



Introduction

Novel techniques are required to assess the biological effects of environmental changes at a rate comparable to which they occur.¹ Satellite imaging has the potential to gather environmental information in urban and remote areas rapidly and with relative ease.² This study assesses the ability of Normalized Difference Vegetation Index (NDVI) satellite data to predict bird species richness. As a surrogate of net primary productivity, mean NDVI poorly predicts avian species richness.³ However, NDVI standard deviation (stdNDVI) and the range in NDVI (rNDVI) are expected to be a proxy for habitat heterogeneity. Since there are a more unique habitats in regions of elevated habitat heterogeneity and dissimilar avian species rely on varying habitats to thrive, a positive correlation between habitat heterogeneity and species richness should exist.⁴ However, this expected correlation was not substantiated. To determine the affect of habitat heterogeneity's rate of change on the ability of stdNDVI or rNDVI to predict avian species richness, regions were defined as experiencing either abrupt or gradual environmental changes temporally prior to the same correlation defined above being tested. Implications of this research include the ability to monitor avian species richness decreases and implement conservation strategies.

Methodology

Ontario Breeding Bird Atlas (OBBA) was the source of presence/absence data for birds in Ontario at a 10 x 10 km resolution. EXCLUDE 10 x 10 km quadrants if:

- less than 10 hr effort⁴
- vary more than 13% in area

The number of species observed (S_{obs}) represented the true species richness (S) for each quadrant. Analyses were completed for the two OBBA (1981-1985 and 2001-2005).^{5,6}

One NDVI image was captured per summer at a resolution of 30 x 30 m for the Ottawa – Kingston area between 1984 and 2005. For each image:

- clouds and water were masked
- NDVI values were multiplied by 1000

Using ArcGIS 9.3 (ESRI), yearly NDVI images were up scaled from 30 x 30 m to 10 x 10 km to match the resolution of the OBBA quadrants.

- quadrants with less than 20% NDVI coverage were ignored
- yearly stdNDVI values were calculated for each quadrant
- two year moving average for stdNDVI was calculated

The percent change in stdNDVI between successive years was determined:

$$[1] \quad \% \text{ stdNDVI change} = (a_1 + a_2/a_1) \times 100\% / c$$

Where:

- a_1 = stdNDVI of the year stdNDVI change is being compared to
- a_2 = stdNDVI of year with data that is closest temporally to a_1 but not prior to a_1
- c = number of years separating a_1 and a_2

The maximum yearly percent change in stdNDVI from 1984 to 1999 was determined for each quadrant for quadrants that had eight or more years of stdNDVI data. A frequency distribution of the maximum percent change in stdNDVI was prepared. Quadrants in the lower 10% of the frequency distribution were considered to be regions of 'gradual stdNDVI change,' while quadrants in the upper 10% of the frequency distribution were considered quadrants that sustained 'sudden stdNDVI change' as manifested in figure 1. For quadrants that experienced 'gradual' and 'sudden' stdNDVI changes, graphs were constructed in excel comparing the change in S between the first OBBA and the second OBBA versus the average change in stdNDVI between 1984-1985 and 2001-2005. All analyses were repeated for rNDVI in addition to stdNDVI.

