Soil chemistry adjacent to roads treated with dust control products at Squaw Creek National Wildlife Refuge

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Introduction

- The health of roadside soils determines the ecological value of roadsides for plants, invertebrates, and wildlife.
- Roadside soils can support native plant communities, filter road runoff, and provide habitat for pollinators and wildlife (*1*, *2*).
- However, roadside soils may also accumulate salts, heavy metals, and hydrocarbons, and transfer them up the food chain (e.g., *3*). Altered soil chemistry can facilitate invasion by exotic plants (*4*, *5*).
- Widespread application of chemical products for dust control may cause product residues to build up in roadside soils (*6*).
- Very few studies have attempted to track dust control products through the environment after application (*6*, *7*, *8*).

Questions

1) Can dust control products applied to unpaved roads be detected in roadside soils one year after application?
2) Are there other changes in soil chemistry associated with proximity to unpaved roads at this site?

Study site and test layout

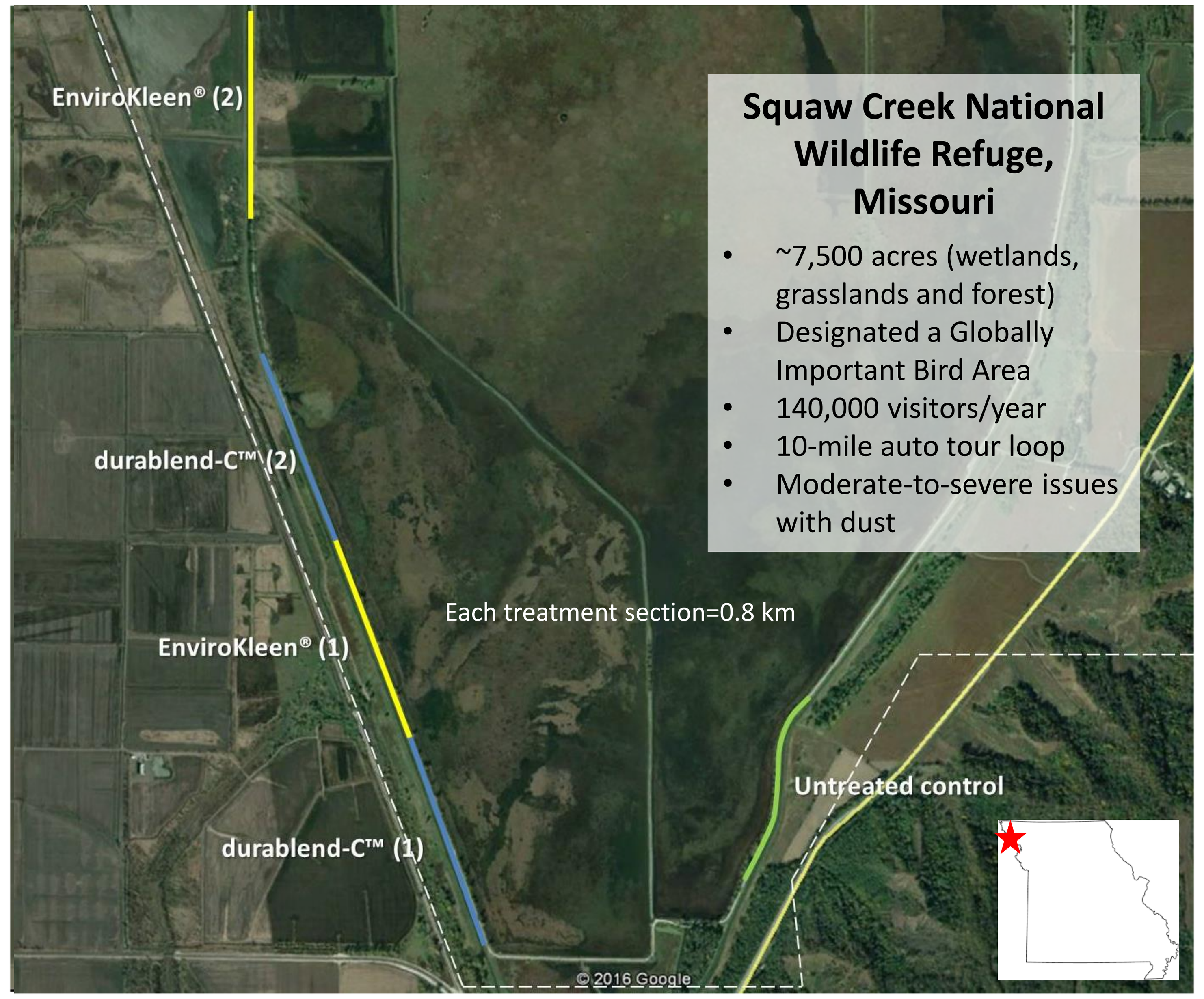
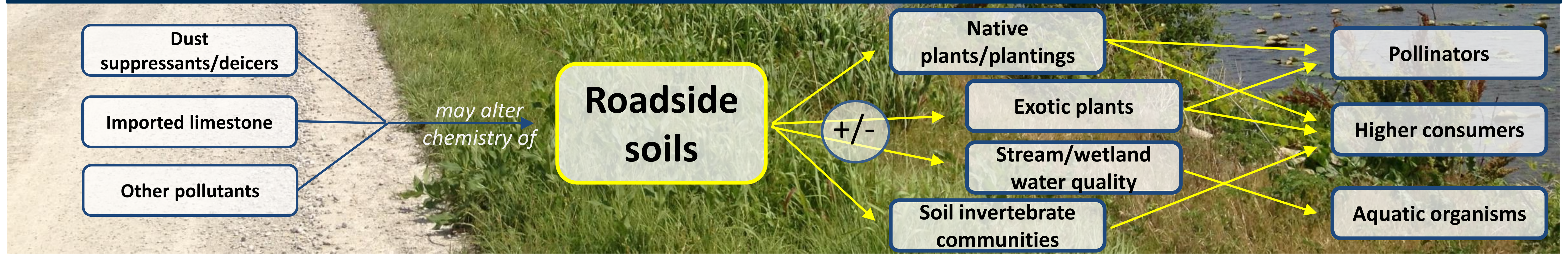


