LANDSCAPE SCALE HABITAT ASSOCIATIONS OF SPRAGUE'S PIPIT (ANTHUS SPRAGUEII) OVERWINTERING IN THE SOUTHERN UNITED STATES

by

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A thesis submitted to the Graduate Council of
Texas State University in partial fulfillment
of the requirements for the degree of
Master of Science
with a Major in Wildlife Ecology
August 2015

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LIST OF ABBREVIATIONS

Abbreviation	Description

AMPI- American Pipit (*Anthus rubescens*)

IMP- Impervious Cover

NLCD- National Land Cover Database

RNDM- Random Locations

SHRD- Shared Locations

SPPI- Sprague's Pipit (*Anthus spragueii*)

TCC- Tree Canopy Cover

USDA- United States Department of Agriculture

USFS- United States Forest Service

ABSTRACT

Sprague's Pipit (*Anthus spragueii*) is a North American endemic migratory grassland songbird that has experienced a substantial population decline over the last half-century. There has been very limited research done on Sprague’s Pipit especially on their wintering grounds. There is no complete account of their historic wintering range and there is also limited knowledge about the status of their current wintering range in the United States and Mexico. On the breeding range, Sprague’s Pipits seem very selective in their habitat use, although there are reports that there may be a broader use of habitats on the wintering grounds. My objective was to determine the habitat types that Sprague’s Pipits associate with at the landscape scale. I used land cover data from the National Land Cover Database GIS layers, CropScape GIS layer and pipit point locations retrieved from eBird. I examined landscape-scale (1, 2 and 5 km) habitat associations of Sprague’s Pipit over wintering in areas of Arizona, New Mexico, Texas, and Louisiana. I then compared these habitat associations to those of random locations and to locations of the closely related American Pipit. I found that Sprague’s Pipit locations had minimum canopy cover and lower percent cover of woody vegetation and certain agriculture land cover types. I also found that although Sprague’s Pipit is known to be negatively affected by non-native and anthropogenic grasslands at fine spatial scales, these grassland types may be suitable for the species at the landscape scale. Sprague’s Pipit also appeared to be much less of a habitat generalist than the more common American Pipit. The results of my study could potentially be used in landscape-level planning for the conservation of the species on its wintering grounds.

I. INTRODUCTION

Sprague's Pipit (*Anthus spragueii*) is a small migratory songbird endemic to North America. Sprague's Pipit has been described as a grassland specialist (Davis et al 2013, Davis, Robbins and Dale 2014, Macias-Duarte et al. 2009) and as a grassland obligate (Fisher 2011b, Koper 2009, Ranellucci 2012), meaning that they require grasslands to complete at least some part of their life cycle. Sprague's Pipits breed in the northern portion of the Great Plains in the north central USA and south central Canada. The species migrates through the Great Plains and overwinters mainly in Texas, Louisiana, New Mexico and northern Mexico (Figure 1). Sprague's Pipits start arriving on the wintering grounds as early as late September, and start leaving for the breeding grounds in late March to mid-April. Although some individuals may remain on the wintering grounds into early May (Arvin 1982).

Sprague's Pipit is protected in all parts of its range; Canada, Mexico and the United States under the Migratory Bird Treaty Act of 1918 as amended (16 U.S.C. 703-711: 40 Stat. 755; U. S. Fish and Wildlife Service 2008a).They are listed as vulnerable on the International Union for the Conservation of Nature (IUCN) Red List (Hilton-Taylor 2000). In 1999 Sprague's Pipit was listed as threatened in Canada under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Sprague's Pipit was petitioned for listing in 2008 by WildEarth Guardians (WildEarth Guardians 2008), and the U. S. Fish and Wildlife Service (USFWS) determined that the petition presented substantial information indicating that listing the Sprague's Pipit is warranted, but is precluded by higher priorities (U. S. Fish and Wildlife Service 2010). Therefore, currently in the United States, Sprague's Pipit is a candidate for listing as "endangered" or “threatened” under the Endangered Species Act of 1973 as amended (16 U.S.C. 1531 et seq.; U. S. Fish and Wildlife Service 2008b, 2010). Even with this protection, Sprague’s Pipits have been experiencing a substantial population decline over the last half century; data from the North American Breeding Bird Survey reveal a population decline of 65.7% across the breeding range in the United States and Canada from 1966 through 2011 (Sauer et al. 2011). The population decline appears to be similar on the wintering grounds. According to Christmas Bird Count (CBC) data, the population has declined 73.1% from 1966/1967 through 2005/2006 (Schmidt 2010).

The main reason for this major decline is likely the anthropogenic changes to and reduction of native prairies that occurs with fire suppression, overgrazing, and conversion of prairie to cropland (Brennan and Kuvlesky 2005, Samson and Knopf 1994). Grasslands are one of the most modified and destroyed habitat types in North America; roughly 20% of the 162 million ha of the Great Plains remains in a natural condition and much of that is fragmented (Samson and Knopf 1994). Fragmentation may be as or more important than sheer area of suitable habitat (Heckert 1994). On the breeding grounds in Alberta and Saskatchewan, the mixed-grass prairie has declined to 26.7% of its historical extent (Samson and Knopf 1994). On the wintering grounds in Texas only 20% of the original short grass prairie remains (Samson and Knopf 1994). The large scale conversion of prairie to agriculture has taken longer in Mexico but it is intensifying. The 2.7 million hectare Valles Centrales in northern Mexico has been transforming into a major agricultural region, from 2006 to 2011 there was a 6 % annual rate of cropland expansion, calculated to have displaced 1,396 Sprague’s Pipits (Pool 2014).

There is much more known about the species on their breeding grounds than on the wintering grounds. Sprague's Pipits have been shown to prefer short and mixed grass native prairie on the breeding grounds (Davis 2004, Grant et. al. 2004, Jones 2010) and are most likely to occur in native habitat patches greater than 145 ha with minimal edge (Davis 2004). Davis et al. (2013) found that Sprague's Pipit occurrence was most greatly influenced by an increased amount of native prairie within an 800 meter buffer of the habitat patch. Koper et al. (2009) found that Sprague's pipit relative abundance within a habitat patch was influenced by the type and proximity of other land cover types, with cropland and wetland having the most negative effect on abundance. Sprague's Pipit also tends to avoid overgrazed areas on the breeding grounds (Maher 1973; Dale 1983; Prescott and Wagner 1996; Davis et al. 1999), presumably due to grass height and density being too low. This culminates in Sprague's Pipits preferring large continuous native grasslands that have minimal human disturbance.

On the wintering grounds Sprague's Pipit is also considered a grassland specialist although the exact habitats that are used differ some from the habitats on the breeding grounds. In the wintering range, Sprague's Pipits will use sparsely vegetated grasslands (Desmond et al. 2005), cultivated lands (Stevens et al. 2013), and heavily grazed grasslands (Grzybowski 1982) provided that shrub cover is minimal. Several studies from Mexico have shown that pipit density is highest in grasslands with a high percentage of grass cover and low numbers of shrubs (Macias-Duarte 2011, Pool et al. 2012). Pool et al. (2012) showed that shrub density negatively impacts Sprague's Pipits, but shrub height is not a major factor. Macias-Duarte (2011) found that taller grass height has a negative impact on Sprague's Pipits. In Texas, the species is typically associated with grasslands that have less than 5% shrub cover and grass heights less than 50 cm (Grzybowski 1982). A different study revealed use of grassland habitat where shrub cover was less than 50% (Igl and Ballard 1999).

One of the reasons that Sprague's Pipit has not received more protection is due to the relative lack of information on the species. In terms of published research, the species is one of the least studied birds in North America. This may be due to its cryptic appearance and behavior as well as low population densities. Alström (2003) stated that the species "usually hides in grass or other short vegetation where only its head and craning neck are visible". The highest density of wintering birds reported in Pool et al. (2012) was 8.4 birds per km^2 at one site while most sites had less than 4 birds per km^2.

