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Ring-necked Pheasant responses to wind energy in Iowa

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Ring-necked Pheasant responses to wind energy in Iowa

by

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ABSTRACT

An important Iowa gamebird, Ring-necked Pheasants (*Phasianus colchichus*) are of value to wildlife managers, who seek to maintain and increase their populations in Iowa. There are a number of challenges facing pheasants in Iowa, and this thesis seeks to inform some of the effort to overcome those challenges, particularly in areas of Iowa with wind farms. We took a large scale view to identify counties that have historically been favorable for pheasants, a smaller scale view to address concerns about wind energy development effects on pheasants, and evaluated an alternative method for conducting pheasant surveys. Our results suggest that male Ring-necked Pheasants are virtually unaffected by Iowa wind turbines. We altered the protocol for a prevailing method of conducting crowing surveys by adding the use of a call playback device and found no difference in pheasant detectability. We observed statistically significant (but we argue not biologically significant) avoidance of wind turbines by pheasants on our study farms. We analyzed a long term dataset of pheasant roadside survey data collected by the Iowa Department of Natural Resources. We used this information to identify counties in Iowa that supported resilient (abundant and consistent) populations of pheasants. We addressed concerns surrounding an energy production method that is generally considered to be good for the environment but raises questions about wildlife impacts and highlighted counties in Iowa that are hotspots for pheasant production and retention.

CHAPTER 1. GENERAL INTRODUCTION

Background

Introduced to Iowa in the early 1900s, the Ring-necked Pheasant (*Phasianus colchicus*) is one of the most widely distributed introduced species worldwide (Hill and Robertson 1988). Pheasants consume mostly plant foods and are often found in crop fields and grasslands (Wildlife Habitat Management Institute 1999), habitat types that are commonly found throughout Iowa. Adequate interspersion of habitat is critical for maintaining healthy pheasant populations (Wildlife Habitat Management Institute 1999), which can be problematic in Iowa's fragmented landscape (Clark et al. 1999, Clark and Bogenschutz 1999). Based on roadside counts and hunter harvest data, pheasant numbers have been on a long-term decline in Iowa (Upland Game Bird Advisory Committee 2010).

Pheasants are an important gamebird in Iowa, both recreationally and economically (Farris et al. 1977). Because of their value, wildlife managers are invested in maintaining and increasing Iowa's Ring-necked Pheasant populations. While different conservation efforts such as the Conservation Reserve Program have helped pheasant populations (Haroldson et al. 2006), there are still a number of challenges facing pheasants in Iowa. These challenges include reduced conservation funding and increased habitat loss from the conversion of grasslands to agriculture. A potential additional threat includes habitat fragmentation due to man-made structures such as wind turbines (U.S. Fish and Wildlife Service 2012).

A robust body of literature already exists for Ring-necked Pheasant management, however with an ever-changing landscape, there is always a need for more research. This thesis aims to add to this body of literature by addressing specific management questions. We took a large scale view to identify counties that have historically been favorable for pheasants, a smaller scale view to address concerns about wind energy development effects on pheasants, and evaluated an alternative method for conducting pheasant surveys. To our knowledge there have been no studies addressing the use of call playback to increase pheasant detectability and only two studies (Johnson et al. 2000, Devereux et al. 2008) that addressed the effects of wind turbines on Ring-necked Pheasants, both of which were larger studies covering multiple bird species.

Goals and Objectives

The overarching goal of this study was to address management questions relating to Ring-necked Pheasants in Iowa. We reached this goal by focusing on three main objectives:

1. Assess the effectiveness of using call playback to increase the detectability of Ring-necked Pheasants during roadside crowing surveys.
2. Document any avoidance behavior exhibited by Ring-necked Pheasants in relation to wind energy infrastructure.
3. Identify Iowa counties that support resilient Ring-necked Pheasant populations by analyzing historical roadside pheasant survey data.

Thesis Organization

This thesis follows the journal format. Chapter 1 introduces the topics of the thesis. Chapters 2 through 4 discuss the research and thesis goals outlined in Chapter 1. Chapter 2 is a paper discussing our use of call playback during crowing surveys and the resulting effects on detectability. Chapter 3 is a paper that uses the same crowing surveys to identify any pheasant avoidance of wind turbines on multiple wind farms in central Iowa. Chapter 4 is a paper analyzing data previously collected by the Iowa Department of Natural Resources in an effort to identify counties that support resilient (abundant and consistent) populations of Ring-necked Pheasants. Chapter 5 ties together general conclusions from the three journal paper chapters included in this thesis.

CHAPTER 2. RING-NECKED PHEASANT RESPONSES TO PLAYBACK CALLS ON SURVEYS

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RH: Dupuie et al. • Pheasant Crowing Surveys

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Abstract

Point count surveys are a commonly used method for surveying bird populations, including ring-necked pheasants (*Phasianus colchicus*). Crowing indices are used as an indicator of relative abundance for monitoring pheasant populations. Improving detection probability of pheasants during surveys improves the reliability of crowing indices. The use of call playback has been successful in increasing detection probability among a variety of bird species, including other upland game birds. Our study aimed to assess the effectiveness of using call playback to improve detection during ring-necked pheasant crowing surveys. We conducted crowing surveys on and around 5 central Iowa wind farms from mid-April through May from 2015 to 2017. Each survey point was surveyed with and without using a playback device to imitate a crowing male. Across all study sites and years, we detected an average of 2.13 pheasants per survey. Detection probability did not differ significantly between surveys completed using a playback device (p =

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0.34) and not using a playback device (p = 0.35). Detection probability increased with increasing wind speeds (β_{Wind} = 0.140), decreased with increasing cloud cover (β_{Cloud} = -0.001) and increased at the beginning of the survey period (β_{Day} = 0.041), but decreased throughout the remainder of the survey period (β_{Daysq} = -0.001). Temperature did not affect detection probability. While our study did not show any benefit of using call playback to increase pheasant detection probability it also did not hinder detection. With the relatively low cost of implementing playback into surveys, we would encourage future crowing surveys to further test the effectiveness of playback, particularly in areas with higher pheasant densities and in different habitats.

KEY WORDS call count, call playback, crowing survey, Iowa, *Phasianus colchicus,* ring-necked pheasant, wind turbine

There are many methods used to count birds, primarily point counts and line transects (Rosenstock et al. 2002). While there are numerous variations, point counts are the most widely used method for surveying birds (Ralph et al. 1995) and often include the collection of ancillary data such as distance to each detection, sex of the bird, and many others (Rosenstock et al. 2002). Point counts involve an observer recording the number of birds detected in a single location over a set time period (Ralph et al. 1995). A number of these surveys are used as indices (relative estimates) for population abundance (Kendeigh 1944, Verner 1985, Bibby et al. 1992, Ralph et al. 1995).

Crowing surveys are an effective and widely-used index for monitoring ring-necked pheasant (*Phasianus colchicus*) populations (Rice 2003). When crowing surveys are corrected for detection probability they can be an effective pheasant population index (Harwood et al. 2008). For a pheasant to be detected during a survey, it must be present, crowing (only male pheasants crow), and heard by the observer. This information can then be used to estimate the detection probability of crowing pheasants, conditional on their presence in the sampled area (Buckland et al. 2001). Other factors can affect detection probability such as observer skill (Sauer et al. 1994), wind speed (Robbins 1981), day of season (Ralph 1981), temperature (Anderson and Ohmart 1977), and cloud cover (Anderson and Ohmart 1977). Previous studies have suggested that crowing intensity (and thus detection probability) is affected by pheasant density (Gates 1966, Warner and David 1982). This relationship is possibly caused by territorial competition among males (Gates 1966). If density positively affects crowing intensity (because of territorial competition), then imitating crowing males should stimulate competition and induce crowing responses, increasing crowing intensity.

The use of playback equipment to increase detection probability during surveys has been effective with a variety of bird species, most notably with secretive marsh birds (Conway and Gibbs 2005). Using playback involves broadcasting a recording of a vocalizing individual in order to illicit responses from other individuals (Johnson et al. 1981, Marion et al. 1981). While no other studies have used playback equipment to imitate crowing male pheasants, playback has been used to increase detection probabilities of other upland game birds. The use of playback has been effective in surveying for Dusky Grouse (*Dendragapus obscurus*; Stirling and Bendell 1966), Spruce Grouse (*Falcipennis canadensis*; Schroeder and Boag 1989), Red Grouse (*Lagopus lagopus*; Evans et al. 2007), Gray Partridge (*Perdix perdix*; Kasprzykowski and Golawski 2009), and Red-legged Partridge (*Alectoris rufa*; Jakob et al. 2010). In each of these studies, the playback elicited a greater response by (more detections of) the target species than surveys where the playback was not used.

In this study, we conducted two types (with and without playback) of aural point count surveys of crowing male ring-necked pheasants. Our objectives were to: (1) determine the effect of using playback on the detection probability of crowing male ring-necked pheasants, and (2) identify weather and season variables that affected detection probability of crowing male ring-necked pheasants. Based on the positive influence of using playback on detecting other upland game birds as well as the probability that crowing intensity is influenced by pheasant density, we expected the use of playback to increase detection of pheasants.

Study Area

We conducted crowing surveys (as part of a larger study assessing the impacts of wind turbines on pheasants) within an 8 km buffer around five different wind farms in central Iowa. We chose this buffer because 8 km has been documented to be the maximum distance adult pheasants will disperse from winter cover during the spring (Gates and Hale 1974). Creating a buffer zone of this size thus enabled us to account for all pheasants that could possibly be affected by a particular turbine. These wind farms spanned eleven counties, most of them in central Iowa (Figure 1). All sites consisted of mostly intensive row crop agriculture with smaller patches of grassland, rural dwellings, fragmented forest patches, and other habitat types. Topography was generally flat at all sites, with the exception of the Adair Wind Farm, which had some rolling hills. Adair Wind Farm covered a 944 km^2 area across Adair, Audubon, Cass, and Guthrie counties and contained 208 wind turbines. Century Wind Farm was located in Hamilton and Wright counties and had 145 wind turbines in a 512 km^2 area. Franklin Wind Farm had 181 turbines across 756 km^2 in Franklin County and barely extended into Hardin County. The Story Wind Farm spanned Hamilton, Hardin, Story, and Marshall Counties, covered 995 km^2 and contained 203 wind turbines. The Lundgren Wind Farm was entirely within Webster County and comprised a 658 km^2 area; with 107 turbines.

Methods

Crowing Surveys

We conducted spring crowing surveys from 2015 to 2017, beginning in mid-April and continuing until all survey routes had been completed (approximately mid-May). Story was surveyed in all three years; Century, Franklin, and Lundgren were surveyed in 2016 and 2017; and Adair was surveyed in 2017 only. Male pheasants begin crowing in March (for the purpose of attracting a mate), with peak crowing in late April and early May (Farris et al. 1977). Surveys were conducted in the morning, beginning one half hour before sunrise and ended within two hours. One half hour before sunrise until one half hour after sunrise is the best time for conducting surveys (Luukkonen et al. 1997); we added an extra hour to ensure that we could complete all surveys within the time allowed. We did not conduct surveys during mornings with poor weather that included rain or winds >32 km/h.

Wind farms were randomly assigned ten to fifteen routes in proportion to their total area. Routes were surveyed in a randomly chosen order and then repeated during the second half of the survey period, providing two survey dates each year for each route. Each route contained ten survey points. On the second visit, the order in which each point along the route was surveyed was reversed, to correct for any effects of time of day. Each observer surveyed a single route (ten points) on each survey day. One observer surveyed all routes in 2015 and four observers divided and surveyed the routes in 2016 and 2017 for a total of 7 different observers. Survey points were placed along roads with a north/south orientation, and in most cases were located at the midpoint between intersecting east/west roads. An initial survey point was randomly chosen as the start point for each route, with the next point >2 km away in a randomly chosen cardinal direction, until ten total points were assigned to a route. Within an individual route, survey points were chosen without replacement and >2 km away from each other, to avoid double counting of individuals. Some survey points were included on more than one route.

We conducted radial point counts (Buckland et al. 2001) at every survey point. During each survey, the observer recorded the minute each crowing male pheasant was initially detected and measured the distance from the individual to the observer using a laser rangefinder. Only detections within 800 m of the survey point were included, which is the maximum distance at which a crowing pheasant can be reliably detected (Todd Bogenschutz, pers. comm.). Each survey point had a 4-min listening period (Luukkonen et al. 1997). Crowing males were imitated on alternating surveys such that five survey points each day were conducted with playback calls and five were conducted without playback calls. During stops that had playback calls, we imitated a crowing male at the beginning of every minute during the survey. We used a Primos Alpha Dogg™ predator caller, pre-loaded with a pheasant call from the Cornell Lab of Ornithology website, to conduct the playback calls. Playback devices were set at a volume that simulated the volume (80 db) that would be created by a crowing pheasant if it were 2 m from the device. (Todd Bogenschutz, pers. comm.). In addition to information about each detection, at each survey point we recorded wind speed (km/h), temperature (°C), and cloud cover (%) at the beginning of the survey.

All surveys were conducted in a manner intended to meet the general assumptions for conducting point counts. These assumptions are (1) all birds at the point are detected, (2) birds do not move in response to the observer prior to detection, and (3) the distance of each bird to the observer is estimated accurately (Rosenstock et al. 2002). Additionally, we assumed that crowing intensity is independent of population density and that crowing counts are timed in relation to the seasonal trend in crowing (Gates 1966).

Analysis

We used Program DISTANCE (Version 6.0; Thomas et al. 2010) to estimate detection probabilities (*p*) of crowing ring-necked pheasants. In our analyses we post-stratified detection probability by both playback use and observer. Post-stratification allowed us to determine an overall detection probability for each model, while also providing detection probabilities for each category in the model (playback/no playback or individual observers). We also modeled the effects of wind speed (*Wind*), temperature (*Temp*), and cloud cover (*Cloud*) as well as day of season [both as a linear (*Day*) and a quadratic (*Daysq*) trend] on detection probability. We considered a number of detection function models for modeling detection probability and settled on four robust models (Buckland et al. 2001, Childers and Dinsmore 2008): (1) half-normal key with a cosine expansion, (2) half-normal key with a simple polynomial expansion, (3) hazard-rate key with a cosine expansion, (4) hazard-rate key with a hermite polynomial expansion. Playback and observer effects were modeled using a range of distance bins. We modeled these effects (model name in parentheses) using the raw un-binned distances; three distance bins with cutoff points at 250, 500, and 800 m (3 bins 250); three distance bins with cutoff points at 300, 500, and 800 m (3 bins 300); and 4 bins with cutoff points at 300, 500, 650, and 800 m (4 bins). These binning options were chosen after visually inspecting the distribution of raw detections and follow the general advice of Buckland et al. (2001). Weather and season covariates were modeled using the raw distances only. AIC model selection (Burnham and Anderson 2002) was used to determine the best-fitting model for each bin (playback and observer models) and the best-fitting model for the covariates. We also note that our focus is on understanding patterns of detection probability, so the estimates of density are not of interest and are omitted from this paper.

Results

Across the three survey years (2015 – 2017) we detected 4,933 pheasants during 2,320 surveys with an average of 2.13 ± 0.05 (SE) pheasants detected per point. The total number of pheasants detected varied among wind farms and years. Mean number of pheasants detected per point was greatest in 2016 (2.21), although the single greatest mean for a wind farm in any year was Adair in 2017 (2.62).

The best performing model for playback effects binned the raw data into 3 distance bins (3 Bins 250 model; Table 1). There was no difference in detection probabilities between surveys conducted with and without a playback device. Surveys conducted without a playback device (p = 0.35; 95% CL 0.32, 0.38; CV = 4.70%) did not differ statistically from the detection probability on surveys conducted with a playback device (p = 0.34; 95% CL 0.31, 0.38; CV = 4.89%).

Weather and season covariates had varying effects on pheasant detection probability. Detection probability increased with increasing wind speeds (β_{Wind} = 0.140, SE = 0.024), slightly decreased as cloud cover increased (β_{Cloud} = -0.001, SE = 0.001), and did not change with rising temperatures (β_{Temp} = -0.001, SE = -0.007). Detection probability decreased in a linear fashion as the survey season progressed (β_{Day} = -0.028, SE = 0.005); a slightly better-fitting quadratic model showed an initial increase in detection probability at the beginning of the season (β_{Day} = 0.041, SE = 0.011) followed by a decrease throughout the rest of the survey period (β_{Daysq} = -0.001, SE = 0.001). Among all covariate models, day of season as a quadratic function was the best performing model (ΔAIC = 0.00; Table 1).

As expected, there were differences in detection probability among the seven observers. Overall mean detection probability was 0.32, but ranged from 0.17 to 0.56 by observer.

Discussion

In this study, we aimed to evaluate the effectiveness of using a call playback on pheasant crowing surveys to increase pheasant detection probability. Our findings do not support the idea that the use of playback increases detection probability of crowing male ring-necked pheasants. Below, we compare our finding to those of other studies that used playback calls, discuss the roles of weather and season on patterns of detection probability, and comment on the future value of this approach to pheasant surveys.

The detection probabilities observed in our study were lower than those observed in other pheasant studies (ranging from 0.38 to 0.73; Harwood et al. 2008, Giudice et al. 2013). Furthermore, we found no difference in detection probability between surveys conducted with and without playback. This was surprising based on the success of using playbacks to increase detection probability in surveys for other bird species. These successes have been documented in a variety of bird species including secretive marsh birds (Conway and Gibbs 2005), a wide array of forest birds (Gunn et al. 2000), the Golden-winged Warbler (Kubel and Yahner 2007), and woodpeckers (Baumgardt et al. 2014). Additionally, playback has been used effectively to survey other upland game birds (Stirling and Bendell 1966, Schroeder and Boag 1989, Evans et al. 2007, Kasprzykowski and Golawski 2009, Jakob et al. 2010).

While these results were not expected, they are not novel. Previous studies have suggested that pheasant crowing is influenced by pheasant density (Gates 1966, Warner and David 1982), although this conclusion is not supported by a recent study (Luukkonen et al. 1997). Our study aligns with these recent findings. Alternatively, it is possible that our method of artificially increasing pheasant density (imitating a single crowing male) was not sufficient to effect a noticeable change in pheasant crowing rates. Gates (1966) reported an increase in crowing rate equivalent to 8% per 8 additional pheasants located within a study site (2km^2 area). At this rate, the number of pheasants we were detecting during our surveys would not be great enough to detect any differences in crowing rates leading to additional pheasants being detected. The average crowing rate during our 2016 survey season was 0.38 crows per minute, which is within the range reported by other studies (0.30 to 0.54; Gates et al. 1966, Luukkonen et al. 1997). With pheasants crowing roughly once every three minutes, we may have already given enough time within our 4 minute detection period to detect all crowing males, without needing to induce their crowing with our playback device. Luukkonen et al. (1997) supports this idea by suggesting a 4-min listening period, while historical surveys used a 2-min listening period. It is also possible that our volume was not set high enough. While our settings were based on previous work, it is unpublished and therefore not peer reviewed. We used different equipment than this previous research and did not have a way to easily verify volume in the field.

