Pollution Abatement and Increased Beneficial Insects Associated with Sustainable Landscapes

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ABSTRACT

The intent of this paper is to identify the benefits associated with sustainable landscapes. Benefits include nutrient abatement through increased biomass, lowered fertilization, lowered watering requirements, decreased water flow, and decreased runoff; conservation of native plants and their pollinators; conservation of beneficial insects such as predatory and parasitic insects that manage pest insects.

Research was conducted to ascertain the benefits provided by native plants in sustainable landscapes. Data was collected demonstrating that native plants have increased biomass over conventional bedding plants due to persistent stems and roots that slow runoff and absorb phosphorous and nitrogen. Studies revealed that native plants require lower nitrogen, phosphorus, and potassium levels for peak flowering. Sustainable landscapes were found to use mulch that conserves moisture as well as providing habitat for beneficial ground predators such as ants and ground beetles. The role of native plants in providing nectar and pollen for beneficial insect conservation was determined by observation of insect behavior at flowers, by capturing insects in sticky traps, and by counting ants at bait stations. The preference of specific plant species for specific taxonomic groups of beneficial insects was evaluated.

INTRODUCTION

A fundamental question for managing urban ecosystems is, "How can the components of the ecosystem be manipulated to make the ecosystem more sustainable?" This can be accomplished with a reduction of runoff associated with non-point source pollution such as lawn fertilizers and pesticides, as well as increased self-regulation of insect pests by beneficial insects.

The conventional urban landscape found in the United Sates consists of an expanse of lawn, a few shade trees and shrubs, and an occasional bed of flowers. This is substantiated by the Lawn Institute, which estimates 81% of the 30 million acres that comprise landscapes around single-family homes is sod (Daniels, 1995). Ordinarily, the bedding plants used in conventional landscapes are selected because of their low cost and availability rather than the cost of their maintenance needs such as fertilization, watering, and pest control (Hipp et .al 1993). Bedding plants are highly derived cultivars that usually were breed to produce sterile flowers that do not use energy to produce seeds. Without the ability to produce pollen and nectar, these plants offer no food reward to pollinators or beneficial insects such as predators and parasitoids that control pest insects.

In contrast, native plants can produce peak flowers with lower inputs of fertilizers, water, and pesticides. These plants also produce pollen, nectar, and seeds, which are used by beneficial insects. By transforming a conventional urban landscape into a sustainable landscape, nutrients associated with non-point source pollution are reduced, pest populations are regulated by beneficial insects, native plants are conserved, and the aesthetic qualities associated with floral displays are maintained.

For this paper, a *sustainable landscape* is defined as a landscape type where native and introduced species are well suited to the existing light, moisture, and soil conditions, and which requires low inputs of labor, fertilizers, herbicides, insecticides, and fungicides to thrive. A sustainable landscape preserves and protects nature's balance, while providing aesthetic pleasure (Krischik 1996). A *conventional landscape* is a landscape type made up of primarily highly bred cultivars of plant species, which require high inputs of nutrients, water, and pesticides to flower. A conventional landscape provides aesthetic pleasure, but is costly to maintain and needs high input of nutrients which then may enter storm drains, streams, and lakes. Also, landscapes with only bedding plants are ecologically unbalanced because the flowers do not provide pollen or nectar for beneficial insects such as native pollinators, predatory insects, and parasitoids.

EXPERIMENT DESIGN AND METHODS

SITE DESCRIPTION

The Minnesota Landscape Arboretum is located in east-central Minnesota, approximately 15 miles southwest of Minneapolis. The Arboretum represents a mosaic of land uses that are located according to topography and design. Naturalized areas provide a transition zone between the display gardens and undisturbed habitats. The varying terrain offers different microclimates for native and introduced plants. Approximately 435 native species or about one-fourth of the known flora of Minnesota have been found on the Arboretum property. This diversity of plants supports a wide range of wildlife that moves freely throughout the property (Anonymous 1998).

The Minnesota Landscape Arboretum was chosen for the site of the experiments because it had both conventional and sustainable landscapes in close proximity on its grounds. The research was conducted from July through September of 1998. Two types of landscapes were chosen: a sustainable landscape planted with native plants (Table 1) and a conventional landscape planted with bedding plants (Table 2). The sustainable landscape received minimal watering, no fertilization, no pesticide treatments, and bark mulch was added to retain moisture. The conventional landscape received daily watering, pesticide treatments, and routine fertilization. The two landscape types were within 500 yards of each other. Each landscape type was replicated. The two plots of sustainable landscape were 662 sq. ft and 777 sq. ft. The four plots of conventional landscape were 528 sq. ft, 561 sq. ft, 495 sq. ft, and 682 sq. ft.

Twenty-four locations were chosen in each landscape type and identified using numbered flags. The flagged locations were chosen based on proximity to specific plant species in order to obtain representative and replicated samples of the entire landscape. These locations were used for data collection for nutrient and moisture analysis, behavioral observations of beneficial insects visiting flowers, sticky trap collection, and ant diversity analysis.

Table 1. Plant species found in the sustainable landscape

SUSTAINABLE LANDSCAPE	
Asclepias incarnata – swamp milk weed (asci)	Lobelia cardinalis - cadinal flower (card)
Asclepias tuberosa – butterfly milkweed (asct)	Lobelia siphilitica - great blue lobelia (gbl)
Campanula rotundifolia - harebell (camp)	Monarda fistulosa - wild bergamot (monf)
Chelone obliqua – turtlehead (turt)	Physostegia virginiana – obedient plant (phys)
Cimcifuga racemosa – black snake root (cimci)	Rudbeckia hirta - blackeyed Susan (rudb)
Dalea purpurea – purple prairie clover (purp)	Rudbeckia laciniata – yellow coneflower (ycone)
Echinacea purpurea- purple cone flower (ech)	Silphium integrifolium – rosinweed (sil)
Eupatorium maculatum – spotted joe pye weed (joe)	Silphium terebinthinaceum – prairie dock (tere)
Filipendula rubra – queen of the prairie (fili)	Solidago canadensis - tall goldenrod (scan)
Gentiana quinquefolia - stiff gentian (gent)	Solidago rigida – stiff goldenrod (srig)
Helianthus tuberosus – jerusalem artichoke (helg)	Verbena stricta - Hoary vervain (blv)
Heliopsis helianthoides –false sunflower (help)	Vernonia fasciculata - iron weed (iron)
Liatris pycnostachya –prairie blazing star (liat)	

Table 2. Plant species found in the conventional landscape

CONVENTIONAL LANDSCAPE	
Ageratum houstonianum – ageratum (ager)	Heliotropium arborescens–heliotrope (heli)
Amaranthus sp –amaranthus (ama)	Hunnemannia fumariifolia – Mex. Tulip poppy (hunn)
Anchusa capensis- bugloss (anch)	Lobularia maitima– sweet alyssum (lobu)
Antirrhinum majus – snapdragon (snap)	Mirabilis jalapa – four O' clock (mira)
Begonia x semperflorens – wax begonia (beg)	Nicotiana alata – flowering tobacco (nico)
Calendula – pot marigold (clen)	Nierembergia frutescens –cup flower (nier)
Callistephus chinensis – China aster (call)	Pelargonium x hortorum – zonal geranium (ger)
Canna x generalis- canna (canna)	Petunia sp – garden petunia (pet)
Cleome hasslerana- spider flower (cleo)	Phlox drummondii – annual plox (phlox)
Celosia argentea – cocks comb century yellow (cel)	Salvia farinacea - salvia (salf)
Centaurea cyanus – bachelor buttons (bach)	Salvia spendens – salvia (sals)
Cosmos sp – cosmos (cosmo)	Salvia viridis - salvia (salv)
Dahlia sp – dahlia hybrids (dahl)	Sanvitalia sp – procumbens (sanv)
Dianthus sp – pinks (dian)	Tagetes sp – marigold (mari)
Gaillardia sp – blanket flower (gail)	Zinnia elegans – creeping zinnia (zin)
Gazania sp – gazania (gaz)	

NUTRIENT ABATEMENT AND WATER CONSERVATION

Plant Nutrients and Percent Moisture in Vegetative Material

The goal of this experiment was to determine the levels of nitrogen, phosphorus, potassium, and moisture needed for peak flowering for species in each landscape type. Plants that require lower inputs of nutrients for peak flowering assist in lowering nonpoint source pollution. Also, plants requiring less water for peak flowering reduce water usage and runoff. Samples of plant foliage were collected from two plant species in the conventional and sustainable landscapes. From the conventional landscape, the vegetative material was collected from the bedding plants *Pelargonium* (n=6) and *Petunia* (n=6). In the sustainable landscape, *Liatris pycnostachya* (n=6) and *Echinacea purpurea* (n=6) were sampled. These species were chosen because they are popular plants in each landscape type. Samples were collected on two dates, August 5 and September 2, and brought that same day to the University of Minnesota Soil Lab for testing for nitrogen, phosphorus, potassium, and moisture analysis. Samples were dried and prepared by dry ash -10% HCl method and analyzed by an ARL 3560 ICP-AES. Data was analyzed by t-test (SAS).

