A Pilot Invertebrate Survey of Bluff Lake Nature Center

A meadowhawk (*Sympetrum sp.*) caught near the ephemeral pool by the outflow of Bluff Lake.

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Bluff Lake Nature Center

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Introduction

Located in Denver, Colorado in the Central Parkneighborhood, Bluff Lake is a nature center and outdoor classroom used to teach the local community about Colorado's native species, serving around 8,000 public school students from Denver and Aurora with classroom lessons and field trips each year. Since The late 1990's we have strived to teach visitors about Bluff Lake's ecology, and to do that we have to be able to properly identify the organisms we have present on-site.

At Bluff Lake Nature Center there is a wide range of biodiverse organisms that coexist and interact in complex ways. The most diverse group on -site are the invertebrates, but there has never been an effort to survey them in BLNC's history. As urban development increases and the world changes, so does our wildlife. To better understand all our wildlife, we have to go down the food chain to understand why populations fluctuate. Getting to know our insects and other invertebrates will aid in managing Bluff Lake as a whole.

This research was conducted by our land manager Erickson Smith and intern Anali Blue. Anali is very interested in insects and was looking to expand her knowledge. With help from Erickson Smith they were able to construct a survey with multiple methods.

Methods

With extensive research on websites such as *Using Pitfall Traps to Monitor Insect Activity* from the Virginia Cooperative Extension, three separate methods were established to survey invertebrates: pitfall traps, sweep nets, and hanging traps. A pitfall trap is defined as "a device used to trap insects that are active on the ground surface. Pitfall traps usually consist of a beaker that is buried so that the lip of the beaker is level with the ground surface" (Amateur Entomologists' Society, 2022)

For the pitfall trap method,we chose four survey sites with two-three traps within each region. Each site was chosen to sample four different habitats represented at Bluff Lake: ephemeral pool, wetland, prairie, and woodland. The equipment used were one-quart mason jars, fish food, and natural debris. The traps were placed in holes deep enough to submerge a jar up to its lip , then fish food was placed at the bottom as bait, and finally covered with debris to camouflage the trap and protect it from the elements.

Figure 1: Trap C1 (prairie). These photos show how the mason jar was buried so the lip of the jar was flush with the ground, and then covered with bark to protect it from the elements and camouflage the trap.

The hanging traps were made from plastic two-liter soda bottles and hung from trees in two locations with paracord and filled with a sugar water solution as bait for flying insects. The hanging traps were hung in two locations: by the bird blind at the west end of Bluff Lake, and next to the ephemeral

pool that is fed by the lake's outflow when water levels are high. Both sites were chosen for their proximity to water and abundance of flying insects observed in each location.

Figure 2: Trap H2 (ephemeral pool). This photo shows how the the hanging traps were placed in the environment to trap flying insects.

The sweep net surveys were conducted at seven different sites around Bluff Lake Nature Center."Sweep nets are sturdy nets, often with a canvas bag, that are used to collect insects and other invertebrates from long grass"(Amateur Entomologists' Society, 2022). Each site was chosen for different types of dominant vegetation in the area, and the sites as a whole were spaced out to cover the majority of the property. The main types of vegetation surveyed were: willows; rabbitbrush; native grasses and meadow plants like American licorice; native shrubs and trees belonging to genera *Ribes* and *Acer*; prairie communities that included rabbitbrush, young cottonwoods, and beeplant. Some types

of vegetation were sampled more than once due to the dominance of certain plants like willows and rabbitbrush at BLNC, but each site was only surveyed once. The primary method of collecting was butterfly nets that were 16 inches in diameter and three feet deep. Each site was surveyed by two people, each with a net. During a five-minute collection period, the nets were cast across vegetation to collect insects, and vegetation was beaten over nets to collect insects within the foliage. When very few insects were caught during the first sweep, a second five-minute sweep was conducted to sample the same area.

After checking pitfall traps or conducting sweep net surveys, the insects captured were examined one-by-one to determine their species. Scoops. Mason jars, and magnifying bug boxes were used to contain, view and identify the invertebrates. The data recorded for these surveys included the date, time, weather conditions (air temperature, wind speed, and cloud cover), taxa identified, and descriptions of each invertebrate's physical features. Pitfall trap surveys also included the number of each organism identified and if they were alive or dead. Quantities of organisms were not recorded for the sweep net surveys, since quantities collected may reflect more on the effort of each sweep net, and less the actual quantity of insects present on the landscape. Results were recorded on paper datasheets in the field, and manually entered into an Excel database in the office.

