Biologically Effective Management of Residential Landscapes

Llewellyn L. Manske PhD
Research Professor of Range Science
North Dakota State University
Dickinson Research Extension Center
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The health of soil on residential landscapes can be improved by increasing the biomass and activity of soil microorganisms through application of biologically effective prairie grazingland principles. Growth and development of soil microorganisms is limited by access to short carbon chain energy from living plants. Grass plants in prairie ecosystems exudate large quantities of short carbon chain energy into the soil as a result of biologically effective grazing management coordinated with grass plant phenological growth stages. These same biogeochemical processes can be activated in residential landscapes without partial defoliation of grasses from a herd of cattle. Improvement of urban soil health is a great complement to nontraditional landscaping programs.

Nontraditional Landscaping Programs

Homeowners living in the arid, semi-arid, and subhumid western states have slowly been adopting nontraditional landscaping concepts which apply natural resource conservation and common sense to residential landscapes that reduce irrigation water use, lower nonrenewable energy use, diminish fertilizer, herbicide, and pesticide material, decrease noise, air, and water pollution, and minimize plant maintenance labor. These conservational landscaping methods have been identified by numerous titles: Xeriscaping, Naturescaping, Sustainable Landscaping, Greenscaping, Ecoscaping, and various other names, were developed and/or promoted by: Denver Water, Missouri Botanical Garden, US Environmental Protection Agency, Landscape For Life, Wildflowers Across America, Audubon Society, National Wildlife Federation, and several other organizations. All of the nontraditional landscaping programs incorporate the guidelines from the Presidential Memorandum 65 Fed. Reg. No. 81, pg. 24603 for federal projects to use regionally native plants for landscaping, prevent pollution, reduce fertilizer and pesticide use, recycle green waste, and minimize runoff. Each of these individual programs have some unique attributes but generally all promote: the use of native plants adapted to the local precipitation patterns or the use of regional nursery propagated stock selected for hardiness, aesthetics, and low water use; the substitution or elimination of high water use nonnative Kentucky bluegrass lawns; the use of integrated pest management practices; the development of bird and wildlife habitat; the enhancement of insectariums for increasing beneficial insects, and the development of beautiful landscapes that add value to property. Most of the conservational landscaping programs suggest the importance of creating outdoor family living and playing spaces and a few programs also suggest establishing separate secluded sanctuary spaces for human soothing that eliminate stress and restore peace of mind. The nontraditional landscaping programs greatly improve the conservation of natural resources in residential landscapes, however, none of these programs help homeowners increase the soil microorganism biomass and improve soil health.

The goal of this report is not to design another nontraditional landscaping program but to provide information and guidance for homeowners that would like to implement natural resource conservation methods on their property but also want to increase the biomass and activity of the soil microorganisms and improve the soil health. The simple biologically effective practices that can be used to enhance soil quality on residential properties were developed from the research findings of four decades of prairie ecosystem restoration during which it was discovered how to activate the ecosystem biogeochemical processes, the defoliation resistance mechanisms, and the resource competitiveness processes that promote the biological and physiological processes of grass plants and symbiotic soil microorganisms.

Energy for Soil Microbes

All of the conservational landscaping programs imply that it is highly desirable to have healthy soil with active soil microorganisms, however, none of these nontraditional landscaping methods provide guidance as to how homeowners could restore the health and increase the biomass of soil microorganisms of residential soils. As a replacement practice, these programs promote amending the existing poor quality soil with enriching composted material produced from organic yard rubbish, and it is suggested that compost amended soils will perform similar to healthy soils for a couple of years, then repeat the method. Homeowners who are composting their organic yard waste should continue the practice; this is a good way to recycle organic refuse. The composted material should be used to amend the soils in the areas where annual plants are grown, like the vegetable garden and the annual flower beds.

Do not add composted material or fertilizer to areas where perennial plants grow that will be managed to increase microorganism biomass. Fertilizer and mineral nitrogen amendments decrease the quantity and activity of soil microorganisms.

