

University of Nebraska - Lincoln

**DigitalCommons@University of Nebraska - Lincoln**

---

Environmental Studies Undergraduate Student  
Theses

Environmental Studies Program

---

2020

## The Changing Habitat And Decline Of Ring-Necked Pheasant Populations In Otoe County, Nebraska

Jacob T. Herman

Follow this and additional works at: <https://digitalcommons.unl.edu/envstudtheses>



Part of the [Environmental Education Commons](#), [Natural Resources and Conservation Commons](#), and the [Sustainability Commons](#)

---

This Article is brought to you for free and open access by the Environmental Studies Program at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Environmental Studies Undergraduate Student Theses by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

THE CHANGING HABITAT AND DECLINE OF *RING-NECKED PHEASANT*  
POPULATIONS IN OTOE COUNTY, NEBRASKA

by

Jacob T. Herman

AN UNDERGRADUATE THESIS

Presented to the Faculty of  
The Environmental Studies Program at the University of Nebraska-Lincoln  
In Partial Fulfillment of Requirements  
For the Degree of Bachelor of Science

Major: Environmental Studies  
With the Emphasis of: Natural Resources  
Minor: Fisheries & Wildlife Management

Under the Supervision of Dr. David Wedin & Dr. Christine Haney.

Lincoln, Nebraska

May, 2020

## THE CHANGING HABITAT AND DECLINE OF *RING-NECKED PHEASANT* POPULATIONS IN OTOE COUNTY, NEBRASKA

### Abstract

Since the early 20th century, wildlife conservation in United States has walked a fine line of growth and decline. The implementation of the *Ring-Necked Pheasant* in Nebraska has brought a wealth of tradition and revenue to the state across multiple generations. This thesis analyzes how habitat changes in Otoe County, Nebraska have affected the *Ring-Necked Pheasant* population, and what programs are in place to counteract the issue. To answer this question, the study compared five different aerial photos taken from Google Earth Pro and the county archives located in Hardin Hall at the University of Nebraska- Lincoln. The results of the study showed a significant change in critical habitat across various demographics of landscape such as native prairie grass, row-crop farmland, and forestation. Results also revealed that although the pheasant population has not increased, it has maintained a sustainable level above complete eradication due to corrective private land use alternatives. From a conservation perspective this study emphasizes the need for practical private land usages and the critical impact of habitat loss on game species.

### Introduction

This study correlates the effect of habitat changes within Otoe County, and Southeast Nebraska, and the decline of the *Ring-Necked Pheasant* (*Phasianus colchicus*) population. There are many different variables that were assessed during this study. Starting with looking at the 100-year history of wildlife conservation and the production of agriculture, this study will outline the cause and effect of various Presidential Administrations, major natural epidemics, and the implementation and importance of conservation. Highlighting the introduction of pheasants in Nebraska illustrates how the *Ring-Necked Pheasant* became established within the state, and its importance. The biology of the *Ring-Necked Pheasant* gives a brief insight of the anatomy of the bird, its preferred habitat, and sustainable food sources. Looking at the significance of herbicidal use and the effects on plant genetics within agricultural production, shows why successful crop growth over the elimination of insects and weedy cover, can be detrimental towards pheasant survival. Analysis of data related to both predation and harvesting, highlights how predators (and

associated predator management) contribute to the mortality rate, and indicate why predator management is not always the answer. Similarly, this analysis identifies both a positive and negative effect related to fall and winter hunting. The central focus of this study utilizes aerial footage of various Otoe County townships dating back to 1949 through to present day, sourced from the archives of Hardin Hall at the University of Nebraska, to distinguish such changes. Identifying the increase and decrease of row-crop land, woody edge space, and grassland cover over a significant period, highlights the need to sustain habitat for *Ring-Necked Pheasant* populations. The analysis of Conservation Reserve Program (CRP) data in Otoe County help indicate a numerical significance. Finally, this paper will include a discussion of how private landowner alternatives, precision agriculture, and non-profit programs like Pheasants Forever are leading to the development of viable populations of the *Ring-Necked Pheasant* throughout Otoe County, and the entire State of Nebraska.

Initial questions throughout this research include, why are populations of *Ring-Necked Pheasant* not increasing in Nebraska, even with programs like the Conservation Reserve Program in place and active? How impactful is upland game hunting to the economy of Nebraska?

Ensuring the preservation of the *Ring-Necked Pheasant* in Nebraska is not only an economic factor, but it has social, educational, conservational, and personal implications. The *Ring-Necked Pheasant* has replaced the American Bison as a symbol of the Great Plains and Mid-West region since the buffalos near eradication in the late 19<sup>th</sup> century. Promoting conservation of this upland game species will take effort, outreach, and passion.