Figure 1. Layout of experimental treatment sections on the southern half of the Squaw Creek auto tour loop. Refuge boundary in white.

Importance of roadside soils



Methods

Initial product applications

Two products applied to replicated sections of the Squaw Creek auto tour loop (**Fig. 1**). All road sections (including untreated control) received new surface aggregate prior to road preparation.

- **durablend-C™**—Polymer-enhanced calcium chloride from EnviroTech Services, CO. Applied as one Compact & Cap™ mixed-in application
- **EnviroKleen®**—Synthetic fluid with binder from Midwest Industrial Supply, OH. Applied as initial topical application and a maintenance dose ~10 months later


Road preparation


durablend-C™ application


EnviroKleen® application

Soil sampling

- One year after initial applications
- Composite samples (10 cm depth) were taken at 1 m and 4 m from the road's edge (**Fig. 2)** along four replicated transects perpendicular to each road section
- Transects were placed on the east side of the road and in comparable habitats (vegetation, canopy cover, slope) to the greatest degree possible

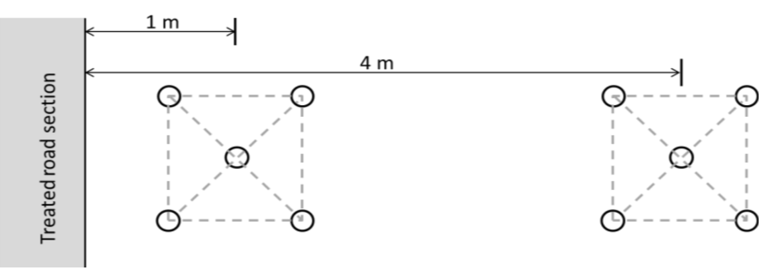


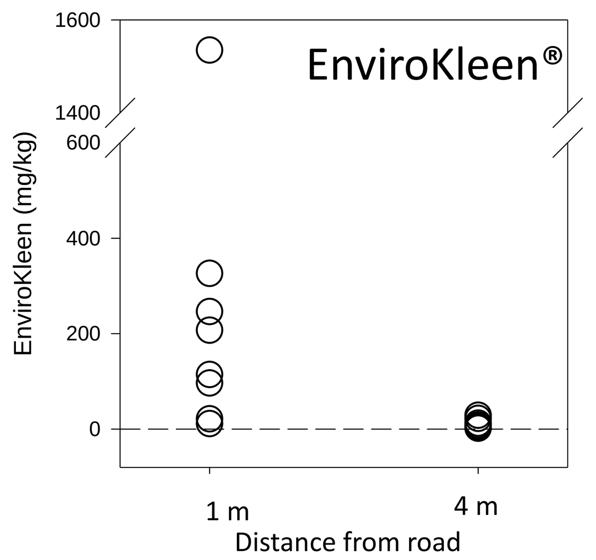
Figure 2. Detail of soil sampling locations at 1m and 4m along one roadside transect. Five subsamples (circles) were taken in a 1-m^2 area and combined into a composite sample for each location.

Soil analysis

- For the synthetic fluid EnviroKleen®**,** a unique signature was detected by gas chromatography/mass spectrometry (GC/MS)
- Analysis required development of a method for two-phase extraction (hexane/dicholoromethane), followed by GC/MS to look for specific ions characteristic of EnviroKleen®
- Only soils adjacent to EnviroKleen® or untreated sections were analyzed for EnviroKleen®
- For the calcium choride-based durablend-C™, soil conductivity was used as an indicator
- All samples analyzed for pH, conductivity, NO_3-N, P, K, Ca, Mg, Na, and S by Texas A&M Extension AgriLife
- Analysis of variance was used to examine the effect of road treatment and distance from road's edge on soil conductivity and calcium. Bonferroni corrections were applied for multiple comparisons

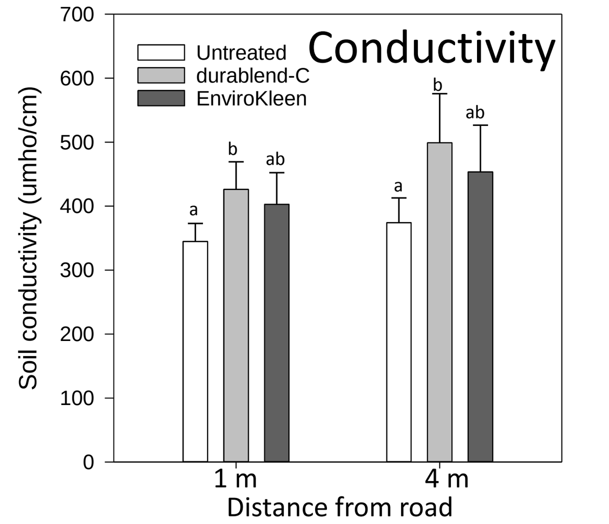
Preliminary results

Figure 3. EnviroKleen® residues detected in individual soil samples adjacent to EnviroKleen®-treated road sections. Note break in y-axis.



