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Landfill Cover Revegetation Using Organic Amendments and Cobble Mulch in the Arid Southwest

Richard Aguilar, Stephen F. Dwyer, Bruce Reavis, Gretchen Newman
and Samuel R. Loftin

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Landfill Cover Revegetation Using Organic Amendments and Cobble Mulch in the Arid Southwest

Richard Aguilar
YMP Performance Assessment Department

Stephen F. Dwyer, Bruce Reavis, and Gretchen Newman
Environmental Restoration Technology Department

Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-0778

Samuel R. Loftin
MS-M887
Los Alamos National Laboratory
Los Alamos, NM 87545

Abstract

Cobble mulch and composted biosolids, greenwaste, and dairy manure were added to arid soil in an attempt to improve plant establishment and production, minimize erosion, increase evapotranspiration, and reduce leaching. Twenty-four plots (10 x 10 m) were established in a completely randomized block design (8 treatments, 3 plots per treatment). Treatments included 1) non-irrigated control, 2) irrigated control, 3) non-irrigated greenwaste compost (2.5 yd³ per plot), 4) irrigated greenwaste compost (5 yd³ per plot), 5) non-irrigated biosolids compost (2.5 yd³ per plot), 6) irrigated biosolids compost (5 yd³ per plot), 7) cobble-mulch, and 8) non-irrigated dairy manure compost (2.5 yd³ per plot). Soil samples were collected from each plot for laboratory analyses to assess organic matter contents, macro-nutrient levels and trace metal contents, and nitrogen mineralization potential. All plots were seeded similarly with approximately equal portions of cool and warm season native grasses.

The organic composts (greenwaste, biosolids, dairy manure) added to the soils substantially increased soil organic matter and plant nutrients including total nitrogen and phosphorus. However, the results of a laboratory study of the soils' nitrogen mineralization potential after the application of the various composts showed that the soil nitrogen-supplying capability decreased to non-amended soil levels by the start of the second growing season. Thus, from the standpoint of nitrogen fertilizer value, the benefits of the organic compost amendments appear to have been

relatively short-lived. The addition of biosolids compost, however, did not produce significant changes in the soils' copper, cadmium, lead, and zinc concentrations and thus did not induce adverse environmental conditions due to excessive heavy metal concentrations.

Supplemental irrigation water during the first and second growing seasons did not appear to increase plant biomass production in the irrigated control plots over that produced in the non-irrigated control plots. This surprising result was probably due to the cumulative effects of other factors that influenced the initial establishment and production of plants in the plots (e.g., plant species competition, seed germination delay times, differences in nutrient release and availability).

Variation within individual plots, and among the three replicate plots associated with each treatment, rendered many of the recorded differences in vegetation establishment and production statistically insignificant. However, after two complete growing seasons the highest total plant foliar cover and the greatest biomass production and plant species diversity occurred in the cobble-mulched plots. These results suggest that cobble-mulch may be the desired amendment in re-vegetated arid landfill covers if the principal objectives are to quickly establish vegetation cover, stabilize the site from erosion, and increase water usage by plants, thereby reducing the potential for leaching and contaminant movement from the landfill's waste-bearing zone.

Acknowledgements

We wish to thank the City of Albuquerque Public Works Department for supplying the biosolids compost used in this research. Gratitude is especially extended to J. Steven Glass for his dedication and continued interest in the implementation of field studies that investigate the beneficial use of biosolids and their composts. We also thank Andrew Bristol and his staff at the New Mexico State University's Soil, Water, and Air Testing Laboratory for their assistance with soil and plant analyses. Gratitude is also extended to Dr. Bill Lindemann, Professor of Soil Science, at New Mexico State University for his many helpful insights on the probable interactions among the soils and vegetation. Finally, we would like to thank all technical and support staff from Sandia and the USDA Forest Service's Rocky Mountain Station not included in the authors list of this document for their valuable contributions to this research.

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1.0 Introduction

Sandia National Laboratories (SNL) implemented a project designed to evaluate alternative waste landfill cover designs for arid regions. This project, the Alternative Landfill Cover Demonstration (ALCD), includes six prototype landfills (Figure 1) on which the effectiveness of different engineered cover designs for waste isolation are being tested (Dwyer et al. 1998). The landfills have been designed with surface and subsoil water monitoring devices (e.g., surface runoff water collection troughs, timed-domain refractrometry (TDR), and leachate collection basins). These landfill covers were installed to compare costs and document the performance of alternative landfill cover technologies, on a direct side-by-side basis, for interim stabilization and/or final closure of landfills in arid and semiarid environments.

As an extension of the ALCD landfill cover study, a multiplot soil amendment study, was established to evaluate the benefits of soil amendments for plant establishment and growth on disturbed sites such as landfill covers. This approach differs notably from current revegetation technologies employed in landfill revegetation projects wherein covers are generally re-seeded with appropriate plant species and mulched upon closure of the landfill. Generally, no soil amendments are applied to landfill surfaces.

The ultimate goals of a cover system design are to minimize future maintenance while protecting human health and the environment (EPA 1991, p. 1). Although the isolation of the buried waste from surface waters and percolating leachate is a major criteria for an effective landfill cover, cover stability from erosion is also important. Therefore, the establishment and maintenance of an effective vegetative cover early on is essential.

The EPA encourages design innovation for landfill covers as long as the alternative design is equivalent to the EPA-recommended design or will successfully meet the intent of the regulations governing the recommended design (EPA 1991, p. 1). Current EPA regulations and guidelines state that a properly designed and maintained cover should minimize percolating water movement through the landfill cover and prevent the leaching of waste constituents into the underlying groundwater. A goal of this study was to obtain information that could be used to help establish guidelines for improving topsoil conditions and encourage maximum vegetation establishment and growth on arid landfill covers. The specific objective of this research was to establish the conditions that maximize evapotranspiration and minimize soil erosion and leaching potential. It is these factors that will most ensure the continued isolation of near-surface wastes and contaminants in arid and semiarid environments.

Soils in arid regions are often low in organic matter and associated plant nutrients. These limitations often make successful revegetation difficult. Consequently, landfill cover "topsoil" could potentially benefit from organic amendments in an attempt to increase soil fertility and improve soil water retention for subsequent plant uptake.

To minimize leaching and transport of soil contaminants in landfills, an effective vegetative cover consisting of plants that are biologically active when leaching potential is greatest is essential. Indigenous grassland plants in arid and semiarid regions are well adapted to prolonged dry soil conditions because they can effectively "shut down" during the frequent intervals of no precipitation. Utilization of precipitation water by these plants during the typical growing season

(May through October) can be almost 100% creating little opportunity for saturated flow and leaching in soils (Aguilar and Aldon 1991). The potential for saturated soil conditions and leaching can exist, but these occurrences are generally restricted to prolonged wet periods in the early spring (March through April). Early spring, when warm season grasses and forbs are dormant and the soils remain saturated from the winter recharge period, is the greatest potential for saturated soil conditions and leaching (Aguilar and Aldon 1991).

In addition to traditional organic amendments such as dairy manures and their composts, treated municipal waste water solids (biosolids) have been successfully used as a soil conditioner and fertilizer in degraded rangeland (Aguilar et al. 1994; Fresquez et al. 1990a & 1990b). Recent studies have also shown that cobble mulching in arid regions can ultimately result in greater vegetation cover establishment and production because cobbles on the ground surface reduce the evaporative losses from the underlying soil, thereby increasing the quantity of water available for plant uptake (White and McDonnell 1988).

The use of organic matter amendments as a fertilizer and soil conditioning agent and the use of cobble mulch as a method for promoting plant water availability may also reduce incidences of costly secondary efforts to establish adequate vegetation cover in failed projects. Furthermore, the beneficial use of organic amendments to increase vegetation establishment on landfill covers and other disturbed sites represents a desirable alternative to non-beneficial disposal practices, such as land-filling, to dispose of organic wastes.

1.1 Technical Objectives

The ALCD soil amendment study had two primary technical objectives:

1. Evaluate the changes in soil properties resulting from soil amendments including biosolids, greenwaste, and dairy manure composts, and
2. Quantify the differences in plant establishment and production under the various organic treatments tested, and correlate these to soil properties.

Water is probably the single most important variable influencing plant establishment and growth in arid and semiarid regions. The desired primary function of the cobble mulch treatment was to increase the availability of water to plants by enhancing the infiltration of water through the cobble inter-spaces to the underlying surface soil. The cobble layer would then serve to decrease the direct evaporation of this water, thereby making more water available for plant uptake within the rooting zone.

The study plots were monitored for two years after the project's implementation. Soils in the study plot were sampled and analyzed prior to the incorporation of the organic amendments into the upper six inches of soil. The soils were re-analyzed in Spring 1997 and Spring 1998 to assess changes in organic matter and nutrient contents resulting from the amendments. Seedling establishment, growth, and survival of plants were evaluated by comparing species abundance and biomass (*see* Section 2.4) within the various plots at the end (e.g., late fall) of each of the

two growing seasons monitored during the study. The eight surface soil amendment treatments evaluated were:

1. Control non-irrigated
2. Control irrigated
3. Greenwaste compost (2.5 yd³) non-irrigated
4. Greenwaste compost (5.0 yd³) irrigated
5. Biosolids compost (2.5 yd³) non-irrigated
6. Biosolids compost (5.0 yd³) irrigated
7. Cobble mulch (surface application, 2-3 inch diameter stones) non-irrigated
8. Dairy manure compost (2.5 yd³ per plot) non-irrigated.

Irrigation water quantities are given in Section 2.5.

2.0 Methodology

2.1 Field Experimental Design and Site Preparation

The soil amendment study site was a triangularly-shaped area of approximately 2 acres (0.8 ha) located east of the project's existing alternative landfill design covers. Study plots were delineated in a completely randomized block design consisting of 24 plots (eight treatments × three replicates of each treatment). The existing native vegetation (arid rangeland grasses and shrubs) within the study site was scraped away and the topsoil (upper 30 cm of soil) was then graded and moved to one corner of the site for temporary storage. The underlying soil was mechanically "ripped" to a depth of 30 to 60 cm to disrupt the natural soil structure. The stockpiled soil was then spread back uniformly onto the site as topsoil. The cumulative effect of the vegetation and topsoil removal and ripping of subsoil was to simulate site disturbance during a landfill excavation and the subsequent replacement of topsoil after closure of the landfill. Seventy-two soil samples were collected (upper 15 cm of topsoil were extracted with the aid of a spade) from the study area (24 plots, 3 samples per plot) to establish pretreatment conditions among the 24 study plots prior to the addition of various amendments.

2.2 Plot Establishment

The layout of the 24 (10 m x 10 m) study plots (Figures 2 and 3) within the triangularly shaped area included approximately 3.0 m buffer strips between each plot (boundary runoff control structures were not needed because of the nearly-level, 0-2% slope gradients, topographic characteristics of the study area). The greenwaste and biosolids composts were donated by the City of Albuquerque's Public Work's Wastewater Utility Division.

The dairy manure compost and cobbles were purchased locally from private enterprises. Either 2.5 yd³ or 5.0 yd³ (depending upon the treatment) of organic amendment was applied to each plot with a front-end loader (0.5 yd³ bucket) and spread uniformly over that entire plot. The amendments were then rototilled to a depth of approximately 15 cm. All the plots were seeded with a mixture of cool and warm season native grassland species (Table 1) using a typical agricultural rangeland seeder pulled by a tractor.

2.3 Soil Sampling and Laboratory Analyses

Three (3) soil samples were obtained from random sites within each plot to establish the soil chemical baseline prior to the addition of the organic amendments and cobble mulch (Appendix B). Each soil sample (approximately 1.0 kg) was taken from the upper 15 cm of soil. The samples were placed in air-tight, Zip-lock[®] plastic bags and transported to a greenhouse where they were allowed to air dry. The soil samples were passed through a 2 mm (#10) sieve to separate the fine-earth fraction (less than or equal to 2.0 mm diameter particles) from coarse fragments (greater than 2.0 mm diameter). The soil passing through the sieve (fine-earth fraction) was then re-bagged and transported to New Mexico State University's Soil Water and Air Testing Laboratory for textural and chemical analyses. This soil sampling procedure was repeated in Spring 1997 and Spring 1998 to establish the fertility status of the soils in each plot at

the beginning of each growing season and to compare the fertility status of the amended soils to the pretreatment soils (*see* Appendix B).

Soil samples were analyzed for pH, electrical conductivity (EC), percent organic matter, total nitrogen (TKN), total phosphorus (TP), potassium chloride-extractable ammonium-nitrogen ($\text{NH}_4\text{-N}$) and nitrate-nitrogen ($\text{NO}_3\text{-N}$), sodium bicarbonate extractable- phosphorus (Ext-P) and total contents of cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn) and molybdenum (Mo). In addition, the textural characteristics of the soils were determined on soils obtained during the first sampling period (Fall 1996). Organic-C contents were determined by chromic acid oxidation using the modified Walkley-Black method described by Nelson and Sommers (1975). Total nitrogen was determined on Kjeldahl digests (Bremner and Mulvaney 1982). The methodology outlined by Olsen and Sommers (1982) was used to obtain an index of plant-available phosphorus (NaHCO_3 -extractable P) in these alkaline soils. Potassium chloride (KCl) extractable $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ were determined colorimetrically following the procedures outlined by Bremner (1965). The EC and pH measurements were made on 1:1 soil:water pastes.

Laboratory-induced mineralization of nitrogen in soil samples can be used as an index of soil nitrogen levels that could potentially become available for plant uptake in the field. Composite soil samples from each study plot were analyzed for nitrogen mineralization potential at the University of New Mexico's Department of Biology. Following collection in the field, the samples were kept cool and transported in sealed ice containers to the university. Upon arrival at the university laboratory, each sample was sieved and the fine-earth fraction (material less than 2.0 mm diameter) was retained for analysis. Water content (expressed as the fraction of dry/wet weight) of each sample was determined by weight loss upon drying at 105° C. Organic matter (expressed as percent) was determined by loss upon ignition of dried samples at 500° C.

After determining water-holding capacity (WHC; White and McDonnell 1988), a portion of each sample was adjusted to 50% of determined WHC and six subsamples were apportioned into plastic cups. Each cup contained approximately 10 g dry-weight mineral soil. One subsample of each sample was immediately extracted with 100 ml 2 N KCl for $\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N}$ analyses. The remainder of the cups were covered with plastic wrap, sealed with a rubber band, and incubated in the dark at 20 °C. The plastic wrap minimized water loss during incubation, yet exchange of CO_2 and O_2 was sufficient to keep the subsamples aerobic during incubation. Moisture content was monitored by mass loss and replenished as needed (just once during the 75-day incubation period on Day 42). At 2-week intervals, one subsample of each sample was removed and extracted with KCl for 18-24 hrs. The clarified KCl was filtered and analyzed for $\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N} + \text{NO}_2^-\text{-N}$ on a Technicon AutoAnalyzer.

2.4 Vegetation Analyses

Plant establishment and growth on the various study plots were evaluated using the Community Structure Analysis (CSA) field transect method (Pase 1981). The CSA technique was used to determine plant foliar density and cover. Foliar cover is defined as the area of the ground surface covered by above-ground plant parts projected to the ground surface. Plant density is the number of plants per unit area. These two vegetation abundance indices were measured for total vegetation (all plant species combined), and grass (species listed in Table 1), forb

(globemallow—*Sphaeralcea*, Indianwheat – *Plantago*, etc.), and weed species (Russian thistle—*Salsola Kali* and summer-cypress—*Kochia Scoparia*).

Two vegetation transects, each 9-m long, were established on each study plot (a buffer zone of 0.5 m along the periphery of the plot boundaries was eliminated from the transect measurements). A measuring tape was laid on the ground along the transects and the vegetation composition was measured each meter along the tape by setting down a small frame (approximately 10 cm x 5 cm in size) and recording the percentage cover of all plant species occurring within the frame. At two locations along each transect (3 m and 7 m) the total number of plant species were recorded within a larger frame (0.5 m x 1.0 m). The average density and foliar cover for each treatment was calculated from the data recorded for the three replicate plots for each treatment (see Appendix C).

The above-ground plant biomass production on each study plot was estimated by harvesting all of the above-ground plant material present within a 0.5-m frame placed at four random grid locations within the plot. Sample locations were designated using a random number generator to select four grid-cells within a grid composed of 200 cells per plot (0.5 m² area per grid-cell). The harvested plant material was placed in large paper bags (approximately 12-liter capacity) and transported to the laboratory for processing. The samples were oven-dried at 60 °C for 24 hours and weighed. Total plot biomass (kg/ha) was then estimated from the average sample biomass (g/0.5m²) collected from each plot.

