

**Reconciling spatial and temporal patterns of bird species richness in  
North and Central America.**

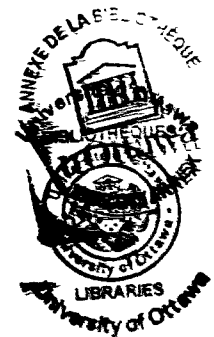
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*I would like to dedicate this work to all those people who motivated me before and during the develop of my research, particularly to my Family, my supervisor David Currie and Bio-mates Gen, Brian, Jaynie and "Mick", A-C Tony, Robin, Marsha, Richard and Johnny.....Thanks a lot!*

## Abstract

Vertebrate species richness varies greatly among regions in North America. Recent studies have shown that this variation covaries strongly with climatic and topographic factors (Currie, 1991, Kerr and Packer, 1997). Bird species richness also changes seasonally. If climatic factors directly or indirectly control species richness, then when climatic factors change, one would expect species richness to change. On the other hand, if there is no causal link between species richness and climate, then species richness need not change when climatic factors change. To test this hypothesis of a causal connection between richness and climate, we first tested whether or not changes in bird species richness track seasonal changes in climate. Second, since richness decreases from summer to winter in some areas (e.g., northern North America) but increases in others (e.g., Central America), we tested whether richness-climate relationships are consistent from northern Canada to Nicaragua. We tested additional hypotheses addressing the importance of topographic (elevation), geologic (soil nutrients), and biotic factors (habitat heterogeneity and vegetation –normalised difference vegetation index-NDVI). To do this, we determined the numbers of species of birds in 651 equal-area quadrats (37,000 km<sup>2</sup>) in both summer (May to July) and winter (January to March). We compared both the spatial and seasonal variation in richness to the variation in climatic, topographic, geologic and biotic variables. We found that 88.5% of spatial variability in bird species richness in North and Central America could be statistically explained by a monotonically function of climatic variables (seasonal temperature and precipitation), with small influences of topography (elevation), habitat heterogeneity, and NDVI. Our results are consistent with the hypothesis

that broad-scale patterns of bird species richness in North America and northern Central America, both spatial and seasonal, are mainly determined by climatic variables and by the presence of vegetation. The patterns do not differ among geographic regions, but they may depend upon the grain (quadrat size) employed.

## Résumé

La richesse en espèces de vertébrés varie considérablement entre les différentes régions de l'Amérique du Nord. Des études récentes démontrent que cette richesse en vertébrés covarie étroitement avec les facteurs climatiques et topographiques (Currie, 1991; Kerr et Packer, 1997). Aussi, la richesse en espèces d'oiseaux change selon les saisons. Si les facteurs climatiques affectent directement ou indirectement la richesse en espèces d'oiseaux alors on pourrait s'attendre à une variation dans la richesse en espèces d'oiseaux lors de changements des facteurs climatiques. Inversement, s'il n'y a pas de lien de cause à effet entre le climat et la richesse en espèces cette dernière ne devrait pas être modifiée si le climat est modifié. Pour tester l'hypothèse d'un lien de cause à effet entre le climat et la richesse en espèces d'oiseaux nous avons d'abord vérifié si les modifications de la richesse en espèces d'oiseaux varient selon les changements de climat. Aussi, comme la richesse décroît de l'été à l'hiver à certains endroits (par exemple en Amérique du Nord) mais qu'elle croît ailleurs (en Amérique Centrale), nous avons vérifié si les relations entre le climat et la richesse en espèces sont constantes de nord du Canada jusqu'au Nicaragua. Des hypothèses additionnelles concernant l'importance de la topographie (élévation), de la géologie (nutriments retrouvés dans le sol) et des facteurs biotiques (hétérogénéité de l'habitat et de la végétation - index normalisé de différence de végétation -NDVI) ont été testées. Pour ce faire, nous avons déterminé le nombre d'espèces d'oiseaux présentes dans 651 quadrats de superficie égale (37 000 km<sup>2</sup>) en été (mai à juillet) et en hiver (janvier à mars). Nous avons comparé la variation de la richesse dans l'espace et entre les saisons aux variables climatiques, topographiques, géologiques et biotiques. Nous avons

démontré que 88,5% de la variabilité spatiale en richesse des espèces au nord et au centre de l'Amérique pouvait être expliquée statistiquement par une fonction linéaire croissante de conditions climatiques (températures saisonnières et eau disponible sous forme de précipitations). Les autres variables, topographie (élévation), hétérogénéité de l'habitat et NDVI n'ont que peu d'influence sur la richesse en espèces d'oiseaux. Nos résultats confirment l'hypothèse selon laquelle les modèles de distribution de la richesse en espèces d'oiseaux, à grande échelle, dans l'espace et selon les saisons en Amérique du Nord et au centre-nord de l'Amérique, sont surtout influencés par des variables climatiques et par la présence de végétation. Les tendances ne sont pas différentes entre les régions géographiques mais elles peuvent dépendre de l'échelle (grandeur du quadrat) utilisée.

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# **Chapter I**

## **1.0 Background**

### **1.1 Species richness follows a pattern**

Four decades have passed since Hutchinson (1959) asked the question in Santa Rosalia, Italy “Why are there so many kinds of living things?” Hutchinson’s students, such as MacArthur in collaboration with Wilson (1963), and Preston (1960) later presented their ideas about the relationships between the abundances of individuals, species richness, area, and latitudinal gradients. Richness not only varies greatly over broad geographic scales, it also shows very regular geographic patterns (Simpson, 1964; Cook, 1969). Explanation of the factors responsible for this variation has been a challenge ever since.

### **1.2 What processes are responsible for those plant and animal species richness patterns?**

Mechanisms hypothesized to affect plant and animal species richness have been the subject of much debate. Mechanisms hypothesized to control richness at relatively small scales might be easier to identify, since those factors are easier to control and to manipulate experimentally. In contrast, when broad scales are considered, the mechanisms affecting patterns of plant and animal species richness can only be addressed with observational (correlational) analyses, since experiments are impossible.

In this study, we consider three important hypotheses regarding the spatial distributions of plant and animal richness. Many authors have hypothesized that species richness depends mainly on climatic factors such as temperature and precipitation (Currie

& Paquin, 1987; Turner *et al.*, 1987; Currie, 1991; Adams & Woodward, 1989; O'Brien, 1993; O'Brien, 1998; Badgley & Fox, 2000; Lennon *et al.*, 2000; O'Brien, 2000). In other cases, the number of plant and animal species has been related to habitat heterogeneity (MacArthur & MacArthur, 1961, Askins & Philbrick, 1987; Kerr & Packer, 1997). Finally, some authors such as Latham and Ricklefs (1993) postulate that differences in evolutionary history are the main influence on the number of plant and animal species.

### **1.3 Climate and richness**

Hutchinson (1959) and others (Brown 1981; Wright 1983; Wright *et al.*, 1993) proposed that the number of individuals in an assemblage depends upon the amount of available energy in a system, and that this, in turn, affects species richness. According to Hutchinson's idea (1959), every organism requires a certain amount of energy to survive and reproduce. A species population requires a minimum number of individuals to avoid extinction. Therefore a population requires a minimum amount of energy. Total richness could, at least in principle, be limited by partitioning of the total available energy among species.

If available energy limits the number of species in an assemblage, then richness should covary with the climatic factors that influence organisms' energy budgets (e.g., temperature and primary productivity) (Currie & Paquin 1987; Currie 1991; Currie & Fritz 1993; Francis & Currie 1998; Kerr & Currie 1999). Specifically, areas with higher temperature and water availability should have higher species richness. Currie and Paquin (1987) for example, found that plant species richness was strongly related to actual

evapotranspiration (AET). Currie and Paquin (1987) argue that the same model could be extended to other regions of the world such as the British Isles. A few years later, Currie (1991) observed that AET and PET (potential evapotranspiration) could also explain between 80% to 93% of animal species richness variability in North America.

A possible mechanism of what controls animal richness is suggested by Rosenzweig and Abramsky (1993), and Gaston (2000). They proposed that animal species depend directly or indirectly on plants, from which they obtain food and dwelling. Vegetation growth depends upon solar radiation and water (precipitation). Therefore, animals depend at least indirectly by the path mentioned above, from temperature and precipitation.

Turner *et al.*, (1987), and Lennon *et al.*, (2000) proposed that, in taxonomic groups whose richness declines in winter (e.g., birds), winter species richness depends upon summer primary productivity that is concentrated in the summer. Therefore richness should relate most strongly to summer climatic conditions. They compared how summer (June-May) and winter (December-February) bird species richness correlate with seasonal climatic conditions. The relationship they found was quite significant explaining 88% of bird richness variation. Simultaneously, Badgley and Fox (2000) observed a similar good relationship between climate and mammal species richness variations. They found that they could explain 77% of richness variation by using different measures for seasonal temperature. When they combined climatic variables with elevation, they could explain up to 88% of total mammal richness variation in North America.

Kleidon and Mooney (2000) proposed a different mechanism by which climate might affect richness. They developed a model that relates plant growth and phenology

to climatic variables (particularly temperature and water) to generate potential spatial distributions of individual plant species. They generated a random set of parameters for a pseudo-species, and they determined the climatic conditions under which this pseudo-species would survive (if any). They then tallied the number of species that would survive in different regions to predict plant species richness as a function of regional climate. Although they did not explicitly test their model against actual data, the qualitative trends their model predicts resemble observed patterns of richness.

#### **1.4 Habitat heterogeneity and species richness**

The availability of different ecological niches has also been hypothesized to control species richness (MacArthur & MacArthur, 1961; Bell *et al.*, 2000). In the case of animals, greater species richness could occur when there are more plant species, distinct habitat types furnished by vegetation (e.g., vegetation layers), or more distinct vegetation assemblages (e.g., along altitudinal gradients). On broad scales, elevational range in a region has been regarded a surrogate for the availability of different niches. For example, Kerr and Packer (1997) showed that mammal species richness is strongly related to variation in elevation in the U.S.

#### **1.5 Time and species richness**

Evolution has presumably produced the plant and animal species present on earth today. Since evolution is a relatively slow process, longer periods of time and higher rates of evolution should therefore lead to higher species richness. Conceivably, regions having different evolutionary histories could therefore have different species richness as a

result of these differences (e.g., Monkkonen & Helle, 1989, Monkkonen, 1992, Monkkonen *et al*, 1992, Latham & Ricklefs, 1993, Monkkonen, 1994, Monkkonen & Viro, 1997) Several authors (Latham and Ricklefs, 1993, Guo, 1999, Qian & Ricklefs, 1999, Ricklefs, 1999) have proposed that richness may depend upon the time available for evolution. The main evidence for these hypotheses is that, after controlling for climate, richness differs significantly among regions of the world. There is a little direct evidence (e.g., corals in the south Pacific Ocean) that richness depends directly upon any measure of evolutionary history (but cf. Stehli and Wells 1971, Fraser and Currie, 1996, Currie and Paquin, 1987, Kerr and Currie, 1999). Although this hypothesis is still currently discussed, we will not consider it further in this study.

### **1.6 The purposes of this study**

Richness is more strongly related to climate than any other factor to date, however, the evidence is entirely correlational. Ideally, the next step would be an experiment that manipulates climate. If richness depended upon climatic variables, then changes in those climatic variables should cause a change in richness. Clearly, a manipulative experiment of this sort is impossible. However, it is possible to observe a natural experiment (*sensu* Diamond, 1986). Climatic variables (i.e., heat and available water) change seasonally, and these changes should be reflected in changing bird species richness if time scale of the response is small enough. Moreover, if climate directly and strongly determines species richness, then the bird species richness-climate relationship should be consistent in different parts of the world.

To test these two predictions, we first describe the bird species richness patterns in North America and northern Central America during winter (December to February) and summer (May to July). We test whether the spatial patterns of richness during the different seasons (winter and summer) relate to temperature, precipitation and the interaction of these two variables in a consistent way. We also test whether the species richness-climatic variables relationship is consistent between North America and northern Central America as a test of its generality.

## Chapter II

### Does climate determine broad-scale patterns of species richness? A test by natural experiment

#### Introduction

Species richness – the number of different species that occurred in a given area – varies enormously from place to place. Over broad spatial scales (quadrat sizes  $>10^4$  m<sup>2</sup>, extending of  $10^3$  –  $10^4$  km), these variations show smooth gradients, with high richness in the humid tropics, and low richness in deserts, high latitudes, and high altitudes. Identifying the factors that regulate these patterns of species richness has been referred to as the Holy Grail of ecology.

Both terrestrial plant and animal species richness covary strongly with climate, and to a lesser extent with topographic variables, over broad scales. Climatic and topographic variables can statistically explain from 70% to  $>90\%$  of the spatial variability in richness (Currie & Paquin, 1987, Turner *et al.* 1987, Currie, 1991, Kerr & Packer, 1997, Badgley & Fox, 2000, Lennon *et al.*, 2000). Moreover, these richness-habitat correlations are very similar in different parts of the globe, even though the evolutionary histories of different regions may differ dramatically (Adams & Woodward 1989, Francis & Currie *in press*).

These strong and consistent statistical relationships suggest that there may also be a causal relationship, i.e., that variations in climatic variables and topography directly or indirectly determine plant and animal species richness. An experiment to test this hypothesis would change climate and/or topography and observe the effect on richness. If climate or topography changed, then richness should change, as contemporary correlations through space would predict. Clearly, a deliberate experiment modifying

broad-scale patterns of climate or topography is impossible. However, it is possible to exploit a “natural experiment” (*sensu* Diamond 1986): to observe seasonal changes in climatic variables and concomitant changes in richness.

The purpose of this study is to test the hypothesis that climate *per se* affects broad-scale patterns of species richness (i.e. that the correlation reflects an underlying causal relationship). Temperature and available water show strong seasonal fluctuations in many parts of the American continent. Richness also changes as birds migrate, mammals hibernate, trees become dormant. Since changes in bird richness are relatively easy to quantify, we first test whether seasonal variations in bird species richness in North America and northern Central America track seasonal changes of temperature and available water (precipitation). Specifically, we test whether the same statistical relationship between richness and climatic variables that exists during the summer persists during the winter.

We also test several competing hypotheses concerning broad-scale patterns of species richness, each of which suggest that a link between richness and climate may not be general. First, Kerr and Packer (1997) observed that, in Currie’s (1991) study of the spatial variation of mammal species across Canada and the United States, richness increased as a function of potential evapotranspiration (PET) only in cold areas (annual  $PET < 1,000 \text{ mm}\cdot\text{yr}^{-1}$ ). In warmer areas (annual  $PET \geq 1,000 \text{ mm}\cdot\text{yr}^{-1}$ ) richness was nearly independent of PET, but elevation statistically explained a significant portion of richness variation. If richness is related to climate only in cold regions, then there is little point in looking for broader richness-climate relationships.

It is possible that richness depends upon availability of energy, primarily in the form of food resources (Hutchinson 1959; Connell & Orias, 1964; Rosenzweig & Abramsky, 1993). Food resources for birds will depend (directly for granivores; indirectly for insectivores and predators) upon primary productivity, which in turn covaries strongly with summer climatic variables (Leith, 1975), Winter bird richness may depend primarily upon resources stored during the summer, as Lennon *et al.*, (2000) suggested for birds in UK. This hypothesis predicts that richness in both seasons should be correlated to summer temperature and precipitation, but that the relationships will differ, with richness at a lower level in winter than in summer.

If richness depends upon primary productivity, then richness may relate to other variables that can potentially affect productivity. For example, Huston (1993) argued (but did not actually show statistically) that plant diversity at the global scale is inversely related to soil fertility: in general, soils in the tropics are poor, but richness is high. Thus, one would expect to see a negative relationship between bird richness and soil nutrients. It is also possible that richness would be more closely related to a more direct measure of the broad-scale differences in vegetation biomass and/or productivity such as the normalized difference vegetation index (NDVI).

Finally, it has also been hypothesised that climatic stability may favour higher species richness by allowing a greater degree of specialization than in variable environments (Klopfer & MacArthur, 1960, *quoted in* Pianka, 1966; Pianka, 1966). Since many birds migrate between summer and winter, differences between summer and winter climatic conditions presumably cannot influence richness within a particular season. However, within-season climatic variability could potentially influence richness

in that season. We therefore also examine the relationship between richness and within-season climatic variability. These ideas are summarized in Table 1.

To test these hypotheses, we tallied species richness of continental bird species in summer and winter using a grid system extending from northern Canada to Nicaragua. We then related these patterns of richness to temperature and available water, soil nutrients, NDVI, and measures of within-season climatic variability.

## Methods

We first built an equal-area grid of 651 quadrats, covering continental North and Central America to as far south as Nicaragua. Quadrats fully on land are equal-area (37,000 km<sup>2</sup>), with 2° latitudinal span and decreasing longitudinal span as they approach the equator (2° at 42°N).

