Phytoremediation with Native Plants

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Introduction

Phytoremediation harnesses natural processes to assist in the clean-up of pollutants in the environment. The mechanisms by which plants promote the removal of pollutants are varied, including uptake and concentration, transformation of pollutants, stabilization, and rhizosphere degradation, in which plants promote the growth of bacteria underground in the root zone that in turn break down pollutants. While the use of phytoremediation is increasing, relatively little attention has been paid to the ecological characteristics of the plants used. This research investigated the possibility of achieving soil clean-up using native plants that also provided aboveground benefits, including wildlife habitat.

Not all of forms of phytoremediation would be appropriate in a project using native plants. If the contaminant is taken up by the plant, the use of native species encourages entry of the contaminant into the food chain. Indeed, some researchers working on phytoaccumulation of metals voice this concern (Black 1995). However, phytoremediation *ex plantae* does not pose this problem because contaminants are not sorbed but rather degraded in place by bacteria. These *ex plantae* techniques — rhizosphere degradation and phytostabilization — are therefore most appropriate for consideration of the use of native plants. Rhizosphere degradation is appropriate for *in situ* degradation of a variety of organic contaminants. During rhizosphere degradation plants naturally promote increased microbial growth in their root zone (Cunningham and others 1996; Paul and Clark 1996; Westover and others 1997) — mostly gram negative bacteria (Atlas and Bartha 1997) that are stimulated by the exudation of carbohydrates, amino acids, and other compounds from roots (Rovira 1959; Rovira 1965). The microorganism density in the rhizosphere is commonly between 5 and 20 times greater and can be 100 times greater than that in the surrounding soil (Gray and Parkinson 1968; Knatznelson 1965). Rhizosphere bacterial communities are superior for contaminant degradation for three reasons. First, the sheer quantity of microorganisms (Bowen and Rovira 1976; Rice and others 1997) — two to four orders of magnitude greater bacterial abundance (Anderson and others 1994) — degrades more xenobiotic contaminants. Second, groups of bacterial species are sometimes able to provide degradative pathways when acting synergistically, but not alone (Lappin and others 1985; Slater and Bull 1982). The diverse exudates provided by roots promote the assemblage of such synergistic communities. Third, the root zone increases overall microbial diversity, especially that of the key group of organisms, gram negative bacteria (Liu and others 1991).

Completed rhizosphere degradation projects and experiments have used a taxonomically limited array of species. For cleanup of petroleum hydrocarbons, which are the target of the proposed study, members of the grass family (Poaceae) are by far most commonly used (Aprill and Sims 1990; Flathman and Lanza 1998; Nichols and others 1997; Qiu and others 1997). Other families used are the pea family (Fabaceae) (Qiu and others 1997; RTDF 1999) and willows (Salicaceae) (Flathman and Lanza 1998). Species are often used together, for example, a mixture of rye (10–15%), legume (20–25%) and fescue (60–70%) (RTDF 1999), but research to date has not systematically considered the potential benefits of planting diverse native communities.

Some phytoremediation projects have utilized native species. The explanations for doing so include avoiding the introduction of exotic species into sensitive ecosystems (Newman and others 1998; Schnoor 1997: 15), statutory requirements for restoration, and the benefits from the adaptation of indigenous species to local growing conditions (Frick and others 1999). Others have used native species in laboratory trials for their functional characteristics (Aprill and Sims 1990). V.L. Holland and colleagues have paired phytoremediation with ecosystem restoration to create a process they call "ecoremediation," showing that bacterial diversity is greater at sites with greater plant diversity.

We hypothesized that native species would have advantages over the conventional agricultural species for several reasons, especially in southern California. First, native southern California plants have dense, deep root systems adapted to the seasonal rainfall of the Mediterranean climate (Hellmers and others 1955), with highest biomass compared to other regions (Jackson and others 1996; Kummerow and others 1977). Second, native species should have more mychorrhizal associates in the soil, which affect the availability of root exudates to the rhizosphere and can thereby enhance microbial composition in the rhizosphere (Barea and others 1975; Rambelli 1973). Third, diverse native communities will provide a greater diversity of root structure and exudates to act as substrates for bacteria. Diverse communities of plants increase total resource use and enhance nutrient cycling on a yearly timescale because of seasonal complementarity (Hooper and Vitousek 1998; Tilman and others 1996). This increased productivity should also result in increased rhizosphere degradation. Finally, diverse assemblages of native plant species in phytoremediation will also provide different aboveground habitats. Wildlife habitat and its associated esthetic and educational value provide valuable collateral benefits.

The consideration of root zone, species ecology, and diversity effects, suggest that we can chose a set of native species to be used in phytoremediation that perform as well or better than exotic species. This study therefore compares exotic and diverse native plant assemblages to control conditions in terms of contaminant degradation. If native species perform well, they will offer a superior choice for rhizosphere degradation projects because of their lower cost to maintain and compatibility with local ecosystems.

Our research concentrated on a few questions that will provide guidance on the potential use of native plants in phytoremediation in the local environment. These were addressed in the field and in a laboratory experiment. In the laboratory, we addressed the following questions. How do two exemplar native plants compare with a control in terms of 1) root biomass and surface area at three depths, 2) degradation of petroleum hydrocarbons in the soil, and 3) composition and abundance of petroleum-degrading bacteria in the rootzone. In the field, we investigated whether native plants are acceptable to residents of an inner-city neighborhood and evaluate whether native plants attract and maintain a native insect fauna.

Laboratory Study

As the project progressed, we determined that it would be impossible to perform controlled phytoremediation experiments in experimental gardens in neighborhoods. It was difficult to determine what sites might serve as experiments and controls, and it would have been very expensive to characterize them. None of the sites was entirely under our control—all were subject to additional manipulation by residents, and possibly to additional dumping of contaminants. We therefore decide to perform experiments including detailed investigation of the root zones in the lab.

Materials and Methods

Growth of Experimental Plants

A number of species were planted in the curbside "city strips" of the Temple-Beaudry neighborhood to determine whether they would thrive under local conditions. These included California sunflower (*Encelia californica*), California sagebrush (*Artemisia californica*), Black Sage (*Salvia mellifera*), California poppy (*Eschscholzia californica*), and Narrow-leaved Bedstraw (*Galium angustifolia*). These plants were monitored for about eight months, during which time they were protected from major physical disturbance by an artistic iron rebar structure placed over the plants (Figure 1). Black sage and California sagebrush were selected for the laboratory work based on their survival and vigorous growth in the field. Bermudagrass (*Cynodon dactylon*), which is commonly used in phytoremediation projects, was used as the control.

Figure 1. Native plants in city parkway with artistic rebar protection. Shrub species grew well while protected, although cut-through foot traffic, as shown, harmed plants.

Four replicates for each of the three species were planted, for a total of twelve pots. The pots were made of 1-foot sections of 10-inch plastic pipe. The three sections were fastened together with duct tape to form pots three feet deep. Wooden plates formed the bottoms, and holes were provided for water drainage. The sectional construction allowed them to be readily separated when the growth period of the experiment was completed. The tape was removed and the soil and roots were cut through with a knife, producing three separate samples.

Soil was collected from an oil well site in Temple-Beaudry neighborhood (Figure 2a). It was screened, then mixed as a single batch in a 70 gallon cement mixer to ensure that all of the samples were identical. One qt of motor oil to was added to ensure sufficient contaminant concentrations for our determinations.

Before planting, one sample was collected from each pot in a closed lid glass jar. Samples were stored in refrigerator to prevent any microbial activity. Plants were obtained from a nursery and planted in randomly chosen pots on 20 November 2003 (Figure 2b). Plants were watered frequently during the first days and the time between watering was increased toward the end of the project. A total of 33 liters of water were used for each plant during the growth months, for an average of 0.187 liters a day. Pots were brought into laboratory on 24 May 2004 for the post experiment sample collection. Each pot was disassembled into the three sections. Roots from each section were carefully extracted from the soil for further analysis. The soil from each section was thoroughly mixed and samples were taken into sealed glass jars and stored in the refrigerator.

Figure 2. (a) Collection of contaminated soil from Temple-Beaudry neighborhood from lot with oil well. (b) Pots with plant treatments at outset of controlled experiment.

Terminal Restriction Fragments (TRF) Determinations

While our experiments were designed to determine the overall effect of the plants on contaminant degradation, in rhizosphere degradation the microorganisms do the work. We characterized the microbial communities before and after the growth period using Terminal Restriction Fragment Length Polymorphism (TRF) analysis.

Most microbe identification techniques that were being used before recent developments in genetic methods were based on gene sequencing. In most of those methods the 16S rRNA genes are amplified and sequenced. Although this has certain advantages it can be very time consuming in community identification of samples with many species present, as is the case with soil samples.

In the TRF technique, PCR with an appropriate primer is used to amplify specific sections of the 16sRNA gene for all of the microorganisms in the sample. These are then digested with a restriction enzyme to break them into fragments. Because the sequences in the gene vary with microbial species, fragments of different lengths are produced for each. These fragments are then subject to electrophoretic separation, producing a peak for each fragment. The height of each peak reflects the number of fragments in the mix, and presumably the number of microorganisms in the original sample. While errors are conceivable, (two species might produce fragments of similar lengths, and some species may have multiple copies of the gene), it is expected that the electropherogram will provide an approximate representation of the species present and their approximate relative abundances. It is possible to test the samples with a second or third restriction enzyme to eliminate such errors, but that was not done in this case. The details of the TRF method are described elsewhere (Kaplan 2001; Clement 1997).

Root Extraction and Scanning.

Roots were collected from the separated sections of the pots. Care was taken to remove the soil from the roots as thoroughly as possible. Each sample was individually scanned by a dual light system scanner (Epson LC4800) and the scan was analyzed by image analysis software (WinRhizo). In some sections, because of the high density of the roots, scanning was done in several batches and then the numbers were combined. The software provided geometrical data such as length, surface area, volume and average diameter of the roots. The roots from each section and the above-soil foliage were weighed. They were then dried at 100 °C overnight, and weighed again.

Total Petroleum Hydrocarbon Measurement.

Soil samples taken before and after the experiment from each section were analyzed for total petroleum hydrocarbon (TPH) to investigate the efficacy of phytoremediation. TPH was extracted from the soil using an ultrasonic extraction method and was injected into a gas chromatograph (GC) for TPH quantification (EPA 8015M method). Measurements were completed by Enviro-Chem laboratory.

Results and Discussion

TRF analysis

The raw results of the TRF are electropherograms showing peak strengths and detention times. Fragments with the same detention times represent the organisms that are likely the same. The strength of the peak gives us an estimate of the relative abundance of that species. The multivariate analysis technique Principal Components Analysis (PCA) detected the patterns in the results for all of the samples to identify the environmental variables that determine the composition of the culture of microorganisms in the soil. This analysis determines the main sources of variation in a dataset by creating linear combinations of variables that best describes the overall variation in the dataset (Figure 3).

The first component explains the largest part of the variation in the bacterial community. It is evident from inspection that the first component represents the change with time over the growth period of the experiment—all of the initial samples have positive scores while all of the final samples have negative scores, representing a significant change in the bacterial community during the experiment. The second component loosely corresponds with depth in the pots. The ordination illustrates a substantial and similar change in the microbial community under all treatments as a result of plant growth and watering, and a somewhat weaker effect of depth on the microbial community during the experiment. Samples from middle and bottom sections are partially separated, but with significant overlap. Because the soil in the top section was mixed with the soil from the nursery at the time of planting, the significance of its separation from the others cannot be evaluated.

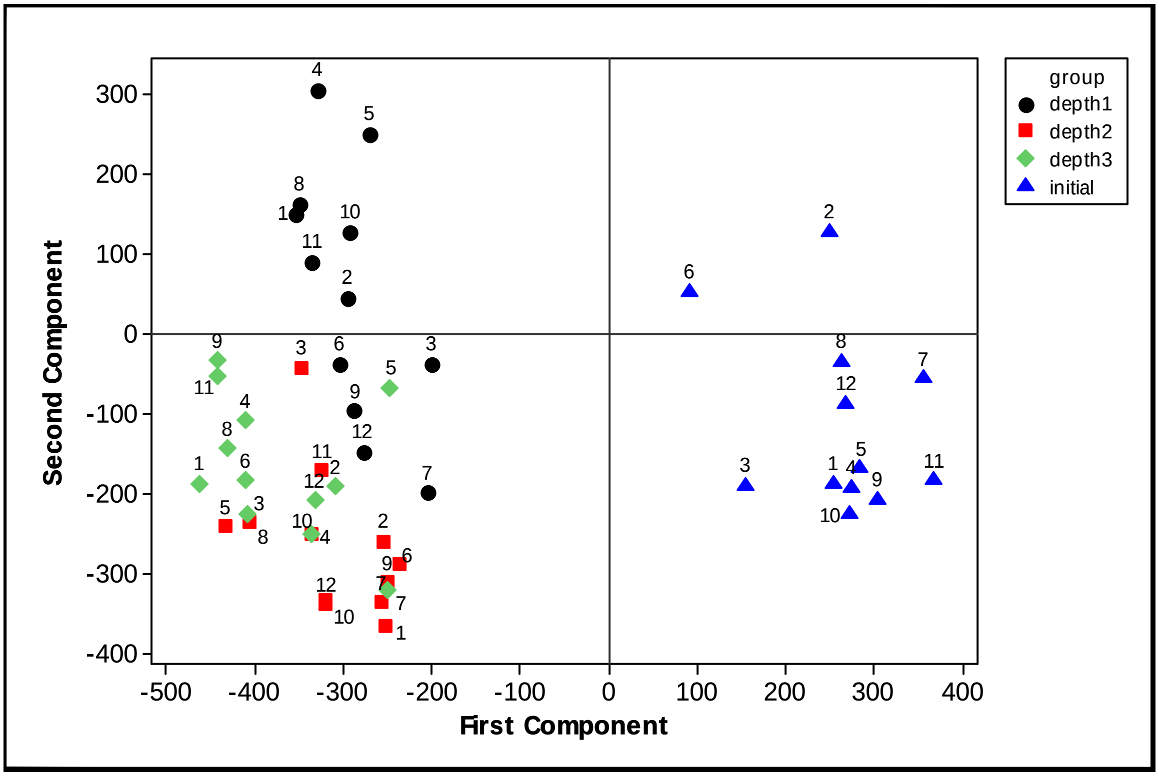


Figure 3. Multivariable PCA analysis performed on results of TRF test.

The multivariate analysis can also represent similarities among the microbial ecosystems in the form of dendrograms (Figure 4).

The overall level of similarity was increased in the post-growth period samples, suggesting the growth of favorable organisms for TPH degradation. Another dendrogram that includes all the samples (Figure 5) shows the significant difference between the initial and post experiment samples. The difference between pre- and post-treatment communities results in large part from a reduction in the number of different TRF patterns found in the soil samples, which indicates a growth of specific subpopulations during the treatment. These changes were in part from increases in actinomycetes (TRFs 75, 77, 79, and 81), gamma-proteobacteria associated with petroleum hydrocarbon degradation (TRFs 230-231), and others.

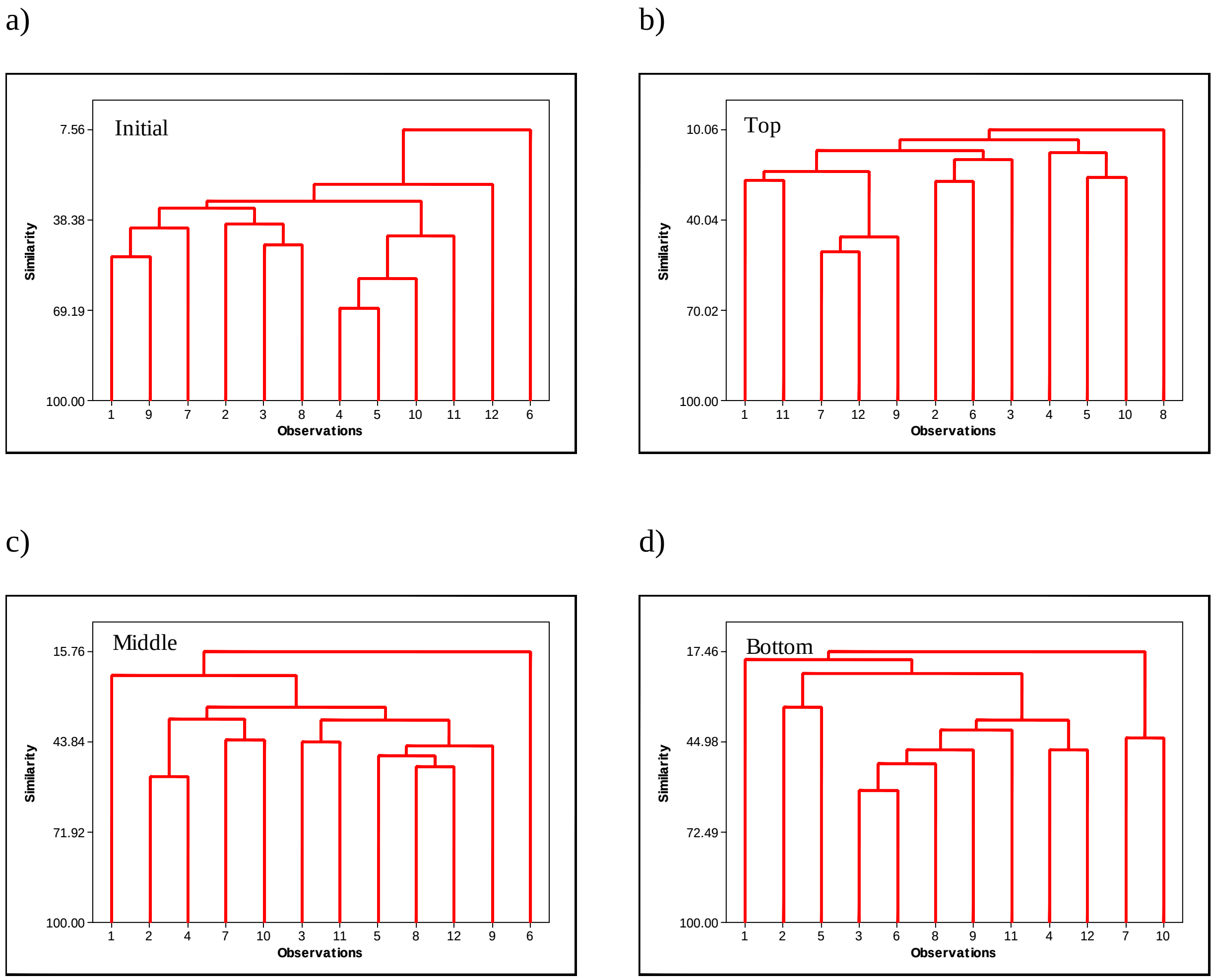


Figure 4. Dendrograms showing the similarity between microbial communities in different samples. (a) initial, (b) post experiment (top section), (c) post experiment (middle section), (d) post experiment (bottom section).

