THE LOWER FOX RIVER watershed monitoring program

Tracing the Source of Suspended Sediment in L. Fox River Streams using Radionuclide Analysis

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Project Objective

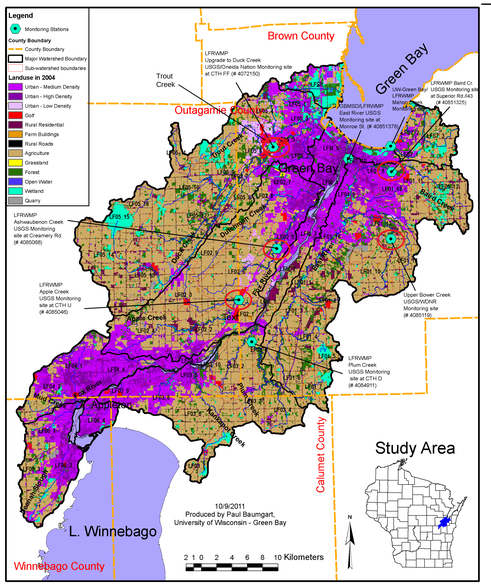
Determine relative contributions of suspended sediment sources to streams in Lower Fox watersheds through the use of radionuclide fingerprinting techniques (% contributions from: stream bank, upland ag soils, urban, gully erosion).

Why Radionuclides as Tracers?

•Relatively uniform distribution within a region (compared to other tracers)
•Half lives different
•Pb-210 (22 years) Cs-137 (30 yr) Be-7 (53 days)

•Cs-137, historical peak in 1960's, essentially no more deposition
•Pb-210 and Be-7, both naturally present, continuous deposition
•Pb-210: excess (atmospheric deposition) vs supported

Stream stations shown with RED circles



METHODS

- Sources: stream suspended sediment, soil cores, stream bank, urban/construction sites (detention pond cores); ----- samples collected from 2006 to May 2011
- Suspended sediment (streams) including limited winter and Spring snowmelt samples from Baird North/South (total of 92 samples, sufficient mass for analysis)
- Soils – 4 fields (along transects, composite for each sample, surface 2 cm, top 10 cm, bottom 10 cm, total of 17 cores; total of 37 sections)
- Sub-soil (4 samples)
- Stream bank (6 samples - Baird Creek)
- Detention ponds: 4 Green Bay sites: Huron-Sitka, Whittier, I-43 NE, I-43 NW (6 cores, 2 to 4 cm sections, 35 sections analyzed); cored during winter, under ice
- UW-Green Bay sampling, processing, chemical analysis
- UW-Milwaukee (Val Klump) radionuclide analysis (Cs-137, Pb-210, Be-7)

Stream sampling: Time-integrated suspended sediment sampler

Suspended sediment and water monitoring locations

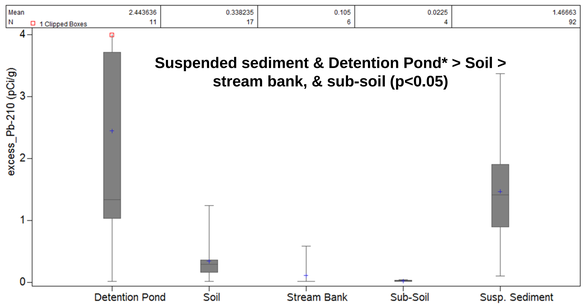
Watershed	Water sampling (flow, TSS, TP, DP), and continuous flow monitoring period	Suspended sediment tube sampling period	Initial sediment tube placement	Number of analyzed samples
Apple Creek at CTH U / Campground (117 km2)	LFRWMP: 2004-2006	2006-09	6/6/2006	6
Ashwaubenon Creek at Creamery Road (48 km2)	LFRWMP: 2004-2006	2006-09	7/19/2006	7
Baird Creek Main Stem at Superior Road (54 km2)	LFRWMP: 2004-2011	2006-11	6/6/2006	22
Baird Creek North Branch	intermittent	2006-11	8/10/2006	19
Baird Creek South Branch	intermittent	2006-11	8/10/2006	25
Bower Creek at CTH MM (36 km2)	USGS/WDNR: 2007-2008	2006-09	10/1/2006	6
Duck Creek at CTH FF (276 km2)	LFRWMP: 2004-2008	2006-09	8/1/2006	5
Trout Creek at CTH FF	UWGB: 2008	2008-09	5/1/2008	2
			TOTAL	92