## **Background: 100 Years of Conservation**

On a national scale, America's first acknowledgement and defense of the wild game birds began in 1900 when Congress passed the *Lacey Game and Wild Birds Preservation and Disposition Act*. It was the first national legislation for wildlife conservation. The Federal law enforced a halt to transportation of wild game through state borders, if harvested illegally. The Act-controlled importation of exotic species and helped increase sportsmen's clubs' efforts toward wildlife restoration and strengthened individual state game laws.

After the election of President Theodore Roosevelt in 1901, the Agriculture Department formed the *Division of Economic Ornithology and Mammalogy*. Later known to be the *Bureau of Biological Survey*, this Division formulated the *Reclamation Act of 1902* which federally funded 30 reservoir and dam projects. Although the Act was not directly related to wildlife, it created a significant impact on future wildlife populations.

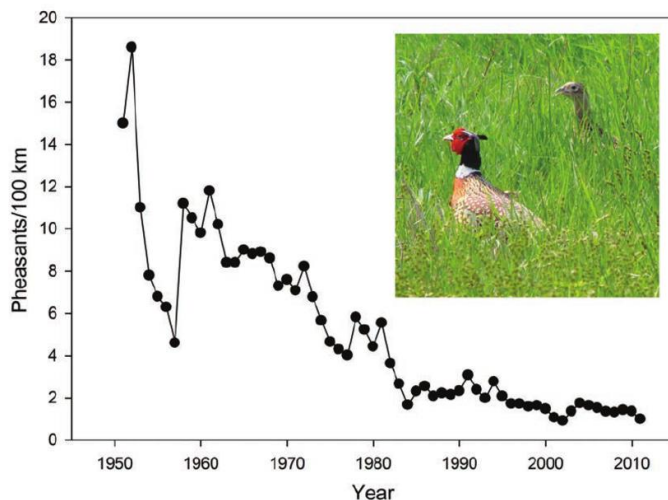
Research of wildlife management did not begin until the 1930's. Under the control of "the father of wildlife management", *Aldo Leopold*, the U.S. government offices conducted the first legitimate analysis of wildlife populations in the mid-west region. The *Stock Market Crash of 1929* and *Dust Bowl* during the early part of 1930's took a toll on wildlife populations across the country. Funding was directed away from waterfowl and gamebird programs to help strengthen predator control in order to conserve livestock. Wildlife conservation again took another hit throughout the 1950's when the federal government increased funding into military power during the Red Scare and decreased important funding for many wildlife and conservation programs.

At the turn of the 1960's, the Nixon Administration, known widely as one of the most environmentally conscious presidential campaigns, enacted several Acts and programs. Among these, most notably are: *The Clean Air Act*, *Clean Water Act*, and the *Environmental Protection Agency (EPA)*. Also, during President Nixon's time in office, he signed the *National Environmental Policy Act (NEPA)*. NEPA ultimately led to the requirement of open hearings for public input and making the decision of environmental concerns a legitimate democratic process.

After the agricultural boom of the 1970's, wildlife conservation was back on the national scene across the 1980's and 1990's, with programs more familiarly known today like *Conservation Reserve Program (CRP)*, the *Wetlands Reserve Program (WRP)*, the *Wildlife Habitat Incentive Program (WHIP)*, the *Grasslands Reserve Program (GRP)* and the *Environmental Quality Incentive Program (EQIP)*. All programs governed by the *Natural Resources Conservation Service*, funded private landowners to take specific areas of land out of agricultural production, and implement or improve conservational efforts for habitat (Brown. R.D. 2007).

### **Pheasants in Nebraska**

During the beginning stages of the 20<sup>th</sup> century, the *Ring-Necked Pheasant* was introduced to Nebraska through possible migration north from Kansas. The first intentional introduction was recorded in 1909 outside of the town of Ord, in Valley County (Silcock, W.R., and J.G. Jorgensen. 2018). The climate of Nebraska allowed for easy adaptation of the *Ring-Necked Pheasant*, and habitat association with grain-culture and open plains played a key part in permanent establishment.