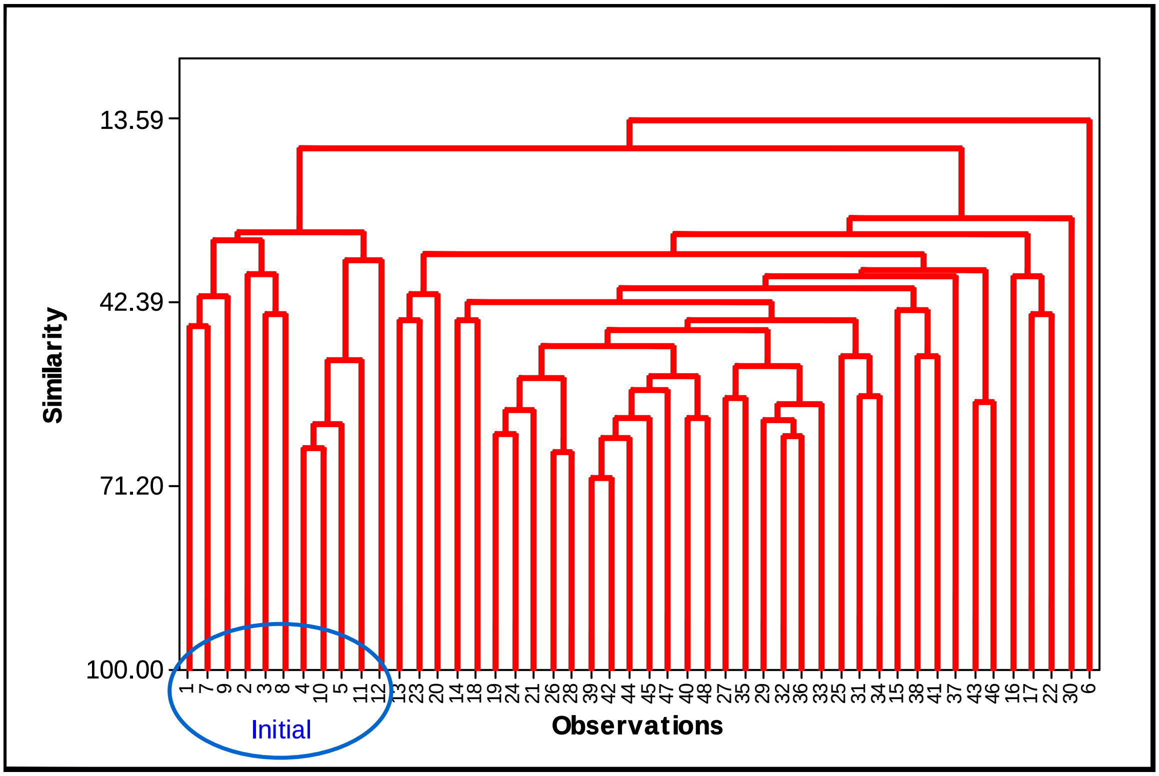


Figure 5. Dendrogram including all the samples in the experiment. Initial samples: 1-12, Post experiment (Top section): 13-24, Post experiment (Middle section): 25-36, Post experiment (Bottom section): 37-48.

The microbial communities differed slightly by plant treatment. For example, samples from three of the four grass treatments clustered separately from the samples from either of the native plants, while one sample from a grass treatment clustered weakly with the natives. This pattern was not repeated in the middle or top sections of the pots.

Root image analysis

Results of the root analysis are shown in Table 1. These results are then grouped into the three species and plotted versus the depth of the pot (Figure 6).

Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial (Weight, g)	Dry (Weight, g)
1_1	6825.7	414.8	132.0	2.0	0.19	48264	1.6	1.3
1_2	12646.0	791.3	251.6	4.0	0.20	74396	1.8	1.5
1_3	6542.4	426.1	135.6	2.2	0.21	36098	1.0	0.8
Plant	G						42.5	24.9
2_1	3809.5	574.7	182.9	7.4	0.48	11894	12.8	11.0
2_2	4528.5	457.1	145.5	3.7	0.32	12642	4.3	3.9
2_3	2019.7	193.8	61.7	1.5	0.31	5260	1.6	1.4
Plant	SB						51.0	35.8
3_1	4066.3	556.6	177.2	6.5	0.44	7591	17.8	11.9
3_2	8472.2	1013.8	322.7	9.7	0.38	17201	8.6	7.1
3_3	7965.3	1001.1	318.7	10.0	0.40	22469	9.0	8.0
Plant	BS						75.1	44.9
4_1	23863.5	1619.8	515.9	8.8	0.22	151469	5.1	4.8
4_2	17791.4	1172.1	373.1	6.2	0.21	87063	2.5	2.4
4_3	10419.8	686.7	218.6	3.6	0.21	42705	1.8	1.7
Plant	G						30.3	26.0
5_1	1888.1	321.5	102.3	4.5	0.54	4049	11.7	8.9
5_2	2770.5	309.1	98.4	2.8	0.36	7132	2.9	2.5
5_3	2912.7	276.9	88.1	2.1	0.30	5946	1.5	1.4
Plant	SB						61.1	44.1
6_1	2878.5	413.9	131.7	5.6	0.46	7290	11.1	8.4
6_2	6871.9	758.5	241.5	6.8	0.35	18888	6.5	4.9
6_3	4850.1	570.6	181.6	5.4	0.37	14177	4.5	4.1
Plant	BS						82.4	46.3
7_1	12373.8	854.2	271.9	4.7	0.22	78873	3.1	2.8
7_2	14143.6	930.8	296.3	4.9	0.21	67097	2.8	2.6
7_3	10535.6	755.3	241.4	4.3	0.23	38189	2.3	2.2
Plant	G						39.8	35.0
8_1	2004.0	398.6	126.9	6.5	0.63	2894	11.3	10.1

Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial (Weight, g)	Dry (Weight, g)
8_2	3755.7	384.1	122.3	3.2	0.33	4770	2.9	2.6
8_3	1525.7	160.3	51.0	1.3	0.33	2054	1.0	0.9
Plant	SB						24.0	20.3
9_1	2710.9	369.6	117.6	4.8	0.43	7814	10.3	8.3
9_2	5350.7	519.8	165.5	4.1	0.31	17285	3.2	2.9
9_3	6494.3	691.2	220.0	5.9	0.34	17912	5.4	4.1
Plant	BS						74.0	48.3
10_1	5380.6	389.2	123.9	2.3	0.23	22219	1.7	1.6
10_2	14058.3	907.1	288.7	4.7	0.21	52359	2.0	1.9
10_3	4903.5	339.7	108.1	1.9	0.22	19154	0.8	0.8
Plant	G						19.0	16.7
11_1	2519.8	363.7	115.8	4.3	0.46	5726	10.5	8.0
11_2	2737.9	267.5	85.2	2.1	0.31	8003	1.5	1.3
11_3	749.2	64.6	20.6	0.4	0.28	3132	0.2	0.2
Plant	SB						69.9	41.2
12_1	5990.7	652.0	207.5	5.9	0.35	18870	14.4	10.9
12_2	9234.0	927.6	295.3	7.5	0.32	19550	6.0	5.2
12_3	14355.7	1514.1	481.8	12.8	0.34	35822	10.8	9.7
Plant	BS						49.6	36.0

Table 1. First part of the sample number is associated with the pot number and the second part represents the section of the pot (1 for top, 2 for middle and 3 for bottom).

The rhizosphere is the suitable zone for the growth of microorganisms. Because the volume of rhizosphere is directly related to the surface area of the roots, the surface area may be used as a parameter for comparing different species of plants. Figure 6(a) shows the surface area of different plants versus the depth of the root. Because grass is a commonly used plant for phytoremediation we compare the native plants to the grass. The mid-depth surface area of the black sage is very close to that of the grass and in the deepest section of the pot it is almost twice as great. Black sage had greater volume of roots at all depths than grass, and both California sagebrush and black sage had greater average diameter. This latter result is predictable because of the difference between woody shrub and grass morphology.

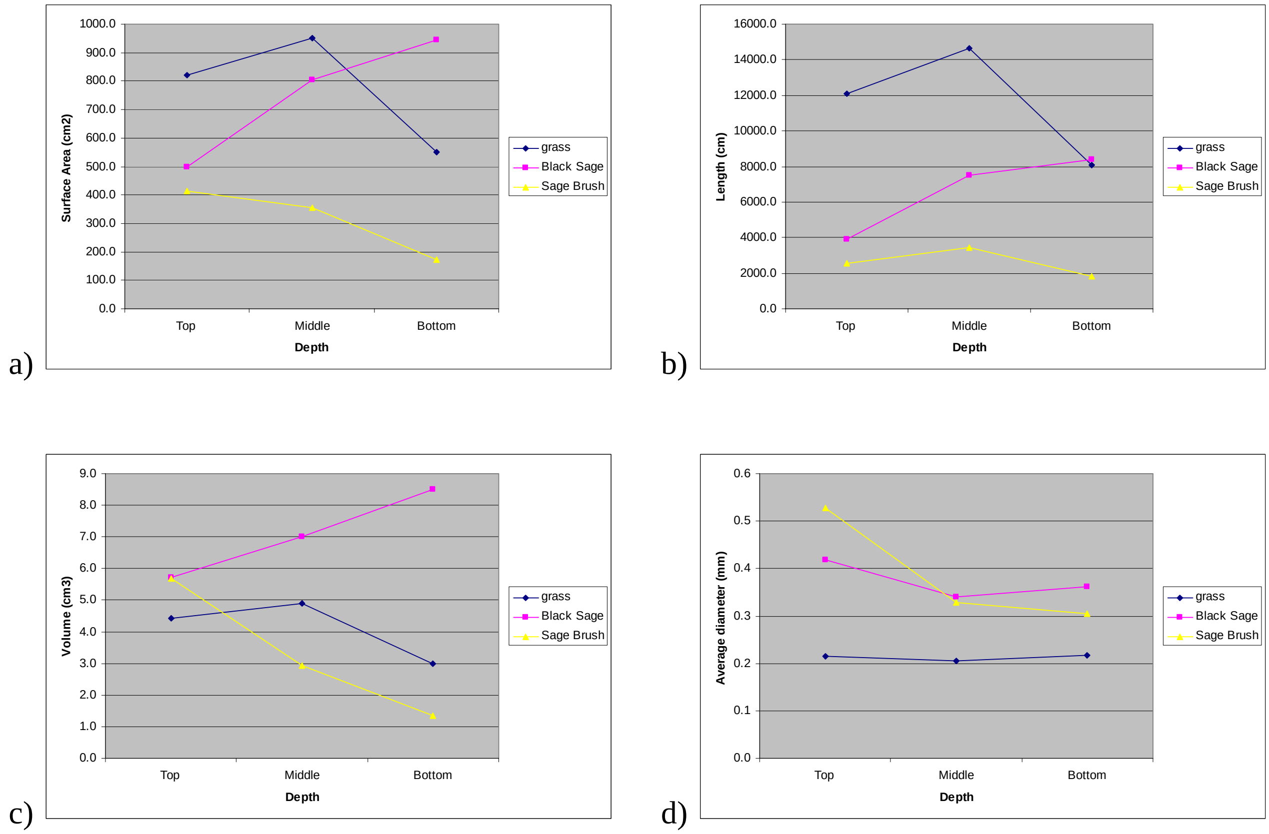


Figure 6. Physical properties of plant species are plotted versus the depth of the root. a) surface area, b) length, c) volume and d) average diameter.

Total Petroleum Hydrocarbon Analysis

Results of the TPH analysis for before and after of the experiment in each section are shown in Table 2. Because soil in the top part of the pots was mixed with the nursery soil in the original pots of the plants the concentrations in the top part were not measured after the experiment and only the removal efficiencies for middle and bottom sections are shown in the table.

Pot #	Initial (ppm)	Middle (ppm)	Bottom (ppm)	Removal %, Middle	Removal %, Bottom
1 (G)	13500	9370	8160	31	40
2 (SB)	13200	11400	7830	14	41
3 (BS)	13800	10800	11100	22	20
4 (G)	10600	10500	9260	1	13
5 (SB)	11000	10300	9470	6	14
6 (BS)	10800	12100	10200	-12	6
7 (G)	13400	19400	9570	-45	29
8 (SB)	12100	11100	7630	8	37
9 (BS)	10900	12500	8760	-15	20
10 (G)	15500	12500	8550	19	45
11 (SB)	11900	10200	7730	14	35
12 (BS)	11900	9990	9310	16	22

Table 2. Removal efficiencies of TPH in middle and bottom sections of the pots. G is used for grass, SB for California sage brush and BS for black sage.

Since the results in the middle section are not very consistent no meaningful conclusion regarding the degradation of TPH can be drawn from the results. In the bottom section, however, results are less variable and all of them show reductions. The average reduction in the bottom section is 32% for grass, 17% for black sage and 32% for California sagebrush. All of these represent significant reduction of hydrocarbon concentration (compared with a presumption of 0% reduction; $P < 0.001$) in the bottom section, while no significant difference on average from 0% reduction is found in the middle section.

Field Study

Methods

We collaborated with the public art group ARTScorpsLA to work in the Temple-Beaudry neighborhood of Los Angeles. ARTScorpsLA has developed a community art park called Spiraling Orchard in this neighborhood, and organized the community through the establishment of the Spiraling Orchard Community Council. This area was the first oil field in the city, with active oil wells present from the early 1900s. Visible oil contamination is present at many of the oil wells still operating in the neighborhood.

To evaluate the feasibility of using native plants in the compacted and contaminated soils of the neighborhood, and to educate and involve the community in the project, we planted a garden of native plants in a city parkway in February 2003. ARTScorpsLA, and the Spiraling Orchard Community Council initiated this project and named the overall project “Spiraling Roots.” With separate funding, ARTScorpsLA planned to plant 30 such native gardens in the neighborhood over the next three years.

The original pilot planting included a range of native species appropriate to the topographic position of the neighborhood. These were: California sagebrush (*Artemisia californica*), black sage (*Salvia mellifera*), white sage (*Salvia apiana*), California sunflower (*Encelia californica*), bedstraw (*Galium angustifolium*), California poppies (*Eschscholzia californica*), lance-leafed dudleya (*Dudleya lanceolata*), and verbena (*Verbena lasiostachys*). Community members and volunteers did the planting. They also constructed arches of rebar in the strip that were viewed as an artistic enhancement and which discouraged pedestrians from walking through the garden.

Figure 7. (a) Installation of native plant garden with rebar sculpture in city parkway along Bixel Street. (b) Native American blessing of streetside garden by neighborhood youth.

To evaluate the potential for native plants to enhance local biodiversity we conducted a series of general entomological surveys in the neighborhood with entomologist Ken Osborne. During visits on August 13, 2003, January 25, 2004, and April 28, 2004, we conducted sweep netting and directed capture of arthropods within the Spiraling Orchard park and the surrounding neighborhood. Youth from the neighborhood assisted on surveys.

Figure 8. Sweep net and vacuum sampling of vegetation by entomologist Ken Osborne.

During the April 28, 2004 visit, Osborne conducted 1-minute vacuum sampling (Allen-vac) of two native gardens in parkways, in addition to similar timed samples within the Spiraling Orchard park, which is dominated by exotic plant species. These included two samples from mixed *Salvia* and *Encelia* plantings, two samples from *Artemisia*, and four samples from various exotic plants in the park. All arthropods in the vacuum samples were sorted, assigned to morphospecies, tabulated, and curated.

Figure 9. (a) Show-and-tell of local insects with neighborhood youth and volunteers. (b) Local field assistant.

Results

While protected, the plants grew well in the street-side garden, and the shrubs quickly reached three feet tall. When the rebar was removed, however, the heavy use of the street and sidewalk led to pedestrian traffic through the plantings. The plants that survived best were the larger shrubs, in particular California sagebrush and black sage. While the smaller grew well in the soils on site, they could not tolerate the disturbance of pedestrian traffic.

Sweep samples, directed capture, and vacuum sampling collected 120 morphospecies of insects in and around the Spiraling Orchard park. Many morphospecies have not yet been determined and have been assigned to orders, families, or genera were possible. Many singletons (77) and doublets (20) were recorded, which suggests that further sampling would increase the total species number. The most common insects were thrips and leafhoppers.

The most notable feature of the vacuum samples is the abundance of native leafhoppers on the native plants (148) with relatively few on exotic plants (18), with the reverse pattern for thrips on native (24) and exotic (232) plants.