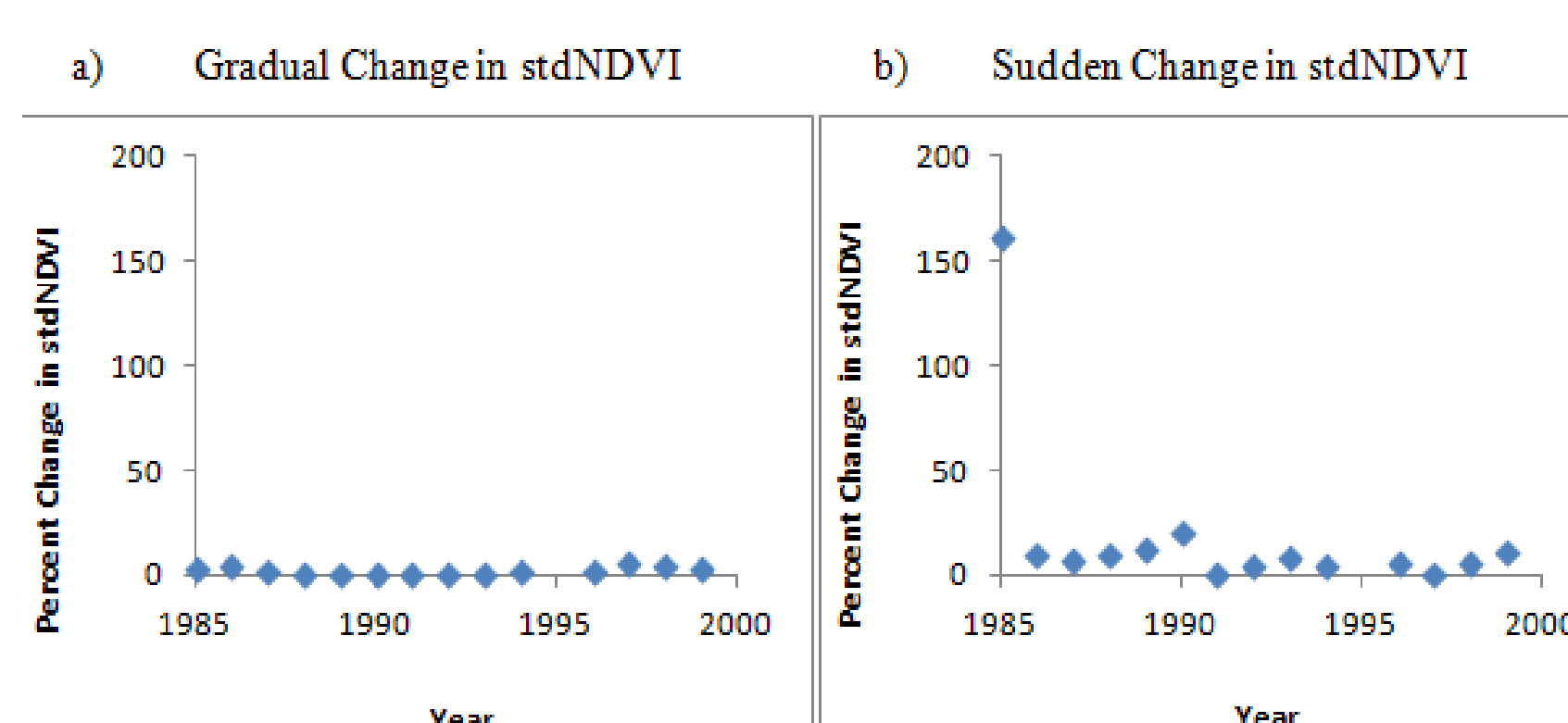


Figure 1: OBBA quadrants that experienced gradual change (a) and sudden change (b).