The organisms in the soil are different than the organisms in a compost pile and the processes of decomposition of organic matter in the soil are different than the descriptions of decomposition in a compost pile. Soil microorganism biomass in the soil is limited by access to simple short carbon chain energy because they are achlorophyllous saprophytes that live on dead organic matter that is low in labile (readily available) carbon energy and these organisms can not fix carbon from carbon dioxide and sunlight energy. The carbon in senescent leaves and stems does not provide the needed energy for soil microorganisms. During senescence, perennial plants translocate all reusable material from the cells to other parts of the plant. The carbon that remains in dead leaves and stems is structural fiber carbohydrates that are difficult to break down and the decomposing organisms require other organic sources of energy and nitrogen. The energy in structural carbohydrates is lost during microbial decomposition and dissipated from the soil as heat. The source for short carbon chain energy for soil microorganisms is from living plants.

Healthy grass plants capture and fix carbon from atmospheric carbon dioxide during photosynthesis that combines sunlight energy, carbon, hydrogen, and oxygen to produce simple carbon chain carbohydrates in quantites greater than the amount needed for grass tiller growth and development. This surplus short chain carbon compounds are available to supply the energy needed by the soil microorganisms. If the surplus carbon energy is not removed from the grass plant, it will be oxidized to carbon dioxide during respiration and lost to the atmosphere. The only time in which the surplus carbon energy can be moved from the grass tiller through the roots into the soil is while the tiller is in the vegetative growth stage between the three and a half new leaf stage and the flower stage. During vegetative growth, the aboveground foliage consists primarily of crude protein (nitrogen) and water; most of the carbon is still in the belowground parts. Partial defoliation of the aboveground vegetative leaves that removes 25% to 33% of the aboveground weight removes more nitrogen than carbon from the plant and disrupts the tillers C:N ratio forcing that tiller to release (exudate) a large portion of the surplus carbon out of the roots into the soil. As the grass leaves mature, complex structural fiber carbohydrate compounds develop which increases the carbon content of the aboveground leaves and stems; partial defoliation after the flower stage no longer disrupts the C:N ratio and carbon energy is no longer forced out of the grass tiller into the soil.

Healthy grazed prairie pasture soils with active microorganisms develop when biologically effective management activates the biogeochemical processes of soil microorganisms and the physiological processes within grasses and other perennial plants. Grass plants, soil organisms, and graminivores have developed complex symbiotic relationships during 30 million years of coevolution. The grazing graminivores depend on grass plants for nutritious forage. Grass plants depend on soil organisms for mineralization of essential elements, primarily nitrogen, from the soil organic matter. The main sources of soil organic matter are dead plant and soil microbe material and grazing animal waste. Soil organisms depend on grass plants for energy in the form of short carbon chains. Grass plants exudate short carbon chain energy through the roots into the soil following partial defoliation of the aboveground leaf material by grazing animals. Grass plants produce double the leaf biomass than is needed for plant growth; the extra quantity provides nutritious forage for the grazing graminivores.

Grass plants can not distinguish the difference of partial defoliation from cattle, horses, rhinoceroses, or mechanical cutting machines. The critical factors that cause the exudation of plant carbon energy into the soil are the phenological growth stage of the grasses and the quantity of leaf material defoliated. The grass type has to be able to be managed by low maintenance practices. High maintenance Kentucky bluegrass that requires great quantities of supplemental irrigation water and large amounts of fertilizers, herbicides, and pesticides that cause soil microorganisms to decrease cannot be used to enhance soil quality.