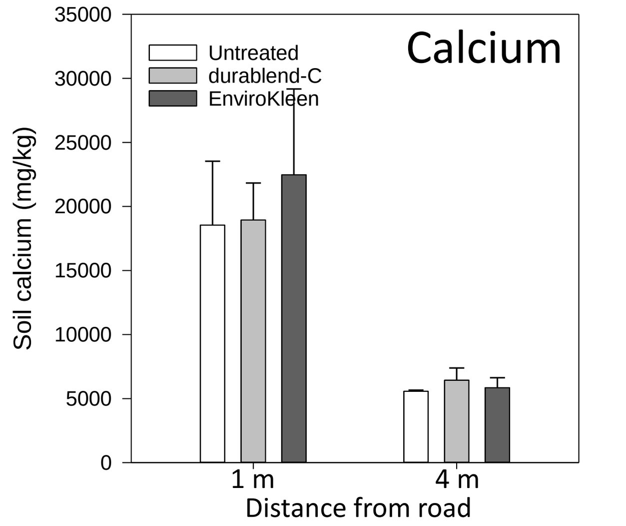
- EnviroKleen® concentrations ranged from 12 to 1535 mg/kg at 1 m from the road's edge, and from 1 to 22 mg/kg at 4 m (**Fig. 3**)
- EnviroKleen® was not detected in soils adjacent to untreated road sections

Figure 4. Conductivity of soils adjacent to untreated and treated road sections. Bars are means (n= 4-8) ± standard deviation. Different letters indicate significant differences (*P<0.05*) among treatments at a given distance.



- Soil conductivity was slightly elevated in soils adjacent to road sections treated with durablend-C™ relative to untreated at both distances (**Fig. 4**)
- Soil conductivity did not differ between 1 m and 4 m samples for a given product

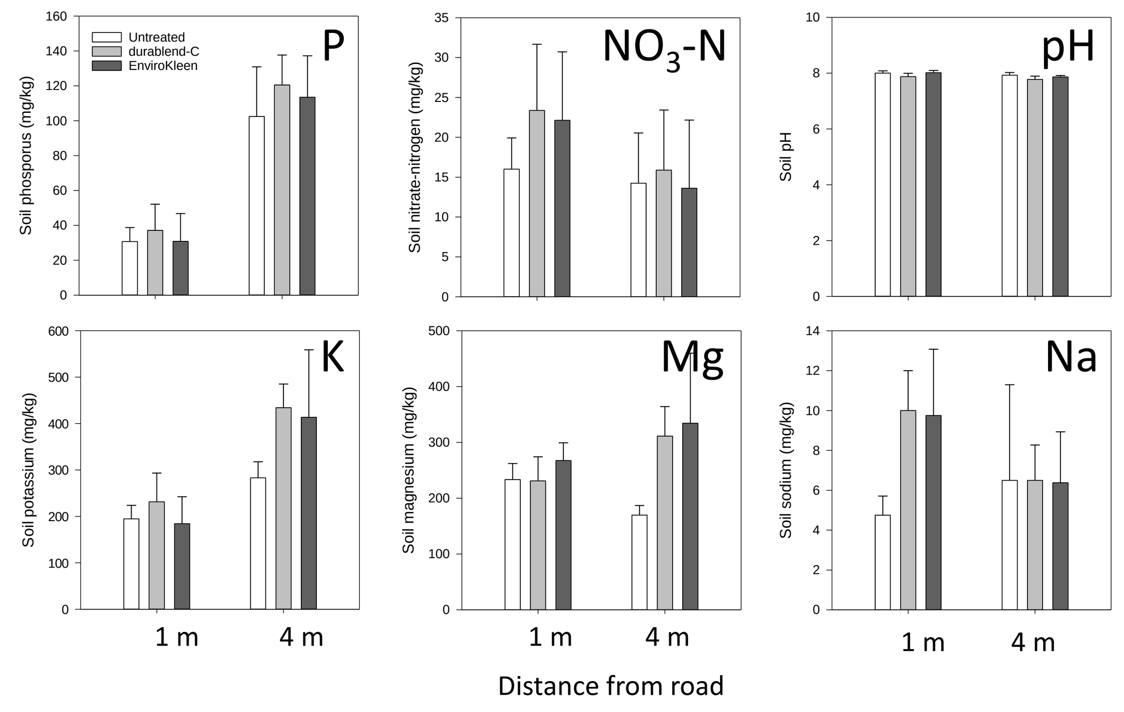
Figure 5. Calcium concentrations in soils adjacent to untreated and treated road sections. Bars are means (n= 4-8) ± standard deviation.



- Calcium concentrations were high (up to 30,000 mg/kg) in soils adjacent to any road section at 1 m (**Fig. 5**)
- Mean calcium was more than three times higher at 1 m than at 4 m from the road's edge (*P<0.01*)

Preliminary results—continued

Figure 6. Additional results from analyses of soils adjacent to untreated and treated road sections. Bars are means (n=4-8) ± standard deviation.