More insects were captured in vacuum samples of exotic vegetation (335) than on native vegetation (241). The proportions of different orders, roughly representing guilds, differed between native and exotic plantings. Proportionally more Hymenoptera (bees and wasps), Neuroptera (lacewings), Collembola (springtails), and Psocoptera (barklice), were found around exotic vegetation, while proportionally more Coleoptera (beetles), Homoptera (aphids, cicadas, and leafhoppers), Heteroptera (true bugs), Lepidoptera (butterflies and moths), and Thysanoptera (thrips) were found on native vegetation.

Table 3. Invertebrate species observed in Spiraling Orchard Park and Spiraling Roots study sites, collected by sweep netting and vacuum sampling (August 2003, January 2004, April 2004).

Order	Family	Species	Comments
Coleoptera	Coccinellidae	*Psyllobora vigintimaculata*	Mildew-feeding ladybeetle
	Dermestidae	*Anthrenus sp*	Common pest, eats wood
	Scarabaeidae	*Cotinus texana*	Metallic green fig beetle
		Five unidentified Coleoptera species	
Collembola		One unidentified Collembola	
Dermaptera	Carcinophoridae	*Euborellia annulipes*	Invasive earwig
Diptera	Bombyliidae	*Villa moliter*	
	Calliphoridae	*Phaenicia sericata*	green bottle fly
	Dolichopodidae	*Condylostylus pilicornis*	
	Drosopphilidae	*Drosophila* sp.	
	Muscidae	*Musca domestica*	
	Sarcophagidae	*Sarcophaga* sp.	
	Syrphidae	*Allograpta oblique*	widespread hover fly predatory larvae
		Eristalis tenax	drone fly, bee mimic
		Eristalis aenea	
		Eupeodes volucris	aphidophagous hover fly
		Volucella mexicana	aphidophagous hover fly
		16 unidentified Diptera species	
Heteroptera	Anthochoridae	*Anthochoris* sp.	predatory bug
	Coriidae	*Leptoglossus clypealis*	leaf-footed bug
	Lygaeidae	*Nyssius* sp.	seed bug

	Miridae	*Europiella* sp.	
		Lygus sp. 1	
		Lygus sp. 2	
		Taylorilygus pallidulus	broken-back bug
		5 unidentified Heteroptera	
Homoptera	Cicadellidae	*Empoasca decora*	Native to southern California
		Empoasca sp. 1	
		Empoasca sp. 2	
		12 unidentified Homoptera	
Hymenoptera	Anthophoridae	*Melissodes*	(male) solitary bee
	Anthophoridae	Xylocopa varipuncta	*carpenter bee*
	Apidae	*Apis mellifera*	honey bee, not native
	Formicidae	*Iridomyrmex humilis*	Argentine ant, not native
	Halictidae	*Agapostemon* sp.	native bee
	Sphecidae	*Bembix americana*	predatory wasp
		Cerceris femurrubrum	
		Philanthus crabroniformis	
		Sceliphron caementarium	black and yellow mud dauber –eats spiders
	Vespidae	*Polistes apachus*	not native, from TX
		Polistes fuscatus	paper wasp
		27 unidentified Hymenoptera	
Lepidoptera	Hesperiidae	*Erynnis funeralis*	funereal duskywing, not common garden species, foodplant deerweed
		Erynnis tristis	oak foodplant, not common garden species
		Hylephila phyleus	firey skipper, common
		Lerodia eufala	foodplant grasses not common garden species
		Polites sabuleti	foodplant saltgrass not common garden species
	Lycaenidae	Leptotes marina	*Plumbago, common*
		Strymon melinus	Hairstreak, common
	Nymphalidae	*Agraulis vanillae*	Gulf fritillary, common
		Vanessa annabella	West coast lady, common
		Vanessa cardui	Painted lady, common
	Pieridae	*Colias eurytheme*	common
		Pieris rapae	common
		4 unidentified moths	
Neuroptera	Chrysidae	*Chrysopa* sp.	green lacewing, larvae eat aphids
		3 unidentified Neuroptera	

Orthoptera	Acrididae	*Schistocerca nitens*	grey bird locust
		Trimerotropis pallidipennis	pallidwinged grasshopper
	Tettigoniidae	*Scudderia mexicana*	katydid
Psocoptera		3 unidentified Psocoptera	barklice
Thysanoptera	Thripidae	*Frankliniella occidentalis*	
		2 unidentified Thysanoptera	

Table 4. Proportional representation of orders in vacuum samples from native and exotic vegetation (April 2004).

	Percent of Total Specimens in Vacuum Samples	
Order	Native Vegetation	Exotic Vegetation
Coleoptera	11.8	5.8
Collembola		1.4
Diptera	21.6	17.4
Heteroptera	11.8	7.2
Homoptera	23.5	13.0
Hymenoptera	11.8	34.8
Lepidoptera	5.9	1.4
Neuroptera	0	4.3
Psocoptera	0	5.8
Thysanoptera	13.7	8.7

The number of species found in each vacuum sample ranged from 5 to 27. *Artemisia* samples contained 5 and 9 species, *Salvia*/*Encelia* samples contained 10 and 27 species, and exotic plant samples contained 11 to 24 species.

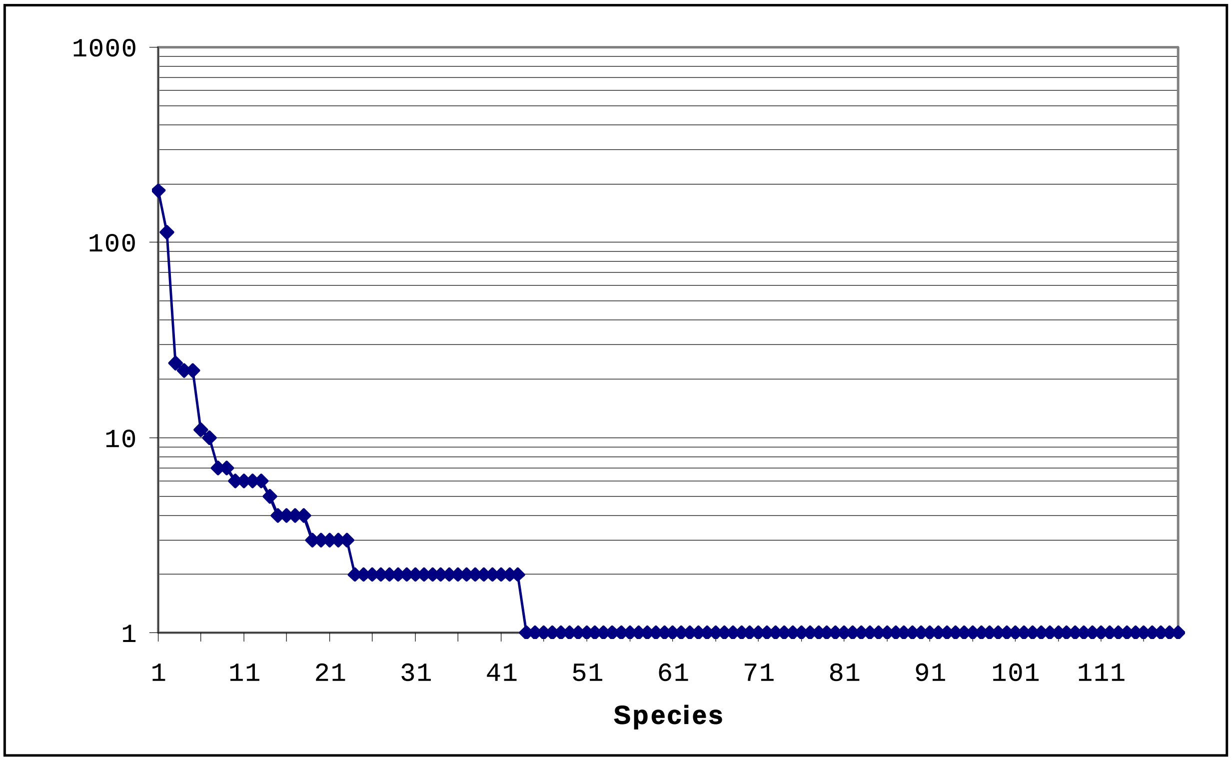


Figure 10. Rank species abundance curve for samples from native and exotic vegetation.

Community Outreach for the Spiraling Roots Project

In conjunction with the Spiraling Roots project, research team members coordinated efforts with the local community. The community is already organized through efforts of ARTScorpsLA, a "land art nonprofit that works with community residents to transform vacant urban land into outdoor communal art parks." In the Temple-Beaudry neighborhood ARTScorpsLA had previously developed the "Spiraling Orchard" art park, and an associated neighborhood council, Vecinos de Spiraling Orchard. The Spiraling Roots neighborhood plantings were coordinated both with ARTScorpsLA and Vecinos de Spiraling Orchard. Specific activities included:

1. Conducted a training session with staff involved in the Spiraling Roots project at ARTScorpsLA headquarters.

2. Participated in site visit with environmental artist Mel Chin as part of ARTScorpsLA's Spiraling Roots activities.

3. USC researchers met with Vecinos de Spiraling Orchard on several occasions to discuss project, outcomes, problems, and remedies.

4. Worked alongside community members to plant streetside native gardens, preceded by brief presentation about project and introducing the native plants and their characteristics.

5. Participated in several community festivals, including a Native American blessing of first streetside planting.

6. Participated in several community clean-up days with local residents.

7. Attended community festivals.

8. Scheduled insect monitoring on same day as community clean-up and enlisted local children to conduct sweep netting of insects.

9. Met with community leaders and representatives of Mountains Recreation Conservation Authority about potential use of phytoremediation in development of natural park adjacent to study area at Belmont High School.

10. Met with community leaders and representatives of Natural History Museum of Los Angeles County about development of citizen science program in neighborhood.

In addition, Dr. Longcore participated in the development of an article with the School of Engineering's online Illumin magazine, including a video description of the project. Click here to view:

Conclusions

This study was intended to be an initial effort to determine whether native species can be used in urban neighborhoods for phytoremediation. Restoration of petroleum-contaminated urban land by phytoremediation is a complex process involving the biological characteristics of the plants, the ecological characteristics of the rhizosphere microbial communities they support, and the social and political system that sets priorities and defines goals. While phytoremediation may be used as a short-term treatment option to rehabilitate land for residential or commercial development, it is also possible to imagine it as the first step in creation of wildlife habitat. Plants could clean up the petroleum contamination even as they are becoming the producers at the base of a self-sustaining urban ecosystem.

This is only possible, however, if the species used are natives, well adapted to the local climate and soils and capable of supporting the animals that are also well adapted to the area. But only a small number of plant species has been established as being effective in phytoremediation. This does not mean that many plants have been shown ineffective—just that relatively few have been carefully evaluated. Thus it is valuable to determine whether native species are also effective.

Effectiveness of Native Plants for Phytoremediation

Results for disappearance of petroleum hydrocarbons in the bottom third of the plants indicated that California Sage was as effective as the commonly used Bermuda grass. All three plant types produced similar modifications in the bacterial communities, and the native species generally had equal or greater root presence. While the results are necessarily limited by the small size of the research project, it seems likely that the native plants are as effective as the grass for phytoremediation. It is unquestionable that their roots will run deeper, allowing phytoremediation to greater depths in the soil.

Insect Surveys

Urban neighborhoods can be important reservoirs of biodiversity, especially if vacant lots are allowed to persist without significant interference (Small and others 2002; Stuke 1998). Two aspects of the insect surveys deserve mention, the overall diversity of the insect community and the structure of the community on the native plantings.

The neighborhood supports a significant native insect community, with many species that would not be expected in densely populated residential neighborhoods. Several of the butterfly species found at the site were not identified as common garden species by Mattoni (1990), including *Erynnis funeralis*, *Erynnis tristis*, *Lerodia eufala*, and *Polites sabuleti*. The wasps included native species with specialized habitat preferences, such as *Bembix americana*, which is associated with open sand (Hogue 1993).

The collections on *Artemisia* plants exhibited similarities with collections on Artemisia in a nature reserve in Riverside County (Burger and others 2003). At both sites, collections vacuum-sampled from *Artemisia* plants included the leafhopper *Empoasca decora* (Cicadellidae: Homoptera) as the most abundant species (113/161 [70%] in our study). The average number of morphospecies was also close, but slightly lower in the urban setting — 9.2 in Riverside vs. 5 and 9 species in our study. Burger et al. (2003) also recorded greater than 50% of specimens as singletons in a collection of 882 individuals of 169 morphospecies. In comparison, on all vegetation we collected 576 individuals of 90 morphospecies, of which 56 (62%) were singletons.

Those orders more common on native vegetation are predominantly phytophagous (Heteroptera, Homoptera, Thysanoptera), while those more common on collections from exotic vegetation were predatory (most of the Hymenoptera) or nectar and pollen feeders (other Hymenoptera). It is an open question whether the native herbivores found on native plants were attracted from the nearest similar native vegetation (over a mile), present in low abundance in the neighborhood and increased in response to the provision of appropriate foodplants, or brought to the neighborhood from the plant nursery on the plants. No matter the explanation, the native plants support a distinctly different insect community than ruderal vegetation or exotic plantings in the neighborhood. This community has similarities with that supported by the same native plants in wildland settings. This is, to our knowledge, the first time that such a small number of native plants in such an urban setting has been shown to support a distinct native fauna.

Use of Native Plants for Phytoremediation in Urban Neighborhoods

Highly developed urban landscapes have received substantial attention in programs designed to clean up contaminants—the term “brownfields” is widely recognized. Cleanup efforts, however, have generally been aimed and large sites intended for redevelopment. Because speed is commonly important in such projects, phytoremediation is less commonly used.

Development of wildlife habitat in urban neighborhoods has been almost entirely ignored. Because a vacant lot or unused city strip cannot become part of a large wilderness area, the presumption has been that they are useless as habitat. We are coming to realize, that while it is true that such small spaces, surrounded by urban noise, light, and pollution, cannot recreate the wilderness that the city replaced, they can support plants, animals, and ecosystems that have social, aesthetic, and natural value. Flowers, diverse and interesting insects, and communities of birds can become common again, even as we acknowledge that the corner lot cannot become a redwood forest.

Phytoremediation with native plants provides a link between the objectives of site cleanup and habitat restoration. The plants whose rhizospheres promote degradation of hydrocarbons will at the same time provide food and habitat for rehabilitated ecosystems as the transition is made from brownfield to greenspace.

The work described here contributed to development of such techniques. While the scope of experiments was restricted by a modest budget, it was shown that there is nothing particularly special about the plants that have been studied and used in formal phytoremediation projects. Plants native to Southern California grew more roots deeper, and roughly matched the performance of a control planting of grass. While more detailed and extensive research is needed, particularly in the field, we have found no reason why native plants should fail. Single native plant species alone performed as well as grass in phytoremediation. Investigating the synergistic effects of multiple native species together (e.g., shrubs, grasses, and annual forbs) would be a promising next step. As expected, the presence of native plants in field trials attracted an insect community that is more typical of the natural ecosystems of the region than the surrounding urban landscape.

Our work indicates that such projects can gain the support of the communities where they are done. Residents had many questions, and often desired showier plants familiar to them from retail gardens. Controlled experiments may be more difficult, but the problems we encountered came more from excess of enthusiasm than lack of it. People liked the street side gardens so well that petunias—decidedly non-native—appeared among the California sagebrush. It should no surprise that the residents of those neighborhoods neglected by landlords and last on the list to receive city services are nonetheless appreciative when bare and polluted dirt is replaced by a healthy green ecosystem.

Literature Cited

Anderson TA, Kruger EL, Coats JR. 1994. Enhanced degradation of a mixture of three herbicides in the rhizosphere of a herbicide-tolerant plant. *Chemosphere* 14:2041-2047.

Aprill W, Sims RC. 1990. Evaluation of the use of prairie grasses for stimulating polycyclic aromatic hydrocarbon treatment in soil. *Chemosphere* 20(1-2):253-265.

Atlas RM, Bartha R. 1997. *Microbial Ecology: Fundamentals and Applications*: Addison-Wesley. 306 p.

Barea JM, Azcon R, Hayman DS. 1975. Possible synergistic interactions between Endogone and phosphate-solubilization bacteria in low-phosphate soils. In: Sanders FE, Mosse B, Tinker PB, editors. *Endomycorrhizas*. London: Academic Press.

Black H. 1995. Absorbing possibilities: phytoremediation. *Environmental Health Perspectives* 103(12):1106-1108.

Bowen GD, Rovira AD. 1976. Microbial colonization of plant roots. *Annual Review of Phytopathology* 14:121-144.

Burger JC, Redak RA, Allen EB, Rotenberry JT, Allen MF. 2003. Restoring arthropod communities in coastal sage scrub. *Conservation Biology* 17(2):460–467.

Cunningham SD, Anderson TA, Schwab AP, Hsu FC. 1996. Phytoremediation of soils contaminated with organic pollutants. *Advances in Agronomy* 56:55-114.

Flathman PE, Lanza GR. 1998. Phytoremediation: current views on an emerging green technology. *Journal of Soil Contamination* 7(4):415-432.

Frick CM, Farrell RE, Germida JJ. 1999. *Assessment of phytoremediation as an in-situ technique for cleaning oil-contaminated sites*. Saskatoon, Saskatchewan: University of Saskatchewan. 88 p.

Gray TRG, Parkinson D. 1968. *The Ecology of Soil Bacteria*. Toronto, Canada: University of Toronto Press.

Hellmers H, Horton JS, Juhren G, O'Keefe J. 1955. Root systems of some chaparral plants in southern California. *Ecology* 36(4):667-678.