Weather variables are known to broadly affect the detection probability of birds (Anderson and Omhart 1977, Robbins 1981). In this study, we did not find strong temperature or cloud cover effects on the detection probability of pheasants. This finding is consistent with other studies (Heinz and Gysel 1970, Luukkonen et al. 1997) Surprisingly, we found that greater wind speeds increased detection probability, even though increasing wind speed is often associated with a decrease in detection probability (Robbins 1981). Ring-necked pheasant crowing rates are not affected during windy conditions (Luukkonen et al. 1997), and their loud call may be easier to hear in a strong wind than other bird calls (Heinz and Gysel 1970). We attribute our unexpected finding to the fact that we did not conduct surveys during mornings with winds >32 km/hr, which may have prevented us from seeing decreases in detection probability due to wind. Alternatively, the relatively moderate wind speeds that we experienced during most of our surveys may have allowed observers to more reliably hear pheasant vocalizations from greater distances. We did not record wind direction during each survey, but it is another variable that could possibly be more important than total wind speed. Vocalizations could be dampened or carried depending on whether the observer is up or down wind from the vocalizing pheasant. It is also important to note that we excluded all vocalizations greater than 800 m. There is the possibility that higher winds may have carried vocalizations from greater distances, leading observers to believe they were within the 800 m radius survey area.

Not surprisingly, we found evidence for a seasonal pattern in the detection probability of ring-necked pheasants, similar to other studies (Gates et al. 1966, Giudice et al. 2013). Detection probability increased throughout the beginning of the survey period, peaked at the end of April, and then decreased for the remainder of the survey period. This aligned with our expectations, because pheasants begin actively crowing (for the purpose of mating) in March and peak in late April and early May (Farris et al. 1977).

We observed a lower overall detection probability ($p = 0.35$) than other studies (Harwood et al., $p = 0.38$ to 0.73; Giudice et al. 2013, $p = 0.53$). We also experienced differences in detection probability among observers, which has been well documented by other studies (Buckland et al. 1993, Sauer et al. 1994, Kendall et al. 1996, Cunningham et al. 1999, Alldredge et al. 2007, Farmer et al. 2012). Our relatively low overall detection probability can be reasonably explained by this observer effect. Four observers had low detection probabilities ($p =$ 0.17 to 0.30) while three others had detection probabilities within the range of other studies (0.39 to 0.56). This suggests that potential observer differences should be considered in the design of crowing surveys with an emphasis on having skilled observers, with as few observers as possible.

Management Implications

To our knowledge, this is the first study to assess the use of call playback to increase detections of ring-necked pheasants. Most of our surveys were conducted in flat, intensively agricultural landscapes where we found no benefit to the use of a call playback. However, the costs of implementing call playback (both economically and logistically) were relatively low for our study and playback calls did not appear to hinder our detections. Conducting surveys in other habitats or regions could provide insights into whether or not call playback is useful. In addition, conducting surveys at different device volumes (particularly higher volumes) may allow additional pheasants to hear the simulated call, thereby increasing detectability. We encourage future studies to continue to evaluate the effectiveness of call playback, especially in other habitats, with different device/volume configurations, and in areas with higher densities of ring-necked pheasants.

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Tables

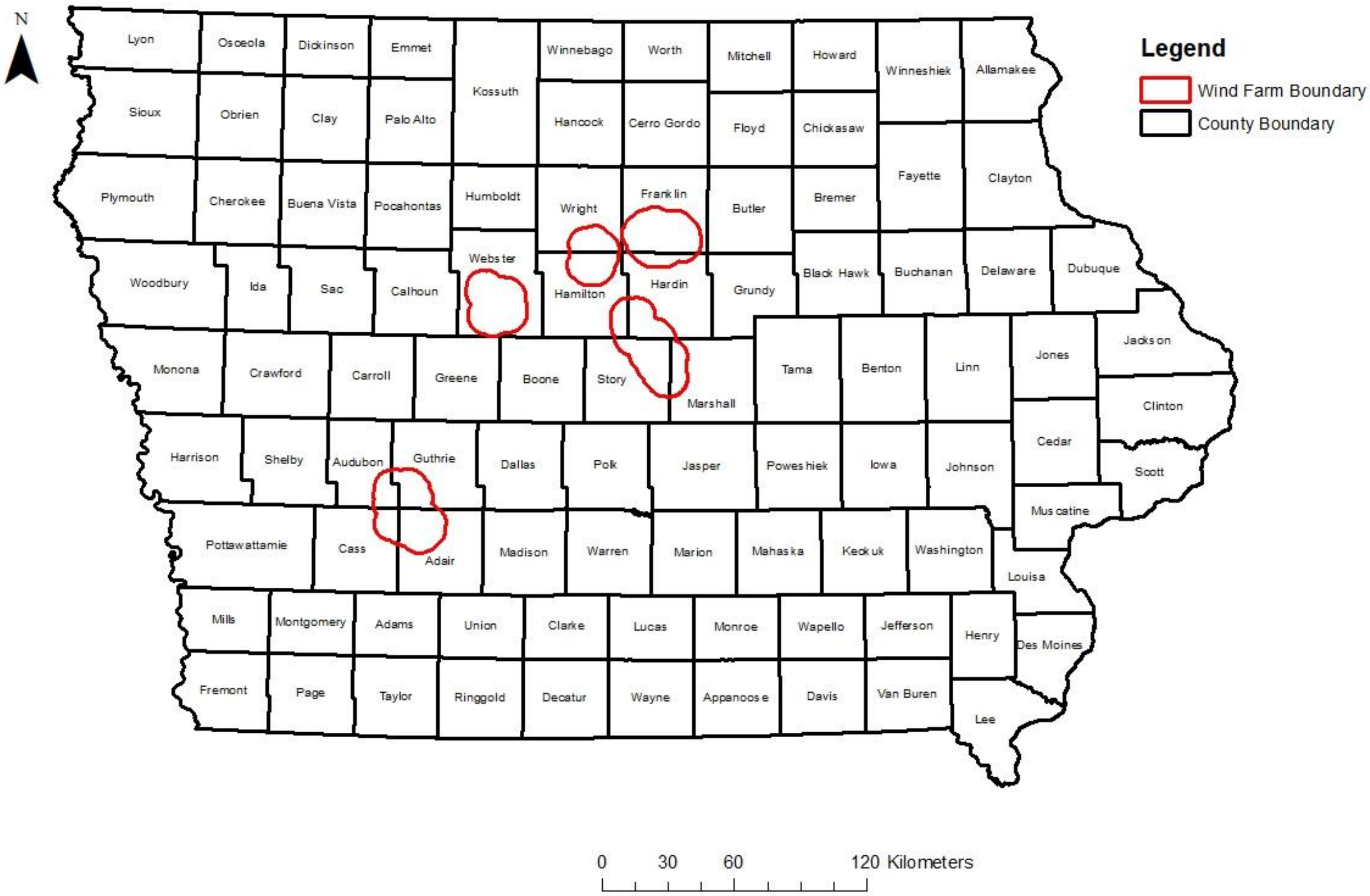
Table 1. Model selection results to understand the detection probability of ring-necked pheasants in Iowa, 2015-2017. Models were run using Program DISTANCE to evaluate the effect of different binning strategies (top panel) and important covariates (bottom panel) on pheasant detectability, are ranked by ascending ΔAIC value, and include the number of model parameters (*K*). Binning strategies were chosen after visually inspecting the raw data and include two options with three cutoff points (cutoff points differ between the two options), one option with four cutoff points, and one option with no cutoff points.

Model	ΔAIC[1,2]	*K*
Playback		
3 bins 250	0.00	4
3 bins 300	445.40	4
4 bins	1573.50	6
No bins	54188.61	6
Covariate		
Day (quadratic)	0.00	5
Day (linear)	14.21	4
Wind	29.90	4
Temperature	60.95	4
Cloud Cover	121.22	3

[1]AIC value of best Playback model was 9997.63
[2]AIC value of best Covariate model was 64108.71

Figures

Figure 1. Map of surveyed wind farms in Iowa (2017). County boundaries are outlined in black and wind farm boundaries are outlined in red. Wind farm boundaries include an 8 km buffer around that farm’s wind turbines.



Summary for online Table of Contents: Our study suggests that call playback does not have either a positive or negative effect on ring-necked pheasant crowing surveys. The use of call playback by managers using crowing surveys as a population index should not alter the results.

CHAPTER 3. RING-NECKED PHEASANT AVOIDANCE OF WIND TURBINES IN IOWA

A paper to be submitted to *The Condor*

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RH: Dupuie et al. • Pheasant Wind Turbine Avoidance

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Abstract

Wind energy is a growing industry in Iowa and across the United States. While wind power provides a “clean” energy source, there are concerns about potential impacts on wildlife. Ring-necked Pheasants (*Phasianus colchicus*) and other upland game birds face potential negative impacts from indirect effects of wind turbine production. Specifically, pheasants may be affected by habitat fragmentation and noise disturbance caused by wind turbines. We designed a study to assess the potential impacts of wind energy development on male Ring-necked Pheasants in central Iowa. Our study encompassed five wind farms in agricultural areas across central Iowa. We conducted 2320 crowing surveys during the early spring from 2015 to 2017 and detected an average of 2.13 ± 0.05 (SE) pheasants per point. We used linear regression to test for relationships between pheasant abundance and wind turbine density, distance from turbine to survey point, and percent land cover in grassland and agriculture. We also tested for correlation between land cover and our turbine measures. Our results suggested that wind turbine density ($\beta_{Density}$ = -0.169) negatively affected pheasant counts and distance to the nearest turbine

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($\beta_{Distance}$ = 0.001) positively affected pheasants counts. Percent land cover in agriculture did not have a significant effect on pheasant count while percent land cover of grass had a positive effect on pheasant counts (β_{Grass} = 0.091). Additionally, there was no correlation between turbine variables and percent land cover. While our results suggest that wind energy infrastructure impacts pheasant abundance, because of the relatively small scale of these effects, we argue they are not biologically significant. Large changes in turbine density and distance equate to changes in only a fraction of a bird. Our study did not find evidence of biologically significant effects of wind turbines on male Ring-necked Pheasant abundance, although we suggest that future studies account for female pheasants as well as different habitat configurations.

KEY WORDS Avoidance, call count, Iowa, *Phasianus colchicus,* Ring-necked Pheasant, wind turbine

Introduction

Wind energy is considered a clean source of power, although it can have negative impacts on wildlife. The biggest cause for concern, and the most documented effect, is direct mortality due to impact with turbine blades (Osborn et al. 2000, Johnson et al. 2002, Smallwood and Thelander 2008, Smallwood and Karas 2009, Bellebaum et al. 2013, Grodsky et al. 2013, Zimmerling et al. 2013, Erickson et al. 2014). Of additional concern are impacts related to indirect effects (Kunz et al. 2005, Kunz et al. 2007, Harr and Vanoy 2009). Indirect effects of wind turbines on wildlife include habitat fragmentation and noise disturbance, among others.

In 2016, 36% of Iowa's electrical power came from wind energy, highest in the United States (American Wind Energy Association 2016). As of February 2018, Iowa also ranks third among all states in number of wind turbines (3,957; American Wind Energy Association 2016).

The state currently has 6,917 megawatts of wind power (2^{nd} among all states) and has more than 2,700 additional megawatts in construction and under development (American Wind Energy Association 2016). The success of the wind energy industry in Iowa suggests that wind turbine construction will continue to expand in the foreseeable future.

The Ring-necked Pheasant (*Phasianus colchicus*) is an economically important gamebird in Iowa (Farris et al. 1977). In 2006, Iowa hunters spent $86 million (excluding license fees) on upland game bird-related activities (Upland Game Bird Study Advisory Committee 2010). Of this money, $70 million came from pheasant hunting (Upland Game Bird Advisory Committee 2010). On average, hunters spent $62 per day afield; more hunters spending more days afield generates greater spending (Upland Game Bird Advisory Committee 2010). The number of hunters and hunting days tends to fluctuate with perceived abundance of the species being hunted (Upland Game Bird Advisory Committee 2010). In order to maintain and increase the economic value of pheasants in Iowa, it is important to maintain and increase the abundance (real and perceived) of Ring-necked Pheasants.

Ring-necked Pheasants are one of the most widely distributed introduced species of bird worldwide (Hill and Robertson 1988). Pheasants were introduced to Iowa in the early 1900s and have been an intensively managed species ever since (Farris et al. 1977). Pheasant numbers, based on roadside counts and reported hunter harvest, have shown a long-term declining trend in Iowa (Upland Game Bird Study Advisory Committee 2010). A major cause of decline among all bird species is habitat fragmentation (Harr and Vannoy 2009). Habitat fragmentation is a landscape-scale process that couples habitat loss with the breaking apart of habitat (Fahrig 2003). Pheasants have been negatively affected by the large scale conversion of grassland to agriculture in the Midwest, including Iowa (Hallet et al. 1988). Studies have highlighted that reducing habitat fragmentation is pivotal in maintaining and increasing local populations of pheasants in Iowa (Clark et al. 1999, Clark and Bogenschutz 1999). One consequence of habitat fragmentation is that it increases the amount of edge habitat available. Decreased survival rates of pheasants from predation have been attributed to the loss of habitat (Riley and Schulz 2001, Shipley and Scott 2006) and an increase in edge within habitats (Schmitz and Clark 1999, Kuehl and Clark 2002).

Federal guidelines identify habitat loss/degradation and habitat fragmentation as risks that need to be assessed when developing wind-energy sites (U.S. Fish and Wildlife Service 2012). Unfortunately, few data have been collected on the impacts of wind turbines on pheasant populations in North America. A study in Europe found that turbines displaced pheasants, although this study was small in scope and focused only on close proximity to turbines (Devereux et al. 2008). A multi-species study done in Minnesota found similar findings (Johnson et al. 2000). Concerns have already been raised that birds could be displaced because of turbine noise or vibration, habitat loss, or barriers created by the construction and presence of wind turbines (Kunz et al. 2005, Kunz et al. 2007, Harr and Vanoy 2009). Avoidance of wind turbines has been documented in Lesser Prairie-Chickens (*Tympanuchus pallidicinctus*; Pruett et al. 2009) and Greater Prairie-Chickens (*Tympanuchus cuipido*; Pruett et al. 2009, Winder et al. 2014a). Lebeau et al. (2014) showed that Greater Sage-Grouse (*Centrocercus urophasianus*) nesting success decreased with proximity to turbines, but survival was unaffected. Proximity to turbine did not affect Greater Prairie-Chicken survival (Winder et al. 2014b) or nest selection and success (Mcnew et al. 2014). A study in the Prairie Pothole Region of North America highlighted a decrease in breeding pair density of ducks on sites with wind energy development (Loesch et al. 2013), while Gue et al. (2013) showed that wind facilities did not affect the survival of breeding female Mallards (*Anas platyrhynchos*) and Blue-winged Teal (*Anas discors*). Thus, there are mixed effects of wind turbines on birds as measured by reproductive success, survival, or changes in abundance.

It is important to critically evaluate the effect of wind turbines on Iowa's wildlife. Study findings can help managers address concerns about wildlife impacts of future wind-power facility construction, and add to a growing body of knowledge on this topic worldwide. To address concerns regarding an increase in wind turbine production in Iowa and a lack of knowledge about effects on pheasant populations, we conducted pheasant crowing surveys on wind farms in central Iowa. Our goal was to assess the impacts of wind energy development on the distribution of pheasants on and adjacent to wind farms in central Iowa.

Study Area

We conducted crowing surveys within an 8 km buffer around five different wind farms in central Iowa. The maximum distance adult pheasants appear to disperse from winter cover during the spring is 8 km (Gates and Hale 1974). Creating a buffer zone of this size thus enabled us to account for pheasants that could reasonably be affected by a particular turbine. These wind farms spanned eleven counties, most of them in central Iowa. All sites consisted of primarily intensive row crop agriculture with smaller patches of grassland, rural dwellings, fragmented forest patches, and other habitat types. Topography was generally flat across at all sites, with the exception of Adair Wind Farm, which had some rolling hills. Adair Wind Farm covered a 944 km^2 area across Adair, Audubon, Cass, and Guthrie counties and contained 208 wind turbines. Century Wind Farm was located in Hamilton and Wright counties and had 145 wind turbines in a 512 km^2 area. Franklin Wind Farm had 181 turbines across 756 km^2 in Franklin County and extended into Hardin County. The Story Wind Farm spanned Hamilton, Hardin, Story, and

Marshall Counties, covered 995 km^2 and contained 203 wind turbines. The Lundgren Wind Farm was entirely within Webster County and comprised a 658 km^2 area with 107 turbines.

Methods

Crowing Surveys

We conducted spring crowing surveys from 2015 to 2017, beginning in mid-April and continuing until all survey routes had been completed (approximately mid-May). Story was surveyed in all three years; Century, Franklin, and Lundgren were surveyed in 2016 and 2017; and Adair was surveyed in 2017 only. Male pheasants begin crowing in March (for the purpose of attracting a mate), with peak crowing in late April and early May (Farris et al. 1977). Surveys were conducted in the morning, beginning one half hour before sunrise and ended within two hours. One half hour before sunrise until one half hour after sunrise is the best time for conducting surveys (Luukkonen et al. 1997); we added an extra hour to ensure that we could complete all surveys within the time allowed. We did not conduct surveys during mornings with poor weather that included rain or winds >32 km/hr.

Each wind farm was randomly assigned ten to fifteen routes in proportion to its total area. Routes were surveyed in a randomly chosen order and then repeated during the second half of the survey period, providing two survey dates each year for each route. Each route contained ten survey points. On the second visit, the order in which each point along the route was surveyed was reversed, to correct for any effects of time of day. Each observer surveyed a single route (ten points) on each survey day. Routes were surveyed by one observer in 2015 and divided up and surveyed by four observers in 2016 and 2017, for a total of 7 observers. In years with multiple observers, routes were randomly assigned to observers and observers did not complete the same route more than once. Each observer conducted surveys on each wind farm being surveyed in that year. Survey points were placed along roads with a north/south orientation and in most cases were located at the midpoint between intersecting east/west roads. An initial survey point was randomly chosen as the start point for each route, with the next point >2 km away in a randomly chosen cardinal direction, until ten total points were assigned to a route. Within an individual route, survey points were chosen without replacement and were >2 km apart to avoid double counting of individuals. Some survey points were included on more than one route.

