Summary of Past Ecological Investigations and Recommendations for Future Investigations at the PGDP: What to Monitor and Why?

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Objective

- Collect, evaluate, and summarize past ecological assessments and management activities
- Provide an ecological strategy to guide future ecological activities
- Produce a "living" document that will serve as the basic reference for ecological assessments and management-related activities

The emphasis of this document is exposure and accumulation of contaminants in "ecological resources".

This knowledge may guide resource managers who are responsible for making decisions and implementing actions to safeguard ecological resources and potential human exposure.

Why ecological (wildlife) monitoring?

Wild species integrate resources and contaminants over temporal and spatial scales providing data not readily available from monitoring abiotic resources such as soil, water, and air.

Phase I

Collect and chronologically organize existing ecological data

Identify contaminants of concern

Develop potential food web contaminant transfer models for terrestrial and aquatic environments

Collect and Chronological Organization of Data

- Existing data, approximately 800 individual documents, located and entered into EndNotes data management system.
- This is and should continue to be an ongoing process.

Metal	Mammals Various[1] 1992 (6)[2]	Deer 1993 (19)	Fish[3] 1998 (67)	Hawk[4] 1998 (69)	Rabbit 1999 (5)	Raccoon 1999 (22)	otter 2000 (74)	Deer 2001 (39)	Deer 2002 (37)	Scrap Yard Mammals[5] 2002 (25)
Aluminum (Al)	✞				✞		✞	✞	✞	✞
Antimony (Sb)		✞			✞	✞	✞	✞	✞	✞
Arsenic (As)	✞	✞			✞		✞	✞	✞	✞
Boron (B)		✞						✞		
Barium (Ba)		✞			✞	✞	✞	✞	✞	✞
Beryllium (Be)		✞	✞	✞	✞	✞	✞	✞	✞	✞
Cadmium (Cd)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Calcium (Ca)		✞						✞		
Chromium (Cr)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Cobalt (Co)		✞			✞	✞	✞	✞	✞	✞
Copper (Cu)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Iron (Fe)		✞			✞	✞	✞	✞	✞	✞
Lithium (Li)		✞								
Lead (Pb)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Magnesium (Mg)		✞					✞	✞		
Manganese (Mn)		✞			✞	✞		✞	✞	✞
Mercury (Hg)	✞				✞		✞	✞	✞	✞
Molybdenum (Mo)		✞						✞		
Nickel (Ni)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Phosphorus (P)		✞								
Potassium (K)								✞		
Selenium (Se)	✞	✞			✞		✞	✞	✞	✞
Silicon (Si)		✞						✞		
Silver (Ag)	✞		✞	✞	✞	✞		✞	✞	✞
Sodium (Na)								✞		
Strontium							-			✞
Thallium (Tl)	✞				✞	✞	✞	✞	✞	✞
Uranium							✞	✞		✞
Vanadium (V)					✞	✞	✞	✞	✞	✞

Polychlorinated biphenyls (PCBs) previously analyzed in biological samples collected on or near the Paducah Gaseous Diffusion Plant, Paducah, KY.

PCB (Aroclor)	Mammals Various[1] 1992 (6)[2]	Deer 1993 (19)	Fish[3] 1998 (67)	Hawk[4] 1998 (69)	Rabbit 1999 (5)	**Raccoon 1999 (22)**	**Otter 2000 (74)**	Deer 2001 (39)	Deer 2002 (37)	Scrap Yard Mammals[5] 2002 (25)
1016	✝				✝		✝	✝	✝	✝
1221		✝			✝	✝	✝	✝	✝	✝
1232	✝	✝			✝		✝	✝	✝	✝
1242		✝						✝		
1248		✝			✝	✝	✝	✝	✝	✝
1254		✝	✝	✝	✝	✝	✝	✝	✝	✝
1260	✝	✝	✝	✝	✝	✝	✝	✝	✝	✝

PCB congener data

Radionuclides previously analyzed in biological samples collected on or near the Paducah Gaseous Diffusion Plant, Paducah, KY.

Radionuclide	Mammal Various[1] 1992 (6)[2]	Deer 1993 (19)	Fish[3] 1998 (67)	Hawk[4] 1998 (69)	Rabbit 1999 (5)	Raccoon 1999 (22)	Otter 2000 (74)	Deer 2001 (39)	Deer 2002 (37)	Scrap Yard Mammals[5] 2002 (25)
Cesium 137					✞			✞		
Neptunion 237					✞				✞	
Plutonium 239/240					✞				✞	
Potassium 40								✞		
Strontium 90					✞					
Technetium 99					✞			✞	✞	
Uranium 234					✞			✞	✞	
Uranium 235					✞			✞	✞	
Uranium 238					✞			✞	✞	

Contaminants of Concern

Metals

Aluminum (Al)
Beryllium (Be)
Cadmium (Cd)
Chromium (Cr)
Lead (Pb)
Mercury (Hg)
Molybdenum (Mo)
Nickel (Ni)
Silver (Ag)
Strontium (Sr)
Uranium