Hogue CL. 1993. *Insects of the Los Angeles basin*. Los Angeles: Natural History Museum of Los Angeles County. 446 p.

Hooper DU, Vitousek PM. 1998. Effects of plant composition and diversity on nutrient cycling. *Ecological Monographs* 68(1):121-149.

Jackson RB, Canadell J, Ehleringer JR, Mooney HA, Sala OE, Schulze ED. 1996. A global analysis of root distributions for terrestrial biomes. *Oecologia* 108(3):389-411.

Kaplan, CW, Astaire, JC, Sanders, ME, Reddy, BS, Kitts, CL. 2001. 16S ribosomal DNA terminal restriction pattern analysis of bacterial communities in feces of rats fed Lactobacillus acidophilus NCFM. *Applied and Environmental Microbiology* 67(4):1935-1939.

Knatznelson H. 1965. Nature and importance of the rhizosphere. In: Baker KF, Snyder WC, editors. *Ecology of Soil-Borne Plant Pathogens*: Prelude to Biological Control. Berkely, CA: University of California Press. p 187-207.

Kummerow J, Krause D, Jow W. 1977. Root systems of chaparral shrubs. *Oecologia* 29:163-177.

Lappin HM, Greaves MP, Slater JH. 1985. Degradation of the herbicide Mecoprop [2-(2-methyl-4-chlorophenoxy)propionic acid] by a synergistic microbial community. *Applied and Environmental Microbiology* 49(2):429-433.

Liu C-M, McLean PA, Sookdeo CC, Cannon FC. 1991. Degradation of the herbicide glyphosphate by members of the family Rhizobiaceae. *Applied and Environmental Microbiology* 57:1799-1804.

Mattoni R. 1990. *Butterflies of greater Los Angeles*. Beverly Hills, CA: Lepidoptera Research Foundation.

Newman LA, Doty SL, Gery KL, Heilman PE, Muiznieks I, Shang TQ, Siemieniec ST, Strand SE, Wang X, Wilson A, M. and others. 1998. Phytoremediation of organic contaminants: a review of phytoremediation research at the University of Washington. *Journal of Soil Contamination* 7(4):531-542.

Nichols TD, Wolf DC, Rogers HB, Beyrouty CA, Reynolds CM. 1997. Rhizosphere microbial populations in contaminated soils. *Water, Air, and Soil Pollution* 95(1-4):165-178.

Nur N, Jones SL, Geupel GR. 1999. A statistical guide to data analysis of avian monitoring programs, BTP-R6001-1999. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service.

Paul EA, Clark FE. 1996. *Soil Microbiology and Biochemistry*. New York: Academic Press. 340 p.

Qiu X, Leland TW, Shah SI, Sorenson DL, Kendall EW. 1997. Field study: grass remediation for clay contaminated with polycyclic aromatic hydrocarbons. In: Kruger EL, Anderson TA, Coats JR, editors. *Phytoremediation of Soil and Water Contaminants*. Washington, DC: American Chemical Society. p 186-189.

Rambelli A. 1973. The rhisozphere of mycorrhizae. In: Marks GC, Kozlowski TT, editors. *Ectomycorrhizae*. New York: Academic Press.

Rice PJ, Anderson TA, Coats JR. 1997. Evaluation of the use of vegetation for reducing the environmental impact of deicing agents. In: Kruger EL, Anderson TA, Coats JR, editors. *Phytoremediation of Soil and Water Contaminants*. Washington, DC: American Chemical Society. p 162-176.

Rovira AD. 1959. Root excretions in relation to the rhizosphere effect. IV. Influence of plant species, age of plants, light, temperature, and calcium nutrition on root exudation. *Plant and Soil* 11:53-64.

Rovira AD. 1965. Plant root exudates and their influence on soil microorganisms. In: Baker KF, Snyder WC, editors. *Ecology of Soil-Borne Plant Pathogens: Prelude to Biological Control*. Berkely: University of California Press. p 170-184.

RTDF. 1999. Field Study Protocol: Phytoremediation of Petroleum Hydrocarbons in Soil.: Remediation Technologies Development Forum, Phytoremediation Action Team.

Schnoor JL. 1997. *Phytoremediation*. Pittsburgh, PA: Ground-Water Remediation Technologies Analysis Center. Report nr TE-98-01. 37 p.

Slater JH, Bull AT. 1982. Environmental microbiology: biodegradation. *Philosophical Transactions of the Royal Society of London B* 297:575-597.

Small EC, Sadler JP, Telfer MG. 2002. Carabid beetle assemblages on urban derelict sites in Birmingham, UK. *Journal of Insect Conservation* 6(4):233–246.

Stuke J-H. 1998. The importance of an urban park area as insect habitat, exemplified by the hoverfly fauna (Dipt. Syrphidae) of the "Stadtwald" in Bremen. Abhandlungen Naturwissenschaftlichen *Verein zu Bremen* 44(1):93-114.

Tilman D, Wedin D, Knops J. 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature* 379(6567):718-720.

Westover KM, Kennedy AC, Kelley SE. 1997. Patterns of rhizosphere microbial community structure associated with co-occurring plant species. *Journal of Ecology* 85(6):863-873.

Appendix I. Data

TRF peaks	name	group	sample	Dpn049	Dpn059	Dpn061	Dpn063	Dpn064	Dpn068
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	500	500	500	500	500	500
29	0-3	initial	3	20636	500	500	500	500	500
28	0-4	initial	4	500	500	500	500	500	500
30	0-5	initial	5	500	500	500	500	500	500
26	0-6	initial	6	500	500	500	500	15553	500
35	0-7	initial	7	500	21151	15878	500	500	500
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	500	17878	500	500	16107	500
29	0-10	initial	10	500	500	500	500	500	500
27	0-11	initial	11	500	12371	500	500	500	500
34	0-12	initial	12	500	29446	31960	500	16651	17804
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	500	20129	500	500	500	500
28	1-5	depth1	5	500	15437	500	500	500	500
25	1-6	depth1	6	500	500	500	500	500	500
29	1-7	depth1	7	500	13857	500	500	500	500
25	1-8	depth1	8	500	23885	500	500	500	500
29	1-9	depth1	9	500	18706	500	500	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	22771	500	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	500	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	18998	500	500	500	500
28	3-4	depth3	4	500	17807	500	500	500	500
27	3-5	depth3	5	500	16429	500	500	500	500
26	3-6	depth3	6	500	16811	500	500	500	500
24	3-7	depth3	7	500	500	500	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	17675	500	500	500	500
26	3-10	depth3	10	500	500	500	500	500	500
24	3-11	depth3	11	500	17863	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn070	Dpn071	Dpn072	Dpn075	Dpn077	Dpn078
29	0-1	initial	1	500	500	500	500	500	14392
32	0-2	initial	2	500	500	27583	500	500	500
29	0-3	initial	3	500	500	500	500	500	500
28	0-4	initial	4	500	500	500	500	500	18995
30	0-5	initial	5	500	500	500	500	500	15800
26	0-6	initial	6	500	500	500	16365	500	500
35	0-7	initial	7	500	500	14874	15984	500	20849
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	500	500	500	500	500	500
29	0-10	initial	10	500	500	500	500	500	19800
27	0-11	initial	11	500	500	19802	16156	500	20674
34	0-12	initial	12	16208	500	19415	15150	500	15495
24	1-1	depth1	1	500	500	500	500	50986	500
23	1-2	depth1	2	500	500	500	17875	20945	500
29	1-3	depth1	3	500	500	500	500	26193	500
20	1-4	depth1	4	500	500	500	500	79403	500
28	1-5	depth1	5	500	500	500	500	39679	500
25	1-6	depth1	6	500	500	500	13677	23541	500
29	1-7	depth1	7	500	500	500	500	21077	500
25	1-8	depth1	8	500	500	12681	500	50343	500
29	1-9	depth1	9	500	500	500	500	30692	500
28	1-10	depth1	10	500	500	500	500	26942	500
24	1-11	depth1	11	500	500	500	12760	29545	19111
28	1-12	depth1	12	500	500	500	500	24210	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	15284	500
26	2-3	depth2	3	500	500	500	500	16042	500
24	2-4	depth2	4	500	500	500	13255	24484	500
21	2-5	depth2	5	500	500	500	20933	19299	500
26	2-6	depth2	6	500	11454	18495	14133	500	500
21	2-7	depth2	7	500	500	500	13984	15019	500
25	2-8	depth2	8	500	500	500	14597	26344	500
23	2-9	depth2	9	500	500	500	16621	28048	500
24	2-10	depth2	10	500	500	500	31974	20633	500
22	2-11	depth2	11	500	500	500	21296	27378	500
21	2-12	depth2	12	500	500	500	31731	29083	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	20207	21571	500
28	3-4	depth3	4	500	500	500	500	19313	500
27	3-5	depth3	5	500	500	500	500	500	500
26	3-6	depth3	6	500	500	500	25327	31004	500
24	3-7	depth3	7	500	500	500	500	17877	500
25	3-8	depth3	8	500	500	500	13639	16838	500
26	3-9	depth3	9	500	500	500	23971	32084	500
26	3-10	depth3	10	500	500	500	500	17784	500
24	3-11	depth3	11	500	500	500	15659	18885	500
27	3-12	depth3	12	500	500	500	500	14800	500

TRF peaks	name	group	sample	Dpn079	Dpn080	Dpn081	Dpn082	Dpn083	Dpn084
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	500	15595	500	35201	23997	500
29	0-3	initial	3	500	500	500	500	500	18163
28	0-4	initial	4	500	29574	500	58160	21542	500
30	0-5	initial	5	500	23504	500	40881	16665	500
26	0-6	initial	6	500	19645	500	500	21026	500
35	0-7	initial	7	500	15867	500	500	14253	500
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	500	500	500	16560	500	500
29	0-10	initial	10	500	27333	500	30543	500	500
27	0-11	initial	11	16466	500	500	23756	13356	500
34	0-12	initial	12	500	500	500	47365	500	17224
24	1-1	depth1	1	43654	500	130090	500	75811	500
23	1-2	depth1	2	500	500	36712	500	500	14372
29	1-3	depth1	3	500	500	30426	46191	500	26865
20	1-4	depth1	4	500	500	223332	500	500	500
28	1-5	depth1	5	500	500	82144	500	500	54481
25	1-6	depth1	6	29335	20459	52557	500	500	78457
29	1-7	depth1	7	17405	500	56295	23843	500	35367
25	1-8	depth1	8	500	500	99966	500	165884	500
29	1-9	depth1	9	36530	500	101223	500	48591	500
28	1-10	depth1	10	500	500	81994	500	500	52970
24	1-11	depth1	11	500	28627	133521	500	41397	58729
28	1-12	depth1	12	22260	500	90525	500	500	55140
22	2-1	depth2	1	17983	500	18339	18299	500	14984
27	2-2	depth2	2	20484	500	37823	17343	500	21927
26	2-3	depth2	3	20025	500	35058	500	51568	500
24	2-4	depth2	4	33856	500	49835	35650	500	31506
21	2-5	depth2	5	19223	500	25644	25492	500	22491
26	2-6	depth2	6	17550	500	500	500	500	500
21	2-7	depth2	7	14118	500	19233	500	500	500
25	2-8	depth2	8	30580	500	21335	31435	500	17207
23	2-9	depth2	9	45960	500	22413	38405	500	500
24	2-10	depth2	10	21093	500	20106	21135	500	13256
22	2-11	depth2	11	31671	500	43746	500	32265	500
21	2-12	depth2	12	28709	500	500	18358	500	500
15	3-1	depth3	1	500	14071	59451	19114	500	29081
24	3-2	depth3	2	15676	500	31077	500	500	20138
27	3-3	depth3	3	26558	500	60064	500	500	38901
28	3-4	depth3	4	35773	500	104814	500	500	83323
27	3-5	depth3	5	500	500	20057	500	500	500
26	3-6	depth3	6	500	500	75933	500	500	64421
24	3-7	depth3	7	500	500	45829	500	500	33690
25	3-8	depth3	8	28996	500	45234	500	500	40471
26	3-9	depth3	9	59060	500	117651	500	500	61733
26	3-10	depth3	10	15595	500	101639	500	500	63135
24	3-11	depth3	11	33507	500	140804	500	500	85250
27	3-12	depth3	12	23436	500	49487	500	500	28709

TRF peaks	name	group	sample	Dpn085	Dpn086	Dpn087	Dpn088	Dpn090	Dpn091
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	22180	500	500	500	500	500
29	0-3	initial	3	500	500	500	500	500	500
28	0-4	initial	4	16730	500	500	500	500	500
30	0-5	initial	5	500	500	500	500	500	500
26	0-6	initial	6	500	14030	500	500	500	500
35	0-7	initial	7	17095	500	500	500	500	500
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	16696	500	500	500	500	500
29	0-10	initial	10	17281	500	500	500	500	500
27	0-11	initial	11	500	500	500	500	500	12258
34	0-12	initial	12	20807	500	13489	500	500	500
24	1-1	depth1	1	37032	500	26007	500	15692	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	92418	500	500	500	500	500
28	1-5	depth1	5	500	500	500	35841	500	500
25	1-6	depth1	6	500	500	14962	500	500	500
29	1-7	depth1	7	15494	500	16921	500	500	500
25	1-8	depth1	8	500	500	48560	500	500	30726
29	1-9	depth1	9	31213	500	16286	500	500	500
28	1-10	depth1	10	500	500	20670	500	500	500
24	1-11	depth1	11	500	500	19550	500	500	500
28	1-12	depth1	12	500	500	16967	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	15399	500	500	500	500	500
26	2-3	depth2	3	500	500	16583	500	500	500
24	2-4	depth2	4	25210	500	15181	500	500	500
21	2-5	depth2	5	11663	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	500	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	12229	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	500	500	30329	500	500	500
27	3-5	depth3	5	500	500	500	500	500	500
26	3-6	depth3	6	500	500	500	500	500	500
24	3-7	depth3	7	500	500	500	500	500	500
25	3-8	depth3	8	500	500	16033	500	500	500
26	3-9	depth3	9	22754	500	16704	500	500	500
26	3-10	depth3	10	500	500	17420	500	500	500
24	3-11	depth3	11	500	500	21203	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn093	Dpn117	Dpn123	Dpn125	Dpn126	Dpn128
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	500	500	500	500	500	500
29	0-3	initial	3	500	500	500	500	500	500
28	0-4	initial	4	500	500	21432	500	500	20664
30	0-5	initial	5	500	500	18510	500	500	17316
26	0-6	initial	6	500	500	500	500	500	500
35	0-7	initial	7	500	500	500	500	500	20614
30	0-8	initial	8	500	500	500	500	500	14199
28	0-9	initial	9	500	500	500	500	500	23542
29	0-10	initial	10	500	500	500	500	500	19922
27	0-11	initial	11	500	500	500	500	500	21884
34	0-12	initial	12	500	500	500	500	500	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	500	500	500
25	1-6	depth1	6	500	500	500	500	500	500
29	1-7	depth1	7	500	500	500	500	500	500
25	1-8	depth1	8	12355	500	18120	14587	500	500
29	1-9	depth1	9	500	500	18874	500	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	500	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	500	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	500	500	23182	16703	18272	500
27	3-5	depth3	5	500	500	500	15396	500	500
26	3-6	depth3	6	500	500	15045	500	500	500
24	3-7	depth3	7	500	500	14181	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	500	23300	500	500	500	500
24	3-11	depth3	11	500	500	14607	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn130	Dpn131	Dpn133	Dpn143	Dpn144	Dpn145
29	0-1	initial	1	19263	500	500	500	500	500
32	0-2	initial	2	500	500	500	500	500	500
29	0-3	initial	3	500	500	500	500	500	500
28	0-4	initial	4	22408	500	500	500	500	500
30	0-5	initial	5	19502	500	500	500	500	500
26	0-6	initial	6	500	500	500	500	36874	50878
35	0-7	initial	7	21033	500	500	500	500	500
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	28581	500	500	500	500	500
29	0-10	initial	10	19786	500	500	500	500	500
27	0-11	initial	11	24770	500	500	500	500	500
34	0-12	initial	12	16786	500	500	500	500	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	500	500	500
25	1-6	depth1	6	500	500	500	500	500	500
29	1-7	depth1	7	500	500	500	500	500	500
25	1-8	depth1	8	500	500	500	500	500	500
29	1-9	depth1	9	500	500	500	500	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	500	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	13904	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	500	500	500	500	500	500
27	3-5	depth3	5	500	500	500	500	500	500
26	3-6	depth3	6	500	500	500	13547	500	500
24	3-7	depth3	7	500	33156	500	13753	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	500	500	500	500	500	500
24	3-11	depth3	11	500	500	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn148	Dpn149	Dpn150	Dpn151	Dpn152	Dpn153
29	0-1	initial	1	70789	500	52050	500	16457	500
32	0-2	initial	2	500	39910	37914	500	500	500
29	0-3	initial	3	500	37343	500	42251	16543	500
28	0-4	initial	4	500	65318	500	46774	18176	500
30	0-5	initial	5	500	58516	42024	500	15725	500
26	0-6	initial	6	500	500	500	500	500	500
35	0-7	initial	7	56609	500	55797	18584	500	500
30	0-8	initial	8	500	49247	32892	17638	500	500
28	0-9	initial	9	500	65260	41991	500	500	500
29	0-10	initial	10	500	56772	500	62417	22797	500
27	0-11	initial	11	500	101457	500	64190	15762	500
34	0-12	initial	12	500	42530	500	500	500	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	20588	500	500
29	1-3	depth1	3	500	500	13916	24521	500	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	13680	500	500
25	1-6	depth1	6	500	500	500	28819	500	500
29	1-7	depth1	7	500	500	500	25815	500	500
25	1-8	depth1	8	500	500	500	19554	500	500
29	1-9	depth1	9	500	500	500	23397	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	27863	500	500
22	2-1	depth2	1	500	500	500	13710	500	500
27	2-2	depth2	2	500	500	500	27617	500	500
26	2-3	depth2	3	500	500	500	34905	500	15853
24	2-4	depth2	4	500	500	500	17838	500	500
21	2-5	depth2	5	500	500	500	21009	500	500
26	2-6	depth2	6	500	500	500	47122	500	500
21	2-7	depth2	7	500	500	500	28869	500	13895
25	2-8	depth2	8	500	500	500	34271	500	500
23	2-9	depth2	9	500	500	13977	82853	500	500
24	2-10	depth2	10	500	500	500	34048	500	500
22	2-11	depth2	11	500	500	500	31965	500	13610
21	2-12	depth2	12	500	500	500	40301	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	39988	16605	500
27	3-3	depth3	3	500	500	500	25216	500	500
28	3-4	depth3	4	500	500	500	13840	500	500
27	3-5	depth3	5	500	500	500	20426	500	500
26	3-6	depth3	6	500	500	500	30011	500	500
24	3-7	depth3	7	500	500	500	34829	500	500
25	3-8	depth3	8	500	500	500	19975	500	500
26	3-9	depth3	9	500	500	500	29742	500	500
26	3-10	depth3	10	500	500	500	36916	500	500
24	3-11	depth3	11	500	500	500	23084	500	500
27	3-12	depth3	12	500	500	500	38163	500	500