Distribution maps of 1543 exclusively continental bird species (609 for Canada/USA and 934 for Mexico until Nicaragua) were superimposed on the grid system using Idrisi V 2 & 32 (Clark Labs, 1987 and 2000). We tallied the total number of species whose ranges overlapped each quadrat, thus obtaining total species richness per quadrat. We did this for both winter and summer birds. Summer birds were defined as species resident in a particular location during May to July. Winter birds were species whose distribution ranges include a particular location during December to February. Species that stayed year round in a particular location were counted among both the summer and winter birds. We did not consider species on offshore islands, extirpated species, migrants that only pass through a particular location, nor vagrants or accidental visitor species.

We used three sources for distribution range maps for North American and Northern Central American (NCA) birds. For 478 species in Canada and the United States, we used the *Birds of North America* (American Ornithologists' Union, 1992), a collection of monographs on each North American species. We had to complement this source with the National Geographic *Field Guide to the Birds of North America* (1999) for 131 species not yet issued as monographs. For Mexico and the northern Central American countries, we used the *Guide to the Birds of Mexico and Northern Central America* (Howell & Webb, 1995).

Using the same grid system, we extracted environmental variables from several published sources. We calculated mean temperature ( $^{\circ}\text{C}$ ) and the total accumulated precipitation ( $\text{mm month}^{-1}$ ) from Legates and Willmott (1989) for each quadrat for December to February and for May to July. We also calculated the variance and standard deviation of monthly temperature and precipitation for these two periods. Finally, we calculated mean annual temperature ( $^{\circ}\text{C}$ ), and total accumulated precipitation ( $\text{mm}\cdot\text{yr}^{-1}$ ) in each quadrat.

To test whether patterns of bird richness are related to habitat heterogeneity as reflected by topography (cf. Kerr & Packer 1997), we obtained the maximum, minimum, and mean elevation (m) per quadrat from Fleet Numeric Oceanography Center (1985). As a second measure of habitat heterogeneity, we considered the number of different vegetation types per quadrat, based on Leemans' global Holdridge life zones classification (1989), which distinguishes 39 different vegetation types.

To test whether richness depends upon soil nutrient availability (cf. Huston 1993), we used the FAO-UNESCO classification (UNEO/GRID, 1986) units, and we determined the predominant soil type per quadrat. Thereafter, we obtained the cation exchange capacity ( $\text{CEC } \text{meq } 100\text{g}^{-1}$ ) from FAO-UNESCO maps at 1:5,000,000 scale for North America and Central America (1975). We refer to this variable as soil fertility.

To test whether richness depends upon vegetation density or productivity, we determined the mean normalized difference vegetation index (NDVI) from Gallo (1992). NDVI is a measure of the photosynthetically absorbed radiation, derived from measures of visible and near-infrared light observed with AVHRR satellite imagery (Lo Seen Chong *et al.*, 1993). Thus, although NDVI is not a direct measure of vegetation or

primary productivity, the two are highly correlated (Gould, 2000) We calculated NDVI in each quadrat for the winter and summer months, as well as for the whole year

All variables, both dependent and independent, were first transformed to be as close to normality as possible (this way the residuals would show a better normality) Temperature, NDVI, and habitat heterogeneity were reasonably symmetrically distributed, so we left them untransformed We  $\log_{10}$  transformed precipitation and its standard deviation, as well as soil fertility Elevation was cubic root transformed Winter and summer bird species richness were fifth root transformed

To quantify relationships between the geographic variation of environmental descriptors (see appendix figure 1) and bird species richness, we first examined the relationship in bivariate plots to determine their shapes and the distribution of the residuals To determine if there were interactions among variables, we also examined plots of richness as a function of pairs of environmental variables, with contours fitted with distance-weighted least squares Finally, we fitted least-squares multiple regressions to these relationships, adding terms as hypothesis testing dictated (as opposed to using an automated stepwise procedure) All analyses were done using SYSTAT v.10 (SPSS Inc, 2000)

Any geographic data of the type we studied here will entail a degree of spatial autocorrelation We have not explicitly address autocorrelation here However, since the main effect of spatial autocorrelation is to make hypothesis test overly liberal (i e , the number of sample units overestimates the true number of degrees of freedom), we only retained variables in our models with  $p \leq 10^{-4}$

## Results

The spatial pattern of summer bird richness map across North America in our data (Figure 1A) is very similar to that presented by Cook (1969). Our winter bird richness map is similar to the pattern presented by Root (1988) for the United States and southern Canada (Figure 1 B). The small differences between our maps and these earlier ones are probably due to the different quadrat systems and the different sources of bird distribution data used. The highest concentration of bird species richness we observed was during the summer in Mexico in the state of Veracruz (close to Los Tuxtlas biosphere 18.5° N and 95° W). This same area also presents the highest bird species richness during winter.

As earlier work has shown (Currie, 1991), broad-scale patterns of breeding bird richness (i.e., summer richness) are strongly related to annual climate. Summer bird species richness covaries strongly with mean annual temperature (third degree polynomial:  $R^2=0.594$ ,  $n=651$ ,  $p<10^{-5}$ ) and moderately with precipitation (first degree polynomial:  $R^2=0.096$ ,  $n=651$ ,  $p<10^{-5}$ ) (Figure 2 A and B). A multiple regression relating summer bird richness to mean annual temperature, total annual precipitation, and their interaction statistically accounts for 65% of the variance in richness (Table 2, model I). The interaction between temperature and precipitation reflects the fact that richness depends more strongly upon temperature when precipitation is abundant than when it is scarce (Figure 2 C).

## ***I Is richness related to climate only in cold places?***

To test the hypothesis that richness depends upon climate only in cold areas (cf Kerr & Packer, 1997), we divided our study area into quadrats with  $PET \geq 1,000 \text{ mm}\cdot\text{yr}^{-1}$  and quadrats with  $PET < 1,000 \text{ mm}\cdot\text{yr}^{-1}$ . This splits the data at about  $45^\circ\text{N}$  across the continent, and somewhat farther north in low-elevation western areas. We then relate summer bird richness in the two areas to annual temperature, precipitation and elevation, as Kerr and Packer (1997) did.

First, consider only data from Canada and the U S, to be consistent with Currie (1991) and Kerr & Packer (1997). We observe the same pattern that they did: richness appears to be a moderately peaked function of temperature (Figure 3). However, when data from Mexico and northern Central America are included, richness continues to increase with temperature. Further, richness is significantly related to temperature, precipitation and an interaction between the two. This is true in cold areas (following Kerr & Packer: annual  $PET < 1000$ ,  $R^2 = 0.694$ ,  $p < 10^{-5}$ ) (Table 2), warm areas ( $PET \geq 1,000 \text{ mm}\cdot\text{yr}^{-1}$ ) north of Mexico ( $R^2 = 0.542$ ,  $p < 10^{-5}$ ), and warm areas including Mexico and Central America ( $R^2 = 0.418$ ,  $p < 10^{-5}$ ) (Table 2, model III). In sum, richness is not a peaked function of temperature (cf Rosenzweig & Abramsky, 1993) nor does it become independent of climate in warmer areas (Kerr & Packer, 1997).

## ***II Do seasonal changes in richness track seasonal temperature and precipitation?***

According to Bock and Lepthien (1975), and Lennon *et al*, (2000), richness tracks seasonal changes in climatic variables. We find that the patterns of summer and winter richness do relate to the climatic variables in the same season, but the summer and

winter relationships are not congruent (Figures 4 A and B). If richness tracks climate, one would expect the summer and winter patterns of richness as functions of climatic variable to overlap each other. Instead we observe that more species are present in the winter in areas of a given temperature than the summer richness-temperature relationship would predict. When the model relating winter richness and winter climate is used with summer climate to predict summer richness, we observed that richness changes in the direction predicted by changing climate (Figure 4 C), but richness does not solely track seasonal changes in climatic variables, particularly in certain regions of southern North America (e.g., Florida).

### III. *Is winter richness better related to summer climate?*

Why do seasonal changes in richness not track climate? Is it because winter richness depends upon summer conditions, as suggested by Lennon *et al.*, (2000)? We found that winter richness is correlated with summer conditions (Figure 5); however, the relationship is weaker than the relationships with annual conditions and it is comparable to the relationship with winter conditions (model IV, Table 3). Since summer and winter climatic conditions are very strongly correlated with each other (Table 4), it is not surprising that richness correlates to some extent with the conditions in either season.

But might winter richness be related to summer conditions only in cold areas? In the plot of the relationship between winter richness and summer temperature, it appears that the relationship is stronger in cold areas than in warmer areas (Figure 5 B). To test this possibility, we repeated the analyses relating winter richness to summer temperature, precipitation, and their interaction, using only sites where the winter temperature was

colder than  $-15^{\circ}\text{C}$ . We progressively increased the temperature of this break point, and we sought the temperature at which the residual mean squared error was smallest. This was observed at  $-7^{\circ}\text{C}$ . We then split the data set into quadrats warmer, versus colder than  $-7^{\circ}\text{C}$  in winter (roughly, north of  $45^{\circ}\text{N}$  in the East, and north of a diagonal line from southwest Alberta to southern Alaska in the West). We then related winter richness to the summer climatic variables, and to the winter climatic variables in these two areas.

We found that winter richness in areas with cold winters ( $T_{\text{winter}} < -7^{\circ}\text{C}$ ) is most strongly related to summer climatic conditions, somewhat less strongly to annual conditions, and much less strong to winter climate variables (Table 3). Winter richness in areas with warmer winters ( $T_{\text{winter}} \geq -7^{\circ}\text{C}$ ) is better related to annual conditions than to either winter or summer conditions (model V vs VI, Table 3). This is partly consistent with the hypothesis of Lennon *et al.*, (2000), however, it is not obvious that winter richness depends specifically on summer conditions (because winter richness is as closely related to annual variables as it is to summer variables), even in the coldest areas.

#### ***IV. Do seasonal changes in bird species richness track vegetation?***

Are the seasonal changes in bird richness related to changing patterns of vegetation? To test this possibility, we related patterns of richness during summer and winter to the respective levels of NDVI. We find that seasonal richness does relate moderately well to seasonal NDVI (Figure 6). A third degree polynomial function of seasonal NDVI can statistically account for 51.2% of the variability in seasonal species richness ( $p < 10^{-5}$ ). However, once again, the summer and winter patterns are not congruent: for a given level of NDVI, richness is higher in summer than in winter.

When both climate and NDVI are both taken in to account, we find that richness relates very strongly to temperature, precipitation and NDVI in similar, but still distinguishable in summer and winter (Figure 7). There is also a clear pattern in the summer residuals at high levels of richness.

#### ***V. Is bird species richness related to other environmental characteristics?***

Is any of the variability in bird richness might be related to soil fertility as hypothesised by Huston (1993)? We observed that soil fertility (as measured by soil cation exchange capacity) and annual NDVI are weakly negatively related to each other (Spearman  $r=-0.287$ ,  $n=557$ ,  $p<10^{-5}$ ). The correlation between richness and soil fertility is nearly non-existent (Spearman  $r=0.087$ ,  $n=557$ ,  $p=0.04$ ). Inclusion of soil fertility in the model does not significantly reduce the residual sums of squares ( $F_{1,1107}=0.066$ ,  $p=0.80$ ) or reduce the pattern in the residuals. We concluded that bird species richness is not related to soil nutrient levels.

It is often hypothesised that habitat heterogeneity influences patterns of richness. Kerr and Packer (1997) attributed the effect of elevation in their models the increase of habitat heterogeneity in areas with greater differences in relief.

We tested this hypothesis by relating bird diversity to the maximum elevation in a quadrat, the range of elevation, and to the number of different Holdridge life zones per quadrat. However, richness was only weakly related to these variables (number of life zones:  $r^2=0.072$ ; cube root of elevation:  $r^2=0.054$ ), and they did not account for additional variance in richness when added to the model. Therefore, the habitat heterogeneity was not used for further analyses.

Is richness related to climatic stability as Pianka (1966) proposes? We calculated the standard deviation of temperature and precipitation among months within the summer, and within the winter periods (i.e., not the annual variation). We observed that within-season fluctuations of temperature are higher in Canada and USA than farther south in both summer and winter. In contrast, in Mexico and northern Central America, summer fluctuations in precipitation are higher than in the rest of North America. We found that bird richness is negatively related to seasonal variance in temperature, and positively related to variance in precipitation. Richness clearly relates to an interaction between the two variables (Figure 8): richness is high where temperature is stable within seasons, but precipitation varies.

Inclusion of within-season variation of climatic variables along with mean climatic variables, topography, and NDVI yields a regression model that can statistically account for 88.5% of the variance in North and Central American bird species richness distribution (Table 5). In this model (Figure 9), there is no significant residual difference between summer and winter patterns of richness, and there is no obvious pattern in the residuals. There are alternative formulations of the model that do not differ significantly from the one which just considers climatic factors, the interaction between climatic factors, NDVI, and the interaction of NDVI with temperature. Most notably, mean annual precipitation and within-season variance in precipitation are interchangeable.

## **Discussion and conclusions**

The spatial patterns of both richness and climate variables that we observed are very similar to those published in earlier work (e.g., Cook, 1969; Root, 1988), even though we used more recent data sources. We also find, as did earlier work (Schall & Pianka, 1978; Currie, 1991; Kerr & Packer, 1997), that most of the spatial variation in breeding bird species richness can be statistically related to climatic factors: temperature and precipitation.

However, earlier work noted discontinuities in the relationships within continents (Currie, 1991; Kerr & Packer, 1997), and differences in the richness-climate relationships between continents (Schall & Pianka, 1978). In particular, the earlier work suggested that richness depends strongly on temperature in cold places (e.g., Canada), that it is essentially independent of temperature in warm places (e.g., the U.S.), and that it declines in the warmest parts of study areas (e.g., Australia)

In contrast, we found a consistent relationship between breeding bird richness and climate from the arctic to the tropics when we accounted for water, heat, and the interaction between the two. The upper bound to richness continues to increase more or less linearly with temperature (i.e., the highest richness occurs in the warmest places), but the variance of the relationship becomes much larger at high temperatures. The increased variance reflects the interaction between heat and water: richness continues to increase with temperature in warm regions only when there is abundant precipitation. This is essentially equivalent to saying that richness can be limited by either heat or water in warm areas, but only by heat in cold areas. Once this interaction was incorporated into

models, the discontinuities disappear. Earlier studies that report discontinuities in the richness-climate relationships did not take into account this interaction.

This pattern of consistent richness-climate relationships is also true for other organisms. Currie and Paquin (1987) reported that tree richness increased as a plateauing function of actual evapotranspiration in the United States and Canada. Francis and Currie (in press) carried out a study of the global distribution of angiosperm family richness, and they also found a globally consistent relationship between richness and climate characterized by heat, water and an interaction between the two. Kerr and Packer (1997) noted that mammal richness does not increase with PET (or temperature) in the U.S., but clearly mammal richness is higher in warm, wet areas further south (McCoy and Connor, 1980).

If climate were the main driver of patterns of richness, then one would expect to see changes in richness when climatic variables change as Whittaker and Field (2000) imply. Over long time scales, richness should change as a function of global climate change (e.g., Bruun *et al.*, 2001). Over annual cycles, the richness of functionally active organisms can change dramatically (trees exfoliate, mammals hibernate, birds migrate, ectotherms become dormant or even freeze, etc.) Do these changes in richness track climate in a predictable way? We found that, when climatic variables change seasonally, richness changes in the direction that one would predict from climate. This is true even in subtropical areas in Central America, some of which increase in richness in the winter, and some of which decrease. However, the changes are not entirely congruent with changes in mean seasonal climate alone.

It does not appear that this is due to dependence of winter richness on conditions that existed in during the summer (Lennon *et al.*, 2000). Birds in very cold areas clearly do utilize the primary productivity of the previous summer, and the relationship between winter richness and summer conditions is strong in cold areas. However, more broadly, the relationship seems to break down, and it becomes non-significant in regression models that include the factors discussed below.

Rather, we find that the changes in richness between seasons appear to depend upon two additional environmental characteristics: NDVI and within-season climatic stability. Remotely sensed NDVI is a measure of the absorbance of light by foliage, and it has been related both to plant biomass and to plant productivity (Lo Seen Chong *et al.*, 1993; Gould, 2000). Our results suggest that seasonal patterns of bird richness also track changing patterns of vegetation that are not reflected simply in temperature and precipitation.

It is possible that the statistical effects of NDVI and within-season variation in temperature and precipitation actually reflect other variables that differ between summer and winter, but that we did not include in our study. All three of these variables covary with season: NDVI and climatic variability are higher in summer than in winter. However, these variables clearly do more than act as dummy variables in our regressions, since they rectify pattern in the residuals as well as reconciling the difference between summer and winter richness. It is nonetheless possible that these variables may reflect the indirect effects of some other variables.