Sprague's Pipit current range in Mexico is not fully known, there have been several studies to help determine their range. The distribution in Mexico likely varies from year to year depending on multiple factors, such as rainfall during the previous spring and summer and the effect of that rainfall on vegetation growth (Contreras-Balderas 1997). This is likely the case throughout the wintering range. Macias-Duarte (2011) surveyed for and found Sprague's Pipits throughout the Chihuahuan Desert Grasslands. The status of overwintering birds in Mexico is likely to be similar to that in the United States, with loss of native grassland being a main contributor to population decline. Large areas of desert grasslands are undergoing a process of desertification due in part to overgrazing that could also reduce the amount of habitat (Pool et al. 2012).

Landscape analysis can be an informative tool when examining patch occupancy and abundance of a species (Ribic et al. 2009). Site selection on the breeding and wintering grounds is a hierarchical process beginning at a landscape scale when an individual first selects an “ecological neighborhood” (Addicott et al. 1987), then at a finer scale selects a particular type of habitat (Johnson 1980, Hutto 1985). We know that Sprague’s Pipits are affected by landscape characteristics on the breeding grounds (Davis 2004, Davis et al. 2013, Koper 2009) it is therefore likely that there is some form of association with landscape-level habitat on the wintering grounds. To my knowledge no studies have been conducted on the landscape-scale habitat associations of Sprague’s Pipit on the wintering grounds. Herein, I report the first such study.

Because Sprague’s Pipit is such a hard-to-find species, my study utilized data from eBird in order to obtain sufficiently large sample sizes. Regarding use in research, eBird is an underutilized data resource even though it is accumulating one of the largest biodiversity databases in existence (Sullivan 2009). For example, in March 2012 alone there were 3.1 million bird observations entered for North America and as of August 13, 2012 there were over 100 million bird observations, over 7 million checklists, and over 1 million locations sampled. One possible reason for low usage in research is that eBird is a citizen science program, which obviously entails that the data are not collected in the most rigorous or standardized way. There are several issues to consider about the validity of eBird data. First is that the skill of each observer is not known and therefore bias may be created from the misidentification of birds. But because Sprague’s Pipit is a fairly unknown and non-charismatic species it is likely that the species is underrepresented in eBird as many beginning birders are not completely aware of it. Another problem with eBird is that there is not equal “survey effort” across a species range; most eBird reports come from known birding locations like nature preserves, refuges and parks, with fewer reports from private property. The unequal survey effort is easily seen in Figure 2 where most Pipit eBird reports came from areas where there are higher numbers of birders; such as metropolitan areas like Austin and Houston. Exact locations of eBird reports is not always known with high precision in that when submitting a checklist most people select a spot in the middle of the area birded which could be different from where a given bird was actually seen. For example Attwater Prairie Chicken National Wildlife Refuge consists of about 4,264 ha, but there is only one hotspot from eBird, therefore the checklist will only contain that one point but in reality the bird could have been seen anywhere in that 4,264 ha area. For my study, I tried to remove as much of this error as possible (see Methods section). Because eBird has by far the greatest number of observations for Sprague's Pipit (compared to similar citizen science databases) its volume of data outweighs the issues associated with data collection – there is enough data for the researcher to set standards on which data to include.

The primary way that I "corrected for" the non-standardized data collection of eBird was to compare the Sprague's Pipit data to another set of data that contained the same set of survey issues. The American Pipit (*Anthus rubescens*) is a closely related species that occurs within the range of Sprague's Pipit but is also found across North America and the Pacific coastal area of Asia. Moreover, it is not a declining species and can be relatively common in many areas. Therefore, I used the data for the American Pipit as a type of standard against which to compare results found for Sprague's Pipit. Moreover, comparison to American Pipits is biologically interesting in that as a more common species, American Pipits might not be as selective of habitat as are Sprague's Pipits.

Objectives

My objectives were to determine the landscape-level habitat characteristics of Sprague's Pipit point locations within their wintering range, and to determine whether or not these characteristics differ from those of the closely-related American Pipit and random point locations. I compared my results for wintering habitat associations to those that have been documented for the summer breeding grounds. The study is intended to provide information that might be useful to biologists involved in assessing the conservation status of the species.

II. STUDY AREA

Sprague's Pipits primary wintering area in the USA includes most of Texas (excluding the panhandle), the southern portions of Louisiana, New Mexico, and Arizona. Other areas are occasionally used such as southern California, south-central Oklahoma, Georgia, and Florida, although reports from these areas might represent vagrant individuals. Because Sprague's Pipits overwinter regularly only in Texas, New Mexico, Arizona, and Louisiana, these are the only states that were included in the analysis. A substantial portion of the wintering range occurs in northern Mexico, but insufficient land cover data exists for the region, therefore I did not use any eBird data from Mexico.

III. DATA SOURCES

eBird

eBird is an online bird checklist database administered by the Cornell Lab of Ornithology and the National Audubon Society. eBird was launched in 2002 and is open to public participation in that anyone can set up an account and access/contribute data in the form of checklists. eBird provides scientists and amateur birders real-time and archived data on the distribution and abundance of bird species. Each checklist includes species observed (or the number of each species), location, time, date, and an estimate of effort. The checklist is submitted and joins the checklists of everyone else’s in an internal network and is then available on the internet in a variety of formats through query search. Each observation goes through automated data quality filters that were developed by local experts and refined using observations already entered for the location through a program of “artificial intelligence” that learns which birds and how many should be found in the particular location (Sullivan, 2009). Local experts review any “unusual” observations that were flagged by the filters. The goal of eBird is to maximize the utility and accessibility of the massive number of observations made by the birding community.

National Land Cover Database

The National Land Cover Database (NLCD) is a land cover product created by the Multi-Resolution Land Characteristics Consortium (MRLC) which is a partnership of federal agencies led by the United States Geological Survey (USGS). The land cover type layer is a raster layer that is created using satellite imagery that is based primarily on a decision-tree classification using circa 2006/2011 Landsat satellite data. Land cover is divided into 16 classes at a resolution of 30 meters. Data is available for 2006 and 2011.

NLCD Percent Developed Imperviousness

The NLCD Percent Developed Imperviousness (IMP) is a raster data set that is also created using satellite imagery. The data set estimates the amount of man-made impervious cover or surface (roads, buildings, concrete, and asphalt). The resolution is 30 meters with each cell (pixel) having a value that ranges from 0-100 percent (in 1% increments) which indicates what percent of that cell is covered by impervious features. Data is available for 2006 and 2011.

NLCD USFS Tree Canopy Cover Cartographic

The Tree Canopy Cartographic data layer was created through the United States Forest Service (USFS) although it also is based on the same imagery as that used by the NLCD. The layer is the percent canopy cover per pixel. The resolution is set at 30m for each cell. Values for the canopy cover layer range from 0-100% in 1% increments. Data are only available for 2011.

USDA National Agricultural Statistics Service Cropland Data Layer (CropScape)

The Cropland Data Layer is a raster, geo-referenced, crop-specific land cover data layer that is created annually using moderate resolution satellite imagery, and ground-truthed agricultural data. The crop-specific data comes primarily from the Farm Service Agency Common Land Unit data, which means that the farmer reports the type of crop being planted. The primary crop displayed is summer crop and only if a farmer reports a double crop will winter (only) cover be included in the database. Data are available for every year starting in 2008 at 56m resolution, and then 2010 at 30m resolution.

IV. METHODS

eBird

Data from eBird were obtained in May and June of 2014. Data are publicly available and downloaded with permission from www.ebird.org after a formal request by the data user. Sprague's Pipit (SPPI) occurred on a total of 9,500 checklists for all years and across the entire species range. Because I was only interested in the wintering range, I removed all checklists except those for the states of Arizona, Louisiana, New Mexico, and Texas. I removed all checklists that fell outside of the years ranging from 2004 to 2013 because the land-cover data were from 2006 and 2011. This left 2,366 checklists. American Pipit (AMPI) occurred on a total of 188,326 checklists. I removed checklists for AMPI with the same parameters as I did with SPPI. Additionally because my focus was SPPI, I only used AMPI checklists within a county that also contained a SPPI checklist; this reduced the total checklists to 11,593. I then went through each SPPI and AMPI checklist individually to determine its accuracy and validity.