TRF peaks	name	group	sample	Dpn154	Dpn155	Dpn157	Dpn159	Dpn161	Dpn179
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	500	500	500	500	500	500
29	0-3	initial	3	500	500	500	500	500	500
28	0-4	initial	4	500	500	500	500	500	500
30	0-5	initial	5	500	500	500	500	500	500
26	0-6	initial	6	500	17704	500	500	500	500
35	0-7	initial	7	500	500	500	500	500	500
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	500	500	500	500	500	500
29	0-10	initial	10	500	500	25024	500	500	500
27	0-11	initial	11	500	500	500	500	500	500
34	0-12	initial	12	500	500	500	500	14640	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	500	500	500
25	1-6	depth1	6	18627	500	500	500	500	500
29	1-7	depth1	7	500	13869	500	500	500	500
25	1-8	depth1	8	12578	500	500	500	500	500
29	1-9	depth1	9	500	19277	500	500	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	13037	500	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	500	20435
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	15218	500	500	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	16614	14115	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	28244	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	500	500	500	500	500	500
27	3-5	depth3	5	500	500	500	500	500	500
26	3-6	depth3	6	500	500	500	500	500	500
24	3-7	depth3	7	500	26759	500	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	500	15174	500	500	500	500
24	3-11	depth3	11	500	500	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn182	Dpn184	Dpn186	Dpn187	Dpn189	Dpn198
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	500	500	500	500	500	500
29	0-3	initial	3	500	500	500	500	500	500
28	0-4	initial	4	500	500	500	500	500	500
30	0-5	initial	5	500	500	500	500	500	500
26	0-6	initial	6	500	500	500	500	500	15395
35	0-7	initial	7	500	500	500	500	500	500
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	500	500	500	500	500	500
29	0-10	initial	10	500	500	500	500	500	500
27	0-11	initial	11	500	500	500	500	500	500
34	0-12	initial	12	500	500	500	500	500	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	500	500	500
25	1-6	depth1	6	500	500	500	500	500	500
29	1-7	depth1	7	500	500	500	500	500	500
25	1-8	depth1	8	500	500	500	500	500	500
29	1-9	depth1	9	500	500	500	500	500	500
28	1-10	depth1	10	500	500	500	16788	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	46435	65548	63625	39669	18203	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	500	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	500	500	500	500	500	500
27	3-5	depth3	5	500	500	500	500	500	500
26	3-6	depth3	6	500	500	500	500	500	500
24	3-7	depth3	7	500	500	500	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	500	500	500	500	500	500
24	3-11	depth3	11	500	500	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn200	Dpn201	Dpn202	Dpn203	Dpn205	Dpn208
29	0-1	initial	1	23784	18909	500	145242	54590	500
32	0-2	initial	2	500	17127	500	113651	48073	500
29	0-3	initial	3	30398	500	500	123599	45940	500
28	0-4	initial	4	500	28829	500	153217	40854	500
30	0-5	initial	5	500	30369	500	152981	40979	500
26	0-6	initial	6	18406	151747	500	63241	500	500
35	0-7	initial	7	24644	14617	500	167919	500	500
30	0-8	initial	8	19113	24334	500	133633	54173	500
28	0-9	initial	9	28893	500	500	130765	40117	500
29	0-10	initial	10	500	28771	500	133612	40936	500
27	0-11	initial	11	500	35845	500	179706	48681	500
34	0-12	initial	12	13019	21939	500	130992	42197	500
24	1-1	depth1	1	500	500	12599	64021	61247	500
23	1-2	depth1	2	500	33395	500	88509	57240	500
29	1-3	depth1	3	500	30195	500	98914	40917	500
20	1-4	depth1	4	500	16629	500	57325	51253	500
28	1-5	depth1	5	500	19790	500	68614	29430	500
25	1-6	depth1	6	500	31486	500	101855	57009	500
29	1-7	depth1	7	500	28470	500	78935	54273	500
25	1-8	depth1	8	500	19114	22250	78797	41220	500
29	1-9	depth1	9	500	19125	17750	77908	42047	500
28	1-10	depth1	10	500	23214	500	74012	39060	500
24	1-11	depth1	11	500	15124	500	53434	32183	500
28	1-12	depth1	12	500	29566	500	100587	45527	500
22	2-1	depth2	1	500	500	22309	93740	90929	500
27	2-2	depth2	2	500	22979	500	68491	81234	500
26	2-3	depth2	3	500	24162	23073	85055	46527	500
24	2-4	depth2	4	500	23187	500	96132	88710	500
21	2-5	depth2	5	500	16260	24048	125712	80199	500
26	2-6	depth2	6	500	24729	20710	107948	50728	500
21	2-7	depth2	7	500	500	28556	120521	109014	500
25	2-8	depth2	8	500	15065	18571	117432	80420	500
23	2-9	depth2	9	500	21091	500	180817	82916	500
24	2-10	depth2	10	500	500	25258	96190	111938	500
22	2-11	depth2	11	500	24886	33098	189221	78222	500
21	2-12	depth2	12	500	16505	23565	153024	75951	500
15	3-1	depth3	1	500	500	30019	137781	111046	500
24	3-2	depth3	2	500	500	500	68145	105442	500
27	3-3	depth3	3	500	15822	18429	87048	64002	500
28	3-4	depth3	4	500	500	18216	70778	65960	500
27	3-5	depth3	5	500	17720	20303	80363	63208	500
26	3-6	depth3	6	500	17126	21889	85648	68048	500
24	3-7	depth3	7	500	18140	31591	95316	101538	15372
25	3-8	depth3	8	500	18476	20502	88281	72657	500
26	3-9	depth3	9	500	18248	18246	95609	48424	500
26	3-10	depth3	10	500	13320	23293	84953	95494	500
24	3-11	depth3	11	500	14185	21824	98507	57227	500
27	3-12	depth3	12	500	17937	21042	102853	66411	500

TRF peaks	name	group	sample	Dpn209	Dpn211	Dpn212	Dpn213	Dpn214	Dpn215
29	0-1	initial	1	500	500	40243	61761	500	24572
32	0-2	initial	2	500	500	32457	500	37656	500
29	0-3	initial	3	500	500	46265	500	43408	17633
28	0-4	initial	4	500	500	500	48706	35972	500
30	0-5	initial	5	500	500	500	54323	39072	500
26	0-6	initial	6	500	500	44714	36305	500	75341
35	0-7	initial	7	500	500	33065	28557	500	17602
30	0-8	initial	8	500	500	46046	500	34594	24323
28	0-9	initial	9	500	500	500	86556	500	26091
29	0-10	initial	10	500	500	500	39099	30014	500
27	0-11	initial	11	500	500	500	41067	21561	500
34	0-12	initial	12	500	500	500	62306	15637	500
24	1-1	depth1	1	500	500	500	19967	500	43700
23	1-2	depth1	2	500	500	500	28539	500	500
29	1-3	depth1	3	500	500	500	23715	20055	500
20	1-4	depth1	4	500	500	500	500	39010	500
28	1-5	depth1	5	500	500	500	500	35478	500
25	1-6	depth1	6	500	500	500	38223	500	500
29	1-7	depth1	7	500	500	500	37824	500	52065
25	1-8	depth1	8	13416	500	500	18144	500	500
29	1-9	depth1	9	500	500	500	29169	500	13842
28	1-10	depth1	10	500	500	500	500	70808	500
24	1-11	depth1	11	500	500	500	500	500	69213
28	1-12	depth1	12	500	500	500	41974	500	12565
22	2-1	depth2	1	500	500	500	36736	500	44453
27	2-2	depth2	2	500	500	500	28731	500	500
26	2-3	depth2	3	500	500	500	24717	500	500
24	2-4	depth2	4	500	500	500	24704	500	500
21	2-5	depth2	5	500	500	500	15690	500	500
26	2-6	depth2	6	500	500	500	12382	500	500
21	2-7	depth2	7	500	500	500	38166	500	30018
25	2-8	depth2	8	500	500	500	31354	500	26781
23	2-9	depth2	9	500	500	500	28205	500	500
24	2-10	depth2	10	500	500	500	30703	500	43173
22	2-11	depth2	11	500	500	500	18689	500	16047
21	2-12	depth2	12	500	500	500	34704	500	24917
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	52067	500	500
27	3-3	depth3	3	500	500	500	26183	500	500
28	3-4	depth3	4	16684	24948	15725	20486	19251	500
27	3-5	depth3	5	500	500	500	30423	14326	500
26	3-6	depth3	6	500	500	500	17962	500	500
24	3-7	depth3	7	500	500	500	40934	500	500
25	3-8	depth3	8	500	500	500	29410	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	500	500	500	29215	500	500
24	3-11	depth3	11	500	500	500	26956	500	18543
27	3-12	depth3	12	18673	21974	20695	41084	23179	500

TRF peaks	name	group	sample	Dpn216	Dpn217	Dpn218	Dpn219	Dpn220	Dpn221
29	0-1	initial	1	500	20209	500	18677	500	500
32	0-2	initial	2	17504	20260	500	19021	500	500
29	0-3	initial	3	500	21661	500	21277	500	25677
28	0-4	initial	4	17580	500	500	500	500	21659
30	0-5	initial	5	20723	17072	500	16570	500	23276
26	0-6	initial	6	500	17857	500	26910	500	500
35	0-7	initial	7	500	15043	14650	500	500	500
30	0-8	initial	8	500	20623	500	20384	500	18228
28	0-9	initial	9	500	500	500	17810	500	500
29	0-10	initial	10	15563	16840	500	16530	500	21506
27	0-11	initial	11	500	500	500	500	500	500
34	0-12	initial	12	22076	500	500	13108	500	500
24	1-1	depth1	1	500	19285	500	16265	500	28117
23	1-2	depth1	2	500	17654	500	500	70200	500
29	1-3	depth1	3	24872	500	15832	500	27581	43362
20	1-4	depth1	4	500	18952	500	500	44444	500
28	1-5	depth1	5	22368	500	500	17722	50491	500
25	1-6	depth1	6	500	500	500	32470	500	62787
29	1-7	depth1	7	500	21883	500	21684	500	21287
25	1-8	depth1	8	500	500	500	500	500	500
29	1-9	depth1	9	500	14535	500	16125	500	33492
28	1-10	depth1	10	500	500	500	16317	500	36716
24	1-11	depth1	11	500	19238	500	500	500	22511
28	1-12	depth1	12	500	18849	500	21667	500	29914
22	2-1	depth2	1	500	32624	500	500	500	97456
27	2-2	depth2	2	500	500	500	31766	500	44708
26	2-3	depth2	3	500	500	500	16639	500	15221
24	2-4	depth2	4	500	15803	500	17598	500	42920
21	2-5	depth2	5	500	500	500	500	500	25074
26	2-6	depth2	6	500	13017	500	12175	500	500
21	2-7	depth2	7	500	19514	500	18180	500	24987
25	2-8	depth2	8	500	500	500	35351	500	14543
23	2-9	depth2	9	500	11962	500	12686	500	14323
24	2-10	depth2	10	500	25777	500	18525	500	500
22	2-11	depth2	11	500	13665	500	500	500	500
21	2-12	depth2	12	500	16625	500	32589	500	25704
15	3-1	depth3	1	500	500	500	500	500	22280
24	3-2	depth3	2	13835	500	500	13864	500	59112
27	3-3	depth3	3	16684	500	500	23107	500	38134
28	3-4	depth3	4	27864	500	500	19125	500	14285
27	3-5	depth3	5	13588	14462	500	500	24890	83511
26	3-6	depth3	6	500	500	500	22504	500	42784
24	3-7	depth3	7	500	500	500	44226	500	64916
25	3-8	depth3	8	24497	500	500	21160	500	33862
26	3-9	depth3	9	500	500	500	14264	500	32032
26	3-10	depth3	10	500	28407	500	29831	500	67399
24	3-11	depth3	11	500	17630	500	14061	500	16493
27	3-12	depth3	12	26141	18656	500	24919	500	20887

TRF peaks	name	group	sample	Dpn222	Dpn223	Dpn225	Dpn226	Dpn227	Dpn228
29	0-1	initial	1	500	500	17104	500	43390	500
32	0-2	initial	2	500	500	500	17957	500	38467
29	0-3	initial	3	500	500	500	24530	41814	500
28	0-4	initial	4	500	500	500	500	26694	500
30	0-5	initial	5	500	500	500	500	32101	500
26	0-6	initial	6	500	500	500	21690	500	19792
35	0-7	initial	7	500	500	15775	500	34208	500
30	0-8	initial	8	500	500	22802	500	32313	23755
28	0-9	initial	9	500	500	16587	500	41455	500
29	0-10	initial	10	500	500	500	500	36028	500
27	0-11	initial	11	500	500	500	500	24347	500
34	0-12	initial	12	500	500	500	12913	44143	500
24	1-1	depth1	1	500	500	500	14154	500	68733
23	1-2	depth1	2	500	500	17578	500	18096	36133
29	1-3	depth1	3	500	20121	500	22574	500	14114
20	1-4	depth1	4	15248	500	500	500	500	43910
28	1-5	depth1	5	500	14683	500	14664	500	37309
25	1-6	depth1	6	500	500	500	500	500	41655
29	1-7	depth1	7	500	500	16983	500	22578	500
25	1-8	depth1	8	500	500	500	500	500	26801
29	1-9	depth1	9	500	14774	13071	500	16732	500
28	1-10	depth1	10	500	13629	500	500	13629	24698
24	1-11	depth1	11	500	500	500	500	18134	37557
28	1-12	depth1	12	500	14433	14364	500	24005	500
22	2-1	depth2	1	500	500	30066	500	23160	500
27	2-2	depth2	2	500	500	13527	15429	23925	500
26	2-3	depth2	3	500	23080	21736	23202	500	23995
24	2-4	depth2	4	500	500	500	500	16509	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	18117	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	500	500	500	24571
23	2-9	depth2	9	500	500	500	500	13788	500
24	2-10	depth2	10	45364	500	500	500	27466	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	23852	24901
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	18345	500	500	15098	18697
27	3-3	depth3	3	16159	500	500	500	17070	500
28	3-4	depth3	4	500	500	500	500	500	500
27	3-5	depth3	5	34678	500	19983	19614	500	31579
26	3-6	depth3	6	25232	16732	500	13988	18104	500
24	3-7	depth3	7	500	500	500	500	500	500
25	3-8	depth3	8	27978	20452	18208	500	19672	38122
26	3-9	depth3	9	500	500	500	500	13260	18419
26	3-10	depth3	10	500	500	500	500	500	500
24	3-11	depth3	11	500	500	500	17342	500	26544
27	3-12	depth3	12	500	500	500	15730	15495	500