PCBs

Aroclors

1254
1260
1268

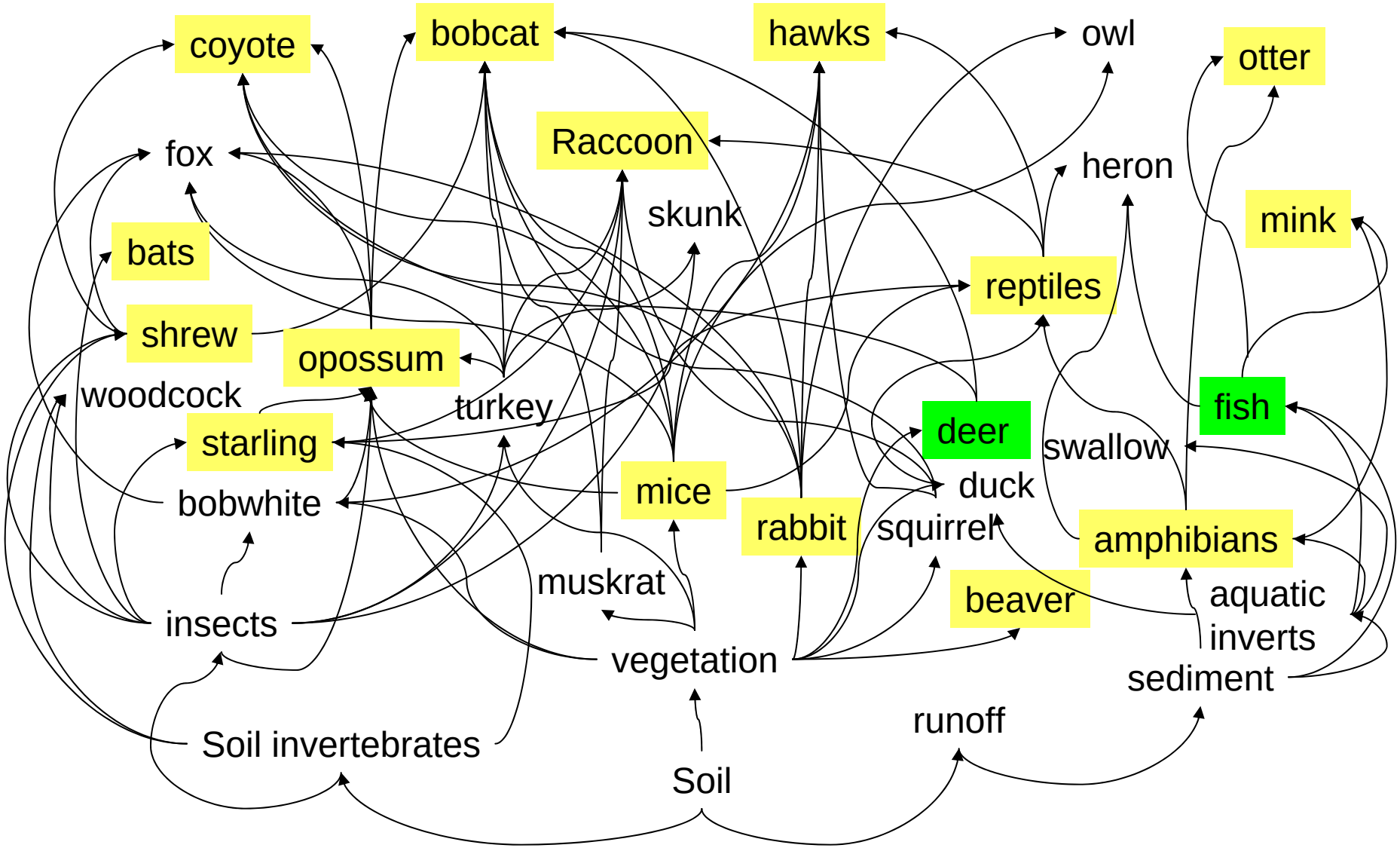
Congeners

Non-ortho
Di-ortho

Radionuclides

Cesium 137
Neptunion 237
Plutonium 239/240
Potassium 40
Strontium 90
Technetium 99
Uranium 234
Uranium 235
Uranium 238

Paducah Food Web Model (contaminants transfer model)

