Using Plants to Remediate Petroleum-Contaminated Soil - Project Continuation – Quarterly Report

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This report covers the October 1, 2001 to January 1, 2002 period and summarizes our current IPEC phytoremediation studies that consist of an on-site field project in southern Arkansas and a mathematical modeling project.

Field Study

The field site in El Dorado, AR is located in a bermed crude oil storage/separation facility that was the site of an intentional spill in 1997 by vandals. The experimental plots consist of four replicates of the following treatments: (1) nonvegetated-nonfertilized control, (2) ryegrass (*Lolium multiflorum L.*) - fescue (*Festuca arundinacea Schreb.*) + fertilizer, and (3) bermudagrass (*Cynodon dactylon (L.) Pers.*) - fescue + fertilizer. Each field plot has 12 microplots (>soil socks=) that contain homogenized soil that allow monitoring of the field treatments, on a smaller scale, with less effect of field variability of the contaminant levels.

While root length values at T=6 months were not significantly different among treatments, by T=17 months both vegetated-fertilized treatments were significantly larger than the nonvegetated-nonfertilized control indicating substantial vegetation growth (Fig. 1). Total Petroleum Hydrocarbon (TPH) Gravimetric, TPH by GC/FID, TPH Criteria Working Group (TPHCWG) Total, and TPHCWG Aliphatic levels analyzed after T=17 months showed that contaminant reductions were significantly greater in the vegetated-fertilized treatments than the nonvegetated-nonfertilized control (Fig. 2). Significant contaminant level decreases in vegetated-fertilized treatments as compared to the nonvegetated-nonfertilized control were consistent with the significant increases in microbial numbers. The T=22 month TPH samples are currently being analyzed.

Mathematical Model

Sensitivity studies of the effect of different plant growth patterns throughout the year were performed after modification of the model equations to include two separate grass species. Simulations in which the average annual biomass was 0.2% (v/v) and 0.45% (v/v) were completed for scenarios in which the root turnover rate was varied, separately for each species, between 10% and 98% per year. Figure 3 presents a typical simulated rooting pattern with cool-warm-cool season grasses planted in sequence. The annualized root turnover depicted in the figure is 95% for the cool season and 30%

for the warm season. Figure 4 presents a summary of the simulations performed over a range of rooting patterns. These results suggest that the most significant effects of phytoremediation are associated with root biomass expressed as length, and the rate of root turnover.

Technology Transfer

Abstracts and titles of poster or oral presentations given during this quarter include:

Kirkpatrick, W.D., P.M. White, G.J. Thoma, D.C. Wolf, C.M. Reynolds, and E.E. Gbur. 2001. Plant response to N addition in petroleum-contaminated soil. *In* Annual Meetings Abstracts [CD-ROM]. ASA, CSSA, SSSA, Madison, WI.

White, P.M., W.D. Kirkpatrick, G.J. Thoma, D.C. Wolf, C.M. Reynolds, and E.E. Gbur. 2001. Field study to evaluate phytoremediation of petroleum-contaminated soil. *In* Annual Meetings Abstracts [CD-ROM]. ASA, CSSA, SSSA, Madison, WI.

White, Jr., P.M., W.D. Kirkpatrick, D.C. Wolf, G.J. Thoma, R.M. Reynolds. 2001. Phytoremediation of crude oil-contaminated soil. *In* 8th Annual International Petroleum Environmental Conference. 6-9 November 2001. Houston, TX.

Thoma, G.J., T.B. Lam, S. Ziegler, D.C. Wolf, R.M. Reynolds. 2001. A mathematical model of phytoremediation of crude oil contaminated soils. *In* 8th Annual International Petroleum Environmental Conference. 6-9 November 2001. Houston, TX.

Abstracts and titles that have been submitted for presentation as posters or presentations in the future include:

White, Jr., P.M., G.J. Thoma, D.C. Wolf, and E.E. Gbur. 2002. Field evaluation of crude oil-contaminated soil phytoremediation. *In* 2002 Southern Branch Agronomy abstracts. ASA, Madison, WI.