2.5 Irrigation Treatments

The effects of supplemental water on vegetation establishment and growth response were tested by irrigating three sets of treatment plots: 1) Control + Irrigation, 2) Biosolids Compost (5 yd³) + Irrigation, and 3) Greenwaste Compost (5 yd³) + Irrigation. The irrigation waters were intended as a supplement to the generally low natural rainfall inputs during the spring and early summer months (March through early July) characteristic of the arid Southwest. The irrigation water was applied with oscillating lawn sprinklers that broadcast along a 12 m² path. Placing the sprinklers at the center of the plots ensured the most uniform application of the water. However, the placement of the sprinklers within the plots was varied depending upon the direction of light winds and breezes. The plots were not irrigated under high wind conditions. Three rain gauges were placed in each plot to record the total water applied with irrigation.

Table 2 shows the total quantities of irrigation water applied on the three sets of plots receiving irrigation water and the average quantities applied during each irrigation session. The complete irrigation data, including individual events, are shown in Appendix A. The target quantity of added water during each irrigation was approximately 0.25 inches (6.4 mm) over a 50-minute period. Water applied to the plots during each session (Appendix A) varied from about 0.18 inches (4.6 mm) to 0.41 inches (10.4 mm). This variation was primarily the result of wind effects on the distribution of the irrigation water within the plots. The plots were irrigated twice as often in 1998 because the occurrence of natural precipitation was less frequent than during the previous summer.

The total natural precipitation during the three month period April through June (Table 3) was substantially lower in 1998 (0.87 inches) compared to the same period in 1997 (3.25 inches). Note that the 1998 precipitation total was over 3.5 times greater than the 1997 precipitation. Statistical analysis using the methods described below (Section 2.6) showed that there were no significant differences in the amounts of irrigation water applied to various treatments receiving the supplemental water over the study's duration.

2.6 Statistical Analysis

Analysis of variance (ANOVA) techniques were used to test for statistically significant differences between treated and control plots in plant cover (grass, forb and weeds) and nutrient and trace elements in soils. The soils statistical analyses included contrasts among plots in properties directly or indirectly influencing plant growth (e.g., pH, EC, CaCO_3 -equiv.), percent organic matter, and quantities of other plant nutrients (e.g., phosphorus, nitrogen) and heavy metals of cadmium, copper, iron, lead, and zinc. The vegetation statistical analyses included comparisons of total plant cover, density, and frequency among treatments.

Repeated measures of analysis of variance was used to test for significant main factors such as treatment and time, significant interactions, normally distributed data, and homoscedasticity (homogeneous variances). If the data were normally distributed and had homogeneous variance, a one-way analysis of variance was carried-out, followed by a Tukey's multiple comparison test. If problems with non-normality or heteroscedasticity were encountered, the "more robust" Pillai's statistic was used, followed by the appropriate multiple comparison test. Unless otherwise noted, a type I error rate of $\alpha = 0.05$ was used for all statistical analyses.

For the nitrogen mineralization potential analysis a one-way ANOVA was used to determine the effect(s) of treatment on soil sum-N content. Samples extracted at the beginning of the incubation and after 70-day incubation were tested. Statistical significance was determined at the $\alpha = 0.05$ level.

3.0 Results and Discussion

3.1 Organic Amendment Properties

The three organic materials tested in this study are biosolids compost (composted municipal sewage sludge from the City of Albuquerque), greenwaste compost (derived primarily from composted organic material such as grass clippings, woody debris – tree branches, etc), and dairy manure compost. Biosolids are rich in organic matter, nitrogen and trace minerals. The U.S. Environmental Protection Agency (EPA 1995) encourages the safe beneficial re-use of this material. Although there has traditionally been some degree of public skepticism about potential health hazards associated with the application of biosolids to land as an organic amendment, properly treated biosolids pose minimal, if any, public hazard when used as an organic amendment (EPA 1995). Albuquerque wastewater biosolids are treated through a program that includes both dedicated land disposal and composting for beneficial re-use. Properly managed, composting qualifies as a “Process to Further Reduce Pathogens” under EPA regulations; that is, composted biosolids may safely be used in the production of crops for direct human consumption. De-watered biosolids are combined with other natural materials like discarded animal waste and chipped yard trimmings to create a moist, porous mixture. Special mixing and turning equipment is used to optimize natural aerobic microbial processes, which convert the mixture into a premium quality soil builder. The 135° F heat produced by naturally occurring microbes pasteurizes the material, killing unwanted bacteria and viruses. After a three-week active composting phase and a three-week curing phase, composted biosolids are screened to remove wood chips, yielding a relatively odor-free product. The greenwaste compost is processed in a similar manner by the City of Albuquerque. At the time of this documentation, specific details about the processing of the dairy manure compost from the commercial vendor were not available, however, the assumption is that this material is processed similarly to the biosolids and greenwaste composts produced by the City of Albuquerque.

The three organic composts contrasted in this study differ somewhat in their chemical composition (Table 4). The biosolids compost had the highest percentages of the two most important plant nutrients, total nitrogen and total phosphorus. The dairy manure compost had both the highest pH and salt content, as indicated by the notably higher EC. This higher salt concentration could potentially limit plant establishment and growth at very high applications of the compost. Thus, the biosolids and greenwaste composts would appear to be the more desirable organic amendments for the re-establishment of vegetation on the study plots. Regarding the contents of cadmium (Cd), copper (Cu), lead (Pb) zinc (Zn) and molybdenum (Mo), plants require only very small amounts of these elements and excess amounts could produce toxicity problems. It is not anticipated that the higher quantities of these elements in the biosolids compost would yield hazardous concentrations in the soils at the study site. As stated previously (Section 2.2), the composts were thoroughly mixed into the upper six inches (15 cm) of the soil, which diluted the concentrations considerably. Additionally, the high pH soils at the study site would likely render these metals immobile and unavailable for plant uptake (Brady 1984, p. 371). The soil concentrations in the study plots amended with biosolids were compared to existing EPA soil concentration limits to ensure that safety standards were not exceeded.

3.2 Soil Properties

3.2.1 Pretreatment Soil Properties

Prior to the addition of organic amendments and cobble mulching, the general textural characteristics, nutrient levels (organic matter, nitrogen, and phosphorus), pH, and EC of the upper 6.0 inches (15 cm) of soil were assessed. These characteristics are listed in Table 5. The plot's specific quantities of the various nutrient and chemical elements associated with each study treatment are listed in Appendix B.

The relatively low organic matter, total nitrogen, and phosphorus contents are typical of arid rangeland soils, wherein plant production and biological activity are limited by low annual precipitation inputs. The alkaline soil pHs (> 7.0) and the relatively high EC and calcium carbonate contents reflect the overall low leaching of soluble salts due to the low annual precipitation at the study site. The low organic matter and associated nitrogen and phosphorus contents in the soil at the study site indicate that organic amendments should enhance plant establishment and productivity.

To objectively assess the effects of the various soil amendment treatments on the nutrient and chemical properties influencing vegetation establishment and subsequent productivity, we needed to establish that the pre-application soil organic matter and nutrient contents among the study plots were not statistically different. The average contents of organic matter, total nitrogen and total phosphorus in pretreatment soils did not differ significantly ($P < 0.05$) prior to the application of the various amendments (Figures 4 - 6). Total phosphorus contents (Figure 6) in particular were quite uniform among the study plots prior to the soil amendments. This was not surprising because the total phosphorus content in soils generally reflects the original content in the parent material and tends to be independent of organic/inorganic transformations (Smeck 1973). The majority of the nitrogen in soil is associated with organic matter and thus, the variation in total soil N observed among the treatments (Figure 5) was correlated strongly with the observed variation in soil organic matter (Figure 4).

3.2.2 Changes in Organic Matter, Total Nitrogen and Phosphorus After Treatment

The changes in organic matter and associated nutrients were measured eight months after the application of the various organic amendments. The addition of 5 yd³ of organic amendments resulted in approximately six-fold increases in organic matter, total nitrogen, and total phosphorus.

The organic matter contents (Figure 7) in the soils of the 5.0 yd³ biosolids and 5.0 yd³ greenwaste compost treatments were significantly higher ($P < 5\%$) than the 2.5 yd³ greenwaste compost or no organic amendment treatments (control and cobble-mulched plots). Changes in total nitrogen (Figure 8) followed a similar trend, however, the 2.5 yd³ biosolids treatment also increased the nitrogen content significantly over the levels observed in the control and cobble-mulched plots. Only the two biosolids composts and the dairy manure compost significantly increased the total phosphorus contents above those measured in the plots without organic

amendments (Figure 9). It is not surprising that the 2.5 yd³ greenwaste compost amendment did not significantly increase the percent soil organic matter, total nitrogen, or total phosphorus contents over levels observed in the control plot soils, considering that this material was substantially lower in total nitrogen and phosphorus (Table 4).

The differences in organic matter, total nitrogen and total phosphorus observed at the start of the first growing season in 1997 (eight months after the applications) were generally sustained into the start of the second growing season in 1998 (18 months after the applications) are shown in Figures 10 through 12. However, the total nitrogen in the dairy manure-amended plots did decrease appreciably, displaying a greater loss of nitrogen than the other organic amended soils (Figure 11).

Not surprisingly, the cobble-mulch treatment did not significantly change the organic matter, total nitrogen and phosphorus contents of the soil over control plot levels in the two-year duration of this study. However, the treatment should eventually lead to increased organic matter, associated nutrients, and greater plant production if the cobble mulch effectively increases the quantity of water available for plant uptake (White et al. 1998).

3.2.3 Changes in pH, EC and Trace Metals after the Soil Amendments

Figures 13a-c and Figures 14a-c show the pH and EC of the soils, respectively, on the various plots prior to the application of the amendments and the subsequent changes resulting from the treatments. Prior to the application of the amendments, there were no significant differences in either pH (Figure 13a) or EC (Figure 14a). Eight months after the amendments, the pH in plots amended with both the 2.5 and 5.0 yd³ biosolids compost treatments and the 5.0 yd³ greenwaste compost had decreased significantly over those in the control plots, while the dairy manure compost and cobble-mulch treatments did not significantly change the pH (Figure 13b). However, only the 5.0 yd³ biosolids compost significantly increased the EC above the control and cobble-mulched plot levels (Figure 14b). By the start of the second growing season (Spring 1998), only the higher amendment of biosolids compost sustained significantly lower pH than the control and cobble-mulched plots (Figure 13c).

A major concern with the addition of organic amendments to soils is the potential increase in soluble salts to levels that might adversely affect plant establishment and growth. As indicated by the EC values recorded for the three compost materials (Table 4), the dairy manure compost had the highest potential for increasing the soluble salts to levels that might adversely affect plant establishment and growth. A soil with an EC exceeding 4.0 dS m⁻¹ is classified as saline and soluble salt contents associated with these high ECs could potentially interfere with the normal growth of most plants (Brady 1984, p. 215). Addition of organic amendments did not increase the soils' EC greater than 4.0 dS m⁻¹ in any of the study plots. Although the dairy manure compost material had substantially higher EC (Table 4) it appears that uniformly mixing the material within the topsoil resulted in dilution of the soluble salts in the plot soils to levels comparable to the other amended soils. The EC levels of the all organic matter-amended soils remained well below 4.0 dS m⁻¹ eight months after the addition of the various amendments and then continued to decrease with time (compare Figures 14b and 14c). The decrease in soluble salts with time are likely the result of progressive leaching below the 15-cm soil sampling depth.

One environmental concern related to the application of biosolids is the potential increase of trace heavy metals in the treated soils to levels potentially above established regulatory standards. Heavy metals in biosolids can accumulate in soils to phytotoxic levels, but this scenario is most likely in soils that receive multiple applications of the material. Subsequent accumulation of heavy metals in plant tissues can result in biomagnification and potential toxicity within consumer organisms. However, the relatively low, one-time application of biosolids in the form of composted material was not expected to increase heavy metal contents beyond regulatory standards.

It was not practical to analyze the soils for changes in the entire array of metals present in the biosolids compost. However, because of the potential toxicity and availability to plants, we analyzed the soils for changes in copper, cadmium, lead, zinc, and total molybdenum contents. With the exception of zinc, the total quantities of these constituents were quite low. Cadmium and molybdenum were below laboratory detection levels and copper ranged from 2 to 10 ppm, with most samples closer to the lower end of the range. The recorded total zinc contents are well within the range (10-30 ppm) reported for natural (unamended) soils (Lindsay 1979, p. 211).

Figures 15, 16 and 17 show the levels of copper, lead and zinc in the soils prior to and after the various treatments. Prior to the application of the amendments (Figures 15a, 16a, 17a), there were no significant differences in the quantities of copper, lead, or zinc among the study plot soils. However, with the addition of the various amendments, distinct differences were observed with greater quantities of all three metals measured in the two biosolids compost-amended soils. However, because of the relatively low levels recorded for all three metals and their relatively high variability, the differences in the soil between the two biosolids composts and the other treatments were generally not significant ($P > 0.05$). The analyses established that the biosolids composts did not increase the soil concentrations of these three potentially toxic metals anywhere near the potentially toxic levels established by the U.S. Environmental Protection Agency (EPA, 1995). This rule stipulates that soil concentration limits for copper, lead and zinc in lands amended with biosolids should not exceed 750, 150, and 1,400 mg kg⁻¹ soil, respectively (EPA 1995, Table 18, p. 117). Comparison of values in Figures 15b-c, 16b-c, and 17b-c show that soil concentrations in the study soils were well below these levels after the organic amendments. Although changes in metal levels in the control plots are observed among the three sampling periods, these minor differences are likely the result of the analytical error and do not affect our contract analyses among treatments.

3.2.4 Soil Nitrogen Mineralization Potential

Soil samples collected in the field and then tested in the laboratory for their potential to mineralize nitrogen indicate that the organic amendments do initially increase nitrogen availability to plants. However, the assimilation of these organic materials by microorganisms as time progresses could potentially reduce nitrogen availability to plants.

Inorganic nitrogen in the initial extractions for the Spring 1997 soil samples was significantly higher in both the 2.5 yd³ and 5.0 yd³ biosolids compost applications (Figure 18a), whereas all other treatments were not significantly different from each another. However, by the end of the incubation period, there were numerous significant differences among treatments (Figure 18b).

The 2.5 yd³ biosolids compost-amended soil had the greatest amount of mineralizable N (20.7 mg N kg⁻¹). In contrast, the two greenwaste composts and the 5 yd³ biosolids compost-amended soil contained only 0.8, 1.0 and 1.5 mg N kg⁻¹, respectively, suggesting strong nitrogen immobilization (tying-up of inorganic nitrogen as organic forms in the biomass of microbes).

The second-year (Spring 1998) soil samples tested for mineralizable nitrogen potential produced very different results for the biosolids-amended plots. Inorganic nitrogen concentrations in the initial soil extractions were low (less than 5 mg kg⁻¹) in all soil samples and there were no significant differences among any of the treatments (Figure 19a). However, at the end of the 70-day incubation (Figure 19b) the treatments were segregated into two distinct groups. The first group comprised the greenwaste and biosolids compost-treated samples. This group yielded low mineralizable nitrogen (less than 3 mg kg⁻¹) and values that were significantly lower than the second group of treatments. The second group included the control, irrigated control, dairy manure compost, and the second group included the control, irrigated control, dairy manure compost, and the cobble-mulch treatments which yielded mineralizable nitrogen values between 7 and 11 mg kg⁻¹. Among this second group of samples the dairy manure compost-treated soils yielded significantly higher mineralizable nitrogen values than the control and cobble mulch samples, but not from the irrigated control samples.

Important changes and consistent patterns are evident when comparing the second year (1998) results to the first year (1997) results. The sum of the nitrate and ammonium in the soil extractions at the end of the 70-day incubation period for the dairy manure compost, the cobble mulch, and the control treatments in 1998 were very similar to those produced for the 1997 analyses. However, the initial high levels of inorganic-N in the soils amended with biosolids compost were not present in the initial extractions in 1998.

Both biosolids compost-treated soils showed minimal change in the quantity of mineralizable nitrogen during incubation in 1998. This indicates net immobilization throughout the incubation period (as carbon dioxide was released through the mineralization process) without a noticeable increase in soil inorganic nitrogen. Strong net immobilization was also indicated for the 5.0 yd³ biosolids-amended soils during the 1997 incubations, but only moderate immobilization occurred for the 2.5 yd³ biosolids-amended soils. As in the previous year, the two greenwaste compost-amended soils displayed high levels of immobilization during the 1998 incubations.

The laboratory nitrogen mineralization potential experiments indicated that, based upon soil nitrogen availability alone, the greatest potential for plant production during the second growing season should occur on the dairy manure compost-amended plots. The experiments also indicated that the lowest plant production should occur in the plots amended with the greenwaste and biosolids composts because these amendments tended to immobilize soil nitrogen over time. However, actual production in the field will also be limited by the availability of soil moisture. The water-amended plots (irrigated control, the 5 yd³ greenwaste, and 5 yd³ biosolids compost-amended plots) would be expected to produce more plant biomass than the 2.5 yd³ dairy manure compost-amended plots if water availability was more limiting than nitrogen.