The relationship between richness and climatic stability shown in Figure 8 suggests that richness is maximal in areas where temperature is seasonally stable, but

where precipitation is variable i.e., in places with a strong rainy period. Flushes of rain and warmth are typically associated with bursts of plant growth and insect abundance, and it is possible that richness is higher in these areas because of greater, or more diverse, resource availability.

Our final model includes a very small effect of elevation (perhaps reflecting habitat heterogeneity), whereas in the earlier models, elevation was non-significant. At more local spatial scales, richness often is related to differences in relief, numbers of vegetation types, or numbers of vegetation layers. These variables have been interpreted as reflecting the number of available niches (MacArthur & MacArthur 1961, Kerr & Packer, 1997, Patterson *et al.*, 1998, Bell *et al.*, 2000). At the broad spatial scales that we have used, it seems likely that large quadrats capture fairly similar amounts of environmental heterogeneity (from an avian point of view). Perhaps quadrats in high elevation areas (which typically also include low valleys) have significantly greater realized heterogeneity. However, habitat heterogeneity study is difficult to quantify adequately when the grain of the study is as large as the one used here. It is certainly possible that habitat heterogeneity would be more important in a study with finer grain and smaller extent (e.g., Willis and Whittaker's 2002).

We find no evidence in support of Huston's (1993) hypothesis that bird richness is related negatively to soil nutrients. Nor did Francis and Currie (in press) find evidence that angiosperm richness is related to soil fertility. Huston's argument was that richness is low in areas of high primary productivity. To the extent that NDVI is a measure of productivity, we found exactly the opposite. Moreover, the patterns of NDVI are

collinear with climate, but they are largely independent of soil nutrients at the scale of this study.

In conclusion, our regression models are consistent with the hypothesis that patterns of bird richness track changes in temperature, precipitation and vegetation over seasonal time scales. Fundamentally, this is a correlative study. Thus, we are reluctant to ascribe causal interpretations to individual elements of the model. Nonetheless, this study represents a “natural experiment” testing the hypothesis that climate has a causal connection with species richness. It had been observed many times earlier that richness was correlated with climatic variables. Here we show that richness changes as climatic variables change in a manner consistent with the spatial correlations.

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A



B

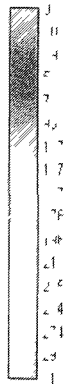
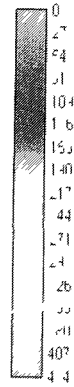


Figure 1. Distribution maps of bird species richness in North and Central America. Summer (A) and winter (B) bird species richness maps are similar to those presented by Cook (1969) and Root (1988) respectively.

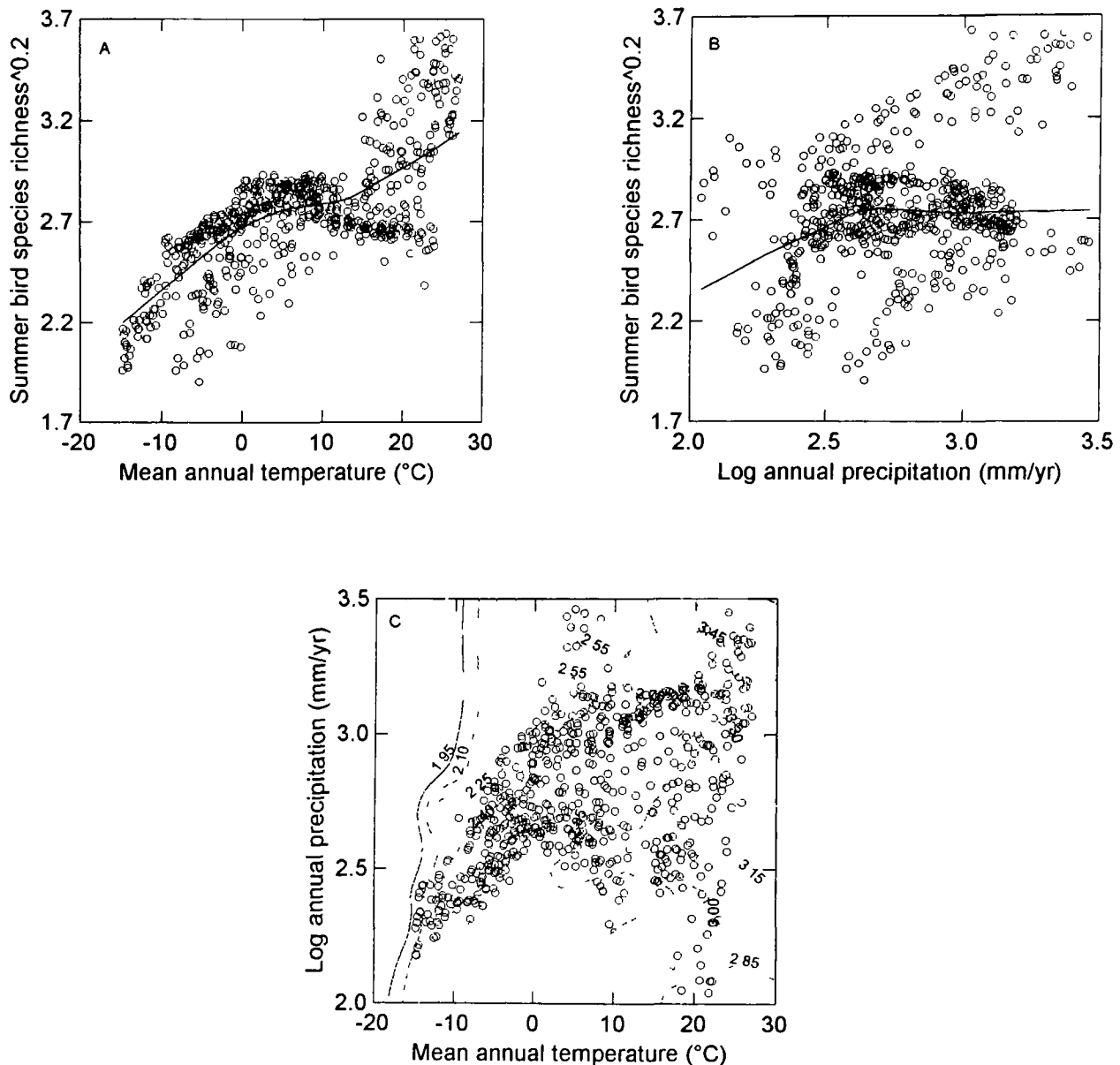


Figure 2. (A) Summer (i.e., breeding) bird species richness vs mean annual temperature (B) Summer bird species richness vs. total annual precipitation. The solid lines represent the underlying trend fitted by LOWESS regression (locally weighted sum of squares) (C) Summer bird richness as function of both annual temperature and precipitation. Isopleths (generated by DWLS -- distance-weighted least squares regression) connect conditions of equal expected species richness. Note that the essentially vertical isopleths at low temperature indicate that richness is independent of precipitation, whereas the diagonal isopleths in the upper right quadrant show that richness depends on both temperature and precipitation at high temperature.

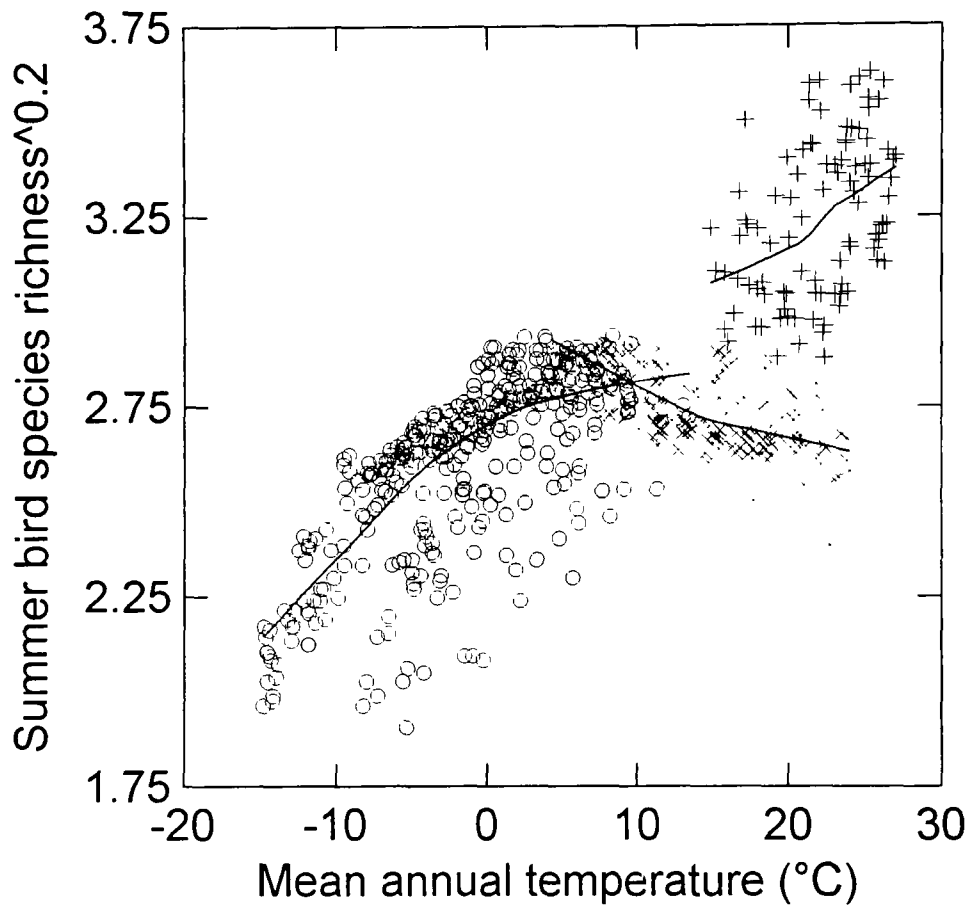


Figure 3. The relationship between summer (i.e., breeding) bird species richness and mean annual temperature in areas of Canada and the United States where annual potential evapotranspiration (PET) is  $<1000 \text{ mm}\cdot\text{yr}^{-1}$  (o), in areas of Canada and the U.S. where PET is  $\geq 1000 \text{ mm}\cdot\text{yr}^{-1}$  (x), and in Mexico and northern Central America (+). The lines are LOWESS trend lines fitted to each of the data subsets. Although earlier results (Currie 1991, Kerr and Packer 1997) suggested that richness was a peaked or saturating function of heat-related variables (PET or temperature), a more complete data set shows that richness continues to increase with temperature

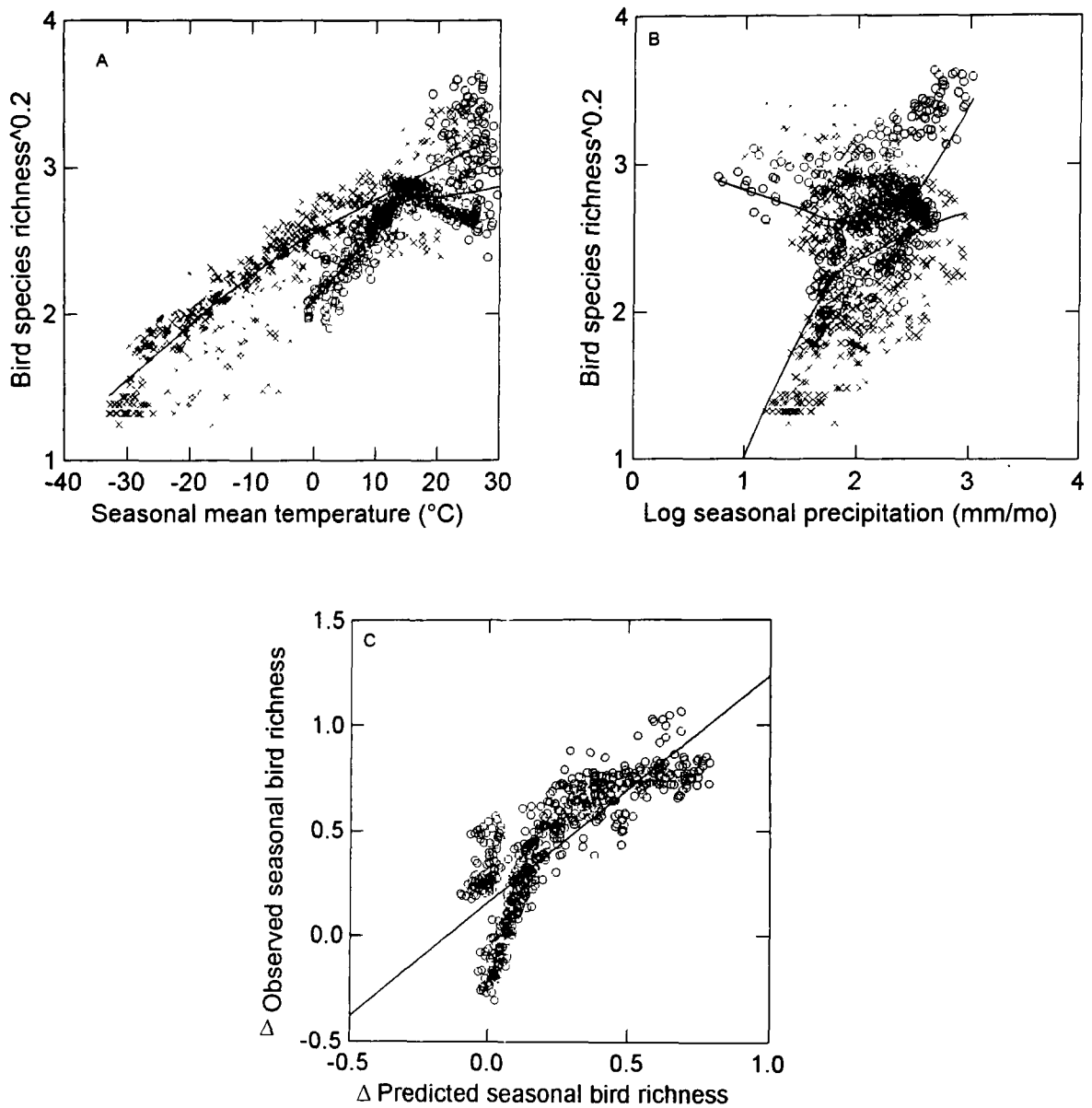


Figure 4. (A) Summer and winter bird species richness as a function of seasonal temperature in summer (o) and winter (x). (B) Summer and winter bird species richness as a function of seasonal precipitation in summer (o) and winter (x). (C) The difference ( $\Delta$ ) between observed summer and winter bird species richness vs. the difference ( $\Delta$ ) between predicted summer and winter richness predicted from the winter richness-climate model (the line represents a 1:1 line). Patterns of summer and winter richness as functions of climate are close, but they are not congruent. Richness changes from winter to summer in the direction one would expect based on the change in climatic variables, but there is clear pattern in the residuals.

