

Impacts of Climate Disruption on Avian Species in the Southern Rocky Mountains: A
Retroanalysis of the Gothic Breeding Bird Survey and Pilot Point Count Surveys at
Rocky Mountain Biological Laboratory Weather Stations.

Student: Elizabeth Liput

Mentor: Ian Billick

Independent Research
Summer 2011

Abstract

Changes in species distributions across elevations can be responses to anthropogenic climate disruption. Movement of species to higher elevations can result in local extirpations and colonization that could escalate and critically endanger native species. Studying systems that have experienced historical and ongoing elevation range changes is vital for understanding species responses to climate disruption. This study examines avian species abundance over time and elevation ranges to investigate response to climate disruption in the Southern Rocky Mountains. Data collected over a thirteen-year period by the Gothic Breeding Bird Survey are used to assess trends in species abundance over time. Point count surveys along an elevation gradient (8,100-11,224ft) are used to determine approximate elevation ranges for comparison with historical ranges. Long-term data from the Breeding Bird Survey suggest that species are responding not through simple upward elevation shifts or general declines, but instead through other interactions with unconsidered factors that may or may not be related to climate disruption. However, point count survey observations indicate that species may be expanding their ranges upwards. This contradiction is likely because surveying along an elevation gradient holds more power for change detection in contrast with a single general area. Regardless, this study concludes that climate disruption is causing complex interactions leading to unforeseen responses.

Introduction:

Climate disruption can cause dramatic responses by species' ranges because of changes in natural environments (Parmesan 2006). Range shifts related to environmental changes have been observed in numerous taxa (Root et al 2003). For example, butterfly species have experienced northward range shifts (Parmesan 1996, 1999). Thompson and Lennon (1999) found northward range movements of British birds over a 20-year period. Northern margins of species latitudinal ranges have moved toward higher latitudes over the past fifty years in North American bird species (Hitch and Leberg 2007, La Sorte and Thompson 2007). Such changes in range can lead to local extirpation and colonization. Altitudinal range shifts have resulted in local extirpation at historical lower range boundaries. Increases in temperature over the past century have contributed to declines in the American Pika (*Ochotona princeps*), which is no longer found lower elevations it inhabited historically (Beever et al 2003). Similarly, the Apollo Butterfly (*Parnassius apollo*) in France no longer occurs at its previous lower range (Parmesan 2006). These local extinctions could escalate, critically endangering species (Sekericioglu et al 2008, La Sorte and Jetz 2011). Local colonizations have also been documented. Pounds et al (1999) found that lowland species established breeding populations in montane cloud forests over a 20-year period. The introduction of species from lower latitudes or elevations could have detrimental effects on native communities, such as increased competition pressures on sensitive species (Böhning-Gaese and Lemoine, 2004).

In consideration of these threats, it is important to research systems which have experienced shifts resulting from climate disruption. Such work would aid in understanding responses to climate disruption by natural communities and in predicting

which species may be threatened or endangered by future changes and accessing appropriate management responses (Root et al 2003).

This study addresses whether changes in the avian community of the southern Rocky Mountains are consistent with the predictions of climate disruption. Gothic Breeding Bird Survey data collected over the past thirteen years was analyzed to investigate long-term changes in species abundance. The Survey is an annual one-day event recording breeding birds in the Gothic, CO area. Three hypotheses are used to consider scenarios of climate disruption. First, altitude range shifts caused by climate disruption will predict trends observed in the Gothic BBS data. In this case, predictions will accurately represent observed trends. Second, climate disruption will negatively affect all species in which case all species will experience declines in abundance. Third, avian species respond uniquely or to factors not considered which may or may not be related to climate disruption.

Secondly, this study seeks to identify changes in species elevation range by documenting current ranges to compare to historical ranges. Point count surveys were performed along an elevation gradient to approximate species elevation ranges. We hypothesize that if species are moving upwards in elevation, birds will be found at elevations above their historical ranges.

Methods

A. Gothic Breeding Bird Survey

a. Generating Predictions

We used elevation ranges documented by Andrews and Righter (1992) to generate a prediction that, for each species, abundance would increase, decrease, or experience no change if altitude range have shifted upwards. For example, if Gothic, CO (~9,250ft) is no longer in the predicted range after a shift upwards a species is predicted to decrease in abundance over time in the Gothic Breeding Bird Survey record. We used two sets of predictions based on scenarios of elevation range shifts of 250ft and 1000ft upwards.

b. Documenting Changes in Abundances

The Gothic Breeding Bird Survey is an annual event which has taken place in mid-late June since 1999. Groups of observers led by at least one experienced birder survey five areas between 6AM and 11AM. Groups record all bird species observed by sight and sound. Species abundance for each year is the sum of individuals of a species observed by all groups.

To identify trends of increasing, decreasing, or no change over time in species abundances, we performed linear regressions on each species with year as the independent variable and species abundance as the dependent variable (R Core Development Team 2009). We categorized significant trends ($p < 0.05$) as increasing or decreasing according to the regression slope and non-significant trends ($p > 0.05$) as no change.

c. Testing Hypotheses

We compared predictions with observed changes in abundances to support or reject hypotheses for scenarios of climate disruption effects.

B. Point Count Surveys

a. Survey Set-Up and Procedure

We surveyed avian species within 8,100-11,224ft at five different weather stations managed by the Rocky Mountain Biological Laboratory (RMBL) located at Almont, Judd Falls, Kettle Ponds, Mexican Cut, and Snodgrass Mt. (Table 1). We surveyed areas around each weather station in addition to a secondary accessible habitat at Almont more than 100m from the weather station for a total of six survey areas. Habitats at each survey area were categorized using the Colorado Breeding Bird Atlas II Habitat Designation Codes (Kingery and Leukering, 2007). Survey points surrounded a focal point at each area generally associated with the weather station. The weather station at Kettle Ponds was inaccessible, so a substitute focal point was chosen. The Almont secondary habitat was positioned along a river, so a linear orientation of survey points was used without a focal point. Four sampling points per focal point were established with additional points added or relocated as necessary to cover habitats within a 100m radius from the focal point. Two additional survey points were added at Judd Falls to survey secondary habitat and one survey point was relocated at Kettle Ponds to cover secondary habitat within 100m. Sampling points were positioned approximately 50m or 100m from the focal point and 90° from one another.