We conducted radial point counts (Buckland et al. 2001) at every survey point. During each survey, the observer recorded the minute each crowing male pheasant was initially detected and measured the distance from the individual to the observer using a laser rangefinder. Only detections within 800 m of the survey point were included, which is the maximum distance at which a crowing pheasant can be reliably detected (Todd Bogenschutz, pers. comm.). Each survey point had a 4-min listening period (Luukkonen et al. 1997). In addition to information about each detection, we recorded wind speed (km/h), temperature (°C), and cloud cover (%) during each survey. Weather conditions can affect pheasant detection (Giudice et al. 2013) and measuring these conditions allowed us to potentially account for these effects.

All surveys were conducted in a manner intended to meet the general assumptions for surveying point counts. These assumptions are (1) all birds at the point are detected, (2) birds do not move in response to the observer prior to detection, and (3) the distance of each bird to the observer is estimated accurately (Rosenstock et al. 2002). Additionally, we assumed that crowing intensity was independent of population density and that crowing counts were timed in relation to the seasonal trend in crowing (Gates 1966).

Analysis

We used R (Version 3.4; R Development Core Team 2008) to test for linear relationships between pheasant counts and the presence of wind turbines. Using simple linear regression (α = 0.05) we tested for relationships between counts and the distance from the survey point to the nearest turbine as well as between counts and the density of wind turbines within a two kilometer radius of the survey point. Additionally, we looked at the linear relationship between pheasant counts and the percentage of land (within a 2 km radius) that is in agriculture and grass. To determine land use, we used a 2009 high resolution land cover map of Iowa, with a 3 m resolution. In order to obtain normality, average pheasant counts and turbine density variables were transformed using the logarithmic transformation $log(x+1)$, where x is the value of the variable. Because male pheasants rely on vocalization to establish and defend territory (Heinz and Gysel 1970), we predicted that we would see some level of avoidance due to noise disturbance. Mean pheasant counts for each survey point were used to interpolate (by kriging) pheasant count maps for each wind farm in every year it was surveyed.

Wind turbines in Iowa are placed almost exclusively in agricultural fields. In order to ensure that any relationships between wind turbine presence and pheasant counts was not an artifact of land use, we tested for correlation (α = 0.20) between our wind turbine measurements and the percentage of land in both of our land use categories. We measured correlation using a simple Pearson's correlation coefficient.

Results

Across three survey years (2015 – 2017) we detected 4933 pheasants during 2320 surveys with an average of 2.13 ± 0.05 (SE) pheasants detected per point (Table 1). Total number of pheasants detected varied among wind farms and years (Table 1). Mean pheasants detected per point was greatest in 2016 ($\bar{x} = 2.21$), although the single greatest mean for any wind farm was Adair in 2017 ($\bar{x} = 2.62$).

Linear regression showed statistically significant effects of the presence of wind turbines on pheasant counts. Pheasant counts increased slightly with increasing distance from the nearest wind turbine ($\beta_{Distance}$ = 0.001, SE = -0.001, P < 0.001). Similarly, they showed a small decrease as the density of wind turbines near the survey point increased ($\beta_{Density}$ = -0.169, SE = 0.021, P < 0.001). The percentage of land in agriculture ($\beta_{Agriculture}$ = 0.007, SE = 0.004, P = 0.13) did not have a statistically significant effect on pheasant counts, but the percentage of grassland (β_{Grass} = 0.091, SE = 0.031, P = 0.004) suggested that pheasant counts increase as the percentage of grassland increase.

There was minimal correlation between turbine variables and land cover measures. Correlation coefficients between the distance to the nearest turbine and grass (*r* = 0.10) and between turbine distance and agriculture (*r* = -0.18) were small. Coefficients between turbine density and grass (*r* = -0.13) as well as between turbine density and agriculture (*r* = 0.18) were similarly small.

Interpolated pheasant count maps for each wind farm in every year it was surveyed highlighted a fairly obvious pattern (Appendix A-E). In general, areas of lowest pheasant counts overlapped areas with wind turbines, although there was variation within and between farms. Within wind farms, there was little variation in the pattern of interpolated counts between years.

Discussion

The objective of our study was to assess the effects that the presence of wind turbines have on Ring-necked Pheasant crowing counts. Because there has been a wide variety of effects of turbines observed to in other game birds (Pruett et al. 2009, Gue et al. 2013, Loesch et al. 2013, Lebeau et al. 2014, McNew et al. 2014, Winder et al. 2014a, Winder et al. 2014b), we expected to see some level of avoidance. Below, we place the findings from our study in a larger context of bird responses to wind energy development, and then suggest how this can affect future conservation and management actions. Wind energy is a growing industry and a key part of clean power. We hope that our findings will contribute to the large body of literature surrounding wind energy and conservation, and help inform future wind energy development and conservation efforts.

Our results show that there were fewer pheasants closer to wind turbines and in areas with a higher density of turbines, but we argue that these results are unlikely to be of biological significance. For every one meter closer to a wind turbine a survey point was located, the number of pheasants detected on the survey decreased by < 0.001%. Similarly, a 1.00% increase in turbine density reduced the average number of pheasants detected by 0.17%. A 100% increase in wind turbine density would only result in a 17% decrease in average pheasant counts. This may seem significant, but at such small counts (survey-wide average of 2.13), a 17% increase in pheasant numbers is only an increase of a fraction of a bird. Scaled to an entire population, these effects may not be large enough to cause concern about the health of the population.

Wind turbines in Iowa are generally placed in agricultural fields, away from the grass patches and ditches where many male pheasants are found crowing during the breeding season. Similar to other upland game birds, there is little to no risk of turbine collision for pheasants; noise disturbance from the spinning of the blades and habitat fragmentation are greater threats (LeBeau et al. 2014, Smith et al. 2016). Noise generated by wind turbines can be quite loud near a turbine, but the volume quickly dissipates at greater distances. Noise levels from wind turbines reach about 120 decibels (push lawnmower) directly underneath the turbine, and quickly fall off to about 40 decibels (refrigerator) at distances of 300 m. (Colby et al. 2009, GE Global Research 2014). Beyond these distances, noise levels reach normal ambient levels and would be unlikely to cause any additional noise disturbance to pheasants. As a result, we may not have seen significant avoidance of wind turbines because pheasants were not close enough to wind turbines placed in row crop agriculture to experience noise disturbance.

It is possible that we did not survey at small enough distances from turbines to detect avoidance by Ring-necked Pheasants. Devereux et al. (2008) found avoidance of wind turbines by pheasants at distances between 150 m and 750 m from a wind turbine, and one of their self-criticisms was that they did not survey at distances closer than 150 m. While our survey did include surveys closer than 750 m to a wind turbine, only 95 survey points (18.3% of all points surveyed) were between 150 m and 750 m from a turbine. None of our survey points were closer than 163 m to a turbine and our farthest survey point was almost 8000 m from a turbine. With such a wide range of distances, any effect at a small scale could have been easily missed.

The wind turbines in our study area were placed exclusively in agricultural fields. This presented us with the possibility that any turbine effects were really just a product of habitat availability. The configuration of habitat is undoubtedly important, although we found only low correlations between our turbine statistics and the percentage of agriculture and grassland at each survey location. Juxtaposition of grassland habitat was not uniform across the study area. While agricultural areas were generally large tracks of contiguous land, grass patches varied from strips along edges (fences, ditches, crop rows) to sizeable parcels of land enrolled in the Conservation Reserve Program. Our measurements did not account for juxtaposition, which could be more important than percent cover. It may be that turbines found in areas with better habitat could cause greater disturbances to pheasant populations. Avoidance of wind turbines would presumably be easier to detect in larger, denser pheasant populations.

Our results suggest that pheasant counts are not affected by the percentage of agriculture in the area and only slightly affected by the percentage of grassland in the area, which is in contrast to a number of other studies (Nusser et al. 2004, Nielson et al. 2008, Jorgensen et al. 2015). One reason for this may be that we did not have enough difference in habitat composition across all of our survey points to identify any effects. The total percentage of grassland at a point ranged from 2.2% to 71.8% and the total percentage of land in agriculture ranged from 9.0% to 93.6%, however across all survey points, nearly 80% of the land was in row crop agriculture while less than 15% of all land was grassland. With the majority of the study area being used for agriculture, there may not be enough habitat heterogeneity to identify any significant habitat effects.

Our study found no biologically significant avoidance of wind turbines by male Ring-necked Pheasants in Iowa. Male pheasant counts changed very little from close proximity to a turbine out to a distance of 8000 m, suggesting that habitat may play a greater role in their distribution across Iowa's agricultural regions. Based on historical Iowa Department of Natural Resources roadside surveys, pheasants exist in greater abundances in regions with greater percentages of grassland (Bogenschutz and McInroy 2017). The wind farms we surveyed have less grass cover than these regions. It is important to recall that this finding applies only to male pheasants, and that hens could have a different response. It also only focuses on abundance and does not address other factors such as home range, dispersal distances, and survival. We suggest that future studies measure effects on hens and chicks and focus on understanding possible avoidance of wind turbines at distances <200 m from a wind turbine, and that habitat juxtaposition be considered simultaneously.

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Tables

Table 1. Summary statistics for male Ring-necked Pheasant crowing surveys in central Iowa, 2015-2017. Results are reported by wind farm and by year. Survey dates, number of surveys completed, number of birds detected, and mean counts per point are reported.

Wind Farm	Year	Dates	No. of Surveys	No. of Birds	No./Point
Total	2015	13 Apr - 23 May	300	577	1.92
Story			300	577	1.92
Total	2016	11 Apr - 24 May	820	1816	2.21
Story			300	714	2.38
Century			200	317	1.59
Franklin			220	364	1.65
Lundgren			200	421	2.11
Total	2017	13 Apr - 27 May	1200	2540	2.12
Story			300	708	2.36
Century			200	357	1.79
Franklin			220	394	1.97
Lundgren			200	348	1.74
Adair			280	733	2.62
Total	All	11 Apr - 27 May	2320	4933	2.13

Appendix A. Story Maps

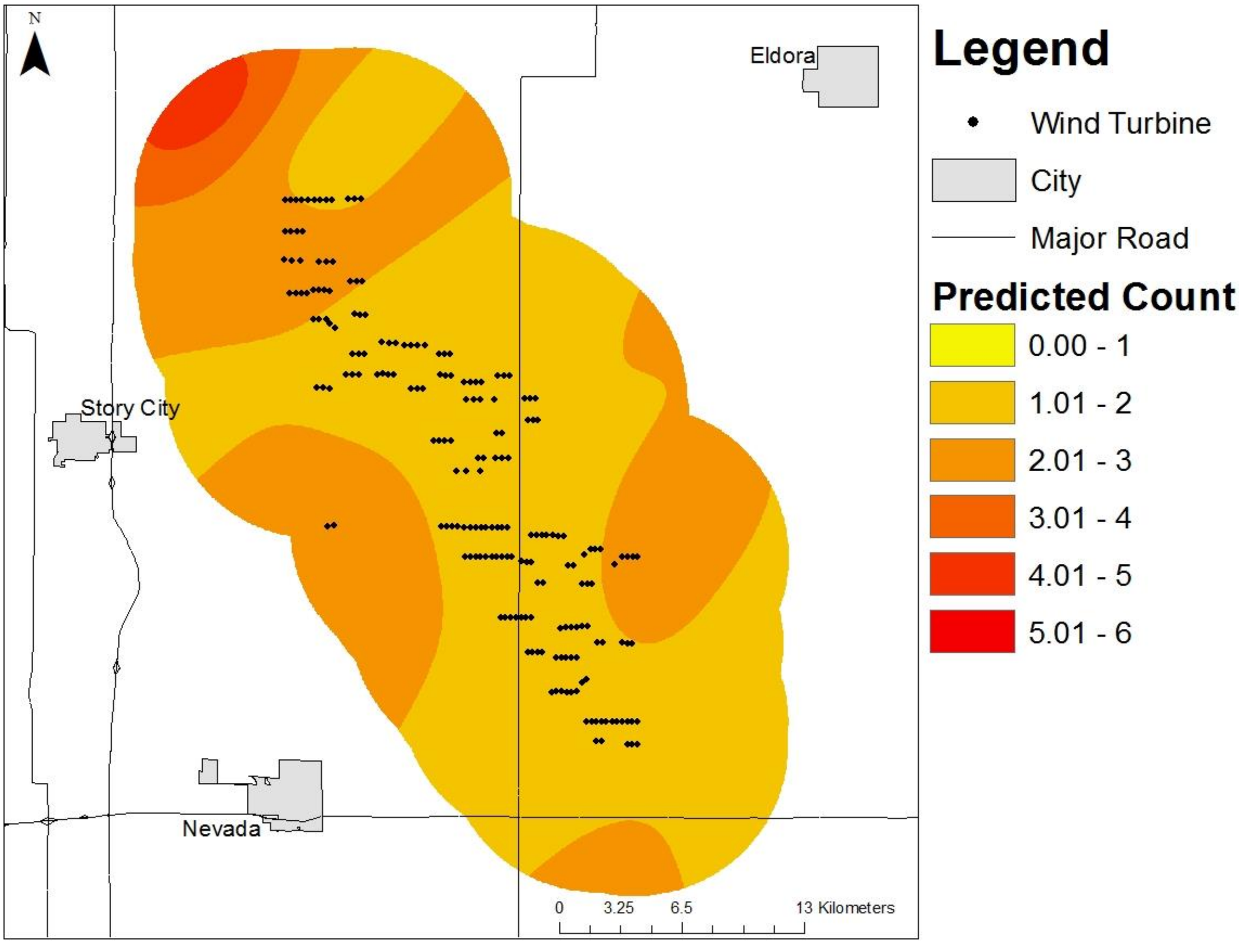

Figure A1. Interpolated density map of the average number of pheasants detected across the Story Wind Farm for 2015 with locations of wind turbines, cities, and major roads included.

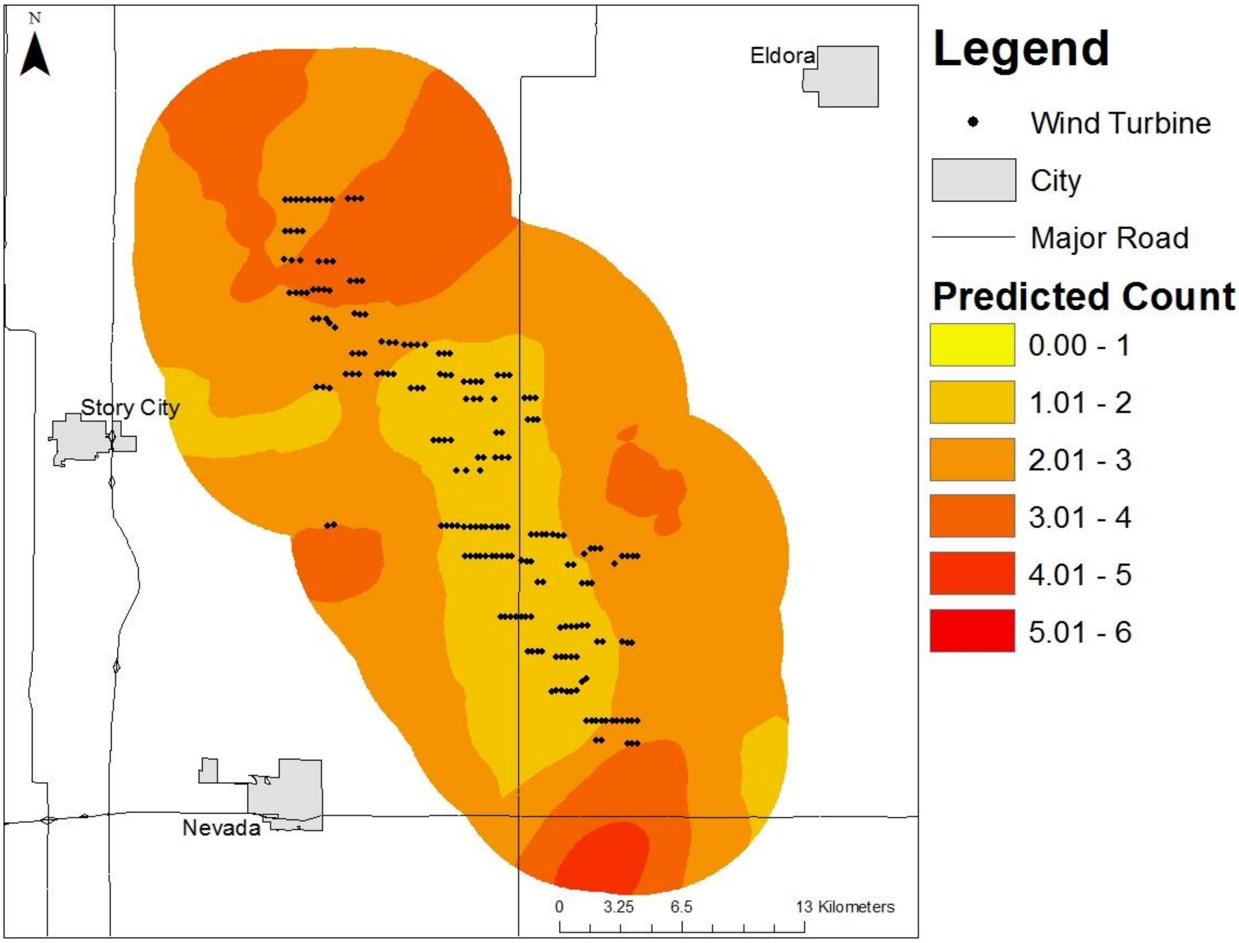

Figure A2. Interpolated density map of the average number of pheasants detected across the Story Wind Farm for 2016 with locations of wind turbines, cities, and major roads included.