To Identify the insects, a combination of field guides and the iNaturalist app were used. The books used were the *Kaufman Field Guide to Insects of North America* by Eric R Eaton, and Kenn Kaufman, and *Guide to Colorado Insects* by Boris C. Kondratieff,, and Whitney Cranshaw. iNaturalist was used both to identify insects, and verify our conclusions because iNaturalist is an online community of scientists, ecologists, subject matter experts, and amateurs, and submissions can be reviewed by the public. When a different species identification was suggested by a community member

on iNaturalist, we reviewed that user's credentials and record on iNaturalist. When they were an expert in their field, or one of the top observers for a certain taxa, we opted to trust their identification and changed the species in our database.Over the course of 5 weeks in mid-summer, we conducted two surveys of every pitfall trap, and surveyed seven different sites with sweep nets over the course of four outings. The hanging traps were checked periodically, but never routinely emptied and their contents were not recorded.

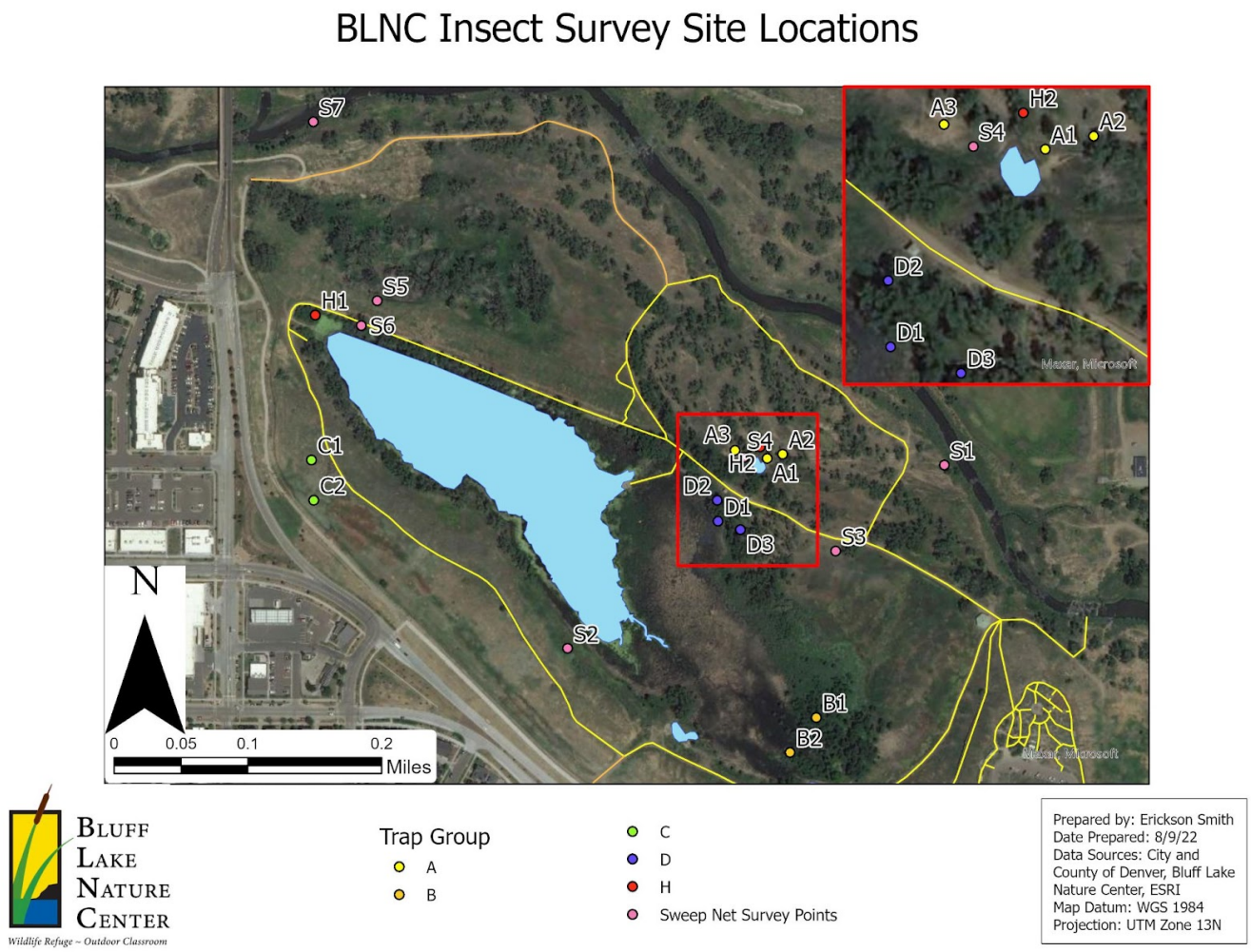


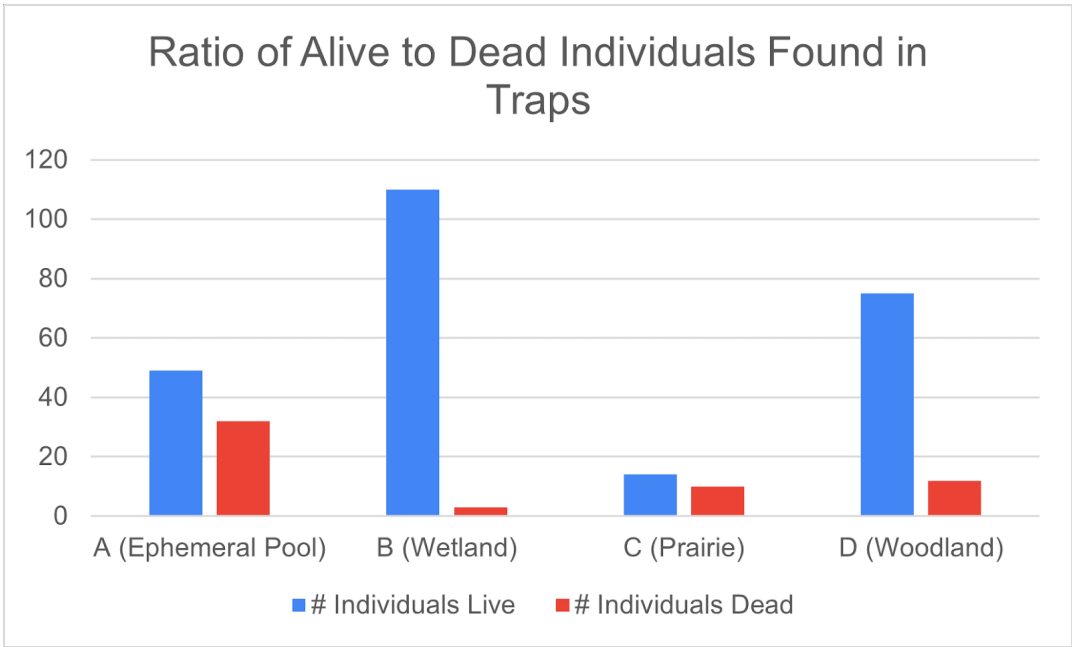
Figure 3: A map of invertebrate trap and sweep net sites at Bluff Lake Nature Center that were surveyed in the summer of Fall 2022.

Results

Between the pitfall trap surveys and sweep net surveys, we identified 36 invertebrates down to species, 25 to genus, five to subfamily, 14 to family, two to suborder, and four to tribes (see Appendix A). Of the 35 species identified, 25 were new to Bluff Lake managers, and the surveys documented 44 genera for the first time at Bluff Lake (including the genera of the organisms identified to species). There were a total of 12 sites surveyed (4 pitfall, 1 hanging trap by lake, 1 in a pitfall trap site, 7 sweep), and each pitfall trap site either had two or three traps, for a total of 10 trap sitesNone of the identifications made were via hanging traps.