Survey points were determined using ArcGIS by creating a 100m buffer around the GPS coordinates of the focal point (ESRI Inc. 2009). Lines were drawn from the focal point to the buffer in the desired direction to obtain the GPS coordinates of the identified survey point. Points were located in the field using a GeoXT unit equipped with Terrasync software (Trimble Navigation, Sunnyvale, CA). In the case that this method yielded an inaccessible position, an appropriate substitute was chosen (Snodgrass Mt.). In one case a point was relocated to cover secondary habitat. We mapped focal points and surveying points using a GeoXT unit equipped with Terrasync software and archived spatial data in RMBL's spatial database to allow repetition of surveys by future scientists.

Sites were each visited three times between July 7 and August 2 2011 (Table 2). Return visits were always spaced at least three days apart. Point counts took place at each sampling point between 6:00AM and 10:40AM. We randomly determined sampling point order to prevent bias towards a particular sampling point (Urbaniak and Plous, 2011). Each point count consisted of a one-minute waiting period for avian acclimation to human presence followed by a ten-minute sampling period. A trained observer equipped with binoculars (Nikon Monarch X 10X42, Melville, NY), an iPhone 3GS (Apple Inc., Cupertino, CA), and a compass recorded all avian species identified by sight and sound in addition to time observed, approximate distance and direction. For each sampling period, approximate weather conditions were recorded in the form of temperature, wind (Beauford scale), and cloud cover. No point counts were taken during moderate precipitation or wind greater than Level 5 on the Beauford scale. Audio recordings of

survey periods during a site visit were performed at least once per survey point using either video (Sony Cybershot DSC-H55, New York, NY) or audio (Olympus Digital Voice Recorder VN-3100PC, Center Valley, PA) recording to confirm observations and identify any unknown avian vocalizations.

b. Survey Analysis

We compiled avian species lists for each survey area. Approximate altitude ranges for each species observed were identified and compared to known ranges (Andrews and Righter, 1992). We plotted the discovery curve for each survey area with time surveyed as the independent variable and number of species observed as the dependent variable to examine observation efficacy and determine species list completeness. In addition, species diversity was examined by performing linear regression with elevation as the independent variable and number of species as the dependent variable (R Core Development Team 2009).

Results

A. Gothic Breeding Bird Survey

We identified altitude ranges for eighty-three species observed during the Gothic Breeding Bird Survey between 1999 and 2011 (Appendix 1). Predicted abundance trend is given in Appendix 2. Appendix 3 provides statistics from linear regressions performed to identify observed abundance trends. Linear regression performed upon each species of number observed and year gave an approximately equal number of species with increasing and decreasing slopes (Table 3). At $\alpha = 0.05$, 4 species had increasing slopes and 5 species had decreasing slopes. At $\alpha = 0.10$, there were 6 species each with increasing and decreasing slopes. Predicted trends were compared with observed trends for elevation shifts of 250ft and 100ft as well as alpha levels of 0.05 and 0.10 (Table 4). No species predicted to increase or decrease based upon elevation shifts demonstrated changes in the respective direction. In addition, numbers of species that increased and decreased are nearly equivalent, indicating that species abundance decreases were not noticeably more common than increases.

B. Point Count Surveys

Thirty-nine avian species were observed during a 26-day period during July 2011 across all survey areas (Appendix 4). Discovery curves indicate that surveying was reasonable in sampling all species at the Almont Weather Station, Kettle Ponds, and Mexican Cut survey areas but not at the Almont Riparian, Judd Falls, and Snodgrass Mt. survey areas (Appendix 5). Elevation did not predict the number of species observed at each survey site (Figure 1). Six species were observed above their documented ranges (Appendix 6, Table 7).

Discussion

Gothic Breeding Bird Survey data do not support predictions under either the altitude shift scenario or overall negative effect scenario for climate disruption response. Instead, trends observed are likely responses to variables not considered by the two hypotheses from which predictions were derived. The conclusion that avian species as well as many other organisms respond to a complex assortment of factors is consistent with previous studies and reviews (Parmesan 1996, 2006, La Sorte and Thompson 2007). Such factors include phenology, physiology, niche requirements, and climatic tolerances in addition to factors unrelated to climate disruption such as human disturbance through land use (Parmesan 2006).

Changes in the phenology of birds could be closely interacting with climate disruption effects through species abundances. For instance, changing phenology could explain concurrent changes in abundance. For example, American Robins have been shown to arrive in Gothic earlier despite consistent time of snowmelt (Inouye et al 2000). Robins may be experiencing arrivals before resources become sufficiently available, forcing birds to wait longer before recovering body mass post-migration. This could prove detrimental and explain the decline in American Robins observed (Inouye et al 2000).

However, phenology could also be causing observed changes in abundance. The breeding bird survey is conducted once per year, so changes in relative abundances could be results of changing phenology instead of changes in range or relative abundance. For example, if there is a trend toward earlier migrant arrival in the year, observed abundances during the breeding bird survey would increase, even if site conditions are becoming increasingly unsuitable for avian species.

Changes in species abundances could also be attributable to local anthropogenic factors. Human disturbance may be the sole cause of observed changes but could also be exacerbating the effects of climate disruption (La Sorte and Thompson 2007). Species could be decreasing or increasing due to human disturbance such as changes in land use. Thus, the significant trends observed in six species may represent combined effects of climate disruption and human disturbance. Remaining species may be responding less strongly to such anthropogenic change or may be responding on a longer timescale.

While trends from the Breeding Bird Survey did not support range shifts associated with climate disruption, observations from point count surveys along an elevation gradient found evidence of birds at higher elevations than documented. This result supports the hypothesis that climate disruption is causing upward shifts in elevation range and is consistent with previous results examining northward range shifts (Hitch and Leberg 2007, La Sorte and Thompson 2007). Hitch and Leberg (2007) describe range changes that could be gradual northward movement that may represent range expansion but not necessarily a range shift. Similarly, point count observations could represent a gradual movement to higher elevations in response to climate disruption.