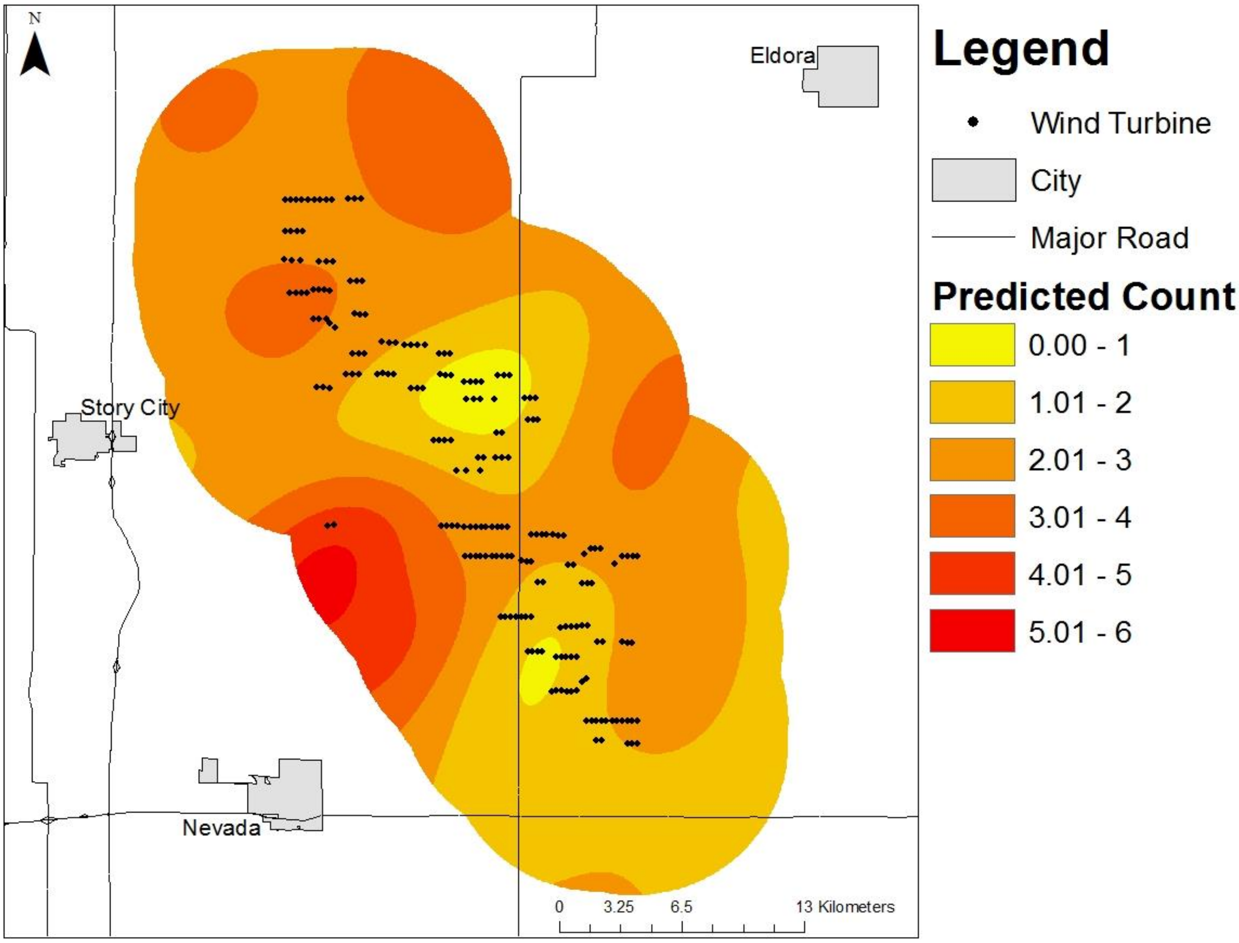

Figure A3. Interpolated density map of the average number of pheasants detected across the Story Wind Farm for 2017 with locations of wind turbines, cities, and major roads included.

Appendix B. Century Maps

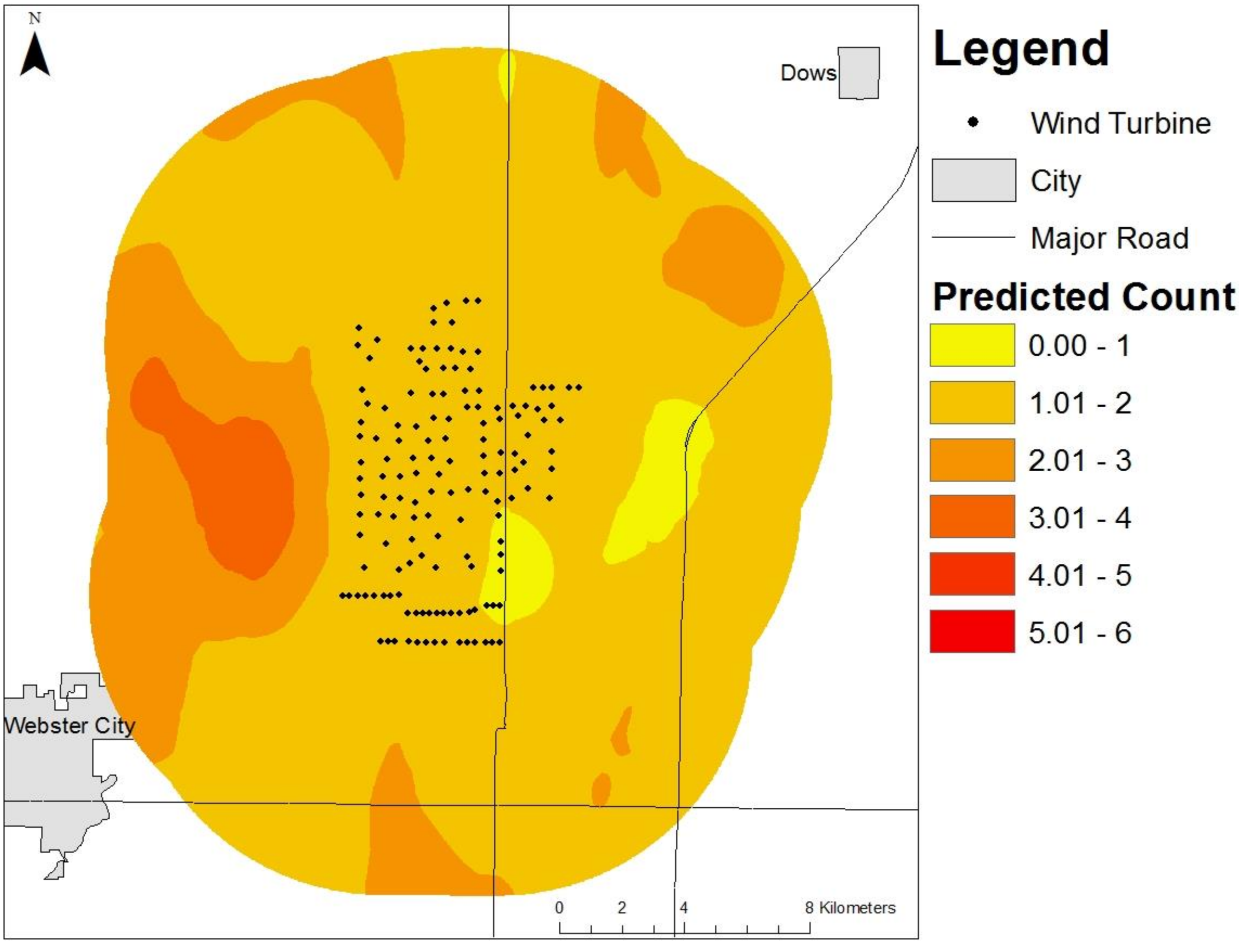

Figure B1. Interpolated density map of the average number of pheasants detected across the Century Wind Farm for 2016 with locations of wind turbines, cities, and major roads included.

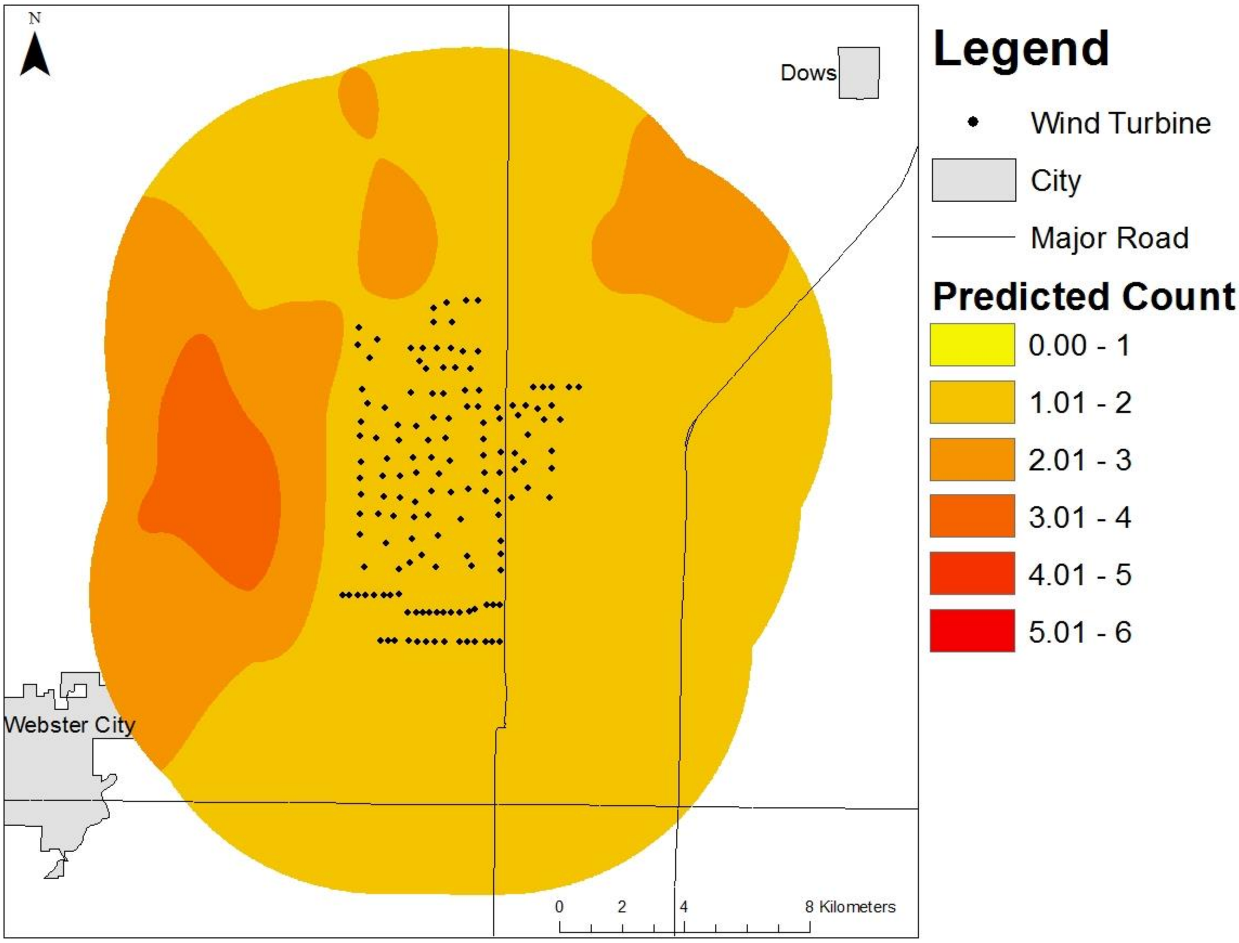

Figure B2. Interpolated density map of the average number of pheasants detected across the Century Wind Farm for 2017 with locations of wind turbines, cities, and major roads included.

Appendix C. Franklin Maps

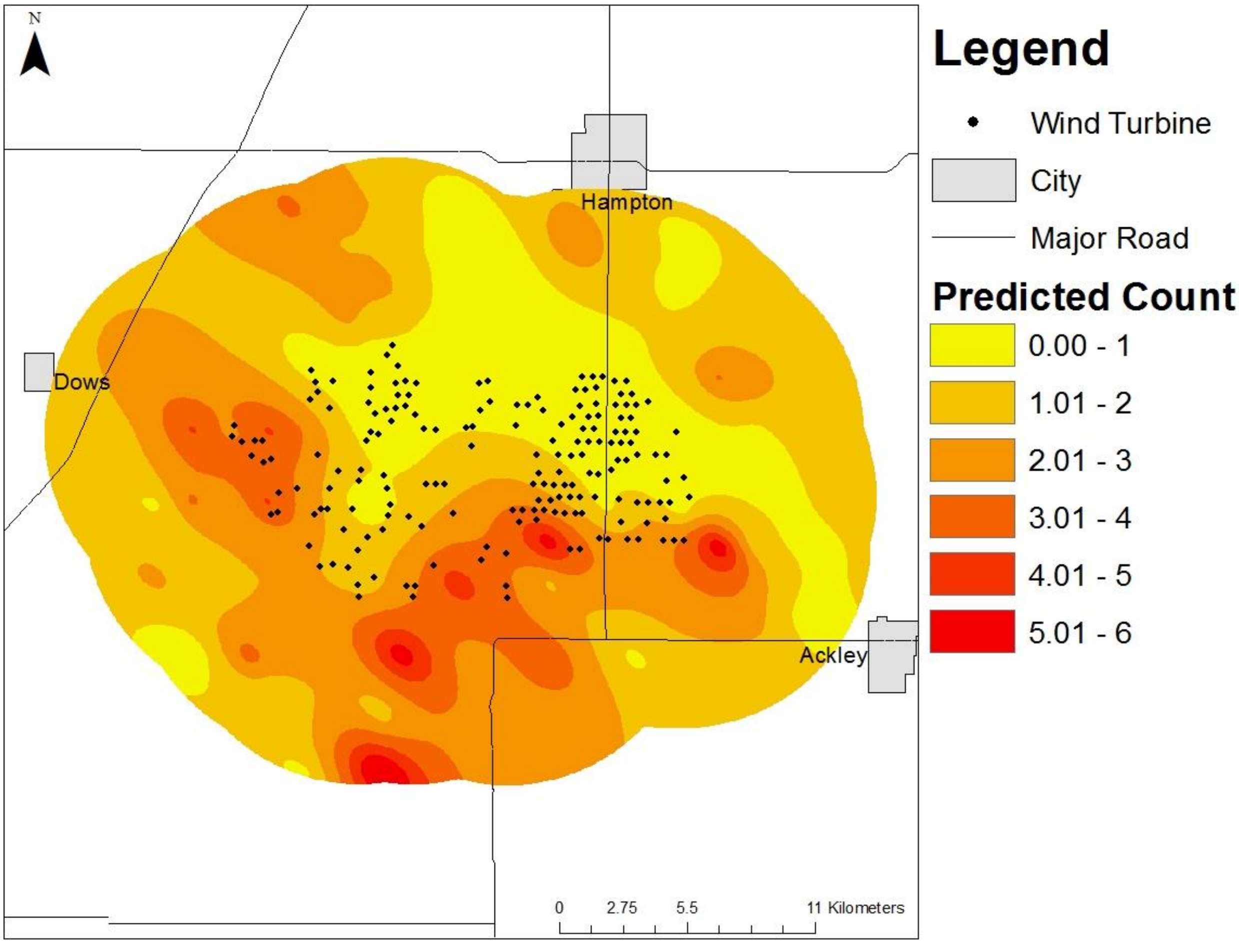

Figure C1. Interpolated density map of the average number of pheasants detected across the Franklin Wind Farm for 2016 with locations of wind turbines, cities, and major roads included.

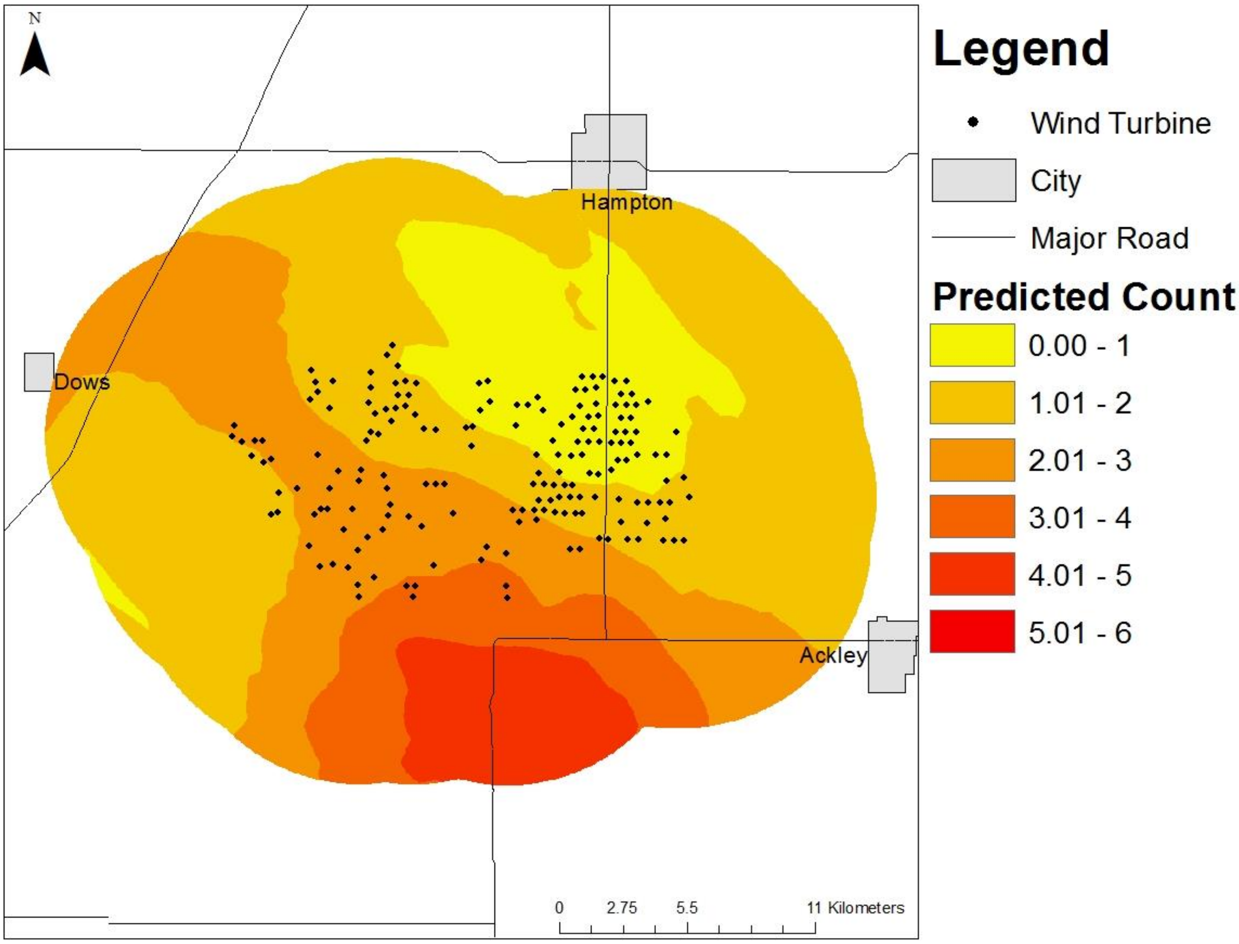

Figure C2. Interpolated density map of the average number of pheasants detected across the Franklin Wind Farm for 2017 with locations of wind turbines, cities, and major roads included.