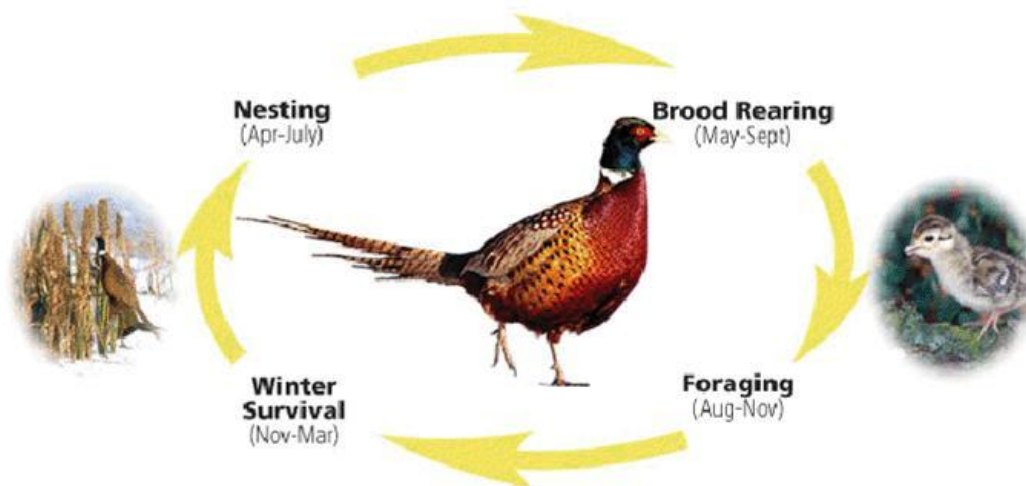


(Powell. 2015)

By the mid 1920's, the *Ring-Necked Pheasant* population was so abundant, that over 15,000 pheasants were trapped in Howard County (Northwest of Lincoln), and distributed throughout 49 other counties. By WWII, *Ring-Necked Pheasant* population reached as high 130,000 birds (Nebraska Pheasants Forever. 2020). Numbers have declined since due to agricultural intensification as shown in the figure above. (Silcock, W.R., and J.G. Jorgensen. 2018).

### **Biology of the Ring-Necked Pheasant**

The *Ring-Necked Pheasant* is a medium-sized bird with a small long head, and thin tail. They are sexually dimorphic, which means the males (Rooster) have much more color, and are larger than the female (Hen) (Delacour. 1977.) Both sexes are swift runners and strong flyers for short distances. As a polygynous species, a single male will reproduce with several females. The *Ring-Necked Pheasant* will breed seasonally from the middle of March, to early June. (Giudice, J., J. Ratti. 2001.)



(Nebraska Pheasants Forever. 2020.)

After hatch, most young will not live beyond the first fall season. The annual survival rate for adult females is 21-46%, compared to a male's 7%. Much of that difference is accounted to seasonal harvest by human influence (Giudice, J., J. Ratti. 2001.)

Commonly occupied in grassland and agricultural habitats. The *Ring-Necked Pheasant* prefers open cover such as tall grass prairie as its primary location. It can also be found in roadside ditches, hedges, marshes, and bushes. All primarily for good predation cover. (Federation of Alberta Naturalists. 2007). The *Ring-Necked Pheasant* will occupy agricultural locations as primary food source, but due to the increase of agricultural production, operations have been found devastating to adequate habitat (Whitfield. 1984.).

The primary diet of a *Ring-Necked Pheasant* includes a variety of grain, seeds, berries, and including small insects and invertebrates. Pheasants are commonly ground dwelling and will scratch for food in the undergrowth of most vegetation with their beak. High food consumption



times are generally in the early morning and evening (Dale, et al. 1956.). Common agricultural crops consumed by pheasants are corn, wheat, barley, and flax (Giuduce and Ratt. 2001.).

### **Herbicide Use**

Herbicides are used to control weed coverage in row crop fields. In a study conducted by the Natural Resources Conservation Service, through the United States Department of Agriculture researchers found an 80% decrease in adult pheasant numbers and reduced chick survival in fields unnecessarily sprayed after harvest (Kansas Department of Wildlife and Parks. 1999.). Another study done in the central high plains of Kansas conducted a study researching the correlation of wheat- stubble height and weed control on winter pheasant abundance. The study concluded that herbicide application to stubble reduced indices of winter pheasant population by > 80%. (Rodgers, R. 2002).

### **Harvest: Predation**

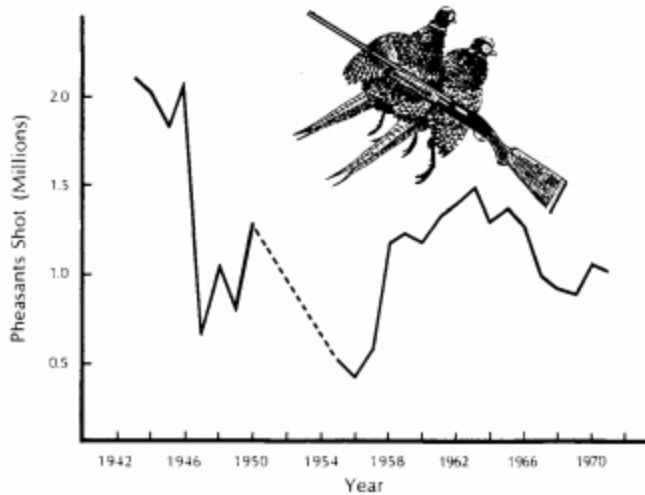
A common allegation to the decline of *Ring-Necked Pheasant* is the increased pressure of predation. There is not a single predator in Nebraska that receives more blame association than the Coyote (*Canis latrans*). However, the misunderstanding is that coyotes primarily focus their hunting on foraging for smaller rodents and rabbits, rather than an adult pheasant or nest as much as other mammalian predators. I.e. The Red Fox (*Vulpes vulpes*), Striped Skunk (*Mephitis mephitis*), and Raccoon (*Procyon lotor*). Studies have shown that with an increased range, and the territorial nature of coyotes, that this can result in a lower population of other destructive nesting predators such as the ones previously listed. Predation ultimately accounts for three quarters of unsuccessful nests, and almost all adult mortality in pheasant populations, separate from hunting (Pheasants Forever. 2020).