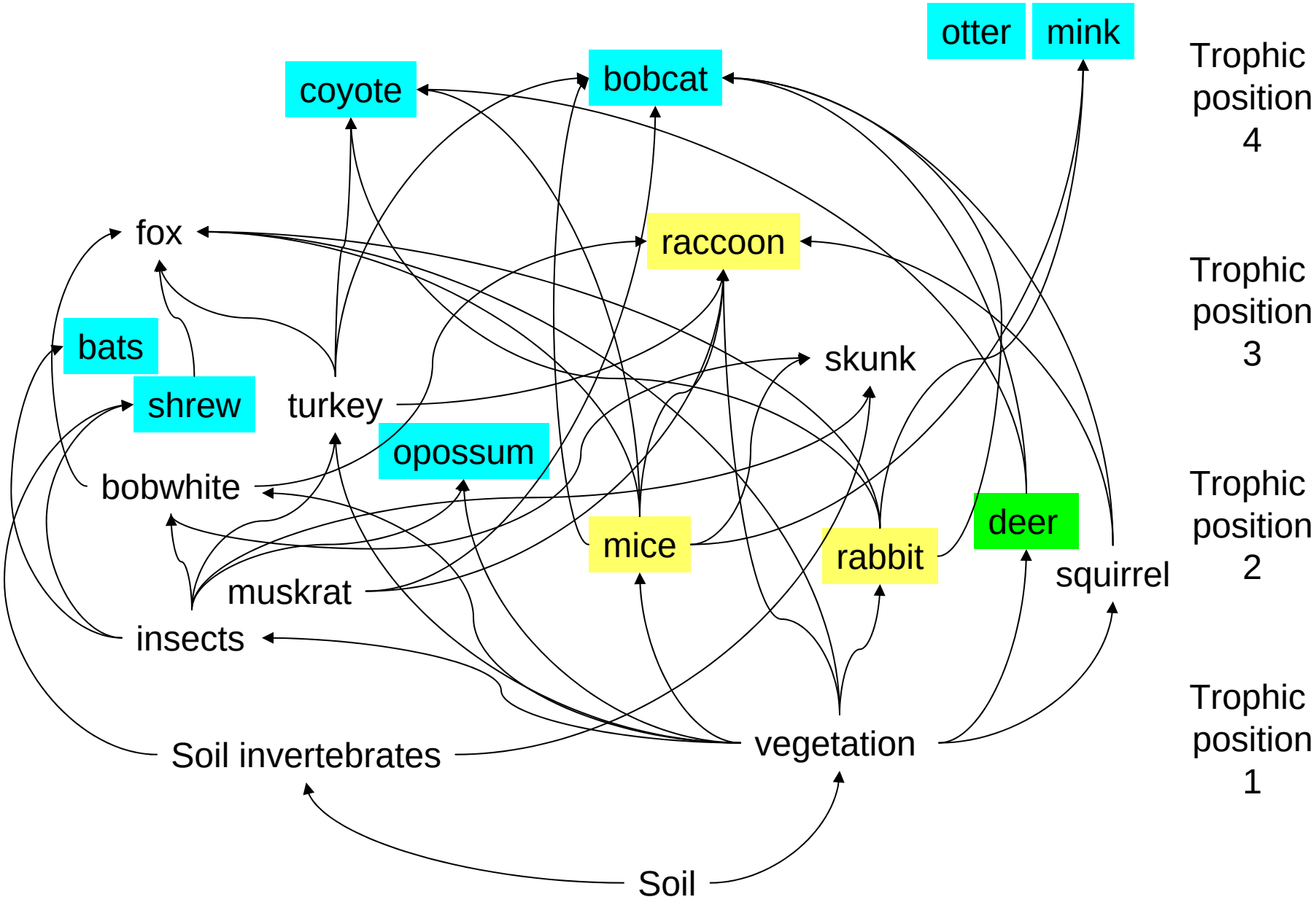


Phase II

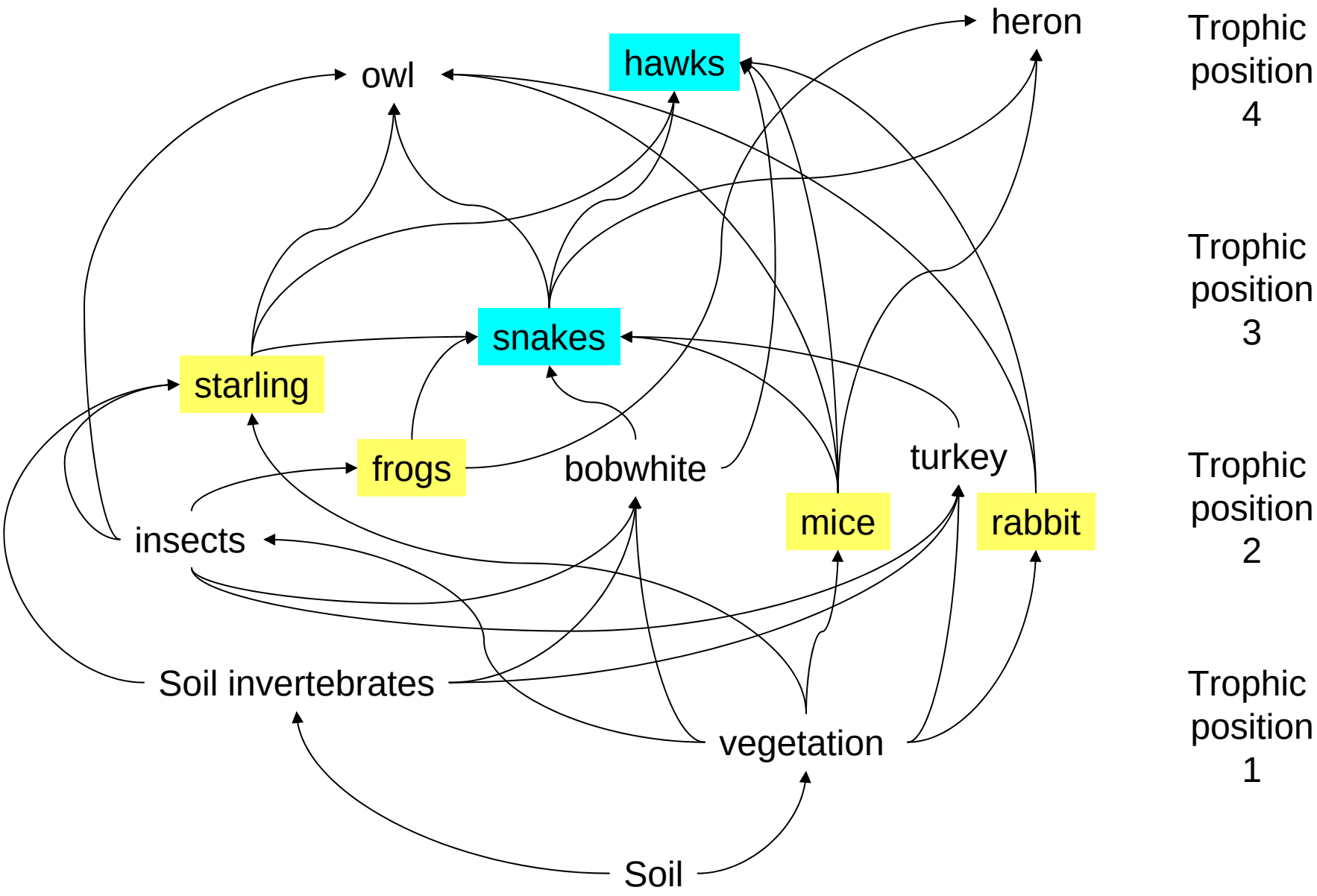
Perform a detailed evaluation and summation of existing ecological assessments and management-related activities

Merge existing data from historical studies with potential food web conceptual models to identify existing data gaps

Terrestrial Mammalian Food Web (contaminant transfer model)



Terrestrial Avian Food Web (contaminant transfer model)



Phase III

Develop a strategy that provides an extensive summary of chronology and results of historical ecological assessments

Provide a framework for future ecological study that addresses identified data gaps and information needed for future management decisions.