Biomass of Vegetative Material

The goal of this experiment was to determine the ability of the two landscape types to reduce nonpoint source pollution. It was investigated whether native species maintain a greater vegetative biomass that would aid nutrient abatement by providing persistent vegetative structure above and below ground to slow runoff and absorb nutrients. The biomass experiment was conducted on September 2 at the identical location as the nutrient sampling, utilizing the same plant species, but not the same individuals. Samples of vegetative material were removed from *Pelargonium* (n=15), *Petunia* (n=15), and Tagetes (n=15) in the conventional landscape and from *Liatris pycnostachya* (n=15), *Echinacea purpurea* (n=15), and *Rudbeckia hirta* (n=15) in the sustainable landscape. The plants were measured to determine total length and then separated into leaves, flowers, and stem. Once separated, the samples were weighed and then dried at 70 degrees Celsius for 10 days for determination of the dry weight and percent moisture. Data was analyzed by t-test (SAS).

Ground Litter

The goal of this survey was to determine the differences in quantity of ground litter in each landscape. Ground litter made up of predominantly carbon material lowers nitrogen levels by denitrification and also lowers the need for watering because it holds moisture. Ground litter samples were collected on September 2, by randomly choosing 15 locations in each landscape type. At each location, all ground litter on the soil surface was collected inside a 10-inch diameter hoop and weighed. Data was analyzed by t-test (SAS).

CONSERVATION OF BENEFICIAL INSECTS

Behavioral Observation at Flowers

The goal of this survey was to determine the number and taxonomic groups of beneficial insects visiting each landscape type. Teams of two researchers observed flowers at each of the 24 flagged locations in the two landscape types, eight times in the three month experimental period. Observations were conducted for 2-two minute intervals between 1000 and 1500 hours at each flagged location. The number of inflorescences visited and the taxonomic groups of insects were recorded. Data was collected on July 23, 24, 28, 30 and August 4, 6, 11 and 12. Data was analyzed by ANOVA and multiple range test, REGWQ (SAS).

Ant Diversity

Baiting experiments were conducted to compare the abundance and variety of ant species in each landscape. Round pieces of filter paper (Mr. Coffee filters) with a diameter of eight inches were placed flush with the soil and pierced with the site flag. Two baits, a carbohydrate source (Welch's grape jelly) and a protein source (Friskies cat tuna), were placed on each filter to attract ants. Each landscape type had 24 bait stations. The baits were exposed in the landscapes for a period of 18 hours. Direct visual counts were taken at the 48 locations, three times in the evening from 1600 to 2000 hours, and once the next day at 800. Data was collected on July 26, 27, and August 2,5,6,12,13,23 and 24. Ants were captured and preserved in alcohol for later counting and species identification. Data was analyzed by ANOVA and multiple range test, REGWQ (SAS).

Sticky Traps for Determining Insect Diversity

The goal of this experiment was to determine the number and taxonomic groups of flying insects in each landscape type. The study was designed so data could be collected on the number of parasitic hymenoptera and generalist predators flying in each landscape type.

Since sustainable landscapes have native plants that provide pollen and nectar, we hypothesized that more beneficial insects would be caught in sticky traps in sustainable landscapes. Standard greenhouse yellow sticky traps (21 x 15 cm) were placed at the 24 flagged locations in each landscape and left for a 48-hour period. This was repeated on four dates: July 24, 30, August 6, and 13. In the laboratory, the insects were counted and identified as to taxonomic group under a dissecting microscope at 12 X magnification. Data was analyzed by ANOVA and multiple range test, REGWQ (SAS).

NATIVE PLANT CONSERVATION

Data on insect visits to flowers was analyzed to determine which species of plants were preferred by insects. Also, the top ten plant species preferred by specific taxonomic groups of insects were determined. Data was analyzed by ANOVA and multiple range test, REGWQ (SAS).

RESULTS

NUTRIENT ABATEMENT AND WATER CONSERVATION

Plant Nutrients and Percent Moisture in Vegetative Material

Nitrogen, phosphorous, and potassium are important nutrients associated with reproductive and vegetative growth of plants. Nitrogen, phosphorus, and potassium were significantly higher in bedding plants such as *Petunia* and *Pelargonium*, compared to native plants such as *Liatris pyconstachya* and *Echinacea purpurea* (Figure 1).

Plants in conventional landscapes were found to have 52% greater nitrogen levels, 34% greater phosphorous levels, and 43% greater potassium levels then plants in the sustainable landscapes. The mean and standard error for nitrogen in plants found in sustainable and conventional landscapes were as follows: (sustainable mean 2.12 +/- standard error 0.06; conventional mean 4.44 +/- standard error 0.15) (nitrogen t-test, df=1, n= 48, $p<0.001$)

The mean and standard error for phosphorus in plants found in sustainable and conventional landscapes were as follows: (sustainable mean 0.30 +/- standard error

0.026; conventional mean 0.44 +/- standard error 0.01; $p<0.0001$) (phosphorus t-test, df=1, n=48, $p<0.001$)

The mean and standard error for potassium in plants found in sustainable and conventional landscapes were as follows: (sustainable, mean 2.25 standard error 0.09; conventional mean 3.94 standard error 0.41; $p<0.0001$) (potassium t-test, df=1, n=48, $p<0.001$)

As we showed for nutrients, bedding plants needed more water for peak flowering. Moisture levels were found to be 18% higher in bedding plants than native plants in sustainable landscapes. The mean and standard error for percent moisture for plants in sustainable and conventional landscapes were as follows: (sustainable mean percent moisture 75 +/- standard error 0.71; conventional mean percent 92+/- standard error 0.60) (moisture t-test, df=1, n=48, $p<0.001$)

Figure 1. Nitrogen, phosphorus, and potassium of plants found in sustainable and conventional landscapes.

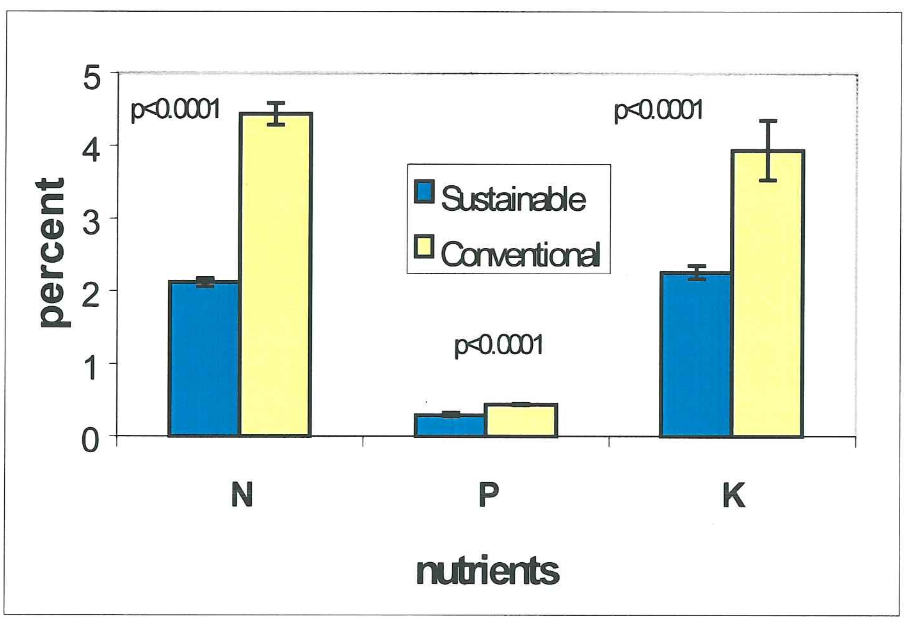
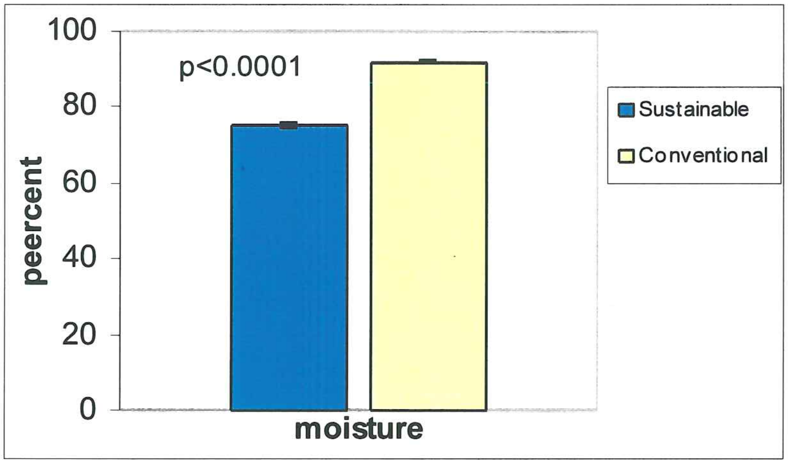


Figure 2. Percent moisture of plants found in sustainable and conventional landscapes.



Biomass of Vegetative Material

Biomass was investigated because plants higher in biomass have more surface area available to slow runoff and absorb nutrients in runoff. It was found for all biomass parameters investigated, such as wet and dry weight, that native plants had significantly more biomass and less moisture compared to conventional plants (Figure 3).

The mean total wet weight was 36% greater in plants found in sustainable landscapes. The mean total dry weight was 69% greater in plants found in sustainable landscapes. The mean total length was 60% greater in plants found in sustainable landscapes. The mean percent moisture was 29% greater in plants found in sustainable landscapes.