Conclusions

- **This study is the first to detect and quantify EnviroKleen®, a synthetic fluid dust control product, in roadside soils.**
- **Soil conductivity was marginally elevated in soils adjacent to roads treated with durablend-C™, a calcium chloride-based product.**
- **Dramatic changes in soil chemistry (elevated calcium) at 1 m were likely driven by dust deposition from the limestone road surface.**
- **At least in some cases, proximity to the road itself may be a more important influence on roadside soil chemistry than treatment with dust control products (pattern seen for P and K, as well as calcium).**
- **Understanding the environmental transport and fate of products after application is key for predicting the risk of harm to plants, soil invertebrates, or wildlife.**

Literature cited

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Acknowledgments

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Quantifying the effect of dust control treatments at Squaw Creek National Wildlife Refuge: Roads and roadside organisms

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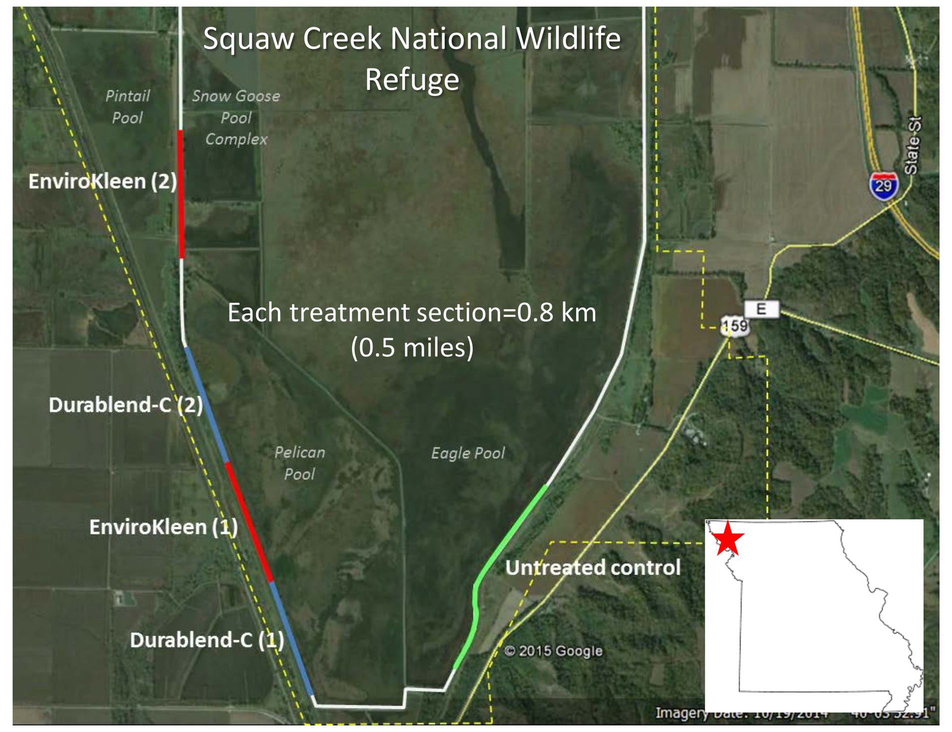
Introduction

- Dust control is a challenge for all unpaved road managers.
- Fugitive dust from unpaved roads creates human health concerns in the form of inhalable particulate matter, decreases visibility and driver safety, and compromises road surface integrity through the loss of fine particles.
- Chemical dust control treatments have many benefits, but may also have the potential to harm roadside plants and animals.
- Road managers need better information on the potential impacts of applications of dust control chemicals on roadside organisms. This need is especially great for road managers on wildlife refuges or in national parks and forests.

Objective

To evaluate product performance and environmental safety of selected dust control products under real-world conditions

Study site and test layout



Squaw Creek National Wildlife Refuge, Missouri

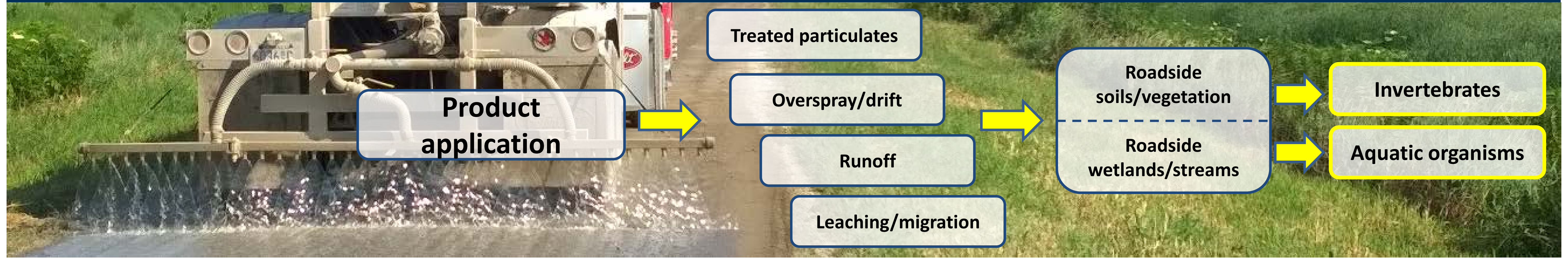
- ~7,500 acres (wetlands, grasslands and forest)
- Designated a Globally Important Bird Area
- Roads immediately adjacent to wetland habitats
- 140,000 visitors/year
- Moderate-to-severe issues with dust

Figure 1. Layout of experimental treatment sections on the southern half of the Squaw Creek auto tour loop. Refuge boundary in yellow.


