



¹ Silberberg, Martin S. (2009) *Chemistry, The Molecular Nature of Matter and Change*, 5th ed., McGraw-Hill, pp. 771 and ff.



If some oxygen should be present during denitrification, an intermediate gas, nitrous oxide (N₂O) is formed. Nitrous oxide is considered to be a strong pollutant that, like CO₂, absorbs infrared energy to contribute to global warming, as well as contributing to the destruction of the ozone layer.

Some biologists believe the amount of nitrogen gas, N₂, created through denitrification approximately equals the amount that is biologically fixed. Others describe a more complex cycle with other chemical reactions supplying some of the atmospheric N₂.

Recent research could significantly impact our view of the Nitrogen Cycle: Experiments have shown that nitrogen fixing by microbes may not be limited to soil-borne species, but can take place on leaves as well.² Obviously, if N₂ in the atmosphere can be converted directly to usable, absorbable N on plant leaves (perhaps with the help of a bacterial spray), another "Green Revolution" could be in the offing.

As with all elements on earth, nitrogen atoms are neither destroyed or created. Scientists estimate that a single atom of N takes about 625 years to "make the circuit" in the Nitrogen Cycle.

It should be noted that the majority of nitrogen on earth (over 97%) is locked up in our geological formations and is generally unavailable for a Nitrogen Cycle that lasts a few hundred years. If rock-bound N were to be included, the Nitrogen Cycle would have to be expanded to many millennia.

The building and structure of DNA, the production of proteins from amino acids, the formation of the amino acids themselves, and photosynthesis are just some of the biological processes that could not happen without a viable and productive Nitrogen Cycle, and the microbial world that makes it possible.

² Pennisi, Elizabeth. (May 22) "Leaf Bacterial Fertilize Trees Scientists Claim," Science Magazine, Vol. 348. (Issue 6237), p. 844.



CAPE-FORGET-ME-NOT
SUMMER-FORGET-ME-NOT
Anchusa capensis

HEIGHT: 8-15"
WIDTH: 4-8"
BLOOMS: May to October
SUN: Full sun to partial shade
WATER: Moderate
HARDINESS: USDA zones 5-10 (up to 5,000')
CULTURE: Average soil
INTRODUCED: 2012
PERENNIAL

Trim evergreen rosettes produce a bounty of dazzling cobalt-blue flowers with fetching white eyes throughout the garden season. This will naturalize with moderate self-sowing in many border situations, filling blank corners of the border with luminous twilight blue. Also grows in amended sandy or clay soils.



www.plantselect.org

Colorado State University
DENVER BOTANIC GARDENS

Garden Tip: Blue Flowering Plant for Naturalizing

Have you always wanted a true blue flower in the garden? Are you willing to allow this self-seeding plant to naturalize? Then Plant Select® has introduced the plant for you.

This South African native has been in cultivation for years, but has not been common in US gardens. It makes a good addition to a perennial bed, blooming from April to frost if deadheaded periodically. Each plant can be short lived, so allow some flower stems to develop seed.

In southeastern Colorado, this plant will prefer part shade. If in full sun, provide regular irrigation.

If you need any special accommodation(s) to participate in any Colorado State University Extension event, please contact CSU Extension-Pueblo County at 719-583-6566. Your request must be submitted at least five (5) business days in advance of the event. Colorado State University, U.S. Department of Agriculture and Pueblo County cooperating. Extension programs are available to all without discrimination.



A Year of Tree Issues by Linda McMulkin, CSU Extension-Pueblo County

Last November, an extreme drop in temperature from balmy to sub-zero damaged many woody plants in our area. Since the polar vortex event, I've fielded nearly 1,000 calls from homeowners asking for advice on how to save their trees and shrubs. With the help of CSU Extension colleagues, local green industry, and the Pest-Serve network, I've learned a great deal about how plants responded to the freeze and why plants failed, survived, or seemed fine and then failed.

Fall freeze events can damage woody plants in several ways. The nice fall we all enjoyed kept woody plants from entering dormancy, setting them up for damage if an extreme freeze event happened. And it did. Immediately after the freeze, a series of questions began circulating among tree lovers, including how hardened were the leaf and flower buds, what would be the impact on the still hydrated vascular tissues, and how badly would the cambium be damaged. We decided to wait and see what problems spring would reveal.

A simple botany lesson is in order here. The stem of a woody plant is made up of layers, each with a specific function. From the outside in, the tissues are bark (protection), cork cambium (makes new bark), phloem (moves photosynthates throughout the plant, including to the roots), cambium (makes new phloem and xylem) and xylem (moves water and nutrients from the roots). If any of those tissues are damaged, plant health is compromised, as is long term survival. The list of tree questions this year seemed to change month to month. Early in the spring, lack of leaves were the biggest issue. I started by recommending a wait and see attitude with trees and a "cut them back to the ground" attitude toward shrubs that didn't leaf out. But June, I said "cut it down" to nearly everything.

Disease issues ranged from fireblight and gummosis in early spring, to bacterial wetwood and *Cytospora* by mid spring, and a return of Thousand Canker questions by late spring. This summer, I have gotten several calls about *Marssonina* and *Septoria* leaf spot on cottonwoods and aspen, and black spot on roses. Higher than normal humidity has certainly contributed to the spread and continued development of these fungal and bacterial pathogens. I learned this year that liquids oozing from branches and the trunk of trees is heavy when soil moisture is high, with the large uptake of water supplying needed moisture for pathogen development or, in peaches, just a release of unneeded water (count me surprised).