The history of predation removal in the United States has indicated a double-edge sword as indicated in March 2001 study through the University of Missouri. This study suggested that predator reductions can be ethically questionable, and habitat management directed to changing the effects of predators on a landscape scale is expensive (Riley & Shulz. 2001).

Experts have focused more on less-expensive methods to help improve *Ring-Necked Pheasant* populations and nesting success. Amount and arrangement of habitat that will increase nesting success through the reduced effectiveness of predators can reduce predation up to 80% (Pheasants Forever. 2020).

## **Hunting**

*Ring-Necked Pheasant* hunting in Nebraska has played a significant role in the eco-tourism throughout the state. Since the Mid-1940's the entire state has been open to hunting. As of 2019, Pheasant Hunting in Nebraska raises \$32 million a year in license sales (Little. 2020). As shown in the graph below from a publication by (Baxter & Wolfe. 1973), human harvest of the *Ring-Necked Pheasant* has indicated an obvious decline in pheasant harvest. State-wide surveys have shown that almost 60% of Rooster populations in the fall have been harvest by hunters (Trautman. 1968).



(Baxter & Wolfe. 1973)

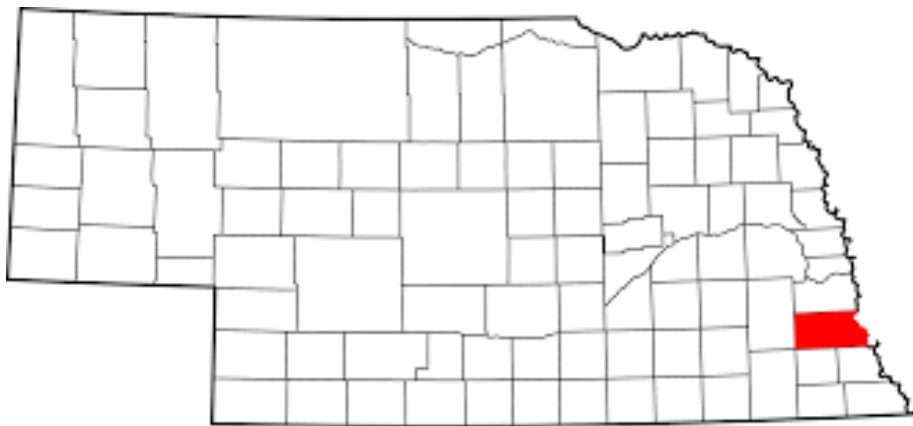
The survival of the *Ring-Necked Pheasant* male rooster in hunted populations is significantly lower compared the female hen. In recent years however, hunters could harvest 93% of pre-hunted rooster numbers without harming the overall population. That percentage however is very unusual compared to the normal range of 45-65%. States with higher harvest rates, like Nebraska on average, show around 70% rooster kill (Pheasants Forever. 2020).

## Hypothesis

There are many different confounding variables that are linked to the decline of *Ring-Necked Pheasant* populations in Nebraska, i.e. various presidential administration decisions on wildlife conservation, agricultural production- including the overuse of herbicides, and the mortality of predation and human harvest. However, this research paper hypothesizes that, the loss of significant and needed habitat to sustain appropriate population numbers, is one of the primary reason for population declines of the *Ring-Necked Pheasant* in Nebraska.

## Method

This study is comprised of a review of literatures, along with the observational analysis of several aerial photos from Google Earth Pro, Nebraska Land Survey, and the county archives within the University of Nebraska- Lincoln. The purpose of studying aerial photos was to visually document the landscape usage and changes in an area, in relation to *Ring-Necked Pheasant* population numbers over a period. The area that was chosen to be studied was a 36-square mile area located in the township of Palmyra, in Otoe County, Nebraska.



(Benbennick, David. 2006)



Figure 1- Represents the 36- square mile township observed in this study, outlined in black. Note that the town of Palmyra is located at the southern point of the township in grid square 34. Each grid square represents 1- square mile.