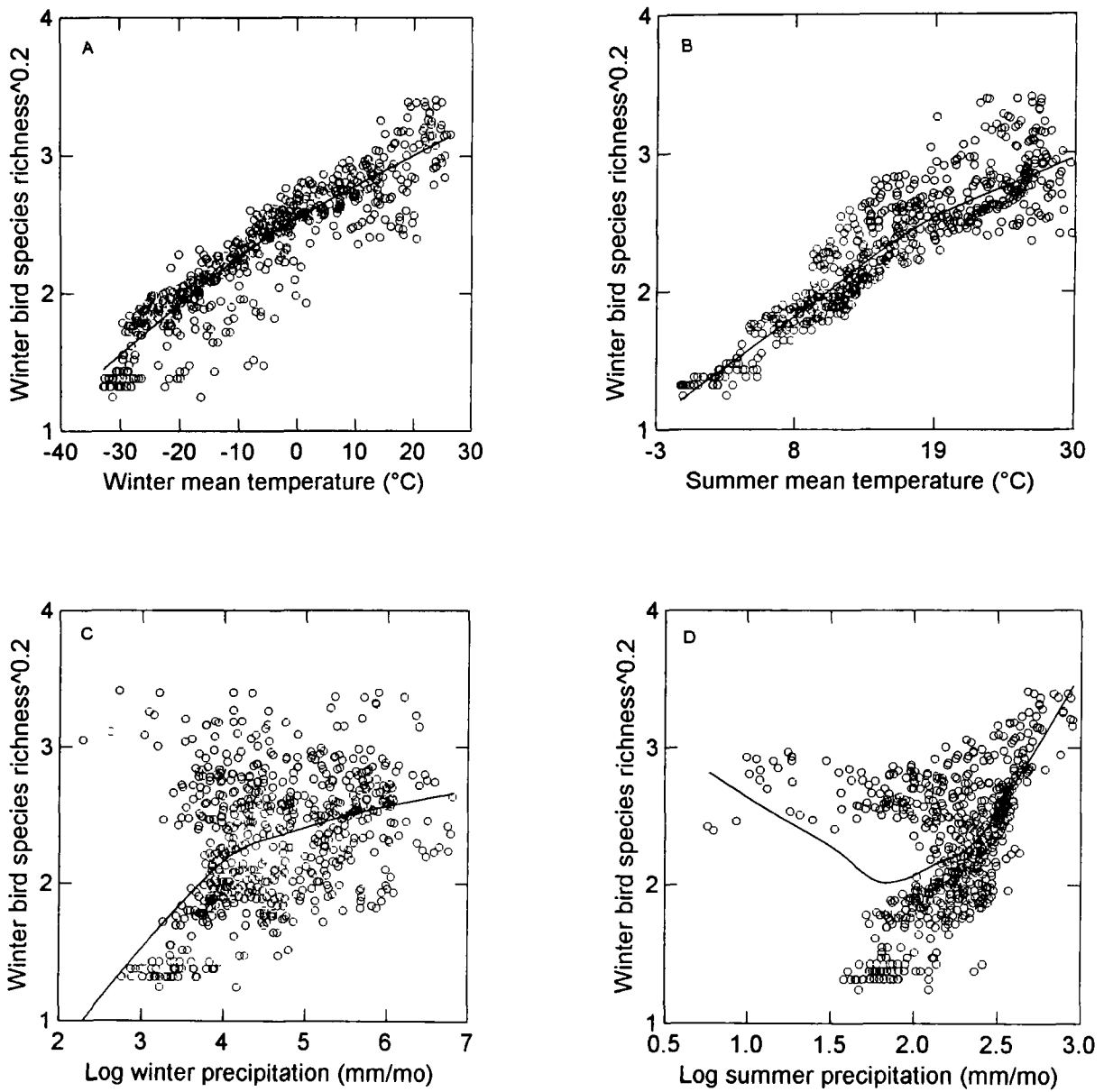


Figure 5. Plots of winter bird species richness vs. winter (A) and summer (B) temperature. Winter bird species richness vs. winter (C) and summer (D) precipitation

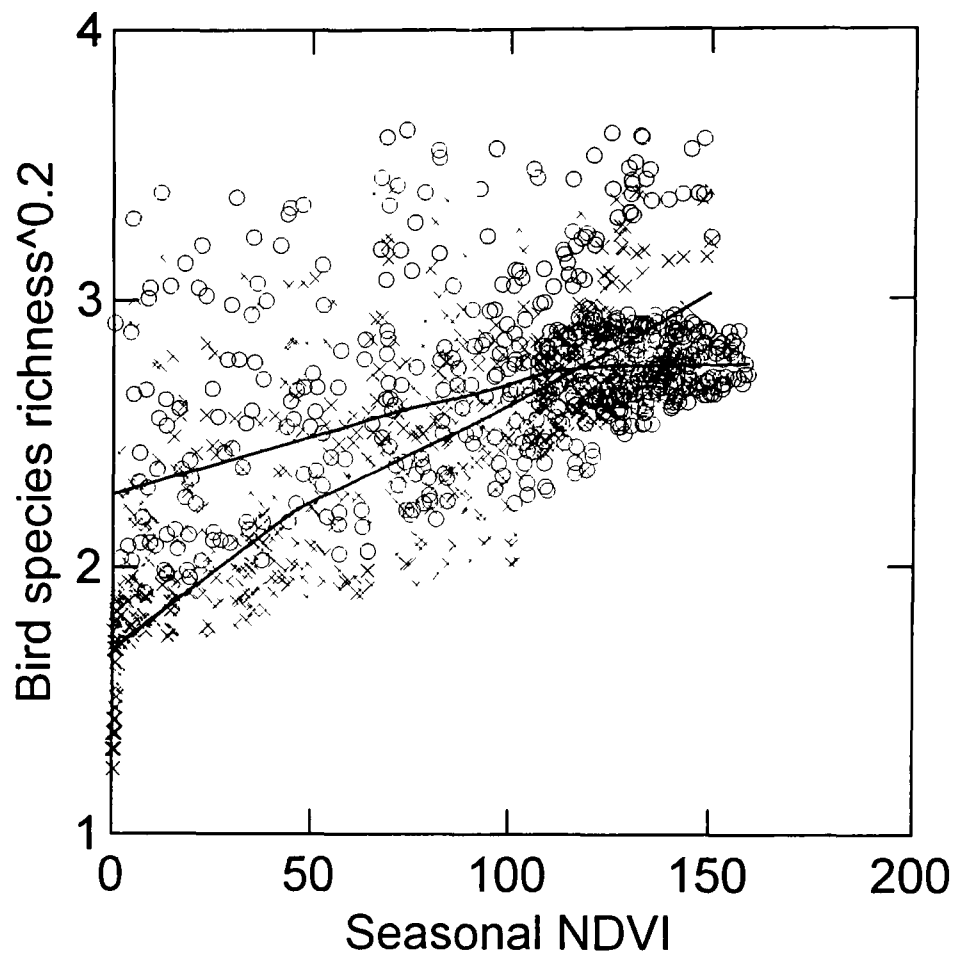


Figure 6. Bird species richness during summer (o) and winter (x) as functions of the NDVI during the corresponding season. The lines represent LOWESS trend lines (summer – upper, winter – lower).

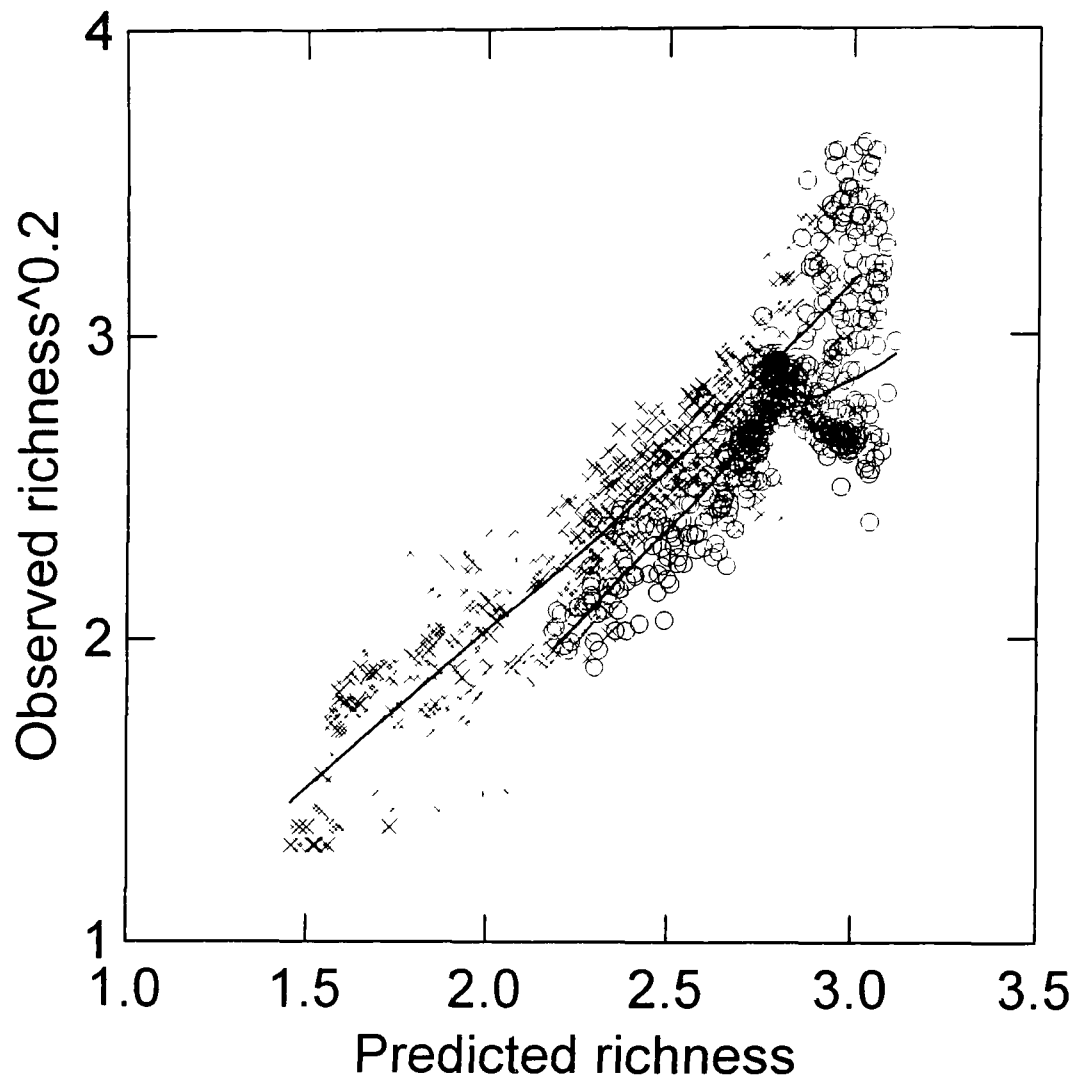


Figure 7 Observed bird species richness versus the predicted values of temperature, precipitation and NDVI during the summer (o) and the winter (x) There remains clear pattern in the residuals in areas of high summer richness

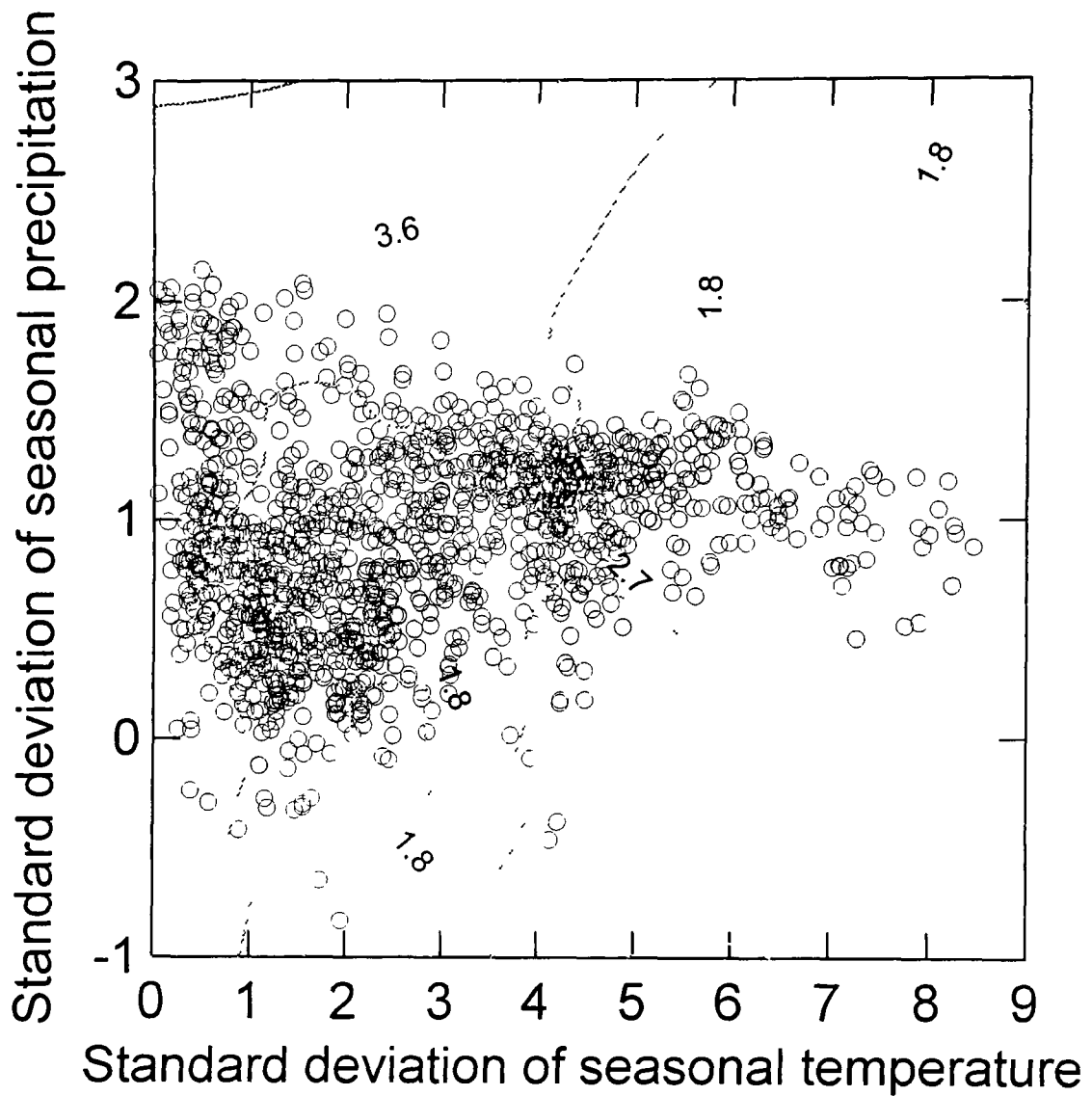


Figure 8 Fifth root transformed seasonal bird species richness as a function of the interaction of the standard deviation of  $\log_{10}$  transformed seasonal precipitation and seasonal temperature. According to this graph bird species richness increases with within-season variability of precipitation, but only in areas of stable temperature.

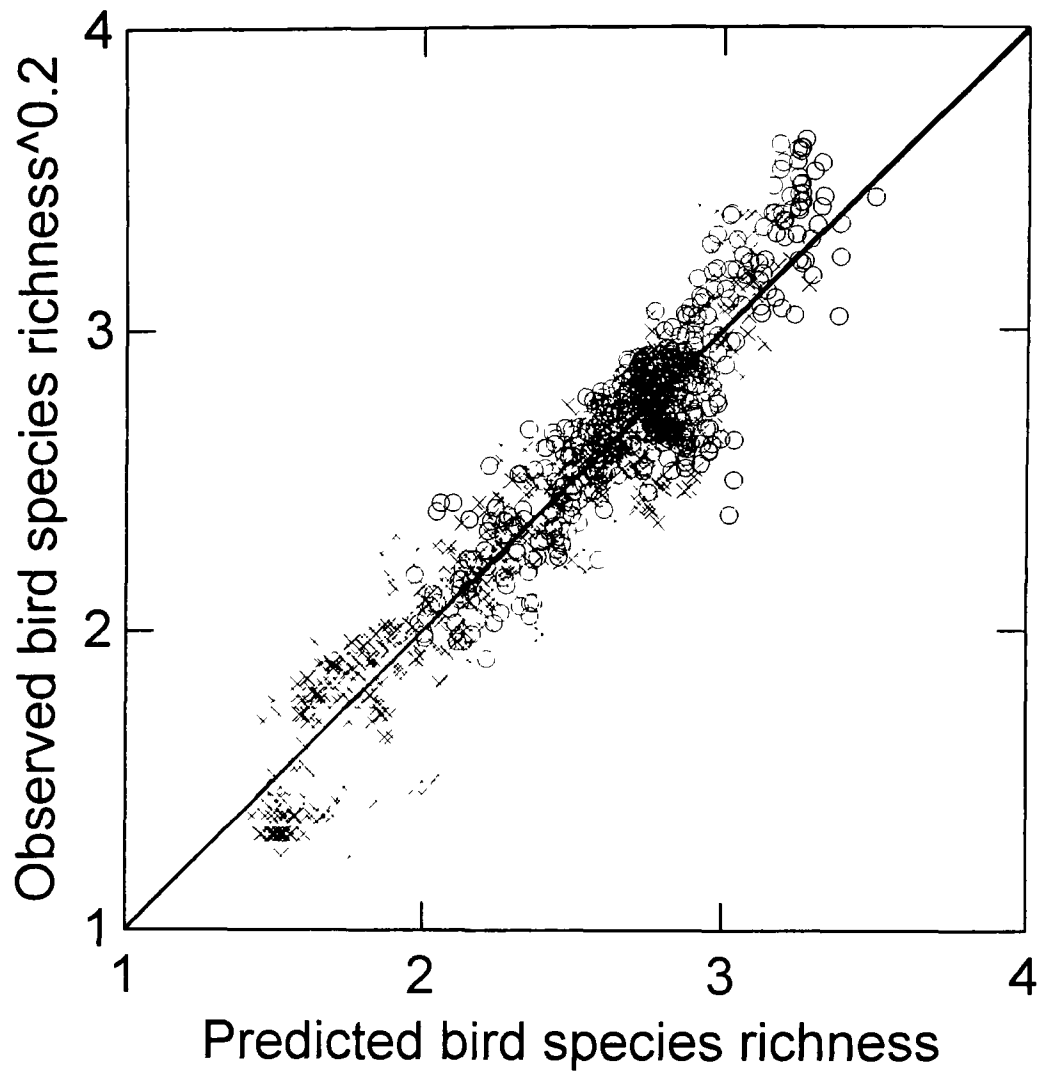


Figure 9. Observed species vs. values predicted from seasonal climate and NDVI, climate variability, and topography. In the graph it can be observed how winter (x) and summer (o) bird species richness fit into a single line. Climatic variables, topography, and NDVI yield a regression model that can statistically account for 88.5% of the variation in seasonal bird richness.