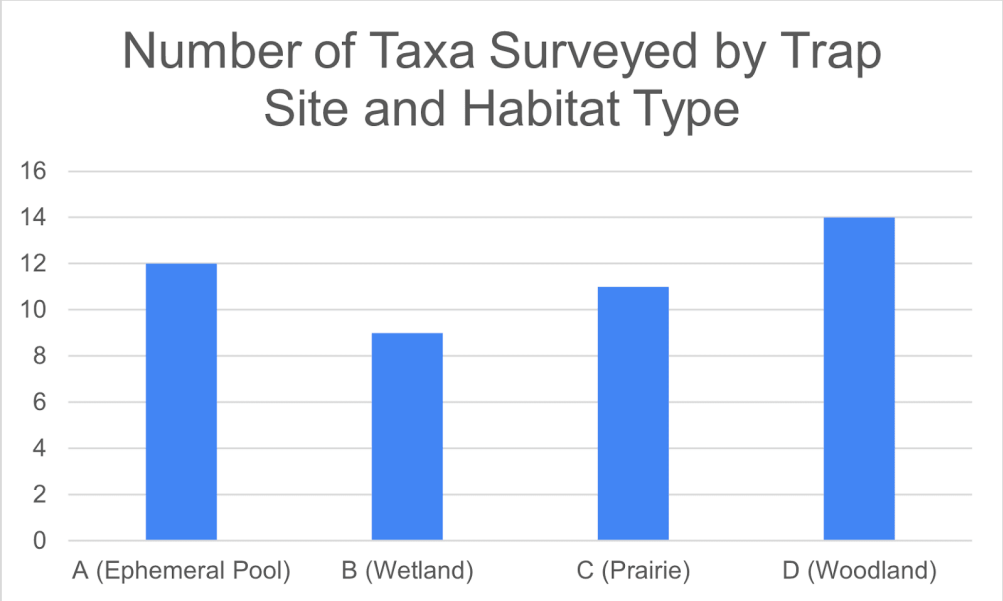
During pitfall surveys we collected 305 individuals, 204 which were alive and 57 dead.

Chart 1: This table shows the ratio of alive to dead invertebrates found at each pit-fall trap location, and the dominant habitat type by location.



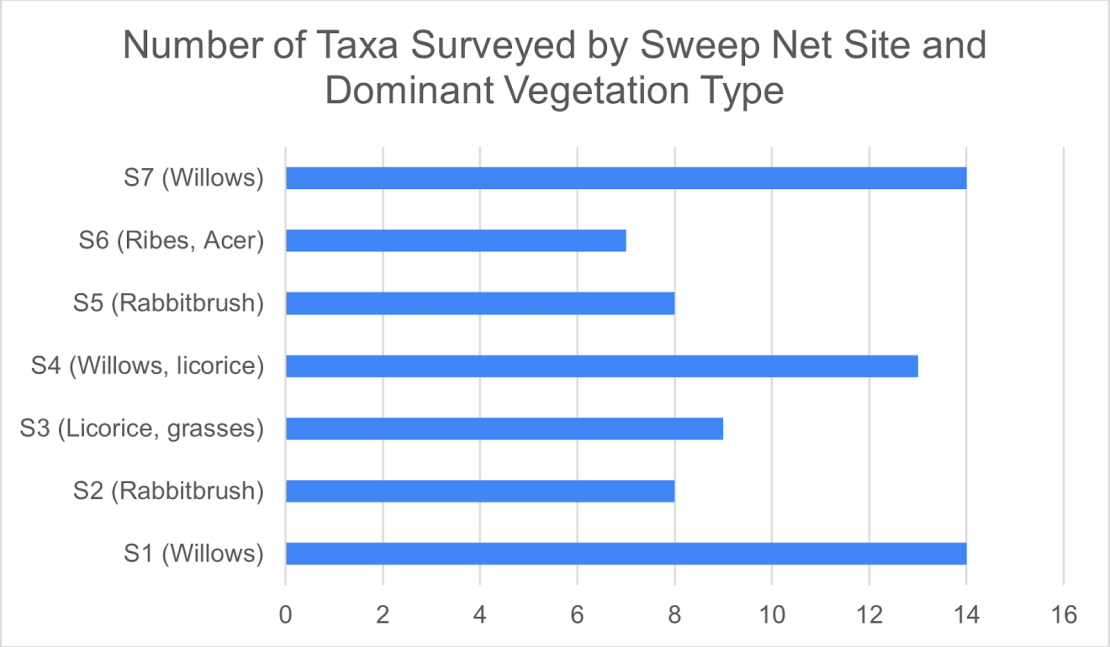
The woodland site had the most diversity with 14 taxa identified; the wetland site had the least diversity with only nine taxa represented (see Appendix B).

Chart 2: This table shows the number of taxa identified at each pit-fall trap survey location, and the dominant habitat type at each location. Most individuals were identified to species, but some were identified to genus, subfamily, family, and suborder.



In the sweep net surveys, the two sites that surveyed willows and other riparian plants along Sand Creek were the most diverse, representing 14 taxa at each site. The least diverse site was along the dam on the northern shore of the lake, where gooseberry, currant bushes, and boxelders were primarily sampled: only seven taxa were documented using this vegetation (see Appendix B).

Chart 3: This table shows the number of taxa identified at each sweep net survey location, and the dominant vegetation type at each location. Many individuals were identified to species, but some were identified to genus, subfamily, family, and suborder.