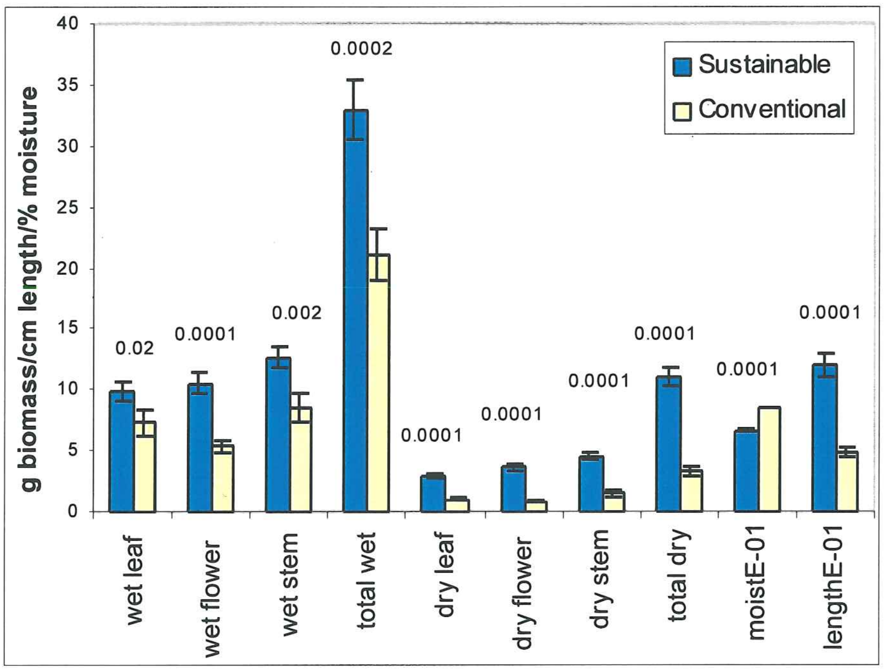
The mean and standard error for total wet weight in sustainable and conventional plants were as follows: (sustainable mean 32.93+/- standard error 2.42; conventional mean 21.06 +/- standard error 2.21; $p<0.0001$) (t-test, df=1, n=90, $p<0.0001$)

The mean and standard error for total dry weight in sustainable and conventional plants were as follows: (sustainable mean 11.04 +/- standard error 0.82; conventional mean 2.36 +/- standard error 0.40; $p<0.0001$) (t-test, df=1, n=90, $p<0.0001$)

The mean and standard error for mean length (centimeters) in sustainable and conventional plants were as follows: (sustainable mean 119.69+/- standard error 9.83; conventional mean percent 48.23+/- standard error 4.01; $p<0.0001$) (t-test, df=1, n=90, $p<0.0001$)

The mean and standard error for percent moisture in sustainable and conventional plants were as follows: (sustainable mean 66% +/- standard error 0.71; conventional mean 85%+/- standard error 0.59; $p<0.0001$) (t-test, df=1, n=90, $p<0.0001$)

Figure 3. Biomass , length, and moisture of plants found in sustainable and conventional landscapes.

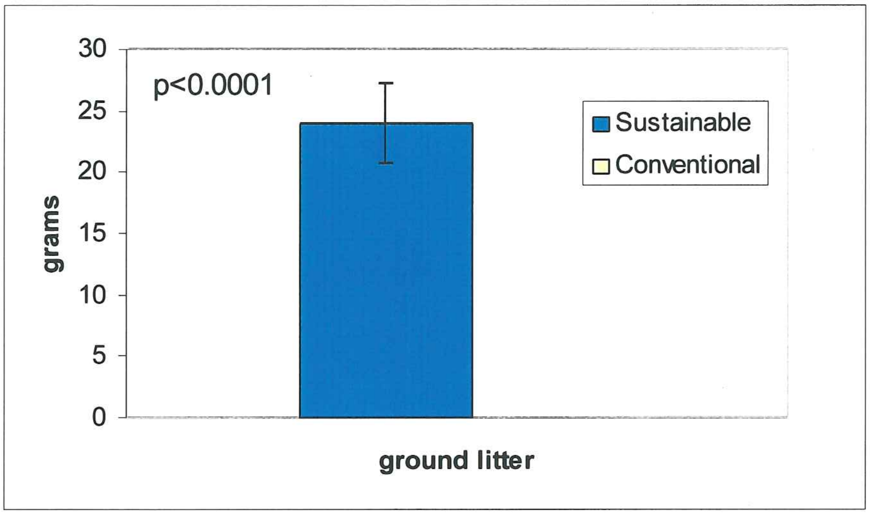


Ground Litter

Ground litter conserves moisture as well as provides habitat for beneficial ground living insects such as ants and carabid ground beetles. Sustainable landscapes had significantly more ground litter than conventional landscapes (Figure 4).

The mean and standard error for ground litter in sustainable and conventional landscapes were as follows: (sustainable mean 24.26 +/- standard error 3.21; conventional mean 0.00 +/- standard error) (t-test, df=1, n=30, p<0.0001)

Figure 4. Amount of ground litter present found in sustainable and conventional landscapes.



(No ground litter was found in the conventional landscape)

CONSERVATION OF BENEFICIAL INSECTS

Behavioral Observation at Flowers

Insects prefer sustainable landscapes (Figure 5). The mean insect visits were 86% greater in sustainable landscapes. The mean and standard error for insect observation in landscape type were as follows: (sustainable mean 12.30 +/- standard error 0.72; conventional mean 1.71 +/- 0.12 standard error; p<0.0001) (ANOVA, F=217.47, df=1,364, p<0.0001 for habitat, p=0.115 for date, and p= 0.1527 for hab*date)

On an individual basis there were significant differences found in insects' preference to landscape type. Of the 12 taxonomic groups identified, 8/12 taxonomic groups chose the sustainable landscape for flower visits. The taxonomic groups were: bumblebee (bumbleb), other bees (otherb), spider wasps, Pompilidae (pomp), Cantharidae, goldenrod soldier beetles (GSB), lepidoptera (leps), dragonflies (drflies), ambush bugs (ambushb), other bugs (otherb). Only one insect, the honeybee (honeyb) preferred the conventional landscape. There was no significant difference found in syrphid fly (sflies) and lady beetles (lbugs) preference of landscape types (Figure 6). All means and standards errors are listed in Table 4.

Figure 5. Behavioral observation: Number of beneficial insects found in sustainable and conventional landscapes.

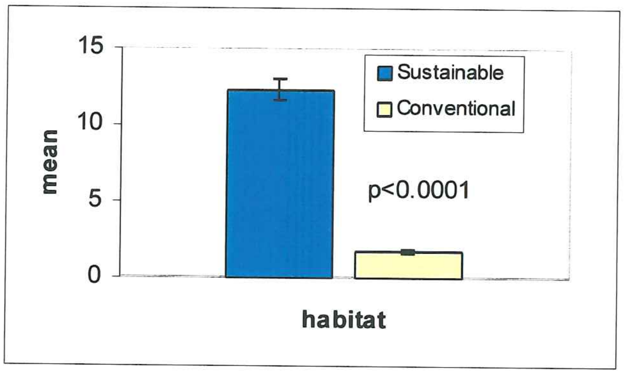


Figure 6. Behavioral observation: Taxonomic group of beneficial insects found in sustainable and conventional landscapes.

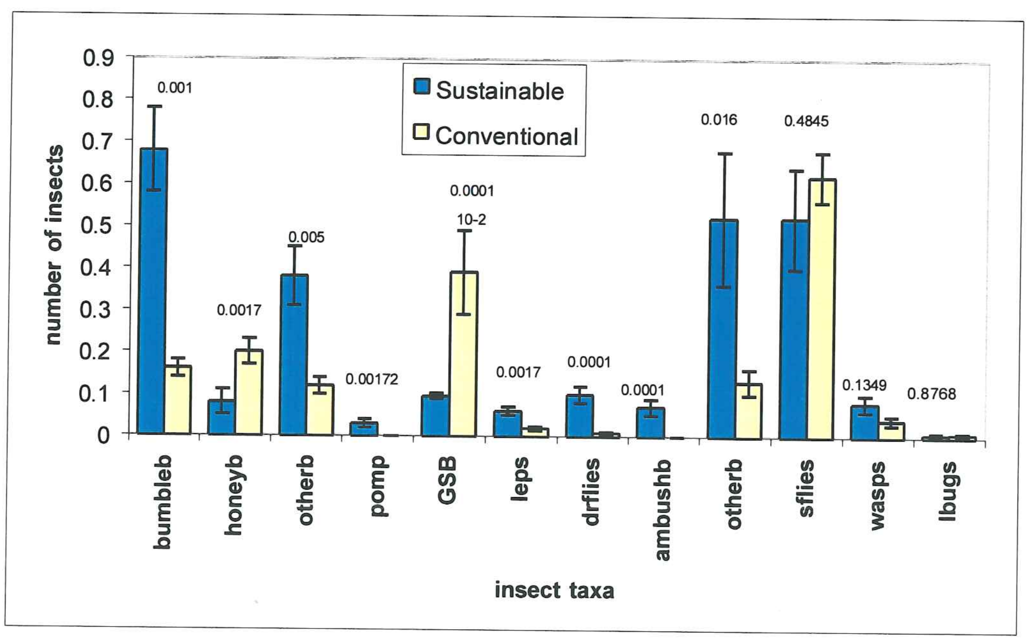


Table 3. Behavioral observation: Total numbers of beneficial insects found in sustainable and conventional landscapes.

