# What Explains Variation in Abundance of Prairie Species in Alberta?

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## INTRODUCTION

Alberta seeks to develop its natural resources while supporting environmental values, including biodiversity[1]. In the case of biodiversity, a basic goal of management is to maintain a viable population of each species. With large numbers of species present in a given region—the Alberta Biodiversity Monitoring Institute (ABMI) monitors over 1100 species of vascular plants in Alberta alone—planning on an individual species basis isn't realistic; the goal of maintaining biodiversity is usually addressed by conserving representative areas of each habitat type in the region. However, there are several aspects to "habitat" that influence species presence and abundance. Species differ among ecosystem and vegetation type. Species may also vary geographically or along climate gradients (e.g, more of a species in the south, or in wetter climates). In extensively disturbed regions, management attention has recently shifted to the landscape configuration of remaining areas of native vegetation, using measures like patch size or distance from edge. Understanding which of these habitat factors affect species' abundances most is important to determine priorities in land-use management decisions, such as evaluating existing protected areas or establishing new ones, supporting conservation covenants, or establishing a conservation offset system.

We used information collected by the ABMI to evaluate how species' abundance varies in relation to local ecosystem types, geographic location, and climate and landscape measures in prairie Alberta. Managers can use these results to help guide their decisions about which features to consider in biodiversity-related land management decisions in the region.

**Laboratory studies manipulate levels of variables to separate out their effects. In field studies, it is difficult to separate the effects of variables that covary naturally—for example, we cannot move ecosystems around to separate their effects on species abundance from the effects of climate! Instead we rely on statistical techniques to estimate the "pure" and "shared" effects of two or more correlated variables. A "shared" effect occurs when two correlated variables explain the same variation. A "pure" effect of a variable is independent of other variables. For example, a species may be more common in the dry mixedgrass subregion and more common in the south of the province (where the dry mixedgrass occurs). In this case, there is a shared effect of latitude and subregion. There may also be a "pure" effect of latitude, if the species is more or less abundant in the southern part of the dry mixedgrass subregion than in the northern part. Or, there may be a "pure" effect of subregion, if the species is more common in the dry mixedgrass than in the foothills at the same latitude.**

**The distinction between pure and shared effects is important to managers. For example, if the effect of latitude on species is entirely shared with the effect of subregion, there is no need to consider latitude in management decisions, such as the creation of protected areas—incorporating subregions would represent the species adequately. However, if latitude also has a pure effect, designating northern and southern areas within subregions would have value.**

[1] Alberta Environmental Protection and Enhancement Act, 2010, Revised Statutes of Alberta 2000 Chapter E-12, 40(c), http://www.qp.alberta.ca/documents/Acts/E12.pdf

## METHODS

We compiled information from 343 sites that ABMI surveyed in the Grassland and Parkland (excluding the Peace River subregion) Natural Regions and the dry mixedwood subregion of the Boreal Region (Figure 1). We modeled habitat relationships for 76 bird species and 151 vascular plant species recorded at 25 or more of those sites [2], to calculate how much variation in abundance is due to local ecosystems, location and climate, and landscape effects.

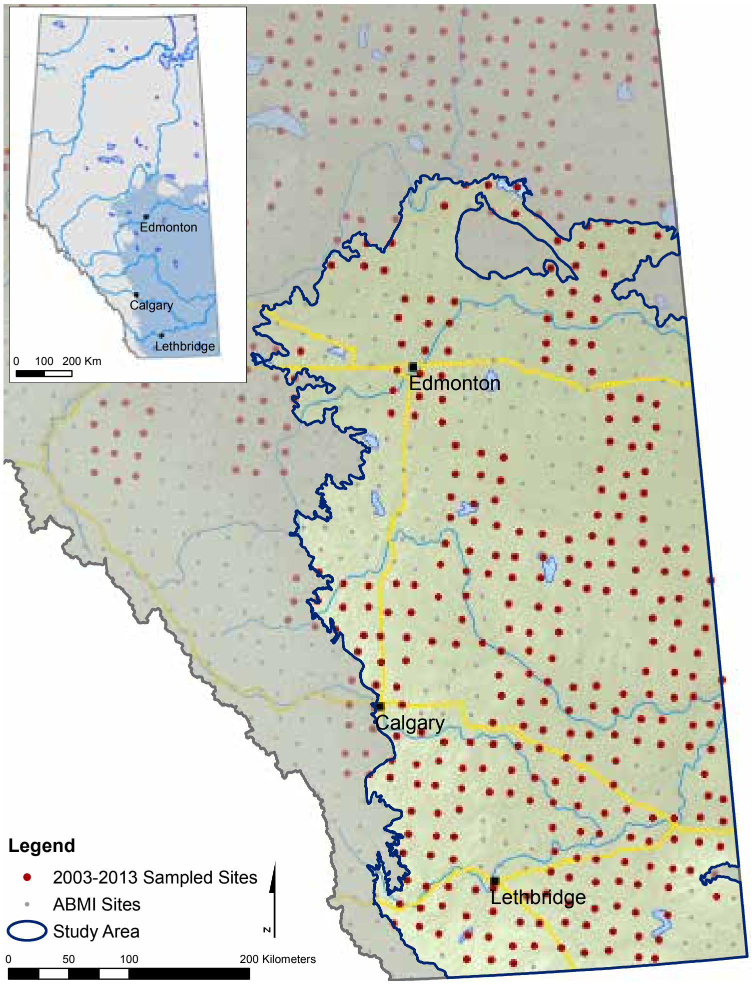
Our analysis used several steps to determine how important different factors are in explaining species' abundances. We first fit statistical models to see how a species' abundance varies with human footprint types. We then added models that relate the species' abundance to three sets of variables (Figure 2):