3.3 Vegetation Response to Soil Amendments

3.3.1 First Year Vegetation Response

The total (all species) plant foliar cover percentages for the replicate plots associated with the various treatments after the first growing season are presented in Table 6 and the means and standard errors are plotted in Figure 20a. The values reported in Table 6 show the large variation within treatments. The highest plant foliar cover (Figure 20a) occurred on the cobble-mulch treated plots, followed by the irrigated biosolids (5 yd³) treatment. The lowest foliar cover occurred in the 2.5 yd³ biosolids compost treatment. Due to the large within treatment variability, the only significant difference ($P < 0.05$) occurring among treatments was between the cobble mulch and the 2.5 yd³ biosolids compost treatment.

The first year total plant density (number of plants per unit area) for the replicate plots associated with the various treatments are presented in Table 7. Averages and standard errors are plotted in Figure 20b. High variability within treatments was again observed (Table 7). Plant density was significantly greater for the greenwaste compost (2.5 yd³) than all other treatments, and the number of plants in the dairy manure compost-treated plots was significantly less than most of the other treatments.

The cover percentages and density of grasses, forbs, and weeds for the treatment replicate plots are outlined in Tables 8–13. The overall effect of the organic amendments and cobble mulch after one growing season appears to have been the increased establishment and production of weed species accompanied by the inhibition of grass and forb species establishment and growth. In many of the plots where total plant cover and density were dominated by weeds (Russian thistle – *Salsola Kali*, and summer cypress – *Kochia Scoparia*), grass and particularly forb establishment was greatly compromised. In general, the plots with organic amendments and the cobble-mulch treated plots had much higher percentages of weed foliar cover (Table 12) and numbers of weed plants (Table 13). Averages and standard errors for percentage cover and density of grasses and weeds are plotted in Figures 21a-b and 22a-b. Treatment averages for forbs were not plotted because their absence in many of the plots rendered statistical analysis unnecessary.

Total grass cover production and grass density was not found to be significantly different among any of the treatments during the first growing season (Figures 21a and 21b). However, the percentage cover by weeds on the cobble mulch plots was significantly higher than for the other treatments (Figure 22a). Figure 22b shows that the largest number of weeds were established in the greenwaste compost (2.5 yd³) treatment. Comparison of the percentage of weed cover (Figure 22a) and weed density (Figure 22b) reveals an interesting difference between the cobble mulch and 2.5 yd³ greenwaste treated plots.

Although the total weed density on the 2.5 yd³ greenwaste treated plots was much higher than on the cobble-mulched plots, the weed cover percentage was higher on the latter. This indicates that the weeds (especially Russian thistle – *Salsola kali*) growing in the cobble-mulched plots were larger plants that consequently covered more of the ground surface.

3.3.2 Second Year Vegetation Response

Total plant foliar cover percentages associated with the eight study treatments after the second growing season (1998) are outlined in Table 14. Large variations among the plots associated with each treatment were again recorded. Averages and standard errors associated with each treatment are plotted in Figure 23a. The highest mean percent total plant foliar cover was again measured on the cobble-mulch treated plots. This was the only amendment treatment that was significantly greater ($\alpha = 0.05$) than the control (unamended) plots. The remainder of the site treatments did not vary significantly among each other or from control plots.

The second year (1998) total plant density for the replicate plots associated with the various treatments are outlined in Table 15; averages and standard errors are plotted in Figure 23b. Large variation among the replicate plots for each treatment was again observed

(Table 15), especially for the 2.5 yd³ greenwaste treatment. Only the 5.0 yd³ greenwaste compost-amended plots had significantly greater total plant density than the control (unamended) plots.

Ground cover and density of grasses, forbs, and weeds recorded after the second growing season for the various treatments are outlined in Tables 16 through 21. As in the first growing season, grass and forb establishment was greatly suppressed in those plots where total plant cover and density were dominated by weeds (Russian thistle – *Salsola Kali* and summer cypress – *Kochia Scoparia*). Figures 24a-b and 25a-b show the mean grass and weed foliar cover and density relationships among the eight treatments. Figures for forbs were not constructed because their absence in many of the plots rendered contrasts among the eight study treatments unnecessary.

The 2.5 yd³ greenwaste compost-treated plots had the highest percent grass cover and greatest number of grass plants established, while grass density and cover was lowest in the cobble-mulched plots (Figures 24a-b). The cobble-mulched plots had the highest total weed cover, and this was significantly greater than the percentage cover in the two sets of control plots (irrigated and non-irrigated), or the 2.5 yd³ biosolids and 2.5 yd³ greenwaste compost-treated plots (Figure 25a). However, due to the large within treatment variation, the difference between the cobble-mulched and the 5.0 yd³ biosolids and greenwaste compost-treated plots, and the 2.5 yd³ dairy manure compost-treated plots was not significant.

Comparison of the percentage of weed cover (Figure 25a) and weed density (Figure 25b) again revealed the inverse relationship between total plant density and cover between the cobble-mulched and 5.0 yd³ greenwaste treated plots. As observed after the first growing season (Figure 22a-b), the weed cover percentage was highest on the cobble-mulched plots. However, the weed density on the 5.0 yd³ greenwaste treated plots was higher than on the cobble-mulched plots. These statistics again reflected the larger weed plants growing in the cobble-mulched plots.

Differences in total plant biomass production among the treatments for the two growing seasons are outlined in Table 22 and plotted in Figure 26a-b. During the first growing season (1997), the cobble-mulched plots, as well as all of the organic-amended plots (with the exception of the 2.5 yd³ biosolids-treated plots), had greater biomass production than the control plots. The total biomass production on the cobble-mulched plots was approximately 40% greater than that in the

non-irrigated control plots (0.7 kg m^{-2} vs. 0.5 kg m^{-2}). However, due to large within treatment variations, the differences among treatments were not statistically significant ($\alpha = 0.05$) as shown in Figure 26a. An interesting finding was that the supplemental irrigation water did not appear to increase plant biomass production in the irrigated control plots over the production in the control non-irrigated plots. One possible explanation for this is that the vegetation was not sufficiently moisture-stressed during the 1997 growing season and, therefore, did not respond to supplemental irrigation with greater biomass production. Some of the other plant establishment and production indices (Figures 21a-b, 22a) reflected a positive response to the supplemental irrigation, but again, due to large within treatment variations, the differences among the various treatment plots were not statistically significant (Figures 26a).

Figures 27 through 34 contrast the differences in plant establishment and growth in representative plots subjected to the various surface amendment treatments. The photographs below were all taken in late September 1997 with the primary objective of documenting vegetation composition (plant density, height and vigor, and percent cover) within each plot. Direct comparisons among the various treatments are somewhat difficult because the photographic distance and angle of exposure from the plots varied. However, the photographs still provide a general indication of the differences in plant establishment and growth among the various treatments. As stated earlier, all of the organic amendments, with exception of the higher (5 yd^3) application of greenwaste compost, increased both plant establishment (plant density) and growth (biomass production) when compared to the unamended control plots.

Biomass production on all study plots in 1998 was substantially reduced in comparison to the first growing season (Table 22). The difference can be attributable to the lower precipitation during the 1998 growing season. As discussed earlier (Section 2.5), the total precipitation during the three-month period between April and June 1998 was 0.87 inches (22.1 mm). This precipitation total was much lower than that occurring during the same period in 1997 (3.25 inches or 83.0 mm). Total biomass production on the non-irrigated control plots in 1998 was only 22% of the total in 1997, 0.11 kg m^{-2} versus 0.50 kg m^{-2} , respectively (Table 22). Comparison of the 1998 control irrigated plots with the 1997 control non-irrigated plots indicates that the supplemental irrigation water did not provide the quantity of water needed by the vegetation to attain 1997 levels of production (Figures 24a-b).

During the second growing season, the cobble-mulched plots, the 5.0 yd^3 biosolids compost and the dairy manure compost treatments produced the highest total plant biomass (Figure 24b). Although production on the cobble-mulched plots was statistically greater than production on the control plots (irrigated and non-irrigated) and most of the other organic amendments, the difference between the cobble-mulched plots and the treatments with the next highest biomass production (dairy manure and 5.0 yd^3 biosolids compost) was not statistically significant.

4.0 Summary and Conclusions

Organic amendments (composted biosolids, greenwaste, and dairy manure) significantly increased organic matter and associated plant nutrients in the study plot soils. This increase, in turn, resulted in differences in plant establishment and production. All organic amendments initially increased soil organic matter and plant nutrients (including total nitrogen and phosphorus). However, laboratory experiments on the soils' nitrogen mineralization potential after the application of the various composts indicated the nitrogen-supplying capability of the organic composts had decreased to levels comparable to those in the non-amended soils by the second growing season. Thus, from the standpoint of nitrogen fertilizer value, the benefits of the organic compost amendments appear to have been relatively short-lived. This finding was surprising given that the benefits of organic amendments to soil fertility in arid environments have been shown to persist for longer periods (White et al. 1997). An important difference between the White et al. (1997) study results and our results are that the organic amendments in the former study were applied to the surface as a mulch treatment. In this study the organic composts were incorporated and mixed uniformly into the upper six inches of soil by rototilling. Incorporation and mixing within the soil may have resulted in more rapid mineralization and subsequent immobilization of the nitrogen in the soil and ultimately resulted in decreased plant-available soil nitrogen levels. Neither of the two applications rates (2.5 yd^3 or 5.0 yd^3 per 100 m^2) of biosolids compost produced significant change in trace heavy metal contents in the soils (see Section 3.2.3, Figures 13-15).

The amendments, including the cobble mulch, tended to favor the establishment of weed species (Russian thistle-*Salsola Kali*, and summer cypress-*Kochia Scoparia*), possibly at the expense of the more desirable grass and forb species (see Figures 19-23, Sections 3.3.1 and 3.3.2).

Large within treatment variation in plant biomass production, during each of the two growing seasons evaluated, rendered many of the differences among the treatments statistically insignificant at the significance level of the statistical analyses ($\alpha = 0.05$). Although the organic compost-amended plots produced greater biomass production than the control plots, the differences were due largely to greater establishment and production of weed species as is generally observed in revegetation studies of disturbed sites.

An interesting finding was that supplemental irrigation water did not increase plant biomass production in the irrigated control plots over that produced in the non-irrigated control plots. Furthermore, although overall plant production was substantially reduced in 1998 (the drier of the two growing seasons), the supplemental irrigation did not increase plant foliar cover and biomass production to those levels observed in the non-irrigated control plots in 1997. Mature plant communities in arid and semiarid rangeland generally respond favorably to any moisture received. However, we conclude that many other factors (e.g., seed germination, seedling establishment, plant species competition, nutrient release and availability) are involved in the initial establishment and production of plants in re-seeded arid rangeland sites. Consequently, differences in the quantity of water received (precipitation and irrigation) alone did not account for the differences in vegetation establishment and subsequent growth observed at our study site during these first two growing seasons.

The dominance of weedy species on all treatment plots during the study's first two years is not surprising and the findings are consistent with what is generally observed at other disturbed sites. Although secondary succession varies from site to site, the general pattern of plant re-establishment is colonization and dominance by annual weeds in the first and second year followed by an increase in perennial species after the second year (Whittaker, 1970, p.174). At the ALCD site we anticipate that the Russian thistle and summer cypress, which dominated the plant cover and density during the study's first two years, will progressively decrease and the numbers of native perennial grasses and forbs will continue to increase with time.

Depending upon the overall objective of a revegetation effort, the strong establishment and production of weed species during the early period following revegetation may still be a desirable outcome. In landfill closure, the primary objective is to limit the infiltration of water to the underlying waste so that the creation of leachate that could possibly migrate to underlying groundwater is minimized (EPA, 1991). Another important objective is to minimize the potential for surface soil erosion. The various amendments evaluated in this study certainly increased plant cover establishment and biomass production. These two parameters are essential for maximizing evapotranspiration and minimizing surface soil erosion. The highest percentage of plant foliar cover and the greatest biomass production occurred on the cobble-mulched plots. Consequently, we conclude that cobble mulch was the most effective of the various treatments evaluated during the two-year duration of this study.

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6.0 Tables

Table 1. Grass species selected for revegetation of the soil amendment study plots.

Grass Species	Desired Establishment* (percent)	Quantity in Mixture** (lbs/acre)
Warm Season Grasses		
<i>Bouteloua gracillis</i> (blue grama)	20	1.0
<i>Hilaria jamesii</i> (galleta)	10	3.0
<i>Sporobolus cyptandrus</i> (sand dropseed)	50	0.5
Cool Season Grasses		
<i>Oryzopsis hymenoides</i> (Indian ricegrass)	10	3.0
<i>Stipa comata</i> (needle & thread)	10	4.0
Totals	100	11.5

* Approximate percentage of total species in number of plants per given area.

** Note that differences in weight among the various species can result in large differences in the mass ratio (lbs/acre) of seed required in the seed mixture.

Table 2. Quantities (inches) of irrigation water applied to selected plots during late spring and early summer months (May–July).

Treatment	Replicate Plot	1997		1998	
		Total Annual Irrigation	Plot Average per Session	Total Annual Irrigation	Plot Average Per Session
Control + Water	1	1.76	0.25	3.58	0.26
	2	1.90	0.27	3.15	0.23
	3	2.08	0.30	3.34	0.24
Greenwaste (5 yd ³) + Water	1	1.90	0.27	3.28	0.23
	2	1.55	0.22	3.86	0.28
	3	1.72	0.25	3.42	0.24
Biosolids (5 yd ³) + Water	1	1.49	0.21	4.03	0.29
	2	1.45	0.21	3.82	0.27
	3	1.59	0.23	3.58	0.26

Table 3. Total precipitation (inches) at the ALCD study site during April through June, 1997 and 1998.

Natural Precipitation (inches) at ALCD Project Site				
Year	Apr	May	Jun	Total
1997	1.69	0.61	0.95	3.25*
1998	0.70	0.00	0.17	0.87

*1997 precipitation total is over 3.5 times greater than 1998

Table 4. Chemical composition of the three organic composts evaluated for their plant establishment and growth enhancement capabilities.

Compost	Percent		pH	EC (ds m ⁻¹)	Mg kg ⁻¹				
	TKN	Total P			Cu	Cd	Pb	Zn	Mo
Dairy Manure	0.88	0.36	8.73	13	17	<1	<10	61	1
Greenwaste	0.67	0.21	7.82	6	25	<1	13	62	1
Biosolids	1.05	0.62	7.39	7	93	1	34	138	5

Table 5. General textural characteristics and chemical composition of the upper 6.0 inches (15 cm) of soil at the study site plots before the application of organic compost amendments.

Soil Property	Value
Texture	70% sand, 15% silt, 15% clay (sandy loam texture)
Organic Matter	0.54-0.78%
Total Nitrogen Content (TKN)	287 – 470 mg kg ⁻¹
Total Phosphorus (P)	224 – 263 mg kg ⁻¹
Hydrogen Ion Concentration (pH)	7.79 - 7.89
Electrical Conductivity, EC	0.56 – 1.47 (ds m ⁻¹)
Calcium Carbonate (CaCO ₃) – Equiv.	4.0 – 12.0%

Table 6. Percentage of total (all species combined) plant foliar cover measured in the replicate plots for each treatment in Fall 1997.

Treatment	Total Plant Foliar Cover (%)		
	Plot 1	Plot 2	Plot 3
Control	33.9	42.2	26.4
Control + Water	45.3	38.1	49.2
Greenwaste (2.5 yd ³)	60.8	54.2	43.3
Greenwaste (5 yd ³) + Water	28.6	55.3	39.2
Biosolids (2.5 yd ³)	13.6	36.7	33.6
Biosolids (5 yd ³) + Water	58.2	55.0	47.5
Cobble Mulch	48.1	53.7	73.9
Dairy Manure (2.5 yd ³)	53.1	30.0	46.7

Table 7. Density of plants (all species combined) per square meter measured within the replicate plots for each treatment in Fall 1997.

Treatment	Density of All Plants (per m ²)*		
	Plot 1	Plot 2	Plot 3
Control	11.8	16.5	14.8
Control + Water	12.5	14.3	13.8
Greenwaste (2.5 yd ³)	27.0	26.8	18.0
Greenwaste (5 yd ³) + Water	10.8	8.3	8.8
Biosolids (2.5 yd ³)	15.3	14.3	14.5
Biosolids (5 yd ³) + Water	6.3	7.0	9.0
Cobble Mulch	8.8	8.8	15.8
Dairy Manure (2.5 yd ³)	7.0	4.0	4.5

*Number of plants were measured within 0.5 m² frames at 3- and 7-m positions along CSA transects, for a total of four replicates.