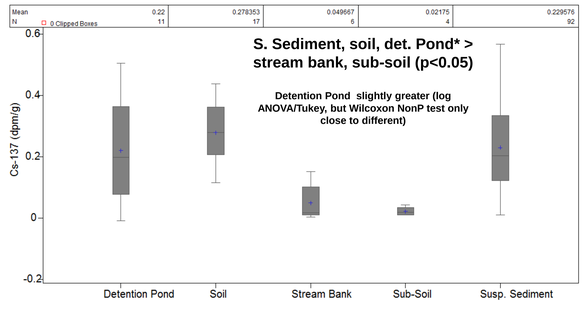
RESULTS

Source	n	Mean activity level of radionuclide: Ex-Pb-210 (pCi/g)	Cs-137 (dpm/g)	K-40 (dpm/g)
Suspended sediment	92	**1.47**	**0.23**	6.02
Detention Pond	19	2.49	0.22	6.54
Soil	37	**0.33**	**0.28**	7.28
Sub-Soil	4	0.02	0.02	8.36
Stream Bank	6	0.10	0.05	5.35

•Cs-137 shows no apparent enrichment (from soil to suspended sediment)

•Pb-210 in suspended sediment much higher than soil source --- **enrichment or something else**?





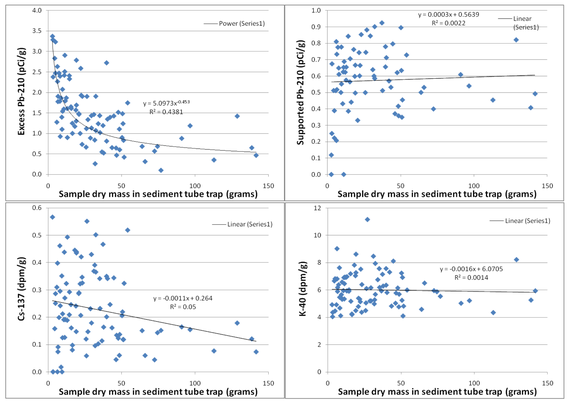
*** 2 & 4 cm det. Pond sections included; only surface soil surface sections included**

PRELIMINARY CONCLUSIONS: source contributions

- Can distinguish source materials such as soils from stream bank based on: Cs-137 & excess Pb-210
- However, excess Pb-210 in suspended sediment and detention pond much higher than expected (enriched by runoff from soil surface layer & hard surfaces with recent deposition of atmospheric Pb-210, that doesn't get mixed with deeper soil; and from selective transport of smaller particle sizes?)
- Over all streams combined, suspended sediment in traps more likely from soils than stream banks or sub-soil
- Next step: mixing models to estimate contributions from different sources (possibly with additional chemical analysis from student Jared Olejniczak

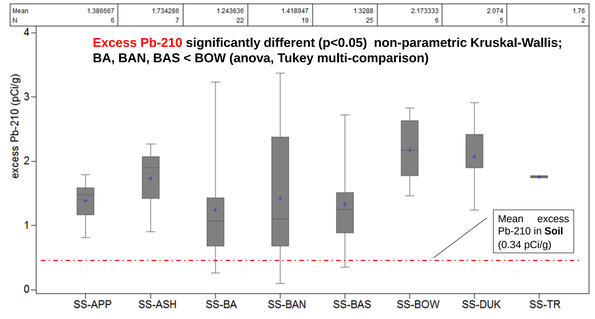
RESULTS

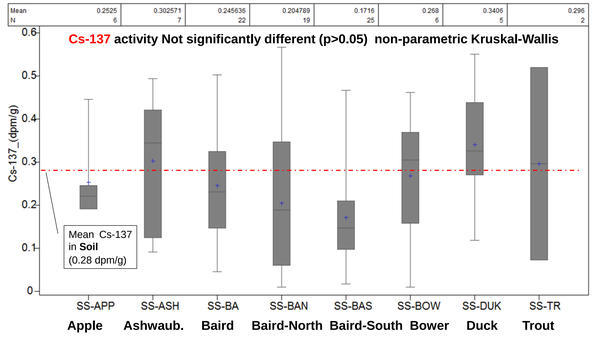
Excess Pb-210 (activity/g) in suspended sediment decreases with larger sample mass (intense events); not for other radionuclides