Results

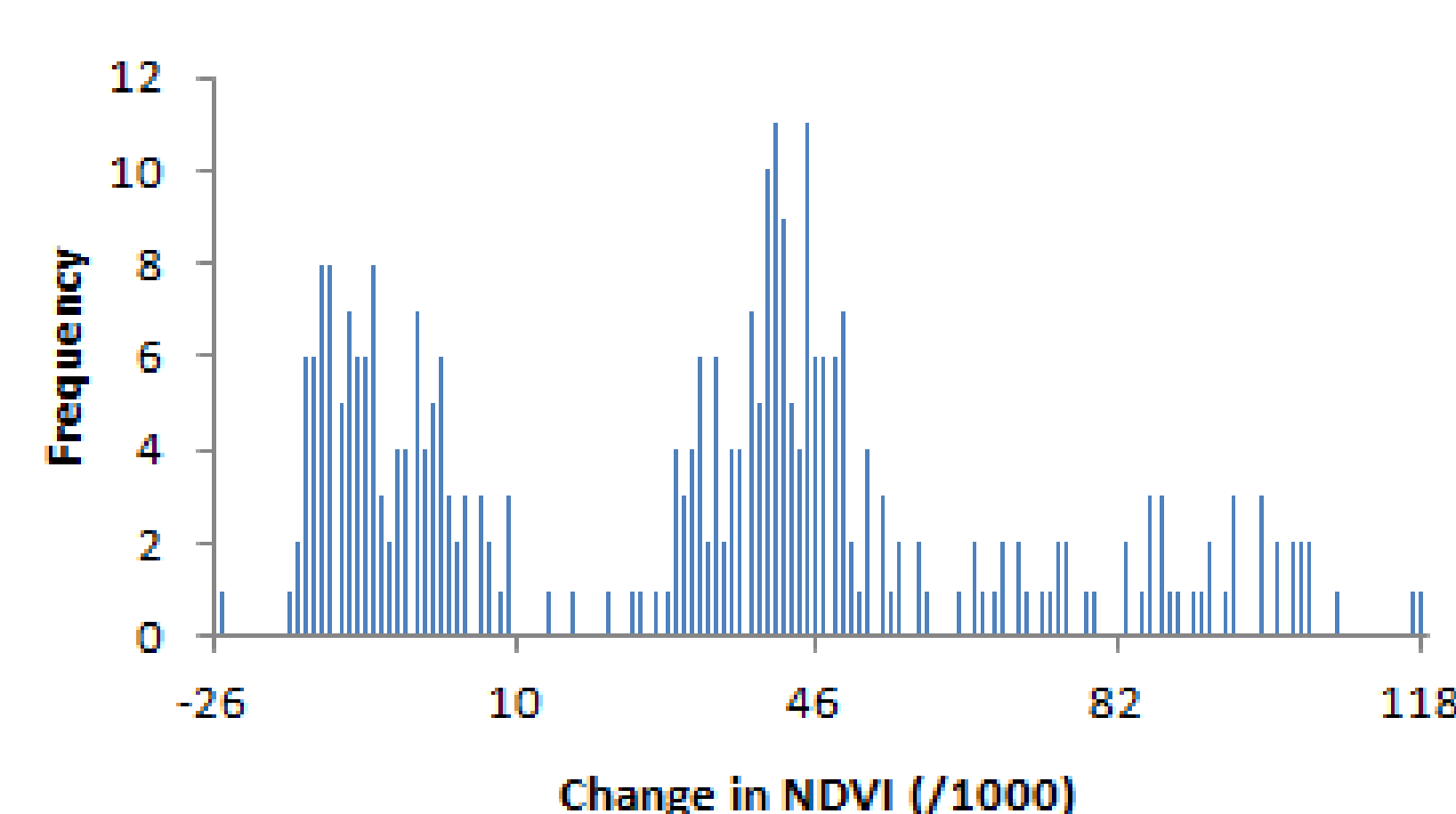


Figure 2: Frequency distribution of the change in average NDVI in the Ottawa – Kingston area between 1984-1985 and 2001-2005, n=312 quadrants with less than 13% variation in area, over 20% NDVI coverage and greater than 10hr surveying.

The bimodal distribution in figure 2 of the change in NDVI between 1984-1985 and 2001-2005 depicts that the majority of quadrants experienced a notable increase in NDVI between 1984-1985 and 2001-2005 while a considerable number of quadrants underwent a marginal decrease in NDVI.

As depicted in Figure 3, the average stdNDVI between 1984-1985 and 2001-2005 in the Ottawa – Kingston region increased by 19.58%. With this notable increase in stdNDVI – and therefore habitat heterogeneity – an increase in species richness between the first and second OBBA was also observed in the Ottawa – Kingston area of 9.53%. Analyses performed to determine if a similar positive correlation existed between stdNDVI and species richness at an increased spatial resolution of 10 x 10 km generated insignificant results as manifested in Figure 4.