Why Eliminate Bluegrass

Kentucky bluegrass lawns are so beautiful, why would the nontraditional landscaping programs promote substitution of other lawn grasses and why would the city of Denver, Colorado and the state of Nevada ask their citizens to eliminate Kentucky bluegrass lawns. Basically, Kentucky bluegrass and meadow bromegrass are the two nonnative perennial grasses that have weak lead tillers and produce abundant secondary vegetative tillers without much hormone control from the lead tillers which has a great biological cost of about double the water use requirements than the other perennial grasses that have strong lead tillers. States in western United States receive less growing season precipitation than the minimum quantity of water required by Kentucky bluegrass lawns and homeowners develop strong compulsions to supplement with irrigation water.

The long-term precipitation in western North Dakota at Dickinson during the 183 day perennial plant growing season period from mid April to mid October is 12.34 inches. During that period, a Kentucky bluegrass lawn requires 26.14 inches of water, compelling the homeowner to provide 13.80 inches of irrigation water per perennial plant growing season. A ⅓ acre city lot has 14, 520 ft^2, if the entire lot is Kentucky bluegrass lawn, the irrigation water from city water or well water would be 124,855.33 gallons of water. The Determination: 14,520 ft^2/⅓ ac lot X 5.20 lbs for 1 inch water per ft^2 = 75,504.0 lbs on lot with 1 inch of water X 13.8 inches of water = 1,041,955.20 lbs water ÷ 8.3453 lbs/gal = 124,855.33 gal of irrigation water.

Other lawn grasses, fairway crested wheatgrass, creeping red fescue, and bad river blue grama lawns, have less than 50% of the water requirements of Kentucky bluegrass at about 13.07 inches per 183 day perennial plant growing season. With 12.34 inches of precipitation, only 0.73 inches of irrigation water may need to be provided at 6,604.67 gallons of water. The Determination: 75,504.0 lbs on a lot with 1 inch water X 0.73 inches of water = 55,117.92 lbs water ÷ 8.3453 lbs/gal = 6,604.67 gal of irrigation water or 5.3% of irrigation water required by Kentucky bluegrass lawns.

Most cities in western United States use surface water (rivers, lakes, reservoirs, snow melt) for their municipal water supply. The rising demand for treatable clean water is growing greater than the quantity of available surface water. In the near future, increasing numbers of western cities and states will be restricting the uses of municipal water. Currently, more than 50% to 60% of western municipal potable water is being used to irrigate urban lawns and ornamental landscape plants. By planting low water use lawns and ornamental plants in residential landscapes as promoted by the forward thinking nontraditional landscaping programs, most of the municipal water currently used to irrigate urban landscapes can be transferred back to human use.

Homeowners that have well water to irrigate their landscape plants usually consider the water that is below their property to be their water to use. Even though, the entire quantity of precipitation plus the aquifer irrigated water that soaks into the soils of their property only moves down three or four feet never reaching the aquifer and never contributing to the recharge of that aquifer. The quantity of water that homeowners use from the aquifer is technically a deficit quantity that they do not replace, creating a moral dilemma. Should property owners who remove greater quantities of aquifer water than the quantity of water they replace have some obligation to the other aquifer property owners. Would the answer be the same if a large company drilled a well into that aquifer and pumped enormous quantities of water that drew the aquifer depth below the small property owners well pipe level. How should urban aquifer water be managed equitably.

Low Maintenance Lawns

Management of low maintenance lawn grasses that releases (exudates) the surplus short carbon chain energy from tillers at vegetative growth stages into the soil to nourish the soil microorganisms requires mowing dates and mower height to be coordinated with grass tiller phenological growth stages. The critical phenological growth stages are identical for all perennial grass types. Grass growth stages are determined by the length of sunlight, resulting in different calendar dates at which early cool season, cool season, and warm season grasses reach the critical phenological growth stages. These calendar dates do not change more than three days from year to year. Three requisite actuator mowing periods are required for full beneficial effect: 1) the preseason cut during the last two weeks of April that removes dead and senescent leaf parts permitting sunlight to the green portions of the carryover leaves; 2) the first partial defoliation cut of green leaves during the vegetative growth stages after the three and a half new leaf stage and before the flower stage that causes the surplus short carbon chain energy to be exudated into the soil; and 3) the second partial defoliation cut of current leaves during mid August that permits sunlight to reach most of the green leaves of the young secondary vegetative tillers to increase carbohydrate storage for use during the winter.