TRF peaks	name	group	sample	Dpn229	Dpn230	Dpn231	Dpn232	Dpn234	Dpn236
29	0-1	initial	1	27842	21768	500	26050	44190	64732
32	0-2	initial	2	500	46424	500	29346	45437	44274
29	0-3	initial	3	30555	29104	500	54215	41538	66023
28	0-4	initial	4	20398	500	500	34710	32892	69558
30	0-5	initial	5	25325	16255	500	38384	36464	71193
26	0-6	initial	6	26578	500	500	46623	80481	42273
35	0-7	initial	7	26534	19467	20768	500	47034	66368
30	0-8	initial	8	500	37557	500	22098	57044	67225
28	0-9	initial	9	26894	20347	500	32768	39222	67881
29	0-10	initial	10	25220	17241	500	23263	43777	56460
27	0-11	initial	11	14960	500	500	500	24685	52804
34	0-12	initial	12	500	26727	22999	500	24058	60127
24	1-1	depth1	1	500	34740	500	127661	39297	17656
23	1-2	depth1	2	500	47741	89785	164935	91520	49144
29	1-3	depth1	3	28987	33545	500	170855	58330	58684
20	1-4	depth1	4	500	21070	35171	107864	41087	30672
28	1-5	depth1	5	500	34622	500	143332	33299	26042
25	1-6	depth1	6	500	500	61751	85161	52953	63744
29	1-7	depth1	7	89876	38097	28197	93585	56146	48244
25	1-8	depth1	8	500	19343	59777	126508	32762	18825
29	1-9	depth1	9	38731	33887	500	170700	44456	25903
28	1-10	depth1	10	500	37974	53803	120864	54029	26399
24	1-11	depth1	11	24172	35535	61866	148968	59921	32838
28	1-12	depth1	12	28588	34712	500	161397	45801	30759
22	2-1	depth2	1	47737	44658	500	215979	42898	500
27	2-2	depth2	2	83511	63034	56065	139013	37774	43261
26	2-3	depth2	3	500	28505	68954	219228	57430	54281
24	2-4	depth2	4	39489	27491	79248	196487	39099	27701
21	2-5	depth2	5	500	27164	129511	301801	27430	31495
26	2-6	depth2	6	500	18753	66149	200045	18941	37746
21	2-7	depth2	7	92852	60931	500	230122	43441	47259
25	2-8	depth2	8	500	20754	94008	249851	16222	500
23	2-9	depth2	9	500	500	75204	201624	16275	21721
24	2-10	depth2	10	35244	26763	47890	219352	37260	18994
22	2-11	depth2	11	500	18948	73690	210387	27630	45698
21	2-12	depth2	12	500	24742	89046	242872	500	29019
15	3-1	depth3	1	500	28025	88180	344395	12899	500
24	3-2	depth3	2	500	69034	500	243907	40380	52443
27	3-3	depth3	3	19600	32490	82464	215294	22687	33975
28	3-4	depth3	4	21023	25169	54602	152743	24546	29703
27	3-5	depth3	5	500	93521	500	201613	43077	50013
26	3-6	depth3	6	17095	29143	59296	196748	24759	35861
24	3-7	depth3	7	109662	500	500	119386	500	66176
25	3-8	depth3	8	500	33468	60702	230704	37469	23195
26	3-9	depth3	9	500	26759	46942	165615	21732	36128
26	3-10	depth3	10	52268	500	500	136336	500	38070
24	3-11	depth3	11	500	37433	500	217210	23705	21476
27	3-12	depth3	12	18306	29562	79726	184616	28146	35619

TRF peaks	name	group	sample	Dpn237	Dpn238	Dpn239	Dpn240	Dpn241	Dpn242
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	500	21339	500	500	500	500
29	0-3	initial	3	21093	500	500	500	500	500
28	0-4	initial	4	500	500	500	500	500	500
30	0-5	initial	5	500	500	500	500	500	500
26	0-6	initial	6	500	65814	500	500	500	500
35	0-7	initial	7	500	500	500	500	500	500
30	0-8	initial	8	16355	500	500	500	500	500
28	0-9	initial	9	500	500	500	500	500	500
29	0-10	initial	10	500	500	500	500	500	500
27	0-11	initial	11	500	500	500	500	500	500
34	0-12	initial	12	500	13113	500	500	500	500
24	1-1	depth1	1	12744	13972	500	500	500	500
23	1-2	depth1	2	500	18394	500	500	500	500
29	1-3	depth1	3	500	21419	500	500	500	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	500	500	500
25	1-6	depth1	6	500	500	500	500	500	500
29	1-7	depth1	7	500	500	500	500	500	500
25	1-8	depth1	8	500	500	500	500	500	500
29	1-9	depth1	9	500	500	500	500	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	12907	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	40773	500	21904	500	500	500
27	2-2	depth2	2	30610	17718	500	14151	13317	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	500	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	500	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	14954	12905	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	13802	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	15537	500	500	500	500	500
27	3-5	depth3	5	14166	500	500	500	500	500
26	3-6	depth3	6	500	500	500	500	500	500
24	3-7	depth3	7	500	500	500	500	500	15286
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	13151	500	500	500	500
26	3-10	depth3	10	500	500	500	500	500	17031
24	3-11	depth3	11	500	500	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

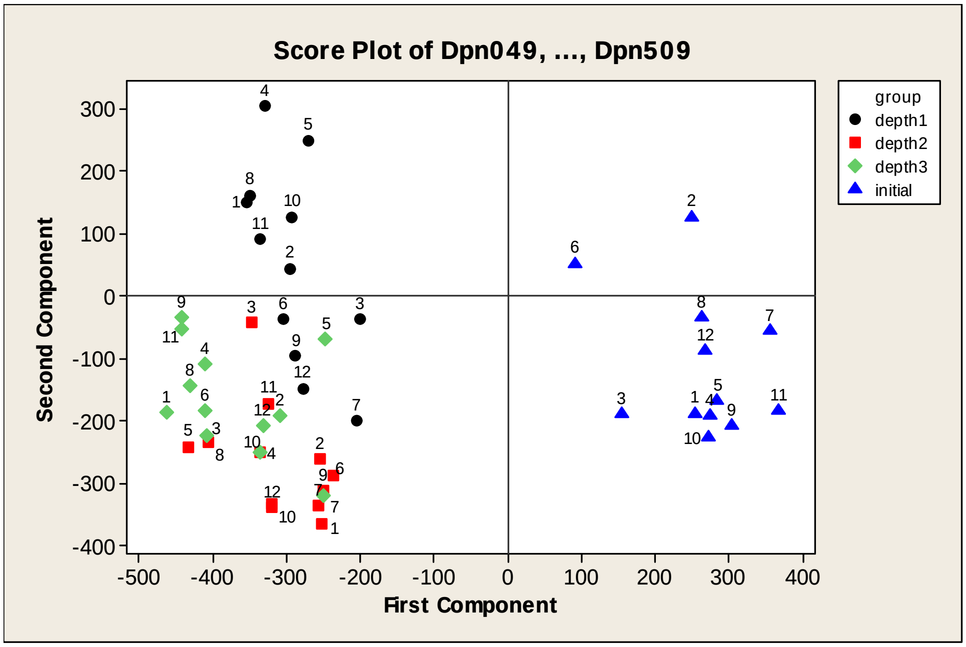
TRF peaks	name	group	sample	Dpn244	Dpn246	Dpn247	Dpn255	Dpn257	Dpn258
29	0-1	initial	1	500	500	500	500	19585	42320
32	0-2	initial	2	500	500	500	500	16764	500
29	0-3	initial	3	500	500	500	500	500	500
28	0-4	initial	4	500	500	500	500	500	500
30	0-5	initial	5	500	14059	500	500	500	500
26	0-6	initial	6	500	500	500	500	500	500
35	0-7	initial	7	500	500	500	500	500	17154
30	0-8	initial	8	500	500	500	500	500	22688
28	0-9	initial	9	500	500	500	21875	19447	500
29	0-10	initial	10	500	500	500	500	500	500
27	0-11	initial	11	500	500	500	500	11723	500
34	0-12	initial	12	500	500	500	500	500	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	14942	14647	500	500	13970	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	500	15876	500
25	1-6	depth1	6	500	500	500	500	500	500
29	1-7	depth1	7	500	500	500	500	500	500
25	1-8	depth1	8	500	500	500	500	500	500
29	1-9	depth1	9	500	500	500	500	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	500	500	500	500	13826	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	11929	500
26	2-6	depth2	6	500	500	500	500	500	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	500	500	16775	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	37054	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	500	500	500	500	500	500
27	3-5	depth3	5	500	500	500	500	500	500
26	3-6	depth3	6	500	500	500	500	500	500
24	3-7	depth3	7	13159	500	500	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	16122	500	12769	500	14189	500
24	3-11	depth3	11	500	500	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn259	Dpn260	Dpn261	Dpn263	Dpn333	Dpn335
29	0-1	initial	1	500	14093	500	500	500	500
32	0-2	initial	2	47192	20057	500	500	500	500
29	0-3	initial	3	42221	23546	500	500	500	500
28	0-4	initial	4	500	52906	16158	500	500	500
30	0-5	initial	5	500	41268	500	500	500	500
26	0-6	initial	6	500	500	500	36152	500	500
35	0-7	initial	7	43096	14506	500	500	500	500
30	0-8	initial	8	45910	23154	500	500	500	500
28	0-9	initial	9	44184	20730	500	500	500	500
29	0-10	initial	10	500	85894	20710	500	500	500
27	0-11	initial	11	21772	94617	500	500	500	500
34	0-12	initial	12	500	54557	500	500	500	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	14852	500
20	1-4	depth1	4	500	17527	500	500	500	500
28	1-5	depth1	5	500	16346	500	500	500	500
25	1-6	depth1	6	22162	500	500	500	500	500
29	1-7	depth1	7	500	14750	500	13298	500	500
25	1-8	depth1	8	500	500	500	500	500	500
29	1-9	depth1	9	500	12746	500	500	500	500
28	1-10	depth1	10	500	20462	500	14634	500	500
24	1-11	depth1	11	500	13161	500	500	500	500
28	1-12	depth1	12	500	15507	500	500	500	500
22	2-1	depth2	1	17439	500	500	500	500	500
27	2-2	depth2	2	500	14878	500	500	500	500
26	2-3	depth2	3	500	19247	500	500	500	500
24	2-4	depth2	4	500	18109	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	500	500
21	2-7	depth2	7	500	14438	500	500	500	500
25	2-8	depth2	8	21182	500	500	500	500	500
23	2-9	depth2	9	12371	31227	500	500	500	12686
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	17160	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	500	500	500	500	500
28	3-4	depth3	4	500	500	500	500	500	500
27	3-5	depth3	5	500	500	500	500	500	500
26	3-6	depth3	6	500	500	500	500	500	500
24	3-7	depth3	7	500	500	500	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	500	20038	500	500	500	500
24	3-11	depth3	11	500	500	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

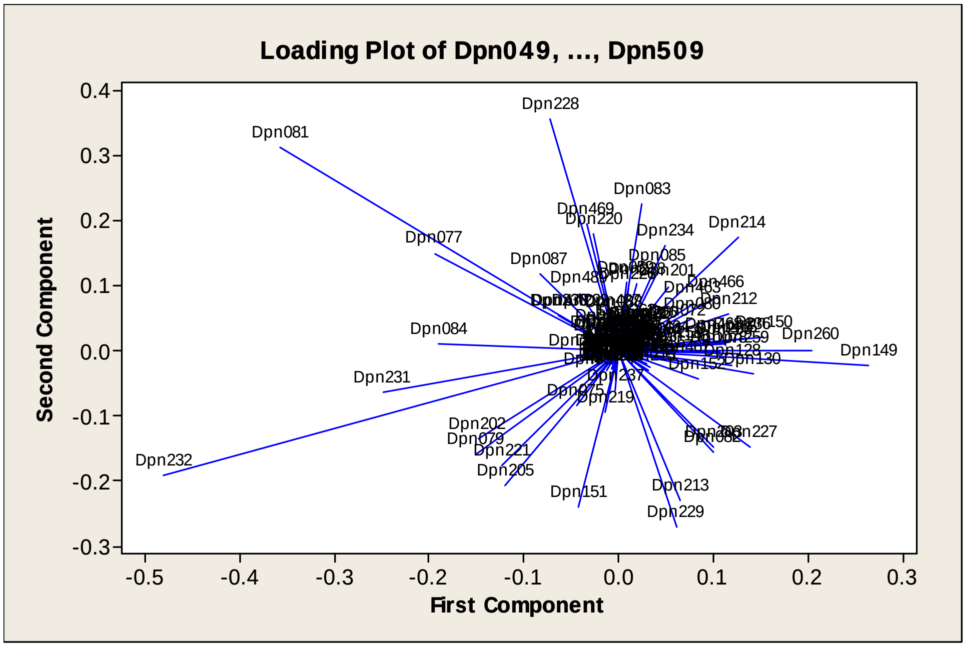
TRF peaks	name	group	sample	Dpn336	Dpn337	Dpn435	Dpn461	Dpn462	Dpn463
29	0-1	initial	1	15187	500	500	500	500	16065
32	0-2	initial	2	500	500	16184	500	31947	27618
29	0-3	initial	3	500	500	500	18566	500	500
28	0-4	initial	4	500	500	18286	500	500	500
30	0-5	initial	5	500	500	500	500	500	500
26	0-6	initial	6	500	500	500	500	500	500
35	0-7	initial	7	500	500	500	500	500	17919
30	0-8	initial	8	15731	500	500	500	500	19408
28	0-9	initial	9	500	500	500	500	500	25195
29	0-10	initial	10	500	500	500	500	500	500
27	0-11	initial	11	500	500	500	500	500	500
34	0-12	initial	12	22912	500	500	500	500	500
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	500	500	500	500	500	500
28	1-5	depth1	5	500	500	500	500	500	20251
25	1-6	depth1	6	500	500	500	500	500	13808
29	1-7	depth1	7	500	500	500	500	500	500
25	1-8	depth1	8	500	500	500	500	500	500
29	1-9	depth1	9	500	500	500	500	500	500
28	1-10	depth1	10	500	500	14824	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	500	500	500
21	2-7	depth2	7	500	16883	500	500	500	500
25	2-8	depth2	8	500	500	500	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	27674	500	500	500	500
24	3-2	depth3	2	500	15436	500	500	500	500
27	3-3	depth3	3	500	12525	500	500	500	500
28	3-4	depth3	4	500	500	500	500	500	500
27	3-5	depth3	5	500	14498	500	500	500	500
26	3-6	depth3	6	500	500	500	500	500	500
24	3-7	depth3	7	15384	500	500	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	500	500	500	500	500
26	3-10	depth3	10	500	500	500	500	500	500
24	3-11	depth3	11	500	500	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

TRF peaks	name	group	sample	Dpn049	Dpn059	Dpn061	Dpn063	Dpn064	Dpn068
29	0-1	initial	1	500	500	500	500	500	500
32	0-2	initial	2	500	500	500	500	500	500
29	0-3	initial	3	20636	500	500	500	500	500
28	0-4	initial	4	500	500	500	500	500	500
30	0-5	initial	5	500	500	500	500	500	500
26	0-6	initial	6	500	500	500	500	15553	500
35	0-7	initial	7	500	21151	15878	500	500	500
30	0-8	initial	8	500	500	500	500	500	500
28	0-9	initial	9	500	17878	500	500	16107	500
29	0-10	initial	10	500	500	500	500	500	500
27	0-11	initial	11	500	12371	500	500	500	500
34	0-12	initial	12	500	29446	31960	500	16651	17804
24	1-1	depth1	1	500	500	500	500	500	500
23	1-2	depth1	2	500	500	500	500	500	500
29	1-3	depth1	3	500	500	500	500	500	500
20	1-4	depth1	4	500	20129	500	500	500	500
28	1-5	depth1	5	500	15437	500	500	500	500
25	1-6	depth1	6	500	500	500	500	500	500
29	1-7	depth1	7	500	13857	500	500	500	500
25	1-8	depth1	8	500	23885	500	500	500	500
29	1-9	depth1	9	500	18706	500	500	500	500
28	1-10	depth1	10	500	500	500	500	500	500
24	1-11	depth1	11	500	500	500	500	500	500
28	1-12	depth1	12	500	500	500	500	500	500
22	2-1	depth2	1	500	500	500	500	500	500
27	2-2	depth2	2	500	500	500	500	500	500
26	2-3	depth2	3	500	500	500	500	500	500
24	2-4	depth2	4	500	500	500	500	500	500
21	2-5	depth2	5	500	500	500	500	500	500
26	2-6	depth2	6	500	500	500	22771	500	500
21	2-7	depth2	7	500	500	500	500	500	500
25	2-8	depth2	8	500	500	500	500	500	500
23	2-9	depth2	9	500	500	500	500	500	500
24	2-10	depth2	10	500	500	500	500	500	500
22	2-11	depth2	11	500	500	500	500	500	500
21	2-12	depth2	12	500	500	500	500	500	500
15	3-1	depth3	1	500	500	500	500	500	500
24	3-2	depth3	2	500	500	500	500	500	500
27	3-3	depth3	3	500	18998	500	500	500	500
28	3-4	depth3	4	500	17807	500	500	500	500
27	3-5	depth3	5	500	16429	500	500	500	500
26	3-6	depth3	6	500	16811	500	500	500	500
24	3-7	depth3	7	500	500	500	500	500	500
25	3-8	depth3	8	500	500	500	500	500	500
26	3-9	depth3	9	500	17675	500	500	500	500
26	3-10	depth3	10	500	500	500	500	500	500
24	3-11	depth3	11	500	17863	500	500	500	500
27	3-12	depth3	12	500	500	500	500	500	500