Typical dust conditions prior to treatment


Auto tour loop immediately adjacent to wetland

Ecological pathways



Methods

Initial applications

Two products applied to replicated sections of the Squaw Creek auto tour loop (**Fig. 1**). All road sections (including untreated control) received new surface aggregate prior to road preparation. Products were applied according to vendor specifications.

- **durablend-C™**—Polymer-enhanced calcium chloride from EnviroTech Services, CO. Applied as one Compact & Cap™ mixed-in application.
- **EnviroKleen®**—Synthetic fluid with binder from Midwest Industrial Supply, OH. Applied as initial topical application and a maintenance dose ~10 months later.

Performance monitoring

- 6 visits over 17 months post-application
- Replicated dust measurements made with mobile-mounted DustTrak DRX meter
- Road surfaces assessed and documented
- Discussions with refuge staff and visitors


Road preparation


durablend-C™ application


EnviroKleen® application

Methods—Roadside organisms

Aquatic organism test

- Composite surface aggregate samples from all test sections (treated and untreated) taken immediately after application, 11 and 16 months post-application.
- 600-g subsamples soaked in deionized water to create leachates (overlying water).
- Leachates used in 96-hr toxicity tests with juvenile rainbow trout (*Oncorhynchus mykiss*) under static conditions at 12°C.

Roadside invertebrate sampling

- Invertebrates trapped during June-July 2015 as an indicator of invertebrate response after a year of potential product exposure.
- Pitfall and sticky traps installed along four transects adjacent to each test section of road.
- Pitfall traps opened for two 24-hr sampling periods; sticky traps deployed for a 2-week period.

Results—Product performance

- Treatment with either product reduced dust by 89-99% relative to the untreated section (**Fig. 2**) for a period of 11 months after initial applications. These reductions occurred with a single application (durablend-C™) or an application and maintenance dose (EnviroKleen®).
- Refuge staff reported better road surface condition and a reduced need for maintenance on treated sections. No maintenance blading was required for 17 months post-application.

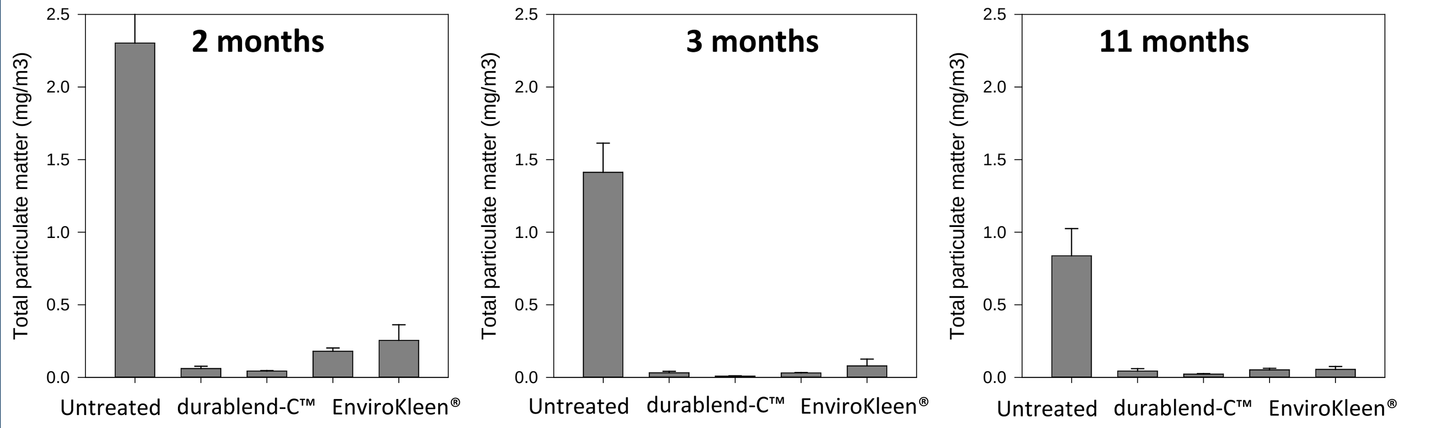


Figure 2. Dust production (average total particulate matter) measured while driving on test sections under standard conditions on three sampling dates (1 sample/sec, n=3 trips/section). Error bars represent standard deviations.

Results—Aquatic organism test

- No leachate caused significant mortality of juvenile rainbow trout in 96-hour tests, despite differences in water quality parameters among leachates (**Table 1**).

Table 1. Leachate test results from treated and untreated aggregates collected from Squaw Creek roads at three sampling periods. Survival values are from three replicate jars with five fish/jar. Water quality values are means (n=2-4) with standard deviations in parentheses.

Aggregate sample source and timing		Rainbow trout survival	Conductivity (µS/cm)	pH	Hardness (mg/L as $CaCO_3$)
durablend-C™	At application	100%	1780 (136)	6.95 (0.04)	788 (65)
	11 months	100%	496 (68)	7.08 (0.15)	216 (30)
	16 months	100%	423 (97)	7.1 (0.22)	185 (43)
EnviroKleen®	At application	100%	124 (17)	7.5 (0.37)	56 (5)
	11 months	100%	68 (7)	7.4 (0.34)	34 (9)
	16 months	97%	90 (22)	7.26 (0.1)	43 (8)
Untreated	At application	100%	85 (12)	7.59 (0.67)	47 (7)
	11 months	100%	93 (22)	7.67 (0.72)	49 (7)
	16 months	100%	79 (13)	7.62 (0.72)	43 (1)
Control water[1]	n/a	93%	253 (1)	7.81 (0.26)	106 (0)

[1]CERC well water diluted to a hardness of ~100 mg/L as $CaCO_3$

Results—Roadside invertebrates

- More than 20 families of invertebrates were captured in roadside traps.
- Capture rates along road sections treated with either product were comparable to those along the untreated road section (**Fig.3**)
- Analyses of species composition along each section are ongoing.