The preseason cut will be at the shortest mower height intended to remove most of the gray colored dead leaves and the tan colored upper portion of the carryover leaves that have ruptured cell walls and can not regreen. The lower portion of the carryover leaves do not have ruptured cell walls and will regreen with chlorophyll that will provide photosynthate to support new leaf growth.

The second actuator mowing removes only 25% to 33% of the aboveground leaf weight that causes surplus carbon energy to be released into the soil. The greatest quantity of surplus short carbon chain energy will be at the vegetative leaf stage with the greatest leaf area which occurs just before the first flower stalks reach anthesis. Cool season grasses are long day plants and start the flower phenophase period before 21 June (the longest day) during the period of increasing day length. Warm season grasses are short day plants and start the flower phenophase period after 21 June during the period of decreasing day length and increasing night length. It is critical that the mower height be set to remove only 25% to 33% of the aboveground leaf weight. If the mower height is set to remove 50% of the leaf weight, the grass tillers will not fully recover the lost leaf area and secondary vegetative tiller development will be remarkably low. Grass tillers live for two growing seasons, the first year they remain vegetative and the second year they produce a seed head. When the second mowing period removes 50% of the leaf weight, the decrease in secondary tiller numbers will not be obviously visible until the next growing season, which will be too late for the homeowner to make the direct connection with last years removal of 50% leaf weight and this years low grass tiller density. Before the flower stage, grass tillers require as much leaf area as possible, however, partial defoliation of vegetative tillers must occur to activate the processes to exudate the surplus carbon chain energy into the soil to nourish the soil microorganisms. Removal of 25% to 33% of the aboveground leaf weight causes the exudation of the surplus carbon energy and leaves sufficient leaf area for the tillers to recover and remain productive.

The third actuator mowing, should occur during mid August, is intended to enhance grass tiller preparation for winter and next years early vegetative growth. All perennial grasses start the winter hardening processes in mid August that continues until hard frost. The mid August mowing will be at the tallest mower height that removes the standing flower stalks and the senescent leaf tips exposing as much green leaf to the sun as possible. The mowing should permit sunlight to reach the young green leaves of the secondary vegetative tillers. These leaves produce most of the stored starches that perennial grass plants will live on during the winter. A large quantity of stored carbohydrates results in robust tillers the next spring. During the winter hardening period, cool season grasses produce fall tillers which are next seasons vegetative tillers grown early during the pervious fall. Warm season grasses produce fall buds that will produce new vegetative tillers early the next spring.

Side note: amending nitrogen to grass that is in the winter hardening process prevents the development of full hardiness. Grasses that are not fully hardened use substantially greater quantities of stored carbohydrates during winter respiration, most likely causing depletion of the supply resulting in plant winter kill before spring.

The three requisite actuator mowing treatments remove plant parts. These plant parts contain some quantity of ecosystem essential elements. When these clippings are left on the lawn and rain moves them to the soil, the microorganisms in the soil decompose the complex organic compounds to essential elements. These transformed essential elements are available for growth of new plant organs or more soil microorganisms which are critical for maintaining the lawn productivity. If the plant clippings were to be removed from the lawn ecosystem, the quantity of available essential elements would decrease rather than increase and the lawn grasses and soil microorganisms production would decrease rather than increase. The clippings must stay with the lawn ecosystem.