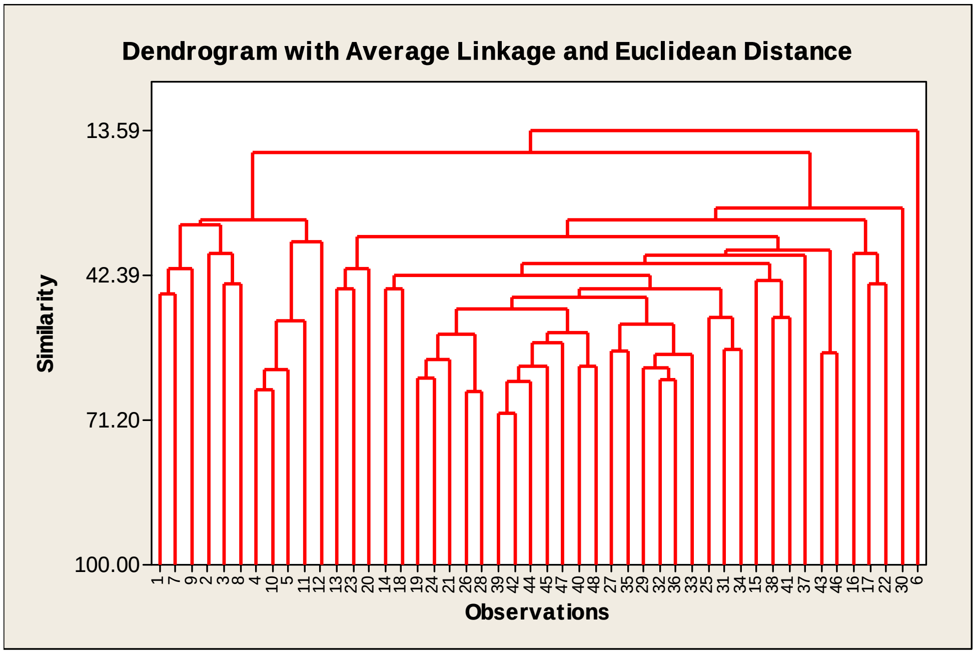
PCA analysis of all the samples



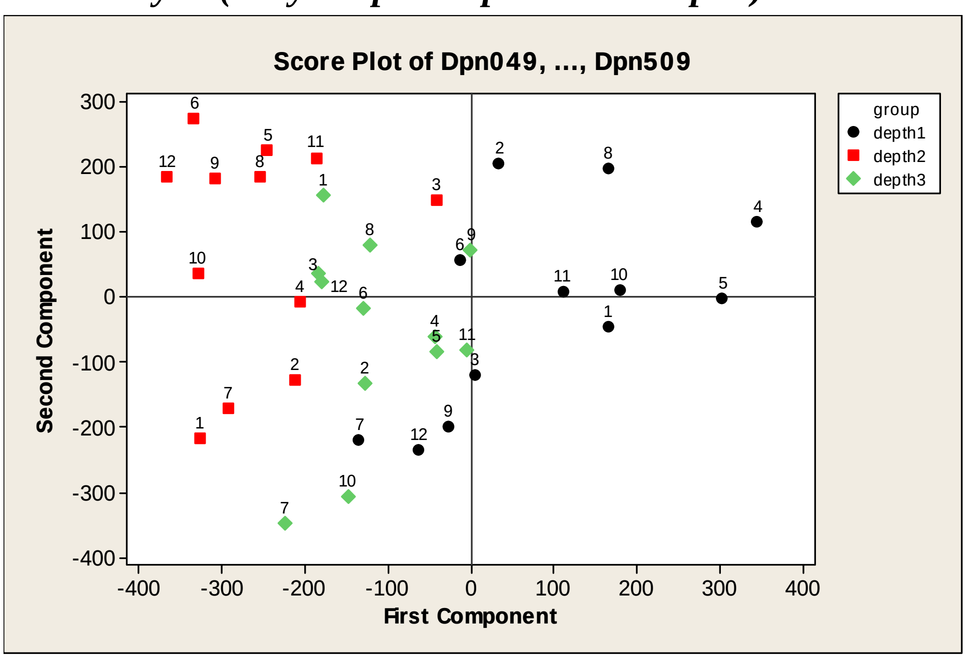
PCA analysis, Loading presentation (All samples)



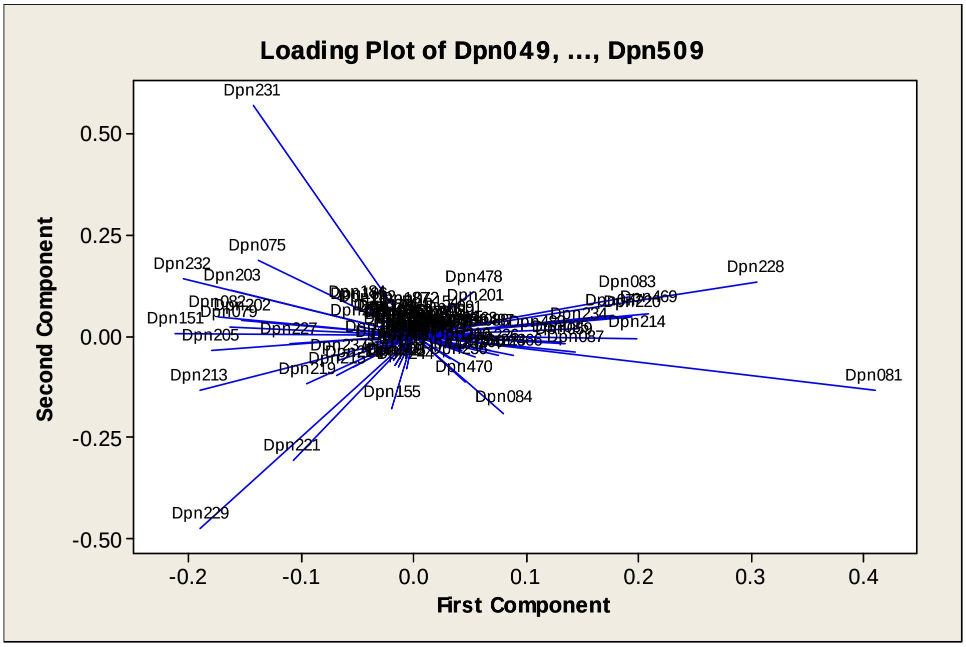
Dendogram for all the samples



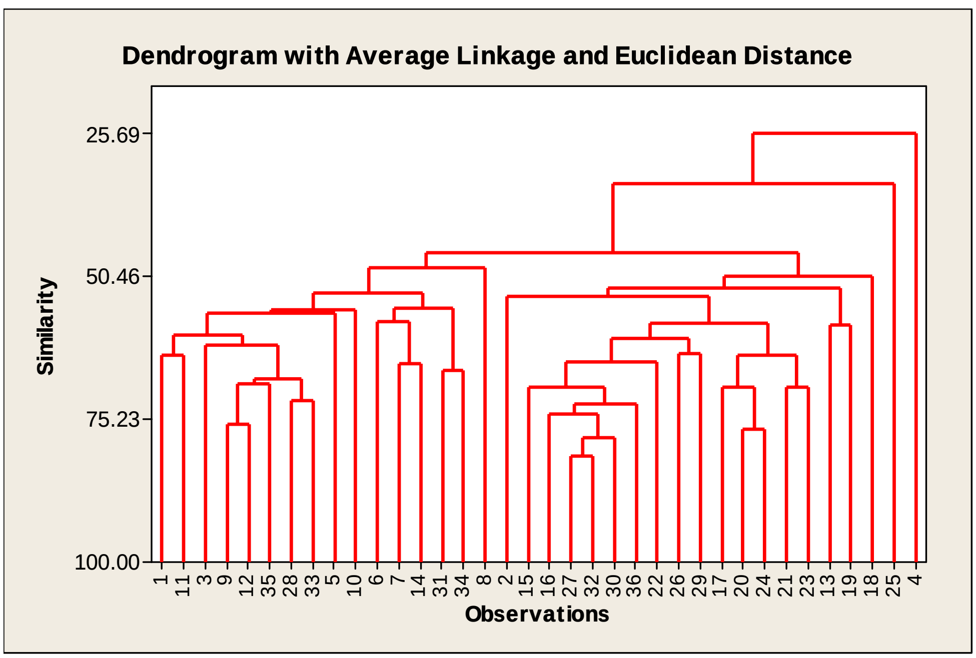
PCA analysis (Only the post-experiment samples)



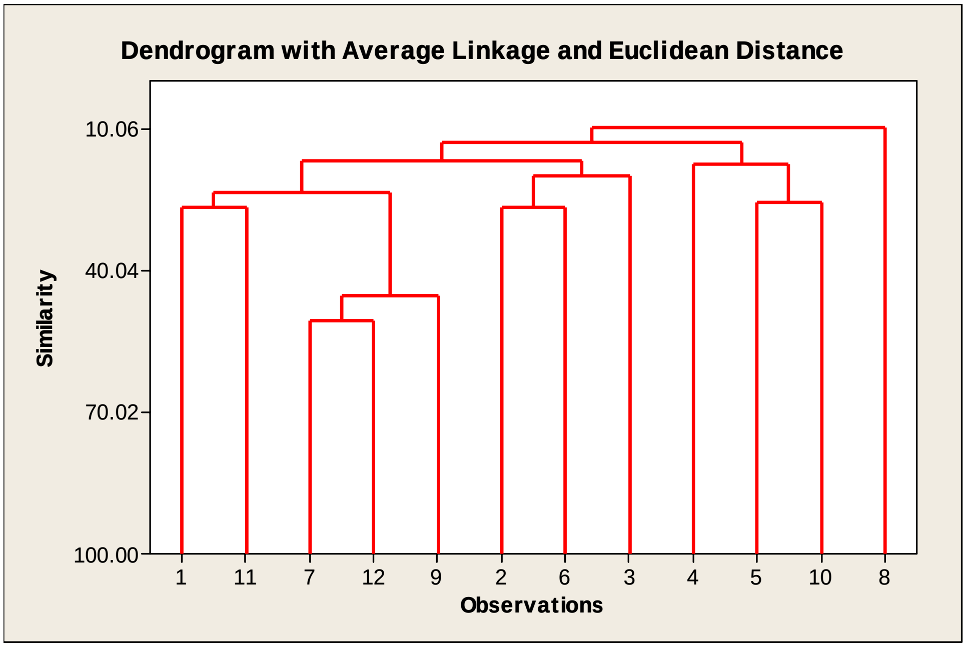
PCA anslysis, Loading presentation (Only Post-experiment samples)



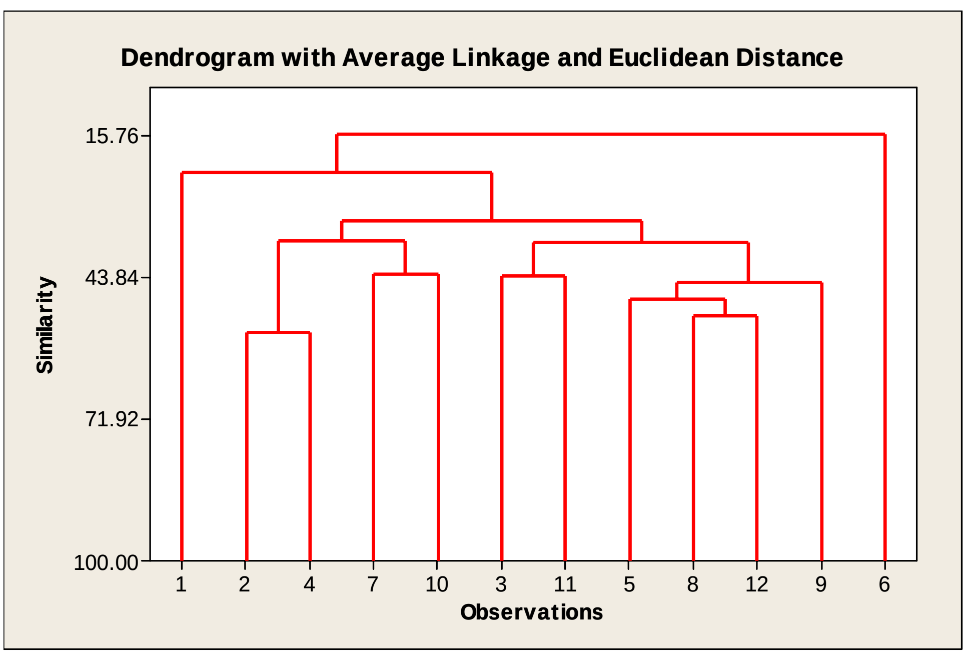
Dendogram (Only post-experiment samples)



Dendogram (Post-experiment, top section)



Dendogram (Post-experiment, middle section)



Dendogram (Post-experiment, bottom section)

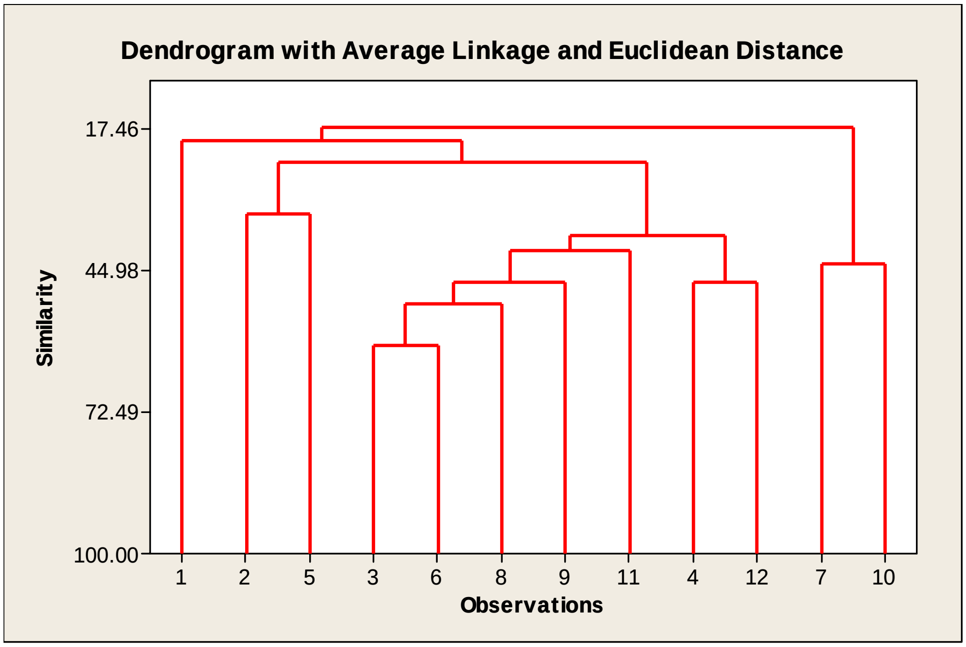


Image Processing Data

Top	1
Middle	2
Bottom	3
AD	Average Diameter
V	Volume
PA	Projected Area
SA	Surface Area
BS	Black Sage
SB	Sage Brush
G	Grass

								Weight (g)	Weight (g)
Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial	Dry
	8_1_1	825.9	198.64	63.23	3.8	0.766	1523		
SB	8_1_2	1178.05	199.92	63.64	2.7	0.54	1371		
	8_1	2003.95	398.56	126.87	6.5	0.633	2894	11.3	10.1
8	8_2_1	1532.99	171.69	54.65	1.53	0.357	1929		
	8_2_2	2222.71	212.45	67.63	1.62	0.304	2841		
	8_2	3755.7	384.14	122.28	3.15	0.326	4770	2.9	2.6
	8_3	1525.65	160.26	51.01	1.34	0.334	2054	1	0.9
	Plant							24	20.3
	12_1_1	1081.7	143.5	45.67	1.51	0.422	2949		
	12_1_2	1006.57	148.37	47.23	1.74	0.469	4187		

								Weight (g)	Weight (g)
Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial	Dry
	12_1_3	989.57	112.17	35.71	1.01	0.361	2232		
	12_1_4	2912.86	247.92	78.91	1.68	0.271	9502		
	12_1	5990.7	651.96	207.52	5.94	0.346	18870	14.4	10.9
	12_2_1	1590	158	50.4	1.25	0.317	3030		
	12_2_2	1464	158	50.2	1.35	0.343	3073		
	12_2_3	1270	143	45.5	1.28	0.358	3099		
	12_2_4	1563	170.4	54.3	1.48	0.347	3640		
BS	12_2_5	1691	157.7	50.2	1.17	0.294	3316		
	12_2_6	1656	140.5	44.7	0.95	0.27	3392		
12	12_2	9234	927.6	295.3	7.48	0.320	19550	6	5.2
	12_3_1	2373.9	236.1	75.16	1.87	0.317	7205		
	12_3_2	1873.9	203	64.6	1.75	0.345	3918		
	12_3_3	1690.9	181.6	57.8	1.55	0.342	3312		
	12_3_4	1340	154	49	1.42	0.367	2754		
	12_3_5	2466	257.8	82	2.15	0.333	6393		
	12_3_6	1622	181.36	57.7	1.61	0.356	3947		
	12_3_7	1927	205	65.27	1.74	0.339	6070		
	12_3_8	1062	95.2	30.3	0.68	0.285	2223		
	12_3	14355.7	1514.06	481.83	12.77	0.336	35822	10.8	9.7
	Plant							49.6	36
	2_1_1	471	103.46	32.93	1.81	0.699	1977		
	2_1_2	938.84	144.47	45.99	1.77	0.49	1930		
	2_1_3	413.15	89.15	28.38	1.53	0.687	869		

								Weight (g)	Weight (g)
Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial	Dry
SB	2_1_4	751.84	109.26	34.78	1.26	0.463	1815		
	2_1_5	1234.71	128.37	40.86	1.06	0.331	5303		
2	2_1	3809.54	574.71	182.94	7.43	0.480	11894	12.8	11
	2_2_1	1450.77	141.04	44.89	1.09	0.309	3770		
	2_2_2	1518.6	146.53	46.64	1.13	0.307	4355		
	2_2_3	1559.14	169.5	53.95	1.47	0.346	4517		
	2_2	4528.51	457.07	145.48	3.69	0.321	12642	4.3	3.9
	2_3	2019.66	193.78	61.68	1.48	0.305	5260	1.6	1.4
	Plant							51	35.8
	1_1_1	1252.3	74.32	23.66	0.35	0.189	8857		
	1_1_2	1789.89	111.21	35.4	0.55	0.198	12866		
	1_1_3	1681.44	104.14	33.15	0.51	0.197	11698		
	1_1_4	2102.02	125.14	39.83	0.59	0.19	14843		
G	1_1	6825.65	414.81	132.04	2	0.193	48264	1.6	1.3
	1_2_1	2399.45	152.16	48.43	0.77	0.202	12705		
	1_2_2	2604.23	167.47	53.31	0.86	0.205	15858		
1	1_2_3	1820.9	118.95	37.86	0.62	0.208	11913		
	1_2_4	2203.16	133.09	42.36	0.64	0.192	12535		
	1_2_5	3618.25	219.64	69.62	1.06	0.193	21385		
	1_2	12645.99	791.31	251.58	3.95	0.199	74396	1.8	1.5
	1_3_1	3379.76	218.43	69.53	1.12	0.206	19121		
	1_3_2	3162.61	207.62	66.09	1.08	0.209	16977		
	1_3	6542.37	426.05	135.62	2.2	0.207	36098	1	0.8