Ecological Monitoring at the Paducah Gaseous Diffusion Plant: Historical Evaluation and Guidelines for Future Monitoring

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Recommendations for Future Investigations at the PGDP:

What to Monitor and Why?

Criteria for species selection

Based on one or more of the following criteria:

Identified data gaps at PGDP

Trophic position

Suitability for monitoring

- Ability to obtain adequate sample size
- Home range
- Existing standardized capture techniques
- History of use in contaminant studies

Availability of a literature-derived contaminant database

Species Recommended for Monitoring

Mammalian species

Regular

Deer
Raccoon

Opportunistically

Otter
Bobcat

Odocoileus virginianus

Procyon lotor

Lynx rufus

Species Recommended for Monitoring

Avian species

Sturnus vulgaris

Regular

Kestrel
Starling

Falco sparverius

Opportunistically

GB Heron
Hawks

Ardea herodias

Species Recommended for Monitoring

Reptilian/amphibian

Regular

Northern Water Snake
Bullfrog

Rana catesbeiana

Nerodia sipedon

Opportunistically

Snapping turtle
Red eared slider

Trachemys scripta

Monitoring Protocols are Provided

Starling:

24 starling nest boxes placed along or near the security fence of the PGDP

12 nest boxes placed in suitable grassland habitat at least 5 km from the plant (reference)

Measure productivity by recording the number of nests constructed, number of eggs laid/nest, number of eggs hatched/nest, and number of chicks that survive 15 days post-hatch

Measure contaminants of concern in 15-day old chicks

Contaminants of Concern

Metals

Aluminum (Al)
Beryllium (Be)
Cadmium (Cd)
Chromium (Cr)
Lead (Pb)
Mercury (Hg)
Molybdenum (Mo)
Nickel (Ni)
Silver (Ag)
Strontium (Sr)
Uranium (U)

PCBs

Aroclors

1254
1260
1268

Congeners

Non-ortho
Di-ortho

Radionuclides

Cesium 137
Neptunion 237
Plutonium 239/240
Potassium 40
Strontium 90
Technetium 99
Uranium 234
Uranium 235
Uranium 238

Objectives:

1. Measure contaminants of concern in selected species
    1. metals should be measured in muscle, kidney, and liver tissue
    2. PCBs should be measured in fat and liver tissue
    3. radionuclides should be measured in bone, muscle, and liver tissue (depending)

2. Compare measured tissue concentrations with concentrations of concern

3. Compare results from PGDP samples with those collected from reference

It is not suggested that all species selected as indicator species be monitored every year

it is recommended that all species be initially monitored for 3 consecutive years

followed by monitoring every other year for 6 years

then once every three years

The “Living” Work Sheets

Table 1.2. Literature values for mammalian concentrations of concern in diet and tissues, and maximun (mg/kg) detected in representative species collected from the PGDP.

	Mammalian Concentrations of Concern		Deer	Raccoon	Small Mammals
Metal (mg/kg)	Diet	Tissue	Tissue	Tissue	Tissue
Aluminum (Al)			13.4 ms (15) 3.70 kd (7) 63.2 lv (7)	20.5 ms (9) 2.54 lv (9) 7.18 kd (13)	372 wb (13)
Beryllium (Be)			0.1 ms (7) 0.16 kd (7) 0.23 lv (7)	0.02 kd (10)	nd kd (14)
Cadmium (Cd)		100 fw kd (2, 16) 350 dw kd (16)	0.24 ms (15) 1.33 lv (13) 3.9 kd (7)	16.1 kd (10) 0.27 lv (9)	6.45 dw kd (14)
Chromium (Cr)			2.14 ms (7) 10.8 lv (13) 1.99 kd (7)	2.3 lv (11) Σ [illegible]	3.69 wb (13)
Lead (Pb)	>20 bw (2)	>35 µg/dl bl (2) >25 dw kd (2) >10 dw lv (2) >20 fw lv (3)	1.48 kd (7) 3.3 lv (15) 3.5 ms (15)*	2.6 kd (10)	21.64 dw kd (14)
Mercury (Hg)	>2 ww (4)	>10 fw lv (18) >1.1 fw kd (17) >0.5 bl (19)	6.6 ms (15) 2.1 lv (15) 0.09 kd (7)	0.18 kd (13) 0.51 lv (9) 0.05 ms (9)	0.08 wb (13)
Molybdenum (Mo)			1.3 lv (15)		
Nickel (Ni)	500 (6)		1.49 ms (15) 16.5 lv (13) 0.86 kd (7)	[illegible] 2.2 kd (13)	8.85 dw kd (14)
Silver (Ag)	250 µg/L water (6) 6 diet (6)	13.9 wb (6)	5.49 kd (7) 6.5 lv (15) 33.5 ms (7)	7.7 kd (10)	0.12 wb (13)
Strontium (Sr)			0.16 lv (13)	0.52 kd (13)	14.9 wb (13)
Uranium			0.66 lv (13) 0.085 ms (15)	5.4 kd (10)	3.74 wb (13)
PCB (mg/kg)					
1254			0.046 ms (15)		
1260		>10 fw ft (5) 153 >10 fw ft (5) 138 >7 fw ft (5) 180 >3 fw ft (5)	0.11 ft (7)	16 ft (9) 39.5 ft total PCBs (10)	103 wb (13)
1268			0.11 ft (7)		

Table 1.3. Literature values for avian concentrations of concern in diet and tissues, and maximum concentrations (mg/kg) detected in representative species collected from the PGDP.