Fairway crested wheatgrass is an introduced early cool season grass that could appear not too different from a Kentucky bluegrass lawn but could be managed as a low maintenance lawn. The preseason cut should occur during the last two weeks of April. The carryover leaves will have regreened to about half their length; the cell walls in the top portion have ruptured and will not regreen. A few new leaves should be visible during mid to late April. Crested wheatgrass flowers early during 28 May to 10 June. The second actuator cut should occur during the two week period before 28 May. During the vegetative stages, 1 to 30 May, healthy mature stands of crested wheatgrass can grow an inch per day, which would equal 300 pounds per acre per day. The mower height for the second cut should be set to remove only 25% to 33% of the aboveground leaf weight. After the flower stage, the rate of leaf growth slows, but most likely, monthly mowing periods will be required. From early June to late July the mower height can be set to remove 50% of the aboveground leaf weight.

The third actuator cut should occur during mid August. Raise the mower height to leave the greatest quantity of green leaves as possible. The third cut is intended to remove any seed heads and the senescent tips of older leaves to permit sunlight to reach the lower young green leaves of secondary vegetative tillers. Soon after mid August, numerous fall tillers will develop. Resist reducing the leaf height of the secondary tillers and fall tillers which will become the producing carryover leaves during the early portion of the next growing season.

Creeping Red Fescue is a cool season grass consisting of numerous horticultural subspecies. Select a cultivar that has short stature and produces rhizomes. Avoid the cultivars that are tall and used for pasture grass. Standard old school recommendation is to use red fescue in a mixture, however, for a low maintenance lawn use it as a monoculture. The preseason cut should occur during the last two weeks of April. The carryover leaves should be green on the lower half and most likely there will be no new leaves in late April. The second actuator cut should occur during the two week period before 21 June and the mower height should be set to remove only 25% to 33% of the aboveground leaf weight. Creeping red fescue will most likely not require another mowing until mid August. However, if the fescue seed stalks that appear during mid June to mid July are viewed to have no aesthetic qualities, they can be cut at the basal leaf height. The seeds are not needed; the creeping red fescue lawn will thicken vegetatively with rhizomes. The third actuator cut should occur during mid August. Raise the mower height to leave the greatest quantity of green leaves as possible. The secondary vegetative tillers should be growing vigorously during August and several fall tillers should develop during late August.

Bad River Blue Grama is a short warm season grass. Management of a warm season grass lawn is entirely different from management of a cool season grass lawn. Standard old school recommendation is to use a mixture of blue grama and buffalo grass. The gray green color of buffalo grass leaves gives the appearance of dust covered dingy spots in the lawn. Blue grama and buffalo grass should not be mixed but can be grown at different locations of the same landscape. A low maintenance blue grama lawn should be a monoculture. The preseason cut should occur during the last two weeks in April. There will be no green color on the carryover leaves in April. Set the mower height to remove the previous years gray colored senescent leaves. Shading from old leaves greatly hinders growth of new leaves. Warm season grass lawns green up later than cool season grass lawns, however, the trade off is that warm season grass lawns remain green during mid summer when cool season grass lawns go dormant or require large quantities of irrigation water. The second actuator cut should occur during the two week period after 21 June and the mower should be set to remove only 25% to 33% of the aboveground leaf weight. Some seed heads will develop following the second cutting. Most people view blue grama seed heads to be aesthetically pleasing and can remain uncut. However, if the entire neighborhood is hard core high maintenance mow every week Kentucky bluegrass lawns, the blue grama seed heads can be cut at the basal leaf height. The seeds are not needed; the blue grama lawn will thicken vegetatively with rhizomes. The third actuator cut should occur during mid August. Raise the mower height to leave the greatest quantity of green leaves as possible. Warm season grasses do not produce fall tillers but do produce fall buds.