Table 8. Percentage of grass foliar cover measured within the replicate plots for each treatment in Fall 1997.

Treatment	Grass Foliar Cover (%)		
	Plot 1	Plot 2	Plot 3
Control	1.95	3.05	0.56
Control + Water	4.17	0.00	3.33
Greenwaste (2.5 yd ³)	0.28	8.90	6.67
Greenwaste (5 yd ³) + Water	0.56	3.33	3.06
Biosolids (2.5 yd ³)	0.28	0.06	1.67
Biosolids (5 yd ³) + Water	0.00	0.28	*
Cobble Mulch	1.11	0.00	
Dairy Manure (2.5 yd ³)	1.67	0.00	0.00

*No grasses encountered along the two transects recorded within the plot.

Table 9. Density of grasses established within the replicate plots for each treatment in Fall 1997.

Treatment	Density of Grasses (per m ²)		
	Plot 1	Plot 2	Plot 2
Control	3.0	2.5	3.3
Control + Water	7.0	6.0	2.5
Greenwaste (2.5 yd ³)	1.8	7.0	6.5
Greenwaste (5 yd ³) + Water	1.5	2.0	2.3
Biosolids (2.5 yd ³)	11.3	0.8	2.8
Biosolids (5 yd ³) + Water	1.3	0.8	-*
Cobble Mulch	0.0	0.3	-*
Dairy Manure (2.5 yd ³)	1.0	0.5	0.5

* No grasses encountered within the four 0.5 m² grids where plant density was measured within the plot.

Table 10. Percentage of forb foliar cover measured in the replicate plots for each treatment in Fall 1997.

Treatment	Forb Foliar Cover (%)		
	Plot 1	Plot 1	Plot 3
Control	0.56	1.39	1.39
Control + Water	4.17	_*	_*
Greenwaste (2.5 yd ³)	0.83	_*	_*
Greenwaste (5 yd ³) + Water	_*	_*	_*
Biosolids (2.5 yd ³)	0.28	0.00	_*
Biosolids (5 yd ³) + Water	_*	_*	_*
Cobble Mulch	0.00	_*	_*
Dairy Manure (2.5 yd ³)	_*	_*	_*

*No forbs encountered along the two transects recorded within the plot.

Table 11. Density of forbs established within the replicate plots for each treatment in Fall 1997.

Treatment	Density of Forbs (per m ²)		
	Plot 1	Plot 2	Plot 3
Control	0.3	1.0	0.0
Control + Water	0.0	_*	_*
Greenwaste (2.5 yd ³)	0.5	_*	_*
Greenwaste (5 yd ³) + Water	_*	_*	_*
Biosolids (2.5 yd ³)	0.5	0.5	_*
Biosolids (5 yd ³) + Water	_*	_*	_*
Cobble Mulch	0.3	_*	_*
Dairy Manure (2.5 yd ³)	_*	_*	_*

* No forbs encountered within the four 0.5 m² grids where plant density was measured in the plot.

Table 12. Percentage of weed foliar cover measured in the replicate plots for each treatment in Fall 1997.

Treatment	Weed Foliar Cover (%)		
	Plot 1	Plot 2	Plot 3
Control	31.39	37.77	24.45
Control + Water	36.94	38.06	45.83
Greenwaste (2.5 yd ³)	60.56	44.44	36.67
Greenwaste (5 yd ³) + Water	28.06	51.95	36.11
Biosolids (2.5 yd ³)	13.06	36.67	31.94
Biosolids (5 yd ³) + Water	58.22	55.00	47.23
Cobble Mulch	48.06	52.56	73.89
Dairy Manure (2.5 yd ³)	51.39	30.00	46.66

Table 13. Density of weeds established within the replicate plots for each treatment in Fall 1997.

Treatment	Density of Weeds (per m ²)		
	Plot 1	Plot 2	Plot 3
Control	8.5	13.0	11.5
Control + Water	5.5	8.3	11.3
Greenwaste (2.5 yd ³)	25.3	19.3	11.5
Greenwaste (5 yd ³) + Water	9.3	6.3	6.5
Biosolids (2.5 yd ³)	3.5	13.5	11.3
Biosolids (5 yd ³) + Water	5.0	7.0	8.3
Cobble Mulch	8.8	8.8	15.3
Dairy Manure (2.5 yd ³)	6.0	3.5	4.0

Table 14. Percentage of total (all species combined) plant foliar cover measured in the replicate plots for each treatment in Fall 1998.

Treatment	Total Plant Foliar Cover (%)		
	Plot 1	Plot 2	Plot 3
Control	21.1	23.6	24.5
Control + Water	13.3	10.8	40.6
Greenwaste (2.5 yd ³)	26.7	40.3	39.2
Greenwaste (5 yd ³) + Water	25.0	32.8	36.9
Biosolids (2.5 yd ³)	31.4	42.0	30.6
Biosolids (5 yd ³) + Water	51.4	38.1	21.4
Cobble Mulch	63.6	60.0	41.7
Dairy Manure (2.5 yd ³)	41.7	29.5	31.1

Table 15. Density of plants (all species combined) per square meter area measured within the replicate plots for each treatment in Fall 1998.

Treatment	Density of All Plants (per m ²)		
	Plot 1	Plot 2	Plot 3
Control	228.5	189.0	182.0
Control + Water	370.0	446.0	358.0
Greenwaste (2.5 yd ³)	404.0	129.5	136.5
Greenwaste (5 yd ³) + Water	712.5	477.0	553.5
Biosolids (2.5 yd ³)	241.0	493.5	522.0
Biosolids (5 yd ³) + Water	389.0	296.0	292.5
Cobble Mulch	433.5	169.5	318.0
Dairy Manure (2.5 yd ³)	331.0	321.0	323.0

* Number of plants were measured within 0.5 m² frames laid the ground at the 3- and 7-m points along the CSA transects, for a total of four replicates.

Table 16. Percentage of grass foliar cover measured within the replicate plots for each treatment in Fall 1998.

Treatment	Grass Foliar Cover (%)		
	Plot 1	Plot 2	Plot 3
Control	6.11	5.83	7.50
Control + Water	8.89	1.11	12.22
Greenwaste (2.5 yd ³)	6.67	20.28	32.77
Greenwaste (5 yd ³) + Water	4.45	2.51	3.33
Biosolids (2.5 yd ³)	10.56	1.67	1.95
Biosolids (5 yd ³) + Water	0.00	0.33	0.00
Cobble Mulch	0.00	0.00	0.00
Dairy Manure (2.5 yd ³)	0.56	1.11	0.00

* No grasses encountered along the two transects recorded within the plot.

Table 17. Density of grasses established within the replicate plots for each treatment in Fall 1998.

Treatment	Density of Grasses (per m ²)		
	Plot 1	Plot 2	Plot 2
Control	9.5	6.5	11.5
Control + Water	24.5	15.5	5.0
Greenwaste (2.5 yd ³)	26.5	35.0	13.5
Greenwaste (5 yd ³) + Water	8.0	7.5	1.0
Biosolids (2.5 yd ³)	24.0	4.5	8.0
Biosolids (5 yd ³) + Water	3.5	2.0	0.0
Cobble Mulch	1.0	0.0	0.0
Dairy Manure (2.5 yd ³)	3.5	1.0	0.5

* No grasses encountered within the four 0.5 m² grids where plant density was measured within the plot.

Table 18. Percentage of forb foliar cover measured in the replicate plots for each treatment in Fall 1998.

Treatment	Forb Foliar Cover (%)		
	Plot 1	Plot 1	Plot 3
Control	0.56	0.00	0.00
Control + Water	0.28	2.22	0.00
Greenwaste (2.5 yd ³)	0.83	0.00	0.00
Greenwaste (5 yd ³) + Water	0.28	0.00	0.00
Biosolids (2.5 yd ³)	5.56	4.17	4.44
Biosolids (5 yd ³) + Water	0.00	0.00	0.00
Cobble Mulch	0.00	0.00	0.00
Dairy Manure (2.5 yd ³)	3.06	0.00	0.00

* No forbs encountered along the two transects recorded within the plot.

Table 19. Density of forbs established within the replicate plots for each treatment in Fall 1998.

Treatment	Density of Forbs (per m ²)		
	Plot 1	Plot 2	Plot 3
Control	1.0	4.0	0.0
Control + Water	2.0	0.5	0.0
Greenwaste (2.5 yd ³)	9.0	0.0	0.0
Greenwaste (5 yd ³) + Water	0.0	0.5	0.0
Biosolids (2.5 yd ³)	4.5	1.0	0.0
Biosolids (5 yd ³) + Water	0.0	0.0	0.0
Cobble Mulch	0.5	0.5	0.0
Dairy Manure (2.5 yd ³)	1.5	0.0	0.0

* No forbs encountered within the four 0.5 m² grids where plant density was measured in the plot.

Table 20. Percentage of weed foliar cover measured in the replicate plots for each treatment in Fall 1998.

Treatment	Weed Foliar Cover (%)		
	Plot 1	Plot 2	Plot 3
Control	14.44	17.78	16.95
Control + Water	4.17	9.72	26.11
Greenwaste (2.5 yd ³)	19.44	19.17	6.12
Greenwaste (5 yd ³) + Water	20.27	30.28	33.61
Biosolids (2.5 yd ³)	9.45	36.11	23.89
Biosolids (5 yd ³) + Water	51.39	38.06	21.11
Cobble Mulch	63.62	60.00	41.67
Dairy Manure (2.5 yd ³)	38.06	28.34	31.11

Table 21. Density of weeds established within the replicate plots for each treatment in Fall 1998.

Treatment	Density of Weeds (per m²)		
	Plot 1	Plot 2	Plot 3
Control	218.0	178.5	170.5
Control + Water	343.5	430.5	352.5
Greenwaste (2.5 yd ³)	377.5	85.0	123.0
Greenwaste (5 yd ³) + Water	704.5	469.0	552.5
Biosolids (2.5 yd ³)	212.0	488.0	514.0
Biosolids (5 yd ³) + Water	385.5	296.0	290.5
Cobble Mulch	433.0	169.0	316.5
Dairy Manure (2.5 yd ³)	326.0	320.0	322.5

Table 22. Total above ground biomass production (means and standard errors) in the study plots at the end of the two growing seasons (October 1997 and 1998).

Treatment	Above Ground Biomass Production (kg m⁻²) ± S.E	
	1997	1998
Control	0.50 ± 0.13	0.11 ± 0.04
Control + Water	0.42 ± 0.03	0.09 ± 0.13
Greenwaste (2.5 yd ³)	0.55 ± 0.07	0.13 ± 0.03
Greenwaste (5 yd ³) + Water	0.57 ± 0.22	0.12 ± 0.09
Biosolids (2.5 yd ³)	0.32 ± 0.10	0.11 ± 0.04
Biosolids (5 yd ³) + Water	0.60 ± 0.04	0.23 ± 0.04
Cobble Mulch	0.70 ± 0.09	0.32 ± 0.20
Dairy Manure (2.5 yd ³)	0.57 ± 0.04	0.21 ± 0.04

7.0 Figures

Figure 1. Oblique aerial photograph of the six landfill covers comprising the Alternative Landfill Cover Demonstration Project (ALCD).

**Figure 2. Soil amendment study plot layout at the ALCD project site.
(diagrammatic only, not to scale)**

Figure 3. Oblique aerial photograph of the soil amendment study plots at the ALCD project site. The beneficial effects of the organic amendments and cobble mulch on plant establishment and growth are visible in top photograph taken during the second growing season.

Figure 4. Organic matter contents in the study plot soils prior to the application of soil amendments, Fall 1996. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 5. Total nitrogen contents in the study plot soils prior to the application of soil amendments, Fall 1996. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 6. Total phosphorus contents in the study plot soils prior to the application of soil amendments, Fall 1996. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 7. Organic matter contents in the study plot soils eight months after the application of soil amendments, Spring 1997. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 8. Total nitrogen contents in the study plot eight months after the application of soil amendments, Spring 1997. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 9. Total phosphorus contents in the study plot soils eight months after the application of soil amendments, Spring 1997. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 10. Organic matter contents in the study plot soils twenty months after the application of soil amendments, Spring 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 11. Total nitrogen contents in the study plot twenty months after the application of soil amendments, Spring 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 12. Total phosphorus contents in the various study plot soils twenty months after the application of soil amendments, Spring 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 13. Soil pH at the various study plots (a) pre-application levels, (b) eight months after amendment applications, and (c) 20 months after amendment applications. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 14. Soil electrical conductivity (EC) at the various study plots (a) pre-application levels—Fall 1996, (b) eight months after amendment applications—Spring 1997, and (c) 20 months after amendment applications—Spring 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 15. Total copper (Cu) contents in soils at the various study plots (a) pre-application levels—Fall 1996, (b) eight months after amendment applications—Spring 1997, and (c) 20 months after amendment applications—Spring 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 16. Total lead (Pb) contents in soils at the various study plots (a) pre-application levels—Fall 1996, (b) eight months after amendment applications—Spring 1997, and (c) 20 months after amendment applications—Spring 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 17. Total zinc (Zn) contents in soils at the various study plots (a) pre-application levels—Fall 1996, (b) eight months after amendment applications—Spring 1997, and (c) 20 months after amendment applications—Spring 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 18. Nitrogen mineralization potential of the soils in the various study plots eight months after amendment applications, Spring 1997: (a) initial extraction, (b) extraction after 70-day incubation period. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 19. Nitrogen mineralization potential of the soils in the various study plots 20 months after amendment applications, Spring 1998: (a) initial extraction, (b) extraction after 70-day incubation period. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 20. Total plant foliar cover (percent of ground surface covered) and density (number of plants per unit area) measured on the various study plots after the first growing season—Fall 1997: (a) percent total plant cover, (b) total plant density. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 21. Grass foliar cover (percent of ground surface covered) and density (number of plants per unit area) measured on the various study plots after the first growing season—Fall 1997: (a) percent grass foliar cover, (b) grass density. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 22. Weed foliar cover (percent of ground surface covered) and density (number of plants per unit area) measured on the various study plots after the first growing season—Fall 1997: (a) percent weed foliar cover, (b) weed density. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

(a)

(b)

Figure 23. Total plant foliar cover (percent of ground surface covered) and density (number of plants per unit area) measured on the various study plots after the second growing season—Fall 1998: (a) percent total plant cover, (b) total plant density. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 24. Grass foliar cover (percent of ground surface covered) and density (number of plants per unit area) measured on the various study plots after the second growing season—Fall 1998: (a) percent grass foliar cover (b) grass density. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 25. Weed foliar cover (percent of ground surface covered) and density (number of plants per unit area) measured on the various study plots after the second growing season—Fall 1997: (a) percent weed foliar cover, (b) weed density. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 26. Total plant biomass production measured on the various study plots: (a) after the first growing season—Fall 1997 (b) after the second growing season—Fall 1998. Values reported are means with standard errors—bars with the same letter are not significantly different ($P > 0.05$).

Figure 27. Photograph of a control (unamended) plot at the end of the first growing season (September 1997). Average foliar cover and density for the treatment were approximately 34% and 14%, respectively.

Figure 28. Photograph of a control + water plot at the end of the first growing season. Average foliar cover and density for the treatment were approximately 44% and 14%, respectively.

Figure 29. Photograph of a greenwaste compost (2.5 yd³) plot at the end of the first growing season. Average foliar cover and density for the treatment were approximately 53% and 24%, respectively.

Figure 30. Photograph of a greenwaste compost (5 yd³) + water plot at end the first growing season (September 1997). Average foliar cover and density of plants for the treatment were approximately 41% and 9%, respectively.

Figure 31. Photograph of a biosolids compost (2.5 yd³) plot at the end of the first growing season. Average foliar cover and density of plants for the treatment were approximately 28% and 14%, respectively.

Figure 32. Photograph of a biosolids compost (5 yd³) + water plot at the end of the first growing season. Average foliar cover and density of plants for the treatment were approximately 54% and 7%, respectively.

Figure 33. Photograph of a cobble-mulch plot at the end of the first growing season (September 1997). Average foliar cover and density of plants were approximately 49% and 11%, respectively.

Figure 34. Photograph of a dairy manure (2.5 yd³) plot at the end of the first growing season (September 1997). Average foliar cover and density of plants for the treatment were approximately 43% and 5%, respectively.

APPENDIX A

Irrigation Data

Table A-1. Quantity of water (inches) added to study plots during individual irrigation session during the 1997 growing season.