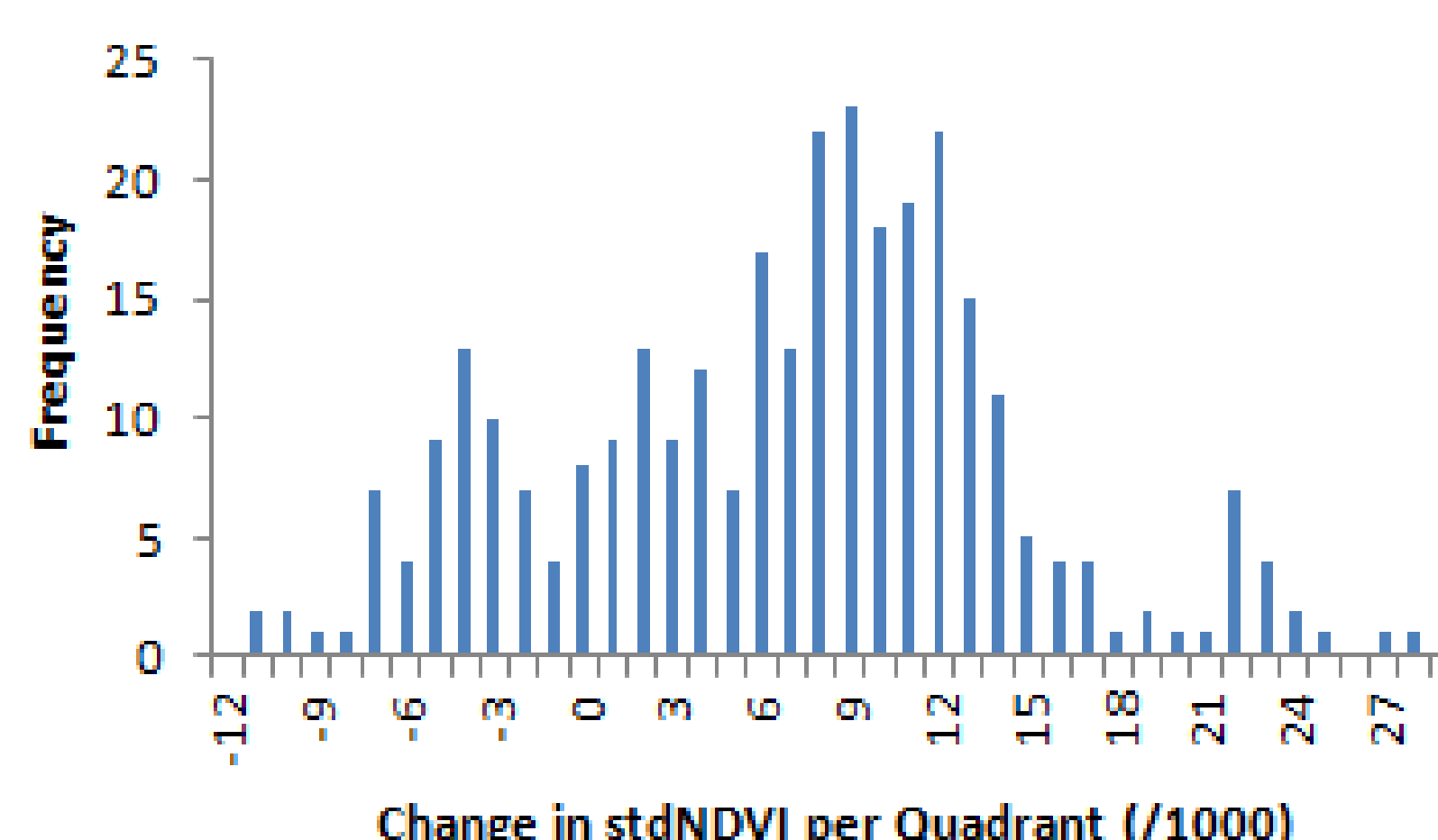


Figure 3: Frequency distribution of the change in stdNDVI in the Ottawa – Kingston area between 1984-1985 and 2001-2005.