	Avian Concentrations of Concern		Starling	Kestrel / Birds of Prey
Metal	Diet	Tissue	Tissue	Tissue
Aluminum (Al)			38.9 fw kd (7)	
Beryllium (Be)				
Cadmium (Cd)	>2 fw (3)	>40 fw lv (3) >100 fw kd (3)	0.7 fw kd (7)	
Chromium (Cr)			3.1 fw kd (7)	
Lead (Pb)		>0.2 mg/L bl (2) >2 fw lv (2) >2 fw kd (2)	5.0 fw kd (7)	
Mercury (Hg)	>3 dw (4)	0.5 fw eg (4) >20 fw lv (4) >20 fw kd (4)	<0.05 fw lv (7)	[illegible]
Molybdenum (Mo)				0.87 lv (8)
Nickel (Ni)	>200 (6)	>10 dw kd (6) >3 dw lv (6)		1.96 lv (8)
Silver (Ag)	100 mg/L water (6) 200 mg/kg diet (6)	1.8 fw eg (6)	<0.17 fw kd (7)	0.76 lv (8)
Strontium				
Uranium				
PCB Aroclor				
1254		>4 fw eg (5) >3 fw br (5)		<0.02 bl (8)
1260	100 mg/kg (5)	126 ~0.1 fw lv (5) total >7 fw eg (5)	126 0.013 fw wc (7) 2.4 fw wc (7)	5.25 lv (8) 0.76 bl (8)

Table 1.4. Literature values for amphibian and reptile concentrations of concern in diet and tissues, and maximum concentrations (mg/kg) detected in representative species collected from the PGDP.

	Concentrations of Concern[a]		Bullfrog	Water Snake
Metal	Diet	Tissue	Tissue	Tissue
Aluminum (Al)			5.74 fw kd (1)	
Beryllium (Be)				
Cadmium (Cd)			1.22 fw kd (1)	
Chromium (Cr)			0.39 fw kd (1)	
Lead (Pb)			1.43 fw kd (1)	
Mercury (Hg)				
Molybdenum (Mo)				
Nickel (Ni)				
Silver (Ag)			ND kd (1)	
Strontium				
Uranium				
PCB Aroclor				
1254				
1260 (ppb)			883.1 wc m (1)	

Table 1.2. Literature values for mammalian concentrations of concern in diet and tissues, and maximun (mg/kg) detected in representative species collected from the PGDP.

	Mammalian Concentrations of Concern		Deer	Raccoon	Small Mammals
Metal (mg/kg)	Diet	Tissue	Tissue	Tissue	Tissue
Aluminum (Al)			13.4 ms (15) 3.70 kd (7) 63.2 lv (7)	20.5 ms (9) 2.54 lv (9) 7.18 kd (13)	372 wb (13)
Beryllium (Be)			0.1 ms (7) 0.16 kd (7) 0.23 lv (7)	0.02 kd (10)	nd kd (14)
Cadmium (Cd)		100 fw kd (2, 16) 350 dw kd (16)	0.24 ms (15) 1.33 lv (13) 3.9 kd (7)	16.1 kd (10) 0.27 lv (9)	6.45 dw kd (14)
Chromium (Cr)			2.14 ms (7) 10.8 lv (13) 1.99 kd (7)	2.3 lv (11) ∑ 1.6 kd (10)	3.69 wb (13)
Lead (Pb)	>20 bw (2)	>35 µg/dl bl (2) >25 dw kd (2) >10 dw lv (2) >20 fw lv (3)	1.48 kd (7) 3.3 lv (15) 3.5 ms (15)*	2.6 kd (10)	21.64 dw kd (14)
Mercury (Hg)	>2 ww (4)	>10 fw lv (18) >1.1 fw kd (17) >0.5 bl (19)	6.6 ms (15) 2.1 lv (15) 0.09 kd (7)	0.18 kd (13) 0.51 lv (9) 0.05 ms (9)	0.08 wb (13)
Molybdenum (Mo)			1.3 lv (15)		
Nickel (Ni)	500 (6)		1.49 ms (15) 16.5 lv (13) 0.86 kd (7)	3.7 lv (11) ∑ 2.2 kd (13)	8.85 dw kd (14)
Silver (Ag)	250 µg/L water (6) 6 diet (6)	13.9 wb (6)	5.49 kd (7) 6.5 lv (15) 33.5 ms (7)	7.7 kd (10)	0.12 wb (13)
Strontium (Sr)			0.16 lv (13)	0.52 kd (13)	14.9 wb (13)
Uranium			0.66 lv (13) 0.085 ms (15)	5.4 kd (10)	3.74 wb (13)
PCB (mg/kg)					
1254			0.046 ms (15)		
1260		>10 fw ft (5) 153 >10 fw ft (5) 138 >7 fw ft (5) 180 >3 fw ft (5)	0.11 ft (7)	13 ft (9) 39.5 ft total PCBs (10)	103 wb (13)
1268			0.11 ft (7)		

Table 1.3. Literature values for avian concentrations of concern in diet and tissues, and maximum concentrations (mg/kg) detected in representative species collected from the PGDP.