**FIGURE 1**

The researcher selected Otoe County related to personal familiarity with the region from a family history of farming and hunting, as well as its known decline of *Ring-Necked Pheasant* populations. Dates selected for aerial review were 1855, 1949, 1971, 2003, and Present Day. Although there is no aerial footage of the landscape from 1855, the land survey document identifies the landscape as surveyed by homesteaders within the region. The researcher chose 1949 as it that was the earliest filed aerial photo date in the archives. Use of the 1971 photo represented the agricultural boom of the 1970's when Earl Butz was the 18<sup>th</sup> United States Secretary of Agriculture. Using 2003 as another benchmark represents a twenty-year mark following the establishment of the Conservation Reserve Program (CRP) which, seeks to minimize agricultural footprint, and increase wildlife habitat. The purpose of present-day footage shows what the landscape looks like today and allows for the ability to overlay all other older photos and visualize the difference in land use and change over a period of approximately 165 years. Utilizing data from the Environmental Working Group (EWG), correlates the amount of CRP in place, and its various uses.

## Results

In the span of 165 years, since the original land survey of the studied township as represented in Figure 2, there is significant indication that prior to initial settlement, that the land primarily consisted of native grassland pasture. The green penciling as shown in Figure 2 represents to the best knowledge of the surveyor as minimal forestation.

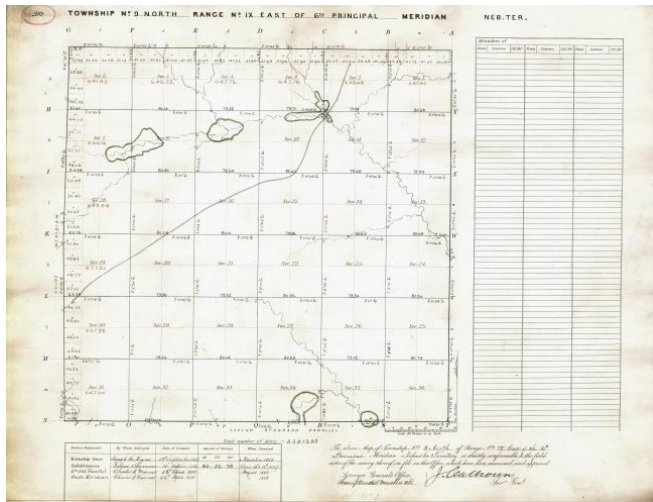


Figure 2- Otoe County,  
Nebraska Land Survey, 1855.

**FIGURE 2**

Shown in figure 3, the study observes a creek bed located in the northern part of the observed township, and center across the picture itself. The creek bed with its tree line coverage plays a great key in indicating the precise area of study. This is where the remainder of the study continues to observe topographical change. Figure 3, represented in 1949, shows, a much more domesticated landscape. Its primary use was row-crop agriculture, as indicated by the shaped and puzzled pieces of land. Aside from farming, there is still minimal forestation other than the creek bed, and grassland pasture remains abundant.

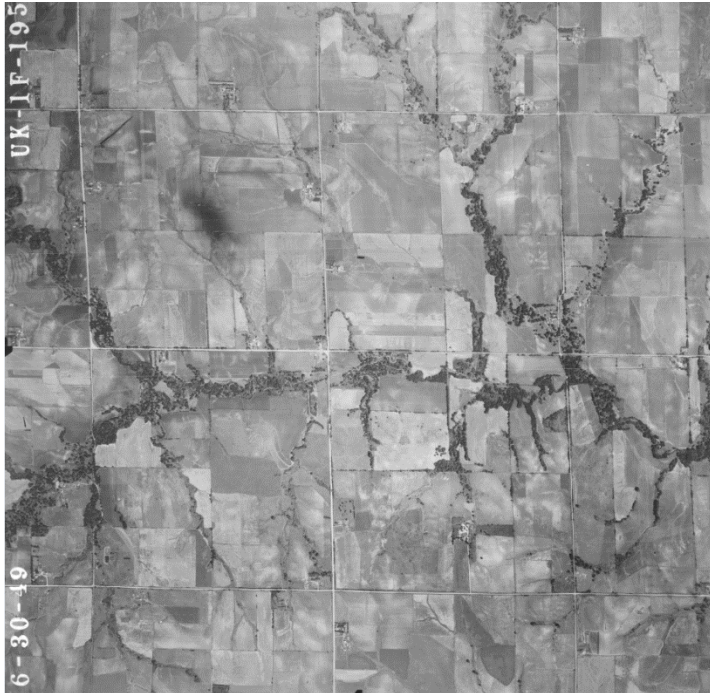


Figure 3- Otoe County Nebraska. Google Earth image, 1949. The image is approximately 3 miles wide; the square grids on the image indicate quarter sections (0.5 by 0.5 mile).