Across both survey methods, the two most common groups were beetles and true bugs with 12 individuals and 10 individuals identified down to species, respectively. The most diverse habitats were the willows along Sand Creek(sweep net survey sites S1 and S7) and the woodland pitfall trap site, with 14 taxa identified at each site. The least diverse habitat was the wetland pitfall trap site with only nine taxa represented.

Discussion

Prior to surveying invertebrates at Bluff Lake this year, all available insect data for Bluff Lake came from iNaturalist observations submitted by the public. It was unclear how many new species we would document, though the results were over and beyond expectation. Since systematic surveying had never been done at Bluff Lake it was expected to only identify a few native species but the results showed otherwise: 25 new species and 44 new genera (including the genera of the new species) were identified for the first time at Bluff Lake! The most successful survey method in terms of quantity of invertebrates was the pitfall traps with 305 individuals identified and the hanging traps were the least successful method with no individuals identified. We suspect the hanging traps were unsuccessful because the opening of a two liter soda bottle may not have been large enough for the flying insects present on the landscape. Another issue we ran into was that when individuals were collected in the hanging traps, they quickly decomposed in the liquid at the bottom, making identification near impossible. It's also possible the sugar water solution wasn't tempting for most flying insects at Bluff Lake. Future efforts should consider experimenting with different attractants.

When it comes down to the biodiversity sampled at each site, the woodland pitfall trap site and the willow sweep net sites along Sand Creek were the most diverse, with each site yielding 14 identified taxa. Several disturbance events occurred during the field season which impacted our ability to collect data: a rain event in July filled most of our pitfall traps with water and sediment, and we were unable to identify most of the organisms that remained. We also noticed that if the jars weren't covered enough or deep enough on the ground then there was a chance for disruption, which occurred at the ephemeral pool site and the woodland site, when jars at the trap sites A3 and D3 were pulled out of the ground and left on the surface, and no data was able to be collected. We are still not sure if humans or a

mammal disrupted the study, but in the future, additional measures to camouflage the pitfalls may be necessary.

Some of the pitfall traps had a higher death rate than others: the traps in the prairie had a death rate of 41.6% and the ephemeral pool of 39.5% compared to the 2.65% death rate of the wetlands. This effect can be due to the high heat in the trap from sun exposure, lack of canopy, or predation from other insects. In the future, pitfall traps in high exposure areas may be most successful when daytime temperatures are lower, like in the fall or spring.

The most common taxa between each pitfall trap site were wood ground beetles, ground beetles, and woodlice. We were not able to conduct our last pitfall trap survey due to heavy rain and flooding which made collecting data impossible. We decided to pull the pitfall traps and focus on sweep net surveys after several weeks of moderately consistent rain.

Compared to the pitfall surveys, the sweep net survey data was much different. None of the taxa identified in the sweep net surveys were found in the pitfall surveys. Pitfall data showed many wingless terrestrial invertebrates that live under foliage like ground beetles, spiders, and ants; there were also beetles found during sweep net surveys but they had the ability to take flight or hop far distances. Many taxa collected during sweep net surveys were brush-associated and had little to no contact with the ground. Interestingly, we also found that the composition and quantity of invertebrates surveyed changed between vegetation types around the property: anecdotally, vegetation closer to water and/or shade tended to have more organisms present, while drier areas like rabbitbrush in prairie communities had fewer individual organisms. Our least diverse sweep net site, the *Ribes* and *Acer* plants along the Lake's dam, also had the highest abundance of individuals. It could be that the very high abundance of

eastern boxelder bugs (*Boisea trivittata*) in this habitat occupied more space and tied up more resources, resulting in lower overall invertebrate diversity.

The finding that pitfall traps and sweep net surveys produced different assemblages of invertebrates isn't surprising: we would expect that invertebrates that crawl on the ground and in leaf litter wouldn't be the same species found habitating within shrubs and bushes. Instead, this finding impresses on us the importance of using a variety of survey methods at Bluff Lake to document invertebrate diversity. We used dip nets and mason jars to collect a variety of aquatic invertebrates from the outfalls and Bluff Lake this summer as well, though that data is not included in this report. Those species assemblages, too, were completely different from the pitfall and sweep net species. We predict that should the hanging traps have been more successful, we also would have sampled a different, more airborne set of invertebrate species. Future studies at Bluff Lake should repeat the use of pitfall traps and sweep net surveys, but should also include other methods that sample new habitats, microclimates, etc. Future studies may consider redesigning hanging traps for better collection success, ways to sample invertebrates in Sand Creek and Bluff Lake, invertebrates found in decomposing matter like rotting logs and other plant debris, and other unique habitats, like prairie dog burrows. After this survey, we are confident that there are many more species of invertebrates at Bluff Lake waiting to be documented!