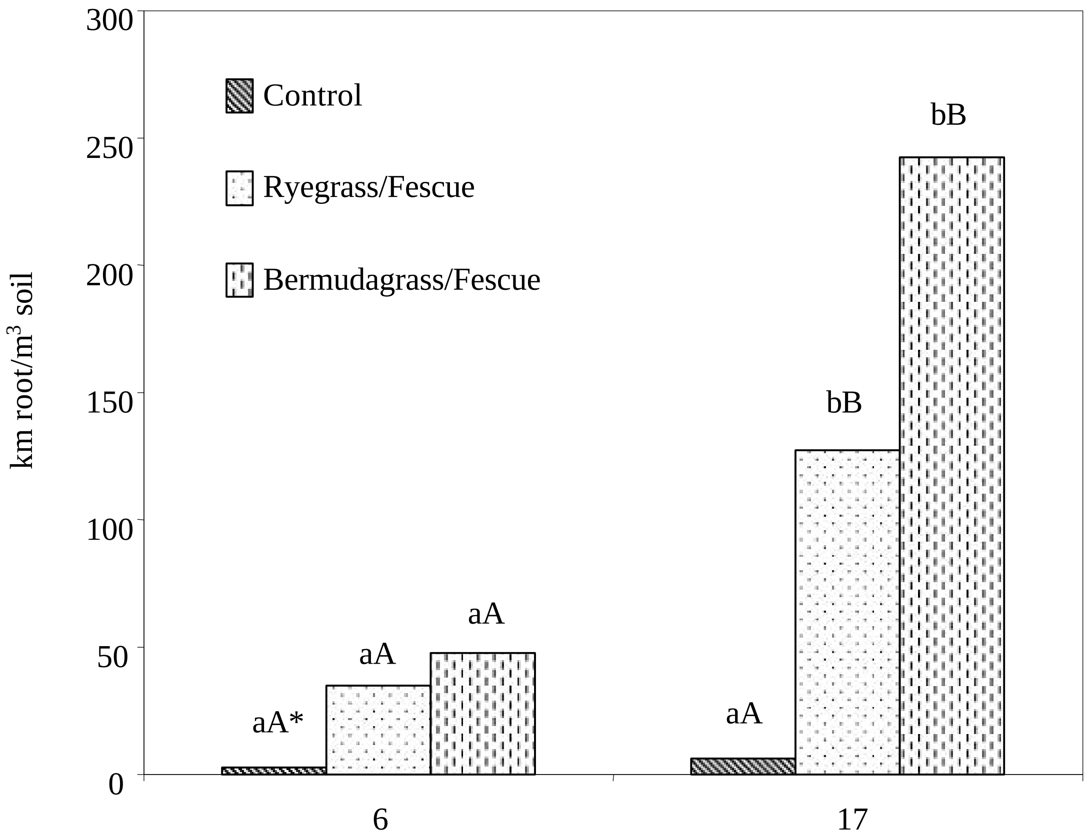

Figure 1. Root length values for the phytoremediation plots at 6 and 17 months after plot establishment. *Bars with the same lower case letter for a given treatment and uppercase letter for a given sample time are not significantly different at the 10% level.