Insects	Sustainable	Conventional
Bumble bee	336	91
Honey bee	41	115
Other bee	185	71
Pomp	19	0
GSB	4,886	221
Leps	33	10
Dragonflies	51	5
Ambush bug	36	0
Other	275	73
S flies	343	359
Wasps	43	21
Lady bugs	4	5
Totals	6,252	971
Number of observations	573	519

Table 4. Behavioral observation: Mean number of taxonomic group of beneficial insects found in sustainable and conventional landscapes.

Insects	Sustain.	Std. Error	Conv.	Std. Error	F value	P value	Sign
Bumble bee	0.68	0.10	0.16	0.02	26.95	0.001	S
Honey bee	0.08	0.03	0.20	0.03	9.96	0.0017	S
Other bee	0.38	0.07	0.12	0.02	12.19	0.0005	S
Pomp	0.03	0.01	0.00	0.00	10.04	0.0017	S
GSB	9.58	0.72	0.39	0.10	166.44	0.00001	S
Leps	0.06	0.01	0.02	0.005	9.97	0.0017	S
Dragonflies	0.10	0.02	0.009	0.004	20.47	0.0001	S
Ambush bug	0.07	0.02	0.00	0.00	20.45	0.0001	S
Other	0.52	0.16	0.13	0.03	5.86	0.0160	S
S flies	0.52	0.12	0.62	0.06	0.49	0.4845	NS
Wasps	0.08	0.02	0.04	0.01	2.24	0.1349	NS
Lady bugs	0.008	0.004	0.009	0.004	0.02	0.8768	NS

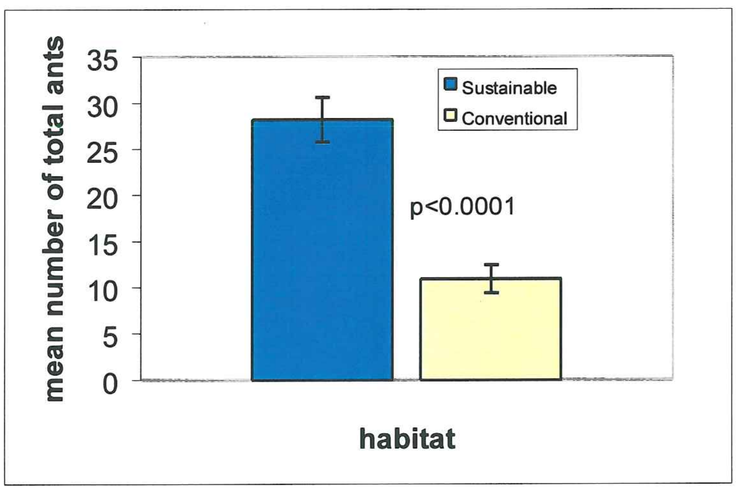
Ant Diversity

The abundance of ants was found to be 61% greater in sustainable landscapes.

The following five species of ants were found in the sustainable landscape: *Crematogaster cerasi, Formica incerta, Formica subseicea, Lasius neoniger, Myrmica americana*. This is compared to one species found in the conventional landscape, *Lasius neoniger* (Figure 7).

The mean and standard error for ant visits by landscape type in sustainable and conventional plants were as follows: (sustainable mean ants 28.17 +/- standard error 2.41; conventional mean ants10.93+/- standard error 1.52) (ANOVA, F+ 14.98,df=1,46, p<0.0003).

Figure 7. Ant diversity: Ant numbers at baiting stations in sustainable and conventional landscapes.



Sticky Traps for Determining Insect Diversity

Sticky traps, which passively capture insects as they fly, showed no significant differences between the two landscape types in total number of insects caught, although the ANOVA showed a date and hab*dat interaction (Figure 8) (ANOVA, F=0.97, df=1,181, p=3.257 for habitat, p<0.0001 for date, and p< 0.0001 for hab*date). We were hoping to capture small parasitic wasps that were missed in behavioral data with sticky traps. However, equal numbers of parasitic hymenoptera (Phym) were found in the two landscape types (Table 5). Data in Table 6 shows greater total numbers of specific taxonomic groups of beneficial insects were higher in sustainable landscapes, such as spiders, bees and goldenrod soldier beetles, but the total number of insects captured did not differ between the two landscape types. Data presented in Tables 5 and 6 does not add up to the total number of insects found in columns two and three. Since insects that were not considered beneficial such as aphids, psyllids, and sawflies were not identified and counted to taxonomic group, only the beneficial insects and total number of insects were counted and identified.

Figure 8. Sticky traps: Number of beneficial insects found in sustainable and conventional landscapes.

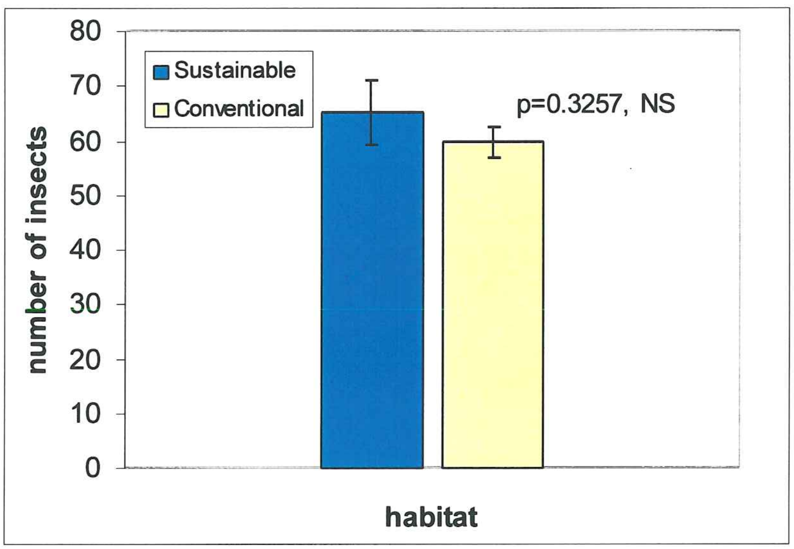


Table 5. Sticky traps: Mean number of insects found in sustainable and conventional landscapes.

	Sustain	Std. Error	Conven.	Std. Error	F value	P value	Sign
Totals	65.10	5.86	59.67	2.69	0.97	0.3257	NS
Spiders	0.90	0.14	0.15	0.04	28.97	0.0001	S
Flies	1.75	0.28	3.38	0.37	15.92	0.0001	S
Bees	0.30	0.08	0.07	0.027	6.94	0.0009	S
P hym	12.21	1.56	16.00	1.57	3.11	0.0793	NS
GSB	1.70	0.21	0.12	0.05	58.35	0.0001	S
Other	0.19	0.04	0.16	0.044	0.50	0.5035	NS

Table 6. Sticky traps: Total number of insects found in sustainable and conventional landscapes.

	Sustainable	Conventional
Totals	6054	5729
Spiders	84	15
Flies	163	325
Bees	28	7
P hym	1136	1535
GSB	159	12
Other	18	2
Totals	1588	1919

NATIVE PLANT CONSERVATION

On a landscape basis, there were significant differences in relative flower visits by beneficial insects. Native plants in sustainable landscapes were found to have a greater frequency of flower visitations than plants in conventional landscapes (Figure 9). (ANOVA, F=264.92, df=1,734, P<0.0001). All means and standard errors are listed in Table 7. The top ten plants visited include nine from the sustainable landscape and one from the conventional landscape. Only *Solidago canadensis* was found to have significantly more visits that the other plants species (43.5 visits). *Cosmos* was the only bedding plant in the top ten .

Analysis of plants preferred by specific taxonomic groups of insects, demonstrated that *Monarda fistulosa* was prefered by bumble bees, *Solidago canadensis* was preferred by other bees, wasps and syrphids, and *Eupatorium maculatum* was preferrred by goldenrod soldier beetles. *Heliotropium* was preferred by honeybees and was the only bedding plant in the conventional landscape to which significant numbers of insects were attracted (Table 8). (ANOVA< F=8.79,df=1,224, P<0.0001; mutiple range test, REGWQ)

Figure 9. Behavioral observation: Top ten plant species for flower visits by insects

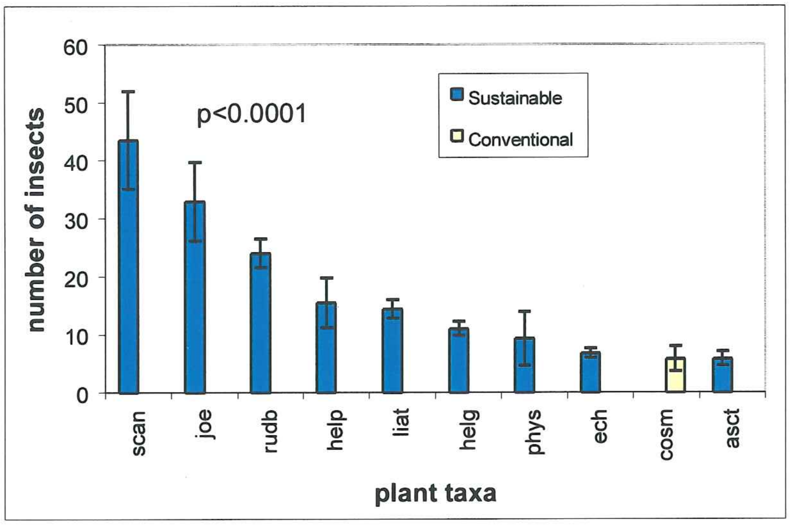


Table 7. Behavioral observation: Top ten plant species for flower visits by insects