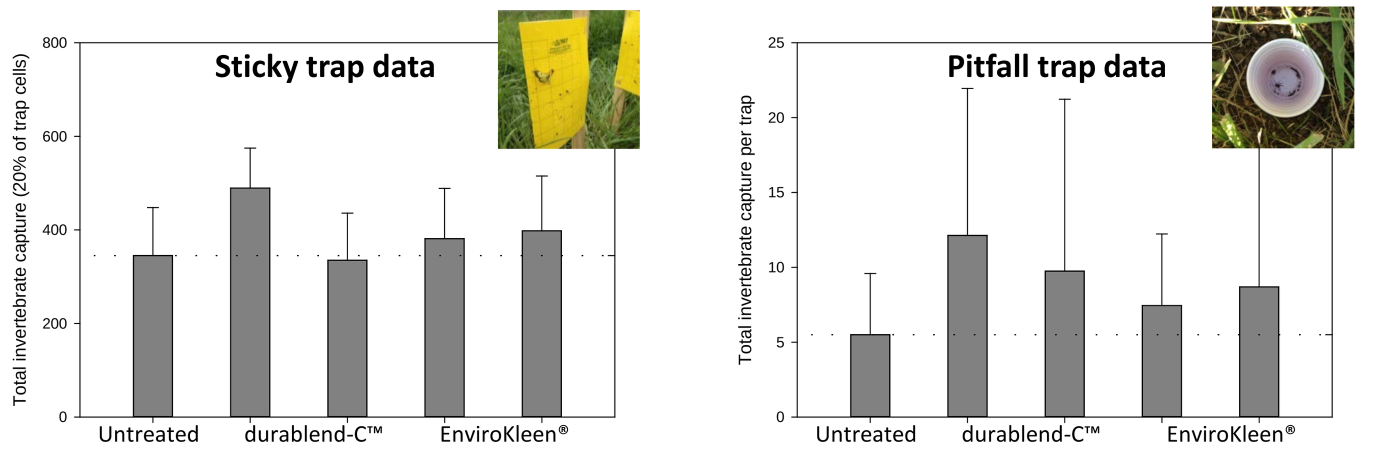


Figure 3. Roadside invertebrate captures on sticky traps (left) and during two cycles of pitfall trapping (right) during summer 2015, approximately one year after initial product applications. Error bars represent standard deviations. Dotted reference line=untreated control value.

Conclusions

- **Treatment with durablend-C™ or EnviroKleen® generally reduced dust production by >90% on treated road sections relative to the untreated section for 11 months after initial applications.**
- **Treatment reduced the need for routine road maintenance and may be a useful strategy for preserving aggregate.**
- **Leachates from treated and untreated aggregates did not negatively affect rainbow trout in short-term toxicity tests.**
- **Dust control treatments did not reduce the number of invertebrates captured in roadside traps the following summer, relative to the untreated section.**
- **These techniques provide an important link between laboratory toxicity test results and field exposures, and could be applied to monitor important target organisms for effects of road treatments in other settings.**

Ongoing work

- Summary of soil chemistry data
- Summary of objective road surface rating data
- Final round of dust measurement (18 months post-application)
- Final comparisons and report, including analysis of product performance, longevity, cost, roadside soil chemistry, and roadside organism responses

Acknowledgments

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Identifying sustainable dust control for low-volume roads: Phase Three field tests of the USGS/USFWS collaboration

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Introduction

- More than 1.5 million miles of roads in the U.S. are unpaved.
- Fugitive dust from unpaved roads creates human health concerns in the form of inhalable particulate matter, decreases visibility and driver safety, and compromises road surface integrity through the loss of fine particles.
- Few studies have investigated potential environmental impacts of dust suppressant application.
- Our previous work (Phases One and Two) identified several products with a low risk of environmental harm when used under recommended conditions.

Overall objective

To provide scientifically defensible information on environmental impacts of dust suppressant products, with the goal of identifying products for use in sensitive habitats such as wildlife refuges

Phase Three objective

To evaluate product performance and verify environmental safety of selected products under real-world conditions