TABLE 1

## Subsidiary hypotheses that might influence bird species richness in North America and northern Central America

Hypothesis	Related factors
1.I.- Elevation is the only term accounting for mammal species richness in warm places where $PET < 1.000 \text{ mmyr}^{-1}$ (Kerr & Packer, 1997).	Topography
1.II.-Relief differences promote habitat complexity and consequently increase mammal species richness (Kerr & Packer, 1997).	Topography
2- Summer temperature is a good indicator for summer as well for winter bird species richness (Lennon <i>et al.</i> , 2000)	Climate
3.- Primary productivity is strongly related with animal species richness (Connell and Orias, 1964; Rosenzweig, 1992; Rosenzweig and Abramsky, 1993; Rosenzweig and Sandlin, 1997)	Niche resource
4.- Soil fertility is inversely related with plant diversity (Huston, 1993), and we might be able to extrapolate the same inversely relation with bird species richness.	Geology
5.- Climatic stability may favour higher species richness (Pianka, 1966)	Climate

TABLE 2

A comparison of models testing the hypotheses of Kerr and Packer (1997) that richness relates to climate only in relatively cold areas (annual PET < 1,000 mm·yr<sup>-1</sup>) whereas richness in warmer areas relates primarily to elevation. The models shown relate summer species richness to temperature (T), precipitation (P) and their interaction in areas having annual PET < 1,000 mm·yr<sup>-1</sup> versus areas with PET ≥ 1,000 mm·yr<sup>-1</sup>. All independent variables are significant at p ≤ 10<sup>-3</sup>. Richness still depends upon climate even in warm areas.

Model	Dependent variable	Independent variables	R <sup>2</sup>	RMSE*	F	n
I	SR <sub>SUMMER</sub>	T <sub>annual</sub> + T <sub>annual</sub> <sup>2</sup> + T <sub>annual</sub> <sup>3</sup> + T <sub>annual</sub> *P <sub>annual</sub> + P <sub>annual</sub>	0.653	0.031	243.48	651
II	SR <sub>SUMMER</sub> where PET <sub>annual</sub> < 1,000 mm yr <sup>-1</sup>	T <sub>annual</sub> + T <sub>annual</sub> <sup>2</sup> + T <sub>annual</sub> *P <sub>annual</sub> + P <sub>annual</sub>	0.694	0.017	213.52	382
III	SR <sub>SUMMER</sub> where PET <sub>annual</sub> ≥ 1,000 mm yr <sup>-1</sup>	T <sub>annual</sub> + T <sub>annual</sub> <sup>2</sup> + T <sub>annual</sub> *P <sub>annual</sub> + P <sub>annual</sub>	0.418	0.046	47.33	269

\*RMSE = Residual mean square error

TABLE 3

A comparison of models relating winter species richness to climate variables (temperature –T, precipitation –P, and their interaction) during the summer (May to July), the winter (January to March) or the entire year in cold areas (winter temperature less than -7°C) and warm areas (winter temperature above -7°C) In each case, we fitted species richness as a function of T, T<sup>2</sup>, T<sup>3</sup>, P, and P\*T All of the terms remain significant (p<0.05) in these models except those noted in the numbered footnotes Models designated with the same superscripts under the heading “Independent variable” do not differ significantly (p>0.05) from one another in their mean squared residual error

RMSE\*=Residual mean square error Winter richness does not depend significantly more strongly on summer conditions

Model	Dependent variable	Independent variables	R <sup>2</sup>	RMSE*	F	n
IV	SR <sub>WINTER</sub>	Summer	0.849*	0.036	725.9	651
		Winter	0.848*	0.036	720.6	651
		Annual	0.907	0.022	1260.6	651
		Summer <sup>a(2)</sup>	0.862*	0.013	470.3	307
V	SR <sub>WINTER</sub> , where T <sub>winter</sub> < -7°C	Winter <sup>b</sup>	0.634*	0.035	104.4	307
		Annual <sup>a(1)</sup>	0.832	0.016	374.7	307
		Summer <sup>c</sup>	0.546	0.036	81.1	344
VI	SR <sub>WINTER</sub> , where T <sub>winter</sub> ≥ -7°C	Winter <sup>c</sup>	0.584	0.033	94.9	344
		Annual <sup>d</sup>	0.682	0.016	145.0	344

\*The residuals from these models were strongly heteroscedastic

<sup>1</sup>=T<sub>annual</sub><sup>3</sup> was not statistically significant

<sup>2</sup>=T<sub>summer</sub>\*P<sub>summer</sub> was not statistically significant

TABLE 4

Spearman rank correlations observed between summer and winter bird species richness (SR), temperature (T) and precipitation (P).

	SR <sub>summer</sub>	SR <sub>winter</sub>	T <sub>annual</sub>	T <sub>summer</sub>
SR <sub>winter</sub>	0.821			
T <sub>annual</sub>	0.660	0.943		
T <sub>summer</sub>	0.669	0.909	0.959	
T <sub>winter</sub>	0.625	0.928	0.987	0.906

	SR <sub>summer</sub>	SR <sub>winter</sub>	P <sub>annual</sub>	P <sub>summer</sub>
P <sub>annual</sub>	0.162	0.449		
P <sub>summer</sub>	0.209	0.420	0.893	
P <sub>winter</sub>	0.081	0.354	0.779	0.520

TABLE 5

Seasonal species richness (SR) variation is mostly explained by climatic factors (temperature –T- and precipitation –P) followed by elevation (E), NDVI, and the log<sub>10</sub> standard deviation of precipitation, and its interaction with standard deviation of temperature. This model has an R<sup>2</sup>=0.88, there is no significant residual difference between summer and winter patterns of richness, and there is no obvious pattern in the residuals (n=1302, F=1241.5, and Residual mean square error =0.023).

Model	Dependent variable	Coefficients	Standardized coefficients	Independent variables	t
VII	SR	-1.35	-48.09	T <sub>seasonal</sub>	-4.87
		4.9X10 <sup>-04</sup>	97.16	T <sub>seasonal</sub> <sup>2</sup>	4.93
		-6.01X10 <sup>-07</sup>	-48.14	T <sub>seasonal</sub> <sup>3</sup>	-4.89
		1.72X10 <sup>-01</sup>	0.17	(log <sub>10</sub> )STDV P <sub>seasonal</sub>	12.87
		-5.19X10 <sup>-02</sup>	-0.26	STDV T <sub>seasonal</sub> *(log <sub>10</sub> )STDV P <sub>seasonal</sub>	-21.1
		2.7X10 <sup>-03</sup>	0.17	E <sup>0.33</sup>	16.35
		3.3X10 <sup>-03</sup>	3.57	NDVI <sub>seasonal</sub>	12.03
		-1.15X10 <sup>-05</sup>	-3.56	T <sub>seasonal</sub> *NDVI <sub>seasonal</sub>	-11.6

All the terms in the model show a P≤10<sup>-5</sup>

## 2.6 Appendix

### Geographic variation of independent variables.

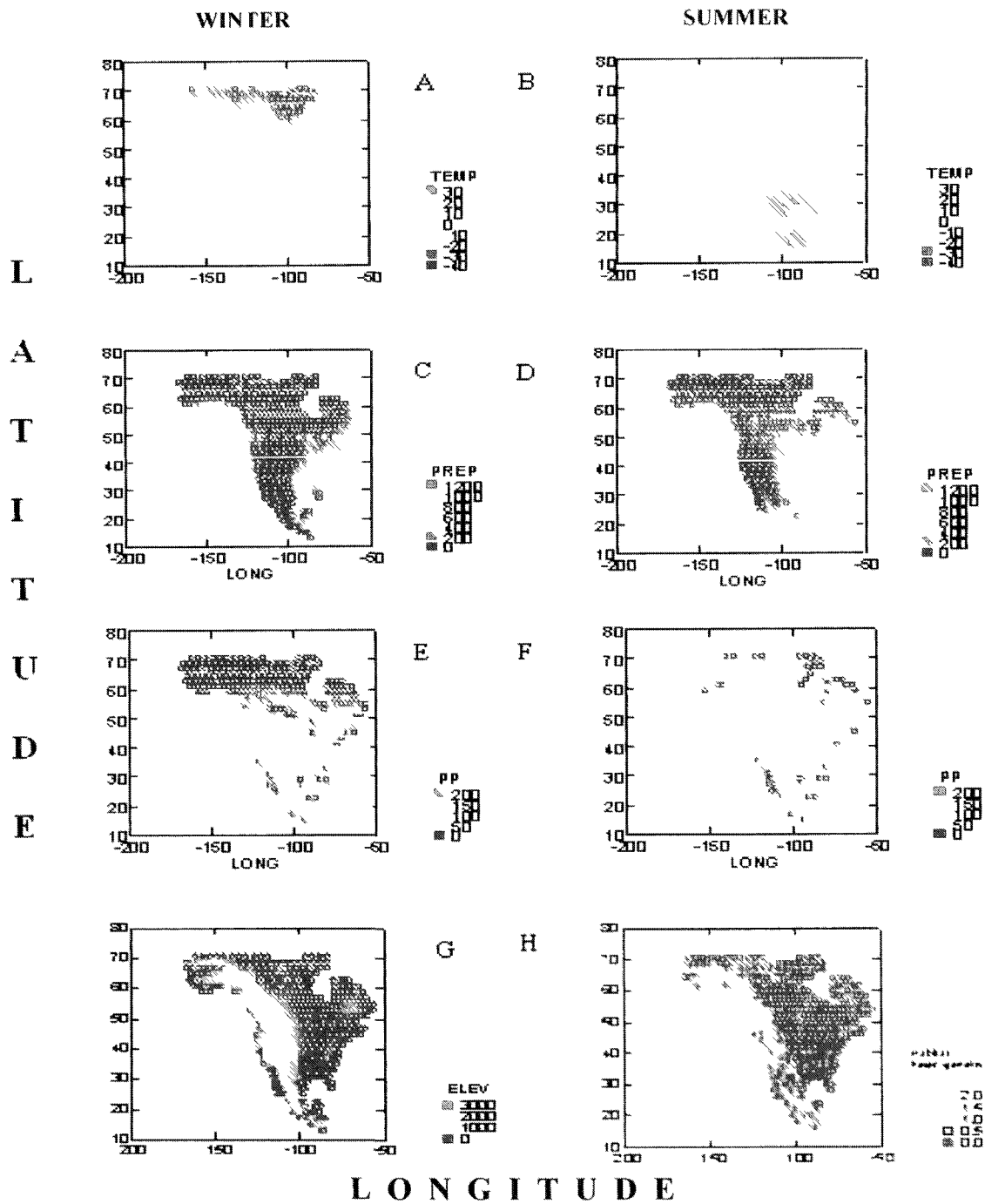


Figure 1 Environmental descriptors (before transformed) and their geographical variation in North America and Northern Central America A, B Winter and summer monthly mean temperature ( $^{\circ}\text{C}$ ) C, D Winter and summer monthly accumulated precipitation ( $\text{mm mo}^{-1}$ ) (We calculated and used temperature and precipitation standard deviations which were included in the developed model) E, F Winter and summer monthly mean primary productivity measured using NDVI (PP) G Mean elevation (m) H Habitat heterogeneity measured base on Shannon-Wiener equation (HDSW)

List of North American and Northern Central American bird species considered in this study.

**Mexico/Northern Central America (Nicaragua).**

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
<i>Abeillia abeillei</i>	x	x
<i>Accipiter bicolor</i>	x	x
<i>A. chionogaster</i>	x	x
<i>A. cooperi</i>	x	x
<i>A. gentilis</i>	x	x
<i>A. striatus</i>	x	x
<i>Actitis macularia</i>		x
<i>Aechmophorus clarkii</i>	x	x
<i>A. occidentalis</i>	x	x
<i>Aegolius acadicus</i>	x	x
<i>A. ridgwayi</i>	x	x
<i>Aeronautes saxatalis</i>	x	x
<i>Agamia agami</i>	x	x
<i>Agelaius phoeniceus</i>	x	x
<i>A. tricolor</i>	x	x
<i>Aimophila botterii</i>	x	x
<i>A. carpalis</i>	x	x
<i>A. cassinii</i>	x	x
<i>A. humeralis</i>	x	x
<i>A. mystacalis</i>	x	x
<i>A. notosticta</i>	x	x
<i>A. quinquestriata</i>	x	x
<i>A. rufescens</i>	x	x
<i>A. ruficauda</i>	x	x
<i>A. ruficeps</i>	x	x
<i>A. sumichrasti</i>	x	x
<i>Aix sponsa</i>		x
<i>Amaurolimnas concolor</i>	x	x
<i>Amaurospiza concolor</i>	x	x
<i>A. relictata</i>	x	x
<i>Amazilia beryllina</i>	x	x
<i>A. candida</i>	x	x
<i>A. cyanocephala</i>	x	x
<i>A. cyanura</i>	x	x
<i>A. luciae</i>	x	x
<i>A. rutila</i>	x	x
<i>A. tzacatl</i>	x	x
<i>A. violiceps</i>	x	x
<i>A. viridifrons</i>	x	x
<i>A. wagneri</i>	x	x
<i>A. yucatanensis</i>	x	x
<i>Amazona albifrons</i>	x	x
<i>A. auropalliata</i>	x	x
<i>A. autumnalis</i>	x	x
<i>A. farinosa</i>	x	x
<i>A. finschi</i>	x	x
<i>A. oratrix</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
A. viridigenalis	x	x
A. xantholora	x	x
Amblycercus holosericeus	x	x
Ammodrammus baileyi	x	x
A. bairdii		x
A. sandwichensis	x	x
A. savannarum	x	x
Amphispiza belli	x	x
A. bilineata	x	x
Anabacerthia variegaticeps	x	x
Anas acuta		x
A. americana		x
A. crecca		x
A. clypeata		x
A. cyanoptera	x	x
A. diazi	x	x
A. discors	x	x
A. fulvigula	x	x
A. platyrhynchos	x	x
A. strepera		x
Anhinga anhinga	x	x
Anser albifrons		x
A. caerulescens		x
A. rossii		x
Anthracothorax prevostii	x	x
Anthus rubescens	x	x
A. spragueii		x
Aphelocoma coerulescens	x	x
A. ultramarina	x	x
A. unicolor	x	x
Aphriza virgata		x
Aquila chrysaetos	x	x
Ara macao	x	x
A. militaris	x	x
Aramides axillaris	x	x
A. cajanea	x	x
Aramus guarauna	x	x
Aratinga astec	x	x
A. canicularis	x	x
A. holochlora	x	x
A. rubritorques	x	x
A. streuna	x	x
Archilochus alexandri	x	x
A. anna	x	x
A. calliope	x	x
A. colubris		x
A. costae	x	x
Ardea herodias	x	x
Arenaria interpres		x
A. melanocephala		x
Arremon aurantirostris	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Arremonops chlorontous	x	x
A. rufivirgatus	x	x
Asio clamator	x	x
A. flammeus		x
A. otus	x	x
A. stygius	x	x
Asphata gularis	x	x
Athene cucularia	x	x
Atlapetes albinucha	x	x
A. brunneinucha	x	x
A. gutturalis	x	x
A. pileatus	x	x
A. virenticeps	x	x
Attila spadiceus	x	x
Aulaconrhynchus prasinus	x	x
Auriparus flaviceps	x	x
Automolus ochrolaemus	x	x
A. rubiginosus	x	x
Aythya affinis		x
A. americana	x	x
A. collaris		x
A. valisineria		x
Basileuterus belli	x	x
B. culicivorus	x	x
B. delatitri	x	x
B. lachrymosa	x	x
B. rufifrons	x	x
Basilinna leucotis	x	x
B. xantusii	x	x
Bolborhynchus lineola	x	x
Bombycilla cedrorum		x
Botaurus lentiginosus	x	x
B. pinnatus	x	x
Branta bernicla		x
B. canadensis		x
Brotogeris jugularis	x	x
Bubo virginianus	x	x
Bubulcus ibis	x	x
Bucephala albeola		x
B. clangula		x
Burhinus bistratus	x	x
Busarellus nigricollis	x	x
Buteo albicaudatus	x	x
B. albonotatus	x	x
B. brachyurus	x	x
B. jamaicensis	x	x
B. lagopus		x
B. lineatus	x	x
B. magnirostris	x	x
B. nitidus	x	x
B. platypterus		x