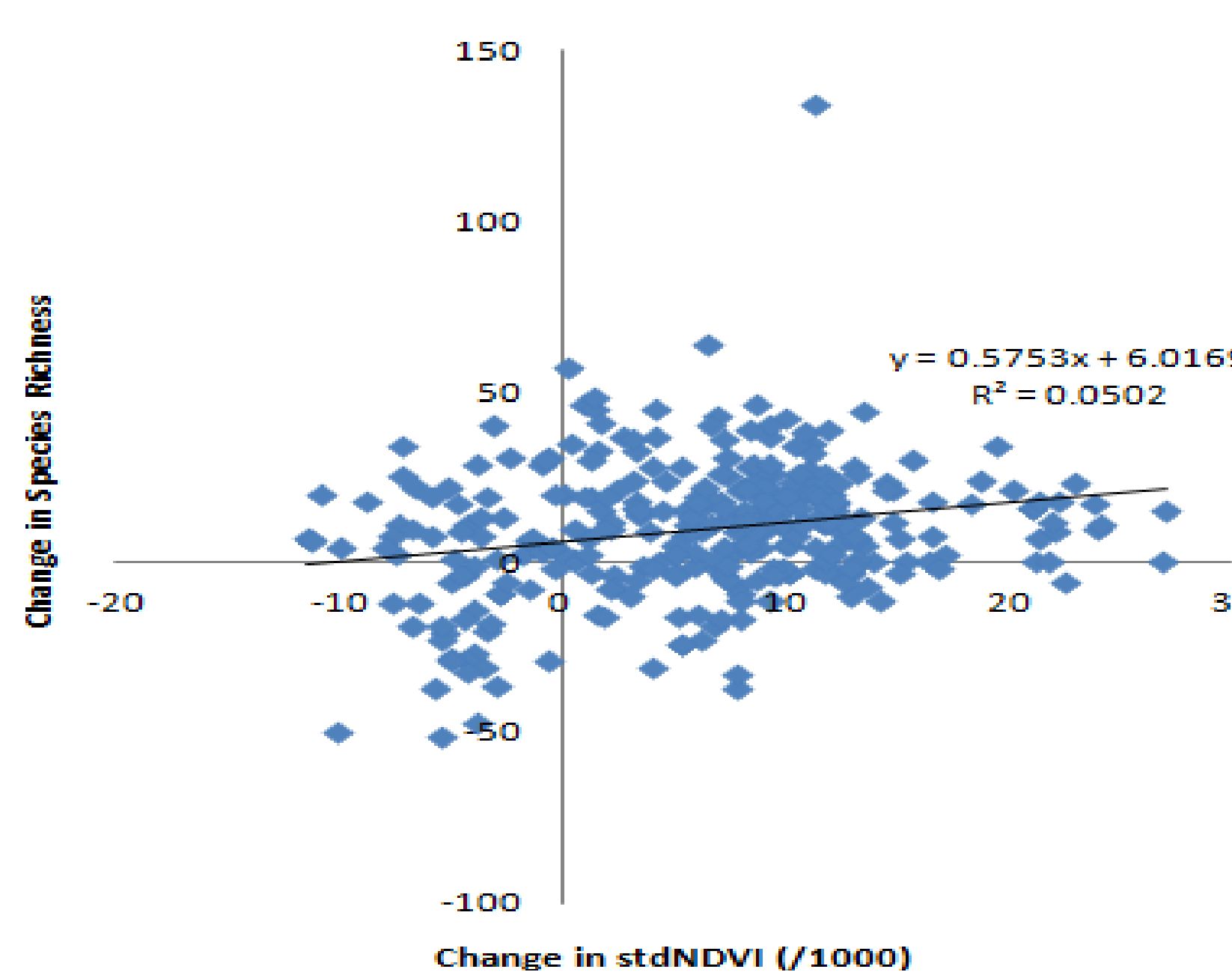


Figure 4: Avian species richness as a function of the change in stdNDVI between 1984-1985 and 2001-2005 per 10 x 10km quadrant. All 312 quadrants used in Figure 3 are included, regardless if they underwent gradual, moderate, or sudden change.

While insignificant results were observed in Figure 4, it is evident that a significant correlation between stdNDVI/rNDVI and avian species richness at a resolution of 10 x 10 km exists in quadrants experiencing gradual changes in stdNDVI/rNDVI. These correlation are depicted in Figures 5 and 6 respectively. In these two figures, there is a significantly stronger correlation between the change in stdNDVI or rNDVI and the change in species richness for quadrants that experienced gradual as opposed to sudden change.