1) Local ecosystem. Explanatory variables in this set included combinations of broad soil groups (productive, saline+clay, rapid draining), natural subregions, and a variable indicating the probability that the site was treed prior to settlement [3].

2) Space/climate. Seven climate variables were used in various combinations along with latitude and longitude.

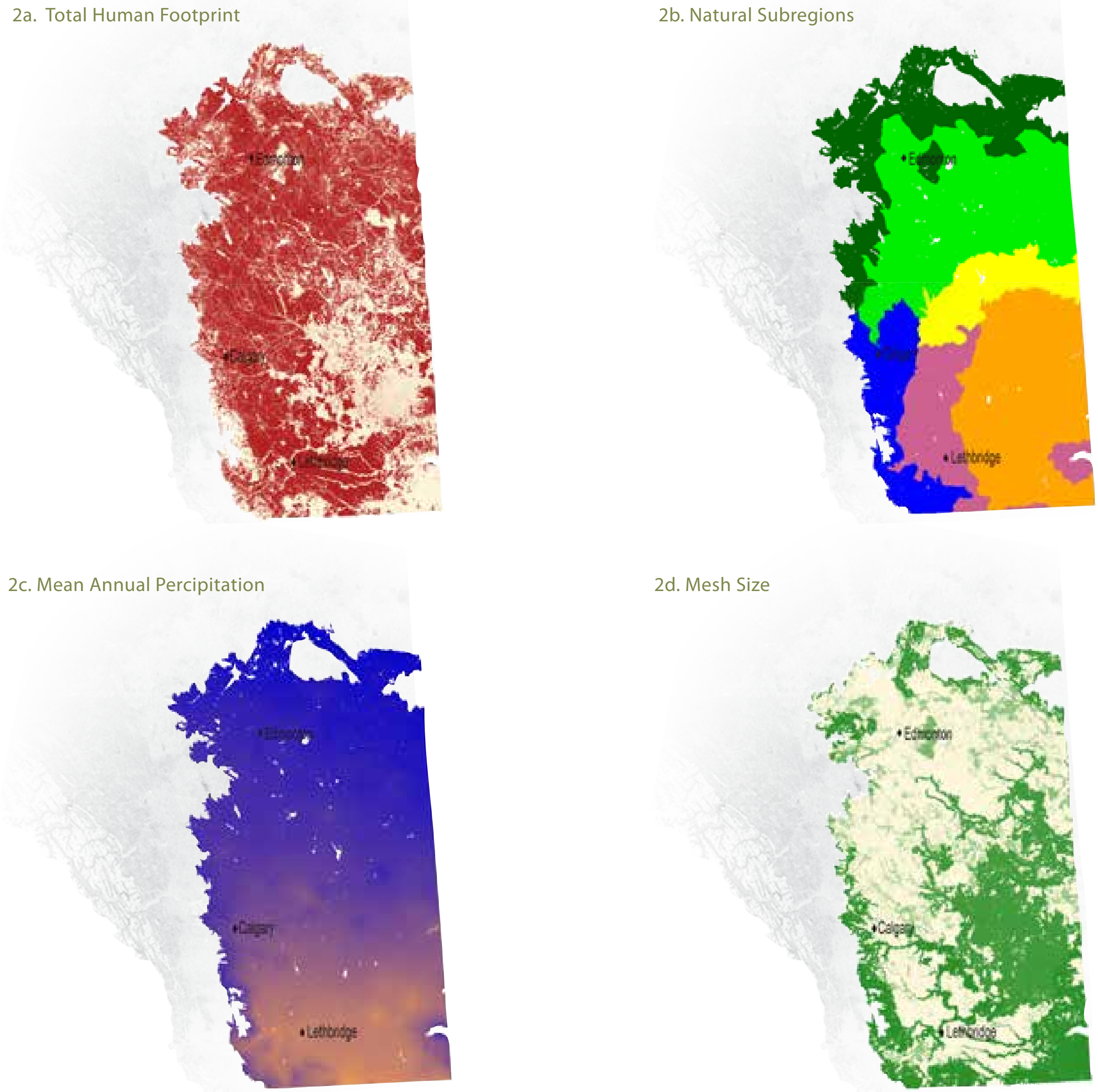
3) Landscape. Analyses in this set used all combinations of three variables derived from a map of patches of native vegetation:[4] patch size, distance to edge of patch, and mesh size (a variable that is high where human footprint is low and vice versa).