Appendix D. Lundgren Maps

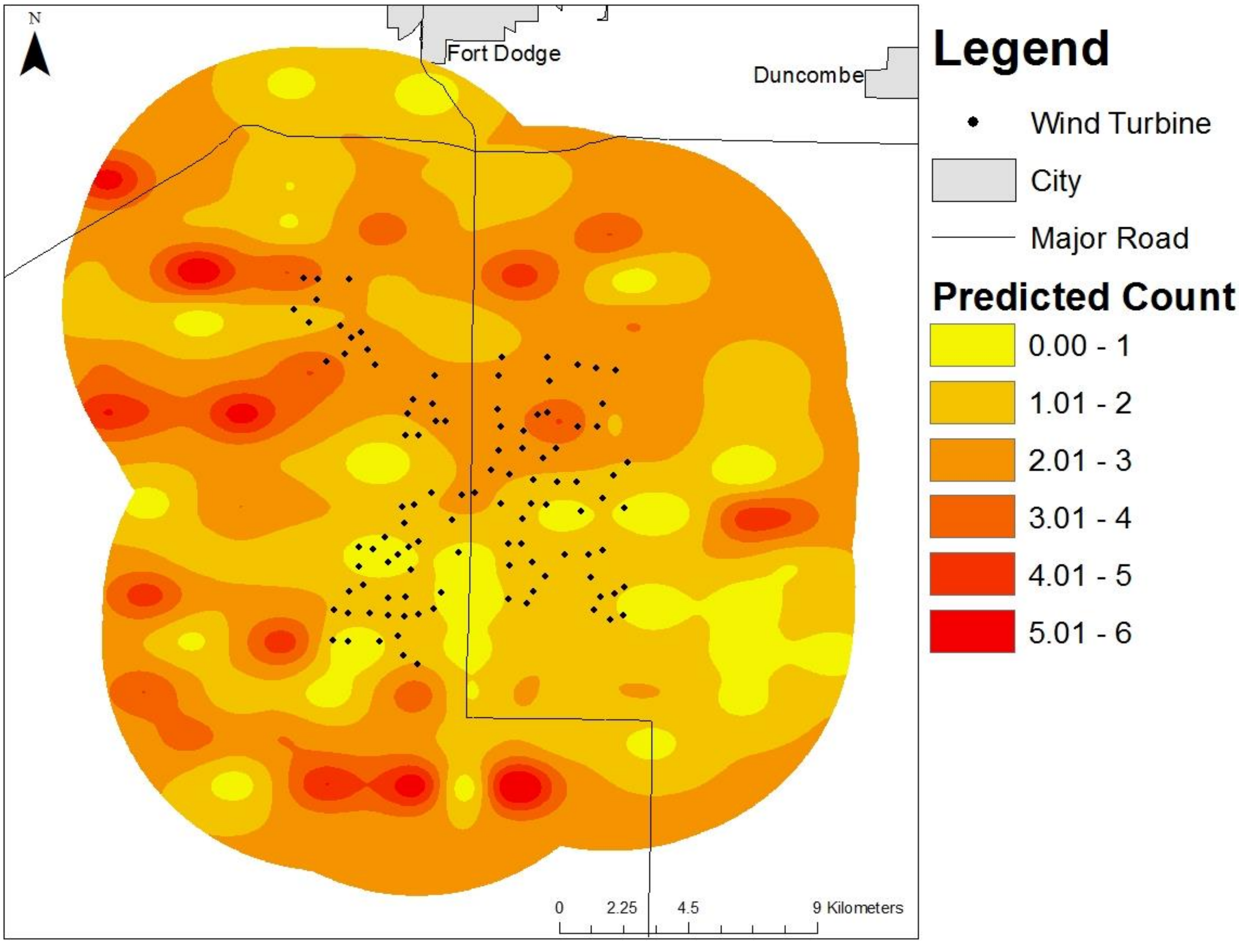

Figure D1. Interpolated density map of the average number of pheasants detected across the Lundgren Wind Farm for 2016 with locations of wind turbines, cities, and major roads included.

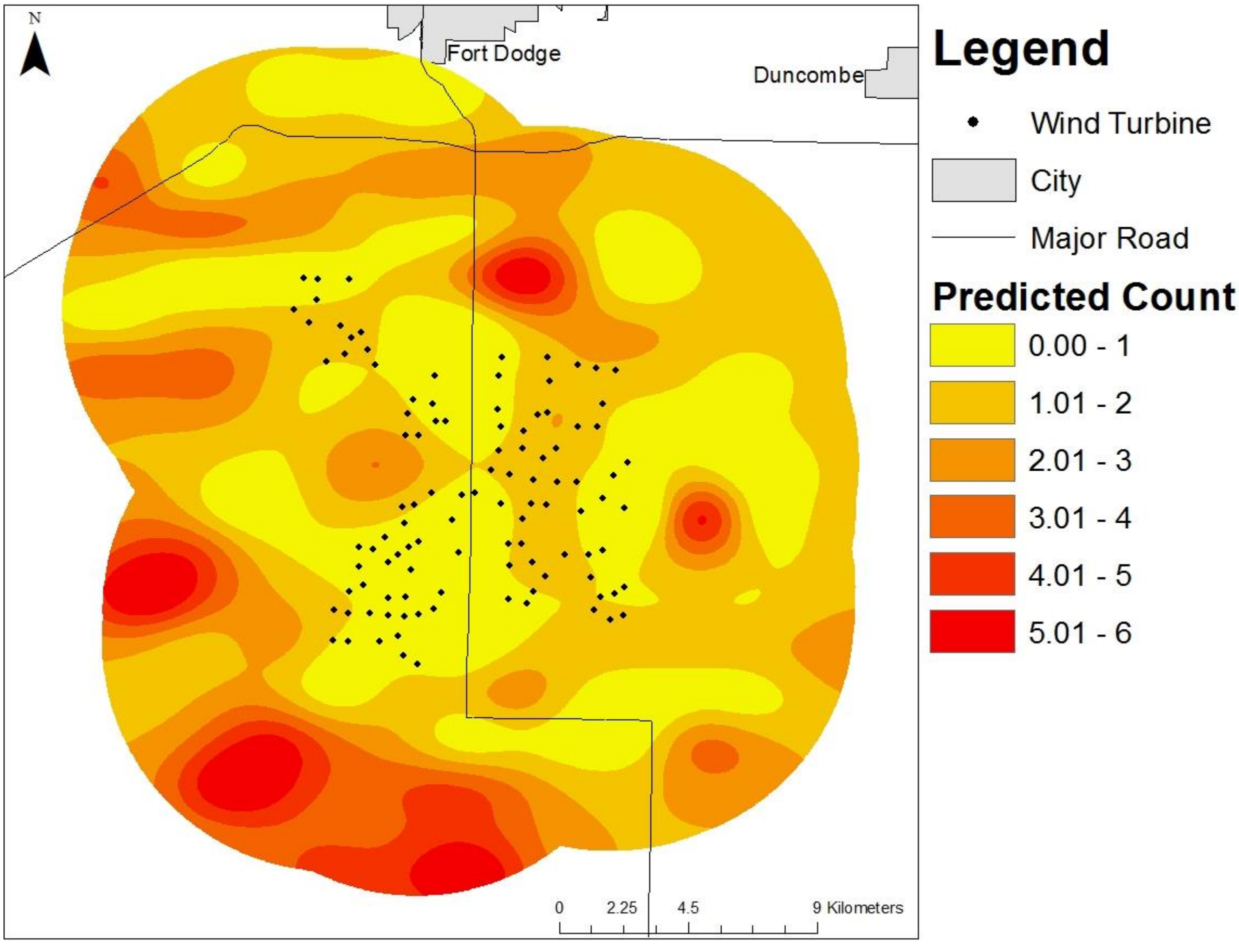

Figure D2. Interpolated density map of the average number of pheasants detected across the Lundgren Wind Farm for 2017 with locations of wind turbines, cities, and major roads included.

Appendix E. Adair Map

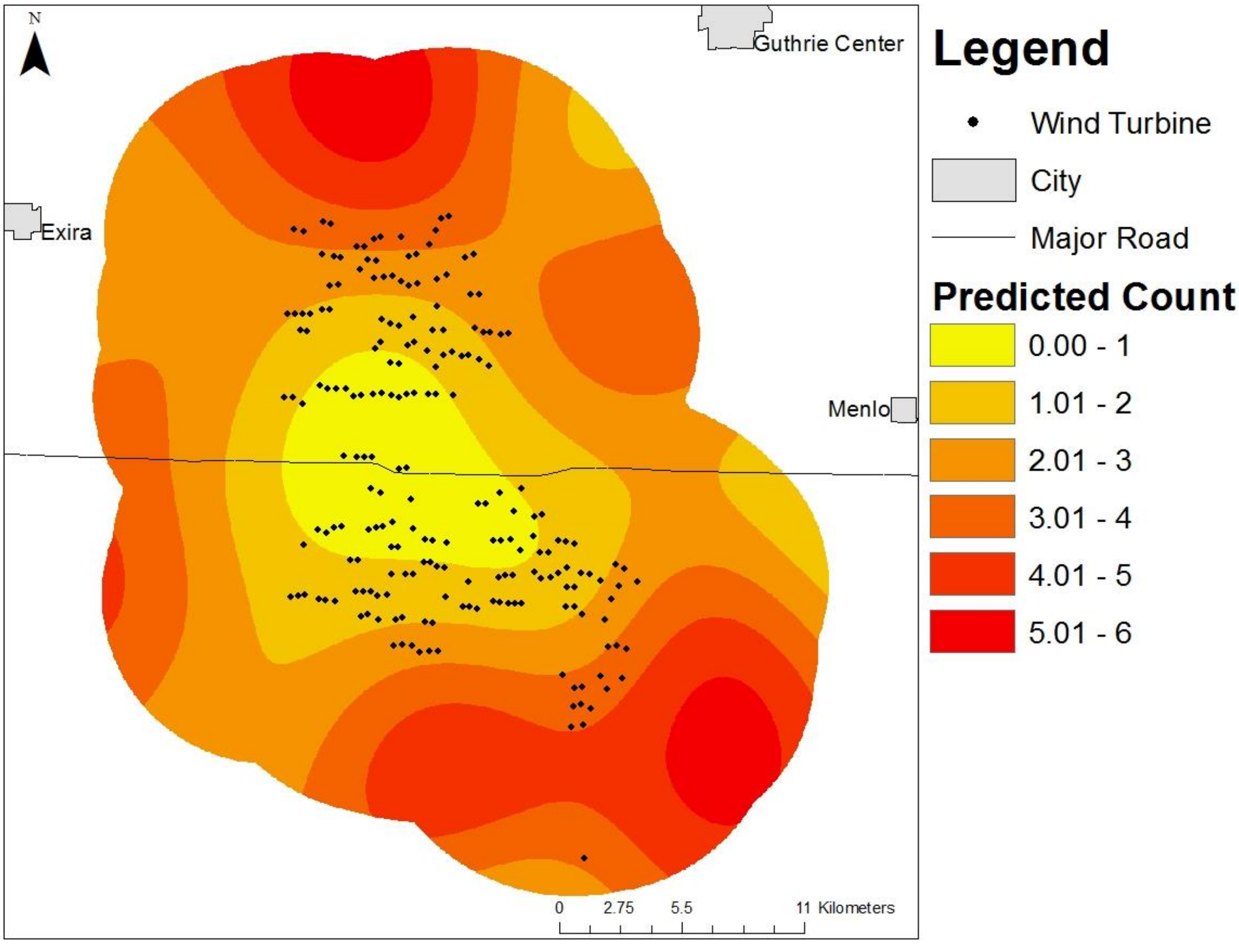

Figure E. Interpolated density map of the average number of pheasants detected across the Adair Wind Farm for 2017 with locations of wind turbines, cities, and major roads included.

CHAPTER 4. RESILIENCY OF IOWA'S RING-NECKED PHEASANTS USING THE IOWA ROADSIDE SURVEY

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RH: Dupuie et al. • Pheasant Resilience

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Abstract

The Iowa Department of Natural Resources (IDNR) has collected population information on ring-necked pheasants (*Phasianus colchicus*) using roadsides surveys since 1962. These surveys have allowed the DNR to amass a large amount of information about pheasant population trends throughout Iowa. We used this large dataset to determine which counties in Iowa supported the most resilient (abundant and consistent) populations of ring-necked pheasants. We did this by assigning each county a score based on its pheasant abundance and population consistency and then combining those scores to create a resiliency score. Mean pheasant counts across all counties ranged from 1.68 birds per survey in Monroe County to 23.84 birds per survey in Poweshiek County. Consistency (similarity over time) was relatively low across the state, with Fayette and Hancock counties having the highest percentage of surveyed years that were consistent (12.00%). All land use covariates showed effects on the consistency of

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pheasant populations. Coefficient of variation (CV) increased with an increase in land enrolled in the Conservation Reserve Program (β_{CRP} = 0.526, SE = 0.135, P < 0.001). An increase in percent coverage of corn (β_{Corn} = -0.236, SE = 0.035, P <0.001), soybeans (β_{Soy} = -0.253, SE = 0.041, P < 0.001), and both combined (β_{Total} = -0.095, SE = 0.018, P < 0.001) decreased CVs. Adair, Fayette, and Hancock counties had the most resilient populations according to our analysis, although no counties received the highest possible score. Our analysis suggests that the higher elevation counties in western Iowa as well as a small pocket of counties in northeastern Iowa support the most resilient ring-necked pheasant populations. These results could help inform wildlife managers in Iowa about which areas of the state can support the most resilient populations and will benefit the most from an investment of future conservation resources.

KEY WORDS Iowa, *Phasianus colchicus*, population index, resiliency, ring-necked pheasant, roadside survey

There are a number of definitions for the term “resilience” (Brand and Jax 2007). The original definition, proposed by Holling (1973) is that resilience is a “measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables”. Mostly used to determine the stability of ecosystems, measuring resilience is a way for biologists to identify areas that are resistant to disturbance as well as areas that are at risk when disturbed. This information helps when creating habitat management plans for ecosystems and populations. To measure resilience with regard to populations, biologists must be able to estimate population size.

Wildlife surveys are used by wildlife managers to assess population sizes and make informed management decisions. There are a variety of different survey techniques used for different species, habitats, and questions. For the ring-necked pheasant (*Phasianus colchicus*), there are two primary survey techniques used to estimate population size: roadside surveys and crowing counts (Rice 2003). Roadside surveys involve an observer driving slowly along a road and counting the total number of pheasants (male and female, adult and chick) detected (Rice 2003). Crowing counts are used to survey adult male pheasants only and involve an observer conducting a point count survey, recording the number of unique pheasant vocalizations they hear (Gates 1966). In Iowa, wildlife managers primarily use roadside surveys to estimate ring-necked pheasant populations in order to predict future harvest numbers (Klonglan 1962).

Ring-necked pheasants are one of the most widely distributed introduced species of bird worldwide (Hill and Robertson 1988). Pheasants were introduced to Iowa in the early 1900's for recreational hunting and have been an intensively managed species ever since (Farris et al. 1977). Pheasants were originally only present in Northern Iowa, but eventually their range expanded to encompass the entire state (Farris et al. 1977). A stable or increasing pheasant population is important to maintain and increase the economic value of pheasants in Iowa. Pheasant numbers, based on roadside counts and reported hunter harvest, peaked in the 1940s and 1950s (Farris et al. 1977) and have shown a long-term declining trend in Iowa since the 1960s (Upland Game Bird Study Advisory Committee 2010). In addition to long term trends, ring-necked pheasant populations are susceptible to steep declines in response to harsh winters (Warner and David 1982). Habitat fragmentation is considered the leading cause of population decline of pheasants in Iowa (Farris et al. 1977, Warner and Etter 1986), specifically due to massive conversion of grassland habitat to agricultural land. Common pheasant habitat types include crop fields and native and non-native grasslands (including narrow strips such as fencerows) (Wildlife Habitat Management Institute 1999). Thus, the ring-necked pheasant remains a fairly common and widespread bird, although long-term declines raise concerns about their persistence in Iowa.

In addition to a decline in pheasant numbers, conservation funding has also been declining, exemplified by the reduction in conservation funding from recent Farm Bill legislation (USDA Economic Research Service 2014). With a continuing decrease in conservation dollars, it becomes increasingly more important for wildlife managers to manage wildlife habitat in an efficient way. Focusing management and restoration efforts on areas that produce the largest benefits will help managers continue to manage effectively with less economic resources. In order to aid this effort, we designed an analysis of existing pheasant roadside survey data aimed at pinpointing counties in Iowa that would receive the greatest conservation benefit for less economic investment.

We use the term “resilient” to identify counties in Iowa that can sustain populations of ring-necked pheasants and also are consistent, with low year to year variation. We believe these resilient counties would benefit the most from conservation efforts (such as habitat restoration and improvement) because they provide opportunities for abundant populations of ring-necked pheasants with lower risk of population decline. The objectives of our analysis were to (1) rank mean pheasant counts for each county relative to other counties, (2) quantify population consistency (year to year variation) for each county, and (3) from these data determine the counties that support the most resilient pheasant populations. Collectively, this information will provide insights into regions of Iowa that have supported consistently high pheasant populations and can identify areas with lower populations that may not be cost-effective areas to manage.

Methods

Roadside Surveys

Roadside ring-necked pheasant surveys were conducted in every county in Iowa, although not every county had a survey during every year of the study (1962-2015). Survey routes were manually chosen by Iowa Department of Natural Resources (IDNR) employees with a focus on areas with habitat suitable for ring-necked pheasants. Routes were also designed to avoid paved roads as much as possible. The IDNR staff conducted yearly roadside pheasant surveys (Suchy et al. 1991) from 1962 to 2015. Surveys were done between July and October, with the majority of surveys (98%) occurring in August. Surveys began at sunrise and were completed within 2 hours. Every effort was made to conduct surveys during favorable weather conditions that included heavy dew, winds <16 km/h, and sunny skies. These were the best conditions for increasing the possibility of detecting pheasants during the survey (Klonglan 1955). Surveys were not run if there was fog or rain. For each survey, each observer drove slowly (~24 km/h) for 48 km along primarily unpaved roads. Observers recorded the number of pheasants (either sex) that were sighted on either side of the road during the survey. Pheasants seen at any distance from the road were counted, although distance from the road was not recorded. Chicks in broods were excluded in count totals for the purpose of this analysis. Individual surveys were completed by a single observer, although up to 170 observers helped with surveys in any given year. Survey counts were used as an index for pheasant abundance.

Aggregating pheasant survey data

We chose to aggregate the survey data at the county level because (1) coverage for many routes was inconsistent across years, (2) routes could be easily assigned to a county, (3) data at the county level still retained sufficient spatial resolution to look for patterns of resiliency, and (4) land use data were only available at the county level. To do this, each county was assigned a mean pheasant count for each year, which was the mean number of pheasants detected per route run in that county that year. Counties with only one survey conducted in a given year were assigned a mean pheasant count equal to the number of pheasants counted during that single survey. Counties with two or more surveys in a given year were assigned a mean pheasant count equal to the mean of the total number of pheasants counted during each survey in that county. Counties with no surveys in a given year were not assigned a mean pheasant count for that year.