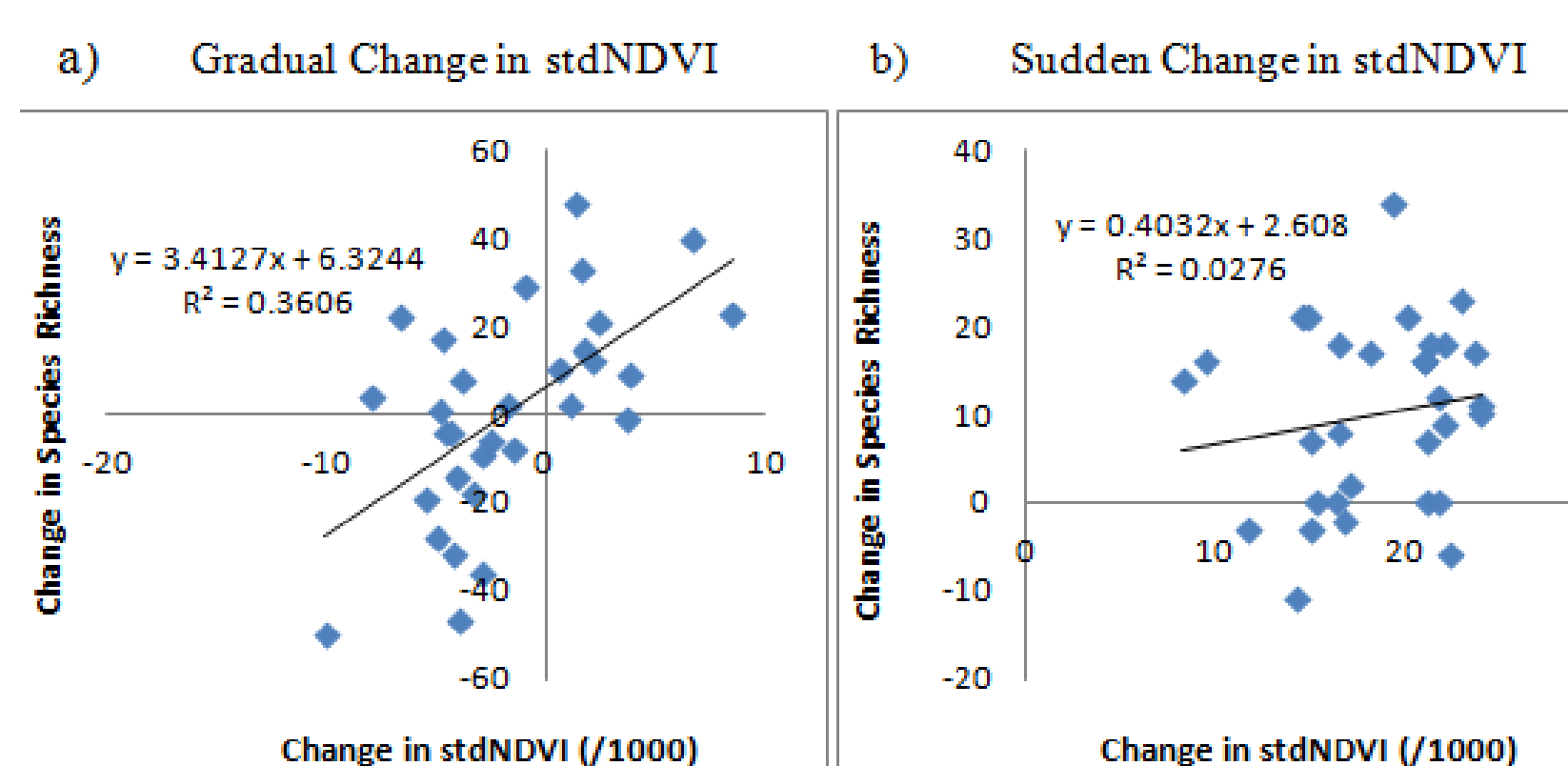


Figure 5: Avian species richness as a function of the change in stdNDVI between 1984-1985 and 2001-2005 per 10 x 10km quadrant. a) represents 31 quadrants that experienced a 'gradual change' in stdNDVI while b) represents 31 quadrants that experienced a 'sudden change' in stdNDVI.