	Avian Concentrations of Concern		Starling	Kestrel / Birds of Prey
Metal	Diet	Tissue	Tissue	Tissue
Aluminum (Al)			38.9 fw kd (7)	
Beryllium (Be)				
Cadmium (Cd)	>2 fw (3)	>40 fw lv (3) >100 fw kd (3)	0.7 fw kd (7)	
Chromium (Cr)			3.1 fw kd (7)	
Lead (Pb)		>0.2 mg/L bl (2) >2 fw lv (2) >2 fw kd (2)	5.0 fw kd (7)	
Mercury (Hg)	>3 dw (4)	0.5 fw eg (4) >20 fw lv (4) >20 fw kd (4)	<0.05 fw lv (7)	0.08 lv (8)
Molybdenum (Mo)				0.87 lv (8)
Nickel (Ni)	>200 (6)	>10 dw kd (6) >3 dw lv (6)		1.96 lv (8)
Silver (Ag)	100 mg/L water (6) 200 mg/kg diet (6)	1.8 fw eg (6)	<0.17 fw kd (7)	0.76 lv (8)
Strontium				
Uranium				
PCB Aroclor				
1254		>4 fw eg (5) >3 fw br (5)		<0.02 bl (8)
1260	100 mg/kg (5)	126 ~0.1 fw lv (5) total >7 fw eg (5)	126 0.013 fw wc (7) 2.4 fw wc (7)	5.25 lv (8) 0.76 bl (8)

"A Living Document"

Contaminants may be added to or deleted

Species selected for monitoring can be changed if warranted following review and consensus of responsible parties

It is the intent of this document to suggest that the contaminants of concern be analyzed in selected tissues in all future ecological studies conducted at the PGDP

A living document has no end ☺

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Species Recommended for Monitoring

Mammalian	Avian	Reptilian/amphibian
Regular		
Deer	Kestrel	Northern Water Snake
Raccoon	Starling	Bullfrog
Opportunistically		
Otter	GB Heron	Snapping turtle
Bobcat	Hawks	Red eared slider

Table 1.4. Literature values for amphibian and reptile concentrations of concern in diet and tissues, and maximum concentrations (mg/kg) detected in representative species collected from the PGDP.

	Concentrations of Concern[a]		Bullfrog	Water Snake
Metal	Diet	Tissue	Tissue	Tissue
Aluminum (Al)			5.74 fw kd (1)	
Beryllium (Be)				
Cadmium (Cd)			1.22 fw kd (1)	
Chromium (Cr)			0.39 fw kd (1)	
Lead (Pb)			1.43 fw kd (1)	
Mercury (Hg)				
Molybdenum (Mo)				
Nickel (Ni)				
Silver (Ag)			ND kd (1)	
Strontium				
Uranium				
PCB Aroclor				
1254				
1260 (ppb)			883.1 wc m (1)	

Kidney and liver Cd concentrations > 10 mg/kg FW = Cd contamination

Kidney Cd concentrations > 100 mg/kg FW = life threatening

Paducah deer max kidney Cd = 3.88 mg/kg

Liver Pb concentrations > 20 mg/kg FW = concern

Paducah deer max liver Pb = 3.3 mg/kg

Paducah river otter max liver concentration = 4.85 mg/kg FW

Tissue Hg concentrations > 4.0 mg/kg FW = concern

Liver Hg concentrations >10 mg/kg FW = sublethal effects

Paducah river otter liver Hg concentrations = 1.38 mg/kg FW

Liver total PCB concentrations > 4 mg/kg FW = concern

Paducah mink liver concentration = 1.1 mg/kg Aroclor 1260 (n = 1)

Paducah river otter liver concentration = 2.47 & 4.75 mg/kg Aroclor 1260

Table 1-1. Literature values for mammalian concentrations of concern (mg/kg) in diet and tissues, and maximum concentrations (mg/kg) detected in representative species collected from the PGDP.

	Mammalian Concentrations of Concern		Deer	Raccoon	Small Mammals	Bobcat/Otter
Metal	Diet	Tissue	Tissue	Tissue	Tissue	Tissue
Aluminum (Al)			63.2 lv (7)	20.5 ms (9)	124 mg/kg wb (13)	142 lv (12)
Beryllium (Be)			0.23 lv (7)	0.02 kd (10)	nd kd (14)	0.05 kd (12)
Cadmium (Cd)		100 fw kd (2) 350 dw kd (16)	0.24 ms (15) 0.42 lv (15) 3.9 kd (7)	4.6 kd (10)	6.45 dw kd (14)	0.27 kd (11) ?
Chromium (Cr)			3.3 kd (8)	2.3 lv (11) ?	3.03 dw kd (14)	0.67 (11) ?
Lead (Pb)	>20 bw (2)	>35 µg/dl bl (2) >25 dw kd (2) >10 dw lv (2) >20 fw lv (3)	1.48 kd (7) 3.3 lv (7) 3.5 ms fw (15)	2.6 kd (10)	21.64 dw kd (14)	1.5 kd (12) 4.85 lv (12)
Mercury (Hg)	>2 ww (4)	>25 fw lv (4) >25 fw kd (4)	0.09 kd (7)	0.51 lv (9)	0.04 wb (13)	1.38 lv (12)
Molybdenum (Mo)						
Nickel (Ni)	500 (6)		0.86 kd (7)	3.7 lv (11) ? 1.3 kd (10)	8.85 dw kd (14)	0.93 lv (12)
Silver (Ag)	200 ug/L water (6) 6 diet (6)	13.9 wb (6)	33.5 ms (7)	7.7 kd (10)	0.12 wb (13)	4.8 lv (12)
Strontium (Sr)			0.12 lv (15)		7.0 wb (13)	
Uranium			0.006 lv (15) 0.085 ms (15)		0.81 wb (13)	
PCBs						
1254						
1260		>10 fw ft (5)	0.15 ft (7)	13 ft (9) 39.5 ft total PCB (10)	9.1 wb (13)	33.5 ft (11)

Table 1-1. Literature values for mammalian concentrations of concern (mg/kg) in diet and tissues, and maximum concentrations (mg/kg) detected in representative species collected from the PGDP.