We determined an overall mean pheasant count for each county by taking the mean count of all surveys across all years for that county. Each county was given a Pheasant Mean Count Score based on this overall mean. We chose to assign scores instead of using raw counts in order to easily group similar counties together and rank them in an intuitive manner. Counties were assigned a value from 1 to 6, with 1 being the lowest possible score and 6 being the highest possible score (Table 1).

Next, to determine pheasant population consistency, we calculated a coefficient of variation (CV) for each county in each year, starting in 1966. While the roadside survey began in 1962, we did not include the first four years in our analysis because CVs were calculated using the mean pheasant count for the year the CV was being calculated for as well as the means for the previous four years. In order for a CV to be assigned to any given county in any given year, that county had to have been assigned a mean pheasant count for four out of the five years in that period. County/year combinations not meeting this criterion were not assigned a CV. A county was considered to have a consistent pheasant population in a given year if it had a CV of 15% or less. Each county was assigned a Population Consistency Score based on the percentage of years that it had a consistent population out of all years that a CV was calculated for it. Again, we used a scoring system in place of raw data to easily rank and compare counties. Counties were assigned a value from 1 to 6, with 1 being the lowest possible score and 6 being the highest possible score (Table 1).

Landscape Effects

We used R (Version 3.2; R Development Core Team 2008) to test for linear relationships between yearly CVs and different land use types. Using simple linear regression we tested for relationships ($\alpha = 0.05$) between CV and the percentage of land in each county each year that was enrolled in the Conservation Reserve Program (CRP), had been planted with corn, had been planted with soybeans, and had been planted with either corn or soybeans. We obtained land use data from the National Agricultural Statistics Service in the form of the number of acres in each county that were either planted in one or both of our row crops or enrolled in CRP. County/year combinations were only included in this part of our analysis if acreage data was available for that county in that year. Not all counties had data available during every year. The first year CRP acreage data was available was 1986, and our earliest row crop data is from 1966. CRP allows landowners to convert farmland to grassland, which has been correlated with an increase in pheasant abundance (Haroldson et al. 2006). Conversely, increases in row crop agriculture have been correlated with decreases in pheasant abundance (Taylor et al. 1978).

Pheasant Resiliency Score

We next combined information about mean pheasant counts and population consistency to characterize each county with respect to resiliency. Each county was assigned a Pheasant Resiliency Score (PRS) by summing its two other scores: Pheasant Mean Count Score and Population Consistency Score. The range of possible Pheasant Resiliency Scores ranged from 2 (minimum values for both prior scores) to 12 (maximum values for both prior scores). Low PRSs signify counties that have neither robust pheasant populations nor pheasant populations that are consistent from year to year. High PRSs signify counties that have healthy pheasant populations that are relatively consistent from year to year. Middle value PRSs signify intermediate population sizes and consistency or opposing extremes (such as low consistency but large population size). In addition to looking at mean count, consistency, and resiliency scores across the entire dataset (1962-2015), we also scored the time periods before (1962-1986) and after (1985-2015) the CRP was introduced.

Results

A total of 224 routes were surveyed across all 99 counties in Iowa from 1962 to 2015. The number of years each route was surveyed varied from 7 to 54, with 54 years being the length of the study period. The mean pheasant count across all routes was 8.94 but ranged from 0.50 on two routes (Decatur and Madison counties) to 25.80 on a route in Poweshiek County. During any given year, anywhere from 0 to 4 routes were surveyed in each county. When routes were collapsed to counties (Appendix A), each county was surveyed for anywhere from 31 (Chickasaw County) to 54 (25 counties) years. Mean pheasant counts across all counties ranged from 1.68 in Monroe County to 23.84 in Poweshiek County (Figure 1). Mean pheasant counts were greater prior to the introduction of CRP (11.77, SD = 6.20) compared to post implementation (6.08, SD = 2.64; paired $t = 10.76$, $df = 98$, $p < 0.001$; Appendix B).

Consistency within counties was generally low across the survey period, but ranged from 0.00% of all years surveyed in 46 counties to 12.00% of all years surveyed in Fayette and Hancock counties (Figure 2). The number of counties that had consistent populations within years varied from 0.00% of all counties surveyed in four different years to 7.53% of all counties surveyed in 1974. The general trend was more consistent years in the 1960s and 1970s, with a dip in the 1980s and early 1990s. Consistency improved again in the 1990s and continued through the rest of the study period, although not to the levels of the earlier years. Consistency was generally low both before and after the introduction of CRP, although there were more individual counties with high consistency prior to the introduction of CRP (Appendix B). All land use covariates affected the consistency of pheasant populations. The coefficient of variation increased with an increase in CRP land (β_{CRP} = 0.526, SE = 0.135, P < 0.001). An increase in percent coverage of both corn (β_{Corn} = -0.236, SE = 0.035, P <0.001) and soybeans (β_{Soy} = -0.253, SE = 0.041, P < 0.001) decreased CVs. Combining both corn and soybeans (β_{Total} = -0.095, SE = 0.018, P < 0.001) had a similar effect, although it was weaker.

Resiliency scores were generally low, with only a few counties receiving high scores (Figure 3). Ten counties received the lowest possible score (2). The highest resiliency scores received were 9 (Adair and Fayette counties) and 10 (Hancock county). No counties received an 11 or 12, the highest possible score. Across Iowa, resiliency was higher prior to 1986, when land began to be placed into CRP (Appendix B).

Discussion

Our objective was to identify Iowa counties that support resilient (abundant and consistent) populations of ring-necked pheasants as indicated by roadside counts. There was no consistent pattern of high resiliency across the state but there was a pattern of slightly greater resiliency in the counties bordering the eastern edge of the Loess Hills, and in those scattered across the eastern Iowa Plains region. A pocket of relatively high resilience also exists in the northeastern part of the state. These higher resiliency scores were largely driven by higher consistency scores, except in the strip along eastern edge of the Loess Hills, which had higher mean counts than other surrounding counties.

Mean pheasant counts followed the general trend of being greatest in a diagonal band running from the northwestern part of the state to the southeast corner. This was similar to the IDNR’s yearly roadside survey reports (Bogenschutz and McInroy 2017). Consistency scores were highest in the eastern part of the state. We believe that these scores are driven by the low pheasant population numbers in this area. Southeast Iowa has poor pheasant habitat, and was the last part of the state to have a hunting season (Farris et al. 1977). In areas with low populations, year to year consistency is generally higher because there is less room for variability, even in poor weather years. It is also important to understand that consistency was low in general, with the most consistent county being “consistent” in only 12% of all years included in the study. This general lack of year-to-year consistency is in line with the historically variable trends in pheasant populations discussed previously.

All of our land use variables affected ring-necked pheasant population consistency in Iowa. Our agricultural variables (percent land cover in corn, soybean, and both corn and soybeans) all had a positive relationship with population consistency. Consistency decreased with increased amounts of CRP. A logical explanation is that these variables have the opposite effect, because population size and yearly survival are known to increase with more grass cover and decrease in areas dominated by agriculture (Perkins et al. 1997, Clark and Bogenschutz 1999, Riley and Schulz 2001, Haroldson et al. 2006). However, increases in overall survival and abundance do not necessarily equate to reduced year-to-year variation. Although on an overall downward trend, Iowa pheasant populations have historically been variable from year to year (Bogenschutz and McInroy 2017). Year-to-year pheasant mortality can be negatively impacted by severe weather (Perkins et al. 1997, Clark and Bogenschutz 1999, Gabbert et al 1999, Randel 2009). During years where pheasant mortality is high due to severe weather, it makes intuitive sense that annual variation in abundance would be greater in populations that go from a high abundance to a low abundance (i.e., in CRP landscapes) compared to a population that drops from a low abundance to a slightly lower abundance (i.e., in row crop dominated landscapes).

Ultimately, higher pheasant abundance and greater amounts of habitat do not always indicate less annual variation and often actually leads to greater variation.

We were surprised to find a reduction in resiliency after the implementation of CRP, since CRP has been correlated with increased pheasant abundance (Haroldson et al. 2006). However, as previously mentioned, pheasant numbers in Iowa are on a historical downward trend. It is possible that CRP has had a positive impact on pheasant abundance (Nusser et al. 2004), but does not outweigh the overall negative impact of the large-scale conversion of Iowa's land to agriculture (Hiller et al. 2015). This could be addressed by comparing the rate of decline in pheasant abundance in counties with large amounts of CRP to counties with little or no CRP.

The Iowa roadside count for ring-necked pheasants is a long-term dataset that can offer insight into the spatial and temporal patterns in abundance statewide. These findings can help inform decisions about which counties in Iowa should receive the greatest benefit from increased habitat management efforts. Maximizing the benefits of restoration efforts is increasingly important at a time when conservation dollars are scarce. Our study indicates that pheasant populations in Adair, Hancock, and Fayette counties are the most resilient, but not necessarily the most abundant. It appeared that high consistency scores drove the high resiliency scores for these counties, which may suggest that our consistency scores had too much weight in the analysis. This highlights the fact that there are two factors that drive resiliency, and knowing which factor is driving resiliency in that area could be important when making management decisions for that county. Focusing on improving existing habitat in high consistency counties may allow them to support more abundant populations, while focusing on restoring and creating additional habitat in high abundance counties may help protect those populations in years of harsh weather.

It is important to acknowledge that our analysis and observations were made within the context of roadside surveys and their limitations. Roadside surveys are used as indices, and thus are not direct counts of abundance (Rosenstock et al. 2002). Roadside surveys were standardized for a number of species in Iowa in 1963 (Klonglan 1962) and their validity has been tested by a number of subsequent studies (Kline 1965; Scwartz 1973, 1974, 1975; Wooley et al. 1978; Suchy et al. 1991). These studies agree that this type of survey is the best current practice for statewide monitoring of populations, but acknowledge that there are limitations. Suchy et al. (1991) found that mean number of pheasants counted explained 70% of year to year variation in pheasant harvest, which they used as an indicator of population size. It is reasonable to believe that the variation in the roadside survey method (Fisher et al. 1947) may have interfered with our own measures of variation and caused our measurements to be greater (or smaller) in any given year. Future studies using roadside surveys should account for this variation when calculating their own measure of variation. An analysis done in Washington found that roadside brood counts had predictive capability only at a broad scale (Rice 2003). While our study only included adult pheasants, the survey methods were similar in both studies. Our study was statewide and had at least one survey completed in each county, which we feel believe satisfies the broad-scale requirement.

Acknowledgements

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Tables

Table 1. Scoring categories for the mean count of ring-necked pheasants per county and percentage of consistent years throughout the duration of the Iowa roadside pheasant survey (1962-2015). Scores range from 1 (lowest) to 6 (highest).

Score	Mean Birds/County	Consistent Years (%)
1	0.00 - 4.00	0.00 - 2.00
2	4.01 - 8.00	2.01 - 4.00
3	8.01 - 12.00	4.01 - 6.00
4	12.01 - 16.00	6.01 - 8.00
5	16.01 - 20.00	8.01 - 10.00
6	20.01 - 24.00	10-01 - 12.00

Figures

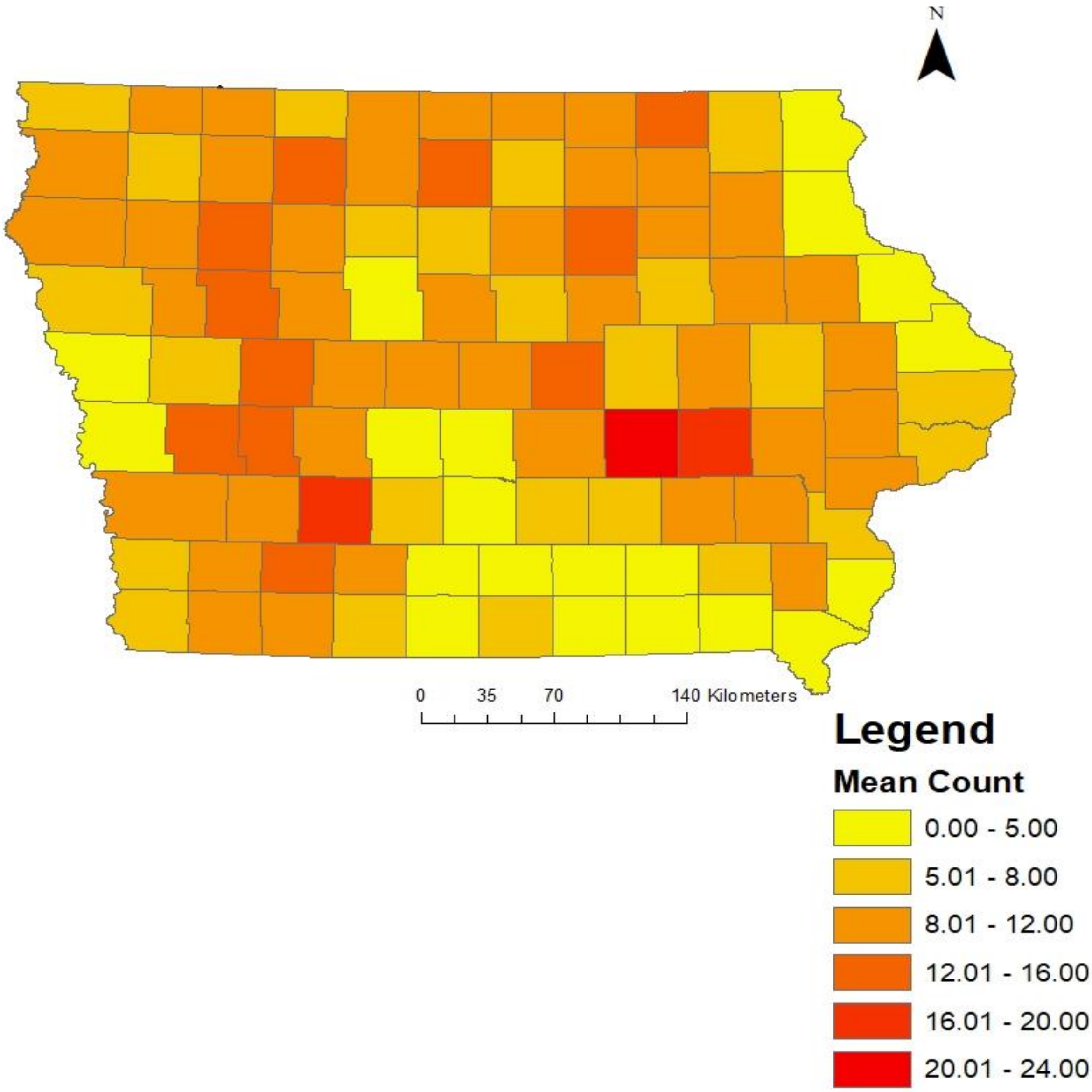

Figure 1. Map of mean ring-necked pheasant counts in each Iowa county for all years of Iowa's roadside pheasant survey (1962 - 2015).

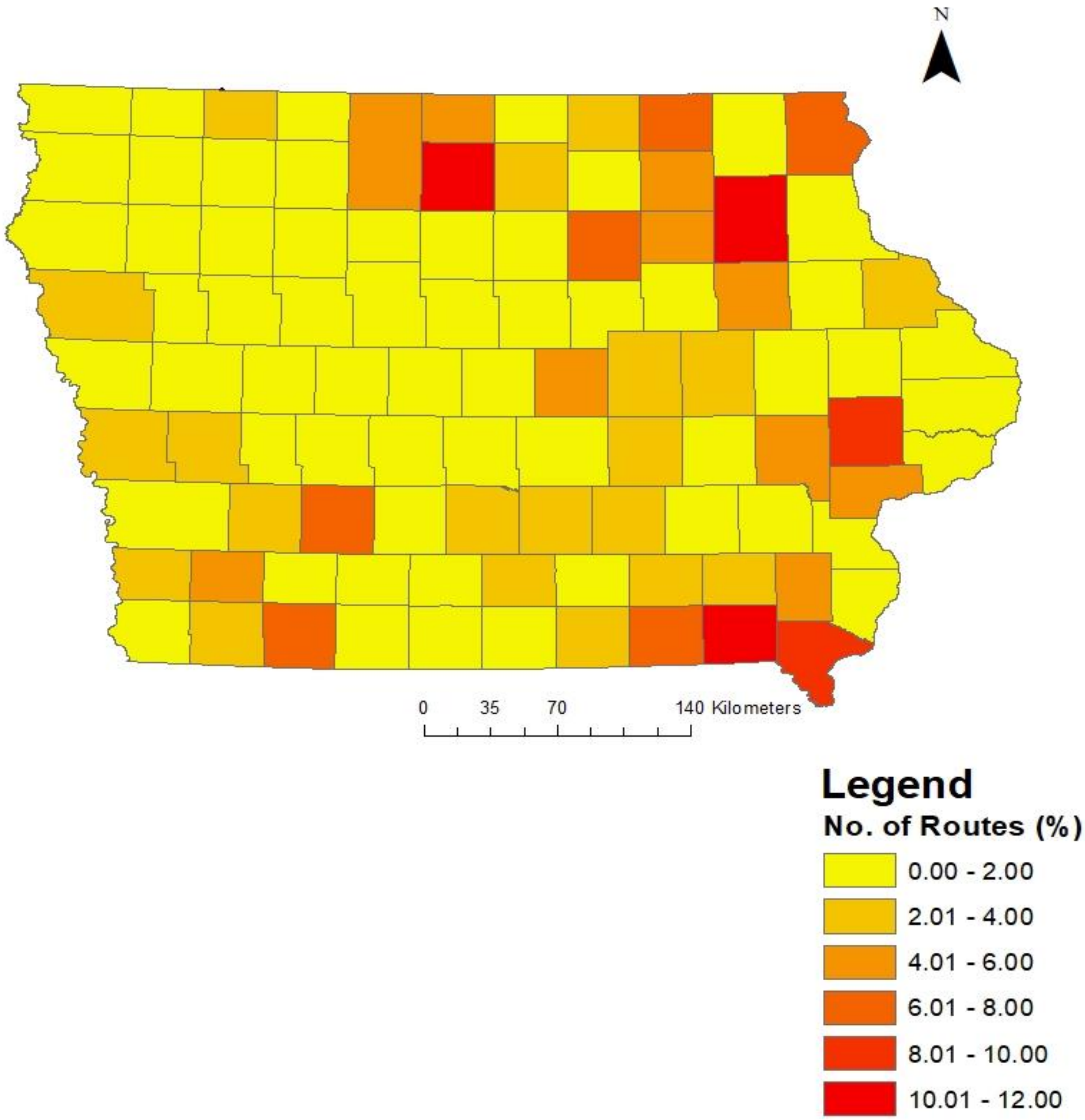

Figure 2. Map of percentage of years Iowa counties had consistent populations of ring-necked pheasant (measured with Coefficient of Variation) during Iowa's roadside pheasant survey (1962 - 2015).