**FIGURE 3**

Relating back to a graph used earlier in this document, referred to now as Figure 4, shows the peak population of Ring-Necked Pheasant in Nebraska at the turn of the 1950's. Note that as the graph moves closer toward present day, that the population of Ring-Necked Pheasant significantly declines. This is believed due to the increase of commercialized agriculture throughout the 1970's, as represented in Figure 5.

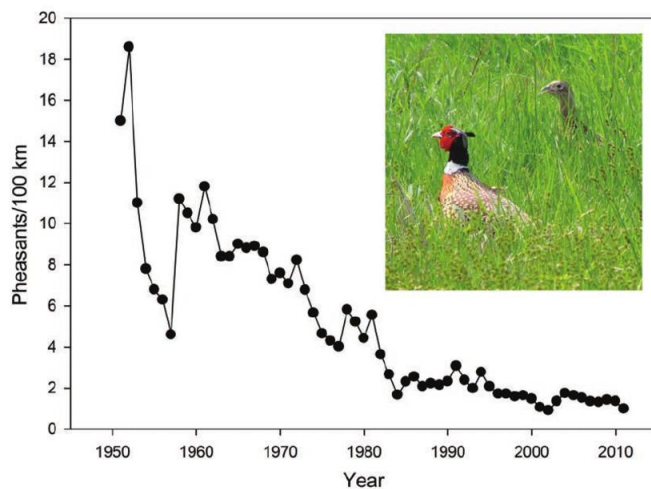


Figure 4- (Powell. 2015)

**FIGURE 4**

While studying Figure 5, represented by 1971, it is observed that row-crop agriculture continues to shape the landscape throughout the township. Although forestation remains at a minimal level, it is noted that the density of the creek bed as reduced. This is believed to be because of fence row farming and utilizing as much of the land as possible. Looking back at Figure 4, the data shows that 1970 was the beginning of the steady population decline in *Ring-Necked Pheasant*.

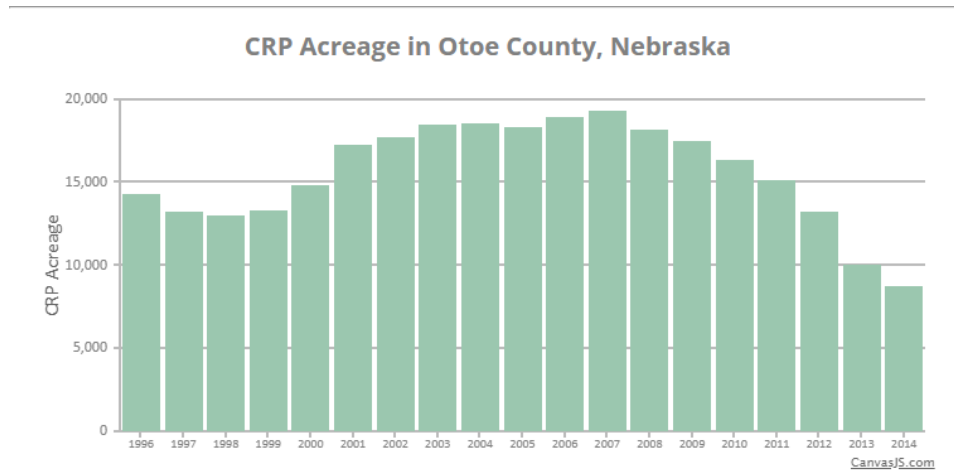


Figure 5- Otoe County, Nebraska.  
Google Earth image, 1971.

**FIGURE 5- 1971**

As the study begins to move into the new millennium, Figure 6 represents the acreage of CRP in Otoe County, Nebraska from 1996-2014. The CRP (Conservation Reserve Program) was officially established in the 1985 U.S. Farm Bill. CRP is utilized as a cost-share and rental payment program set fourth through the USDA to allow farmers and private land owners to donate at a cost, portions of their land in an attempt to establish critical habitat for various wildlife, including the *Ring-Necked Pheasant*.





**FIGURE 6**

Figure 6- (EWG. 2020)

Since the implementation of the CRP program, referring to Figure 4, it is noted that following 1980, the *Ring-Necked Pheasant* population, though at its lowest point, neither increases nor decreases. Instead, it continues to maintain a steady population. As the study observes Figure 7, represented by 2003. The figure shows that there is a significant change in reduction of row-crop agriculture, and more implementation of native grassland pasture. It is also noted that although the forestation of the creek bed continues to decline, that there is now a pond put in place to the northeast of the photo. Whether the purpose of that pond is used for irrigation, or possibly a wetland reserve is unknown.