Why did the elevation survey support the hypothesis for upward shift in species ranges while the Breeding Bird Survey did not? The two studies could disagree because the strength of surveying along an elevation gradient is greater as a technique for detecting change. The Gothic Breeding Bird Survey takes place in a general area at a single elevation where the point count surveys examined six different survey areas at five different elevations. This conclusion is supported by previous methodology of Popy et al (2010) a study that detected a weak upward trend in elevation of avian communities after

a 10-year period using surveys along an elevation gradient. Weather station point counts simulate such an analysis through comparison between observed ranges in 2011 and documented ranges from 1992 (Andrews and Righter), a nearly twenty-year difference. In addition, timescale may have also contributed to the Gothic Breeding Bird Surveys lack of trend detection. Thirteen years may have been simply insufficient time to observe significant trends through surveying a single location. Also, surveying along a gradient allowed detection of trends of the actual elevation range as opposed to populations in a single area. Thus, point count surveys could detect expansions and contractions in addition to shifts in range. If species ranges are expanding, then species abundances would increase at higher elevations but remain the same at lower elevations as was observed by RMBL weather station surveys. Lastly, the retroanalysis did not consider differences in effort between years. Number of observers differed between years, so total effort was variable. The analysis performed used no standardization of sampling effort to account for such variation.

Considering the deficiencies of the analyses and research methods, future research should focus on secondary analyses, continued surveying and deepening our understanding of upward range shifts. A second retroanalysis should be performed taking into account variation in sampling effort to determine if sampling effort confounded any abundance trends. Bird surveying should continue through the Gothic Breeding Bird Survey and in addition to point count surveys along an elevation gradient. Such surveys should be expanded to include more habitats at chosen elevations to decrease limitation of elevation species lists by habitat. Similarly, research should focus on factors that may mediate between climate disruption and avian species in cause-effect relationships. For instance, studying the relationship between habitat and which species move upward. Species that inhabit environments at lower elevations similar to environments at higher elevations may be initial indicators of changes in avian species elevation ranges. Community responses should also be examined. Lastly, anthropogenic factors should be investigated to determine if they are causing observed trends and how they may be interacting with climate disruption. Examination of human disturbance through land use such as agriculture and recreation could prove a useful first step.

The study performed contributes to a baseline of information regarding avian species altitude ranges and responses to climate disruption. Considering the contradiction between long-term data from the Gothic Breeding Bird Survey data and a comparison between altitude ranges observed by point count surveys and documented ranges from 1992 (Andrews and Righter), it is clear that avian species are not responding as simpler scenarios of climate disruption effects may predict. Following research can deepen the understanding of responses by organisms to climate disruption.

Literature Cited

- Andrews, Robert, and Richter, R. (1992). *Colorado Birds: A Reference to Their Distribution and Habitat* (1st ed.). Denver Museum of Natural History Press.
- Beever, E. a, Brussard, P. F., and Berger, J. (2003). Patterns of Apparent Extirpation Among Isolated Populations of Pikas (*Ochotona princeps*) in the Great Basin. *Journal of Mammalogy*, 84(1), 37-54. doi:10.1644/1545-1542(2003)084<0037:POAEAI>2.0.CO;2
- Böhning-Gaese, K., and Lemoine, N. (2004). Importance of Climate Change for the Ranges, Communities and Conservation of Birds. *Advances in Ecological Research*, 35, 211-236.
- ESRI Inc. (2009). ArcGIS. Denver, CO.
- Hitch, A. T., and Leberg, P. L. (2007). Breeding distributions of north American bird species moving north as a result of climate change. *Conservation biology : the journal of the Society for Conservation Biology*, 21(2), 534-9. doi:10.1111/j.1523-1739.2006.00609.x
- Inouye, D. W., Barr, B., Armitage, K. B., & Inouye, B. D. (2000). Climate change is affecting altitudinal migrants and hibernating species. *Proceedings of the National Academy of Sciences of the United States of America*, 97(4), 1630-3. Retrieved from <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=26486&tool=pmcentrez&rendertype=abstract>
- Kingery, Hugh E., and Luekering, T. (2007). Atlas II The Second Colorado Breeding Bird Atlas: Field Worker's Handbook.
- La Sorte, F. a, and Jetz, W. (2010). Projected range contractions of montane biodiversity under global warming. *Proceedings. Biological sciences / The Royal Society*, 277(1699), 3401-10. doi:10.1098/rspb.2010.0612
- La Sorte, F. a, and Thompson, F. R. (2007). Poleward shifts in winter ranges of North American birds. *Ecology*, 88(7), 1803-12. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/17645026>
- Parmesan, C. (1996). Parmesan 1996_Climate and species' range.pdf. *Proceedings of the National Academy of Sciences of the United States of America*, 97(4), 1630-1633.
- Parmesan, C. (2006). Ecological and Evolutionary Responses to Recent Climate Change. *Annual Review of Ecology, Evolution, and Systematics*, 37(1), 637-669. doi:10.1146/annurev.ecolsys.37.091305.110100

- Parmesan, C., Ryrholm, N., Stefanescu, C., Hillk, J. K., Thomas, C. D., Descimon, H., Huntley, B., et al. (1999). Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature*, 399(June), 579-583.
- Popy, S., Bordignon, L., & Prodon, R. (2009). A weak upward elevational shift in the distributions of breeding birds in the Italian Alps. *Journal of Biogeography*, 37(1), 57-67. doi:10.1111/j.1365-2699.2009.02197.x
- Pounds, J. A., Fogden, M. P. L., & Campbell, J. H. (1999). Biological response to climate change on a tropical mountain. *Nature*, 398(April), 611-615.
- R Development Core Team. (2009). R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from <http://www.r-project.org>
- Root, T. L., Price, J. T., Hall, K. R., & Schneider, S. H. (2003). Fingerprints of global warming on wild animals and plants. *Nature*, (tier 2), 57-60. doi:10.1038/nature01309.1.
- Sekercioglu, C. H., Schneider, S. H., Fay, J. P., & Loarie, S. R. (2008). Climate change, elevational range shifts, and bird extinctions. *Conservation biology: the journal of the Society for Conservation Biology*, 22(1), 140-50. doi:10.1111/j.1523-1739.2007.00852.x
- Thomas, C. D., & Lennon, J. J. (1999). Birds extend their ranges northwards. *Nature*, 399(May), 6505-6505.
- Urbaniak, G.C., and Plous, S. (2011). Research Randomizer (Version 3.0). Retrieved August 7, 2011, from <http://www.randomizer.org>

Figures and Tables

Table 1 - Weather station site elevation, habitat designation, number of survey areas, and survey points.