Treatment	Irrigation (inches)								
	Jun 2	Jun 13	Jun 20	Jun 26	Jun 30	Jul 8	Jul 18	Mean	STD
<i>Control + Water</i>									
Plot 2	0.20	0.38	0.27	0.20	0.22	0.30	0.33	0.27	0.07
Plot 3	0.23	0.39	0.29	0.28	0.27	0.35	0.27	0.30	0.05
Plot 17	0.26	0.21	0.32	0.26	0.24	0.22	0.25	0.25	0.03
<i>Greenwaste Compost (5 yd³) + Water</i>									
Plot 1	0.24	0.26	0.27	0.27	0.28	0.29	0.29	0.27	0.02
Plot 11	0.24	0.22	0.22	0.24	0.19	0.17	0.27	0.22	0.03
Plot 18	0.23	0.27	0.26	0.21	0.25	0.25	0.25	0.25	0.02
<i>Biosolids (5 yd³) + Water</i>									
Plot 14	0.18	0.23	0.23	0.2	0.2	0.23	0.22	0.21	0.02
Plot 15	0.19	0.24	0.17	0.21	0.23	0.22	0.19	0.21	0.02
Plot 24	0.22	0.25	0.21	0.24	0.26	0.2	0.21	0.23	0.02

Table A-2. Quantity of water (inches) added to study plots during individual irrigation sessions during the 1998 growing season.

Treatment	Irrigation (inches)															
	May 28	Jun 1	Jun 4	Jun 8	Jun 11	Jun 15	Jun 18	Jun 22	Jun 25	Jun 28	Jul 1	Jul 13	Jul 16	Jul 20	Mean	STD
<i>Control + Water</i>																
Plot 2	0.21	0.21	0.23	0.24	0.24	0.2	0.19	0.18	0.2	0.22	0.22	0.26	0.29	0.26	0.22	0.03
Plot 3	0.25	0.21	0.26	0.27	0.29	0.23	0.18	0.23	0.2	0.23	0.23	0.2	0.26	0.3	0.24	0.04
Plot 17	0.28	0.26	0.24	0.25	0.26	0.25	0.21	0.2	0.19	0.28	0.21	0.3	0.35	0.3	0.26	0.04
<i>Greenwaste Compost (5 yd³) + Water</i>																
Plot 1	0.27	0.23	0.25	0.24	0.21	0.18	0.2	0.22	0.15	0.2	0.27	0.24	0.31	0.31	0.23	0.05
Plot 11	0.31	0.18	0.32	0.3	0.35	0.33	0.2	0.17	0.23	0.15	0.28	0.22	0.31	0.41	0.27	0.08
Plot 18	0.3	0.19	0.26	0.24	0.27	0.23	0.17	0.2	0.19	0.23	0.26	0.24	0.28	0.36	0.24	0.05
<i>Biosolids (5 yd³) + Water</i>																
Plot 14	0.21	0.38	0.25	0.29	0.4	0.27	0.22	0.23	0.29	0.27	0.33	0.27	0.33	0.29	0.29	0.06
Plot 15	0.33	0.24	0.28	0.22	0.23	0.22	0.31	0.22	0.3	0.25	0.28	0.28	0.38	0.28	0.27	0.05
Plot 24	0.33	0.3	0.33	0.25	0.28	0.22	0.28	0.16	0.13	0.23	0.24	0.24	0.32	0.27	0.26	0.06

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APPENDIX B

Soil Chemical and Physical Data

Table B-1. Soil chemical data, pretreatment analysis (Fall 1996).

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
1	Greenwaste Compost (5 yd ³) + H ₂ O	1	0.56	364	5.8	7.6	211	5.5	165	11.06	4.32	2.64	7.69	0.93	7.5	0.95	0.1
		2	0.45	243	4.4	7.1	196	6.7	115	14.01	6.28	7.01	7.72	2.09	1.9	2.20	1.9
		3	0.44	342	4.8	7.9	220	5.2	175	6.85	2.45	2.60	7.80	0.89	7.6	1.20	0.5
2	Control + H ₂ O	1	0.46	208	4.5	6.6	173	6.7	93	13.59	6.44	5.30	7.75	1.83	11.5	1.67	1.2
		2	0.36	123	3.2	5.1	182	7.0	61	28.20	13.22	10.70	7.75	3.20	11.9	2.35	2.2
		3	0.32	172	4.2	6.7	189	6.4	76	22.34	10.78	10.03	7.78	2.85	12.1	2.46	2.3
3	Control + H ₂ O	1	0.53	277	4.6	7.4	209	7.3	114	11.08	5.08	4.27	7.80	1.31	11.7	1.50	0.9
		2	0.34	317	5.2	8.3	214	6.4	140	11.20	4.52	3.72	7.76	1.17	9.5	1.33	0.7
		3	1.02	329	4.5	6.3	221	5.8	142	6.53	2.71	1.87	7.83	0.81	13.3	0.87	0.0
4	Biosolids Compost (2.5 yd ³)	1	0.73	377	2.8	9.5	240	6.6	180	13.60	4.67	2.96	7.72	1.31	7.7	0.98	0.2
		2	0.65	391	4.4	9.3	244	6.4	186	10.58	3.63	2.73	7.80	1.08	7.4	1.02	0.2
		3	0.19	377	3.0	9.0	235	6.5	172	11.59	4.07	2.59	7.78	1.26	8.2	0.92	0.1
5	Greenwaste Compost (2.5 yd ³)	1	0.51	362	3.9	8.2	233	6.5	167	13.07	4.54	2.82	7.81	1.38	8.6	0.95	0.1
		2	0.32	362	3.3	8.8	235	6.4	164	14.63	5.31	3.46	7.77	1.50	8.4	1.10	0.4
		3	0.50	348	6.1	8.0	238	6.4	151	15.97	5.76	3.12	7.75	1.53	8.7	0.95	0.1
6	Greenwaste Compost (2.5 yd ³)	1	0.64	387	6.0	5.0	264	6.4	190	10.11	3.41	2.28	7.74	1.01	7.2	0.88	0.0
		2	0.73	450	4.2	10.0	250	6.4	199	12.59	3.88	2.28	7.78	1.24	6.9	0.79	0.1
		3	0.60	415	4.5	9.4	260	7.3	201	11.07	3.49	2.20	7.80	1.08	7.1	0.82	0.0
7	Cobble Mulch	1	0.84	447	4.6	10.2	268	7.0	222	7.93	2.27	1.58	7.84	0.98	5.9	0.70	0.2
		2	0.70	446	4.2	10.3	257	6.4	226	8.40	2.37	1.66	7.83	0.95	6.6	0.72	0.1
		3	0.91	422	5.1	10.2	280	6.1	226	8.68	2.57	1.85	7.66	1.03	6.4	0.78	0.1
8	Biosolids Compost (2.5 yd ³)	1	0.92	545	4.3	10.8	266	4.1	271	7.50	1.94	1.09	7.71	0.58	4.2	0.50	0.1
		2	0.95	513	5.0	10.2	262	5.2	254	8.26	2.15	1.14	7.71	0.91	5.2	0.50	0.1
		3	0.89	553	4.9	10.6	250	5.7	247	7.74	2.03	1.11	7.74	0.91	4.8	0.50	0.1

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-1 (continued)

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
9	Dairy Manure (2.5 yd ³)	1	0.63	273	3.7	6.3	210	5.1	120	4.88	2.29	2.13	7.85	0.74	13.4	1.12	0.4
		2	0.68	310	2.8	7.3	230	5.5	168	5.69	2.10	1.72	7.82	0.89	7.8	0.87	0.0
		3	0.69	269	3.9	7.0	212	5.2	142	6.07	2.30	2.34	7.87	1.05	9.4	1.14	0.4
10	Cobble Mulch	1	0.70	333	4.7	7.5	229	5.2	168	6.42	2.31	2.05	7.94	0.87	8.2	0.98	0.2
		2	0.93	350	4.2	8.0	215	5.2	181	7.50	2.62	2.08	7.90	1.00	7.7	0.92	0.1
		3	0.89	377	5.3	8.1	229	5.1	192	6.81	2.26	1.84	7.88	0.91	6.9	0.86	0.0
11	Greenwaste Compost (5 yd ³) + H ₂ O	1	0.90	371	4.4	8.7	234	5.7	207	5.66	1.79	1.41	7.92	0.92	6.7	0.73	0.1
		2	0.83	385	4.8	8.7	233	5.7	211	6.00	1.78	1.28	7.98	0.81	6.1	0.65	0.1
		3	0.38	376	3.1	8.6	229	5.5	202	6.63	2.05	1.48	7.97	0.85	6.5	0.71	0.1
12	Greenwaste Compost (2.5 yd ³)	1	0.96	401	5.7	8.4	235	5.2	207	5.65	1.76	1.49	8.00	0.75	5.6	0.77	0.1
		2	0.85	353	4.3	8.5	242	5.9	194	7.17	2.38	1.95	7.97	1.09	6.9	0.89	0.0
		3	0.76	367	3.7	8.2	235	5.8	197	6.02	1.96	1.61	7.66	0.82	6.2	0.81	0.1
13	Dairy Manure (2.5 yd ³)	1	0.70	387	5.0	8.6	240	4.6	211	5.05	1.52	1.31	7.75	0.66	6.1	0.72	0.1
		2	0.75	419	4.5	8.4	232	4.9	204	5.28	1.64	1.39	7.72	0.78	6.0	0.75	0.1
		3	0.91	420	3.5	8.5	241	4.4	219	4.74	1.51	1.31	7.71	0.63	5.1	0.74	0.1
14	Biosolids Compost (5 yd ³) + H ₂ O	1	0.83	391	4.8	8.8	236	4.6	211	6.06	1.98	1.44	7.72	0.80	6.4	0.72	0.1
		2	0.60	380	4.7	8.0	244	2.8	210	5.85	1.97	1.42	7.74	0.81	6.1	0.72	0.1
		3	0.63	421	3.6	8.9	242	2.1	209	5.91	1.92	1.27	7.80	0.80	6.0	0.64	0.1
15	Biosolids Compost (5 yd ³) + H ₂ O	1	0.78	457	4.3	8.3	266	2.4	232	5.10	1.43	0.91	7.83	0.81	5.5	0.50	0.1
		2	0.73	472	3.2	8.3	255	0.8	276	4.57	1.07	0.39	7.87	0.58	3.4	0.23	0.1
		3	0.68	533	3.5	8.6	279	0.2	315	4.04	0.92	0.28	7.88	0.59	2.5	0.18	0.1
16	Control	1	0.51	255	4.3	6.1	220	1.5	132	3.25	1.16	0.98	7.92	0.51	7.8	0.66	0.1
		2	0.70	380	5.3	7.9	242	1.8	199	4.09	1.33	1.16	7.86	0.74	6.3	0.70	0.1
		3	0.67	387	4.1	7.3	245	2.1	203	4.38	1.49	1.19	7.92	0.67	6.1	0.69	0.1

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-1 (continued)

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
17	Control + H ₂ O	1	0.62	357	4.5	7.7	228	1.8	191	3.69	1.31	1.34	7.94	0.59	6.4	0.85	0.0
		2	0.55	406	3.9	9.0	336	2.1	240	4.29	1.34	0.90	7.93	0.71	4.9	0.54	0.1
		3	0.67	395	6.4	8.9	268	2.8	242	5.15	1.61	1.05	7.90	0.73	5.0	0.57	0.1
18	Greenwaste Compost (5 yd ³) + H ₂ O	1	0.80	470	3.6	8.8	261	3.4	243	5.58	1.70	1.09	7.93	0.77	5.3	0.57	0.1
		2	0.81	466	5.4	8.1	263	2.4	231	4.82	1.43	1.00	7.98	0.69	4.7	0.56	0.1
		3	0.68	450	5.3	8.7	265	3.4	244	4.80	1.47	1.11	7.97	0.70	4.5	0.63	0.1
19	Cobble Mulch	1	0.62	508	3.5	7.8	275	2.4	245	4.22	1.23	0.80	8.03	0.61	3.7	0.48	0.1
		2	0.66	486	3.9	8.8	286	3.4	257	4.43	1.20	0.79	8.06	0.62	3.9	0.47	0.1
		3	0.86	867	3.9	8.4	280	3.1	238	4.56	1.38	0.94	8.01	0.62	4.8	0.54	0.1
20	Dairy Manure (2.5 yd ³)	1	0.96	508	5.7	7.4	273	1.2	234	3.93	1.09	0.59	7.98	0.63	5.8	0.37	0.1
		2	0.74	491	3.9	7.7	251	1.5	230	4.58	1.36	1.01	8.02	0.65	4.6	0.59	0.1
		3	0.78	436	5.2	7.8	253	1.5	234	4.69	1.36	0.98	8.01	0.68	4.7	0.56	0.1
21	Control	1	0.47	342	5.3	7.1	235	1.5	231	2.67	1.01	0.80	7.80	0.52	7.2	0.59	0.1
		2	0.58	384	4.1	6.4	242	2.8	204	3.27	1.07	1.14	7.76	0.45	5.6	0.77	0.1
		3	0.50	383	3.9	6.5	247	4.1	190	3.59	1.17	1.19	7.74	0.50	6.1	0.77	0.1
22	Control	1	0.52	316	5.5	5.8	204	3.1	150	2.85	1.19	1.70	7.79	0.50	7.3	1.20	0.5
		2	0.48	331	5.5	7.0	222	2.1	179	3.42	1.25	1.83	7.77	0.58	6.3	1.20	0.5
		3	0.69	340	4.9	7.9	233	2.1	189	3.64	1.29	1.75	7.79	0.56	5.4	1.11	0.4
23	Biosolids Compost (2.5 yd ³)	1	0.62	407	3.6	6.1	274	0.2	141	2.94	1.15	1.70	7.90	0.48	4.9	1.19	0.5
		2	0.56	435	4.6	6.1	316	1.5	157	2.93	1.07	1.08	7.89	0.41	4.1	0.76	0.1
		3	0.54	415	7.9	7.3	276	1.8	183	3.31	1.15	1.06	7.87	0.54	4.7	0.71	0.1
24	Biosolids Compost (5 yd ³) + H ₂ O	1	0.48	375	5.0	4.2	261	2.1	115	1.16	0.55	2.36	8.15	0.36	8.3	2.55	2.4
		2	0.50	362	5.9	4.4	278	1.8	98	1.73	0.64	1.90	8.07	0.33	6.8	1.74	1.3
		3	0.61	393	4.0	4.3	267	2.1	100	2.11	0.98	0.92	8.03	0.36	8.0	0.74	0.1

^a = mmhos/cm ^b = meq/L or cmol(+) kg⁻¹ ^c = percent ^d = ppm or mg/kg

Table B-1 (continued)

Plot	Treatment	Sample Replicate No.	C ^a	Cd ^d	Pb ^d	Zn ^d	Mo ^d
1	Greenwaste Compost (5 yd ³) + H ₂ O	1	7.00	1	7.10	25.71	2
		2	5.65	1	6.19	22.82	2
		3	6.23	1	6.73	26.38	2
2	Control + H ₂ O	1	4.79	1	5.16	21.12	2
		2	5.09	1	5.68	21.28	2
		3	5.00	1	5.41	23.43	2
3	Control + H ₂ O	1	5.69	1	5.60	24.03	2
		2	5.93	1	5.76	25.26	2
		3	5.44	1	5.46	28.08	2
4	Biosolids Compost (2.5 yd ³)	1	6.61	1	7.04	31.21	2
		2	6.85	1	6.91	30.20	2
		3	6.88	1	7.00	25.34	2
5	Greenwaste Compost (2.5 yd ³)	1	6.69	1	7.28	24.59	2
		2	6.18	1	6.97	25.08	2
		3	6.38	1	6.50	27.59	2
6	Greenwaste Compost (2.5 yd ³)	1	9.14	1	7.38	28.39	2
		2	7.05	1	6.90	25.75	2
		3	7.54	1	7.09	30.28	2
7	Cobble Mulch	1	7.70	1	7.62	28.92	2
		2	7.26	1	7.58	28.39	2
		3	7.62	1	8.86	28.66	2
8	Biosolids Compost (2.5 yd ³)	1	8.19	1	9.09	34.40	2
		2	8.51	1	7.96	39.03	2
		3	7.32	1	7.73	29.86	2

^a = mmhos/cm ^b = meq/L or cmol(+) kg-1 ^c = percent ^d = ppm or mg/kg

Table B-1 (continued)