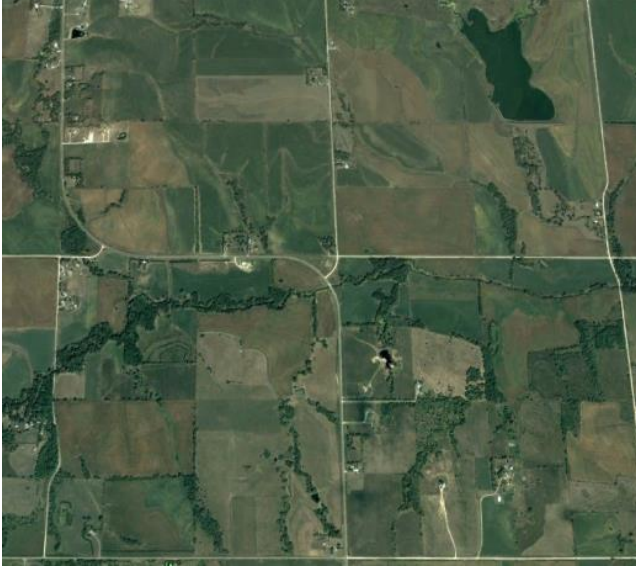


Figure 7- Otoe County, Nebraska.  
Google Earth image, 2003.

**FIGURE 7**

In the final image, the study observes Figure 8, the most current aerial photo from Google Earth Pro. Although the photo is expanded larger than the previous images. It still indicates the original creek bed. Along with the creek bed, it is noted that there is a significant increase in urbanization and commercial development.

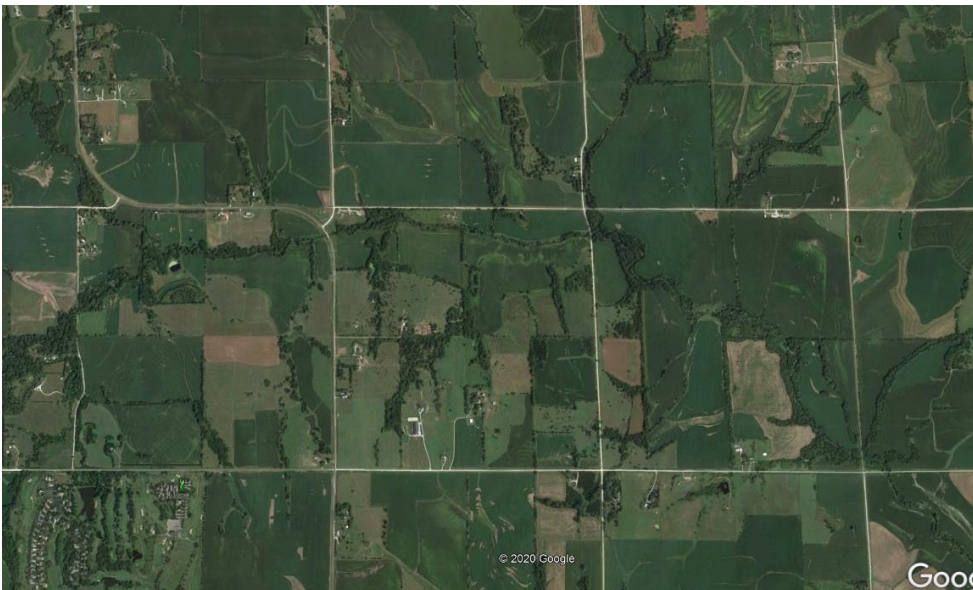
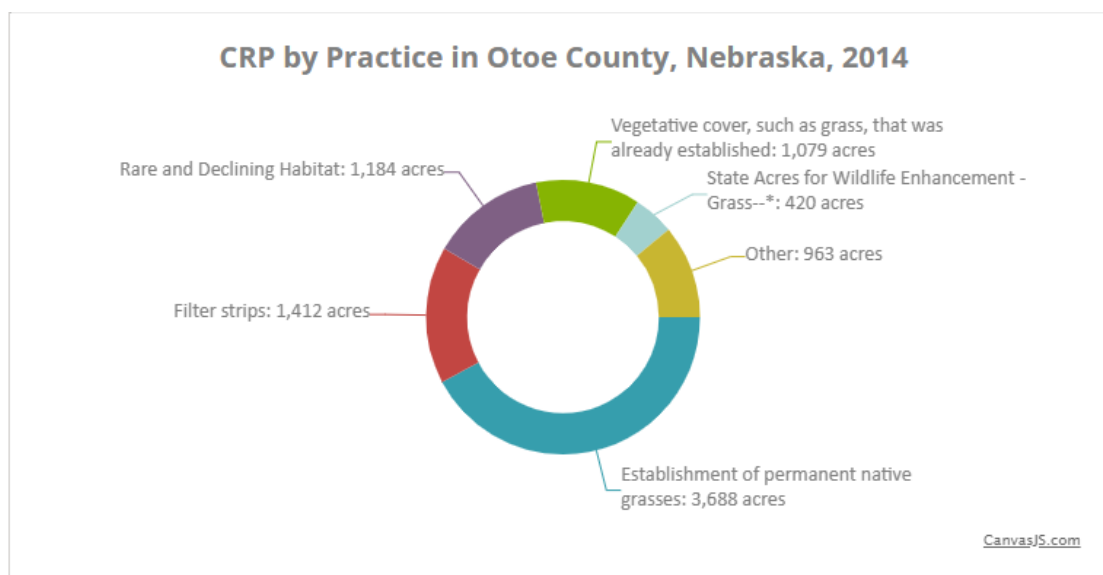


Figure8- Otoe County,  
Nebraska. Google  
Earth image, 2020.