	Elevation (ft)	Habitat	Survey Areas	Survey Points
Almont	8100.3937	Montane Sagebrush (SMS) and Low-Elevation Riparian (LRD)	2	N,S,E,W and 1,2,3,4*
Judd Falls	9852.3622	Large, Pure Aspen Forest (FAP)	1	N,S,E,W,NE,SW
Kettle Ponds	9383.2021	Mid-Elevation Carr (SMC)	1	N,S,E,W
Mexican Cut	11223.7533	Riparian Coniferous Forest (FRC)	1	N,S,E,W
Snodgrass Mt.	11141.7323	Upland Coniferous Forest - Lodgepole Pine (FUCL)	1	N,S,E,W**

Table 2 - Survey dates for five weather station sites

Visit #	1	2	3
Almont	7-Jul-11	14-Jul-11	22-Jul-11
Judd Falls	10-Jul-11	18-Jul-11	29-Jul-11
Kettle Ponds	12-Jul-11	20-Jul-11	28-Jul-11
Mexican Cut	21-Jul-11	26-Jul-11	30-Jul-11
Snodgrass Mt.	13-Jul-11	19-Jul-11	2-Aug-11

Table 4 - Linear regression statistics for species with statistically significant trends at alpha = 0.05 and 0.10. (+) , (-) indicates decreasing, and S indicates remains the same. (+)/(-) = Statistically significant when $\alpha = 0.10$. (++)/(--)= Statistically significant when $\alpha = 0.05$.

Species	Species	P-Value	Regression Trend
Mountain	Bluebird	0.06928	(+)
Red	Crossbill	0.06153	(+)
American	Crow	0.002991	(++)
Cordilleran	Flycatcher	0.03289	(++)
Flammulated	Owl	0.04206	(--)
American	Robin	0.02835	(--)
Pine	Siskin	0.01922	(--)
Lincoln's	Sparrow	0.01369	(++)
Barn	Swallow	0.05306	(-)
Northern Rough-winged	Swallow	0.02515	(--)
White-throated	Swift	0.06943	(--)
MacGillivray's	Warbler	0.04202	(++)

Table 5 - Comparison of observed and predicted abundance trends for two elevation shifts at two alpha levels. (+) indicates increasing, (-) indicates decreasing, and S indicates remains the same.

		Observed							
		250ft					1000ft		
			(+)	(-)	S		(+)	(-)	S
Predicted	$\alpha = 0.05$	(+)	0	1	17		0	2	21
		(-)	0	0	1		0	0	5
		S	3	4	57		3	3	49
	$\alpha = 0.10$	(+)	0	2	16		0	3	20
		(-)	0	0	1		0	0	5
		S	5	4	55		5	3	47

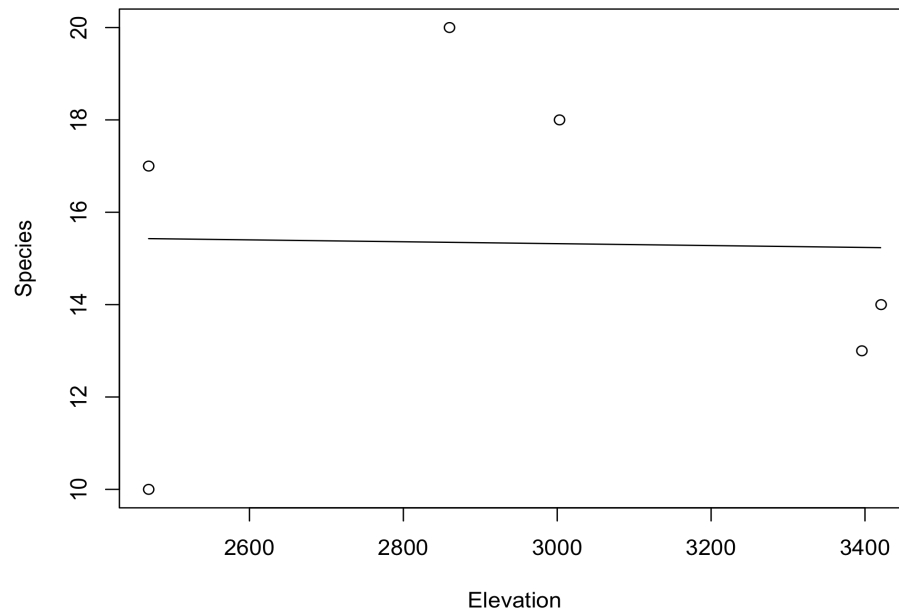


Figure 1 - Number of Species Observed At A Location Against Elevation.

Table 3 - Observed and Documented Ranges of Species Observed Above Documented Range and Comparison

Species	Species	Documented Lower Limit (ft)	Documented Upper Limit (ft)	Observed Lower Limit (ft)	Observed Upper Limit (ft)	Compared To Documented?
Dark-Eyed	Junco	5900	11200	9852.3622	11223.7533	Slightly Above
Ruby-Crowned	Kinglet	7600	11200	11141.7323	11223.7533	Slightly Above
Hermit	Thrush	7000	11200	8100.3937	11223.7533	Slightly Above
MacGillivray's	Warbler	6000	11000	8100.3937	11223.7533	Above
Yellow-Rumped	Warbler	7000	11000	9852.3622	11223.7533	Above
Western	Wood-Pewee	3500	10000	9383.2021	11141.7323	Above *

*Observed 1,141ft above documented range.

Appendix 1 - Observed species status in Gothic, CO based on documented elevation ranges.