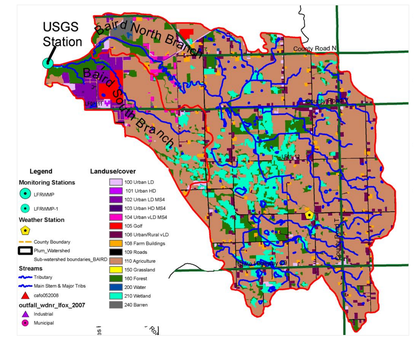
- **Observation:** Compared to Cs-137, excess Pb-210 activity is enhanced in suspended sediment samples, relative to soils and other sources – why?:
  - Samples not sieved to remove sand-sized particles. Excess Pb-210 activity is higher in finer particles (adsorbed). But K-40 and supported Pb-210 are same for all sizes (absorbed in parent soil material, not from atmospheric deposition). Excess Pb-210 from fallout is ongoing. Cs-137 deposition no longer significant.
  - Enrichment of excess Pb-210 due to selective transport that favors deposition of coarser soil particles lower in excess Pb-210 and transport of finer particles with higher surface areas.
  - Runoff from small to moderate intensity events carries mostly surface soil that has elevated Pb-210 activity which has built up since last event --- relative to lower mixed soil layers (and from directly from Pb-210 in precipitation). High intensity erosion events which erode deeper into the soil will likely be characterized by lower excess Pb-210 activity than low intensity events, AND a similar pattern is unlikely to be observed for Cs-137 or K-40;
- Issue: Sand-sized particles not removed from samples, so K-40 and supported Pb-210 similar for all sources. Can excess Pb-210 be utilized as tracer to apportion contributions from different sources or areas?

Suspended sediment from streams: excess Pb-210 & Cs-137





Baird North branch, South branch, Main stem compared

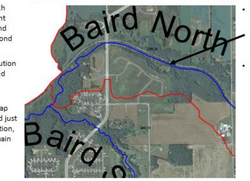


- Which trib contributes more suspended sediment?
- North branch = 45 km², Ag (brown), wetland (cyan)
- South branch < 8.8 km², more urban (purple)
- Lower main stem, banks & catchment

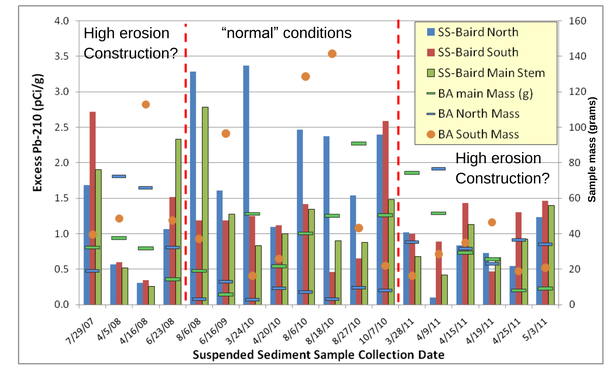
Baird Creek 2008: road/pond built

- North branch development with road and detention pond
- Trib contribution of suspended sediment?
- Sediment trap tubes placed just before junction, and DS @ main stem

Baird Creek 2010 after road/pond built



- North branch road and detention pond now finished
- Which trib contributes more suspended sediment



- **Middle 8 Paired events/period compared for Baird Main, North & South tribs**
- Excess Pb-210: Nonparametric Wilcoxon Scores by Trib, significant p = 0.026 Kruskal-Wallis test (not paired sign rank sum test yet)
- Log-transformed Excess Pb-210: Trib significant p = 0.005 with ANOVA repeated measures on event (p=0.07 on event); Tukey multi-paired comparison found:
- BAN different/higher than BAS & BA; BA & BAS NOT different (based on Pb-210)
- Suggests over middle 8 events, smaller South branch major source to main stem
- Cs-137: no signif. difference between Tribs (p=0.16), with ANOVA repeated measures on event, and Wilcoxon scores by station not significant at p = 0.18 (K-40 also not significant, p=0.94)
- **Remaining 10 Paired events compared for Baird Main, North & South tribs**
- Excess Pb-210: Nonparametric Wilcoxon Scores by Trib: NOT significant p = 0.15 Kruskal-Wallis test event significant effect (p=0.004)
- Log-transformed Excess Pb-210: p = 0.075 NOT significant at 0.05 level with ANOVA repeated measures on event (but significant on event p=0.0001)
- BAN appears to not be different than BAS & BA during these periods (although ex-Pb-210 is lower); BA & BAS NOT different (based on ex-Pb-210)
- Suggests over remaining 10 events, North & South branch similar to main stem
- Cs-137: no signif. difference between stations (p=0.53), with ANOVA repeated measures on event, and Wilcoxon scores by station not significant at p = 0.35
- **PRELIMINARY: 1st and 3rd periods highly erosive; construction problems?**