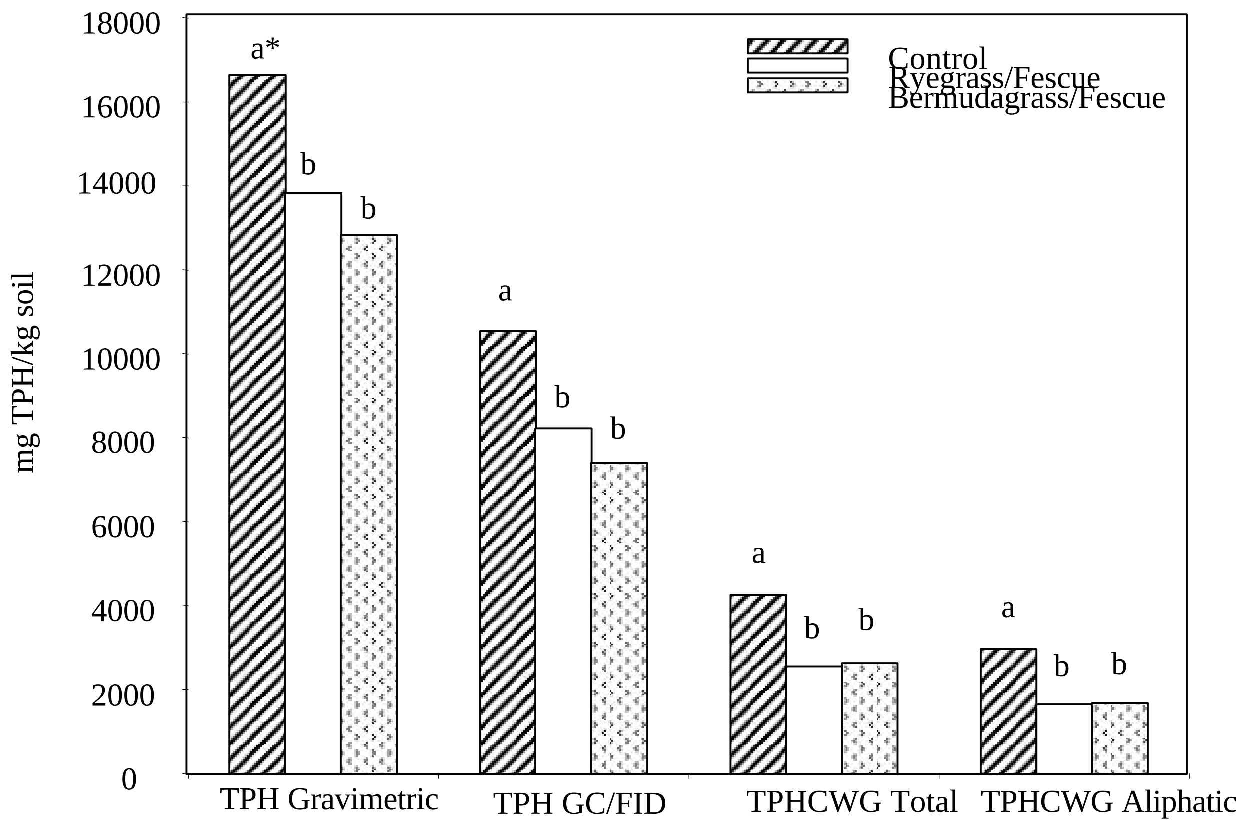

Figure 2. Total petroleum hydrocarbon levels in the phytoremediation plots after 17 months of treatment. *Bars with the same letter for a given parameter are not significantly different at the 10% level.