Species	Species	Lower Range (ft)	Upper Range (ft)	Gothic Current Status
Brewer's	Blackbird	3500	12000	C
Red-Winged	Blackbird	3500	11000	R
Mountain	Bluebird	5500	13300	C
Lazuli	Bunting	3500	9500	R
Black-capped	Chickadee	3500	8900	R
Mountain	Chickadee	8000	11200	C
Brown-Headed	Cowbird	3500	12000	U
Brown	Creeper	6000	11500	U
Red	Crossbill	6000	10000	C
American	Crow	3500	10000	C
American	Dipper	5500	11500	U
Mourning	Dove	3500	11500	U
Golden	Eagle	3500	14000	U
Cassin's	Finch	5300	11000	C
Purple	Finch	3500	6500	R
Northern (Red-shafted)	Flicker	3500	11500	U
Cordilleran	Flycatcher	6000	11200	U
Dusky	Flycatcher	5500	11000	U
Hammonds	Flycatcher	7000	11000	U
Olive sided	Flycatcher	6000	11300	U
Willow	Flycatcher	5000	10000	U
American	Goldfinch	3500	9000	X
Canadian	Goose	3500	9000	X
Black headed	Grosbeak	3500	11200	R
Pine	Grosbeak	8600	11500	U
Blue	Grouse	6000	12800	C
Coopers	Hawk	5500	8400	X
Red-tailed	Hawk	3500	10000	U
Sharp Shinned	Hawk	5500	11200	R
Great Blue	Heron	3500	9000	X
Black-Chinned	Hummingbird	3500	7000	X
Broad-tailed	Hummingbird	5800	11200	U
Blue	Jay	3500	5900	X
Gray	Jay	5500	11200	U
Steller's	Jay	5000	12000	U
Dark-eyed	Junco	5900	11200	C
American	Kestrel	3500	10000	R
Belted	Kingfisher	3500	9000	X
Golden-crowned	Kinglet	8100	11200	C
Ruby Crowned	Kinglet	7600	11200	C
Common	Mallard	3500	11000	R
Common	Merganser	5500	10000	R
Clark's	Nutcracker	5600	12000	U
Red-Breasted	Nuthatch	6000	11400	U
Flammulated	Owl	6000	10000	C
Pygmy	Owl	5000	10000	R
Western Wood	Peewee	3500	10000	U

Common	Raven	5000	14000	C
American	Robin	3500	11200	C
Spotted	Sandpiper	3500	11500	U
Red naped	Sapsucker	6000	11500	U
Pine	Siskin	6000	11200	U
Townsend's	Solitaire	5000	7000	X
Chipping's	Sparrow	3500	11000	U
Fox	Sparrow	7500	11000	U
Lincoln's	Sparrow	6900	12000	C
Savannah	Sparrow	3500	11000	U
Song	Sparrow	3500	10000	R
Vesper	Sparrow	3500	13000	R
White-crowned	Sparrow	8000	13000	U
Barn	Swallow	3500	10000	U
Cliff	Swallow	3500	10000	U
Northern Rough-winged	Swallow	3500	8900	X
Tree	Swallow	3500	10200	R
Violet-Green	Swallow	5800	13000	C
Black	Swift	8600	14000	U
White-throated	Swift	5700	10000	R
Western	Tanager	5800	10200	R
Hermit	Thrush	7000	11200	U
Swanson's	Thrush	6500	11000	U
Green-tailed	Towhee	5500	11200	U
Solitary	Vireo	5000	8000	X
Warbling	Vireo	3500	10200	C
MacGillivray's	Warbler	6000	11000	U
Orange-crowned	Warbler	6000	9000	X
Townsend's	Warbler	3500	8000	X
Wilson's	Warbler	10000	13000	X
Yellow	Warbler	10000	3500	U
Yellow-rumped	Warbler	7000	11000	C
Downy	Woodpecker	3500	11000	R
Hairy	Woodpecker	5500	11200	U
Three-toed	Woodpecker	8000	11500	R
House	Wren	3500	11000	C

Appendix 2 - Predicted abundance status and change type with elevation range shifts of 250ft and 1000ft.

Species	Species	Predicted Status (250ft)	Predicted Change (250ft)	Predicted Status (1000ft)	Predicted Change (1000ft)
Brewer's	Blackbird	C	S	C	S
Red-Winged	Blackbird	C	(+)	C	(+)
Mountain	Bluebird	C	S	C	S
Lazuli	Bunting	R	S	R	S
Black-capped	Chickadee	R	S	R	S
Mountain	Chickadee	C	S	C	S
Brown-Headed	Cowbird	C	(+)	C	(+)
Brown	Creeper	U	(-)	U	(-)
Red	Crossbill	C	S	C	S
American	Crow	C	S	C	S
American	Dipper	U	S	U	S
Mourning	Dove	U	S	U	S
Golden	Eagle	U	S	U	S
Cassin's	Finch	C	S	C	S
Purple	Finch	R	S	R	S
Northern (Red-shafted)	Flicker	U	S	U	S
Cordilleran	Flycatcher	U	S	U	S
Dusky	Flycatcher	U	S	C	(+)
Hammonds	Flycatcher	U	S	U	S
Olive sided	Flycatcher	U	S	U	S
Willow	Flycatcher	U	S	U	S
American	Goldfinch	U	(+)	U	(+)
Canadian	Goose	U	(+)	U	(+)
Black headed	Grosbeak	U	S	U	S
Pine	Grosbeak	U	S	X	(-)
Blue	Grouse	C	S	C	S
Coopers	Hawk	X	S	R	(+)
Red-tailed	Hawk	U	S	U	S
Sharp Shinned	Hawk	R	S	R	S
Great Blue	Heron	R	(+)	R	(+)
Black-Chinned	Hummingbird	X	S	X	S
Broad-tailed	Hummingbird	U	S	U	S
Blue	Jay	X	S	X	S
Gray	Jay	U	S	R	(-)
Steller's	Jay	C	(+)	C	(+)
Dark-eyed	Junco	C	S	C	S
American	Kestrel	R	S	R	S
Belted	Kingfisher	U	(+)	U	(+)
Golden-crowned	Kinglet	C	S	C	S
Ruby Crowned	Kinglet	C	S	C	S
Common	Mallard	C	(+)	C	(+)
Common	Merganser	R	S	R	S
Clark's	Nutcracker	U	S	U	S
Red-Breasted	Nuthatch	U	S	R	(-)
Flammulated	Owl	C	S	C	S
Pygmy	Owl	R	S	R	S