Plot	Treatment	Sample Replicate No.	Cu ^d	Cd ^d	Pb ^d	Zn ^d	Mo ^d
9	Dairy Manure (2.5 yd ³)	1	5.18	1	5.39	30.36	2
		2	6.44	1	6.64	23.78	2
		3	5.55	1	5.63	21.09	2
10	Cobble Mulch	1	6.48	1	6.45	46.07	2
		2	5.90	1	5.99	28.08	2
		3	6.43	1	6.33	36.60	2
11	Greenwaste Compost (5 yd ³) + H ₂ O	1	6.42	1	6.52	32.00	2
		2	6.16	1	8.81	32.57	2
		3	6.14	1	6.50	30.61	2
12	Greenwaste Compost (2.5 yd ³)	1	6.73	1	6.48	25.14	2
		2	6.32	1	6.60	29.00	2
		3	6.43	1	6.32	25.35	2
13	Dairy Manure (2.5 yd ³)	1	6.73	1	6.47	27.66	2
		2	7.90	1	6.27	24.54	2
		3	7.11	1	6.49	35.52	2
14	Biosolids Compost (5 yd ³) + H ₂ O	1	6.48	1	6.80	25.47	2
		2	7.63	1	7.88	27.41	2
		3	7.14	1	7.41	33.87	2
15	Biosolids Compost (5 yd ³) + H ₂ O	1	9.84	1	8.07	32.35	2
		2	8.54	1	8.12	30.53	2
		3	10.03	1	10.71	36.02	2
16	Control	1	6.13	1	7.06	24.60	2
		2	6.97	1	8.17	38.40	2
		3	7.44	1	7.91	27.37	2

^a = mmhos/cm

^b = meq/L or cmol(+) kg⁻¹

^c = percent

^d = ppm or mg/kg

Table B-1 (continued)

Plot	Treatment	Sample Replicate No.	C _E ^a	Cd ^c	Pb ^d	Zn ^d	Mo ^d
17	Control + H ₂ O	1	6.37	1	7.10	41.58	2
		2	7.40	1	7.70	66.67	2
		3	7.27	1	8.41	54.30	2
18	Greenwaste Compost (5 yd ³) + H ₂ O	1	7.44	1	7.71	56.11	2
		2	7.29	1	8.08	28.32	2
		3	7.15	1	7.59	33.50	2
19	Cobble Mulch	1	8.15	1	8.34	83.62	2
		2	7.57	1	8.22	33.17	2
		3	7.22	1	8.02	29.86	2
20	Dairy Manure (2.5 yd ³)	1	7.26	1	6.89	50.02	2
		2	7.17	1	7.08	76.76	2
		3	6.95	1	7.35	35.96	2
21	Control	1	6.51	1	7.77	26.08	2
		2	6.55	1	7.15	37.15	2
		3	6.68	1	7.83	26.41	2
22	Control	1	6.64	1	9.52	24.99	2
		2	5.93	1	6.64	22.78	2
		3	5.98	1	7.02	29.26	2
23	Biosolids Compost (2.5 yd ³)	1	7.69	1	7.40	26.59	2
		2	8.21	1	8.18	29.56	2
		3	8.06	1	7.60	28.81	2
24	Biosolids Compost (5 yd ³) + H ₂ O	1	6.69	1	6.05	23.67	2
		2	6.46	1	6.34	38.75	2
		3	7.02	1	6.02	24.05	2

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-2. Soil chemical data, first growing season (Spring 1997).

Plot	Treatment	Sample Replicate No.	OM ^a	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtrP ^d	ExtrK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
1	Greenwaste Compost (5 yd ³) + H ₂ O	1	1.51	650	--	3.0	304	32.8	95	5.62	2.68	5.33	7.81	1.47	10.5	2.62	2.5
		2	2.91	1119	--	2.5	339	39.4	101	6.40	2.67	5.13	7.79	1.37	6.6	2.41	2.2
		3	0.92	566	--	2.0	238	12.8	38	2.74	0.85	1.78	8.06	0.46	7.2	1.33	0.7
2	Control + H ₂ O	1	0.45	350	--	3.0	190	12.1	19	5.79	2.37	3.44	7.97	1.14	11.0	1.70	1.2
		2	0.44	365	--	2.0	206	7.2	21	2.76	1.01	1.67	8.07	0.55	9.8	1.22	0.5
		3	0.35	306	--	2.5	171	9.4	25	29.80	12.15	10.03	7.80	3.46	14.4	2.19	1.9
3	Control + H ₂ O	1	0.53	348	--	2.0	210	7.5	25	2.12	0.74	0.88	8.06	0.45	8.6	0.74	0.1
		2	0.48	302	--	2.5	224	9.4	20	1.83	0.73	1.03	8.11	0.38	14.9	0.91	0.1
		3	0.65	313	--	2.9	212	9.4	23	2.16	0.78	0.95	8.10	0.40	12.4	0.78	0.1
4	Biosolids Compost (2.5 yd ³)	1	2.03	977	--	31.0	471	55.2	59	12.91	3.92	2.81	7.70	1.73	8.8	0.97	0.2
		2	1.57	742	--	21.0	434	38.9	54	15.20	5.10	3.59	7.69	2.14	8.8	1.13	0.4
		3	2.13	924	--	9.8	539	67.7	54	4.66	1.34	1.00	7.84	0.69	7.9	0.58	0.1
5	Greenwaste Compost (2.5 yd ³)	1	0.77	487	--	2.0	238	11.4	29	2.84	0.92	1.27	8.08	0.51	8.1	0.93	0.1
		2	1.71	719	--	1.5	290	27.5	63	3.56	1.29	1.75	7.83	0.67	9.1	1.12	0.4
		3	0.84	543	--	2.0	230	15.5	41	7.18	2.38	1.16	7.85	1.00	9.2	0.53	0.1
6	Greenwaste Compost (2.5 yd ³)	1	0.80	543	--	2.5	263	11.1	37	2.60	0.72	1.34	8.04	0.47	6.6	1.04	0.3
		2	1.51	673	--	2.5	273	21.9	54	3.11	0.98	1.70	7.99	0.58	7.6	1.19	0.5
		3	2.52	929	--	2.9	309	31.8	107	4.68	1.39	2.11	7.92	0.81	6.4	1.21	0.5
7	Cobble Mulch	1	0.70	525	--	2.9	215	7.3	29	2.51	0.63	0.95	8.04	0.42	6.7	0.76	0.1
		2	0.54	510	--	2.5	220	8.4	27	2.25	0.58	0.99	8.11	0.35	6.8	0.83	0.0
		3	0.78	485	--	2.5	233	10.1	24	2.01	0.55	1.03	8.11	0.35	7.2	0.91	0.1
8	Biosolids Compost (2.5 yd ³)	1	1.17	759	--	41.9	355	21.5	56	15.80	3.67	2.25	7.68	2.03	4.7	0.72	0.1
		2	1.20	910	--	30.0	381	32.8	53	9.43	2.30	2.31	7.82	1.32	5.0	0.95	0.1
		3	1.09	734	--	43.0	377	27.1	55	13.93	4.02	2.91	7.79	2.12	6.1	0.97	0.2

^a = mmhos/cm ^b = meq/L or cmol(+) kg⁻¹ ^c = percent ^d = ppm or mg/kg

Table B2 (continued)

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
9	Dairy Manure (2.5 yd ³)	1	1.61	1052	--	9.8	425	109.6	221	3.59	2.16	6.29	7.84	1.36	7.8	3.71	4.0
		2	1.62	886	--	5.9	457	109.6	193	2.34	1.53	5.13	8.00	1.09	9.6	3.69	4.0
		3	1.63	1063	--	7.4	383	94.8	187	3.98	2.47	6.37	7.91	1.56	9.0	3.55	3.8
10	Cobble Mulch	1	0.46	442	--	41.9	229	8.3	22	1.77	0.53	0.94	7.99	0.34	7.1	0.88	0.0
		2	0.53	440	--	2.5	220	6.8	20	1.82	0.61	1.28	7.96	0.34	8.0	1.16	0.4
		3	1.15	499	--	3.2	229	7.8	25	2.10	0.67	1.22	7.93	0.36	6.5	1.04	0.3
11	Greenwaste Compost (5 yd ³) + H ₂ O	1	1.24	766	--	2.0	269	23.6	67	3.17	1.03	1.41	7.84	0.50	6.2	0.97	0.2
		2	4.10	1008	--	1.5	404	71.1	202	6.22	2.54	4.89	7.62	1.48	6.6	2.34	2.1
		3	3.88	1242	--	1.7	389	49.6	150	5.98	2.39	3.49	7.64	1.25	5.5	1.70	1.2
12	Greenwaste Compost (2.5 yd ³)	1	1.36	648	--	1.7	234	21.9	52	2.65	0.87	1.45	7.91	0.43	6.9	1.09	0.3
		2	1.31	697	--	1.4	214	16.6	45	2.93	0.93	1.37	7.88	0.44	5.4	0.99	0.2
		3	1.04	655	--	1.6	229	12.8	38	2.38	0.74	1.44	7.94	0.39	5.1	1.15	0.4
13	Dairy Manure (2.5 yd ³)	1	1.72	1144	--	26.0	462	109.6	338	12.74	6.85	13.21	7.77	3.30	6.5	4.22	4.7
		2	1.47	938	--	4.4	310	57.5	112	3.27	1.27	2.53	7.92	0.73	5.1	1.68	1.2
		3	2.00	934	--	6.7	379	68.9	128	3.95	1.53	3.59	7.93	0.81	4.7	2.17	1.9
14	Biosolids Compost (5 yd ³) + H ₂ O	1	4.12	1368	--	94.0	584	81.0	109	26.50	7.94	5.81	7.45	3.44	6.4	1.40	0.8
		2	3.27	1211	--	75.0	738	69.4	93	18.38	5.43	3.99	7.50	2.52	5.2	1.16	0.4
		3	2.07	1108	--	31.4	468	58.9	67	10.02	2.78	2.36	7.68	1.27	5.4	0.93	0.1
15	Biosolids Compost (5 yd ³) + H ₂ O	1	1.91	884	--	11.0	509	48.5	50	4.77	1.25	1.16	7.77	0.60	5.7	0.67	0.1
		2	5.82	788	--	99.0	972	104.6	134	31.42	7.48	4.63	7.38	3.28	3.5	0.52	0.1
		3	3.16	1424	--	91.0	597	64.8	89	23.79	6.01	3.64	7.47	2.72	2.5	0.94	0.1
16	Control	1	0.62	447	--	3.8	220	5.5	21	2.05	0.57	1.06	7.97	0.32	5.8	0.93	0.1
		2	0.65	487	--	4.8	238	5.1	28	3.48	0.98	1.16	7.91	0.54	5.2	0.78	0.1
		3	0.64	440	--	8.6	206	6.0	32	3.81	1.24	1.31	7.88	0.63	6.3	0.82	0.0

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-2 (continued)

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
17	Control + H ₂ O	1	0.70	444	--	4.3	224	7.2	44	2.16	0.66	0.89	7.98	0.33	6.0	0.75	0.1
		2	0.63	450	--	3.4	219	6.7	33	2.27	0.64	0.64	7.97	0.36	5.6	0.53	0.1
		3	0.71	447	--	3.2	250	6.6	34	2.48	0.71	0.89	7.95	0.41	5.2	0.70	0.1
18	Greenwaste Compost (5 yd ³) + H ₂ O	1	1.71	786	--	2.5	308	31.7	81	5.49	1.79	2.45	7.72	0.94	5.4	1.28	0.6
		2	1.57	712	--	2.8	307	24.6	72	4.40	1.31	1.55	7.80	0.67	4.7	0.92	0.1
		3	1.64	725	--	4.2	274	19.0	90	3.43	0.92	1.63	7.90	0.48	4.1	1.10	0.4
19	Cobble Mulch	1	0.75	465	--	2.9	250	6.3	28	2.14	0.49	1.01	7.98	0.30	3.9	0.88	0.0
		2	0.88	528	--	2.8	222	8.0	29	2.14	0.57	0.87	7.95	0.31	4.6	0.75	0.1
		3	0.62	488	--	2.9	253	5.8	25	1.86	0.30	0.87	7.95	0.29	4.9	0.84	0.0
20	Dairy Manure (2.5 yd ³)	1	1.78	997	--	4.4	481	86.0	142	3.55	1.29	2.83	7.95	0.84	4.9	1.82	1.4
		2	1.70	974	--	4.9	411	69.0	98	3.08	1.05	1.82	8.00	0.63	5.0	1.27	0.6
		3	1.49	800	--	5.9	364	58.1	105	3.20	1.10	2.99	7.98	0.70	5.1	2.04	1.7
21	Control	1	0.74	739	--	2.5	221	6.0	30	1.73	0.47	0.66	8.05	0.30	5.3	0.63	0.1
		2	0.66	441	--	2.7	217	6.7	31	1.91	0.60	0.78	7.97	0.34	5.8	0.70	0.1
		3	0.58	394	--	1.9	185	5.2	23	1.77	0.53	1.04	8.04	0.32	6.7	0.97	0.2
22	Control	1	0.58	381	--	2.4	184	4.8	26	1.91	0.57	0.86	8.05	0.34	6.3	0.77	0.1
		2	0.46	410	--	4.7	215	7.8	22	1.61	0.48	1.24	7.99	0.33	6.0	1.21	0.5
		3	0.64	416	--	4.0	217	5.4	22	1.59	0.49	1.21	8.01	0.27	6.3	1.19	0.5
23	Biosolids Compost (2.5 yd ³)	1	1.51	798	--	14.3	353	26.4	45	5.31	1.83	1.65	7.82	0.69	3.8	0.87	0.0
		2	1.88	814	--	14.8	566	34.6	31	5.12	1.67	1.40	7.78	0.73	4.4	0.76	0.1
		3	1.24	663	--	8.1	358	19.7	26	2.57	0.84	0.91	7.87	0.35	5.1	0.70	0.1
24	Biosolids Compost (5 yd ³) + H ₂ O	1	2.20	1038	--	57.1	633	61.4	65	16.95	5.99	3.31	7.47	2.06	7.0	0.98	0.2
		2	4.07	1150	--	62.4	604	70.0	61	17.04	7.38	5.40	7.42	2.47	5.9	1.54	1.0
		3	2.25	1005	--	16.2	504	54.4	102	4.60	2.09	2.76	7.81	0.80	6.5	1.51	1.0

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-2 (continued)

Plot	Treatment	Sample Replicate No.	C ^a	C ^d	Pb ^d	Zn ^d	Mo ^d
1	Greenwaste Compost (5 yd ³) + H ₂ O	1	6	1	8	28	2
		2	7	2	9	29	2
		3	5	1	8	25	2
2	Control + H ₂ O	1	4	1	7	23	2
		2	6	1	7	24	2
		3	4	1	5	20	2
3	Control + H ₂ O	1	11	2	8	25	2
		2	4	1	7	21	2
		3	4	1	6	22	2
4	Biosolids Compost (2.5 yd ³)	1	9	2	10	35	2
		2	9	2	10	34	2
		3	11	1	9	33	2
5	Greenwaste Compost (2.5 yd ³)	1	7	2	8	27	2
		2	6	1	8	27	2
		3	5	1	6	22	2
6	Greenwaste Compost (2.5 yd ³)	1	7	2	10	30	2
		2	6	1	8	34	2
		3	8	1	9	32	2
7	Cobble Mulch	1	7	2	8	27	2
		2	7	1	9	28	2
		3	10	1	7	28	2
8	Biosolids Compost (2.5 yd ³)	1	10	1	10	32	2
		2	11	2	11	36	2
		3	9	1	10	32	2

^a = mmhos/cm^b = meq/L or cmol(+) kg-1^c = percent^d = ppm or mg/kg

Table B-2 (continued)

Plot	Treatment	Sample Replicate No.	Cu ^d	Cd ^d	Pb ^d	Zn ^d	Mo ^d
9	Dairy Manure (2.5 yd ³)	1	7	1	8	29	2
		2	5	1	6	28	2
		3	6	1	7	26	2
10	Cobble Mulch	1	7	1	8	26	2
		2	7	1	7	27	2
		3	6	1	9	26	2
11	Greenwaste Compost (5 yd ³) + H ₂ O	1	7	1	9	28	2
		2	7	1	8	30	2
		3	8	1	9	31	2
12	Greenwaste Compost (2.5 yd ³)	1	2	1	8	22	2
		2	1	1	7	26	2
		3	1	1	7	33	2
13	Dairy Manure (2.5 yd ³)	1	1	1	8	28	2
		2	1	1	7	24	2
		3	2	1	8	29	2
14	Biosolids Compost (5 yd ³) + H ₂ O	1	5	1	7	29	2
		2	8	1	9	35	2
		3	4	1	8	30	2
15	Biosolids Compost (5 yd ³) + H ₂ O	1	5	1	10	32	2
		2	14	1	13	50	2
		3	11	1	11	39	2
16	Control	1	5	1	8	25	2
		2	4	1	8	27	2
		3	5	1	7	23	2

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-2 (continued)

Plot	Treatment	Sample Replicate No.	C _d ^a	Cd ^c	Pb ^d	Zn ^d	Mo ^d
17	Control + H ₂ O	1	5	1	8	29	2
		2	5	1	8	25	2
		3	4	1	8	26	2
18	Greenwaste Compost (5 yd ³) + H ₂ O	1	5	1	9	32	2
		2	6	1	12	31	2
		3	6	1	9	32	2
19	Cobble Mulch	1	6	1	9	21	2
		2	6	1	7	27	2
		3	6	1	8	26	2
20	Dairy Manure (2.5 yd ³)	1	7	1	9	34	2
		2	4	1	8	33	2
		3	6	1	9	30	2
21	Control	1	5	1	8	27	2
		2	5	1	8	24	2
		3	3	1	7	24	2
22	Control	1	3	1	9	23	2
		2	5	1	9	26	2
		3	5	1	9	26	2
23	Biosolids Compost (2.5 yd ³)	1	8	1	9	30	2
		2	11	1	11	38	2
		3	7	1	10	32	2
24	Biosolids Compost (5 yd ³) + H ₂ O	1	11	1	10	33	2
		2	11	1	10	36	2
		3	9	1	10	35	2

^a = mmhos/cm ^b = meq/L or cmol(+) kg-1 ^c = percent ^d = ppm or mg/kg

Table B-3. Soil chemical data, second growing season (Spring 1998).