	Mammalian Concentrations of Concern		Deer	Raccoon	Small Mammals	Bobcat/Otter
Metal	Diet	Tissue	Tissue	Tissue	Tissue	Tissue
Aluminum (Al)			63.2 lv (7)	20.5 ms (9)	124 mg/kg wb (13)	142 lv (12)
Beryllium (Be)			0.23 lv (7)	0.02 kd (10)	nd kd (14)	0.05 kd (12)
Cadmium (Cd)		100 fw kd (2) 350 dw kd (16)	0.24 ms (15) 0.42 lv (15) 3.9 kd (7)	4.6 kd (10)	6.45 dw kd (14)	0.27 kd (11) ?
Chromium (Cr)			3.3 kd (8)	2.3 lv (11) ?	3.03 dw kd (14)	0.67 (11) ?
Lead (Pb)	>20 bw (2)	>35 µg/dl bl (2) >25 dw kd (2) >10 dw lv (2) >20 fw lv (3)	1.48 kd (7) 3.3 lv (7) 3.5 ms fw (15)	2.6 kd (10)	21.64 dw kd (14)	1.5 kd (12) 4.85 lv (12)
Mercury (Hg)	>2 ww (4)	>25 fw lv (4) >25 fw kd (4)	0.09 kd (7)	0.51 lv (9)	0.04 wb (13)	1.38 lv (12)
Molybdenum (Mo)						
Nickel (Ni)	500 (6)		0.86 kd (7)	3.7 lv (11) ? 1.3 kd (10)	8.85 dw kd (14)	0.93 lv (12)
Silver (Ag)	200 ug/L water (6) 6 diet (6)	13.9 wb (6)	33.5 ms (7)	7.7 kd (10)	0.12 wb (13)	4.8 lv (12)
Strontium (Sr)			0.12 lv (15)		7.0 wb (13)	
Uranium			0.006 lv (15) 0.085 ms (15)		0.81 wb (13)	
PCBs						
1254						
1260		>10 fw ft (5)	0.15 ft (7)	13 ft (9) 39.5 ft total PCB (10)	9.1 wb (13)	33.5 ft (11)

Draft

Ecological Monitoring at the Paducah Gaseous Diffusion Plant: Historical Evaluation and Guidelines for Future Monitoring

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Objective 2: Identification of Contaminants of Ecological Concern

- A summary of metal, polychlorinated biphenyl (PCB), and radionuclide data reported in various reports and documents relating to analysis of biological samples has been compiled.

Metal	Mammals Various[1] 1992 (6)[2]	Deer 1993 (19)	Fish[3] 1998 (67)	Hawk[4] 1998 (69)	Rabbit 1999 (5)	Raccoon 1999 (22)	otter 2000 (74)	Deer 2001 (39)	Deer 2002 (37)	Scrap Yard Mammals[5] 2002 (25)
Aluminum (Al)	✞				✞		✞	✞	✞	✞
Antimony (Sb)		✞			✞	✞	✞	✞	✞	✞
Arsenic (As)	✞	✞			✞		✞	✞	✞	✞
Boron (B)		✞						✞		
Barium (Ba)		✞			✞	✞	✞	✞	✞	✞
Beryllium (Be)		✞	✞	✞	✞	✞	✞	✞	✞	✞
Cadmium (Cd)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Calcium (Ca)		✞						✞		
Chromium (Cr)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Cobalt (Co)		✞			✞	✞	✞	✞	✞	✞
Copper (Cu)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Iron (Fe)		✞			✞	✞	✞	✞	✞	✞
Lithium (Li)		✞								
Lead (Pb)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Magnesium (Mg)		✞					✞	✞		
Manganese (Mn)		✞			✞	✞		✞	✞	✞
Mercury (Hg)	✞				✞		✞	✞	✞	✞
Molybdenum (Mo)		✞						✞		
Nickel (Ni)	✞	✞	✞	✞	✞	✞	✞	✞	✞	✞
Phosphorus (P)		✞								
Potassium (K)								✞		
Selenium (Se)	✞	✞			✞		✞	✞	✞	✞
Silicon (Si)		✞						✞		
Silver (Ag)	✞		✞	✞	✞	✞		✞	✞	✞
Sodium (Na)								✞		
Strontium										✞
Thallium (Tl)	✞				✞	✞	✞	✞	✞	✞
Uranium							✞	✞		✞
Vanadium (V)					✞	✞	✞	✞	✞	✞
Zinc (Zn)			✞	✞	✞	✞	✞	✞	✞	✞

Objective 3: Develop Conceptual Food Web Transfer Models

- A generalized conceptual food web model (contaminants transfer model) for the PGDP and surrounding area was developed along with more specific aquatic, avian, and mammalian trophic position models.