Western Wood	Pee-wee	U	S	C	(+)
Common	Raven	C	S	C	S
American	Robin	C	S	C	S
Spotted	Sandpiper	U	S	U	S
Red naped	Sapsucker	U	S	U	S
Pine	Siskin	U	S	U	S
Townsend's	Solitaire	X	S	X	S
Chipping's	Sparrow	U	S	U	S
Fox	Sparrow	U	S	R	(-)
Lincoln's	Sparrow	C	S	C	S
Savannah	Sparrow	U	S	U	S
Song	Sparrow	U	(+)	U	(+)
Vesper	Sparrow	C	(+)	C	(+)
White-crowned	Sparrow	U	S	U	S
Barn	Swallow	C	(+)	C	(+)
Cliff	Swallow	C	(+)	C	(+)
Northern Rough-winged	Swallow	R	(+)	R	(+)
Tree	Swallow	U	(+)	U	(+)
Violet-Green	Swallow	C	S	C	S
Black	Swift	U	S	U	S
White-throated	Swift	R	S	C	(+)
Western	Tanager	U	(+)	U	(+)
Hermit	Thrush	U	S	U	S
Swanson's	Thrush	U	S	U	S
Green-tailed	Towhee	U	S	U	S
Solitary	Vireo	X	S	X	S
Warbling	Vireo	C	S	C	S
MacGillivray's	Warbler	U	S	U	S
Orange-crowned	Warbler	U	(+)	U	(+)
Townsend's	Warbler	X	S	R	(+)
Wilson's	Warbler	X	S	X	S
Yellow	Warbler	U	S	U	S
Yellow-rumped	Warbler	C	S	C	S
Downy	Woodpecker	U	(+)	U	(+)
Hairy	Woodpecker	U	S	U	S
Three-toed	Woodpecker	U	S	U	S
House	Wren	C	S	C	S

Appendix 3 – Linear regression statistics for number of individuals observed against year and observed trend type.

Species	Species	Regression Slope	F Stat	P-Value	Regression Trend
Brewer's	Blackbird	-0.03297	0.02527	0.8766	S
Red-Winged	Blackbird	-0.01648	0.6226	0.4467	S
Mountain	Bluebird	0.3626	4.051	0.06928*	S/(+)
Lazuli	Bunting	-0.03297	0.01452	0.9062	S
Black-capped	Chickadee	0.01648	0.04865	0.8295	S
Mountain	Chickadee	0.06044	0.01665	0.8997	S
Brown-Headed	Cowbird	-0.09341	0.04952	0.828	S
Brown	Creeper	-0.07692	1.167	0.3032	S
Red	Crossbill	0.4176	4.333	0.06153*	S/(+)
American	Crow	0.544	14.37	0.002991**	(+)
American	Dipper	-0.04945	0.06961	0.7968	S
Mourning	Dove	-0.02198	0.2066	0.6583	S
Golden	Eagle	-0.02747	1.923	0.193	S
Cassin's	Finch	0.1154	0.3491	0.5666	S
Purple	Finch	0.01648	0.6226	0.4467	S
Northern (Red-shafted)	Flicker	-0.6923	1.861	0.1998	S
Cordilleran	Flycatcher	0.8077	5.948	0.03289**	(+)
Dusky	Flycatcher	0.01648	0.03224	0.8608	S
Hammonds	Flycatcher	-0.05495	2.254	0.1614	S
Olive sided	Flycatcher	0.03846	0.03758	0.8498	S
Willow	Flycatcher	-0.1648	2.283	0.159	S
American	Goldfinch	-0.03297	1.031	0.3317	S
Canadian	Goose	0.05495	1.923	0.193	S
Black headed	Grosbeak	0.07143	2.462	0.1449	S
Pine	Grosbeak	0.1538	0.3149	0.5859	S
Blue	Grouse	-0.07692	0.939	0.3534	S
Coopers	Hawk	0.01099	0.2683	0.6147	S
Red-tailed	Hawk	0.01099	0.1058	0.7511	S
Sharp Shinned	Hawk	0.03297	1.031	0.3317	S
Great Blue	Heron	0.02747	0.0892	0.7708	S
Black-Chinned	Hummingbird	-0.02747	1.923	0.193	S
Broad-tailed	Hummingbird	-0.1593	0.05129	0.825	S
Blue	Jay	0.04396	1.158	0.3049	S
Gray	Jay	-0.04396	0.02845	0.8691	S
Steller's	Jay	-0.06593	0.7266	0.4122	S
Dark-eyed	Junco	0.4725	0.9187	0.3584	S
American	Kestrel	5.37E-16	2.41E-28	1	S
Belted	Kingfisher	-0.005495	0.06587	0.8022	S
Golden-crowned	Kinglet	0.05495	0.9717	0.3454	S
Ruby Crowned	Kinglet	0.2857	0.4254	0.5277	S
Common	Mallard	0.005495	0.01269	0.9123	S
Common	Merganser	-1.79E-15	1.463E-27	1	S
Clark's	Nutcracker	0.07143	0.5175	0.8242	S
Red-Breasted	Nuthatch	-0.02747	0.03087	0.8637	S
Flammulated	Owl	-0.05495	5.288	0.04206**	(-)
Pygmy	Owl	0	NA	NA	S