Plant Species	Habitat	Mean	Std. Error
1. Solidago canadensis	Sustainable	43.5 a	8.46
2. Eupatorium maculatum	Sustainable	32.9 b	6.76
3. Rudbeckia hirta	Sustainable	24.0 bc	2.49
4. Heliopsis helianthoides	Sustainable	15.4 cd	4.29
5. Liatrus pycnostachya	Sustainable	14.5 cde	1.66
6. Helianthus tuberosus	Sustainable	11.0 fde	1.25
7. Physostegia virginica	Sustainable	9.32 fde	4.57
8. Echinacea purpurea	Sustainable	6.8 fde	0.82
9. Cosmos sp	Conventional	5.9 fde	2.06
10. Asclepias tuberosa	Sustainable	5.8 fde	1.20

(Multiple range test, REGWQ)

Table 8. Behavioral observation: Top ten plant species for flower visits by specific taxonomic groups of insects.

Insect Species	Landscape Type	Plant Species
Bumble bees	Sustainable	Monarda fistulosa
Honey bees	Conventional	Heliotropium arborescens
Other bees	Sustainable	Solidago canadensis
Syrphids	Sustainable	Solidago canadensis
Goldenrod soldier beetle	Sustainable	Eupatorium Maculatum
Wasps	Sustainable	Solidago canadensis
Pomp, dragonflies, leps	_________	No preference
Ambush bugs	_________	No preference

DISCUSSION

For all experiments conducted, sustainable landscapes containing native plants offered significant benefits for nutrient abatement and beneficial insect conservation.

NUTRIENT ABATEMENT AND WATER CONSERVATION

The data suggests that the establishment of a sustainable landscape is an effective method for the prevention of non-point pollution. Non-point pollution is a source of pollution in which wastes are not released at one specific, identifiable point but from a number of points that are spread out and difficult to identify and control (Miller 1986). Pollution is reduced as a result of lowered chemical inputs as well as reduced runoff. Pollution might also be reduced by less fertilization based on soil tests rather than on unsubstantiated marketing campaigns of lawn care services.

Plant Nutrients and Percent Moisture

Optimum plant growth depends on many management factors, one of which is sufficient nutrients. There are 16 essential elements required for plant growth (Rosen et al.1998). The two most important nutrients in terms of pollution are nitrogen (N) and phosphorus (P), since they are most commonly the limiting nutrients in aquatic ecosystems and can lead to eutrophication in surface water.

Eutrophication (over fertilization of surface water) along with the resultant excessive growth of nuisance algae and aquatic weeds is a major environmental concern. Phosphorous has been projected as the major essential nutrient most generally accessible as the target nutrient for the control of the offending plant growth (Browman et al.1979). By controlling the amount of phosphorus entering surface water, eutrophication caused by man can also be reduced.

Eutrophication accounts for approximately 50% of the impaired lake areas and 60% of the impaired rivers in the United States. A significant amount of phosphorus and nitrogen enters surface water from urban non-point sources, such as runoff of fertilizer applied to lawns and gardens. Urban runoff is the third most important cause of lake deterioration in the United States, affecting approximately 28% of the lake areas that do not meet water quality standards (Carpenter et al. 1979).

An alternative to conventional landscapes (which are a potential source of nutrients in urban runoff) is the use of resource efficient plants found in sustainable landscapes. These plants are well adapted to an area and consequently have low water and fertilizer requirements. Native plants, along with improved cultivars such as "Prairie" buffalograss (*Buchole dactyloides*), have been shown to be attractive plant materials that allow the design and construction of aesthetically-pleasing, resource-efficient landscapes that can reduce runoff pollution (Hipp et. al 1993).

The research demonstrated that conventional plants need more water for peak flowering than native plants. Moisture content of bedding plants was 18% greater at peak flowering compared to native plants. Consequently, native plants can produce peak floral displays with less water. Sustainable landscapes would therefore reduce water demands during peak water needs in summer months.

Nitrogen and phosphorus are particularly significant in plant growth and flowering (Brady 1974). Nitrogen levels were found to be 52% higher and phosphorus levels were 43% higher in bedding plants. These findings indicate that plants in sustainable landscapes need lower inputs of nutrients for plant growth and peak flowering. With less nutrient inputs required, there is a lower potential for runoff of nitrogen and phosporus into watersheds.

Biomass of Vegetative Material

One of the key mechanisms by which sustainable landscapes preserve water is their superior capability to trap and hold water runoff, which results in better water infiltration and filtering through the landscape ecosystem. As observed, sustainable landscapes possessed a dry weight that was 69% greater than plants in conventional landscapes. This biomass is composed of a matrix of fine and coarse-textured stems, leaves and various forms of flowers depending on plant species. In addition, native plants produce persistent vegetative stems and large fibrous root systems that hold together soils and reduce erosion especially during the late winter and spring when runoff occurs before any green vegetation is available to slow its course. Many gardeners find when digging up bedding plants in the fall that the roots have barely left the root plug.

Therefore, sustainable landscapes offer one of the most cost-efficient methods to control water and wind erosion of soil. Such control is very important in eliminating dust and mud problems around homes (Beard and Green 1994).

Ground Litter

The two landscapes investigated differed dramatically in the amount of litter. The conventional landscape had no litter present due to gardening practices of removing all senescing plant material. Sustainable landscapes contain litter layers from senesing plant material. Through the falling of leaves and other plant detritus, sustainable landscapes create a layer of litter covering the soil. The benefits for maintaining a layer of litter have been well documented. Mulch reduces water loss from the soil, suppresses weed growth, protects soil from temperature extremes, and provides habitat for beneficial insects such as ants and ground beetles (Carabidae)(Campell, 1991).

The presence of a litter layer has the additional advantage of conserving soil moisture. Although test results vary, it is well documented that moisture evaporation from soil covered by litter is reduced from 10 to 50 percent. By not removing plant residue landscapes begin to build a layer of litter on top of the soil. These pieces of leaves, stems and flowers help protect the soil against erosion from runoff. Litter prevents soil compaction and crusting of the soil surface by absorbing the impact of falling raindrops. Water penetrates better through loose soil, which helps to control water erosion by slowing water runoff and helps to hold soil in place, even on steep slopes. Litter also improves the condition of the soil by decomposing organic matter that remains, further helping the soil to remain loose. This improves root growth, increases the infiltration of water, and also improves the water-holding capacity of the soil. It also becomes a source of nutrients to plants and provides an environment for beneficial insects such as ground beetles (Carabidae) and ants.

A close connection exists between organic matter and available nitrogen content. Since carbon makes up a large part of the organic matter, it draws in available nitrogen as part of the decay process. Organic residue with a wide C/N ratio (50:1) supports heterophic flora such as bacteria, fungi, and actinomycetes that multiply rapidly, yielding carbon dioxide in large quantities. Under these conditions, nitrate nitrogen practically disappears from the soil because of the insistent microbial demand for this element to build their tissues (Brady 1974). The time interval of nitrate depression may vary depending on conditions. For example, the greater the amount of high carbon residue applied, the longer nitrification will be blocked. In addition, the narrower the C/N ratio of residue applied, the more rapidly the cycle will run its course. Soils with higher amounts of organic material were found to harbor higher numbers of beneficial fungi that suppress root rots (Hoitink 1999).

BENEFICIAL INSECT CONSERVATION OF BENEFICIAL INSECTS

Behavioral Observation at Flowers

Greater numbers of beneficial insects were observed in sustainable landscapes visiting native plants. Flowers provide sustenance for many beneficial insects. By creating the right habitat through proper plant selection, landscapes can become home to many beneficial insects. If the landowner is partial to flowers they should be aware that many flowers have been bred to be ornate and have lost the nectar and pollen characteristics that make them attractive to insects.

The Rodale Institute Research Center has conducted research to identify which plants are best for the attraction of beneficial insects. Preliminary findings indicate that insects prefer wildflowers and herbs. Wildflowers have not been bred for appearance and have maintained their natural functions of providing pollen and nectar for beneficial insects.

In addition to nectar and pollen, beneficial insects also require moisture, shelter from the wind, alternate prey to get them through the lean times, and places to spend the winter. The more diverse and varied the habitat which a sustainable landscape provides will better supply these needs (Poncavage 1991).

Ant Diversity

A greater number and more species of ants were found in the sustainable landscape. Only one species was found in the conventional landscape while five species were found in the sustainable landscape. Ants improve soil conditions in many ways. Air penetrates the soil through their burrows, they also bring earth to the surface from deeper soil layers resulting in improved soil condition. Ants are continuously searching vegetation and litter for prey and remove many pest insects.