When determining the accuracy and validity of each point multiple factors were taken into consideration. First the distance traveled by the observer. If the observer traveled more than 10 kilometers along a road (which could induce too much potential error in the actual GPS coordinates) then the checklist was discarded. Ten kilometers was chosen because the largest buffer size has a 5 km radius; therefore, 10 km should contain the actual location assuming the point was placed in the middle of the area that was birded. The next factor scrutinized was the location description reported by the observer. If the observer reported multiple locations or a vague description such as only stating the county then the point was discarded. I also checked the interactive eBird map to see whether the description matched the reported latitude and longitude coordinates. Because misidentification could be an issue, I checked the number of birders for each checklist; I assumed that the likelihood of misidentifying a species probably decreases with multiple observers. I also looked at the other species included in the checklist to see if other similar species were reported. Similar species were species of similar size and coloration as well as those that are commonly found in similar habitats. This was used because if the observer was able to distinguish between multiple similar species then it is likely that he or she would not mis-identify Sprague's Pipit. The last factor I examined was whether the observation was flagged by the eBird system, if flagged then the observer has to give a species description. I read the description of the bird to see if the observer described it accurately.

Once I had a list of acceptable checklists, I removed all duplicates of the same location (as occurs when the same or different birders visit the same site repeatedly). Because not all sites received the same sampling effort, I did not want popular sites to have more influence than less surveyed sites. This left 635 confirmed and valid point locations for Sprague's Pipit and 1,300 locations for American Pipit (Figure 2).

GIS Processing of Land Cover Data

The latitude and longitude coordinates that were obtained from eBird checklists for each species were imported into ArcGIS 10.2. Both Sprague's and American Pipit locations were separated into two groups to coincide with the year of the NLCD data;

eBird data from 2004-2008, used with land cover data from 2006 and eBird data from 2009-2013 used with land cover data from 2011.

I also generated a third set of points at locations where both Sprague's and American Pipits occurred. I did this by joining the American Pipit point class to the Sprague's Pipit point class based on location, and keeping only the locations that matched. There were 144 of these shared locations.

The fourth set of points I generated were random locations within a set distance of Sprague's Pipit points. I restricted the distribution of the random locations to control for the unequal spatial distribution pattern of the Sprague's Pipit points, which is caused by the uneven effort of eBird users. Each Sprague's Pipit point was assigned a random distance (between 8-10 kilometers) and a random direction (between 1-360 degrees). Using the bearing distance-to-line tool in ArcGIS, a line was generated from the Sprague's Pipit point in the randomly generated direction with length equal to the randomly generated line. Using the feature vertices-to-point tool, I created a point at the end of the line. I also reduced the range of random direction for pipit points along the coast and along the US-Mexico border to avoid having random points in Mexico or the open ocean. These random points were used as a comparison to the points for Sprague's and American Pipits with regard to determining whether either species associates with land cover types to a different extent than what is available in the overall landscape (see below).

Land cover composition for each point in each set (SPPI, AMPI, shared [SHRD], and random [RNDM]) was determined for three buffer sizes or spatial extents (circles with radius 1 km, 2 km and 5 km) centered on each point (Figure 3). Use of multiple buffer sizes allowed me to determine if there was any area dependence within the results of the landscape analysis (Niemuth 2000, Bakker et al. 2000).

To analyze the NLCD and CropScape data I used the program FRAGSTATS because buffers at adjacent point locations sometimes overlapped. ArcGIS 10.2 is not able to properly calculate percent cover (and some other tasks) on buffers that overlap because its clipping algorithm works like a cookie-cutter (when the buffered areas are part of the same file) such that buffers that are processed later have missing portions if they overlap with previously processed buffers. In order to surmount this problem, I imported the buffers into FRAGSTATS and created an individual layer (raster) file for every point/buffer. This process was automated through the use of Python computing code. I then applied the Percentage of Landscape Tool (PLAND) in FRAGSTATS to get the percentage of each land cover type within each individual buffer. To simplify subsequent analyses and comparison, I combined similar NLCD land cover categories into nine cover types (Table 1). CropScape contained 99 land cover classes and were combined into 20 types based on similarity (e.g., corn, sweet corn, popcorn, and sorghum were combined into a single class “corn”). Because CropScape uses data from the NLCD to “fill in the blanks” between agriculture fields, the same land cover types that were used in the NLCD layer were used in the CropScape layer with cropland split into 12 additional crop land-cover types. The following crop land-cover types were included for analysis: corn, cotton, legumes, grass crops, tree crops, vegetable crops, greens, rice, large flower crops, short flower crops, other crops, and idle or fallow lands.

To analyze the Impervious Surface and Tree Canopy Cover, data I again used a custom created python script within ArcGIS. This python script created a temporary buffer layer containing only the individual buffer being examined and then used the "zonal statistics as table" tool in ArcGIS on each individual buffer. The zonal statistics tool provides the mean cell value for the entire buffer, thus giving the average cell value within the buffer. Because each cell in the impervious and tree canopy layers is a number representing the percentage of that cell containing either impervious surface or tree canopy, the zonal statistics tool gives the amount of tree canopy or impervious cover within each buffer. The final output was a table containing the average value of the raster layer under each individual buffer for every buffer/point.

Testing for Significant Differences between Point Locations

I used a randomization test to compare the landscape characteristics of the point locations given that the data were not normally distributed and violated the assumption of independence because some of the buffers overlapped. For a given response variable (landscape characteristic) the randomization test compared the difference in observed means of two sets (groups) of points to differences in means of randomized data. The randomization step pooled the two groups of points and then randomly distributed the individual values into two new groups with sizes equal to the original two groups. Each mean of the two new groups was calculated and the difference between these two new means was determined. This randomization process was repeated 1,000 times to form a test (or null) distribution that was then used to derive a p-value assessing whether the observed means were significantly different. The randomization test assesses how likely it would be to get a difference in the observed means as great or greater than the actual difference if the data (point locations) were randomly distributed among the two groups being compared. I did the following series of comparisons: (1) SPPI to AMPI, (2) SPPI to random points, and (3) SPPI to shared locations. These comparisons were separately conducted at all 3 buffer sizes. I also compared SPPI, AMPI, and random points at different buffer sizes to determine if there were any differences between buffer sizes.

V. RESULTS

NLCD Land Cover Types

Grassland was the dominant land cover type for SPPI and AMPI locations, shared locations, and random points at all scales (Figure 4). The largest difference in grassland cover was between SPPI and AMPI locations with SPPI locations averaging 8% more grassland cover per buffer (Figure 4); developed land cover and forest cover both had about 5% more cover per buffer at AMPI locations when compared to SPPI locations. Together, grassland, shrubland, cropland accounted for 63% of the total land cover for SPPI locations while only accounting for 49%, 54%, and 65% for AMPI locations, shared locations, and random points (Figure 4). SPPI had statistically significant higher percentages of barren land, shrubland, grassland, and cropland than did AMPI locations (Table 2), while AMPI locations had significantly higher percentages for open water, developed open space, developed lands, and forests (Table 2). SPPI had significantly higher percentages for open water, developed open space, and barren land compared to random locations. The only land cover type that SPPI had significantly less per point than random locations was forest (Table 2).

When comparing locations to themselves at different buffer sizes, there were differences between 1 km and 5 km. SPPI averaged more developed open space at the 1 km buffer size (1.095, $p=0.001$), and more forest at the 5 km buffer size (1.345, $p=0.03$). AMPI averaged more open space (1.2, $p<0.001$) and barren land (0.4, $p=0.004$) at the 1 km buffer size and more shrub land (3.2, $p<0.001$) at the 5 km buffer size. For random locations, there was only 1 difference between buffer sizes; there was less open water at 5 km (2.0, $p=0.001$).

Crop Types

The majority of crop types constituted little of the total land cover area per point with most crops accounting for less than 1% of the land area per point even when combined into similar groups (Figure 5). Only corn, cotton, hay crops, and rice averaged more than 1% of the land cover per point (Figure 5). When SPPI is compared to AMPI, SPPI points had statistically more corn, and cotton, while containing statistically less hay, tree crops, greens, and other crops (Table 3). When comparing SPPI to random points, SPPI points averaged statistically more corn, idle land and vegetables. The only crop type for which SPPI points had statistically less land cover was cotton (Table 3). There were no differences in any crop type between buffer sizes for SPPI, random locations, and AMPI.