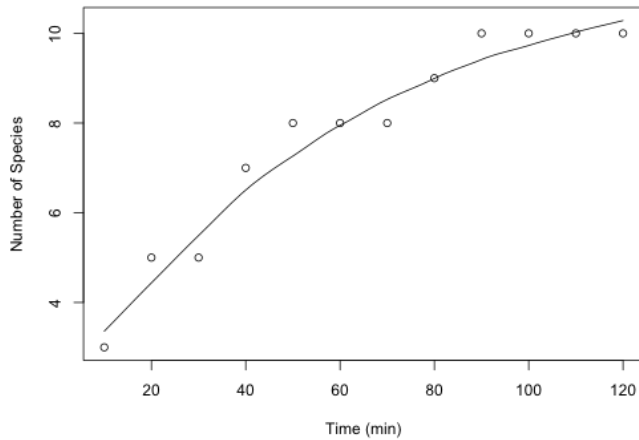
Western Wood	Peewee	-0.0989	0.09589	0.7626	S
Common	Raven	0.08242	0.2449	0.6304	S
American	Robin	-3.385	6.363	0.02835**	(-)
Spotted	Sandpiper	-0.02747	0.1581	0.6985	S
Red naped	Sapsucker	-0.0989	0.02854	0.869	S
Pine	Siskin	-3.198	7.51	0.01922**	(-)
Townsend's	Solitaire	-0.12088	2.029	0.1821	S
Chipping's	Sparrow	0.1484	0.702	0.4199	S
Fox	Sparrow	0.2857	1.601	0.2319	S
Lincoln's	Sparrow	0.8681	8.585	0.01369**	(+)
Savannah	Sparrow	-0.05495	1.923	0.193	S
Song	Sparrow	-0.07143	0.06866	0.7981	S
Vesper	Sparrow	-0.01648	0.6226	0.4467	S
White-crowned	Sparrow	-0.4011	0.4766	0.5043	S
Barn	Swallow	-0.3736	4.696	0.05306*	S/(-)
Cliff	Swallow	-1.1099	1.255	0.2864	S
Northern Rough-winged	Swallow	-0.18681	6.707	0.02515**	(-)
Tree	Swallow	-0.3462	0.6105	0.4511	S
Violet-Green	Swallow	-0.2747	0.2906	0.6006	S
Black	Swift	0.1319	0.2863	0.6033	S
White-throated	Swift	-0.08791	4.046	0.06943*	(-)
Western	Tanager	-0.2473	2.561	0.1379	S
Hermit	Thrush	-0.2418	1.005	0.3377	S
Swanson's	Thrush	0.1099	0.3502	0.566	S
Green-tailed	Towhee	0.3791	3.741	0.07922	S
Solitary	Vireo	-0.17033	3.236	0.09951	S
Warbling	Vireo	-1.429	1.408	0.2604	S
MacGillivray's	Warbler	0.5879	5.291	0.04202**	(+)
Orange-crowned	Warbler	3.54E-16	1.50E-28	1	S
Townsend's	Warbler	-0.4945	5.537	0.03828	S
Wilson's	Warbler	-0.5934	0.6	0.4549	S
Yellow	Warbler	-0.4725	1.568	0.2364	S
Yellow-rumped	Warbler	0.8077	4.127	0.06709	S
Downy	Woodpecker	-0.25275	10.34	0.008233	S
Hairy	Woodpecker	0	NA	NA	S
Three-toed	Woodpecker	0.02747	1.923	0.193	S
House	Wren	0.4451	1.221	0.2928	S

Appendix 4 – Cumulative species list for all point count surveys conducted between 7/7/2011 and 8/2/2011.

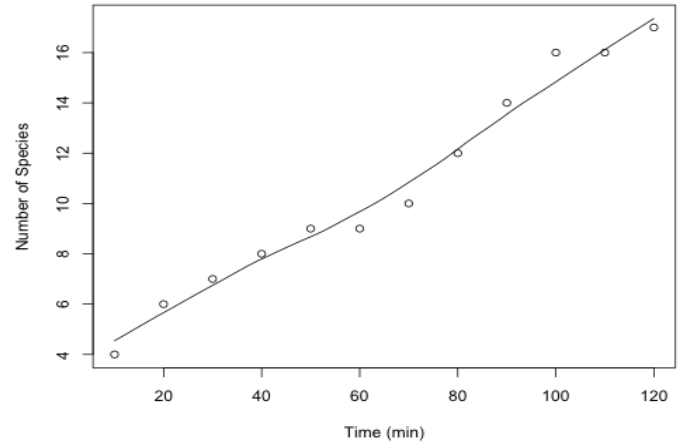
Species	Species
Brewer's	Blackbird
Red-Winged	Blackbird
Mountain	Bluebird
Brown-Headed	Cowbird
American	Crow
Mourning	Dove
Northern	Flicker
Cordilleran	Flycatcher
Olive-Sided	Flycatcher
Pine	Grosbeak
Broad-Tailed	Hummingbird
Rufous	Hummingbird
Gray	Jay
Steller's	Jay
Dark-Eyed	Junco
Ruby-Crowned	Kinglet
Common	Mallard
Common	Raven
American	Robin
Red-Naped	Sapsucker
Pine	Siskin
Fox	Sparrow
Lincoln's	Sparrow
White-Crowned	Sparrow
Violet-Green	Swallow
Hermit	Thrush
Green-Tailed	Towhee
Warbling	Vireo
MacGillivray's	Warbler
Wilson's	Warbler
Yellow	Warbler
Yellow-Rumped	Warbler
Hairy	Woodpecker
Three-Toed	Woodpecker
Western	Wood-Pewee
House	Wren
Rock	Wren

Appendix 5 – RMBL Weather Station Point Count Surveys - Discovery curves for all survey areas: Number of species observed against amount of time surveyed at the area.

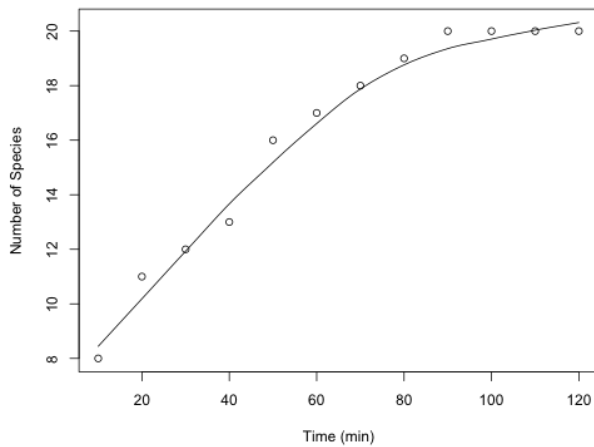
Discovery Curve for the Almont Weather Station