Study site and test layout

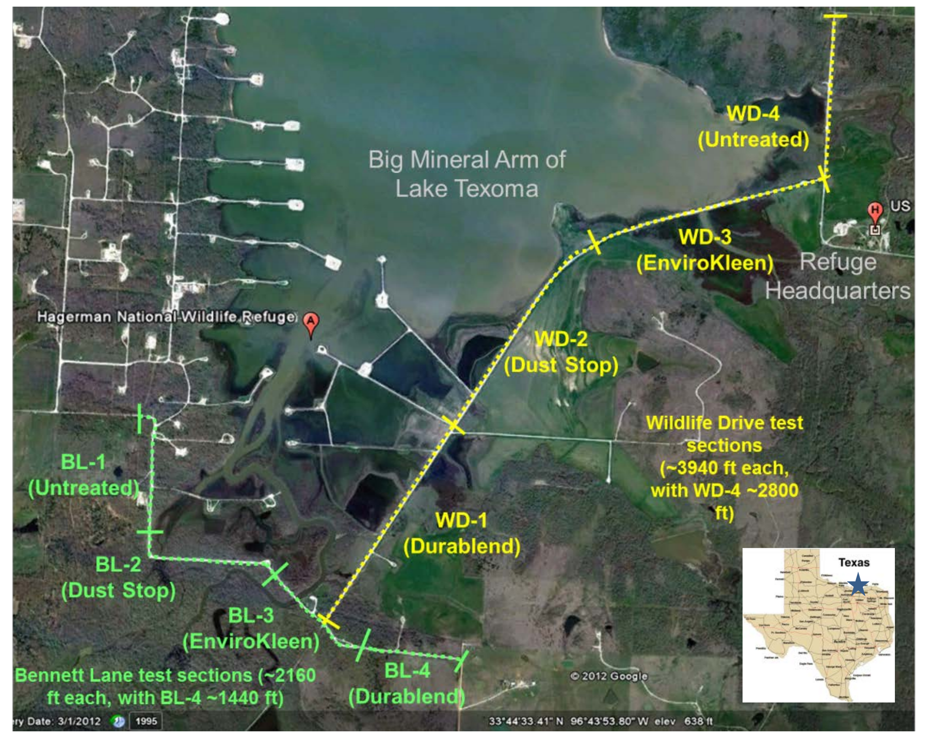
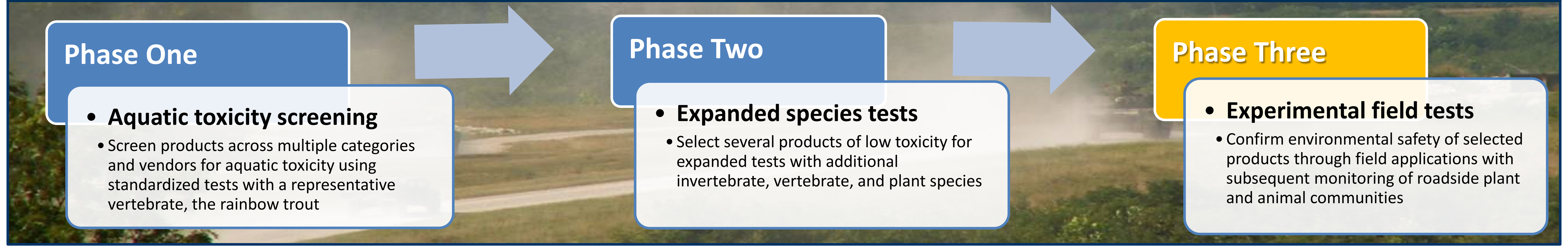


Figure 1. Layout of experimental treatment sections on Wildlife Drive and Bennett Lane.

Hagerman National Wildlife Refuge, Texas

- ~12,000 acres (upland, wetland, open water and cropland)
- Migratory birds and other wildlife
- 150 active oil and gas wells
- Roads receive heavy equipment traffic in addition to 175,000 visitors/year
- Moderate-to-severe issues with dust

Project design



Methods

Central goal

Perform realistic applications and measure relevant endpoints with minimal disruption to normal Refuge activities

Product choice

Products showing low toxicity to aquatic organisms in previous tests were evaluated for compatibility with conditions at Hagerman

Test products were chosen collaboratively by Refuge staff, product vendors, and USGS biologists

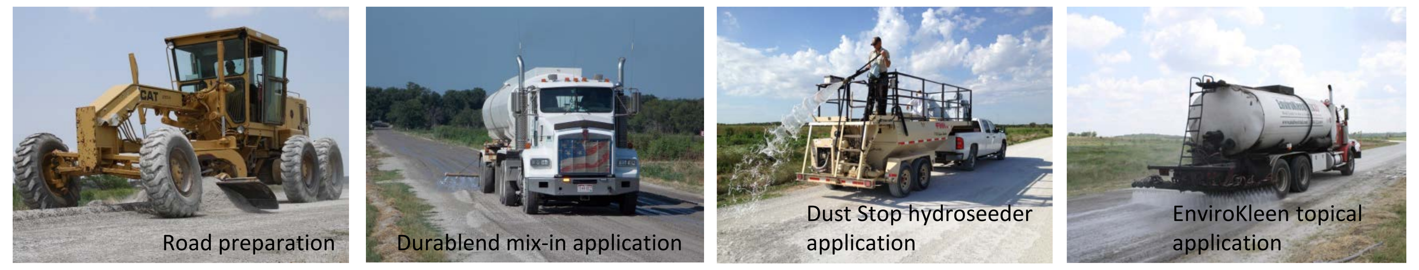
Initial applications

Three products applied to replicated sections of Wildlife Drive and Bennett Lane (**Fig. 1**)

- **Durablend**—Enhanced magnesium chloride from EnviroTech Services, CO, USA
- **Dust Stop**—Cellulose-based powder from Cypher Environmental, MB, Canada
- **EnviroKleen**—Synthetic fluid from Midwest Industrial Supply, OH, USA

Road sections were prepared and products were applied according to vendor instructions

- Durablend and Dust Stop—one application
- EnviroKleen—initial application and maintenance dose after ~2 months