The most common crop type across all points was corn; SPPI points contained higher percentages of corn in comparison to AMPI and random point's at all three scales (Figure 5). SPPI points also contained statistically more idle or fallow land at all three scales when compared to random locations, but there was no difference with idle fields when compared to AMPI (Table 3). SPPI also averaged significantly more cotton per point when compared to AMPI at all three scales, but contained significantly less cotton when compared to random locations at all three scales (Table 3). SPPI averaged statistically more grass crops than random points at 2 and 5 km scales, and had statistically less grass crops than AMPI at 1 km (Table 3).

Tree Canopy Cover

SPPI locations contained less tree canopy cover at all three buffer sizes when compared to either AMPI or random points (Figure 6, Table 4). SPPI locations did not significantly differ in tree canopy cover from the shared locations (Table 4). When comparing species to themselves at different buffer sizes. SPPI locations contained statistically less tree canopy cover at the 1 and 2 km buffer sizes than at the 5 km buffer size (Table 4) while AMPI and random points did not differ amongst buffer sizes (Table 4). AMPI averaged statistically more tree canopy cover than did the random points at the 5 km buffer size.

Impervious Cover

SPPI locations contained less impervious cover than AMPI locations and random locations at all three buffer sizes (Figure 6); all of the comparisons were statistically significant except for SPPI vs. random locations at 1 km (Table 4). SPPI locations did not differ from shared locations at any buffer size. AMPI locations had almost twice as much impervious cover than SPPI locations as well as containing more impervious cover than either random or shared locations (Figure 4).

VI. DISCUSSION

Sprague's Pipit is considered a grassland specialist and has been shown to be negatively affected by shrubs and woody vegetation on the wintering grounds (Macias-Duarte 2011, Pool et al. 2012); thus, it is no surprise that they occurred in areas with less tree canopy and forest compared to random locations. The difference in canopy cover and forest was more evident at smaller spatial scales than at larger scales. At the 1 km scale, Sprague's Pipit locations had an average of 8.4% canopy cover whereas random points had 13.4%, but at the 5 km scale Sprague's Pipit locations had an average of 10.4% canopy cover whereas random points 12.7%. Similar scale-dependent differences in forest cover were also revealed. These results suggest that the species' avoidance of canopy cover and forest habitat is a fairly fine-scale preference. In contrast, American Pipits had about the same percentage of tree canopy cover as did random locations at the 1 and 2 km scales, while having more tree canopy than random locations at the larger 5 km scale. The other type of woody land cover is shrub land, defined as areas with woody vegetation less than 5 m tall that do not interlock or form a true canopy. Sprague's Pipit locations had slightly less shrub cover compared to random points (17.1% vs. 19.3%), but the effect was weak and only marginal significant (p=0.064). Sprague's Pipits did associate with shrub land significantly more so than did American Pipits (17.1% vs. 14.1%). So even though Sprague's Pipits have a negative association with shrubs at finer scales (Macias-Duarte 2011 and Pool et al. 2012), at larger landscape scales shrubs may not be a significant factor.

Sprague's Pipit points had less impervious cover and developed land cover when compared to American Pipits at all three landscape scales. When compared to random locations, Sprague's Pipit locations had significantly less impervious cover at the 2 and 5 km buffers, but with developed land cover Sprague's Pipit locations had only marginally significantly less at the 2 and 5 km buffers (p=0.042, p=0.056). It is likely that the types of development and impervious cover are more important factors than simply the amount of impervious cover when determining its effect on Sprague's Pipits. Sprague's Pipit relative abundance has been shown to be negatively affected by larger paved roads rather than smaller unpaved roads (Sutter 2000). This is likely due to paved roads displacing more habitat than smaller roads. Therefore Sprague's Pipit abundance was negatively affected by larger roads simply because there was less habitat (Sutter 2000). Other studies have shown that roads do not affect Sprague's Pipits; Koper (2009) found that roads were insignificant edge factors when looking at the relative abundance of Sprague's Pipit in native grassland patches. While Jones (2012) showed that daily nest survival was not affected by distance to roads. In central Texas it was shown that wind turbines did not affect abundance of Sprague's Pipit (Stevens 2013). This suggests that development and impervious surfaces are probably affecting Sprague's Pipit negatively only in that they displace native habitat, and not because of disturbance. American Pipits seem to favor developed land cover types, having 12% of their land cover composed of developed lands. This is not surprising because American Pipits are considered more of a habitat generalist, although it might also be that American Pipits are better able to adapt and utilize anthropogenic landscapes than are Sprague's Pipits.

There were more differences between Sprague's and American Pipits than there were between Sprague's Pipit and random locations. This is in part due to the fact that random points were generated from the Sprague's Pipit locations and were therefore spatially closer to the Sprague's Pipit locations than American Pipit locations were to Sprague's Pipit locations – and following Tobler's (1970) first law of Geography, things that are nearby to one another are more similar than are things far from one another. Another reason is that American Pipits are actively selecting for habitat themselves.

American Pipit is also typically considered to be more of a habitat generalist than is Sprague's Pipit. This is seen in the evenness of the land cover types (Figure 4) where American Pipit locations had smaller differences between land cover types. There were also fewer differences between Sprague's Pipit and shared locations than American Pipits and shared locations. This indicates that shared locations more closely resembled Sprague's Pipit habitats, rather than the habitats of American Pipits, suggesting that American Pipits have a broader range of habitats than do Sprague's Pipit, or that Sprague's Pipit have the more restrictive habitat requirements than do American Pipit.

There were multiple crop types that had significant results ($\alpha \leq 0.05$), although because of the small percentage of total land cover that some of these crop types amounted to; it is likely that the results of the comparison are not biologically meaningful. Only cotton, corn, and hay/grain crops composed on average more than 2% of the land cover around either pipit locations or random points. Sprague's Pipits had neither a positive or negative association with most crop types. Sprague's Pipits did not associate with grass/hay crops more than did American Pipits at any scale, but did contain higher amounts of grass/hay crops at the larger 2 km and 5 km scales compared to random locations. The hay category differs in definition between NLCD and CropScape with hay being a harvested crop in CropScape and managed grassland in the NLCD. Therefore the mean percent cover per point for hay is much higher in the NLCD than in CropScape (14.3%, 2.5%). Most of the crop types in CropScape are summer crops; therefore, during the winter when Sprague's Pipits are arriving on their non-breeding grounds, annual crops such as corn and cotton have been harvested. At a landscape scale Sprague's Pipits may not be selecting for the actual crop types, but for the harvested fields.

Sprague's Pipits were positively associated with open space at the smaller 1 km spatial scale. Developed open space is defined by the NLCD as areas with a mixture of some constructed materials, but is mostly vegetation in the form of lawn grasses with impervious surfaces accounting for less than 20% of total cover. These areas are usually lawns, golf courses, or vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. Sprague's Pipit had significantly more of this land cover type at the 1km buffer size than random locations. Looking through the eBird data there were many instances of Sprague's Pipits occurring at golf courses, airports, and sports complexes (large sports fields). It seems that some Sprague's Pipits may be using these areas instead of natural prairies, which suggests that these habitats are perhaps suitable or at least acceptable for use by wintering Sprague's Pipits. But because Sprague's Pipit is known as a native grassland specialist (Davis 2004, Grant et. al. 2004, Jones 2010) it is also possible that these areas are not truly suitable and are actually ecological traps. Another possibility is that there is not enough truly suitable habitat and Sprague's Pipits are using these anthropogenic grasslands because that is what is available. Future research needs to be done to see if these anthropogenic habitats are truly suitable for overwintering Sprague's Pipits.