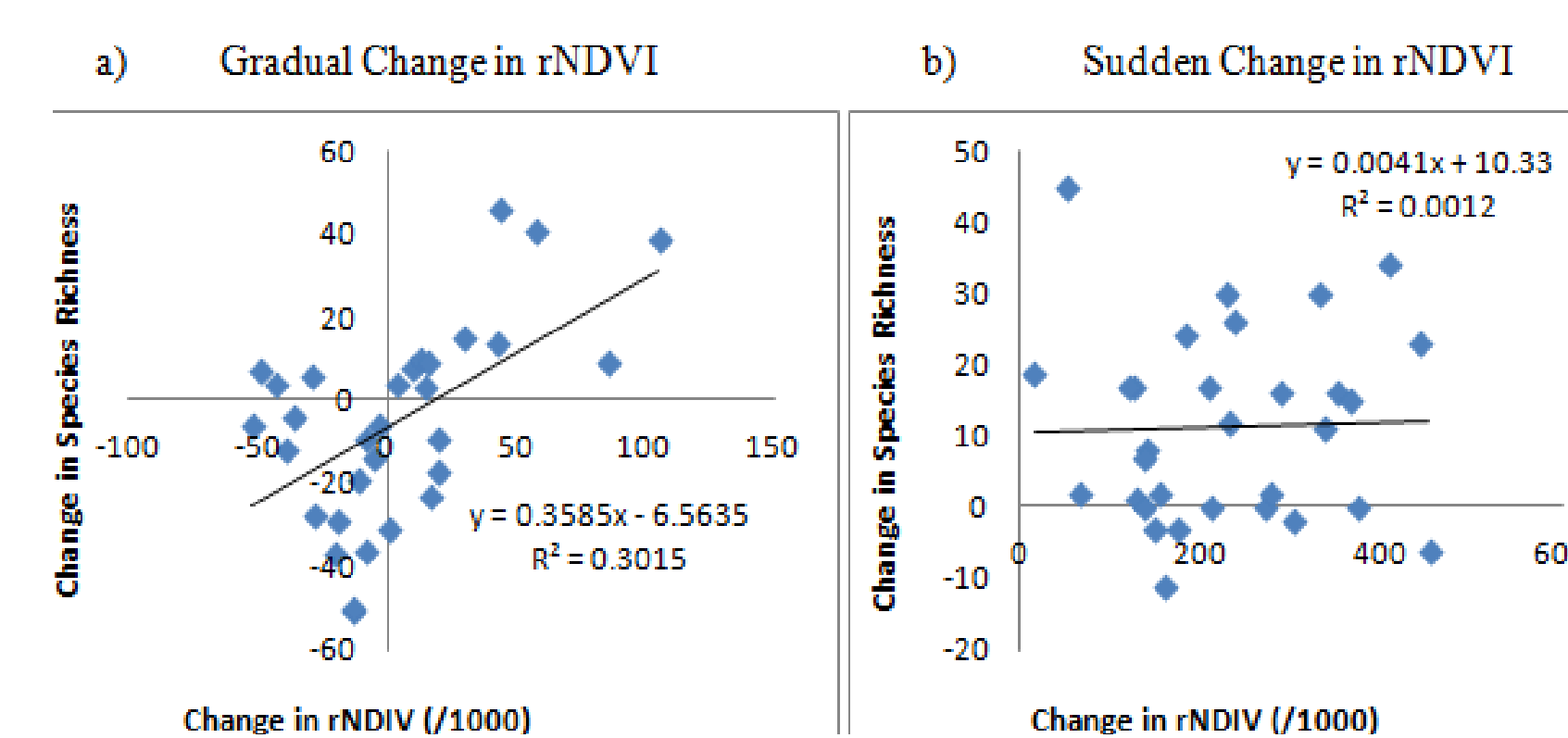


Figure 6: Avian species richness as a function of the change in rNDVI between 1984-1985 and 2001-2005 per 10 x 10km quadrant. a) represents 31 quadrants that experienced a 'gradual change' in rNDVI while b) represents 31 quadrants that experienced a 'sudden change' in rNDVI.

Discussion

This research established that gradual changes in stdNDVI/rNDVI can accurately gauge avian species richness while sudden changes in stdNDVI/rNDVI cannot be used to gauge avian species richness. The Ottawa – Kingston area has a relatively high human population density for Canada and boasts fertile grounds for agriculture.⁷ Processes with the potential to evoke a sudden change in stdNDVI or rNDVI include partial conversion of quadrants' forested land (high NDVI) to urban settlements or agricultural land (low NDVI) corresponding to the first hump in Figure 1. The growth of vegetation on abandoned agricultural fields is likely the cause of gradual changes in stdNDVI and rNDVI corresponding to the second hump in figure 1 showing an increase in NDVI. Based on these assumptions, gradual changes in NDVI were likely gradual *increases* in NDVI while sudden changes in NDVI were likely sudden *decreases* in NDVI. It is assumed that these finding can be applied in other regions not dominated by agricultural land use.

Presumably, a variety of variables not considered in this study such as 'if a sudden change occurred prior to the spring hatching of eggs' would greatly affect bird species richness in quadrants sustaining sudden changes. Contrary to sudden changes, gradual changes occurring throughout the year would not have such an impact on avian richness. This could explain why rNDVI and stdNDVI can be used to accurately predict species richness in quadrants with gradual but not sudden changes.

To accurately measure bird species richness changes and develop precise conservation strategies stdNDVI and rNDVI should be used in conjunction with other measures to predict species richness such as land cover class.⁴

References

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