<i>Bird species</i>	Winter	Summer
<i>B. regalis</i>		X
<i>B. swainsoni</i>	X	X
<i>Buteogallus urubitinga</i>	X	X
<i>Butorides virescens</i>	X	X
<i>Cacicus melanicterus</i>	X	X
<i>Cairina moschata</i>	X	X
<i>Calamospiza melanocorys</i>		X
<i>Calcarius mccownii</i>		X
<i>C. ornatus</i>		X
<i>Calidris alba</i>		X
<i>C. alpina</i>		X
<i>C. canutus</i>		X
<i>C. himantopus</i>		X
<i>C. mauri</i>		X
<i>C. minutilla</i>		X
<i>C. pusilla</i>		X
<i>Callipepla californica</i>	X	X
<i>C. douglasii</i>	X	X
<i>C. gambelii</i>	X	X
<i>C. picta</i>	X	X
<i>C. squamata</i>	X	X
<i>Calocitta formosa</i>	X	X
<i>C. colliei</i>	X	X
<i>Calothorax eliza</i>	X	X
<i>C. enicura</i>	X	X
<i>C. lucifer</i>	X	X
<i>C. pulcher</i>	X	X
<i>Campephilus guatemalensis</i>	X	X
<i>Camptostoma imberbe</i>	X	X
<i>Campylopterus curvipennis</i>	X	X
<i>C. excellens</i>	X	X
<i>C. hemileucurus</i>	X	X
<i>C. rufus</i>	X	X
<i>Campylorhynchus brunneicapilus</i>	X	X
<i>C. chapensis</i>	X	X
<i>C. gularis</i>	X	X
<i>C. jocosus</i>	X	X
<i>C. megalopterus</i>	X	X
<i>C. rufinucha</i>	X	X
<i>C. yucatanicus</i>	X	X
<i>C. zonatus</i>	X	X
<i>Caprimulgus arizonae</i>	X	X
<i>C. badius</i>	X	X
<i>C. carolinensis</i>		X
<i>C. maculicaudus</i>	X	X
<i>C. ridgwayi</i>	X	X
<i>C. salvini</i>	X	X
<i>C. vociferus</i>		X
<i>Caracara plancus</i>	X	X
<i>Cardellina rubrifrons</i>	X	X
<i>Cardinalis cardinalis</i>	X	X

<i>Bird species</i>	Winter	Summer
<i>C sinuatus</i>	x	x
<i>Carduelis atnceps</i>	x	x
<i>C lawrencei</i>	x	x
<i>C notata</i>	x	x
<i>C pinus</i>	x	x
<i>C psaltna</i>	x	x
<i>C trstis</i>		x
<i>Carpodacus cassinii</i>	x	x
<i>C mexicanus</i>	x	x
<i>C purpureus</i>		x
<i>Caryothraustes polioaster</i>	x	x
<i>Cathartes aura</i>	x	x
<i>C burrovianus</i>	x	x
<i>Catharus aurantirostris</i>	x	x
<i>C dryas</i>	x	x
<i>C frantzii</i>	x	x
<i>C guttatus</i>	x	x
<i>C mexicanus</i>	x	x
<i>C mustelinus</i>		x
<i>C occidentalis</i>	x	x
<i>C ustulatus</i>		x
<i>Catherpes mexicanus</i>	x	x
<i>Catoptrophorus semipalmatus</i>		x
<i>Celues castaneus</i>	x	x
<i>Centurus aurifrons</i>	x	x
<i>C chrysogenys</i>	x	x
<i>C hoffmannii</i>	x	x
<i>C hypopoli</i>	x	x
<i>C pucherani</i>	x	x
<i>C pygmaeus</i>	x	x
<i>C urppygialis</i>	x	x
<i>Cercomacra tyrannina</i>	x	x
<i>Certhia amencana</i>	x	x
<i>Ceryle alcyon</i>		x
<i>C torquata</i>	x	x
<i>Chaetura vauxi</i>	x	x
<i>Chamaea fasciata</i>	x	x
<i>Chamaethlypis poliocephala</i>	x	x
<i>Charadrius alexandrinus</i>	x	x
<i>C collans</i>	x	x
<i>C melodus</i>		x
<i>C montanus</i>		x
<i>C semipalmatus</i>		x
<i>C vociferus</i>	x	x
<i>C wilsonia</i>	x	x
<i>Chiroxiphia linearis</i>	x	x
<i>Chloroceryle aenea</i>	x	x
<i>C amazona</i>	x	x
<i>C amencana</i>	x	x
<i>Chlorophanes spiza</i>	x	x
<i>Chlorophonia occipitalis</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Chlorospingus ophthalmicus	x	x
Chlorostilbon auriceps	x	x
C. canivetii	x	x
C. salvini	x	x
Chondestes grammacus	x	x
Chondrohierax uncinatus	x	x
Chrodeiles acutipennis	x	x
C. gundlachii	x	x
C. minor	x	x
Cinclus mexicanus	x	x
Circus cyaneus	x	x
Cistothorus palustris	x	x
C. platensis	x	x
Claravis mondetoura	x	x
C. pretiosa	x	x
Coccothraustes abeillei	x	x
C. vespertinus	x	x
Coccyzus americanus	x	x
C. minor	x	x
Cochlearius cochlearius	x	x
Coereba flaveola	x	x
Colaptes auratus	x	x
Colibri delphinae	x	x
C. thalassinus	x	x
Colinus leucopogon	x	x
C. nigrogularis	x	x
C. virginianus	x	x
Columba cayennensis	x	x
C. fasciata	x	x
C. flavirostris	x	x
C. leucocephala	x	x
C. livia	x	x
C. nigrirostris	x	x
C. speciosa	x	x
Columbina inca	x	x
C. minuta	x	x
C. passerina	x	x
C. talpacoti	x	x
Contopus borealis	x	x
C. cinereus	x	x
C. pertinax	x	x
C. sordidilus	x	x
Coragyps atratus	x	x
Corvus brachyrhynchos	x	x
C. corax	x	x
C. cryptoleucus	x	x
C. imparatus	x	x
C. sinaloae	x	x
Cotinga amabilis	x	x
Coturnicops noveboracensis	x	x
Crax rubra	x	x

<i>Bird species</i>	Winter	Summer
<i>Crotophaga ani</i>	x	x
<i>C. sulcirostris</i>	x	x
<i>Crypturellus boucardi</i>	x	x
<i>C. cinnamomeus</i>	x	x
<i>C. soui</i>	x	x
<i>Cyanerpes cyaneus</i>	x	x
<i>C. lucidus</i>	x	x
<i>Cyanocitta stelleri</i>	x	x
<i>Cyanocompsa cyanoides</i>	x	x
<i>C. perellina</i>	x	x
<i>Cyanocorax beecheii</i>	x	x
<i>C. dickeyi</i>	x	x
<i>C. melanocyaneus</i>	x	x
<i>C. morio</i>	x	x
<i>C. sanblasianus</i>	x	x
<i>C. yucatanicus</i>	x	x
<i>C. yncas</i>	x	x
<i>Cyanolyca cucullata</i>	x	x
<i>C. mirabilis</i>	x	x
<i>C. nana</i>	x	x
<i>C. pumilo</i>	x	x
<i>Cyclarhis guajanensis</i>	x	x
<i>Cygnus colombianus</i>		x
<i>Cynanthus doubledayi</i>	x	x
<i>C. latirostris</i>	x	x
<i>C. sordidus</i>	x	x
<i>Cypseloides cryptus</i>	x	x
<i>C. niger</i>	x	x
<i>C. rutilus</i>	x	x
<i>Cyrtonyx montezumae</i>	x	x
<i>C. ocellatus</i>	x	x
<i>Dactylortyx thoracicus</i>	x	x
<i>Daptrius americanus</i>	x	x
<i>Deltarhynchus flammulatus</i>	x	x
<i>Dendrocincla anabatina</i>	x	x
<i>D. homochroa</i>	x	x
<i>Dendrocolaptes certhia</i>	x	x
<i>D. picummus</i>	x	x
<i>Dendrocygna autumnalis</i>	x	x
<i>D. bicolor</i>	x	x
<i>Dendroica auduboni</i>	x	x
<i>D. caerulescens</i>		x
<i>D. chrysoparia</i>		x
<i>D. coronata</i>		x
<i>D. discolor</i>		x
<i>D. dominica</i>		x
<i>D. goldmani</i>	x	x
<i>D. graciae</i>	x	x
<i>D. magnolia</i>		x
<i>D. nigriscens</i>	x	x
<i>D. occidentalis</i>		x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
D. palmarum		x
D. pensylvanica		x
D. petechia sbsp aestiva, bryanti, & rufivertex	x	x
D. tigrina		x
D. townsendi		x
D. virens		x
Dendrortyx barbatus	x	x
D. leucophrys	x	x
D. macroura	x	x
Diglossa baritula	x	x
Dives dives	x	x
Dromococcyx phasianellus	x	x
Dryocopus lineatus	x	x
Dumetella carolinensis		x
D. glabirostris	x	x
Dysithamnus mentalis	x	x
Egretta alba	x	x
E. caerulea	x	x
E. thula	x	x
E. tricolor	x	x
Elaenia flavogaster	x	x
E. frantzii	x	x
E. martinica	x	x
Elanoides forficatus		x
Elanus leucurus	x	x
Electron carinatum	x	x
Empidonax affinis	x	x
E. albigularis	x	x
E. difficilis	x	x
E. flavescens	x	x
E. flaviventris		x
E. fulvifrons	x	x
E. hammondii		x
E. minimus		x
E. oberholseri	x	x
E. occidentalis	x	x
E. traillii		x
E. wrightii		x
Eremophila alpestris	x	x
Ergaticus ruber	x	x
E. versicolor	x	x
Eucometis penicillata	x	x
Eudocimus albus	x	x
Eugenes fulgens	x	x
Eumomota superciliosa	x	x
Euphagus cyanocephalus	x	x
Eupherusa cyanophrys	x	x
E. eximia	x	x
E. poliocerca	x	x
Euphonia affinis	x	x

<i>Bird species</i>	Winter	Summer
<i>E elegantissima</i>	x	x
<i>E gouldi</i>	x	x
<i>E hirundinacea</i>	x	x
<i>E minuta</i>	x	x
<i>Euptilotus neoxenus</i>	x	x
<i>Eurypyga helias</i>	x	x
<i>Falco columbarus</i>		x
<i>F deiroleucus</i>	x	x
<i>F femoralis</i>	x	x
<i>F mexicanus</i>	x	x
<i>F peregrinus</i>	x	x
<i>F rufigularis</i>	x	x
<i>F sparverius</i>	x	x
<i>Flonsuga mellivora</i>	x	x
<i>Formicarius moniliger</i>	x	x
<i>Forpus cyanopygius</i>	x	x
<i>Fulica americana</i>	x	x
<i>Galbula ruficauda</i>	x	x
<i>Gallinago gallinago</i>		x
<i>Gallinula chloropus</i>	x	x
<i>Geococcyx californianus</i>	x	x
<i>G velox</i>	x	x
<i>Geothlypis beldingi</i>	x	x
<i>G falvovellata</i>	x	x
<i>G nelsoni</i>	x	x
<i>G speciosa</i>	x	x
<i>G tinchas</i>	x	x
<i>Geotrygon albifacies</i>	x	x
<i>G lawrencii</i>	x	x
<i>G montana</i>	x	x
<i>Geranoospiza caerulescens</i>	x	x
<i>Glaucidium brasilianum</i>	x	x
<i>G gnoma</i>	x	x
<i>G griseiceps</i>	x	x
<i>G hoskinsii</i>	x	x
<i>G palmarum</i>	x	x
<i>G sanchezi</i>	x	x
<i>Glyphorhynchus spirurus</i>	x	x
<i>Grallaria guatemalensis</i>	x	x
<i>Granatellus sallaei</i>	x	x
<i>G venustus</i>	x	x
<i>Grus canadensis</i>		x
<i>Gymnocichla nudiceps</i>	x	x
<i>Gymnorhinus cyanocephalus</i>	x	x
<i>Habia fuscicauda</i>	x	x
<i>F rubica</i>	x	x
<i>Haematopus bachmani</i>	x	x
<i>H palliatus</i>	x	x
<i>Haliaeetus leucocephalus</i>	x	x
<i>Haplospiza rustica</i>	x	x
<i>Harpagus bidentatus</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Harpia hapyja	x	x
Harpohaliaetus solitarius	x	x
Heliomaster constanii	x	x
H. longirostris	x	x
Heliornis fulica	x	x
Heliodytes barroeti	x	x
Helminthos swainsonii		x
H. vermivorus		x
Henicorhina leucoprphys	x	x
H. leucosticta	x	x
Herpetotheres cachinnans	x	x
Heteroscelus incannus		x
Himantopus mexicanus	x	x
Hirundo fulva	x	x
H. pyrrhonota	x	x
H. rustica	x	x
Hylocharis eliciae	x	x
Hylomanes momotula	x	x
Hylophilus decurtatus	x	x
H. ochraceiceps	x	x
Hylorchilus navai	x	x
H. sumichrasti	x	x
Icteria virens	x	x
Icterus auratus	x	x
I. bullockii	x	x
I. chrysater	x	x
I. cucullatus	x	x
I. dominicensis	x	x
I. galbula		x
I. graduacauda	x	x
I. gularis	x	x
I. maculialatus	x	x
I. mesomelas	x	x
I. parisorum	x	x
I. pectoralis	x	x
I. pustulatus	x	x
I. spurius	x	x
I. wagleri	x	x
Ictinia plumbea	x	x
Ixobrychus exilis	x	x
Jabiru mycteria	x	x
Jacana spinosa	x	x
Junco bairdi	x	x
J. hyemalis	x	x
J. phaenotus	x	x
Lampornis amethystinus	x	x
L. clemenciae	x	x
L. sybillae	x	x
L. viridipallens	x	x
Lamprolaima rhami	x	x
Lanio aurantius	x	x

<i>Bird species</i>	Winter	Summer
Laniocera rufescens	x	x
Lanius ludovicianus	x	x
Larus argentatus		x
L. atricilla	x	x
L. delawarensis		x
L. occidentalis	x	x
L. philadelphia		x
Laterallus exilis	x	x
L. ruber	x	x
Legatus leucophanius	x	x
Lepidocolaptes affinis	x	x
L.leucogaster	x	x
L.souleyetti	x	x
Leptodon cayanensis	x	x
Leptopogon amaurocephalus	x	x
Leptotila cassinii	x	x
L. jamaicensis	x	x
L. plumbeiceps	x	x
L. verreauxi	x	x
Leucopternis albicollis	x	x
Limnodromus griseus		x
L.scolopaceus	x	x
Limosa fedoa		x
Lipaugus unirufus	x	x
Lophornis brachylopha	x	x
L. helenae	x	x
Lophotrix cristata	x	x
Loxia curvirostra	x	x
Lurocalis semitorquatus	x	x
Melacoptila panmesis	x	x
Manacus candei	x	x
Megarhynchus pitangua	x	x
Melanerpes formicivorus	x	x
M. lewis		x
Melanotis caurulescens	x	x
M. hypoleucus	x	x
Meleagris gallopavo	x	x
G. ocellata	x	x
Melospiza georgiana		x
M. lincolni		x
M. melodia	x	x
Melozone biarcuatum	x	x
M. kieneri	x	x
M. leucotis	x	x
Mergus cucullatus		x
M. merganser		x
Micrastur ruficollis	x	x
M. semitorquatus	x	x
Micrathene whitneyi	x	x
Microcerculus philomela	x	x
Microrhophias quixensis	x	x