VII. MANAGEMENT IMPLICATIONS

Assuming that the main cause for the reduction in Sprague's Pipit population is loss of suitable habitat in the form of grasslands, then optimally we would restore as much agriculture and rangeland to natural prairie as possible. But restoring native grasslands to their former extent is impossible when fulfilling basic human needs for crops and livestock. Therefore, we need to devise other ways of optimizing landscapes for wintering Sprague's Pipits. An example of a possible solution is the Conservation Reserve Program (CRP). CRP is a program administered by the USDA that pays farmers to plant perennial vegetation on erodible and marginal lands, instead of crops. This program has proven to be beneficial to a number of grassland birds (Johnson1993, Veech 2006) but is expensive for the federal government. CRP land that has been in the CRP program for longer lengths of time may not be suitable for Sprague's Pipit in that without management they become overgrown and resemble later successional grasslands, which do contain the fine-scale habitat requirements for Sprague's Pipits. Another way to potentially increase appropriate habitat is to link Sprague's Pipit management with other species that need similar habitat and are already being managed for. An example is the Attwater's Prairie Chicken (*Tympanuchus cupido attwateri*), which requires large expansive mosaic native grasslands.

Restoring agriculture fields to native prairies can be very expensive even at low seeding densities ($243-720/ha) and time consuming (Downey 2013), but restoration has been proven effective on the breeding grounds. Downey (2013) did a side-by-side comparison of a control (native) pasture and restored hay field. Sprague's Pipits and Chestnut-collard Longspurs (*Calcarius ornatus*) were not found on either the control or the treated site until 3 years after initial seeding when they were then both present on the test site and control. Planted grasslands are grasslands that are actively managed to increase biomass as forage usually for livestock, sometimes also referred to as “improved pasture”. Sprague’s Pipits have been known to use planted grasslands occasionally on the breeding grounds (Davis and Fisher 2013). Sprague’s Pipit use of planted fields was related to the amount of surrounding native prairie (Davis and Fisher 2013). When Sprague’s Pipits do use planted grasslands for breeding they find areas within the planted grasslands that resemble suitable native grasslands in terms of vegetation height and amount of bare ground present (Davis and Fisher 2013). Sprague’s Pipit is also known to be area-sensitive on the breeding grounds (Davis 2004, Davis et al 2006), meaning that pipit abundance as well as density increases with grassland patch size. An alternative to restoring agriculture fields would be to convert them to hay/pasture fields. Planted grasslands that are maintained at certain vegetative densities and height could be used as pipit habitat. Pool et al. (2012) recommended that the amount of grass cover be increased up to the optimal 80% and grazed to decrease grass height.

Even though Sprague’s Pipit have been known to avoid overgrazed areas on the breeding grounds (Maher 1973; Dale 1983; Prescott and Wagner 1996; Davis et al. 1999) there is evidence that some level of grazing is beneficial in certain situations on the breeding grounds (Ranellucci 2012). On the wintering grounds overgrazed areas may also be beneficial (Grzybowski 1982). Among the Sprague’s Pipit locations there was 12.2% grassland cover and 14.2% pasture cover, a difference of approximately 2% that was significant ($p = 0.037$, randomization test). Among random locations there was 11.9% grassland cover and 15.2% pasture cover, a significant difference of approximately 3.2%

(p = 0.006, randomization test). Both Sprague's Pipit and random locations had statistically more pasture than grassland. According to the NLCD definitions both cover types are used for grazing and the difference is that grasslands are not subjected to intensive management unlike pasture/hay. Hence Sprague's Pipit locations tend to have more managed grassland than non-managed grassland.

Removing woody vegetation should be a priority because shrub density is a proven negative factor for Sprague's Pipit abundance on the wintering grounds (Macias-Duarte 2011, Pool et al. 2012). This can be accomplished through prescribed burning which also could potentially keep herbaceous vegetation at a more appropriate density (80%) and height (28cm) (Pool et al 2012). Removing woody vegetation is also a potential benefit for a variety of grassland species.

Sprague's Pipit has been described as a native grassland specialist and has been proven to breed more often in native prairie than planted grasslands or agriculture fields (Davis et al. 2014, Davis 2004, Grant et al. 2004). On the breeding grounds there seems to be mixed results as to the utility and effectiveness of planted or anthropogenic grasslands, but on the wintering grounds there appears to be greater use of these grasslands. My results show that on the wintering grounds these planted grasslands may be of benefit to the species at landscape scales, but more studies are needed to determine whether these planted grasslands are as quality of habitat when compared to native grasslands; especially at fine or local scales. It appears as though at the landscape scale Sprague's Pipits are selecting managed as well as non-managed grasslands in proportions equal to their availability, meaning both are suitable at the landscape scale. Planted grasslands or pastures could be used near native prairies to make that prairie more suitable at the landscape scale. Probably the best habitat management strategy for Sprague's Pipit would be to increase the openness of the landscape by reducing woody vegetation, and increasing as much grasslands as possible.

Table 1. Consolidated NLCD land-cover classes. How the fifteen NLCD land-cover classes were combined into nine groups.

Joined Classes	**NLCD Classes**
Open Water	Open Water
Open Space	Developed open
Developed	Developed low
	Developed medium
	Developed high
Barren Land	Barren land
Forest	Deciduous
	Woody Wetlands
	Evergreen
	Mixed
Shrubland	Shrubland
Grassland	Herbaceous
	Hay/Pasture
Cropland	Cropland
Emergent Herbaceous Wetlands	Emergent Herbaceous Wetlands

Table 2. Results of the randomization test comparing the locations of SPPI and AMPI to random (RNDM) and shared (SHRD) locations for NLCD land cover types at the 1 km buffer scale. Significant results (p≤0.05) are bolded.

Land Cover type		SPPI	SPPI	SPPI	AMPI	AMPI
		AMPI	RNDM	SHRD	SHRD	RNDM
Open Water	Difference	**-2.81**	**4.38**	**-3.26**	-0.45	**7.19**
	P	**<0.001**	**<0.001**	**0.009**	0.381	**<0.001**
Developed Open	Difference	**-1.57**	**0.80**	0.73	**2.30**	**2.37**
	P	**<0.001**	**0.021**	0.133	**0.001**	**<0.001**
Developed	Difference	**-5.60**	-1.08	-0.11	**5.49**	**4.52**
	P	**<0.001**	0.119	0.459	**<0.001**	**<0.001**
Barren	Difference	**0.47**	**0.69**	-0.77	**-1.24**	0.21
	P	**0.029**	**0.005**	0.096	**0.006**	0.139
Forests	Difference	**-5.20**	**-3.86**	-1.6	**3.60**	1.34
	P	**<0.001**	**<0.001**	0.099	**0.005**	0.061
Shrubs	Difference	**3.08**	-2.16	**6.26**	**2.97**	**-5.23**
	P	**0.002**	0.064	**0.002**	**0.043**	**<0.001**
Grasslands/pasture	Difference	**8.08**	-0.69	-2.00	**-10.08**	**-8.77**
	P	**<0.001**	0.332	0.21	**<0.001**	**<0.001**
Crops	Difference	**3.20**	1.19	**4.62**	1.42	-2.01
	P	**0.016**	0.225	**0.037**	0.287	0.082
Emergent Herbaceous Wetlands	Difference	0.35	0.30	**-3.46**	**-3.81**	-0.05
	P	0.311	0.361	**0.013**	**0.006**	0.458

Table 3. Results of the randomization test comparing the locations of SPPI and AMPI to random (RNDM) and shared (SHRD) locations for CropScape land cover types at a buffer size of 1 km. Significant results (p≤0.05) are bolded.