FIGURE 1




[2] For field protocols, see http://www.abmi.ca/FileDownloadServlet?filename=10045_ABMI_2014-03-21_Terrestrial_Field_Protocols_(Abridged).pdf&dir=REPORTS_UPLOAD
[3] Diana Stralberg, Univ. Alberta, unpub.
[4] O2, ABMI internal report

**FIGURE 2.**
a) Total human footprint (redder = more footprint), and examples of: b) an ecosystem variable: natural subregions; c) a space/climate variable: mean annual temperature (bluer = colder); and d) a landscape variable: effective mesh size (green = larger mesh size).




For each species, the single best model explaining the relationship between species abundance and each of local ecosystem, space/climate, and landscape was chosen statistically. We then set up four additional models with all combinations of the variables from the best models in each set (i.e., the variables in the best ecosystem model + the variables in the best space/climate model, ecosystem+landscape, space/climate+landscape, and ecosystem+space/climate+landscape).

These analyses were designed to allow us to calculate the amount of variation in species abundances that were explained by human footprint first, and then determine the additional variation explained purely by ecosystem, space/climate, and landscape, and shared by ecosystem+space/climate, ecosystem+landscape, space/climate+landscape, and by all three sets of variables. We also kept track of which variables within each set were best for each species, to see which specific variables were most relevant [5].

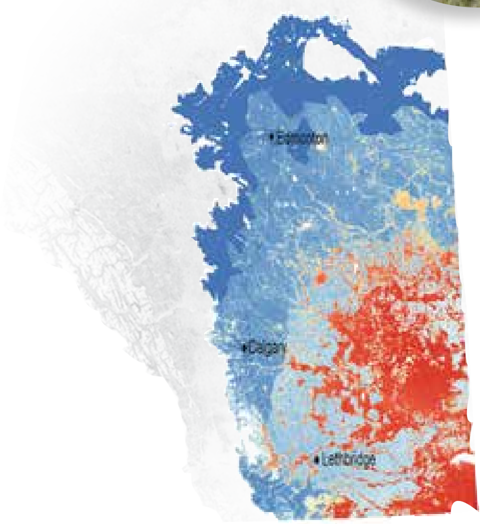
[5] Full details of the statistical approach are available from the authors.

## RESULTS

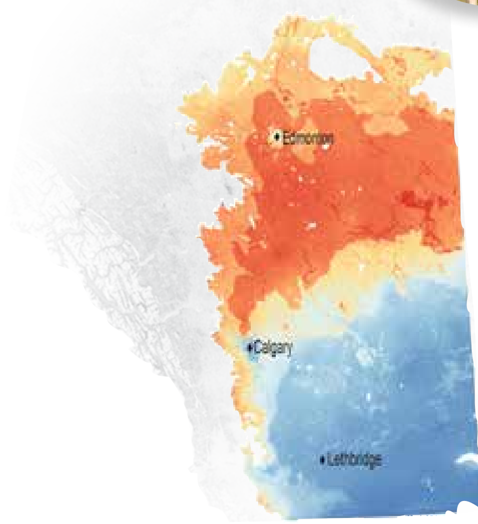
Individual species show a variety of habitat associations (examples in Figure 3). Averaged across species, 33.4% of the variation in abundance of birds and 36.6% of the abundance of plants can be explained by the effects of human footprint, ecosystem, space/climate and landscape. The remaining variation is mainly measurement error, the inevitable variation that comes from having a single, relatively coarse measure at each site (occurrence of a plant species in 0-4 quadrats, occurrence of a bird species in 0-9 point counts). Our interest is in the breakdown of the variation due to human footprint, ecosystem, space/climate, and landscape, which we evaluate in the subsequent analyses.

**FIGURE 3.**
Modeled distributions of Sprague's pipit and house wren (red = higher abundance, blue = lower). Differences between natural subregions are apparent for both species. Sprague's pipit also shows negative effects of human footprint.