<i>Bird species</i>	Winter	Summer
Mimus gilvus	x	x
M polyglottos	x	x
Mionectes oleagineus	x	x
Mitrephanes phaeocercus	x	x
Mniotilta varia		x
Molothrus aeneus	x	x
M ater	x	x
Momotus mexicanus	x	x
M momota	x	x
Morococcyx erythropygus	x	x
Morphnus guianensis	x	x
Myadestes occidentalis	x	x
M towsoni	x	x
M unicolor	x	x
Myctena amercana	x	x
Myarchus cinerascens	x	x
M cinnatus	x	x
M nuttingi	x	x
M tuberculifer	x	x
M tyrannulus	x	x
M yucatanensis	x	x
Myiobius sulphureipygius	x	x
Myioborus miniatus	x	x
M pictus	x	x
Myiodynastes luteiventris	x	x
M maculatus	x	x
Myiopagis viridicata	x	x
M similis	x	x
Mymotherula schisticolor	x	x
Notharchus macrorhynchos	x	x
Notiochelidon pileata	x	x
Nucifraga columbiana	x	x
Numenius americanus		x
N phaeopus		x
Nyctibius grandis	x	x
N jamaicensis	x	x
Nycticorax nycticorax	x	x
N violaceus	x	x
Nyctidromus albicollis	x	x
Nyctiphrynus mcleodii	x	x
N yucatanicus	x	x
Odontophorus guttatus	x	x
Oncostoma cinereigulare	x	x
Onychorhynchus coronatus	x	x
Opornis formosus		x
O tolmiei		x
Oreophasis derbianus	x	x
Oreoscoptes montanus		x
Oriturus superciliosus	x	x
Ornithion semifavum	x	x
Ortalis leucogastra	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
<i>O. poliocephala</i>	x	x
<i>O. vetula</i>	x	x
<i>O. wagleri</i>	x	x
<i>Oryzoborus funereus</i>	x	x
<i>Otus asio</i>	x	x
<i>O. barbarus</i>	x	x
<i>O. cooperi</i>	x	x
<i>O. flammeolus</i>	x	x
<i>O. guatemalae</i>	x	x
<i>O. kennicotti</i>	x	x
<i>O. seductus</i>	x	x
<i>O. trichopsis</i>	x	x
<i>Oxyura dominica</i>	x	x
<i>O. jamaicensis</i>	x	x
<i>Pachyramphus aglaiae</i>	x	x
<i>P. cinnamomeus</i>	x	x
<i>P. major</i>	x	x
<i>P. polychopterus</i>	x	x
<i>Pandion haliaetus</i>	x	x
<i>Panyptila cayennensis</i>	x	x
<i>P. sanctihieronymi</i>	x	x
<i>Parabuteo uncinctus</i>	x	x
<i>Parula americana</i>		x
<i>P. pitiayumi</i>	x	x
<i>Parus atricristatus</i>	x	x
<i>P. gambeli</i>	x	x
<i>P. inornatus</i>	x	x
<i>P. sclateri</i>	x	x
<i>P. wollweberi</i>	x	x
<i>Passer domesticus</i>	x	x
<i>Passarella iliaca</i>		x
<i>Passerina amoena</i>	x	x
<i>P. caerulea</i>	x	x
<i>P. ciris</i>	x	x
<i>P. cyanea</i>		x
<i>P. leclancherii</i>	x	x
<i>P. rositae</i>	x	x
<i>P. versicolor</i>	x	x
<i>Pelecanus erythrorhynchos</i>	x	x
<i>Penelope purpurascens</i>	x	x
<i>Penelopina nigra</i>	x	x
<i>Peucedramus taeniatus</i>	x	x
<i>Phaeochroa cuvierii</i>	x	x
<i>Phaeton aethereus</i>	x	x
<i>Phaethornis mexicanus</i>	x	x
<i>P. superciliosus</i>	x	x
<i>Phainopepla nitens</i>	x	x
<i>Phalacrocorax auritus</i>	x	x
<i>P. brasilianus</i>	x	x
<i>Phalaenoptilus nuttallii</i>	x	x
<i>Pharomachrus micinno</i>	x	x

<i>Bird species</i>	Winter	Summer
<i>Pheuticus chrysopeplus</i>	x	x
<i>P ludovicianus</i>		x
<i>P melanocephalus</i>	x	x
<i>Philodice dupontii</i>	x	x
<i>Philortyx fasciatus</i>	x	x
<i>Phlogothraupis sanguinolenta</i>	x	x
<i>Phoenicopterus ruber</i>	x	x
<i>Piaya cayana</i>	x	x
<i>Picoides arizonae</i>	x	x
<i>P nuttalli</i>	x	x
<i>P scalans</i>	x	x
<i>P stricklandi</i>	x	x
<i>P villosus</i>	x	x
<i>Piculus aeruginosus</i>	x	x
<i>P aunculans</i>	x	x
<i>P rubiginosus</i>	x	x
<i>Picummus olivaceus</i>	x	x
<i>Pionopsitta haematotis</i>	x	x
<i>Pionus senilis</i>	x	x
<i>Pipilo aberti</i>	x	x
<i>P albicollis</i>	x	x
<i>P chlorurus</i>	x	x
<i>P cissalis</i>	x	x
<i>P erythropthalmus</i>	x	x
<i>P fuscus</i>	x	x
<i>P ocai</i>	x	x
<i>Pipra mentalis</i>	x	x
<i>Piprites griseiceps</i>	x	x
<i>Piranga bidentata</i>	x	x
<i>P flava</i>	x	x
<i>P ludoviciana</i>	x	x
<i>P roseogularis</i>	x	x
<i>P rubra</i>	x	x
<i>Pitangus sulphuratus</i>	x	x
<i>Platalea ajaja</i>	x	x
<i>Platyrinchus cancrominus</i>	x	x
<i>Plegadis chihi</i>	x	x
<i>P falcinellus</i>	x	x
<i>Pluavialis squatarola</i>		x
<i>Podiceps nigricollis</i>	x	x
<i>Podilymbus podiceps</i>	x	x
<i>Polioptila albilons</i>	x	x
<i>P caerulea</i>	x	x
<i>P californica</i>	x	x
<i>P melanura</i>	x	x
<i>P nigriceps</i>	x	x
<i>P plumbea</i>	x	x
<i>Poocetes gramineus</i>		x
<i>Porphyula martinica</i>	x	x
<i>Porzana carolina</i>	x	x
<i>P flaviventer</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
<i>Procnias tncarunculata</i>	x	x
<i>Progne chalybea</i>	x	x
<i>P sinaloae</i>	x	x
<i>P subis</i>	x	x
<i>Psaltriparus minimus</i>	x	x
<i>Psarocolius montezuma</i>	x	x
<i>P wagleri</i>	x	x
<i>Pteroglossus toequatus</i>	x	x
<i>Ptilogonys cinereus</i>	x	x
<i>Puffinus auriculans</i>	x	x
<i>Pulsatrix perspicillata</i>	x	x
<i>Pygmornis longuemareus</i>	x	x
<i>Pyrocephalus rubinus</i>	x	x
<i>Quiscalus mexicanus</i>	x	x
<i>Rallus elegans</i>	x	x
<i>R limicola</i>	x	x
<i>R longirostris</i>	x	x
<i>R maculatus</i>	x	x
<i>Ramphastos sulfuratus</i>	x	x
<i>Ramphocaenus melanurus</i>	x	x
<i>Ramphocelus passerinii</i>	x	x
<i>Recurvirostra americana</i>	x	x
<i>Regulus calendula</i>		x
<i>R satrapa</i>	x	x
<i>Rhodinocichla rosea</i>	x	x
<i>Rhodothraupis celaeno</i>	x	x
<i>Rhynchocyclus brevirostris</i>	x	x
<i>Rhynchopsitta pachyrhyncha</i>	x	x
<i>R ternis</i>	x	x
<i>Rhytipterna holerythra</i>	x	x
<i>Riparia riparia</i>		x
<i>Rostrhamus sociabilis</i>	x	x
<i>Rynchops niger</i>	x	x
<i>Salpinctes obsoletus</i>	x	x
<i>Saltator aticeps</i>	x	x
<i>S coerulescens</i>	x	x
<i>S maximus</i>	x	x
<i>Sarcoramphus papa</i>	x	x
<i>Sayornis nigricans</i>	x	x
<i>S phoebe</i>		x
<i>S saya</i>	x	x
<i>Scaphidura oryzivora</i>	x	x
<i>Schiffornis turdinus</i>	x	x
<i>Sclerurus guatemalensis</i>	x	x
<i>S mexicanus</i>	x	x
<i>Seiurus aurocapillus</i>		x
<i>S motacilla</i>		x
<i>S noveboracensis</i>		x
<i>Selasphorus heloisa</i>	x	x
<i>S ellioti</i>	x	x
<i>S platycercus</i>	x	x

<i>Bird species</i>	Winter	Summer
<i>S rufus</i>		x
<i>S sasin</i>		x
<i>Setophaga ruticilla</i>		x
<i>Sialia currucoides</i>		x
<i>S mexicana</i>	x	x
<i>S sialis</i>	x	x
<i>Sicalis luteola</i>	x	x
<i>Sitta carolinensis</i>	x	x
<i>S pygmaea</i>	x	x
<i>Sittasomus griseicapillus</i>	x	x
<i>Spermagra erythrocephala</i>	x	x
<i>S leucoptera</i>	x	x
<i>Sphyrapicus thyroideus</i>	x	x
<i>S nuchalis</i>		x
<i>S ruber</i>		x
<i>S varius</i>		x
<i>Spiza amercana</i>		x
<i>Spizaetus ornatus</i>	x	x
<i>S tyrannus</i>	x	x
<i>Spizastur melanoleucus</i>	x	x
<i>Spizella atrogularis</i>	x	x
<i>S breweri</i>		x
<i>S pallida</i>		x
<i>S passerina</i>	x	x
<i>S pusilla</i>		x
<i>S wortheni</i>	x	x
<i>Sporophila aunta</i>	x	x
<i>S minuta</i>	x	x
<i>S schistacea</i>	x	x
<i>S torquelo</i>	x	x
<i>Stelgidopteryx ridgwayi</i>	x	x
<i>S serripennis</i>	x	x
<i>Sterna antillarum</i>	x	x
<i>S caspia</i>	x	x
<i>S forsteri</i>	x	x
<i>S maxima</i>	x	x
<i>S nilotica</i>	x	x
<i>S sandvicensis</i>		x
<i>Streptoprocne semicollans</i>	x	x
<i>S zonaris</i>	x	x
<i>Strix fulvescens</i>	x	x
<i>S nigrolineata</i>	x	x
<i>S occidentalis</i>	x	x
<i>S varia</i>	x	x
<i>S virgata</i>	x	x
<i>Sturnella magna</i>	x	x
<i>S neglecta</i>	x	x
<i>Sturnus vulgaris</i>	x	x
<i>Synallaxis erythrothorax</i>	x	x
<i>Tachybaptus dominicus</i>	x	x
<i>Tachycineta albilinea</i>	x	x

<i>Bird species</i>	Winter	Summer
T bicolor		x
T thalassina	x	x
Tanagra cabanisi	x	x
T larvata	x	x
Tapera naevia	x	x
Taraba major	x	x
Terenotriccus erythrurus	x	x
Thalurania colombica	x	x
T ridgwayi	x	x
Thamnistes anabatinus	x	x
Thamnophilus doliatus	x	x
T punctatus	x	x
Thraupis abbas	x	x
T episcopus	x	x
Threnetes ruckeri	x	x
Thryomanes bewickii	x	x
Thryothorus albinucha	x	x
T felix	x	x
T ludovicianus	x	x
T maculipectus	x	x
T modestus	x	x
T pleurostictus	x	x
T rufalbus	x	x
T sinaloa	x	x
Tians olivacea	x	x
Tigrioma mexicanum	x	x
Tinamus major	x	x
Tityra inquisitor	x	x
T semifasciata	x	x
Todirostrum cinereum	x	x
T sylvia	x	x
Tolmomyias sulphureus	x	x
Toxostoma bendirei	x	x
T cinereum	x	x
T crissale	x	x
T curvirostre	x	x
T lecontei	x	x
T longirostre	x	x
T ocellatum	x	x
T redivivum	x	x
Tringa flavipes		x
T melanoleuca		x
T solitaria		x
Troglodytes aedon	x	x
T brunneicollis	x	x
T musculus	x	x
T rufociliatus	x	x
Trogon citreolus	x	x
T collans	x	x
T elegans	x	x
T massena	x	x

<i>Bird species</i>	Winter	Summer
<i>T melanocephalus</i>	x	x
<i>T mexicanus</i>	x	x
<i>T violaceus</i>	x	x
<i>Turdus assimilis</i>	x	x
<i>T grayi</i>	x	x
<i>T graysoni</i>	x	x
<i>T infuscatus</i>	x	x
<i>T migratorius</i>	x	x
<i>T plebejus</i>	x	x
<i>T rufitorques</i>	x	x
<i>T rufopalliatus</i>	x	x
<i>Tyrannus couchii</i>	x	x
<i>T crassirostris</i>	x	x
<i>T forficatus</i>	x	x
<i>T melancholicus</i>	x	x
<i>T savana</i>	x	x
<i>T verticalis</i>	x	x
<i>T vociferans</i>	x	x
<i>Tyto alba</i>	x	x
<i>Uropsila leucogastra</i>	x	x
<i>Veniliornis fumigatus</i>	x	x
<i>Vermivora celata</i>	x	x
<i>V chrysoptera</i>		x
<i>V crissalis</i>	x	x
<i>V luciae</i>	x	x
<i>V peregrina</i>		x
<i>V pinus</i>		x
<i>V ruficapilla</i>		x
<i>V superciliosa</i>	x	x
<i>V virginiae</i>		x
<i>Vireo atricapillus</i>	x	x
<i>V belli</i>	x	x
<i>V brevipennis</i>	x	x
<i>V cassini</i>	x	x
<i>V flavifrons</i>	x	x
<i>V flavovindis</i>	x	x
<i>V gilvus</i>	x	x
<i>V gnseus</i>	x	x
<i>V huttoni</i>	x	x
<i>V hypochryseus</i>	x	x
<i>V leucophrys</i>	x	x
<i>V magister</i>	x	x
<i>V nelsoni</i>	x	x
<i>V olivaceus</i>	x	x
<i>V pallens</i>	x	x
<i>V philadelphicus</i>		x
<i>V plumbeus</i>	x	x
<i>V solitarius</i>		x
<i>V vicinior</i>	x	x
<i>Vireolanus melitophrys</i>	x	x
<i>V puichellus</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Volatinia jacanna	x	x
Wilsonia citrina		x
W pusilla		x
Xanthocephalus xanthocephalus	x	x
Xenops minutus	x	x
Xenotriccus callizonus	x	x
X mexicanus	x	x
Xiphocolaptes promeropyrhynchus	x	x
Xiphorhynchus erythropygius	x	x
X flavigaster	x	x
X gutatus	x	x
Zenaida asiatica	x	x
Z aunta	x	x
Z macroura	x	x
Zimmerius vilissimus	x	x
Zonothrichia albicollis		x
Z atricapilla		x
Z capensis	x	x
Z leucophrys		x
Zoothera naevia		x
Z pinicola	x	x

### Canada/USA

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Accipiter cooperii	x	x
A gentilis	x	x
A striatus	x	x
Actitis macularia	x	x
Aechmophorus clarkii	x	x
A occidentalis	x	x
Aegolius acadicus	x	x
A funereus	x	x
Aeronautes saxatalis	x	x
Agelaius phoeniceus	x	x
A tricolor	x	x
Aimophila aestivalis	x	x
A botteri	x	x
A carpalis	x	x
A cassinii	x	x
A quinquestrata	x	x
A ruficeps	x	x
Aix sponsa	x	x
Ajaja ajaja	x	x
Alecton chukar	x	x
Amazilia violiceps		x
A yucatanensis	x	x
Amazona vindigenalis	x	x
Ammodramus bairdii	x	x
A caudacutus	x	x
A henslowii	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
A leconteii	x	x
A maritimus		x
A savannarum	x	x
Amphispiza belli	x	x
A bilineata		x
Anas acuta	x	x
A americana	x	x
A clypeata	x	x
A crecca	x	x
A cyanoptera	x	x
A discor	x	x
A fulvigula	x	x
A penelope	x	x
A platyrhynchos	x	x
A rubripes	x	x
A strepera	x	x
Anhinga anhinga	x	x
Anser albifrons	x	x
Anthus cervinus		x
A rubescens	x	x
A spragueii	x	x
Aphelocoma coerulescens	x	x
A ultramanna	x	x
Aphriza virgata	x	x
Aquila chrysaetos	x	x
Aramus guarauna	x	x
Archilochus alexandri	x	x
A colubris	x	x
Ardea herodias	x	x
Arenaria interpres	x	x
Arenaria melanocephala	x	x
Arremonops rufivirgatus	x	x
Asio flammeus	x	x
A otus	x	x
Athene cunicularia	x	x
Auriparus flaviceps	x	x
Aythya affinis	x	x
A americana	x	x
A collaris	x	x
A marila	x	x
A valisineria	x	x
Baelophus inornatus	x	x
B ridgwayi	x	x
B wallweteri	x	x
Bartramia longicauda		x
Bombycilla cedrorum	x	x
B garrulus	x	x
Bonasa umbellus	x	x
Botaurus lentiginosus	x	x
Brachyramphus brevirostris		x
B marmoratus		x