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃	SAR	ESP
1	Greenwaste Compost (5 yd ³) + H ₂ O	1	2.31	1019	4.8	2.3	760	38.7	384	4.88	2.09	1.36	7.82	0.72	8.7	0.73	0.00
		2	1.73	745	3.30	2.10	637	19.10	370	4.06	1.79	1.99	7.92	0.64	6.90	1.16	0.40
		3	1.02	465	2.80	2.10	566	10.90	218	2.33	0.88	0.99	8.13	0.38	7.10	0.78	0.00
2	Control + H ₂ O	1	0.40	250	2.30	1.80	406	6.80	108	1.53	0.69	0.40	8.20	0.26	11.40	0.38	0.00
		2	0.35	228	2.30	1.60	426	4.90	102	1.68	1.68	0.71	8.34	0.31	11.20	0.64	0.00
		3	0.37	265	5.70	1.50	475	7.20	114	4.30	1.40	0.40	8.07	0.56	12.50	0.24	0.00
3	Control + H ₂ O	1	0.38	321	2.60	1.80	512	7.40	134	1.31	0.54	0.46	8.32	0.23	10.80	0.48	0.00
		2	0.51	346	2.40	1.80	510	8.10	143	1.49	0.59	0.48	8.18	0.25	9.90	0.47	0.00
		3	0.44	329	2.20	1.80	428	6.50	125	1.35	0.56	0.48	8.33	0.24	11.50	0.49	0.00
4	Biosolids Compost (2.5 yd ³)	1	2.06	918	5.20	2.40	1234	79.20	225	3.49	1.08	0.40	7.95	0.44	8.10	0.26	0.00
		2	0.91	507	4.50	2.50	733	22.40	233	2.61	0.92	0.29	8.10	0.36	8.10	0.22	0.00
		3	1.30	714	5.20	2.10	819	32.40	251	3.18	1.14	0.31	7.96	0.42	7.40	0.21	0.00
5	Greenwaste Compost (2.5 yd ³)	1	0.88	608	3.30	1.90	653	14.60	227	2.35	0.95	0.51	8.07	0.36	8.10	0.40	0.00
		2	1.93	872	5.40	1.70	783	28.50	316	4.45	1.87	0.54	7.80	0.57	7.60	0.30	0.00
		3	1.31	625	4.10	2.30	644	19.90	226	2.71	1.10	0.44	8.04	0.40	8.70	0.32	0.00
6	Greenwaste Compost (2.5 yd ³)	1	1.07	733	3.70	2.30	675	18.70	303	3.07	1.23	0.50	8.02	0.45	7.80	0.34	0.00
		2	2.10	969	4.10	2.00	782	37.60	414	3.56	1.47	0.44	7.86	0.55	8.20	0.28	0.00
		3	1.80	721	3.00	2.50	781	22.60	371	3.19	1.23	0.53	8.03	0.48	7.10	0.36	0.00
7	Cobble Mulch	1	1.04	483	2.80	2.10	651	5.90	333	1.43	0.43	0.29	8.22	0.26	6.40	0.30	0.00
		2	0.66	433	2.50	1.70	636	6.80	214	1.73	0.51	0.27	7.90	0.26	6.60	0.26	0.00
		3	0.65	412	2.00	1.10	631	6.80	212	1.61	0.50	0.29	8.00	0.27	7.50	0.28	0.00
8	Biosolids Compost (2.5 yd ³)	1	1.46	707	4.10	2.20	1135	26.60	286	3.42	0.89	0.39	7.87	0.46	4.10	0.26	0.00
		2	2.24	1025	5.40	6.30	610	59.80	542	5.18	1.56	0.25	7.69	0.72	5.30	0.14	0.00
		3	1.30	737	3.60	2.20	424	30.80	327	4.06	1.08	0.38	7.66	0.52	4.10	0.24	0.00

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-3 (continued)

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
9	Dairy Manure (2.5 yd ³)	1	2.26	737	3.40	4.30	412	75.60	537	1.92	0.99	1.30	7.92	0.55	8.00	1.08	0.30
		2	1.47	810	3.20	3.90	436	86.90	387	2.20	1.40	0.50	7.83	0.53	9.90	0.37	0.00
		3	1.91	1239	4.30	5.90	558	124.40	730	2.66	1.82	3.69	7.95	1.01	8.90	2.46	2.30
10	Cobble Mulch	1	0.59	423	2.00	2.50	270	5.60	189	1.25	0.46	0.27	7.89	0.26	8.30	0.29	0.00
		2	0.54	378	2.00	2.00	261	5.70	167	1.21	0.44	0.23	7.95	0.23	8.00	0.25	0.00
		3	0.53	402	1.80	1.70	267	4.70	174	1.69	0.63	0.38	7.92	0.28	6.90	0.26	0.00
11	Greenwaste Compost (5 yd ³) + H ₂ O	1	2.98	1376	3.60	2.30	498	54.40	507	8.23	3.70	1.02	7.71	1.09	6.00	0.42	0.00
		2	4.70	2558	4.60	1.80	565	85.40	620	8.26	3.66	1.84	7.64	1.15	5.40	0.75	0.00
		3	1.61	829	2.70	2.00	365	27.00	339	6.26	2.76	0.70	7.69	0.84	6.80	0.33	0.00
12	Greenwaste Compost (2.5 yd ³)	1	2.32	753	2.50	2.40	326	25.00	304	6.01	2.61	0.77	7.68	0.79	6.70	0.37	0.00
		2	1.56	626	3.20	2.90	320	14.60	268	3.84	1.56	0.53	7.80	0.55	5.20	0.32	0.00
		3	1.40	721	2.40	2.00	328	20.00	308	4.95	2.01	0.90	7.85	0.64	5.10	0.48	0.00
13	Dairy Manure (2.5 yd ³)	1	1.22	695	4.10	3.90	399	51.50	419	4.14	2.15	0.90	7.85	0.74	7.10	0.51	0.00
		2	1.65	732	3.10	5.00	379	42.70	530	3.70	1.67	0.69	7.95	0.68	4.90	0.42	0.00
		3	1.61	930	2.20	4.80	410	56.20	494	2.49	1.04	0.92	7.83	0.48	4.70	0.69	0.00
14	Biosolids Compost (5 yd ³) + H ₂ O	1	2.20	1082	4.20	3.40	570	64.30	554	4.16	1.50	0.36	7.57	0.65	6.10	0.21	0.00
		2	4.00	1005	5.00	3.10	809	93.90	366	7.42	2.25	1.11	7.27	0.84	5.50	0.50	0.00
		3	2.71	793	3.90	3.40	647	51.80	404	5.06	1.67	0.57	7.48	0.64	5.40	0.31	0.00
15	Biosolids Compost (5 yd ³) + H ₂ O	1	1.82	716	3.10	3.70	487	47.10	326	4.68	1.38	0.66	7.52	0.61	4.90	0.38	0.00
		2	3.94	2033	5.60	3.60	359	101.20	631	7.51	2.10	1.04	7.39	1.09	3.50	0.47	0.00
		3	2.60	995	5.80	2.80	769	73.90	437	4.81	1.25	0.70	7.44	0.67	2.50	0.40	0.00
16	Control	1	0.59	362	1.50	2.50	254	4.70	195	1.83	0.66	0.50	7.84	0.33	6.00	0.45	0.00
		2	0.62	374	1.60	2.80	275	4.40	295	2.14	0.84	0.29	7.76	0.39	5.40	0.24	0.00
		3	0.59	369	1.20	2.50	265	4.50	267	2.11	0.85	0.28	7.81	0.36	6.10	0.23	0.00

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-3 (continued)

Plot	Treatment	Sample Replicate No.	OM ^c	TKN ^d	NH ₄ ^d	NO ₃ ^d	TP ^d	ExtP ^d	ExtK ^d	Ca ^b	Mg ^b	Na ^b	pH	EC ^a	CaCO ₃ ^c	SAR	ESP
17	Control + H ₂ O	1	0.52	360	2.80	3.00	275	5.80	197	1.85	0.68	0.38	7.85	0.32	6.10	0.34	0.00
		2	0.52	353	1.80	2.30	239	5.00	206	2.04	0.84	0.38	7.83	0.34	6.00	0.32	0.00
		3	0.57	363	2.00	3.20	282	8.80	196	2.61	0.98	0.46	7.81	0.42	7.00	0.34	0.00
18	Greenwaste Compost (5 yd ³) + H ₂ O	1	1.72	940	2.70	2.30	357	24.40	363	4.72	1.66	0.72	7.61	0.68	5.60	0.40	0.00
		2	2.55	1063	5.40	3.10	389	43.30	581	5.94	2.20	2.14	7.56	1.00	5.10	1.06	0.00
		3	1.69	888	3.00	2.70	368	24.00	439	4.53	1.59	0.78	7.63	0.68	4.30	0.44	0.00
19	Cobble Mulch	1	0.77	470	1.90	1.80	325	6.10	242	2.11	0.67	0.24	7.82	0.30	3.20	0.20	0.00
		2	0.71	468	2.90	2.20	300	5.60	214	1.84	0.55	0.24	7.86	0.28	4.10	0.22	0.00
		3	0.65	511	1.90	2.50	321	6.60	237	1.89	0.53	0.36	7.89	0.28	3.80	0.33	0.00
20	Dairy Manure (2.5 yd ³)	1	1.32	763	3.30	5.20	442	54.10	610	3.39	1.30	0.33	7.59	0.60	4.80	0.22	0.00
		2	1.23	758	3.80	5.20	424	41.80	500	3.07	1.14	0.94	7.60	0.53	4.70	0.65	0.00
		3	2.14	847	4.70	6.30	713	83.80	754	2.98	1.34	0.76	7.66	0.66	5.40	0.52	0.00
21	Control	1	0.68	404	2.50	2.90	288	5.60	210	1.84	0.64	0.23	7.67	0.26	5.70	0.21	0.00
		2	0.68	388	2.20	3.80	343	5.60	208	1.81	0.61	0.21	7.63	0.26	5.60	0.19	0.00
		3	0.52	366	10.00	4.00	278	4.40	157	1.61	0.61	0.46	7.73	0.27	9.00	0.45	0.00
22	Control	1	0.62	396	2.30	2.90	306	5.90	205	1.87	0.58	0.18	7.65	0.25	4.90	0.16	0.00
		2	0.57	352	3.20	2.60	273	4.70	150	1.46	0.53	0.45	7.72	0.23	6.50	0.45	0.00
		3	0.66	378	4.40	3.60	282	5.30	205	1.86	0.79	0.73	7.73	0.32	5.70	0.63	0.00
23	Biosolids Compost (2.5 yd ³)	1	1.41	779	6.10	5.50	476	34.10	453	3.55	1.14	0.45	7.59	0.51	3.80	0.29	0.00
		2	1.36	676	6.70	6.20	450	27.70	355	3.17	1.29	0.41	7.59	0.45	4.50	0.27	0.00
		3	2.00	1022	5.60	6.90	682	56.70	334	4.43	1.38	0.70	7.52	0.55	4.80	0.41	0.00
24	Biosolids Compost (5 yd ³) + H ₂ O	1	2.40	1104	6.00	3.10	775	70.10	421	4.46	1.54	0.54	7.43	0.64	6.90	0.31	0.00
		2	4.04	1337	8.30	3.40	900	147.10	297	7.10	2.48	0.59	7.38	0.78	6.80	0.27	0.00
		3	1.36	643	5.30	5.30	416	30.20	269	2.56	1.40	0.28	7.64	0.39	7.10	0.20	0.00

^a = mmhos/cm^b = meq/L or cmol(+) kg⁻¹^c = percent^d = ppm or mg/kg

Table B-4. Soil textural analysis.

Plot	Treatment	1997 Pretreatment Laboratory Analysis				
		Sample Replicate No.	Sand	Silt	Clay	Texture
1	Greenwaste Compost (5 yd ³) + H ₂ O	1	71.6	14.2	14.2	SL
		2	73.6	13.2	13.2	SL
		3	71.6	13.6	14.8	SL
2	Control + H ₂ O	1	73.6	13.2	13.2	SL
		2	77.6	9.2	13.2	SL
		3	75.6	11.2	13.2	SL
3	Control + H ₂ O	1	75.6	11.2	13.2	SL
		2	73.6	13.2	13.2	SL
		3	75.6	11.2	13.2	SL
4	Biosolids Compost (2.5 yd ³)	1	73.6	12.2	14.2	SL
		2	71.6	14.2	14.2	SL
		3	73.6	12.2	14.2	SL
5	Greenwaste Compost (2.5 yd ³)	1	73.6	12.2	14.2	SL
		2	73.6	12.2	14.2	SL
		3	73.6	13.2	13.2	SL
6	Greenwaste Compost (2.5 yd ³)	1	73.6	11.2	15.2	SL
		2	73.6	11.2	15.2	SL
		3	73.6	11.2	15.2	SL
7	Cobble Mulch	1	71.6	14.2	14.2	SL
		2	71.6	13.2	15.2	SL
		3	69.2	15	15.8	SL
8	Biosolids Compost (2.5 yd ³)	1	64.2	17	18.8	SL
		2	64.2	17	18.8	SL
		3	66.2	16.6	17.2	SL
9	Dairy Manure (2.5 yd ³)	1	72.2	12.6	15.2	SL
		2	71.2	13.6	15.2	SL
		3	71.2	13.6	15.2	SL
10	Cobble Mulch	1	70.2	14.6	15.2	SL
		2	69.2	15.6	15.2	SL
		3	69.2	15.6	15.2	SL
11	Greenwaste Compost (5 yd ³) + H ₂ O	1	68.2	16.6	15.2	SL
		2	69.2	17	13.8	SL
		3	69.2	16	14.8	SL
12	Greenwaste Compost (2.5 yd ³)	1	69.2	16	14.8	SL
		2	71.2	14	14.8	SL
		3	71.2	14	14.8	SL
13	Dairy Manure (2.5 yd ³)	1	71.2	14	14.8	SL
		2	73.2	13	13.8	SL
		3	71.2	15	13.8	SL

Table B-4 (continued)

Plot	Treatment	1997 Pretreatment Laboratory Analysis				
		Sample Replicate No.	Sand	Silt	Clay	Texture
14	Biosolids Compost (5 yd ³) + H ₂ O	1	71.2	14	14.8	SL
		2	71.2	15	13.8	SL
		3	71.2	14	14.8	SL
15	Biosolids Compost (5 yd ³) + H ₂ O	1	69.2	16	14.8	SL
		2	69.2	16	14.8	SL
		3	61.2	21	17.8	SL
16	Control	1	73.2	14	12.8	SL
		2	71.2	14.6	14.2	SL
		3	71.2	14.6	14.2	SL
17	Control + H ₂ O	1	73.2	13.6	13.2	SL
		2	73.2	13.6	13.2	SL
		3	71.2	16.2	12.6	SL
18	Greenwaste Compost (5 yd ³) + H ₂ O	1	71.2	15.2	13.6	SL
		2	68.2	17	14.8	SL
		3	66.6	17.6	15.8	SL
19	Cobble Mulch	1	66.6	19.6	13.8	SL
		2	67.6	18	14.4	SL
		3	66.6	20	13.4	SL
20	Dairy Manure (2.5 yd ³)	1	63.6	21	15.4	SL
		2	66.6	19	14.4	SL
		3	65.6	20	14.4	SL
21	Control	1	69.2	15.6	15.2	SL
		2	68.2	16.6	15.2	SL
		3	69.2	15.6	15.2	SL
22	Control	1	70.2	16.6	13.2	SL
		2	70.2	16.6	13.2	SL
		3	68.2	18.6	13.2	SL
23	Biosolids Compost (2.5 yd ³)	1	66.2	20.6	13.2	SL
		2	64.2	20.6	15.2	SL
		3	65.2	19.6	15.2	SL
24	Biosolids Compost (5 yd ³) + H ₂ O	1	68.2	16.6	15.2	SL
		2	69.2	15.6	15.2	SL
		3	68.2	15.6	16.2	SL

APPENDIX C

Total Biomass Production

Table C-1. Total biomass production (kg m⁻²) on the various study plots, first growing season—1997.