Spragues Pipit



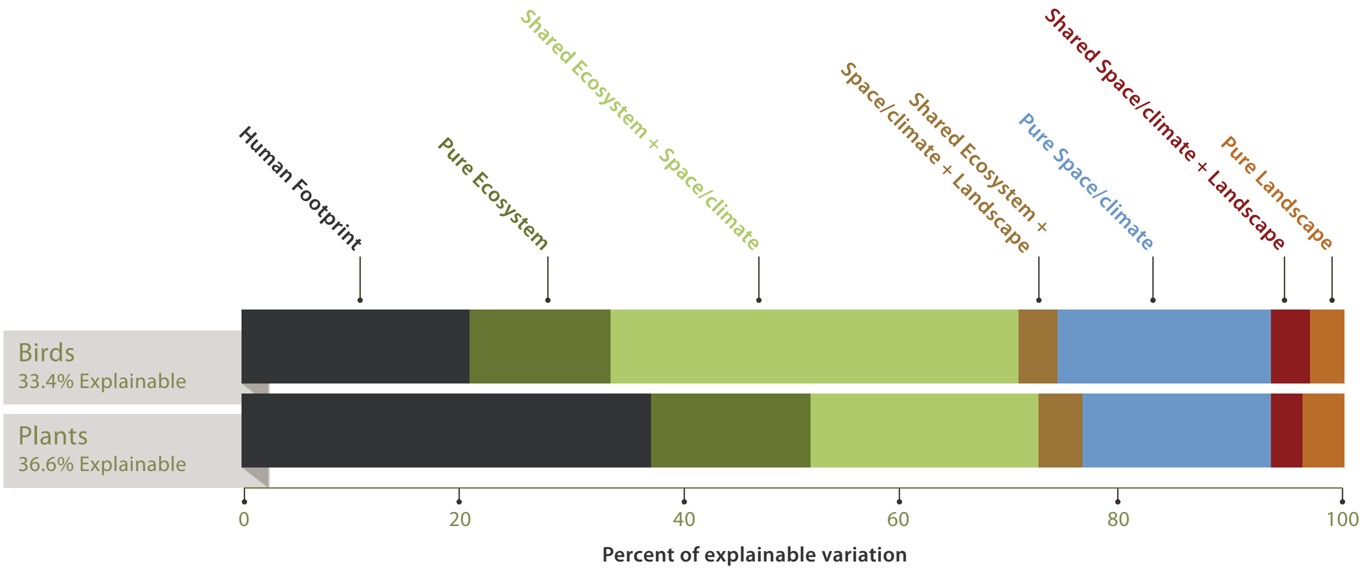

House Wren




Of the explainable variation, 20.4% and 36.7% is attributed to human footprint for birds and plants, respectively. Footprint may be less important for birds because many of the birds we analyzed are generalists.

Almost all the rest of the variation can be explained by ecosystem and space/climate variables, either purely by one or the other, or by both together (shared) (Figure 4). Overall, these two variables account for 89.8% of the remaining, non-footprint explainable variation for birds and 83.7% for plants. Within this component, both pure ecosystem and pure space/climate effect are substantial (Figure 4). The shared ecosystem + space/climate variation is also large, because ecosystem variables (subregions, soils, and probability of being treed) follow space/climate gradients, and the strong influence these have on many species cannot be fully separated. In contrast, landscape variables are of negligible importance, accounting for only 3.2% (birds) and 6.5% (plants) of explainable, non-footprint variation in species' abundances.

**FIGURE 4.**
Breakdown of the explainable variation in the abundance of birds (top) and plants (bottom). See text for explanation of figure.




## Major results and implications

- Human footprint has a major effect on species' abundances—the abundance of bird and plant species clearly differ between native vegetation and areas disturbed by human (agriculture, urban/industrial areas, roads).
- Local ecosystem has an equally important or greater effect on species' abundances compared with human footprint. There is as much, or more, variation in species abundance among ecosystems in the study area as between human disturbed and native areas. Subregions are the most important ecosystem variable, with broad soil types an additional source of variation. As a result, adequate representation of subregions should be a priority for conservation planning that intends to capture the variation of species.
- Spatial location and climate gradients are the third important variable. While some spatial and climatic variation parallels the distribution of ecosystems, there is also a substantial "pure" space/climate effect; that is, species vary geographically or with climate even within one ecosystem type. Spreading out conservation areas would enhance their ability to capture the range of species.
- The landscape variables—patch size, edge distance and mesh size of native vegetation—had little detectable effect on abundances of bird and plant species.

## Caveats

- These results are based on averages across many (broadly distributed) species. We do not have the data to evaluate whether rare and patchily-distributed species have similar patterns.
- Few of our sites are in small patches of native vegetation, as most are in one large patch in the southeast or in human footprint. This weakens the test for landscape effects.
- Results are based on current relative abundance of species. Long-term persistence may be different, although we hypothesize this is not true because agriculture has been in the area for 100 years.

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