CONSERVATION OF NATIVE PLANTS

Native plants have been shown to be important for conservation of biocontrol agents and pollinators (Kevan 1997). discusses how destruction of hedgerows in England has caused a large reduction in pollinator populations, such as bumble bees, which in turn reduces plant fecundity. Also, the removal of native plants from apple orchards has been shown to adversely affect populations of biocontrol organisms of apple pests. This is confirmed by Andow, who found that predation on herbivores was higher in diverse plant assemblages than in simplified plant assemblages (Andow 1991).

CONCLUSIONS

The data obtained through the comparative study and a search of the current literature suggests that establishment of sustainable landscapes is a practicable approach for the prevention of non-point source pollution and the conservation of beneficial insects.

Installation of sustainable landscapes in new developments, and replacement of existing conventional landscapes with resource-efficient plants as neighborhoods are updated, could provide municipalities with a cost-effective, low-maintenance and aesthetically pleasing strategy for mitigating pollution and stabilizing an area's ecological balance (Hipp, et.al 1993).

Regulations such as landscape and fertilizer application ordinances can assist municipalities with this task. Carver County Environmental Services has developed model ordinances and they are attached as Appendixes A and B respectively. Until such guidelines are in place, homeowners should be encouraged to establish sustainable landscapes which then can be used to convince others of their benefits. In addition, education strategies should be adopted to promote soil testing, proper fertilization, and other practices that reduce pollution in landscapes. An example of a phosphorus free-fertilizer education brochure is attached as Appendix C.

ACKNOWLEDGEMENTS

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REFRENCES

Anonymous. 1987. *Minnesota Landscape Arboretum: A Guidebook to the Arboretum.* 150pp.

Anonymous. 1998. *Backyard Conservation It'll Grow on you Mulching.* USDA Washington D.C. 4pp.

Andow, D. A. 1991. Vegetational diversity and arthropod population response. *Annual Review of Entomology*: 36:561-586

Beard, J., R.L. Green. 1994. The Role of Turfgrasses in Environmental Protection and Their Benefits to Humans. *Journal Environmental Quality*.23: 452-460

Brady, C. N. 1974. *The Nature and Properties of Soils.* New York, NY, Macmillan Publishing Co. Inc., 639 pp.

Browman, M.G, R.F. Harris, J.C. Ryden, and J.K.Syers. 1979. Phosphorus Loading from Urban Stormwater Runoff as a Factor in Lake Eutrophication: Theoretical Consideration and Qualitative Aspects. *Journal of Environmental Quality* 8(4): 561-566.

Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1979. Non-point Pollution of Surface Water with Phosphorus and Nitrogen. *Ecological Applications* 8(3): 559.568.

Campbell, S. 1991. The Mulch Book: A Complete Guide for Gardeners. Pownal Vermont. Storey Publishing Inc.,120pp.

Daniels, S. 1995. *The Wild Lawn Handbook: Alternatives to the Traditional Front Lawn.* New York , NY, Macmillan Inc., 223pp.

Hipp, B., H.S.Alexander, and T. Knowles. 1993. Use Of Resource-Efficient Plants to Reduce Nitrogen, Phosphorus, Residential and Commercial Landscapes. Water. *Science Technology* 28(3-5): 205-213.

Jones, S., and L.E. Foote. 1990 *Gardening With Native Wild Flowers.* Portland Oregon, Timber Press, Inc.,195 pp.

Kevan, P. 1997. Pollinating and Flower Visiting Insects and the Management of Beneficial and Harmful Insects and Plants. University of Guelph., pp. 439-452.

Krischik, V., K.J. Bevacqua. 1996. Sustainability in Urban Ecosystems, University of Minnesota Extension Service, University of Minnesota, bulletin FO-6709.

Miller, 1986.*Environmental Science: An Introduction*, Belmont, California. Wadsworth Publishing Company. 400 pp.

Poncavage, J. 1991. Beneficial Borders. *Organic Gardening*. May- June: pp 42-56.

Rosen, C., P. Bierman, and R. Eliason. 1998. Soil Test Interpretations and Fertilizer Management for Lawns, Turf, Garden, and Landscape Plants. University of Minnesota Extension Service, pp 44.

APPENDIX A

CARVER COUNTY MODEL SUSTAINABLE LANDSCAPE ORDINANCE

CARVER COUNTY

CARVER COUNTY
ENVIRONMENTAL SERVICES DEPARTMENT
600 EAST FOURTH STREET
CHASKA, MN 55318

CARVER COUNTY MODEL SUSTAINABLE LANDSCAPE ORDINANCE

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Carver County Model
Sustainable Landscape Ordinance

SECTION 1. PURPOSE

The use of sustainable landscapes made up of wildflowers and other native plants in a managed landscape design can be economical, low-maintenance, effective in soil and water conservation, supportive of wildlife and beneficial insects and may preclude the excess use of pesticides, herbicides, and fertilizers.

The purpose of this ordinance is to establish minimum standards for the provision, installation, and maintenance of sustainable landscape plantings in order to achieve a healthy and safe community by the following means:

A. **Water conservation.** Promote the conservation of potable and non potable water by encouraging the preservation of existing plant communities, encouraging the planting of natural or uncultivated areas, encourage the use of site-specific plant materials, and establish techniques for the installation and maintenance of landscape materials and irrigation systems.

B. **Aesthetics.** Improve the appearance of all areas through the incorporation of open space into development in ways that harmonize and enhance the natural and CONSTRUCTED environment.

C. **Environmental quality.** Improve environmental quality by recognizing the numerous beneficial effects of landscaping upon the environment, including:

1. Improving air and water quality through such natural processes as photosynthesis and mineral uptake.
2. Maintaining permeable land area essential to surface water management and aquifer recharge;
3. Reducing and reversing air, noise, heat, and chemical pollution through the biological filtering capacity of trees and other vegetation;
4. Reducing the temperature of microclimates through the process of evapotranspiration; and
5. Promoting energy conservation through the creation of shade, reducing heat gain in or on buildings or paved areas.

D. **Land value.** Maintain and increase the value of land by requiring landscaping to be incorporated into development, thus becoming by itself a valuable capital asset.

E. **Human value.** Provide direct and important physical and psychological benefits to human beings through the use of landscaping to reduce noise and glare, and to break up the monotony and soften the harsher aspects of urban development.

F. **Preservation of vegetation.** Preserve existing natural vegetation and incorporate native plants, plant communities, and ecosystems into the landscape design, where possible.

G. **Removal of nuisance species.** Eradicate or control certain plant species that have become nuisance because of their tendency to damage public and private works, to have a negative effect upon public health, or to disrupt or destroy native ecosystems.

H. **Improve design.** Promote innovative and cost-conscious approaches to design, installation, and maintenance of landscaping, encouraging water and energy conservation.

I. **Improve administration and enforcement.** Establish procedures and standards for the administration and enforcement of this [ordinance].

SECTION 2. DEFINITIONS

For the purpose of this ordinance, certain terms and words are defined as follows:

noxious weeds The following plant species are defined as noxious weeds by the Minnesota Noxious Weed Rules Chapter 1505.0730:

Common Name	Botanical Name
Field bindweed	*Convolvulus arvensis*
Hemp	*Cannabis sativa*
Loosestrife, purple	*Lythrum salicari, virgatum*, or any combination
Poison ivy	*Rhus radicans*
Spurge, leafy	*Euphorbia esula*
Sowthistle, perennial	*Sonchus arvensis*
Thistle, bull	*Cirsium vulgare*
Thistle, Canada	*Cirsium arvense*
Thistle, musk	*Carduus nutans*
Thistle, plumeless	*Carduus acanthoides*

preservation A means to keep intact desirable components of the existing vegetation at a building or construction site.

site specific planting The selection of plant material that is particularly well suited to withstand the physical growing conditions that are normal for that location.

restoration A means to replant a building or construction site with vegetation native to the region, including grasses, forbs, and trees.

SECTION 3. APPLICABILITY

This ordinance shall apply to new property development or to any permitted landscape renovation in excess of 20 percent on existing individual lots. No department shall issue a permit provided for herein in violation of regulations set forth herein.

SECTION 4. CONFLICTS

If the provisions of this [ordinance] conflict with other ordinances or regulation, the more stringent limitation or requirement shall govern or prevail to the extent of the conflict.

SECTION 5. SUSTAINABLE ADVISORY BOARD.

There is created a Sustainable Advisory Board composed of five members, appointed by the Carver County Board of Commissioners, for three years. The Sustainable Advisory Board (Advisory Board) members shall have knowledge, expertise, or experience in the field of botany, plant ecology, or the design, construction, or maintenance of landscapes. Upon request of any person who wishes to establish and maintain a sustainable landscape to which the notice provisions of Section 9. would be applicable, the Advisory Board shall provide advice and consultation to the person to ensure compliance with provisions set forth in this ordinance, including the use of plant species and plant association, that would be appropriate for and sensitive to the botanic character of the surrounding area.

SECTION 6. SITE DESIGN STANDARDS

A. Creative site development concept for water conservation. Creative site development shall be used in order to promote water conservation. Water requirements may be reduced by providing for:

The preservation of existing plant communities;
The reestablishment of native plant communities;
Limited amount of lawn grass area;
The use of site-specific plant materials (see definitions);
Site development that retains stormwater runoff on site;
The use of pervious paving materials;
Site development that addresses the carrying capacity of the land in its present form; and other environmental sensitive site development concepts.