Crop Type		SPPI AMPI	SPPI RNDM	SPPI SHRD	AMPI SHRD	AMPI RNDM
Corn	Difference	**5.96**	**2.49**	**4.04**	**-1.92**	**-3.47**
	P	**<0.001**	**0.019**	**0.015**	**0.05**	**<0.001**
Legumes	Difference	-0.16	0.28	-0.59	-0.43	**0.44**
	P	0.245	0.104	0.129	0.146	**0.008**
Cotton	Difference	**1.59**	**-1.44**	1.79	1.92	**-3.04**
	P	**<0.001**	**0.04**	0.053	0.457	**<0.001**
Grass Crops	Difference	**-0.95**	0.72	0.97	**1.92**	**1.67**
	P	**0.036**	0.076	0.114	**0.021**	**<0.001**
Tree Crops	Difference	**-0.22**	0.00	0.01	**0.23**	**0.21**
	P	**<0.001**	0.456	0.051	**<0.001**	**<0.001**
Vegetables	Difference	0.02	**0.06**	0.06	0.04	**0.04**
	P	0.275	**0.003**	0.051	0.081	**0.008**
Greens	Difference	**-0.04**	0.00	0.00	0.04	**0.04**
	P	**0.003**	0.253	0.673	0.252	**0.006**
Rice	Difference	-0.20	0.35	-0.96	-0.76	0.55
	P	0.294	0.213	0.137	0.176	0.086
Idle/Fallow	Difference	0.29	**1.72**	-1.44	-1.74	**1.42**
	P	0.321	**0.003**	0.141	0.078	**0.008**

Table 4. Difference between the two groups of a comparison and the significance values for Tree Canopy Cover and Impervious Cover randomization test. Significant results (p≤0.05) are bolded

Tree Canopy Cover				Impervious Cover			
Comparison	Buffer Size(s)	Difference	Pvalue	Comparison	Buffer Size(s)	Difference	Pvalue
SPPI vs. AMPI	1	-6.10	**<0.001**	SPPI vs. AMPI	1	-2.83	**<0.001**
SPPI vs. AMPI	2	-5.45	**<0.001**	SPPI vs. AMPI	2	-3.16	**<0.001**
SPPI vs. AMPI	5	-4.40	**<0.001**	SPPI vs. AMPI	5	-3.20	**<0.001**
SPPI vs. SHRD	1	-1.10	0.219	SPPI vs. SHRD	1	0.23	0.388
SPPI vs. SHRD	2	-0.74	0.29	SPPI vs. SHRD	2	-0.11	0.421
SPPI vs. SHRD	5	-1.67	0.142	SPPI vs. SHRD	5	-0.66	0.159
SPPI vs. RNDM	1	-4.97	**<0.001**	SPPI vs. RNDM	1	-0.44	0.192
SPPI vs. RNDM	2	-4.29	**<0.001**	SPPI vs. RNDM	2	-0.92	**0.024**
SPPI vs. RNDM	5	-2.31	**0.006**	SPPI vs. RNDM	5	-0.88	**0.015**
AMPI vs. RNDM	1	1.14	0.12	AMPI vs. RNDM	1	2.40	**<0.001**
AMPI vs. RNDM	5	2.09	**0.008**	AMPI vs. RNDM	5	2.31	**<0.001**
AMPI vs. SHRD	1	4.99	**<0.001**	AMPI vs. SHRD	1	2.92	**0.001**
AMPI vs. SHRD	5	2.73	**0.05**	AMPI vs. SHRD	5	2.57	**<0.001**
SPPI vs. SPPI	1,2	-0.72	0.182	SPPI vs. SPPI	1,2	0.33	0.248
SPPI vs. SPPI	2,5	-1.30	**0.049**	SPPI vs. SPPI	2,5	0.16	0.383
SPPI vs. SPPI	1,5	-2.02	**0.004**	SPPI vs. SPPI	1,5	0.48	0.11
AMPI vs. AMPI	1,5	-0.32	0.331	AMPI vs. AMPI	1,5	-0.06	0.436
RNDM vs. RNDM	1,5	0.64	0.276	RNDM vs. RNDM	1,5	0.04	0.469

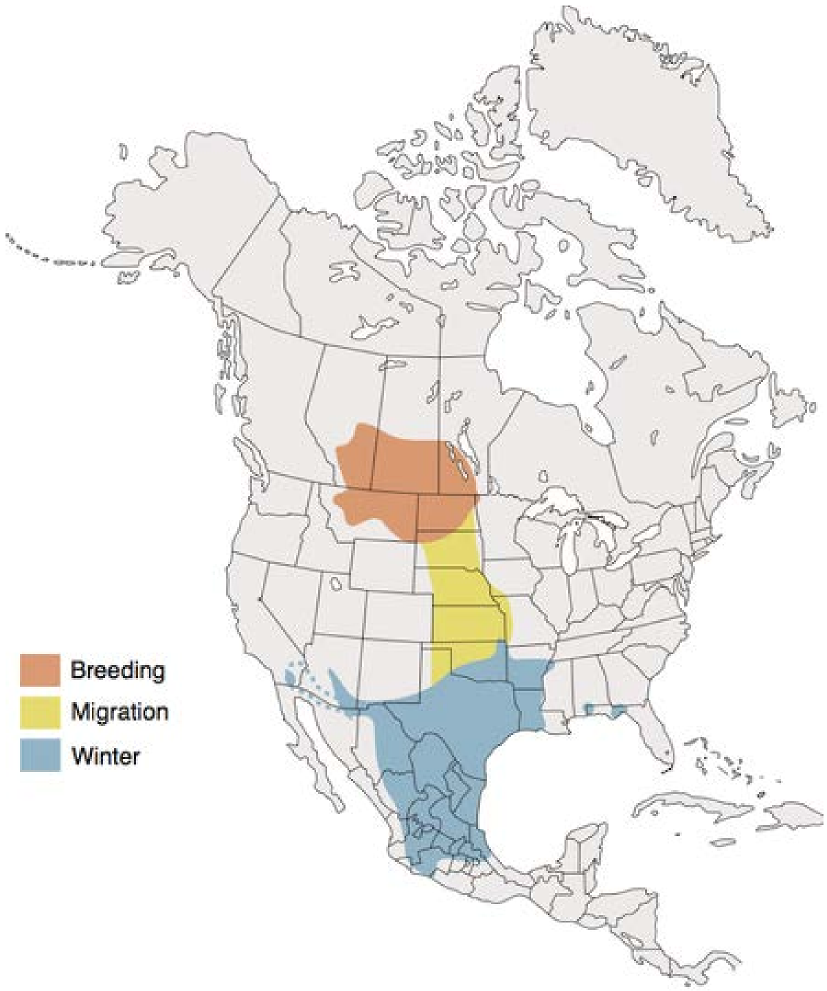

Figure 1. Range map of Sprague's Pipit (as presented in Davis, et al 2014).

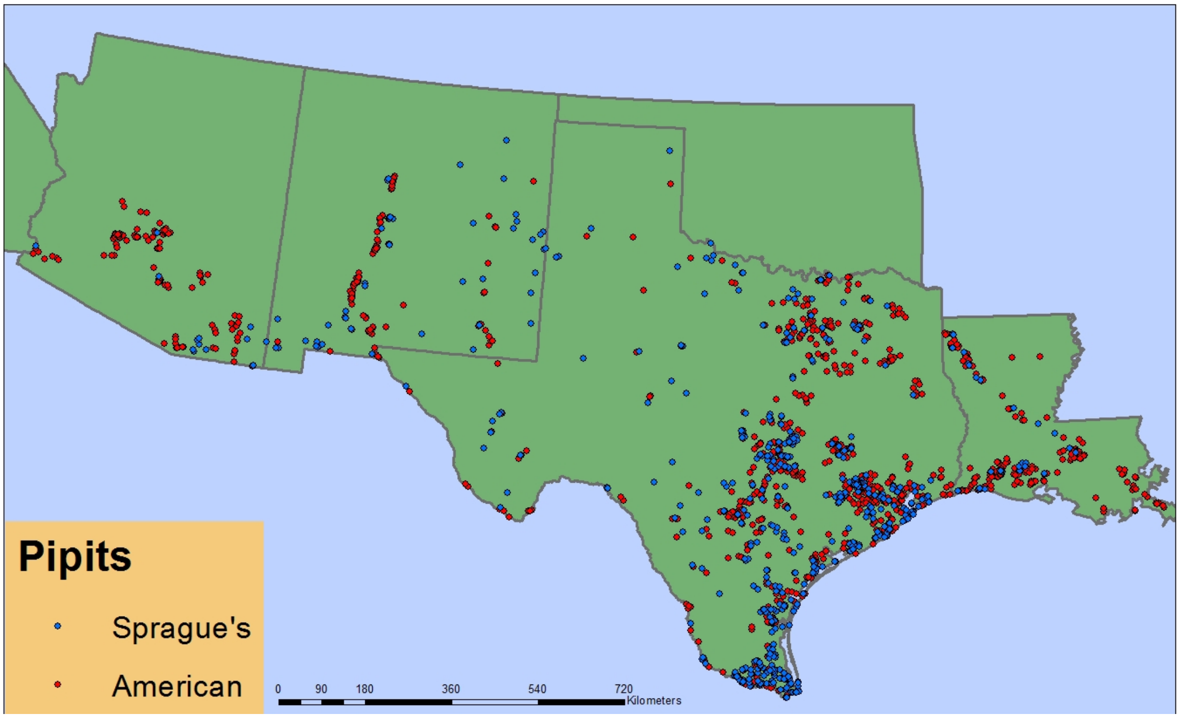

Figure 2. Map showing the locations of Sprague's Pipit and American Pipit that were used in the analysis.