By late June, I began to hear about leaf drop, fruit failure, and general crashing of deciduous trees. According to tree experts, this failure to thrive is most likely the result of damage to the cambium, which adds phloem and xylem each year. As temperatures rose this summer, the lack of new xylem to move water to the leaves resulted in leaves that dehydrated and fell off.

In July, yet another result of freeze damage appeared. Ornamental pears around town started dropping bark and, again, the experts diagnosed cambium damage, this time to the cork cambium (with some implication of the ray cells), which makes new bark (and holds everything together). Yikes.

So, what can you expect next spring? It depends on viability of the tissue layers, the overall health of the tree, whether the phloem is depositing enough photosynthates into the roots to fuel next spring's growth, and any insect and disease issues that take advantage of weakened trees. As much as I wish I could predict future plant health, I'm afraid that I once again have to say, let's wait and see what next year brings.

For more details on plant structures, visit the Colorado Master Gardener GardenNotes site at <http://www.cmg.colostate.edu/gardennotes.shtml#botany>. You will find easy to follow publications on roots, stems, leaves, and all plant parts. 📖



Above: Cottonwood leaves infected with leaf spot resulting in early leaf drop. Photo courtesy of M. Schaeffer.
Below: Pear trees along Union Avenue lost their bark this summer. Photo courtesy of M. Taft, Pueblo Parks Dept.





PARADISE FOUND -- MOUNT RAINIER NATIONAL PARK

by Vic Boley, Colorado Master Gardener, 2012

"Our path was literally strewn with beautiful flowers. This entire region is a paradise for the botanist."

– Major E.S. Ingraham, early climber, 1888

Rising 14,410 feet above sea level, Mount Rainier stands tall and poignant as part of Mount Rainier National Park and Washington State's lush landscape. An active volcano, Mt. Rainier is the most glaciated peak in the contiguous U.S.A., producing six major rivers. As such, the surrounding areas are rich in dark soil, which supplements the wildflower meadows that surround the ring of the volcano as well as the forests that populate the lower slopes.

While visiting Washington on a family road trip this summer, I had the opportunity of seeing Mt. Rainier for myself. This area is breathtaking, and I felt for a moment that I had been transported to some faraway, mountainous fairytale-land. Upon arrival, there are maps with many listed paths, from leisurely walks to adventurous hikes. My family and I chose a path falling somewhere in between the two, which permitted us to see an abundance of wildlife – specifically deer and marmots – as well as a wonderland of wildflowers and trees.

A few days before, while at a local produce and flower shop in Yelm, WA., a cashier at the store told us she recently went hiking in the national park and that the wildflowers were like nothing she had ever seen. We "awww-ed" at her, smiled, and went on our way -- but the moment of seeing these wildflowers in person was almost overwhelming; they carpeted entire areas of the mountain in vibrant splashes of color interlaced with healthy, lush green mountain grasses and trees!

The path we walked was well marked and not crowded -- a pleasant surprise for the high tourist month of June. My wife, daughters, and I enjoyed stopping frequently to read the various markers indicating specific details on the wildflowers and plant-life at each step. The higher we hiked, the thinner the stand of trees became, and we were regularly greeted with small trickling flows of water melting from the glaciated volcano. The forest also became thinner, and the wildflower meadows all the more abundant.

Overall, this area was absolutely wonderful! My family and I enjoyed it and I recommend it to anyone looking for a bit of horticulture adventure.

For more information about Mount Rainier and other national parks, visit

<http://www.nps.gov/index.htm>.

Note from Linda McMulkin, Editor of *From the Ground Up*

This newsletter is my last official task before retirement from CSU Extension-Pueblo County. This publication has come a long way from when we started it in 2008. I want to say thank you to all the authors, photographers, and graphic designers who have contributed to making this publication such a success. And, thanks to all of you who read the newsletter.

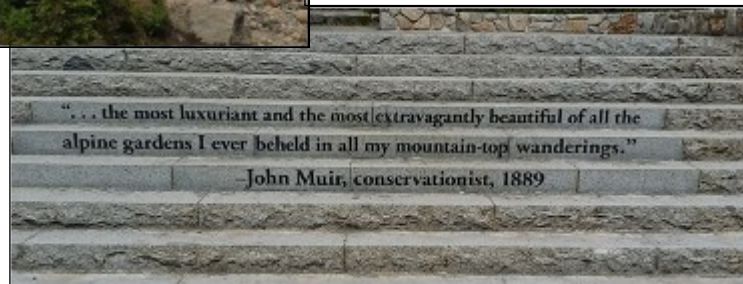
While I will no longer be overseeing *From the Ground Up*, the newsletter will continue under the guidance of a group of Colorado Master Gardeners and CSU Extension staff members MJ Fisher and Carolyn Valdez. Look for the next issue in December, 2015.



A high country meadow and a glacier-fed stream at Mount Rainier National Park, established by President William McKinley in 1899.

Below: a quote from naturalist John Muir, inscribed in the stairway that leads to many hiking trails.

Photos courtesy of V. Boley.



"... the most luxuriant and the most extravagantly beautiful of all the alpine gardens I ever beheld in all my mountain-top wanderings."

—John Muir, conservationist, 1889