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Appendix A: Full Species List

1. Identified to Species

Common Name **Scientific Name**

Beetles

Wood Ground Beetle	*Carabus nemoralis*
Harp Ground Beetle	*Agonum extensicolle*
Predaceous Diving Beetle	*Graphoderus perplexus*
Garden Carrion Beetle	*Heterosilpha ramosa*
Brown-footed Rove Beetle	*Dinothenarus badipes*
Handsome Yucca Beetle	*Enoclerus spinolae*
Ashgray Blister Beetle	*Epicaata fabricii*
Three-lined Potato Beetle	*Lema daturphile*
Japanese Beetle	*Popillia japonica*
Rabbitbrush Beetle	*Trirhabda nitidicollis*
May Beetle/Scarab Beetle	*Phyllophaga lanceolata*
Tomentose Burying Beetle	*Nicrophorus tomentosus*

True Bugs

Eastern Boxelder Bug	*Boisea trivittata*
Scentless Plant Bug	*Brachycarenus tigrinus*
Black-and-red Seed Bug	*Melacoryphus lateralis*
Tarnished Plant Bug	*Lygus lineolaris*

Clouded Plant Bug	*Neurocolpus nubilus*
Lupine Bug	*Megalotomus quinquespinosus*
Euphoria Bug	*Chariesterus antennar*
Green Stink Bug	*Thyanta custator ssp. accerra*
Podisus placidus	*Podisus placidus*
Common Willow Calligrapha	*Calligrapha multipunctata*

Grasshoppers and Katydids

Two-Striped Grasshopper	*Melanoplus bivittatus*
Lakin Grasshopper	*Melanoplus lakinus*
Fork-tailed Bush Katydid	*Scudderia furcata*

Butterflies

Cabbage White Butterfly	*Pieris rapae*
Checkered White Butterfly	*Pontia protodice*

Misc.

Two-striped planthopper	*Acanalonia bivittata*
Seven-spot Ladybird	*Coccinella septempunctata*
European Earwig	*Forficula auricularia*
Leafhopper	*Graphocephala lugubris*
Spotted Spreadwing	*Lestes congener*
Brown Centipede	*Lithobius foricatus*

Western harvester ant	*Pogonomyrmex occidentalis*
Common Pill-bug	*Armadillidium vulgare*

2. Identified To Genus

Common Name	**Scientific Name**
Dragonflies and Damselflies	
Meadowhawks	Sympetrum sp.
Dancer Damselfly (blue-purple)	Argia sp
Dancer Damselfly (Tan)	Argia sp.
Ischnura (forktail) damselfly	Ischnura sp.
Beetles	
Ground Beetle	*Bembidion* sp.
Darkling Beetle	*Eleodes* sp.
Darkling Beetle	*Blapstinus* sp.
Spiny-legged Rove Beetle	*Bledius* sp.
Grasshoppers and Crickets	
Spur-throated grasshopper	Melanoplus sp.
Cave Cricket	Ceuthophilus sp.
Common tree cricket	Oecanthus sp.
True Bugs	

Plant Bug	Phytocoris sp.
Plant Bug	Taedia sp.
Scarlet Plant Bug	Lopidea sp.
Piglet Bug	Bruchomorpha sp.
Stinkbug	Podisus sp.
Spittlebug	Clastoptera sp.

Ants

Thief Ant	Solenopsis sp.
Pavement ant	Tetramorium sp.

Misc.

Green lacewing	Chrysoperla sp.
Clouded Yellow Butterfly	Colias sp.
Leaf hopper	Stictocephala sp.
Green leafhopper	Idiocerus sp.
Centipede	Lithobius sp.
Rock Bristletail	Machilinus sp.
Parasitic Wasp	Brachymeria sp.

3. Identified To Subfamily

Common Name	**Scientific Name**
Robber Fly	Subfamily Asilinae

Green shield bug	Subfamily Pentatominae
Jumping spider	Subfamily Salticinae
Clown beetle	Subfamily Saprininae
Eumeninae wasp	Subfamily Eumeninae

4. Identified To Family

Common Name	**Scientific Name**

Spiders

Running crab spiders	Family Philodromidae
Wolf Spider	Family Lycosidae
Ground spider	Family Gnaphosidae
Curtain-web Spider	Family Dipluridae
House spider	Family Theridiidae
Corinnid sac spider	Family Corinnidae
Crab Spider	Family Thomisidae

Misc.