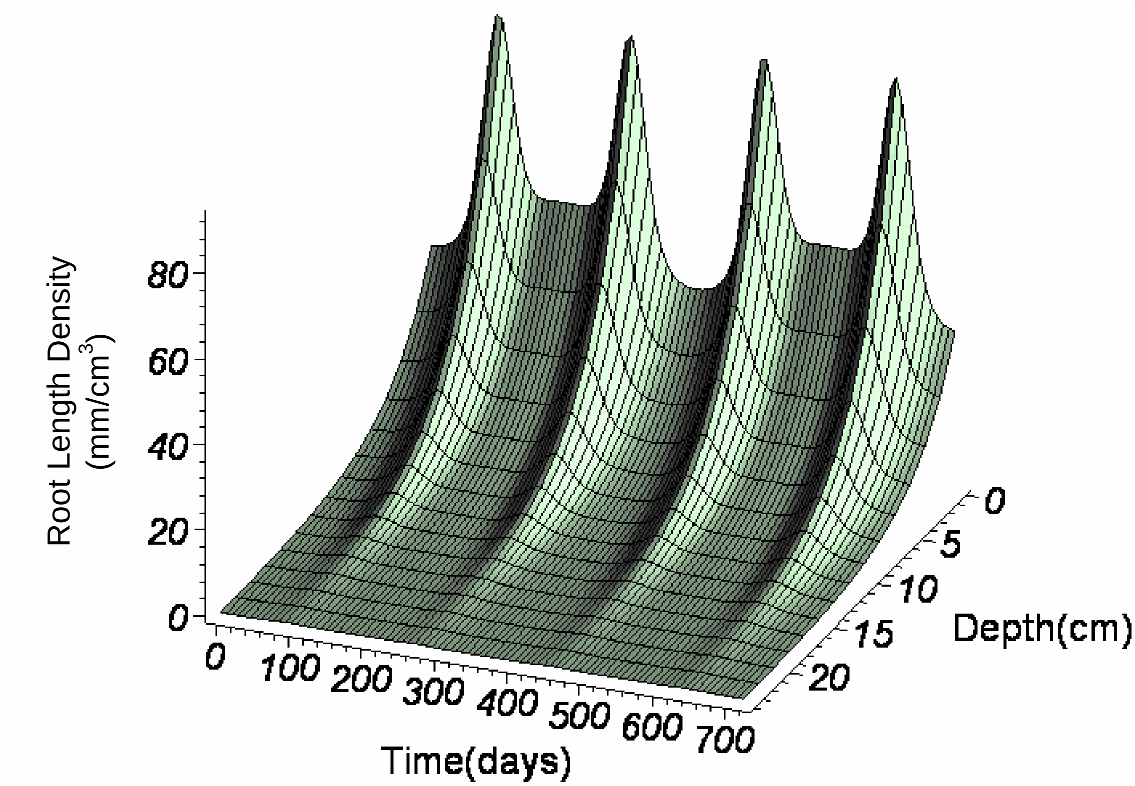

Figure 3. Two year root pattern for cool-warm-cool plantings. The annualized turnover for each seasonal species is 95% for the cool season and 30% for the warm season.

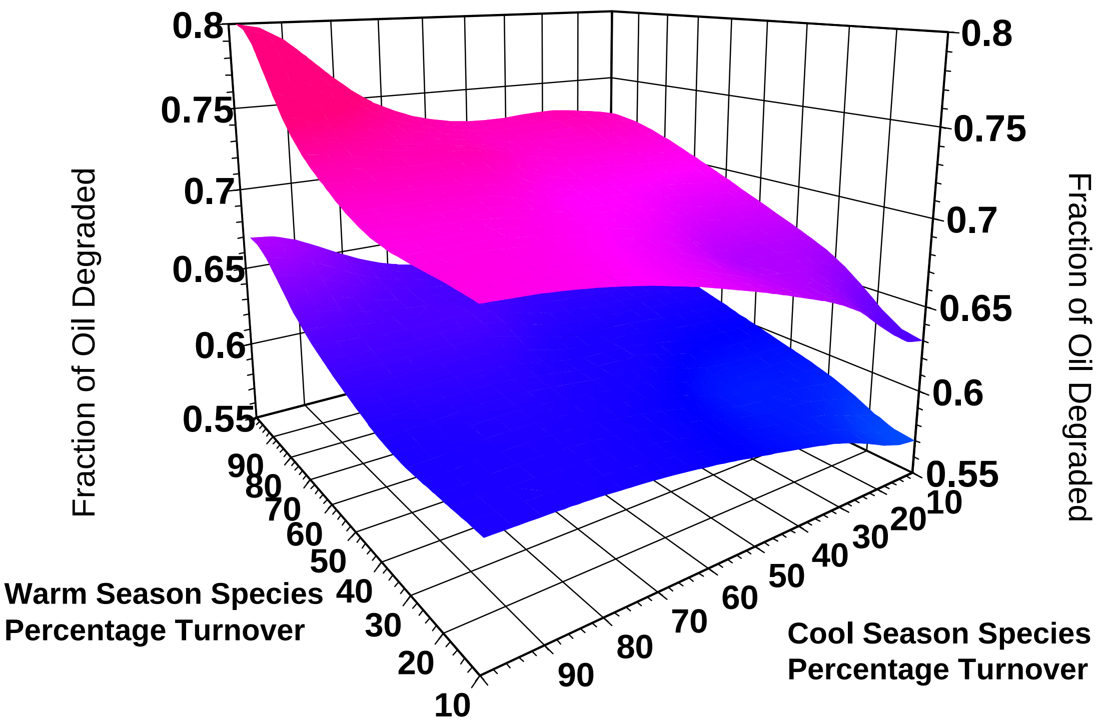

Figure 4. Summary of simulations testing the effects of root biomass and turnover of the efficacy of weathered diesel removal. The upper surface is for a system with 0.45%(v/v) average annual biomass; the lower surface for 0.2% (v/v). The simulation results suggest that the high turnover, but lower biomass system is approximately equivalent to the low turnover, high biomass system. This is apparent with the light purple color in the upper left of the lower surface and the dark blue in the lower right of the upper surface.