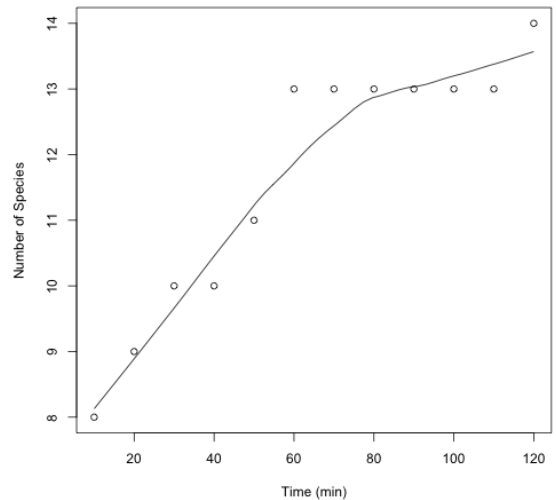
Discovery Curve for the Almont Riparian Area



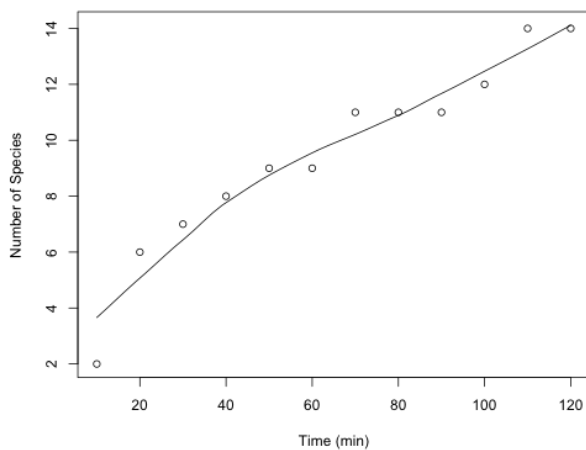
Discovery Curve for Kettle Ponds



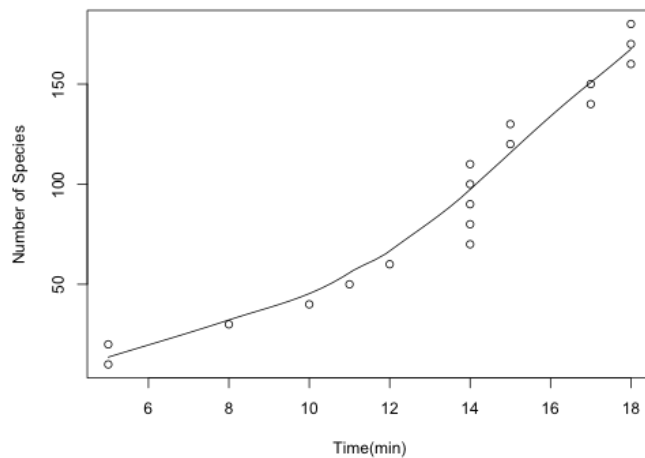
Discovery Curve for Mexican Cut



Discovery Curve for Snodgrass Mt.



Discovery Curve for Judd Falls



Appendix 6 – Observed species ranges in addition to relationship to documented ranges.

Species	Species	Observed Lower Limit (ft)	Observed Upper Limit (ft)	Lower Limit (ft)	Upper Limit (ft)	Compared To Documented?
Brewer's	Blackbird	8100.3937	9383.2021	3500	12000	Within
Red-Winged	Blackbird	9383.2021	9383.2021	3500	11000	Within
Mountain	Bluebird	9383.2021	9383.2021	5500	13300	Within
Black-Capped	Chickadee	8100.3937	8100.3937	3500	8900	Within
Mountain	Chickadee	8100.3937	11223.7533	8000	11200	Within
Brown-Headed	Cowbird	8100.3937	9383.2021	3500	12000	Within
American	Crow	8100.3937	8100.3937	3500	10000	Within
Mourning	Dove	8100.3937	8100.3937	3500	11500	Within
Northern	Flicker	8100.3937	11141.7323	3500	11500	Within
Cordilleran	Flycatcher	8100.3937	8100.3937	6000	11200	Within
Olive-Sided	Flycatcher	9383.2021	11223.7533	6000	11300	Within
Pine	Grosbeak	11141.7323	11223.7533	8600	11500	Within
Broad-Tailed	Hummingbird	8100.3937	11141.7323	5800	11200	Within
Rufous	Hummingbird	9383.2021	11223.7533	4250	13750	Within
Gray	Jay	9852.3622	11223.7533	5500	11200	Within
Steller's	Jay	11141.7323	11141.7323	5000	12000	Within
Dark-Eyed	Junco	9852.3622	11223.7533	5900	11200	Slightly Above
Ruby-Crowned	Kinglet	11141.7323	11223.7533	7600	11200	Slightly Above
Common	Mallard	9383.2021	9383.2021	3500	11000	Within
Common	Raven	8100.3937	8100.3937	5000	14000	Within
American	Robin	8100.3937	11223.7533	3500	11200	Within
Red-Naped	Sapsucker	9852.3622	9852.3622	6000	11500	Within
Pine	Siskin	8100.3937	11223.7533	6000	11200	Within
Fox	Sparrow	9383.2021	9383.2021	7500	11000	Within
Lincoln's	Sparrow	9383.2021	11223.7533	6900	12000	Within
White-Crowned	Sparrow	9383.2021	11223.7533	8000	13000	Within
Violet-Green	Swallow	8100.3937	9852.3622	5800	13000	Within
Hermit	Thrush	8100.3937	11223.7533	7000	11200	Slightly Above
Green-Tailed	Towhee	8100.3937	9852.3622	5500	11200	Within
Warbling	Vireo	8100.3937	9852.3622	3500	10200	Within
MacGillivray's	Warbler	8100.3937	11223.7533	6000	11000	Above
Wilson's	Warbler	8100.3937	9852.3622	10000	13000	Within
Yellow	Warbler	8100.3937	8100.3937	3500	10000	Within
Yellow-Rumped	Warbler	9852.3622	11223.7533	7000	11000	Above
Hairy	Woodpecker	11141.7323	11141.7323	5500	11200	Within
Three-Toed	Woodpecker	11223.7533	11223.7533	8000	11500	Within
Western	Wood-Pewee	9383.2021	11141.7323	3500	10000	Above
House	Wren	9383.2021	9852.3622	3500	11000	Within
Rock	Wren	8100.3937	8100.3937	3500	12000	Within