<i>Bird species</i>	Winter	Summer
<i>Branta bernicla</i>	x	x
<i>B canadensis</i>	x	x
<i>Brotogeris versicolurus</i>	x	x
<i>B chiri</i>	x	x
<i>Bubo virginianus</i>	x	x
<i>Bubulcus ibis</i>	x	x
<i>Bucephala albeola</i>	x	x
<i>B islandica</i>	x	x
<i>B clangula</i>	x	x
<i>Buteo albicaudatus</i>	x	x
<i>B albonotatus</i>		x
<i>B brachyurus</i>	x	x
<i>B jamaicensis</i>	x	x
<i>B lagopus</i>	x	x
<i>B lineatus</i>	x	x
<i>B platypterus</i>	x	x
<i>B regalis</i>	x	x
<i>B swainsoni</i>		x
<i>Buteogallus anthracinus</i>	x	x
<i>Butorides viriscens</i>	x	x
<i>Calamospiza melanocorys</i>	x	x
<i>Calcarius lapponicus</i>	x	x
<i>C mccownii</i>	x	x
<i>C ornatus</i>	x	x
<i>C pictus</i>	x	x
<i>Calidris alba</i>	x	x
<i>C alpina</i>	x	x
<i>C bairdii</i>		x
<i>C canutus</i>	x	x
<i>C fuscicollis</i>		x
<i>C himantopus</i>	x	x
<i>C maui</i>	x	x
<i>C melanotos</i>		x
<i>C minutilla</i>	x	x
<i>C ptilocnemis</i>	x	x
<i>C pusilla</i>		x
<i>C ruficollis</i>		x
<i>Callipepla californica</i>	x	x
<i>C gambelii</i>	x	x
<i>C squamata</i>	x	x
<i>Calothorax lucifer</i>		x
<i>Calypte anna</i>	x	x
<i>C costae</i>	x	x
<i>Camptostoma imberbe</i>	x	x
<i>Campylorhynchus brunneicapillus</i>	x	x
<i>Caprimulgus carolinensis</i>		x
<i>C ridgwayi</i>		x
<i>C vociferus</i>	x	x
<i>Caracara plancus</i>	x	x
<i>Cardellina rubrifrons</i>		x
<i>Cardinalis cardinalis</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
<i>C. sinuatus</i>	x	x
<i>Carduelis flammea</i>	x	x
<i>C. hornemanni</i>	x	x
<i>C. lawrencei</i>	x	x
<i>C. pinus</i>	x	x
<i>C. psaltria</i>	x	x
<i>C. tristis</i>	x	x
<i>Carpodacus cassinii</i>	x	x
<i>C. mexicanus</i>	x	x
<i>C. purpureus</i>	x	x
<i>Cathartes aura</i>	x	x
<i>Catharus fuscus</i>		x
<i>C. guttatus</i>	x	x
<i>C. minimus</i>		x
<i>C. ustulatus</i>		x
<i>Catherpes mexicanus</i>	x	x
<i>Catoptrophorus semipalmatus</i>	x	x
<i>Centrocercus urophasianus</i>	x	x
<i>Cephus columba</i>	x	x
<i>Certhia americana</i>	x	x
<i>Ceryle alcyon</i>	x	x
<i>C. torquata</i>	x	x
<i>Chaetura pelagica</i>		x
<i>C. vauxi</i>		x
<i>Chamaea fasciata</i>	x	x
<i>Charadrius alexandrinus</i>	x	x
<i>C. melodus</i>	x	x
<i>C. montanus</i>	x	x
<i>C. siemipalmatus</i>	x	x
<i>C. vociferus</i>	x	x
<i>C. wilsonia</i>		x
<i>Chen caerulescens</i>	x	x
<i>C. canagica</i>	x	x
<i>C. rossii</i>	x	x
<i>Chlidonias niger</i>		x
<i>Chloroceryle americana</i>	x	x
<i>Chondestes grammacus</i>	x	x
<i>Chordeiles acutipennis</i>		x
<i>C. minor</i>		x
<i>Cinclus mexicanus</i>	x	x
<i>Circus cyaneus</i>	x	x
<i>Cistothorus palustris</i>	x	x
<i>C. platensis</i>	x	x
<i>Clangula hyematis</i>		x
<i>Coccothraustes vespertinus</i>	x	x
<i>Coccyzus americanus</i>		x
<i>C. erythrophthalmus</i>		x
<i>C. minor</i>	x	x
<i>Colaptes auratus</i>	x	x
<i>Colinus virginianus</i>	x	x
<i>Columba fasciata</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
C. flavirostris	x	x
C. livia	x	x
Columbina inca	x	x
C. passerina	x	x
Contopus cooperi		x
C. pertinax		x
C. sordidulus		x
C. virens		x
Coragyps atratus	x	x
Corvus brachyrhynchos	x	x
C. caurinus	x	x
C. corax	x	x
C. cryptoleucus	x	x
C. ossifragus	x	x
Coturnicops noveboracensis	x	x
Crotophaga ani	x	x
C. sulcirostris	x	x
Cyanocitta cristata	x	x
C. stelleri	x	x
Cyanocorax yncas	x	x
Cygnus buccinator	x	x
C. columbianus	x	x
C. olor	x	x
Cyananthus latirostris		x
Cypseloides niger		x
Cyrtonyx montezumae	x	x
Dendragapus canadensis	x	x
D. obscurus	x	x
Dendrocygna autumnalis	x	x
D. bicolor	x	x
Dendroica audubon	x	x
D. caerulescens		x
D. castanea		x
D. cerulea		x
D. chrysoparia		x
D. coronata	x	x
D. discolor	x	x
D. dominica	x	x
D. fusca		x
D. graciae		x
D. magnolia		x
D. nigrescens	x	x
D. occidentalis	x	x
D. palmarum	x	x
D. pensylvanica		x
D. petechia		x
D. pinus	x	x
D. striata		x
D. tigrina		x
D. townsendi	x	x
D. virens	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Dolichonyx oryzivorus		x
Dryocopus pileatus	x	x
Dumetella carolinensis	x	x
Egretta caerulea	x	x
E rufescens	x	x
E tricolor	x	x
E thula	x	x
Elanoides forficatus		x
Elanus leucurus	x	x
Empidonax alnorum		x
E difficilis		x
E flaviventris		x
E fulvifrons		x
E hammondi		x
E minimus	x	x
E oberholseri	x	x
E traillii		x
E virescens		x
E wrightii	x	x
Eremophila alpestris	x	x
Endocimus albus	x	x
Eugenes fulgens		x
Euphagus carolinus	x	x
E cyanocephalus	x	x
Falco columbarus	x	x
F mexicanus	x	x
F peregrinus	x	x
F rusticolus	x	x
F sparverius	x	x
Fratercula cirrhata		x
Fulica americana	x	x
Gallinago gallinago	x	x
Gallinula chloropus	x	x
Gavia adamsii	x	x
G immer		x
G pacifica		x
G stellata		x
Geococcyx californianus	x	x
Geothlypis trichas	x	x
Glaucidium brasilianum	x	x
G gnoma	x	x
Grus americana	x	x
G canadensis	x	x
Guiraca caerulea		x
Gymnorhinus cyanocephalus	x	x
Haemantopus bachmani	x	x
H palliatus	x	x
Haliaeetus leucocephalus	x	x
Helminthos vermivorus		x
Heteroscelus incanus		x
Himantopus mexicanus	x	x

<i>Bird species</i>	Winter	Summer
Hirundo fulva		x
H. pyrrhonota		x
H. rustica		x
Histrionicus histrionicus		x
Icteria virens		x
Icterus bullockii		x
I. cucullatus		x
I. galbula	x	x
I. gularis	x	x
I. parisorum	x	x
I. pectoralis	x	x
I. spurius		x
Ictinia mississippiensis		x
Ixobrychus exilis	x	x
Ixoreus naevius	x	x
Junco hyemalis	x	x
J. phaeonotus	x	x
Lagopus lagopus	x	x
L. leucurus	x	x
L. mutus	x	x
Lampornis clemenciae		x
Lanius excubitor	x	x
L. ludovicianus	x	x
Larus argentatus	x	x
L. atricilla	x	x
L. californicus	x	x
L. canus	x	x
L. delawarensis	x	x
L. fuscus	x	x
L. glaucescens	x	x
L. glaucoides	x	x
L. hermanni		x
L. hyperboreus	x	x
L. livens	x	x
L. marinus	x	x
L. minutus	x	x
L. philadelphia	x	x
L. pipixcan		x
L. thayeri	x	x
Laterallus jamaicensis	x	x
Leptotila verreauxi	x	x
Limnodromus griseus	x	x
L. scolopaceus	x	x
Limnothlypis swainsonii		x
Limosa fedoa		x
L. haemastica		x
L. lapponica		x
Lophodytes cucullatus	x	x
Loxia curvirostra	x	x
L. leucoptera		x
Luscinia svecica		x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Melanerpes aurifrons	x	x
M carolinus	x	x
M erythrocephalus	x	x
M formicivorus	x	x
M lewis	x	x
M uropygialis	x	x
Melanitta fusca		x
M nigra	x	x
M perspicillata		x
Meleagris gallopavo	x	x
Melospiza georgiana	x	x
M lincolni	x	x
M melodia	x	x
Mergus merganser	x	x
M serrator	x	x
Micrathene whitneyi		x
Mimus polyglottos	x	x
Mniotilta vana	x	x
Molothrus bonairensis	x	x
M aeneus	x	x
M ater	x	x
Motacilla alba		x
M flava		x
M lugens		x
Myadestes townsendi	x	x
Myctena amercana	x	x
Myiarchus cinerascens		x
M crinitus	x	x
M tuberculifer	x	x
M tyrannulus		x
Myioborus pictus	x	x
Myiodynastes luteiventris		x
Myiopsitta monachus	x	x
Nomonyx dominica	x	x
Nucifraga columbiana	x	x
Numenius americanus	x	x
N borealis		x
N phaeopus	x	x
N tahitiensis		x
Nyctanassa violocaea	x	x
Nyctea scandiaca	x	x
Nycticorax nycticorax	x	x
Nyctidromus albicollis	x	x
Oenanthe oenanthe		x
O formosus		x
O philadelphia		x
O tolmiei		x
Oreortyx pictus	x	x
Oreoscoptes montanus	x	x
Ortalis vetula	x	x
Otus asio	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
O flammeolus		x
O kennicottii	x	x
O tinchopsis	x	x
Pandion heliaetus	x	x
Parabuteo unicinatus	x	x
Parula americana	x	x
P pitayumi		x
Parus atricapillus	x	x
P bicolor	x	x
P cinctus	x	x
P hudsonicus	x	x
P sclateri	x	x
Passer domesticus	x	x
Passerculus sandwichensis	x	x
Passerella iliaca	x	x
Passerina amoena	x	x
P ciris	x	x
P cyanea	x	x
P versicolor	x	x
Pelecanus erythrorhynchos	x	x
Perdix perdix	x	x
Perisoreus canadensis	x	x
Peucedramus taeniatus	x	x
Phainopepla nitens		x
Phalacrocorax auratus	x	x
P brasilianus	x	x
P pelagicus		x
Phalaenoptilus nuttallii	x	x
Phalaropus fulicaria		x
P lobatus	x	x
P tricolor		x
Phasianus colchicus	x	x
Pheucticus ludovicianus		x
P melanocephalus		x
Phylloscopus borealis		x
Pica nuttalli	x	x
P pica	x	x
Picoides albolarvatus	x	x
P arcticus	x	x
P borealis	x	x
P nuttalli	x	x
P pubescens	x	x
P scalaris	x	x
P stuebeli	x	x
P tridactylus	x	x
P villosus	x	x
Pinicola enucleator	x	x
Pipilo aberti	x	x
P chlorurus	x	x
P erythrophthalmus	x	x
P fuscus	x	x

<i>Bird species</i>	Winter	Summer
<i>P maculatus</i>	x	x
<i>P ludoviciana</i>		x
<i>P olivacea</i>		x
<i>P rubra</i>		x
<i>Pitangus sulphuratus</i>	x	x
<i>Plectrophenax hyperboreus</i>	x	x
<i>P nivalis</i>	x	x
<i>Plegadis chihi</i>	x	x
<i>P faicinelus</i>	x	x
<i>Pluvialis dominica</i>	x	x
<i>P fulva</i>	x	x
<i>P squatarola</i>	x	x
<i>Poecetes gramineus</i>	x	x
<i>Pochyrampus aglaiae</i>		x
<i>Podiceps auritus</i>	x	x
<i>P gnsegena</i>		x
<i>P nigricollis</i>	x	x
<i>Podilymbus podiceps</i>	x	x
<i>Poecile gambeli</i>	x	x
<i>Polioptila caerulea</i>	x	x
<i>P melanura</i>	x	x
<i>Polyborus plancus</i>	x	x
<i>Polysticta stelleri</i>		x
<i>Porphyryla martinica</i>	x	x
<i>Porzana carolina</i>	x	x
<i>Progne subis</i>		x
<i>Protonotaria citrea</i>		x
<i>Psaltirparus minimus</i>	x	x
<i>Ptychorampus aleuticus</i>	x	x
<i>Pyrocephalus rubinus</i>	x	x
<i>Quiscalus major</i>	x	x
<i>Q mexicanus</i>	x	x
<i>Q quiscula</i>	x	x
<i>Rallus elegans</i>	x	x
<i>R limicola</i>	x	x
<i>R longirostris</i>	x	x
<i>Recurvirostra americana</i>	x	x
<i>Regulus calendula</i>	x	x
<i>R satrapa</i>	x	x
<i>Riparia riparia</i>		x
<i>Rissa tridactyla</i>		x
<i>Rostrhamus sociabilis</i>	x	x
<i>Rynchops niger</i>	x	x
<i>Salpinctes obsoletus</i>	x	x
<i>Sayornis nigricans</i>	x	x
<i>S phoebe</i>	x	x
<i>S saya</i>	x	x
<i>Scolopax minor</i>	x	x
<i>Seiurus aurocapillus</i>	x	x
<i>S motacilla</i>		x
<i>S novaboracensis</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
<i>Selasphorus platycercus</i>		x
<i>S. rufus</i>	x	x
<i>S. sasin</i>		x
<i>Setophaga ruticilla</i>		x
<i>Sialia currucoides</i>	x	x
<i>S. mexicana</i>	x	x
<i>S. sialis</i>	x	x
<i>Sitta canadensis</i>	x	x
<i>S. carolinensis</i>	x	x
<i>S. pusilla</i>	x	x
<i>S. pygmaea</i>	x	x
<i>Somateria mollissima</i>		x
<i>S. fischeri</i>		x
<i>S. spectabilis</i>		x
<i>Spectytu cunicularia</i>	x	x
<i>Sphyrapicus nuchalis</i>	x	x
<i>S. ruber</i>	x	x
<i>S. thyroideus</i>	x	x
<i>S. varius</i>	x	x
<i>Spiza americana</i>		x
<i>Spizella arborea</i>	x	x
<i>S. atrogularis</i>	x	x
<i>S. breweri</i>	x	x
<i>S. pallida</i>	x	x
<i>S. passerina</i>	x	x
<i>S. pusilla</i>	x	x
<i>Sporophila torqueola</i>	x	x
<i>Stelgidopteryx serripennis</i>	x	x
<i>Stellula calliope</i>		x
<i>Stercorarius longicaudus</i>		x
<i>S. parasiticus</i>		x
<i>S. pomarinus</i>		x
<i>Sterna aleutica</i>		x
<i>S. antillarum</i>	x	x
<i>S. caspia</i>	x	x
<i>S. dougallii</i>		x
<i>S. forsteri</i>	x	x
<i>S. hirundo</i>		x
<i>S. maxima</i>	x	x
<i>S. nilotica</i>	x	x
<i>S. paradisea</i>		x
<i>Strix nebulosa</i>	x	x
<i>S. occidentalis</i>	x	x
<i>S. varia</i>	x	x
<i>Sturnella magna</i>	x	x
<i>S. neglecta</i>	x	x
<i>Sturnus vulgaris</i>	x	x
<i>Surnia ulula</i>	x	x
<i>Synthliboramphus antiquus</i>	x	x
<i>S. hypoleucus</i>	x	x
<i>Tachybaptus dominicus</i>	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
Tachycineta bicolor	x	x
T thalassina		x
Tetraogallus himalayensis	x	x
Thryomanes bewickii	x	x
Thryothorus ludovicianus	x	x
Toxostoma bendirei	x	x
T crissale	x	x
T curvirostre	x	x
T lecontei	x	x
T longirostre	x	x
T redivivum	x	x
T rufum	x	x
Tringa flaviceps	x	x
T melanoleuca	x	x
T solitana	x	x
Troglodytes aedon	x	x
T troglodytes	x	x
Trogon elegans		x
Tryngites subruficollis		x
Turdus migratorius	x	x
Tympanuchus cupido	x	x
T pallidicinctus	x	x
T phasianellus	x	x
Tyrannus couchii	x	x
T crassirostris		x
T dominicensis		x
T forficatus	x	x
T melancholicus		x
T tyrannus		x
T verticalis	x	x
T vociferans	x	x
Tyto alba	x	x
Vermivora brachmani		x
V celata	x	x
V chrysoptera		x
V crissalis		x
V luciae	x	x
V peregrina		x
V pinus		x
V ruficapilla	x	x
V virginiae		x
Vireo altiloquus		x
V atricapillus		x
V belli		x
V flavifrons		x
V gilvus		x
V griseus	x	x
V huttoni	x	x
V olivaceus		x
V philadelphicus		x
V plunteus	x	x

<b>Bird species</b>	<b>Winter</b>	<b>Summer</b>
V. solitarius	x	x
V. vicinior	x	x
Wilsonia canadensis		x
W. citrina		x
W. pusilla	x	x
Xanthocephalus xanthocephalus	x	x
Xema sabini		x
Zenaida asiatica	x	x
Z. macroura	x	x
Zonotrichia albicollis	x	x
Z. aticapilla	x	x
Z. leucophrys	x	x
Z. querula	x	x