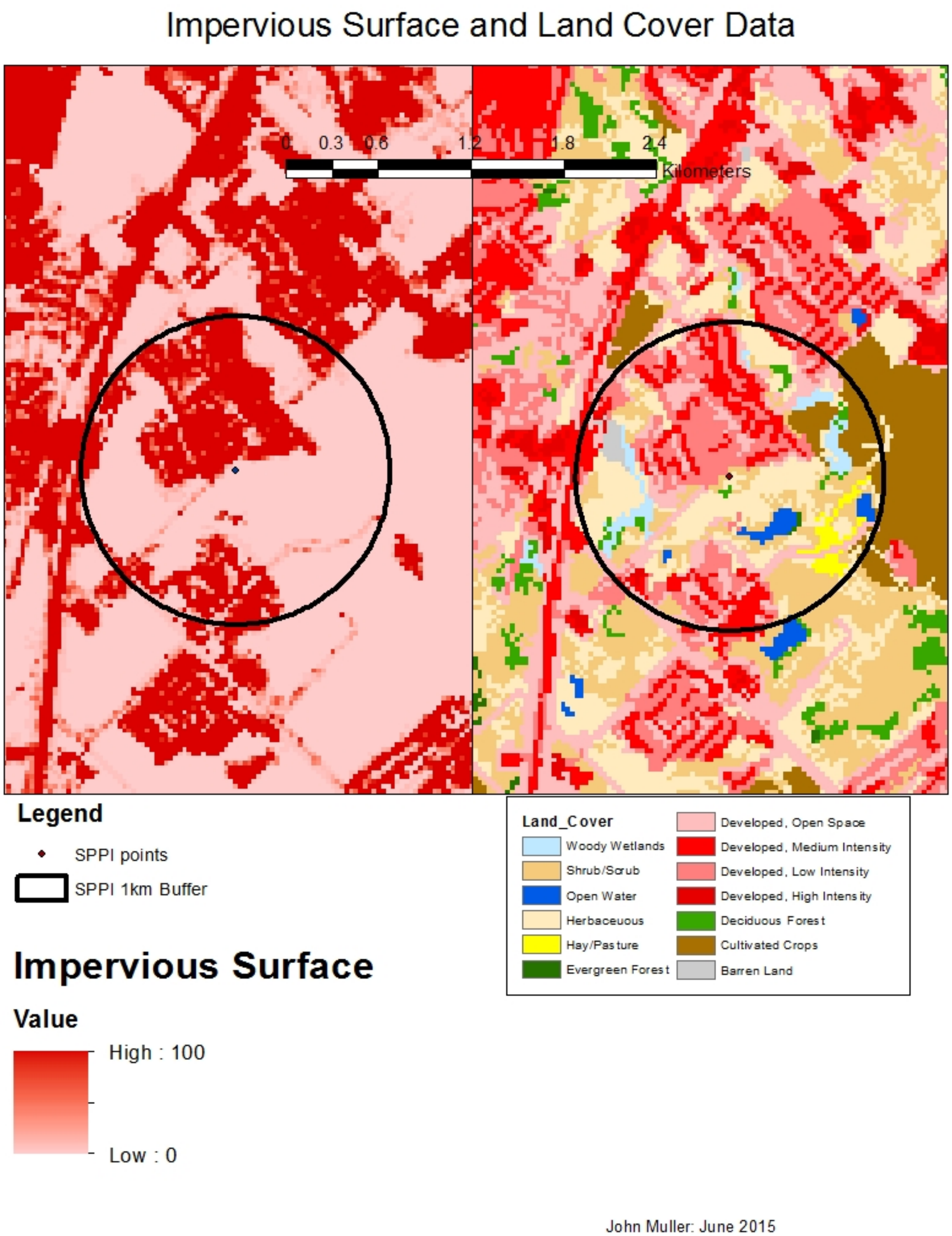

Figure 3. Map showing examples of the same SPPI point and buffer that were analyzed with the impervious surface layer and the NLCD layer.

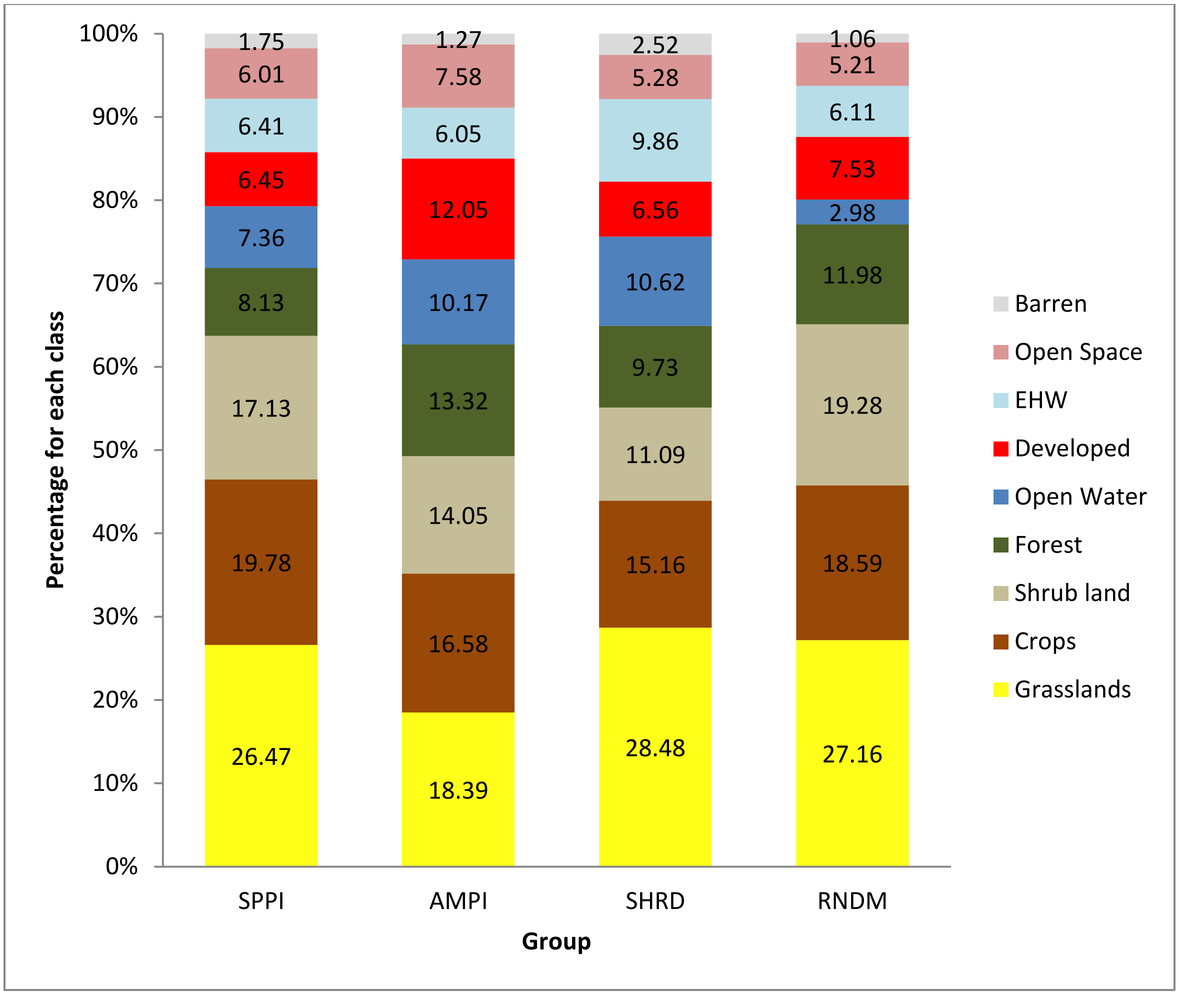

Figure 4. Mean percent cover of the NLCD land cover classes within the 1 km buffers for Sprague's Pipit locations (SPPI), American Pipit locations (AMPI), shared locations (SHRD), and random points (RNDM).