Aquatic Food Web (contaminant transfer model)

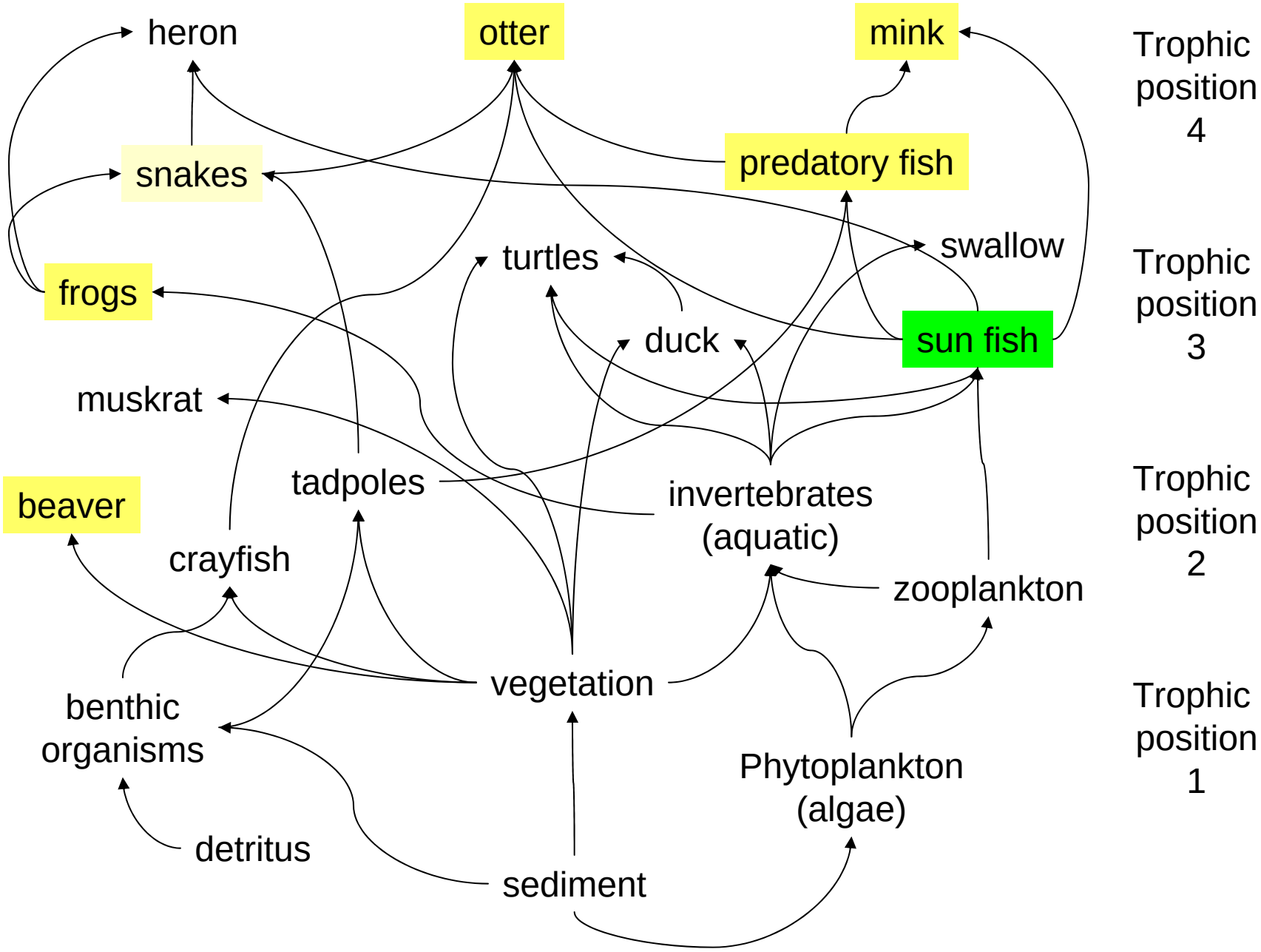

Table 1-1. Literature values for mammalian concentrations of concern (mg/kg) in diet and tissues, and maximum concentrations (mg/kg) detected in representative species collected from the PGDP.

	Mammalian Concentrations of Concern		Deer	Raccoon	Small Mammals	Bobcat/Otter
Metal	Diet	Tissue	Tissue	Tissue	Tissue	Tissue
Aluminum (Al)			63.2 lv (7)	20.5 ms (9)	124 mg/kg wb (13)	142 lv (12)
Beryllium (Be)			0.23 lv (7)	0.02 kd (10)		0.05 kd (12)
Cadmium (Cd)		100 fw kd (2)	3.9 kd (7)	4.6 kd (10)	4.1 dw kd (14)	0.27 kd (11) ?
Chromium (Cr)			3.3 kd (8)	2.3 lv (11) ?	1.94 dw kd (14)	0.67 (11) ?
Lead (Pb)	>20 bw (2)	>35 µg/dl bl (2) >25 dw kd (2) >10 dw lv (2) >20 fw lv (3)	1.48 kd (7) 1.34 lv (7) 0.75 ms fw (15)	2.6 kd (10)	8.28 dw kd (14)	1.5 kd (12) 4.85 lv (12)
Mercury (Hg)	>2 ww (4)	>25 fw lv (4) >25 fw kd (4)	0.09 kd (7)	0.51 lv (9)	0.04 wb (13)	1.38 lv (12)
Molybdenum (Mo)						
Nickel (Ni)	500 (6)		0.86 kd (7)	3.7 lv (11) ?	1.93 dw kd (14)	0.93 lv (12)
Silver (Ag)	200 water (6) 6 diet (6)	13.9 WB (6)	33.5 ms (7)	7.7 kd (10)	0.12 wb (13)	4.8 lv (12)
Strontium (Sr)					7.0 wb (13)	
Uranium					0.81 wb (13)	
PCBs						
1254						
1260		>10 fw ft (5)	0.15 ft (7)	13 ft (9)	9.1 wb (13)	33.5 ft (11)