Buffalograss is a short dioecious warm season grass that is propagated vegetatively by plugs. Buffalograss lawn is low maintenance, low inputs, and low upkeep. Buffalograss and blue grama should not be mixed but can be grown at different locations of the same landscape. Buffalograss lawn would work nicely as grass covered walkways among or between perennial flower beds, or as a lawn in the parts of a residential lot with problem clay soils. Buffalograss lawn does not have the aesthetic impact that a blue grama ornamental lawn has. The preseason cut should occur during the last two weeks of April. There will be no green color on the carryover leaves in April. Lawn mowers set at the lowest setting will remove a few of the previous years taller male flower heads but will not go low enough to cut the previous years gray colored senescent leaves. Battery powered grass scissors can be used successfully to “mow” small areas of buffalograss lawn. The second actuator cut should occur during the two week period after 21 June. A minimum of 25% of vegetative tiller leaf weight needs to be removed to cause the surplus short carbon chain energy to be exudated into the soil. The third cutting in mid August is not necessary.

Understory Grass Ground Cover

The entire residential property usually is not comprised of lawn grass. Some parts of the landscape consist of low water use ornamental perennial shrubs, grasses, and flowers. The microorganisms in the soil under the ornamental plants require short carbon chain energy from living plants. The aesthetic beauty of these ornamental plants would be destroyed if 25% to 33% of the plant weight were to be defoliated just prior to the flower stage. However, a short grass ground cover between and under the ornamental perennial landscape plants can be managed to cause the surplus carbon energy to be exudated into the soil and nourish the soil microorganisms.

Selection of an ideal understory grass ground cover has not been finalized. Three different grasses have been tested as ground cover grasses for several years. The first tested grass was blue grama. It is an attractive grass with short stature. While the ornamental shrubs were young, blue grama held its own for the first couple of years. Under shaded conditions, blue grama survival is inversely proportional to the level of shade. It does remain viable in spots with little shade around shrub roses and upright ornamental grasses. The second grass tested was unfertilized volunteer Kentucky bluegrass that escaped from neighboring yards and backfilled the shaded areas that were voided of blue grama. Kentucky bluegrass can thrive under low light conditions but it does not survive with full shade. The third grass tested was green needlegrass. Green needlegrass was selected to be an ornamental grass because the dark green basal leaves form an attractive fountain shape. By the third year, it was vigorously spreading to areas under the shrub roses and the tall upright lilies where it was clipped as ground cover. The fountain basal leaves quickly changed to a prostrate growth form after a couple of cuttings.

The ground cover grasses require the same three requisite actuator cuttings as lawn grasses to cause the surplus carbon energy to be exudated into the soil. As the soil microorganism biomass increases, the quantity of soil aggregation that looks like grape nut breakfast cereal increases. The soil aggregates increased in the soils under all three ground cover grasses. This indicates that the concept does work. However, all three of the grasses tested have serious undesirable characteristics as understory ground cover plants and the use of these three grasses as ground cover is not recommended.

A paper search for suitable candidates for understory ground cover grasses has lead to the short fescues. The fourth grass to be tested will be hard fescue. It is short statured, shade tolerant, and low maintenance. Most likely there are several other grasses that could serve as understory ground cover.

Troubleshooting Problems

After you have implemented the nontraditional landscaping methods and have reduced irrgation water use, lowered nonrenewable energy use, diminished fertilizer, herbicide, and pesticide material, decreased noise, air, and water pollution, minimized plant maintenance labor, and are increasing soil microorganism biomass, and improving soil health. What do you do if a problem develops. Most of the landscaping industry will still be advising traditional quick fix treatments. Pesticides will harm your beneficial insects, herbicides will harm some of the low maintenance plants, and fertilizer will reduce the soil microorganisms for several years.

A low maintenance lawn with a soil microorganism biomass large enough to decompose organic matter and to mineralize essential elements is a true functional ecosystem. If a problem occurs in a lawn ecosystem, a quick fix treatment will not correct it. The problems that may develop in lawn ecosystems will be caused by some imbalance in an ecosystem process. The solution will be to adjust your defoliation treatments so the treatment effectiveness can rebalance the interactions among the ecosystem components and reestablish the proper functionality of the process that was out of order. Ecological problems are corrected with ecological solutions.

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