B. Minimum open space requirements. Minimum open space requirements shall be required by [the zoning ordinance].

C. Preservation of existing plant communities. When existing natural plant communities occur on a parcel of land to be developed, at least 35 percent of the required open space shall be in the form of preserved natural plant communities.

D. Lawn grass area.

1. *General.* A major portion of water demand used for landscape purposes is required for irrigation of lawn areas. Portions of landscape areas that have been customarily designed as lawn should be:

    a) Preserved as natural plant communities;
    b) Planted as redeveloped native areas; and/or
    c) Planted with traditional mixes of trees, shrubs, and ground covers.
    d) Properly manage non-grass landscape developments of site-specific

planting will typically be able to survive drought conditions better than lawn areas.

2. *Maximum Use Requirements for Allowable Lawn Grass.* No more than 35 percent of the required green space area shall be planted in lawn grass.

E. Required Management Plan

1. *General.* For all areas of preserved plant communities larger than one-half acre in area, the owner shall submit for the approval of the Advisory Board, a narrative management plan indicating the manner in which the owner will preserve the native plant communities. The narrative shall include:

a. Whether the existing vegetation is to be preserved in the existing species composition;
b. If applicable, the manner in which the composition of existing plant material is to be preserved (hand removal of invasion species, prescribed burning, etc.);
c. The maintenance schedule for removal of exotic species and noxious weeds;
d. The maintenance schedule for removal of debris; and
e. Other information that may be required by the AdvisoryBoard that is responsible and necessary to make a determination that the management plan meets the requirements of this [ordinance];

SECTION 7. MAINTENANCE STANDARDS FOR CULTIVATED LANDSCAPE AREAS

A. ***General.*** The owner or assigns of land subject to this [ordinance] shall be responsible for the proper maintenance of said land so as to present a healthy, neat, and orderly landscape area.
B. ***Use requirements for maintenance of mulch layers.*** The required mulch layer shall be maintained on all landscape projects.
C. ***Mowing.*** Grass shall be mowed as required in order to encourage deep root growth and therefore the preservation of irrigation water.
D. ***Watering***
   1. *General.* All watering of planted areas shall be managed so as to:
   Maintain healthy flora;
   Make plant material more drought tolerant;
   Avoid excessive turf growth;
   Minimize fungus growth;
   Stimulate deep root growth;
   Minimize leaching of fertilizer; and
   Minimize cold damage.

   2. *Promoting Deep Root Growth of Trees and Shrubs.* Watering of plants and trees should always be in a sufficient amount to thoroughly soak the root ball of the plant and the surrounding area, thereby promoting deep root growth and drought tolerance.

SECTION 8. MAINTENANCE OF SUSTAINABLE LANDSCAPES

A. ***General.*** All sustainable landscapes shall be inspected [at least once a year] for noxious weeds, trash, or other debris.

B. ***Natural plant communities.*** All natural plant communities shall be managed in order to maintain the plant community for the purpose it was preserved.

1. *Required Management Plan.* When applicable, the Environmental Services Department shall make periodic inspections of the natural areas to verify the owner's adherence to the approved management plan as specified in [section 5E].
2. *Mechanical Equipment Shall Not be Used.* There shall be no use of mechanical equipment in accomplishing the maintenance of preserved plant communities unless specifically authorized in writing by the Environmental Services Department.

SECTION 9. LANDSCAPE PLAN REQUIRED

A. ***General.*** Prior to the issuance of any building permit, a landscape plan shall be submitted to, reviewed by, and approved by the (Advisory Board).

B. ***Nature of required plan.*** A landscape plan for each lot shall be prepared by and bear the seal of a landscape architect.

C. **Contents of Landscape plans**. The landscape plans shall:

1. Be drawn to scale, including dimensions and distances;
2. Show landscape features, including areas of vegetation required to be preserved by law, in context with the location and outline of existing and proposed buildings and other improvements on the site, if any;
3. Delineate the existing and proposed parking spaces, or other vehicular areas, access allies, driveways, and similar features;
4. Include a tabulation clearly displaying the relevant statistical information necessary for the Advisory Board to evaluate compliance with the provisions of this [ordinance]. This includes gross acreage, area of preservation areas, number of trees to be planted or preserved, square footage or paved areas, and such other information as the Advisory Board may require; and
5. Contain such information that may be required by the Advisory Board that is reasonable and necessary to determine that the landscape plan meets the requirements of this [ordinance].

COUNTY BOARD RESOLUTION
Carver County Model Sustainable Landscape Ordinance

WHEREAS, it is the role of local government to provide for appropriate solid waste management and disposal as well as protect the health, safety, and welfare of its residents;

WHEREAS, the current, predominant method of landscaping residential property involves the use of a lawn, the maintenance of which necessitates periodic mowing, watering, fertilizing, and applying of pesticides. Such a landscape is not sustainable because it produces large quantities of yard and other waste, creates air and noise pollution, consumes significant amounts of water, exposes residents and their pets to fertilizer and pesticides, and reduces population of songbirds and beneficial insects;

WHEREAS, the State of Minnesota has prohibited the disposal of yard waste in any solid waste disposal facility in the state after January 1, 1990. It is also a policy of the State of Minnesota to encourage solid waste reduction. Waste Management Act and Related Laws [115A.02 LEGISLATIVE DECLARATION ON POLICY; PURPOSES].

WHEREAS, it is in the public interest to promote activities which reduce air and noise pollution and conserve water supplies;

WHEREAS, there are people and animals which are sensitive to exposure to fertilizer and pesticides, as applied to lawns, and experience acute effects as a result of such exposure, including, but not limited to, severe reaction;

WHEREAS, there exist alternative methods of landscaping, other than the use of lawns, which produce little or no yard waste, do not necessitate the use of lawn mowing machines, need only small amounts of water, and require no fertilizers or pesticides. These alternative methods are not less visually pleasing than lawns, and they promote sustainability by maintaining diversity of plant life, reducing pollution and lowering conserve water.

THEREFORE, BE IT RESOLVED, That the Carver County Board of Commissioners hereby adopts the sustainable Landscape Ordinance No.

APPENDIX B

CARVER COUNTY MODEL LAWN FERTILIZER APPLICATION CONTROL ORDINANCE

CARVER
COUNTY

CARVER COUNTY
ENVIRONMENTAL SERVICES DEPARTMENT
600 EAST FOURTH STREET
CHASKA, MN 55318

CARVER COUNTY MODEL LAWN FERTILIZER APPLICATION CONTROL ORDINACE

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CARVER COUNTY
MODEL ORDINANCE CONCERNING
LAWN FERTILIZER APPLICATION CONTROL

SECTION 1. PURPOSE

The County has conducted studies and has reviewed existing data to determine the current and projected water quality of various lakes within its community. The data indicates that lake water quality may be maintained and improved if the County is able to regulate the amount of lawn fertilizer and other chemicals entering the lakes as a result of storm water runoff or other causes. The purpose of this ordinance is to define regulations that will aid the County in managing and protecting its water resources, which are enjoyed by its residents and other users.

SECTION 2. DEFINITIONS

For the purpose of this section, certain terms and words are defined as follows:

Commercial Applicator is a person who is engaged in the business of applying fertilizer for hire.

Fertilizer means a substance containing one or more recognized plant nutrients that is used for its plant nutrient content and designed for use or claimed to have value in promoting plant growth. Fertilizer does not include animal and vegetable manures that are not manipulated, marl, lime, limestone, and other products exempted by Rule by the Minnesota Commissioner of Agriculture.

Noncommercial Applicator is a person who applies fertilizer during the course of employment, but who is not a commercial lawn Fertilizer applicator.

Pesticide means a substance or mixture of substances intended to prevent, destroy, repel, or mitigate a pest, and a substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

Residential Applicator is a person who applies fertilizer to his or her own property.

SECTION 3. REGULATIONS FOR COMMERCIAL LAWN FERTILIZER LAWN APPLICATORS

Subd. 1. **License Required.** No person, firm, corporation or franchise shall engage in the business of commercial lawn fertilizer applicator within the County unless a license has been obtained from the Environmental Services Department or a designee as provided herein.

Subd. 2. **License Application Procedure.** Applicants for a commercial lawn fertilizer applicator license shall be submitted to the Environmental Services Department or a designee. The application shall consist of the following:

(a) Application Form. Applications forms shall be provided by the County and shall include the following instructions:

(1) Name, address and telephone number of applicant and any individuals authorized to represent the applicant.

(2) Description of lawn fertilizer formula proposed to be applied on lawns within the County.

(3) A time schedule for application of lawn fertilizer and identification of weather conditions acceptable for lawn fertilizer application.

(b) Product Material Safety Data Sheet. A copy of Material Safety Data Sheet, including product chemical analysis of the intended lawn fertilizer, shall be submitted to the County along with the initial application for a license, and, thereafter, at least seven days before fertilizer composition changes are implemented.

(c) Minnesota State Licenses. A copy of all licenses required of the applicant by the State of Minnesota regarding the application of pesticides and fertilizers.

(d) License. The license fee as established in Section 5. The license shall expire on the 31st day of December. The license fee shall not be prorated.