Acalyptrate Fly	Family Acalyptratae
Ground Beetle	Family Carabidae
Typical Leafhopper	Family Cicadellidae
Narrow-winged damselfly	Family Coenagrionidae
Velvet ant	Family Mutillidae

Grey Stinkbug	Family Pentatomidae
Camel Cricket	Family Rhaphidophoridae

5. Identified to Suborder

Common Name	**Scientific Name**
Earthworm	Suborder Lumbricina
Woodlouse	Suborder Oniscidea

6. Identified to Tribe

Common Name	**Scientific Name**
Brown leaf hopper	Tribe macropsini
Scarab Beetle	Tribe sericini
Rove Beetle	Tribe tachyporini

Appendix B: Species Lists By Survey Site

Table 1: Taxa list for the ephemeral pool pit-fall trap site (Trap Group A).

Common Name	Scientific Name	# Live	# Dead
Brown Centipede	*Lithobius foricatus*	1	
Garden Carrion Beetle	*Heterosilpha ramosa*	29	15
Common Pill-bug	*Armadillidium vulgare*	2	
Wood Ground Beetle	*Carabus nemoralis*	1	
Darkling Beetle	*Blapstinus* sp.	5	
Darkling Beetle	*Eleodes* sp.	1	
Pavement Ant	*Tetramorium* sp.		3
Scarab Beetle	Tribe sericini		2
Clown beetle	Subfamily Saprininae	1	
House spider	Family Theridiidae	8	10
Ground spider	Family Gnaphosidae	1	
Wolf Spider	Family Lycosidae		2

Table 2: Taxa list for the woodland pit-fall trap site (Trap Group D).

Common Name	Scientific Name	# Live	# Dead
Common Pill-bug	*Armadillium vulgare*	18	4
Common Willow Calligrapha	*Calligrapha multipunctata*	1	
Wood Ground Beetle	*Carabus nemoralis*	2	3

Predaceous Diving Beetle	*Graphoderus perplexus*	2	1
Brown-footed Rove Beetle	*Dinothenarus badipes*	1	1
European Earwig	*Forficula auricularia*	1	
Tomentose Burying Beetle	*Nicrophorus tomentosus*		1
Thief Ant	*Solenopsis sp.*	5	
Centipede	*Lithobius sp.*	1	1
Rove Beetle	Tribe tachyporini	4	
House spider	Family Theridiidae	31	
Wolf Spider	Family Lycosidae	2	1
Ground Beetle	Family Carabidae	2	1
Curtain-web Spider	Family Dipluridae	2	
Ground Spider	Family Gnaphosidae	3	

Table 3: Taxa list for the prairie pit-fall trap site (Trap Group C).

Common Name	**Scientific Name**	**# Live**	**# Dead**
Western Harvester ant	*Pogonomyrmex occidentalis*	1	7
May Beetle/Scarab Beetle	*Phyllophaga lanceolata*	1	
Black-and-red Seed Bug	*Melacoryphus lateralis*		1
Pavement ant	*Tetramorium* sp.	3	

Rock Bristletail	*Machilinus* sp.	1	
Cave Cricket	*Ceuthophilus* sp.	2	
Crab Spider	Family Thomisidae	1	
Camel Cricket	Family Rhaphidophoridae		2
Velvet ant	Family Mutillidae	3	
Corinnid sac spider	Family Corinnidae	1	
Woodlouse	Suborder Oniscidea	1	

Table 4: Taxa list for the wetland pit-fall trap site (Trap Group B).

Common Name	**Scientific Name**	**# Live**	**# Dead**
Harp Ground Beetle	Agonum extensicolle	10	
Wood Ground Beetle	Carabus nemoralis	16	
Ground Beetle	Bembidion sp.	32	
Ground Beetle	Family Carabidae	48	1
European Earwig	Forficula auricularia	1	
Spiny-legged Rove Beetle	Bledius sp.	1	
Crab Spider	Family Thomisidae	1	
Earthworm	Suborder Lumbricina	1	
Woodlouse	Suborder Oniscidea	Too many to count	2

Table 5: Taxa list for the sweep net survey site S1 (willows).