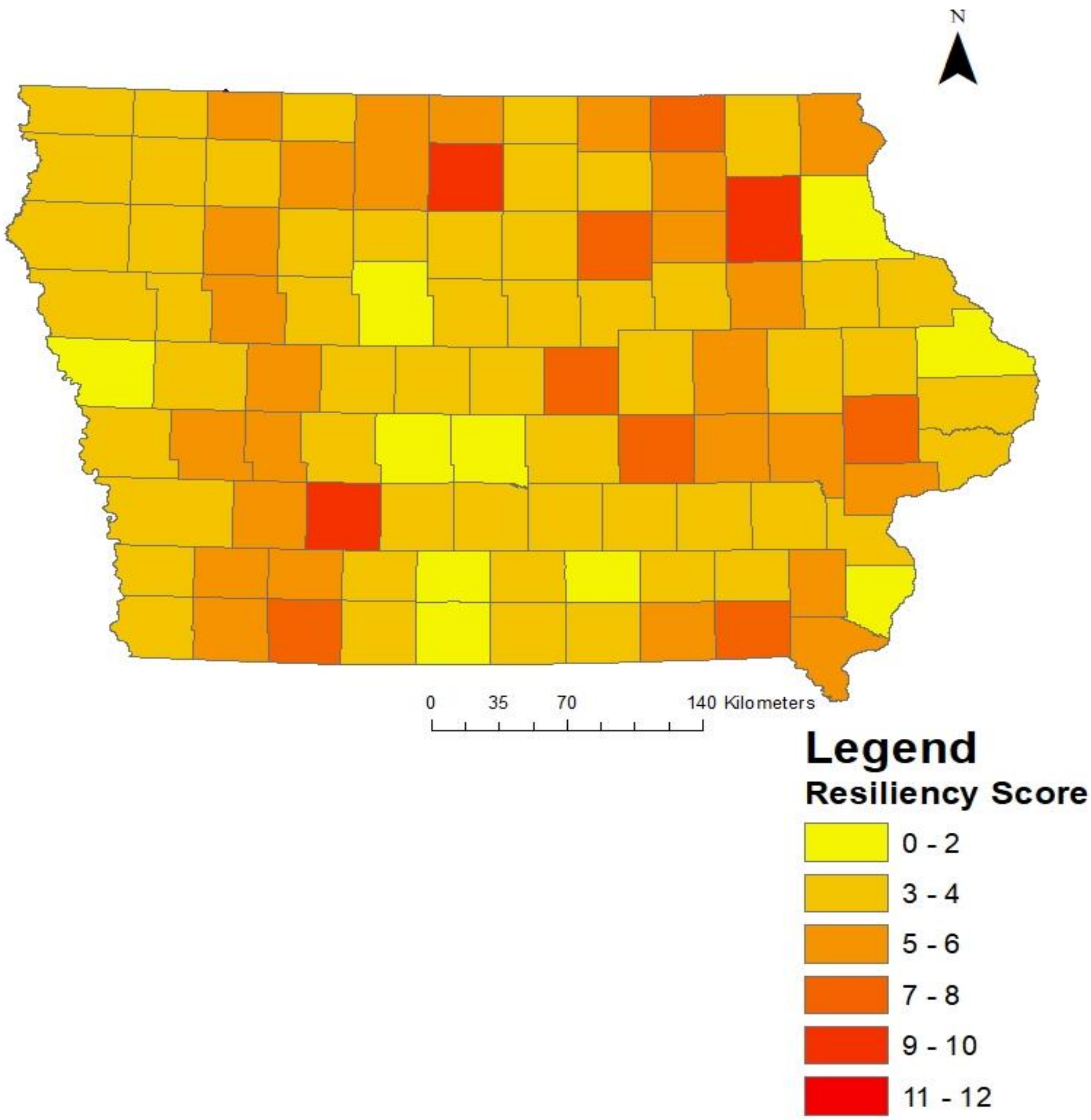

Figure 3. Map of ring-necked pheasant population resiliency scores for all counties across all years of the Iowa roadside pheasant survey (1962 – 2015).

Appendix A. Summary Statistics

Table A1. Mean ring-necked pheasant count, the percentage of total years of consistency (as measured by CV), and total acreage by county across all years of the Iowa roadside pheasant survey (1962-2015).

County	Acres	No. Consistent Years (%)	No. Birds	Consistency Score	Mean Score	Resiliency Score
Adair	364795	8.00	11.77	4	5	9
Adams	272219	0.00	8.05	1	4	5
Allamakee	421810	6.67	6.15	4	1	5
Appanoose	330048	2.17	3.27	2	1	3
Audubon	283755	0.00	4.59	1	4	5
Benton	459583	2.38	9.51	2	3	5
Black Hawk	366277	0.00	8.40	1	2	3
Boone	366825	0.00	9.86	1	3	4
Bremer	280984	6.00	12.45	3	3	6
Buchanan	366611	4.08	8.26	3	3	6
Buena Vista	371389	0.00	6.63	1	4	5
Butler	372161	8.00	8.08	4	4	8
Calhoun	366047	0.00	2.20	1	3	4
Carroll	364765	0.00	4.36	1	4	5
Cass	361610	4.00	4.68	2	3	5
Cedar	372304	10.00	7.19	5	3	8
Cerro Gordo	367670	2.04	8.68	2	2	4
Cherokee	369389	0.00	7.80	1	3	4
Chickasaw	323546	4.17	10.11	3	3	6
Clarke	276080	0.00	11.27	1	1	2
Clay	366447	0.00	9.71	1	3	4
Clayton	508557	0.00	1.89	1	1	2
Clinton	454559	2.00	8.13	1	2	3
Crawford	457738	2.00	8.91	1	2	3
Dallas	378387	0.00	12.57	1	1	2
Davis	322814	6.52	15.67	4	1	5
Decatur	341342	0.00	9.16	1	1	2
Delaware	370421	0.00	4.61	1	3	4
Des Moines	274916	0.00	3.73	1	1	2
Dickinson	258458	2.04	7.29	2	3	5
Dubuque	394664	2.08	6.14	2	1	3
Emmet	257553	2.00	13.38	1	2	3
Fayette	467777	12.00	6.55	6	3	9
Floyd	320707	2.00	4.60	1	3	4
Franklin	372477	0.00	4.28	1	3	4
Fremont	330755	0.00	9.01	1	2	3

Table A1. Continued.

County	Acres	No. Consistent Years (%)	No. Birds	Consistency Score	Mean Score	Resiliency Score
Greene	365429	0.00	8.69	1	3	4
Grundy	320929	0.00	3.16	1	3	4
Guthrie	379351	2.00	5.63	1	3	4
Hamilton	369323	0.00	10.00	1	3	4
Hancock	366539	12.00	10.47	6	4	10
Hardin	364517	0.00	10.47	1	2	3
Harrison	448314	4.00	7.97	2	1	3
Henry	279261	4.26	12.62	3	3	6
Howard	302994	6.82	3.80	4	4	8
Humboldt	278652	0.00	8.23	1	2	3
Ida	276487	0.00	6.01	1	3	4
Iowa	375693	2.00	13.84	1	5	6
Jackson	415799	2.00	2.16	1	1	2
Jasper	468524	0.00	6.92	1	3	4
Jefferson	279443	4.00	4.56	2	2	4
Johnson	398572	6.00	16.20	3	3	6
Jones	369171	0.00	10.79	1	3	4
Keokuk	371014	2.00	13.20	1	3	4
Kossuth	623249	6.00	14.34	3	3	6
Lee	344658	8.16	9.85	5	1	6
Linn	463557	0.00	4.12	1	2	3
Louisa	267106	0.00	10.55	1	2	3
Lucas	277820	2.22	11.65	2	1	3
Lyon	376538	0.00	13.05	1	2	3
Madison	359544	0.00	7.75	1	2	3
Mahaska	366890	2.17	4.66	2	2	4
Marion	364762	2.13	11.06	2	2	4
Marshall	366589	4.35	4.71	3	4	7
Mills	281952	4.00	5.59	2	2	4
Mitchell	300386	4.00	8.94	2	3	5
Monona	447446	0.00	6.32	1	1	2
Monroe	277591	0.00	5.79	1	1	2
Montgomery	272036	4.76	5.57	3	3	6
Muscatine	287415	6.00	1.68	3	3	6
Obrien	366894	0.00	9.58	1	2	3
Osceola	255640	0.00	10.29	1	3	4
Page	342711	2.17	8.79	2	3	5
Palo Alto	364326	0.00	8.96	1	4	5
Plymouth	553512	2.00	14.22	1	3	4

Table A1. Continued.

County	Acres	No. Consistent Years (%)	No. Birds	Consistency Score	Mean Score	Resiliency Score
Pocahontas	370254	2.00	12.12	1	3	4
Polk	378569	0.00	11.52	1	1	2
Pottawattamie	613954	0.00	7.64	1	3	4
Poweshiek	374998	4.00	6.07	2	6	8
Ringgold	344562	2.00	3.75	1	2	3
Sac	370114	0.00	7.56	1	4	5
Scott	299839	0.00	10.49	1	2	3
Shelby	378441	4.00	11.56	2	4	6
Sioux	492500	0.00	11.19	1	3	4
Story	366866	2.00	6.10	1	3	4
Tama	461699	4.00	18.25	2	2	4
Taylor	342082	6.12	7.00	4	3	7
Union	272449	0.00	8.59	1	3	4
Van Buren	313972	10.20	10.40	6	1	7
Wapello	278797	2.04	11.96	2	1	3
Warren	366376	2.08	4.94	2	1	3
Washington	365003	0.00	8.32	1	3	4
Wayne	337169	0.00	23.84	1	2	3
Webster	459706	0.00	7.38	1	1	2
Winnebago	256789	6.00	6.88	3	3	6
Winneshiek	441287	0.00	11.08	1	2	3
Woodbury	562187	2.08	9.08	2	2	4
Worth	257004	0.00	9.26	1	3	4
Wright	372188	0.00	6.38	1	2	3

Appendix B. Score Maps

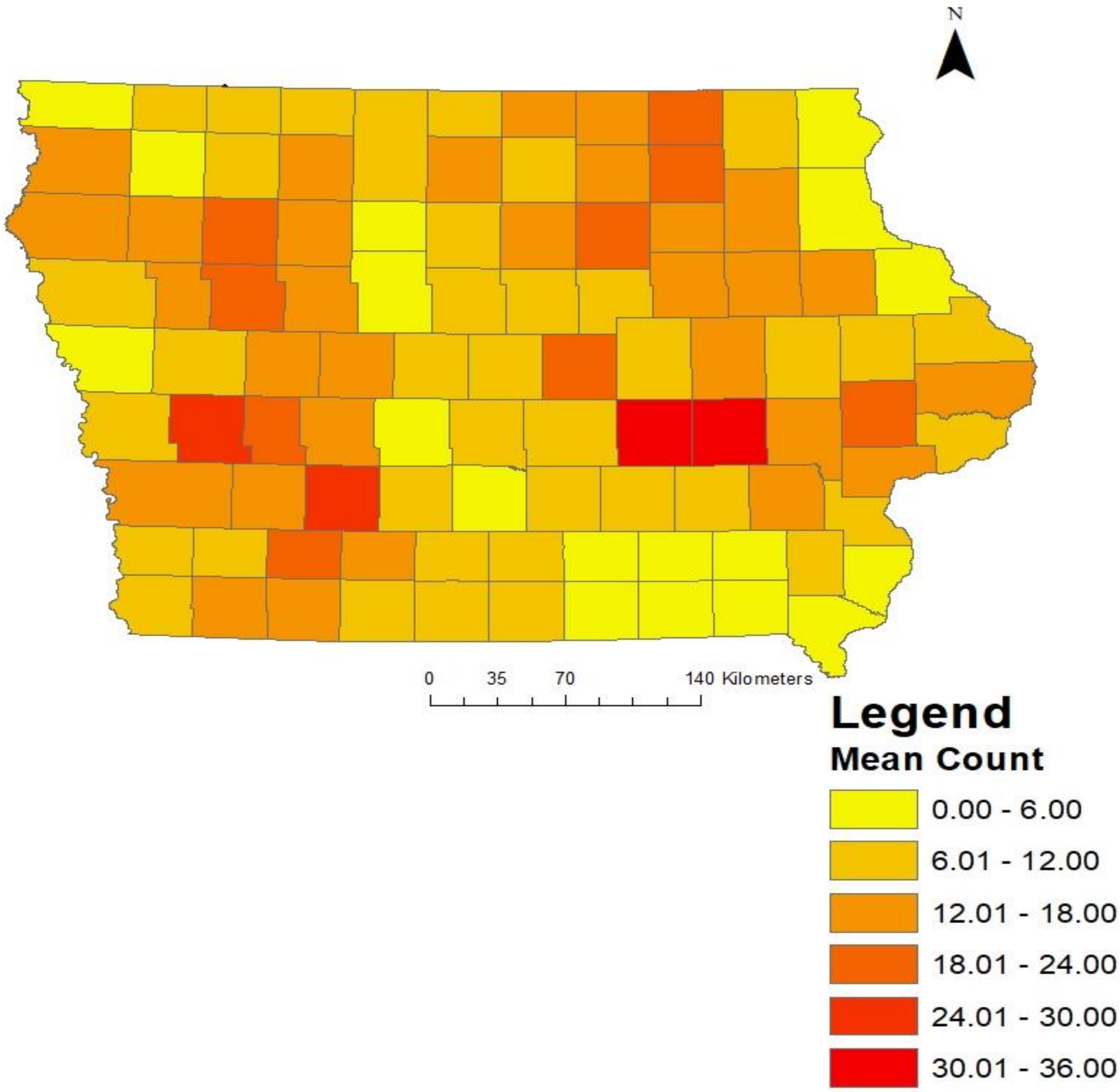

Figure B1. Map of mean ring-necked pheasant count in each Iowa county across all years of Iowa's roadside pheasant survey prior to the introduction of the Conservation Reserve Program (1966-1986).

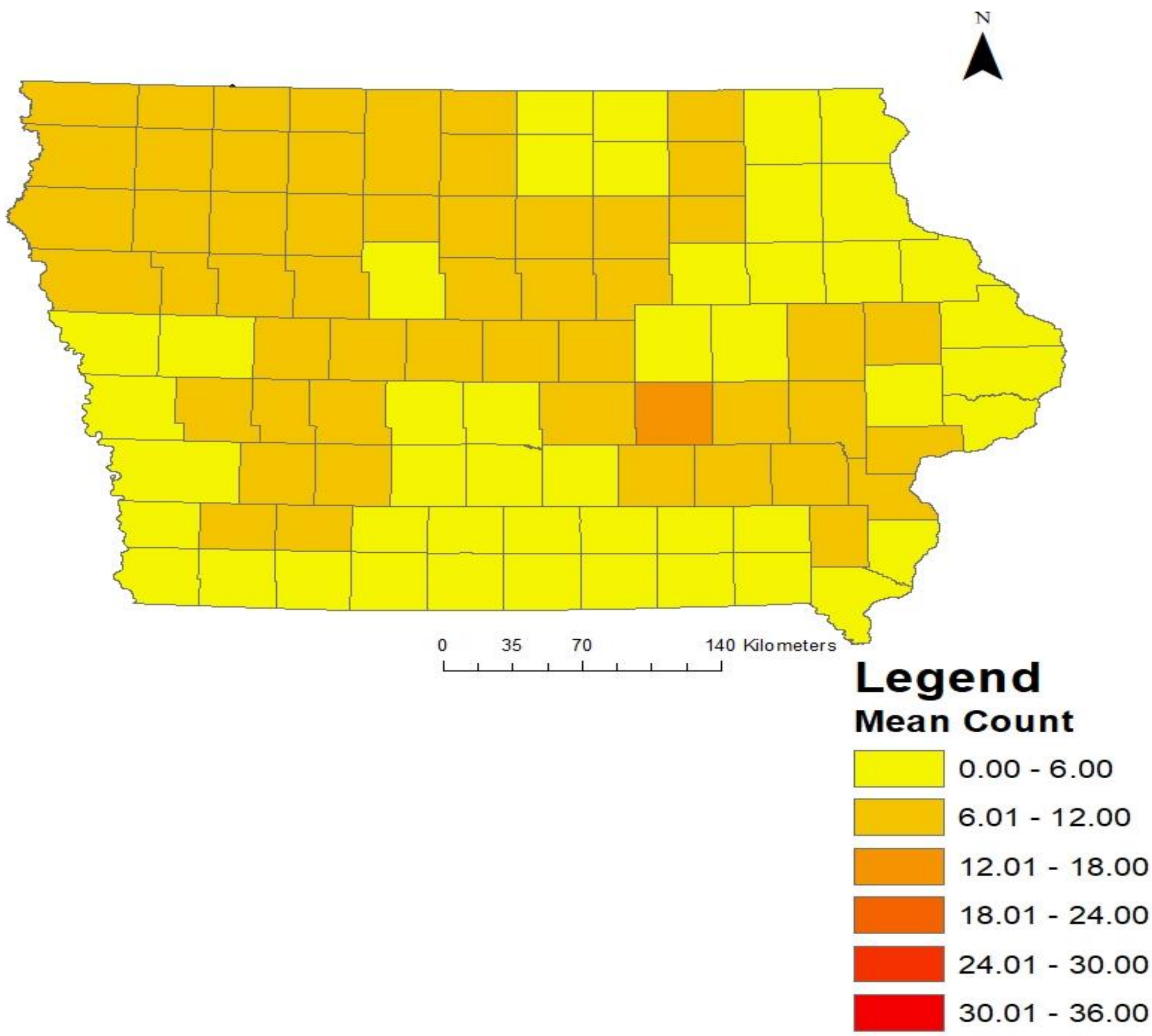

Figure B2. Map of mean ring-necked pheasant count in each Iowa county across all years of Iowa's roadside pheasant survey after the introduction of the Conservation Reserve Program (1986-2015).