Subd. 3. **Conditions of License.** Commercial lawn fertilizer applicator licenses shall be issued subject to the following conditions which shall be specified on the license form:

(a) Random Sampling. Commercial lawn fertilizer applicators shall permit the County to sample any commercial lawn fertilizer applications to be applied within the County at any time after issuance of the initial license.

(b) Possession of License. The commercial lawn fertilizer license, or a copy thereof shall be in the possession of any party employed by the commercial lawn fertilizer applicator when making lawn fertilizer applications within the County.

(c) Possession of Product Material Safety Data Sheet. A copy of product Material Data Safety Sheet of the lawn fertilizer used shall be in the possession of any party employed by the commercial lawn fertilizer applicator when making lawn fertilizer applications within the County.

(d) State Regulations. Licensee shall comply with the provisions of the Minnesota Fertilizer and Soil Conditioner Law as contained in Minnesota Statutes Sections 17.711 through and including 17.729 and amendments thereto. The licensee shall also comply with the provisions of the Pesticide Control as contained in the Minnesota Statutes Chapter 18B.

SECTION 4. GENERAL REGULATION

Subd. 1. Time of Application. Neither commercial, noncommercial or residential applicators may apply lawn fertilizer when the ground is frozen or when conditions exist which will promote or create runoffs.

Subd. 2. Sample Analysis Cost. The cost of analyzing fertilizer samples taken from commercial applicators shall be paid by the commercial applicators if the sample analysis indicates that phosphorus content exceeds the levels authorized herein.

Subd. 3. Fertilizer Content. Neither a commercial nor a noncommercial or residential applicator shall apply any lawn fertilizer, liquid or granular, within the County which contains any amount of phosphorous or other compound containing phosphorous, such as phosphate, **except**:

(a) the naturally occurring phosphorous in unadulterated natural or organic fertilizing products such as yard waste compost

(b) or as otherwise provided in Section 1170.05.

Subd. 4. Impervious Surfaces and Drainage Ways. No person shall apply fertilizer to impervious surfaces, areas within drainage ditches, or waterways.

Subd. 5. Buffer Zone. Fertilizers and pesticides shall not be applied:

a) to any established natural buffer zones as outlined in County Wetland Ordinance No. _____;

b) below the Ordinary High Water lines as established by the Minnesota Department of Natural Resources; or

c) with ten (10) feet of any wetland or water resource.

Subd. 6. **Warning Signs for Pesticide Application.** All commercial or noncommercial lawn fertilizer applicators who apply pesticides to turf areas must post or affix warning signs on the property where the pesticides are applied. The warning signs shall comply with the following criteria and contain the following information:

(a) The warning signs must project at least eighteen (18) inches above the top of the grass line. The warning signs must be of a material that is rain resistant for at least a forty-eight (48) hour period and must remain in place up to forty-eight (48) hours from the time of initial application.

(b) The following information must be printed on the warning signs in contrasting colors and capitalized letters measuring at least one-half inch (1/2"), or in another format approved by the Minnesota Commissioner of Agriculture. The signs must provide the following information:

(1) The name of the business, entity, or person applying the pesticide; and

(2) The following language: "This area chemically treated. Keep children and pets off until (date of safe entry)" or a universally accepted symbol and text approved by the Minnesota Commissioner of Agriculture as recognized as having the same meaning or intent as specified in this subparagraph. The warning signs must include the name of the pesticide used.

(c) The warning sign must be posted on a lawn or yard between two (2) feet and five (5) feet from the sidewalk or street. For parks, golf courses, athletic fields, playgrounds, or other similar recreational property, the warning signs must be posted immediately adjacent to areas within the property where pesticides have been applied and at or near the entrances to the property.

SECTION 5 EXEMPTION TO PHOSPHOROUS REQUIREMENTS.

The limitation pertaining to quantity of phosphorous shall not apply to:

(a) newly established or developed turf and lawn areas during first growing season; or

(b) turf and lawn areas on which a soil test confirms are below phosphorous levels established by the University of Minnesota Extension Services. The lawn fertilizer application shall not contain an amount of phosphorous exceeding the amount of phosphorous and the appropriate application rate recommended in the soil test evaluation.

Phosphorus applied as lawn fertilizer pursuant to the aforementioned exemptions shall be watered into the soil where it is immobilized and generally protected from loss by runoff.

At least 24 hours prior to applying lawn fertilizer that exceeds the phosphorus limits specified in this Chapter, the County must receive notice from the commercial license applicator of the lawn fertilizer application, the reason for exceeding the phosphorous limitations provided in this Chapter and the amount of phosphorous contained in the lawn fertilizer to be applied.

SECTION 6 PENALTY.

Any person violating this Chapter shall be guilty of a petty misdemeanor. The County may revoke a commercial applicator's license for repeat violations of this Chapter.

SECTION 7 LICENSE FEE.

Commercial Lawn Fertilizer:
Applicator License

(a) $100.00, which includes the use of one vehicle.
(b) $ 25.00 for each vehicle used in the application of Fertilizer in the County in excess of first vehicle.

APPENDIX C

Phosphorus-Free Fertilizer

Q & A

Q If I fertilize my lawn, why should I use a phosphorus-free fertilizer?

A Phosphorus from fertilizers runs off lawns and ends up in area lakes and wetlands where it promotes algae growth. Algae can turn a blue lake green and damage or kill the lake's eco-system.

Q If I don't live near a lake, stream or wetland, should I be concerned about using phosphorus-free fertilizer?

One pound of phosphorus in a lake can yield 500 pounds of algae.

A Yes! If you live in the city, r u n – o f f from your lawn flows into the storm sewer system. The storm sewer system empties directly into lakes, wetlands and streams.

Fifteen to thirty percent of phosphorus in urban run-off comes from lawns.

Q How can I tell if a fertilizer is phosphorus-free?

A The make-up of all fertilizers is indicated by a series of three numbers on the package. The middle number indicates the amount of phosphorus the fertilizer contains. Look for a middle number of "0" to be sure you are buying phosphorus-free fertilizer.

Q If phosphorus poses a threat to lakes and wetlands, why is it in fertilizers in the first place?

Carver County residents apply unnecessary phosphorus to their lawns each year.

A In some parts of the country, soils need phosphorus to sustain healthy plant development – but that's not true in our state. Minnesota generally has soils that are rich in phosphorus. In fact, the soil in Carver County has high or very high levels of phosphorus, according to a recent study by Hennepin Parks. The study showed that levels were so high, the vast majority of lawns tested did not need any phosphorus.

In general, Minnesota has soils that are rich in phosphorus.

Q How do I know if ***my*** soil needs fertilizer? If it does, how do I determine what kind to use?

A A soil test will give you a nutrient profile of ***your*** soil. Armed with this information, you can buy the fertilizer that will work best for your lawn. Soil test kits are easy to use. Kits are available from the University of Minnesota Extension Service at 374-8400. The cost to have your soil analyzed is $7.

Q Will I have to change my lawn care practices to successfully use phosphorus-free fertilizer?

A No. Continue to use good lawn care practices.

- Follow the instructions on the bag, if you choose to fertilize.
- Aerate your lawn. Aeration will remove small plugs of grass and loosen the soil. This will promote healthy root development.
- Water your lawn deeply, as needed. A good rule of thumb is to water ½ to 1 inch at a time.
- Mow your grass properly. Maintain grass at a height of 2-3 inches. Cut no more than 1/3 of the grass leaf each time. Also, use a sharp blade or mulching mower so grass clippings can stay on the lawn.

Fertilizer Ordinance

To protect water quality, Carver County regulates the use of fertilizer and pesticides. Under city ordinance:

- Fertilizer may not be applied on hard surfaces.
- You may not apply fertilizer or pesticides near wetlands or waterways.
- Commercial fertilizer applicators must be licensed to work in Plymouth. They, along with businesses which fertilize, must use phosphorus-free fertilizer. Exemptions may be obtained for newly established lawns or for hose for which a soil test has shown that phosphorus is needed. Commercial applicators may not apply fertilizer on frozen ground or when other conditions exist which promote or create run-off.
- For detailed information on requirements, call 361-1800.

Soil Testing

For information on soil testing, call the University of Minnesota – Hennepin Extension Office at 374-8400. A $7 fee is charged for soil analysis.

Finding Phosphorus-Free Fertilizer

Several area stores carry phosphorus-free fertilizer.

STOP! For best results for your lawn and for the environment:

- Read and follow manufacturer's instructions for fertilizer application printed on the bag.
- Wait until mid-May to fertilize.
- Watch the weather forecast. Never fertilize before a heavy rain; never apply fertilizer to wet grass, but water thoroughly after application.
- Mow lawn to normal height 1 to 2 days before applying fertilizer.
- Apply fertilizer at a rate of 4 pounds per 1,000 square feet. Spread fertilizer evenly over the lawn.
- Check the bag for the correct setting for your spreader.
- Fill your spreader on a hard surface where spills can be cleaned up. Never wash fertilizer spills into the street where it is carried to surface water through the storm sewer system.
- Close the gate on the spreader when crossing hard surfaces.
- Use a drop spreader near shoreline areas for more precise application.
- Avoid getting fertilizer into natural drainage areas or pathways where it can be carried into surface water.
- Near shorelines, leave a buffer of natural vegetation to prevent erosion and retain nutrients.

Carver County
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