								Weight (g)	Weight (g)
Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial	Dry
	Plant							42.5	24.9
	5_1_1	470.27	104.12	33.14	1.83	0.705	942		
	5_1_2	563.88	99.84	31.78	1.41	0.564	1254		
	5_1_3	853.94	117.51	37.4	1.29	0.438	1853		
SB	5_1	1888.09	321.47	102.32	4.53	0.542	4049	11.7	8.9
	5_2_1	951.63	108.4	34.5	0.98	0.363	2853		
5	5_2_2	847.61	104.31	33.2	1.02	0.392	2041		
	5_2_3	971.29	96.43	30.69	0.76	0.316	2238		
	5_2	2770.53	309.14	98.39	2.76	0.355	7132	2.9	2.5
	5_3_1	1260.73	118.56	37.74	0.89	0.299	2285		
	5_3_2	963.32	92.46	29.43	0.71	0.306	2128		
	5_3_3	688.61	65.88	20.97	0.5	0.305	1533		
	5_3	2912.66	276.9	88.14	2.1	0.303	5946	1.5	1.4
	Plant							61.1	44.1
	3_1_1	696.31	145.75	46.39	2.43	0.666	1409		
	3_1_2	1361.73	147.67	47	1.27	0.345	1934		
	3_1_3	1066.69	139.21	44.31	1.45	0.415	1427		
	3_1_4	941.54	123.94	39.45	1.3	0.419	2821		
	3_1	4066.27	556.57	177.15	6.45	0.436	7591	17.8	11.9
	3_2_1	975.58	119.54	38.05	1.17	0.39	1931		
BS	3_2_2	1095.01	142.08	45.23	1.47	0.413	2114		
	3_2_3	1233.41	151.78	48.31	1.49	0.392	2857		
	3_2_4	1127.95	143.76	45.76	1.46	0.406	2202		

Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Weight (g) Initial	Weight (g) Dry
3	3_2_5	1237.3	149.51	47.59	1.44	0.385	3208		
	3_2_6	1518.63	169.31	53.89	1.5	0.355	2762		
	3_2_7	1284.29	137.8	43.86	1.18	0.342	2127		
	3_2	8472.17	1013.78	322.69	9.71	0.381	17201	8.6	7.1
	3_3_1	1488.3	185.12	58.93	1.83	0.396	3570		
	3_3_2	1139.21	152.92	48.68	1.63	0.427	2891		
	3_3_3	1232.54	162.22	51.64	1.7	0.419	3463		
	3_3_4	1435.19	183.87	58.53	1.87	0.408	4322		
	3_3_5	1202.93	150.44	47.89	1.5	0.398	4841		
	3_3_6	1467.1	166.56	53.02	1.5	0.361	3382		
	3_3	7965.27	1001.13	318.69	10.03	0.400	22469	9	8
	Plant							75.1	44.9
	6_1_1	810.46	131.61	41.89	1.7	0.517	1135		
	6_1_2	352.22	103.99	33.1	2.44	0.94	691		
	6_1_3	1715.85	178.27	56.74	1.47	0.331	5464		
	6_1	2878.53	413.87	131.73	5.61	0.458	7290	11.1	8.4
BS	6_2_1	834.52	111.15	35.38	1.18	0.424	1392		
	6_2_2	1124.94	138.42	44.08	1.36	0.392	1925		
	6_2_3	1316.02	146.7	46.7	1.3	0.355	2211		
6	6_2_4	1083.4	137.83	43.87	1.4	0.405	1564		
	6_2_5	2513	224.4	71.43	1.59	0.284	11796		
	6_2	6871.88	758.5	241.46	6.83	0.351	18888	6.5	4.9
	6_3_1	1256.2	152.14	48.43	1.47	0.386	2353		

Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Weight (g) Initial	Weight (g) Dry
	6_3_2	937.78	117.84	37.51	1.18	0.4	1454		
	6_3_3	1032.42	131.14	41.74	1.33	0.404	1839		
	6_3_4	1623.73	169.45	53.94	1.41	0.332	8531		
	6_3	4850.13	570.57	181.62	5.39	0.374	14177	4.5	4.1
	Plant							82.4	46.3
SB 11	11_1_1	794.8	143.12	45.56	2.05	0.573	1528		
	11_1_2	568.41	86.19	27.43	1.04	0.483	1060		
	11_1_3	1156.54	134.37	42.77	1.24	0.37	3138		
	11_1	2519.75	363.68	115.76	4.33	0.459	5726	10.5	8
	11_2_1	1356.83	129.99	41.38	0.99	0.305	2991		
	11_2_2	1381.03	137.54	43.78	1.09	0.317	5012		
	11_2	2737.86	267.53	85.16	2.08	0.311	8003	1.5	1.3
	11_3	749.16	64.61	20.57	0.44	0.275	3132	0.2	0.2
	Plant							69.9	41.2
BS 9	9_1_1	554.62	138.18	43.98	2.74	0.793	1240		
	9_1_2	695.51	100.31	31.93	1.15	0.459	1201		
	9_1_3	1460.78	131.06	41.72	0.94	0.286	5373		
	9_1	2710.91	369.55	117.63	4.83	0.434	7814	10.3	8.3
	9_2_1	1535.79	144.35	45.95	1.08	0.299	3279		
	9_2_2	1216.63	125.62	39.99	1.03	0.329	2672		
	9_2_3	914.48	102.15	32.52	0.91	0.356	1842		
	9_2_4	1683.83	147.65	47	1.03	0.279	9492		
	9_2	5350.73	519.77	165.46	4.05	0.309	17285	3.2	2.9

								Weight (g)	Weight (g)
Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial	Dry
	9_3_1	1500.96	163.31	51.98	1.41	0.346	3780		
	9_3_2	1084.25	128.12	40.78	1.2	0.376	2051		
	9_3_3	1332.86	146.99	46.79	1.29	0.351	2464		
	9_3_4	2576.25	252.77	80.46	1.97	0.312	9617		
	9_3	6494.32	691.19	220.01	5.87	0.339	17912	5.4	4.1
	Plant							74	48.3
	7_1_1	2434.8	168.9	53.76	0.93	0.221	14231		
	7_1_2	2467.81	165.48	52.67	0.88	0.213	14825		
	7_1_3	2368.11	162.69	51.79	0.89	0.219	15689		
	7_1_4	2446.1	173.4	55.19	0.98	0.226	16224		
G	7_1_5	2656.95	183.69	58.47	1.01	0.22	17904		
	7_1	12373.77	854.16	271.88	4.69	0.220	78873	3.1	2.8
	7_2_1	2390.03	158.55	50.47	0.84	0.211	10657		
7	7_2_2	2879.02	187.81	59.78	0.97	0.208	15089		
	7_2_3	2999.31	199.22	63.42	1.05	0.211	12573		
	7_2_4	2860.11	186.36	59.32	0.97	0.207	15666		
	7_2_5	3015.12	198.86	63.3	1.04	0.21	13112		
	7_2	14143.59	930.8	296.29	4.87	0.209	67097	2.8	2.6
	7_3_1	2391.93	171.54	54.6	0.98	0.228	9175		
	7_3_2	2391.32	173.44	56.21	1	0.321	8156		
	7_3_3	2639.52	185.38	59.01	1.04	0.224	9985		
	7_3_4	3112.8	224.93	71.6	1.29	0.23	10873		
	7_3	10535.57	755.29	241.42	4.31	0.229	38189	2.3	2.2

Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Weight (g) Initial	Weight (g) Dry
	Plant							39.8	35
	4_1_!	1741.92	141.05	44.9	0.91	0.258	8943		
	4_1_2	2248.21	161.85	51.52	0.93	0.229	13872		
	4_1_3	2919.53	191.26	60.88	1	0.209	18910		
	4_1_4	2585.29	178.58	56.84	0.98	0.22	15180		
	4_1_5	2865.78	200.37	63.78	1.11	0.223	18625		
G	4_1_6	3079.28	195.86	62.66	1	0.203	19780		
	4_1_7	3566.46	233.3	74.26	1.21	0.208	23562		
	4_1_8	3223.83	213.84	68.07	1.13	0.211	21437		
	4_1_9	1633.16	103.65	32.99	0.52	0.202	11160		
	4_1	23863.46	1619.76	515.9	8.79	0.216	151469	5.1	4.8
4	4_2_1	3533.63	227.59	72.45	1.17	0.205	16423		
	4_2_2	3066.23	207.12	65.93	1.11	0.215	15769		
	4_2_3	3156.37	200.91	63.95	1.02	0.203	15011		
	4_2_4	2738.05	187.82	59.78	1.03	0.218	13381		
	4_2_5	2662.52	177.79	56.59	0.94	0.213	13938		
	4_2_6	2634.64	170.84	54.38	0.88	0.206	12541		
	4_2	17791.44	1172.07	373.08	6.15	0.210	87063	2.5	2.4
	4_3_1	2495.73	166.75	53.08	0.89	0.213	10612		
	4_3_2	2492.16	167.74	53.39	0.9	0.214	9268		
	4_3_3	2689.17	168.74	53.71	0.84	0.2	12441		
	4_3_4	2742.7	183.51	58.41	0.98	0.213	10384		
	4_3	10419.76	686.74	218.59	3.61	0.210	42705	1.8	1.7

								Weight (g)	Weight (g)
Pot #	Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial	Dry
	Plant							30.3	26
	10_1_1	1454.87	97.94	31.17	0.52	0.214	6198		
	10_1_2	1497.17	102.38	32.59	0.56	0.218	5693		
	10_1_3	1053.88	87.41	27.82	0.58	0.264	4199		
	10_1_4	1374.63	101.48	32.3	0.6	0.235	6129		
G	10_1	5380.55	389.21	123.88	2.26	0.230	22219	1.7	1.6
	10_2_1	3490.38	217.46	69.22	1.08	0.198	12966		
	10_2_2	2915.52	192.71	61.34	1.01	0.21	9580		
10	10_2_3	2448.38	160.31	51.03	0.84	0.208	8373		
	10_2_4	2404.24	155.86	49.61	0.8	0.206	9983		
	10_2_5	2799.74	180.74	57.53	0.93	0.205	11457		
	10_2	14058.26	907.08	288.73	4.66	0.205	52359	2	1.9
	10_3_1	2714.27	186.67	59.42	1.02	0.219	10534		
	10_3_2	2189.27	152.99	48.7	0.85	0.222	8620		
	10_3	4903.54	339.66	108.12	1.87	0.220	19154	0.8	0.8
	Plant							19	16.7

Image Processing Data Summarized for each plant

Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial (Weight, g)	Dry (Weight, g)
1_1	6825.7	414.8	132.0	2.0	0.19	48264	1.6	1.3
1_2	12646.0	791.3	251.6	4.0	0.20	74396	1.8	1.5
1_3	6542.4	426.1	135.6	2.2	0.21	36098	1.0	0.8
Plant	G						42.5	24.9
2_1	3809.5	574.7	182.9	7.4	0.48	11894	12.8	11.0
2_2	4528.5	457.1	145.5	3.7	0.32	12642	4.3	3.9
2_3	2019.7	193.8	61.7	1.5	0.31	5260	1.6	1.4
Plant	SB						51.0	35.8
3_1	4066.3	556.6	177.2	6.5	0.44	7591	17.8	11.9
3_2	8472.2	1013.8	322.7	9.7	0.38	17201	8.6	7.1
3_3	7965.3	1001.1	318.7	10.0	0.40	22469	9.0	8.0
Plant	BS						75.1	44.9
4_1	23863.5	1619.8	515.9	8.8	0.22	151469	5.1	4.8
4_2	17791.4	1172.1	373.1	6.2	0.21	87063	2.5	2.4
4_3	10419.8	686.7	218.6	3.6	0.21	42705	1.8	1.7
Plant	G						30.3	26.0
5_1	1888.1	321.5	102.3	4.5	0.54	4049	11.7	8.9
5_2	2770.5	309.1	98.4	2.8	0.36	7132	2.9	2.5
5_3	2912.7	276.9	88.1	2.1	0.30	5946	1.5	1.4
Plant	SB						61.1	44.1

Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial (Weight, g)	Dry (Weight, g)
6_1	2878.5	413.9	131.7	5.6	0.46	7290	11.1	8.4
6_2	6871.9	758.5	241.5	6.8	0.35	18888	6.5	4.9
6_3	4850.1	570.6	181.6	5.4	0.37	14177	4.5	4.1
Plant	BS						82.4	46.3
7_1	12373.8	854.2	271.9	4.7	0.22	78873	3.1	2.8
7_2	14143.6	930.8	296.3	4.9	0.21	67097	2.8	2.6
7_3	10535.6	755.3	241.4	4.3	0.23	38189	2.3	2.2
Plant	G						39.8	35.0
8_1	2004.0	398.6	126.9	6.5	0.63	2894	11.3	10.1
8_2	3755.7	384.1	122.3	3.2	0.33	4770	2.9	2.6
8_3	1525.7	160.3	51.0	1.3	0.33	2054	1.0	0.9
Plant	SB						24.0	20.3
9_1	2710.9	369.6	117.6	4.8	0.43	7814	10.3	8.3
9_2	5350.7	519.8	165.5	4.1	0.31	17285	3.2	2.9
9_3	6494.3	691.2	220.0	5.9	0.34	17912	5.4	4.1
Plant	BS						74.0	48.3
10_1	5380.6	389.2	123.9	2.3	0.23	22219	1.7	1.6
10_2	14058.3	907.1	288.7	4.7	0.21	52359	2.0	1.9
10_3	4903.5	339.7	108.1	1.9	0.22	19154	0.8	0.8
Plant	G						19.0	16.7
11_1	2519.8	363.7	115.8	4.3	0.46	5726	10.5	8.0
11_2	2737.9	267.5	85.2	2.1	0.31	8003	1.5	1.3
11_3	749.2	64.6	20.6	0.4	0.28	3132	0.2	0.2
Plant	SB						69.9	41.2

Sample #	Length (cm)	SA (cm2)	PA (cm2)	V (cm3)	AD (mm)	Ntips	Initial (Weight, g)	Dry (Weight, g)
12_1	5990.7	652.0	207.5	5.9	0.35	18870	14.4	10.9
12_2	9234.0	927.6	295.3	7.5	0.32	19550	6.0	5.2
12_3	14355.7	1514.1	481.8	12.8	0.34	35822	10.8	9.7
Plant	BS						49.6	36.0

Appendix II. Text of article from *Los Angeles Times*

L.A. Youths Dig Beautifying a Neighborhood

Along several streets near downtown, a group sows native plants whose roots might help break down petroleum-based pollution in the soil

By Julie Tamaki

Times Staff Writer

February 1, 2004

LA Times Staff Writer Julie Tamaki recently reported on how Los Angeles neighborhoods are testing innovative approaches to removing environmental pollution. The benefits go beyond clean soil...they bring wildlife to the area and beauty to the homes. Not to mention joy to the gardeners' hearts.

Not far from the notorious site of the Belmont Learning Complex near downtown Los Angeles parents and children hoist a pickax and shovels to loosen stiff, rocky soil in front of old apartment houses.

An urban beautification experiment is sprouting miniature gardens along crowded streets that are dotted with active and abandoned oil wells, bringing back a touch of nature to the urban core.

The gardens are the product of Spiraling Roots, a collaboration of artists, scientists and neighborhood residents who have joined forces to revitalize the neighborhood's ailing ecology. Spiraling Roots wants to improve not only the area's appearance, but also its environmental health.

By filling median strips with California poppies and white and black sages, the group hopes that the plants once native to what is now a concrete jungle can dig deep into the ground, helping break down petroleum-based pollution.

"We're trying to answer the question: Can you improve the wildlife conditions above ground and the contamination below?" said Travis Longcore, a research assistant professor at USC's Center for Sustainable Cities.

Longcore, who also is science director of the Urban Wildlands Group, a Los Angeles-based conservation organization, launched Spiraling Roots with the folks from ARTScorpsLA, a collective of artists dedicated to resident-oriented community development.

The art gardens are an effort to "look at how we can make this area more active and healthy," said Tricia Ward, founding artistic director of ARTScorpsLA.

So far about 10 art gardens have been planted on roughly 40-foot-long strips of soil that line residential streets in the Temple-Beaudry area, a low-income neighborhood west of the downtown Civic Center. Plans call for 20 more gardens over the next two years in the project area.

Longcore wants to see if native plants are superior to grass at cleansing soil because they are adapted to the climate, have deeper roots and require less maintenance.

Around the corner, William Todd, chairman of the Studio City Beautification Assn., helped clean up a fledgling garden littered with weeds and dozens of cigarette butts.

Kathy Morales, lead organizer of Vecinos de Spiraling Orchard, a neighborhood group that works with ARTScorpsLA to build community support for the park and gardens, said the gardens have given residents a sense of pride in their community and an incentive to keep their streets clean.

Longcore hopes the project will serve as a model for cleaning up oil-contaminated soil in other neglected neighborhoods.

In addition to monitoring the miniature art gardens, Longcore is using dirt from the Temple-Beaudry area to run a controlled experiment back on campus with Joe Devinny, a professor of environmental engineering at USC.

They want to see which plants cleanse the soil best.

Entomologist Ken Osborne is keeping tabs on whether the gardens in the Temple-Beaudry area will attract more native insects to the community.

He captured the interest of a group of young volunteers with a display of several dozen butterflies, bees and other insects previously collected in the gardens.