Common Name	**Scientific Name**
Ashgray blister beetle	*Epicaata fabricii*
Seven-spot Ladybird	*Coccinella septempunctata*
Fork-tailed Bush Katydid	*Scudderia furcata*
Tarnished Plant Bug	*Lygus lineolaris*
Leafhopper	*Graphocephala lugubris*
Clouded Plant Bug	*Neurocolpus nubilus*
Green lacewing	*Chrysoperla* sp.
Scarlet Plant Bug	*Lopidea* sp.
Green leafhopper	*Idiocerus* sp.
Dancer Damselfly (blue-purple)	*Argia* sp.
Dancer Damselfly (Tan)	*Argia* sp.
Plant Bug	*Taedia* sp.
Plant Bug	*Phytocoris* sp.
Spittlebug	*Clastoptera* sp.

Table 6: Taxa list for the sweep net survey site S2 (rabbitbrush).

Common Name	**Scientific Name**
Cabbage White Butterfly	*Pieris rapae*
Handsome Yucca Beetle	*Enoclerus spinolae*
Rabbitbrush Beetle	*Trirhabda nitidicollis*

Stinkbug	*Podisus* sp.
Piglet bug	*Bruchomorpha* sp.
Spittlebug	Family Clastopteridae

Table 7: Taxa list for the sweep net survey site S3 (licorice, grasses).

Common Name	**Scientific Name**
Lakin Grasshopper	*Melanoplus lakinus*
Two-Striped Grasshopper	*Melanoplus bivittatus*
Checkered White Butterfly	*Pieris rapae*
Clouded Yellow Butterfly	*Colias* sp.
Parasitic Wasp	*Brachymeria* sp.
Dancer Damselfly	*Argia* sp.
Robber Fly	Subfamily Asilinae
Typical Leafhopper	Family Cicadellidae
Acalyptrate Fly	Family Acalyptratae

Table 8: Taxa list for the sweep net survey site S4 (willows, licorice).

Common Name	**Scientific Name**
Two-striped grasshopper	*Melanopus bivittatus*
Lupine bug	*Megalotomus quinquespinosus*
Spotted Spreadwing	*Lestes congener*
Cabbage white butterfly	*Pieris rapae*

Japanese Beetle	*Popillia japonica*
Spur-throated grasshopper	*Melanoplus* sp.
Stink bug	*Podisus* sp.
Scarlet plant bug	*Lopidea* sp.
Leaf hopper	*Stictocephala* sp.
Meadowhawks	*Sympetrum* sp.
Common tree cricket	*Oecanthus* sp.
Jumping spider	Subfamily Salticinae
Grey stinkbug	Family pentatomidae

Table 9: Taxa list for the sweep net survey site S5 (rabbitbrush).

Common Name	**Scientific Name**
Rubber rabbitbrush beetle	*Trirhabda nitidicollis*
Japanese Beetle	*Popillia japonica*
Euphoria bug	*Chariesterus antennar*
Two-striped grasshopper	*Melanopus bivittatus*
Checkered white butterfly	*Pontia protodice*
Green stink bug	*Thyanta custator ssp. accerra*
ischnura (forktail) damselfly	*Ischnura* sp.
Eumeninae wasp	Subfamily Eumeninae

Table 10: Taxa list for the sweep net survey site S6 (Ribes sp., Acer sp.).

Common Name	**Scientific Name**
Japanese Beetle	*Popillia japonica*
Eastern boxelder bug	*Boisea trivittata*
European earwig	*Forficula auricularia*
Scentless Plant Bug	*Brachycarenus tigrinus*
Leaf hopper	*Stictocephala* sp.
Lacewing	*Chrysoperla* sp.
Running crab spider	Family Philodromidae

Table 11: Taxa list for the sweep net survey site S7 (willows).

Common Name	**Scientific Name**
Three-lined potato beetles	*Lema daturphile*
Two-striped grasshopper	*Melanopus bivittatus*
Podisus placidus	*Podisus placidus*
Euphoria bug	*Chariesterus antennar*
Two-striped planthopper	*Acanalonia bivittata*
Green lacewing	*Chrysoperla* sp.
Spur-throated grasshopper	*Melanoplus* sp.
Leaf hopper	*Stictocephala* sp.
Scarlet plant bug	*Lopide*a sp.
Brown leaf hopper	Tribe macropsini

Jumping spider	Subfamily Salticinae
Green shield bug	Subfamily Pentatominae
Narrow-winged damselfly	Family Coenagrionidae
Running crab spiders	Family Philodromidae