Plot	Treatment	Rep 1	Rep 2	Rep 3	Rep 4	Mean	STD
1	Greenwaste Compost (5 yd ³) + H ₂ O	0.27	0.01	0.02	0.03	0.082	0.11
2	Control + H ₂ O	0.23	0.42	0.46	0.25	0.341	0.10
3	Control + H ₂ O	0.26	0.23	0.36	0.26	0.279	0.05
4	Biosolids Compost (2.5 yd ³)	0.08	0.55	0.55	0.50	0.420	0.20
5	Greenwaste Compost (2.5 yd ³)	0.22	0.13	0.13	0.27	0.188	0.06
6	Greenwaste Compost (2.5 yd ³)	0.51	0.97	0.87	0.71	0.764	0.17
7	Cobble Mulch	0.46	0.55	0.44	0.58	0.507	0.06
8	Biosolids Compost (2.5 yd ³)	0.32	0.66	0.41	0.81	0.552	0.19
9	Dairy Manure Compost (2.5 yd ³)	0.41	0.44	0.83	0.39	0.519	0.18
10	Cobble Mulch	0.16	0.50	0.37	0.94	0.494	0.28
11	Greenwaste Compost (5 yd ³) + H ₂ O	0.31	0.30	0.37	0.31	0.323	0.03
12	Greenwaste Compost (2.5 yd ³)	0.55	0.49	0.28	0.28	0.400	0.12
13	Dairy Manure Compost (2.5 yd ³)	0.36	0.24	1.14	0.08	0.455	0.41
14	Biosolids Compost (5 yd ³) + H ₂ O	0.38	0.55	0.61	0.41	0.488	0.10
15	Biosolids Compost (5 yd ³) + H ₂ O	0.70	0.82	0.83	0.48	0.711	0.14
16	Control	0.77	0.59	0.60	0.24	0.548	0.19
17	Control + H ₂ O	0.35	0.22	0.42	0.38	0.343	0.08
18	Greenwaste Compost (5 yd ³) + H ₂ O	0.19	0.54	0.10	0.17	0.250	0.17
19	Cobble Mulch	0.33	0.29	0.39	0.39	0.347	0.04
20	Dairy Manure Compost (2.5 yd ³)	0.30	0.51	0.56	0.30	0.416	0.12
21	Control	0.54	0.15	0.25	0.60	0.382	0.19
22	Control	0.35	0.26	0.12	0.27	0.250	0.08
23	Biosolids Compost (2.5 yd ³)	0.54	0.45	0.37	0.52	0.468	0.07
24	Biosolids Compost (5 yd ³) + H ₂ O	0.72	0.44	0.58	0.70	0.606	0.11

Table C-2. Total biomass production (kg m⁻²) on the various study plots, second growing season—1998.

Plot	Treatment	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Mean	STD
1	Greenwaste Compost (5 yd ³) + H ₂ O	0.09	0.05	0.14	0.12	0.06	0.091	0.04
2	Control + H ₂ O	0.04	0.05	0.03	0.02	0.06	0.040	0.02
3	Control + H ₂ O	0.03	0.04	0.03	0.05	0.06	0.041	0.01
4	Biosolids Compost (2.5 yd ³)	0.15	0.29	0.25	0.32	0.27	0.256	0.06
5	Greenwaste Compost (2.5 yd ³)	0.04	0.07	0.04	0.07	0.07	0.058	0.01
6	Greenwaste Compost (2.5 yd ³)	0.04	0.15	0.14	0.19	0.19	0.142	0.05
7	Cobble Mulch	0.16	0.19	0.17	0.16	0.08	0.153	0.04
8	Biosolids Compost (2.5 yd ³)	0.18	0.29	0.20	0.21	0.18	0.210	0.04
9	Dairy Manure Compost (2.5 yd ³)	0.22	0.19	0.13	0.17	0.25	0.191	0.04
10	Cobble Mulch	0.15	0.19	0.12	0.08	0.09	0.126	0.04
11	Greenwaste Compost (5 yd ³) + H ₂ O	0.17	0.13	0.14	0.11	0.12	0.135	0.02
12	Greenwaste Compost (2.5 yd ³)	0.14	0.12	0.12	0.24	0.15	0.155	0.04
13	Dairy Manure Compost (2.5 yd ³)	0.18	0.23	0.21	0.26	0.31	0.240	0.04
14	Biosolids Compost (5 yd ³) + H ₂ O	0.36	0.81	0.36	0.36	0.24	0.427	0.20
15	Biosolids Compost (5 yd ³) + H ₂ O	0.25	0.41	0.27	0.56	0.31	0.359	0.11
16	Control	0.17	0.10	0.11	0.09	0.13	0.121	0.03
17	Control + H ₂ O	0.36	--	0.16	0.08	0.11	0.177	0.11
18	Greenwaste Compost (5 yd ³) + H ₂ O	0.12	0.10	0.10	0.10	0.13	0.111	0.01
19	Cobble Mulch	0.15	0.08	0.09	0.15	0.11	0.114	0.03
20	Dairy Manure Compost (2.5 yd ³)	0.12	0.14	0.16	0.18	0.38	0.196	0.09
21	Control	0.07	0.03	0.20	0.04	0.04	0.076	0.06
22	Control	0.08	0.04	0.18	0.25	0.05	0.119	0.08
23	Biosolids Compost (2.5 yd ³)	0.22	0.20	0.28	0.17	0.26	0.225	0.04
24	Biosolids Compost (5 yd ³) + H ₂ O	0.13	0.26	0.26	0.17	0.12	0.189	0.06

DISTRIBUTION

- 1 Arizona Department of Environmental Quality
Attn: Julie Linn
M 0701C
3033 N. Central Ave.
Phoenix, AZ 85012-2809
- 1 Battelle
Attn: Larry Smith
Room 10-1-34B
505 King Ave.
Columbia, OH 43201
- 1 Bureau of Land Management
Attn: Brent Lewis
Denver Service Center
Building 50
Denver, CO 80225
- 1 Bureau of Land Management
Attn: Mike Moran
U.S. Department of Interior
Las Vegas Field Office
4765 Vegas Drive
Las Vegas, NV 89109
- 1 Bureau of Land Management
Attn: Stephanie Odell
Farmington District Office
1235 La Plata Highway
Farmington, NM 87401
- 1 Bureau of Land Management
Attn: Sue Skinner
U.S. Department of Interior
Las Vegas Field Office
4765 Vegas Drive
Las Vegas, NV 89109
- 1 California Environmental Protection Agency
Attn: Darryl Petker
8800 Cal Center Dr.
Sacramento, CA 95826
- 1 California Regional Water Quality Control
Board
Attn: Ron Holcomb
Central Valley Region
3614 East Ashlan Avenue
Fresono, CA 93726
- 1 City of Tuscon
Attn: Chris Leverenz, Disposal Administrator
Solid Waste Management Department
P.O. Box 27210
Tuscon, AZ 85726
- 1 Daniel B. Stephens & Associates, Inc.
Attn: Mark Ankeny
6020 Academy NE
Suite 100
Albuquerque, NM 87109
- 1 EIS Environmental Engineers, Inc.
Attn: Wanda Baxter-Potter
1701 N. Ironwood Dr.
South Bend, Indiana 46635
- 1 Exon Research Engineering
Attn: Chris Jimenz
180 Park Ave.
Florran Park, NJ 07932
- 1 Foster Wheeler Environmental Corp.
Attn: Joe Arnett
10900 NE 8th Street
Suite 1300
Bellevue, WA 98004-4405
- 1 Foster Wheeler Environmental Corp.
Attn: Dino Bonoldi
6605 Uptown Blvd. N.E.
Suite 220
Albuquerque, NM 87110
- 1 Geologic Associates
Attn: Horacio Ferriz
426 14th Street
Modesto, CA 95354
- 1 Geologic Associates
Attn: Gary Lass
1360 Valley Vista Dr.
Suite 100
Diamond Bar, CA 91765
- 1 Hemispheric Center for Environmental
Technologies - FIU
Attn: Dave Roelant
10555 West Flagler Street
Miami, FL 33174

<p>1 Idaho Division of Environmental Quality
Attn: Brian Gaber
1410 N. Hilton
Boise, ID 83706-1255</p>	<p>1 New Mexico Environment Department
Attn: Ed Hanson
2044 Galisteo
P.O. Box 26110
Santa Fe, NM 87502</p>
<p>1 Idaho National Engineering & Environmental Lab
Attn: Wayne Downs
P.O. Box 1625
Idaho Falls, ID 83415</p>	<p>1 New Mexico Environment Department
Attn: Stephanie Kruse
2044 Galisteo
P.O. Box 26110
Santa Fe, NM 87502</p>
<p>1 Los Alamos National Laboratory
Attn: Deba Daymon
MS M992
P.O. Box 1663
Los Alamos, NM 87545</p>	<p>1 New Mexico Environment Department
Attn: Peter Maggiore
1190 St. Francis Drive
Santa Fe, NM 87503</p>
<p>1 Los Alamos National Laboratory
Attn: John Hopkins
MS M992
P.O. Box 1663
Los Alamos, NM 87545</p>	<p>1 New Mexico Environment Department
Attn: Will Motz
2044 Galisteo
P.O. Box 26110
Santa Fe, NM 87502</p>
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Dept. of Civil Engineering
MSC-3CE, Box 30001
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2221 Rio Grande N.W.
Albuquerque, NM 87104</p>	<p>1 New Mexico State University
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Dept. of Civil Engineering
MSC-3CE, Box 30001
Las Cruces, NM 88003</p>
<p>1 New Mexico Environment Department
Attn: Stu Dinwiddie
2044 Galisteo
P.O. Box 26110
Santa Fe, NM 87502</p>	<p>1 New Mexico State University
Attn: Nirmala N. Khandan
Dept. of Civil Engineering
MSC-3CE, Box 30001
Las Cruces, NM 88003</p>

- 1 New Mexico State University
Attn: Zohrab Samani
Dept. of Civil Engineering
MSC-3CE, Box 30001
Las Cruces, NM 88003
- 1 New Mexico State University
Attn: Khaled Sobhan
Dept. of Civil Engineering
MSC-3CE, Box 30001
Las Cruces, NM 88003
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Attn: Skip Chamberlain
EM-53
Cloverleaf Building
19901 Germantown Rd.
Germantown, MD 20874
- 1 U.S. Department of Energy
Attn: Charles Davis
232 Energy Way
North Las Vegas, NV 89030
- 1 U.S. Department of Energy
Attn: Michele DeGennaro
Environmental Measurements lab
201 Varick St., 5th Floor
New York, NY 10014-4811
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Attn: Gillian Eaton
Rocky Flats
Tech Site, Bldg. T124A
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Attn: Sue Garrett
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P.O. Box 550, K8-50
Richland, WA 99352
- 1 U.S. Department of Energy
Attn: John Geiger
Savannah River Operations Office
P.O. Box A
Aiken, SC 29802
- 1 U.S. Department of Energy
Attn: Debra Griswold
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87185

1 U.S. Department of Energy
Attn: Thomas Hicks
Savannah River Operations Office
Bldg. 703-46A
P.O. Box A
Aiken, SC 29802

1 U.S. Department of Energy
Attn: John B. Jones
232 Energy Way
North Las Vegas, NV 89030

1 U.S. Department of Energy
Attn: Missy Klem
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87185

1 U.S. Department of Energy
Attn: Scott McMullin
Savannah River Operations Office
P.O. Box A
Aiken, SC 29802

1 U.S. Department of Energy
Attn: Charles Nalezny
19901 Germantown Road
Germantown, MD 20874-1290

1 U.S. Department of Energy
Attn: Elizabeth Oms
U.S. Department of Energy
Kirtland Area Office
Pennsylvania & H Street
Albuquerque, NM 87185-5400

1 U.S. Department of Energy
Attn: James Paulson
Chicago Operations Office
9800 South Cass Ave.
Argonne, IL 60439

1 U.S. Department of Energy
Attn: Elizabeth Phillips
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37830

1 U.S. Department of Energy
Attn: George Rael
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87185

1 U.S. Department of Energy
Attn: Elisabeth Reber-Cox
Oakland Operations Office
Room 700 N
301 Clay Street
Oakland, CA 94612

1 U.S. Department of Energy
Attn: Pam Saxman
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87185

1 U.S. Department of Energy
Attn: Dirk Schmidhofer
Nevada Operations Office
2753 W. Highland Rd.
Las Vegas, NV 89109

1 U.S. Department of Energy
Attn: George Schneider
Idaho Operations Office
785 DOE Place
Idaho Falls, ID 83402

1 U.S. Department of Energy
Attn: Helen Stolz
Nevada
P.O. Box 98518
Las Vegas, NV 89193

1 U.S. Department of Energy
Attn: Maria Vargas
Richland Operations Office
P.O. Box 550
Richland, WA 99352

1 U.S. Department of Energy
Attn: Jef Walker
EM-53
Cloverleaf Bldg.
19901 Germantown Rd.
Germantown, MD 20874

1 U. S. Department of Energy
Attn: Jody Waugh
Grand Junction Office
2597 B ¼ Road
Grand Junction, CO 81503

1 U.S. Department of Energy
Attn: Phillip Washer
Savannah River Operations Office
Bldg. 773-A
P.O. Box 616
Aiken, SC 29803

- 1 U.S. Department of Energy
Attn: Bill Wilborn
Nevada Operations Office
2753 S. Highland Rd.
Las Vegas, NV 89109
- 1 U.S. Department of Energy
Attn: Woody Woolworth
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87185
- 1 U.S. Department of Energy
Attn: James Wright
Savannah River Operations Office
Bldg. 703-46A
P.O. Box A
Aiken, SC 29803
- 1 U.S. Department of Energy
Attn: Paul Zielinski
EM-443
Cloverleaf Bldg.
19901 Germantown Rd.
Germantown, MD 20874
- 1 U. S. Environmental Protection Agency
Attn: David Basinger
Region 9
MailCode WTR-7
75 Hawthorne St.
San Francisco, CA 94105-3901
- 1 U.S. Environmental Protection Agency
Attn: Dave Carson
Mail Location CHL
26 W. Martin Luther King Dr.
Cincinnati, OH 45268-3001
- 1 U.S. Environmental Protection Agency
Attn: Yoon-Jean Choi
Region 1 (MC: HBS)
1 Congress St.
Suite 1100
Boston, MA 02114-2023
- 1 U.S. Environmental Protection Agency
Attn: Kelly Madalinski
401 M. Street S.W.
Mail Code 51102G
Washington, DC 20460
- 1 U.S. Environmental Protection Agency
Attn: Paul Mushovic
Region 8
999 18th Street
Suite 500
Denver, CO 80202
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Attn: Darryl Petker, P.E.
State of California
Integrated Waste Management Board
8800 Cal Center Drive
Sacramento, CA 95826
- 1 U.S. Environmental Protection Agency
Attn: Robert Shelmutt
75 Hawthorn Street. H-2-2
San Francisco, CA 94105-3901
- 1 U.S. Environmental Protection Agency
Attn: Jay Silvernale
Region 8
999 18th Street
Suite 500
Denver, CO 80202
- 1 U. S. Environmental Protection Agency
Attn: Ken Skahn
(5202G)
401 M Street S.W.
Washington, D.C. 20460
- 1 U. S. Environmental Protection Agency
Attn: Steve Wall
Region 9
WST-7
75 Hawthorne St.
San Francisco, CA 94105-3901
- 1 U.S. Geological Survey
Attn: Brian J. Andraski
333 West Nye Lane, Room 203
Carson City, Nv 89706
- 1 University of Illinois
Attn: David Daniel
Dept. of Civil Engineering
1114 Newmark CE, MC 250
205 N. Mathews
Urbana, IL 61801
- 1 University of New Mexico
Attn: Cliff Anderson
Dept. of Civil Engineering
Albuquerque, NM 87131

- 1 University of New Mexico
Attn: John Stormont
Dept. of Civil Engineering
Albuquerque, NM 87131

- 1 University of Texas at Austin
Attn: Bridget Scanlon
Bureau of Economic Geology
University Station, Box X
Austin, TX 78713

- 1 Victor Hauser
13256 George Rd. Suite 200
San Antonio, TX 78230

- 1 Westinghouse Savannah River Company
Attn: Michael Serrato
Savannah River Technology Center
Environmental Sciences Section
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