Initial observations

Applications observed for overspray or runoff

Aggregate samples taken in each section for analysis by CFLHD Lab

Vegetation transects established adjacent to each section

Performance and biological monitoring (2, 4, 8, 16 and 52 weeks post-application)

Replicated dust measurements made with mobile-mounted DustTrak DRX

Road surfaces assessed and documented

Vegetation sampling

Roadside aquatic habitat monitoring

Preliminary results

Product performance

- All three products resulted in smoother, harder surfaces relative to untreated sections on Wildlife Drive (**Fig. 2**)
- All three products reduced dust levels relative to the untreated sections on Wildlife Drive through the first three monitoring periods when exposed to normal Refuge traffic. The dust suppressant effect of Durablend and EnviroKleen continued through the fourth monitoring period (4 months post-application; **Fig. 3**). Overall, dust levels in all sections varied with weather conditions, and variability among replicates increased over time.

Figure 2. Representative photos of treated road surfaces.

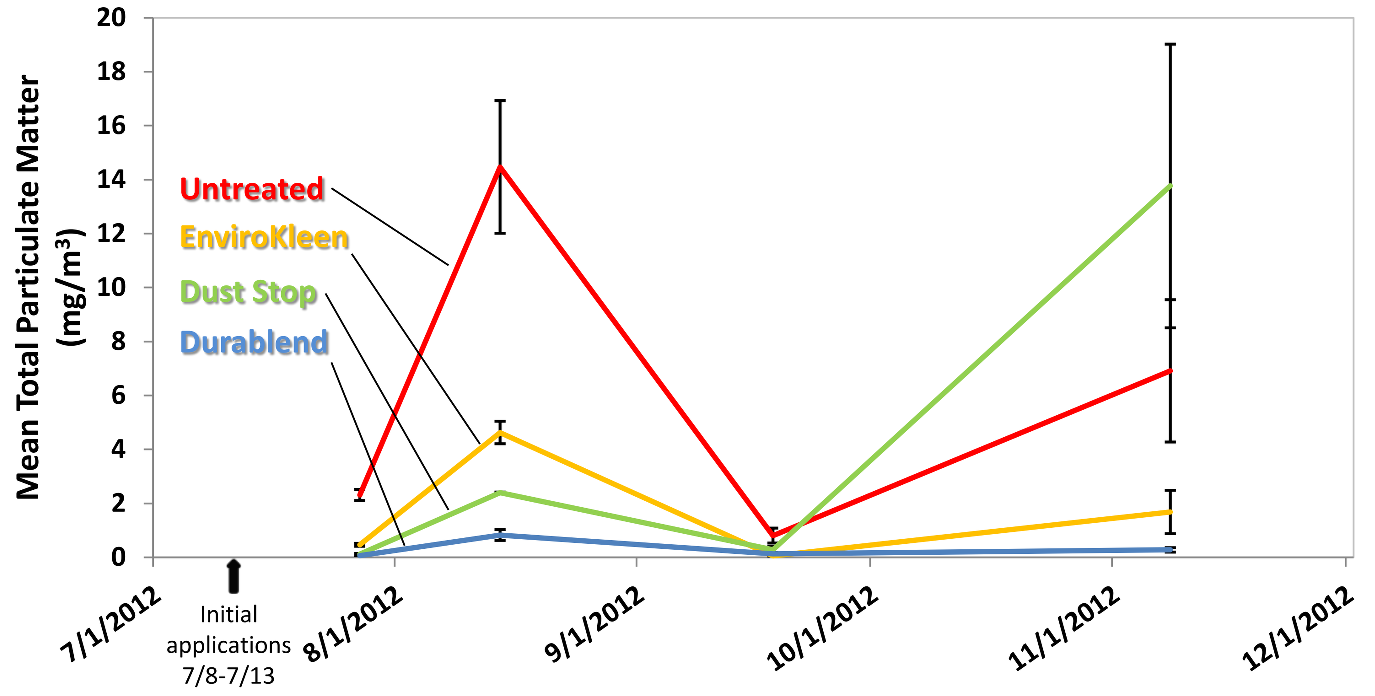


Figure 3. Total particulate matter measured while driving on treated sections of Wildlife Drive under standard conditions on four sampling dates. Points are means ± standard deviation (n=3 trips/section).

Preliminary results continued

Biological monitoring

- Vegetation transects adjacent to treated sections were not compatible with normal Refuge management activities (**Fig.4**)

Figure 4. Representative vegetation transect showing planned sampling locations (yellow arrows) at the time of product applications (left) and a later monitoring visit (right).

- Roadside aquatic habitats were highly variable both spatially and temporally

Preliminary Conclusions

- **All three low-toxicity products chosen for field tests improved the road surface and generally suppressed dust thus far on Wildlife Drive, relative to the untreated section**
- **The mobile-mounted DustTrak DRX aerosol monitor provided practical, replicated measurements of particulate matter mass and size fraction of road dust for comparisons among sections**
- **Dynamic biological monitoring plans were required for compatibility with Refuge activities and site-specific conditions**

Ongoing work

- Final monitoring visit planned July 2013 (52 weeks post-application)
- Aggregate sample analysis (fines content, etc.)
- Analysis of particulate matter including size fraction
- Semi-field tests
  - Treated aggregate samples in leaching tests
  - Experimental dusting tests
- Compilation of Refuge staff observations
- Final comparisons and report, including analysis of product performance, longevity, cost, application procedure, and effect on biological endpoints

Acknowledgments

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