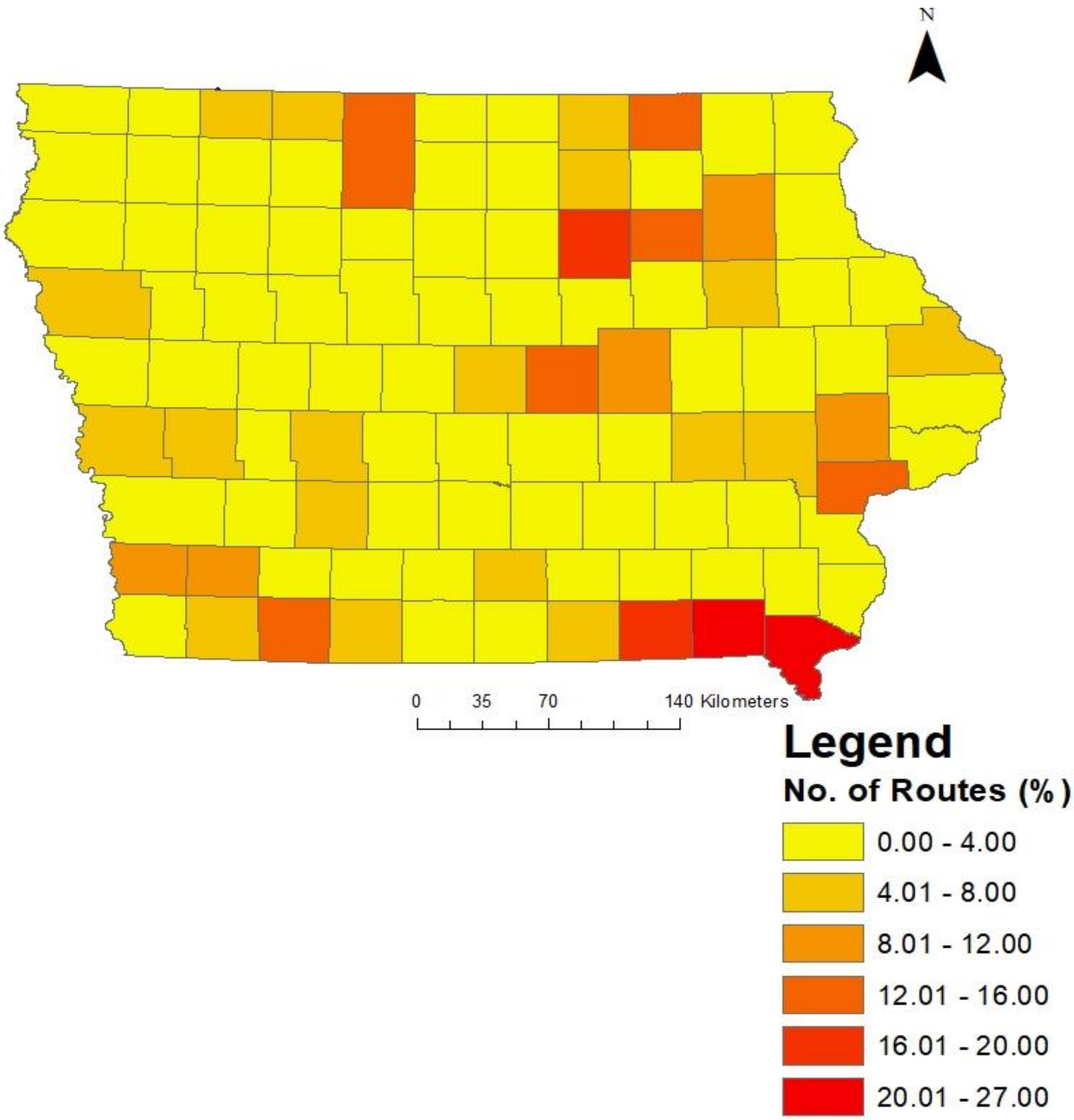

Figure B3. Map of percentage of years Iowa counties had consistent populations of ring-necked pheasant (measured with Coefficient of Variation) during Iowa's roadside pheasant survey, prior to the introduction of the Conservation Reserve Program (1966-1986).

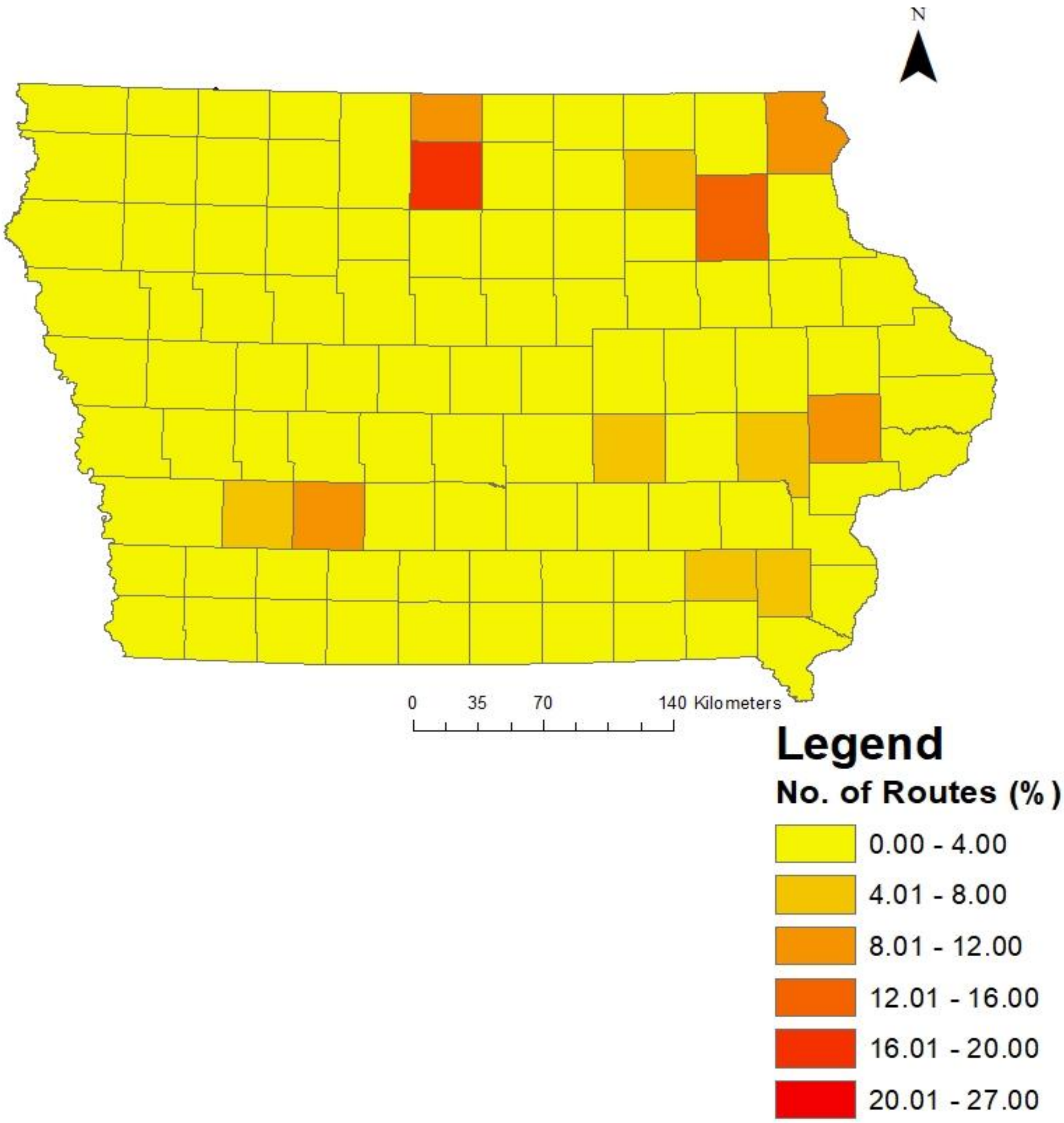

Figure B4. Map of percentage of years Iowa counties had consistent populations of ring-necked pheasant (measured with Coefficient of Variation) during Iowa's roadside pheasant survey, after the introduction of the Conservation Reserve Program (1986-2015).

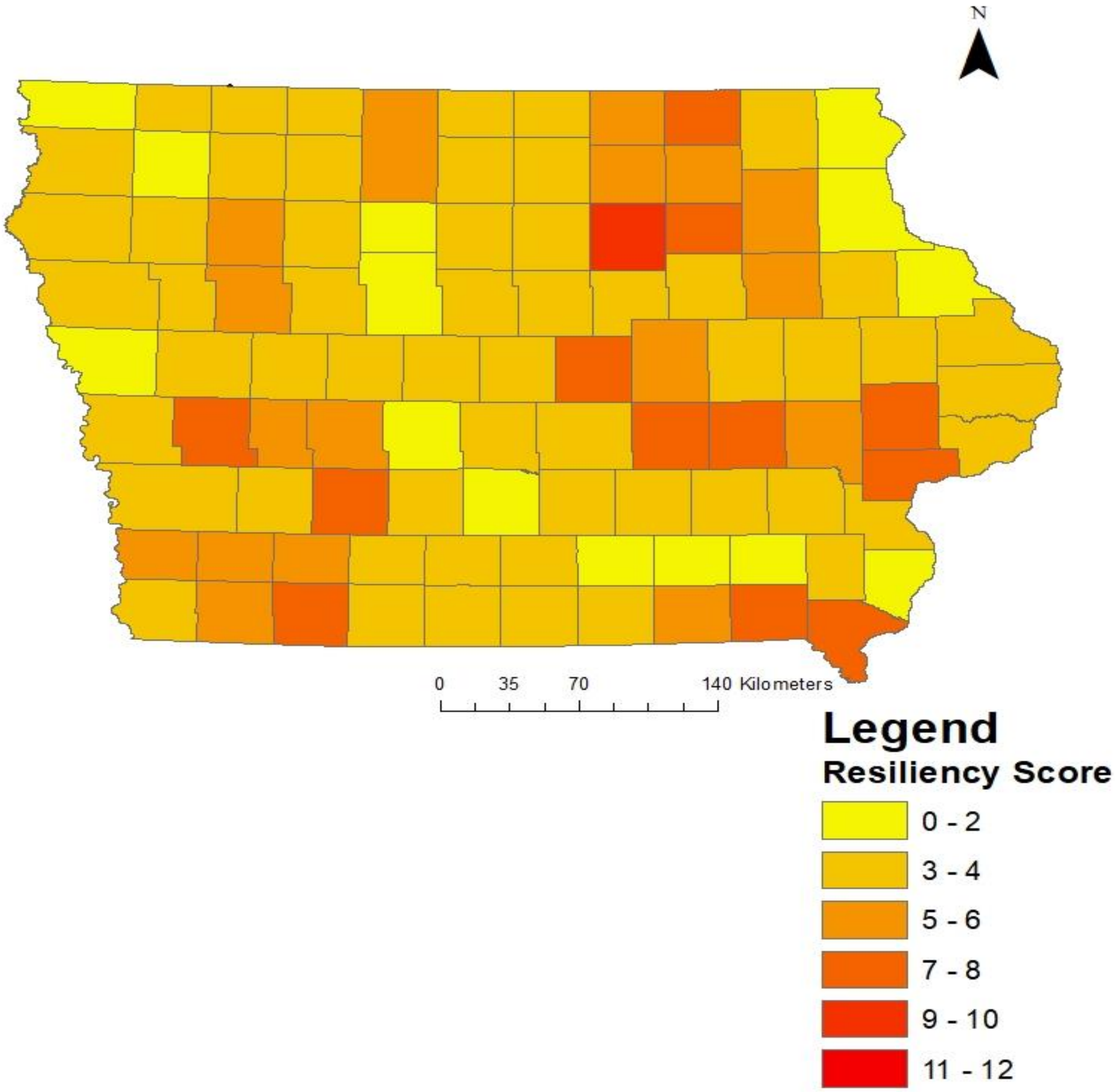

Figure B5. Map of ring-necked pheasant population resiliency scores for all counties across all years of the Iowa roadside pheasant survey prior to the introduction of the Conservation Reserve program (1966-1986).

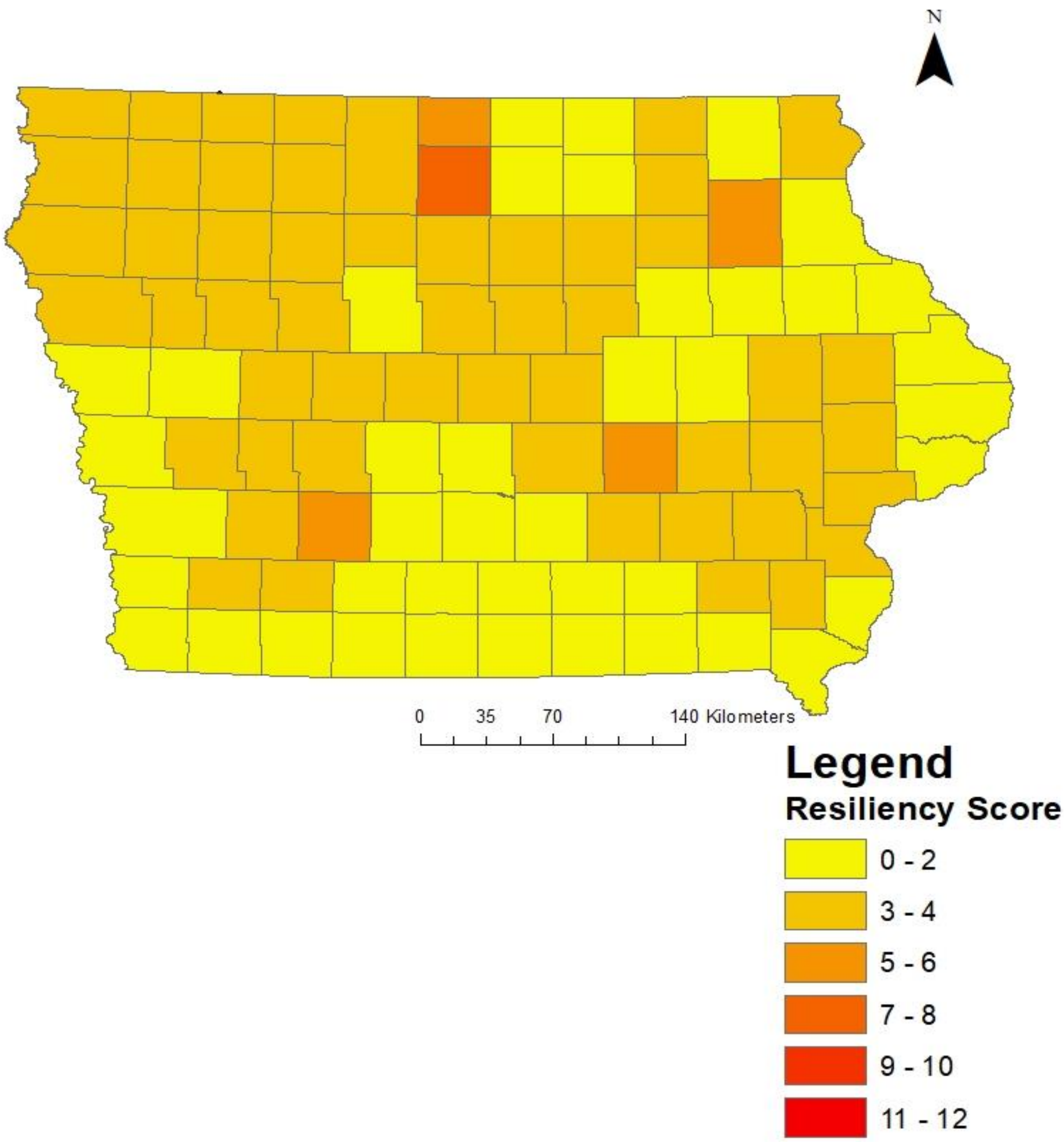

Figure B6. Map of ring-necked pheasant population resiliency scores for all counties across all years of the Iowa roadside pheasant survey after the introduction of the Conservation Reserve program (1986-2015).

CHAPTER 5. GENERAL CONCLUSIONS

Summary

Our study addressed a number of research questions related to Ring-necked Pheasant (*Phasianus colchicus*) management in Iowa. Each chapter outlined a unique question that has either not been addressed or was only a secondary question in previous literature. Maintaining and increasing future populations of Iowa pheasants will be a challenging task, however we believe our results will help inform management decisions and make that task more achievable.

We altered the protocol for a prevailing method of conducting crowing surveys (Luukkonen et al. 1997) by adding the use of a call playback device and found no difference in pheasant detectability. While this does not necessarily improve upon an existing survey method, we provide evidence to suggest that the current survey protocol continue to be the best practices, at least in landscapes similar to central Iowa's wind farms. In addition, adding these devices to a survey does not add much cost (in both dollars and effort) and our results suggest that their use in pheasant crowing surveys would not be a detriment to the survey. With the demonstrated effectiveness of call playback during other upland game bird surveys (Stirling and Bendell 1966, Schroeder and Boag 1989, Evans et al. 2007, Kasprzykowski and Golawski 2009, Jakob et al. 2010), we believe it is reasonable that call playback could be effective for pheasants under different habitat and pheasant density conditions, such as in areas of lower pheasant density (where imitating one pheasant greatly increases the density of calls).

Iowa is a leader in wind energy development across the United States, ranking first in wind energy dependency, second in megawatts generated, and third in total number of wind turbines among all states (American Wind Energy Association 2016). Concerns about the effect of this "green" energy production on pheasants have been previously expressed (Kunz et al. 2005, Kunz et al. 2007, Harr and Vanoy 2009). Our results suggest that male Ring-necked

Pheasants are virtually unaffected by Iowa wind turbines. We observed statistically significant (but we argue not biologically significant) avoidance of wind turbines by pheasants on our study farms. Our study did not fully address avoidance at very small distances (< 400 m), however the placement of Iowa wind turbines is almost exclusively within agricultural fields. We argue that this prevents pheasants from regularly being with this short distance, as they spend the majority of their time in grassland habitats.

Finally, we analyzed a long term dataset of pheasant roadside survey data collected by the Iowa Department of Natural Resources. We used this information to identify counties in Iowa that supported resilient (abundant and consistent) populations of pheasants. With the declining funds for wildlife conservation efforts, it is becoming increasingly important to focus efforts where they will be the most effective. We were able to identify counties with high resiliency, however, it is important to note that we did not have a single county receive the highest possible score, suggesting there is room for improvement across the entire state.

We hope that the results of our studies can be used to improve management and monitoring efforts for Ring-necked Pheasants, both in Iowa and across the United States. We believe our results show an optimistic future for pheasants in Iowa. We addressed concerns surrounding an energy production method that is generally considered to be good for the environment but raises questions about wildlife impacts and highlighted counties in Iowa that are hotspots for pheasant production and retention. While we did not find a definitive reason for using call playback during pheasant crowing surveys, we also did not find cause to dismiss it outright. Continuing to provide sufficient habitat to sustain viable populations of Ring-necked Pheasants will undoubtedly be a challenge. We hope that our results can make that goal more attainable.

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