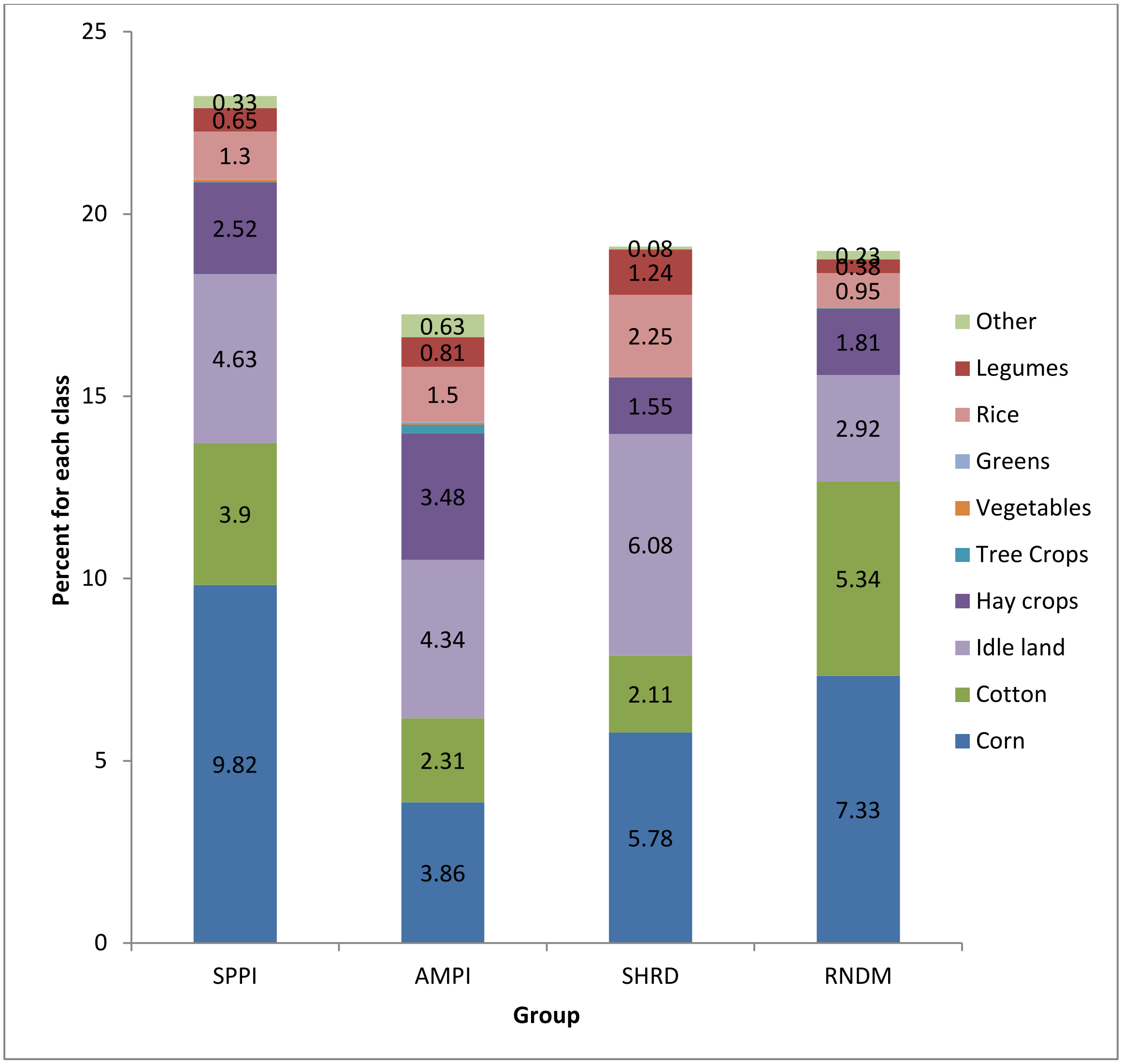

Figure 5. Mean percent cover of the CropScape crop cover classes for Sprague's Pipit locations (SPPI), American Pipit locations (AMPI), shared locations (SHRD), and random points (RNDM).

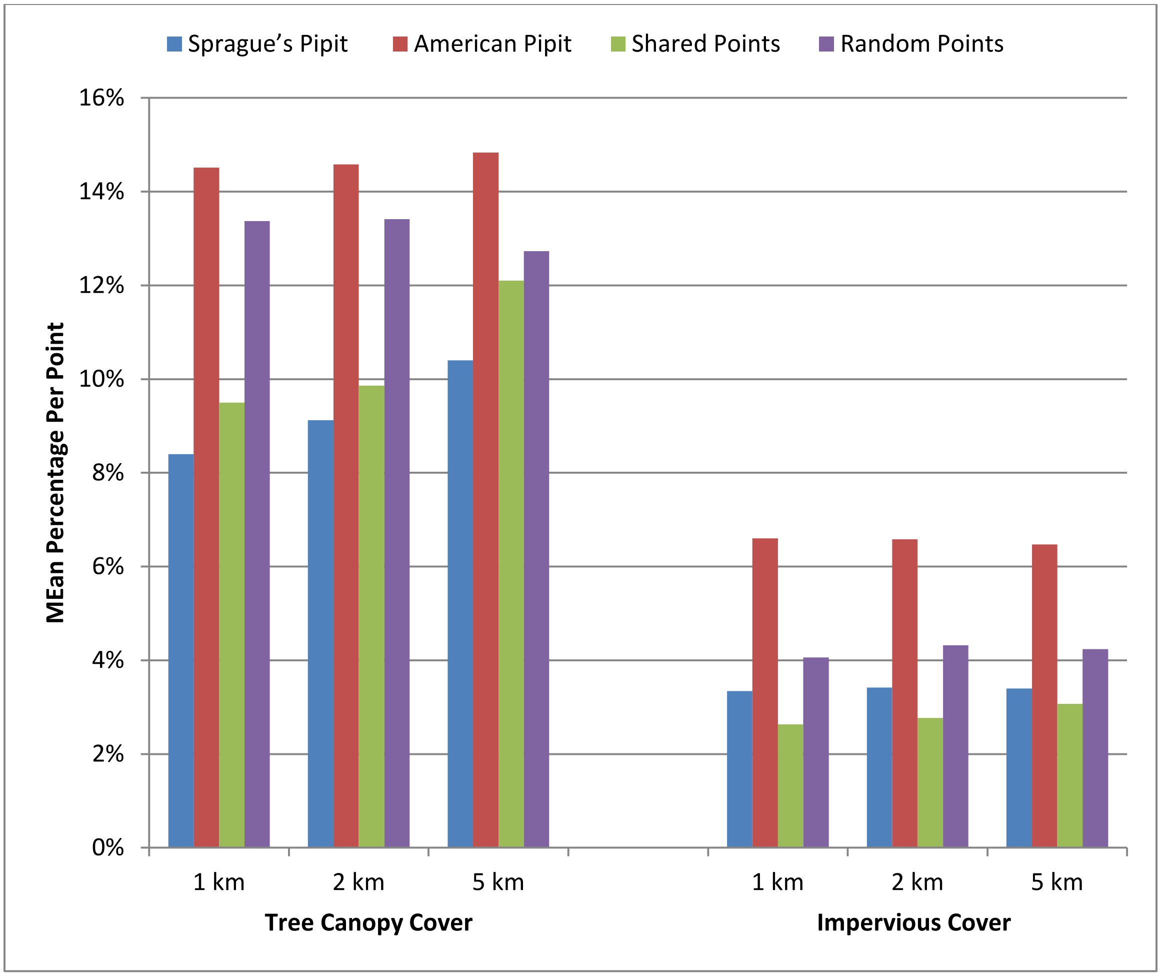

Figure 6. Mean tree canopy cover and impervious surface for Sprague's Pipit locations (SPPI), American Pipit locations (AMPI), shared locations (SHRD), and random points (RNDM) at each buffer size.

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