**FIGURE 8**

## Discussion

After the observation of various aerial photos acquired from the archives of the University of Nebraska at Lincoln, and Google Earth Pro, the study found that across Otoe County, Nebraska, and the Township of Palmyra, that there were significant habitat changes. These habitat changes included deforestation, both increase and decrease of row-crop agriculture and native grassland prairie, and commercial urbanization within a 36- square mile section of Otoe County. It has shown that since 1950, the *Ring-Necked Pheasant* population has significantly decreased. But since the implantation of the Conservation Reserve Program, that although the population of *Ring-Necked Pheasant* has not increased, it has maintained a steady year by year number.



**Figure 9**

Figure 9- (EWS. 2020)

Figure 9 represents a look at the practice of CRP in Otoe County, Nebraska by acres in 2014. The graph indicates that the largest use is the establishment of permanent native grasses, which are significant in ensuring that the population of the Ring-Necked Pheasant remains.

## Alternatives

There is no greater alternative than getting involved! Pheasants Forever is the nation's leading upland wildlife habitat conservation organization. Nebraska alone has 62 active chapters, and ranks 3rd in memberships nationally, with 12,849. Its members are a diversified group of hunters, non-hunters, farmers, ranchers, landowners, conservation enthusiasts and wildlife officials. (Nebraska Pheasants Forever. 2020.)

Other alternatives consist of continued funding through programs like CRP and Wetland Restoration. As well as increased education involving the matters of private land use practices such as habitat buffer strips. Since the installation of Precision Agriculture, row-crop fields are able to maintain increased yields, while decreasing physical footprint.



(Pheasants Forever. 2020)

## Conclusion

This thesis was designed to highlight the correlation of the decline of the *Ring-Necked Pheasant* population in Nebraska and habitat changes in Otoe County. The thesis studied a literature review that discussed the 100-year history of conservation background throughout the United States, how the *Ring-Necked Pheasant* was introduced into the State of Nebraska, and the biology of the *Ring-Necked Pheasant*. This thesis also highlighted how the use of herbicides in agriculture, and the effects of harvesting through predation and hunting, also played a role in the decline of the *Ring-Necked Pheasant*. The primary study of this thesis was the observation of various aerial photos of a 36-square mile township north of the town of Palmyra in Otoe County. It was determined by the researcher that the decline of important habitat, along with topographical changes, as one of the primary reasons for the decline of the *Ring-Necked Pheasant* in Otoe County, Nebraska.

## **Acknowledgements**

I would like to thank Dr. David Gosselin for mediating this course. I would especially like to thank both my thesis advisor, Dr. David Wedin, and my thesis reader, Dr. Christine Haney, for all their guidance and help offered throughout these final two semesters. I would also like to thank Dr. Larkin Powell and Dr. John Carroll for their in-depth expertise and borrowed literature.

A special thank you to my parents, Tom and Emily, for their unconditional, and continued support. As well as installing both the love of the outdoors in me at such an early age, and the drive to finish my education. I love you both, Go Big Red!

## References

1. Brown, R. D. 2007. The history of wildlife conservation and research in the United States--with implications for the future. Proceedings of the Taiwan Wildlife Association 2007, 1–30. Taiwan National University.
2. Silcock, W.R., and J.G. Jorgensen. 2018. Ring-necked Pheasant (*Phasianus colchicus*), Version 1.0. In Birds of Nebraska.
3. Powell, Larkin. 2015. Hitler's Effect on Wildlife in Nebraska: World War II and Farmed Landscapes. *Great Plains Quarterly*. 35. 1-26.
4. Pheasants Forever Nebraska. (n.d.). Retrieved from <https://nebraskapf.com/history-new/>
5. Delacour, J. 1977. *The Pheasants of the World*. Surrey, England: Spur Publications.
6. Giudice, J., J. Ratti. 2001. "The Birds of North America Online". Ring-necked Pheasant.
7. Federation of Alberta Naturalists, 2007. *The Atlas of Breeding Birds of Alberta: a second look*. Altona, Manitoba, Canada.
8. Whitfield, P. 1984. Pheasants. Pp. 230-231. *Illustrated Animal Encyclopedia*.
9. Dale, F., J. Lauckhart, J. McKean. 1956. *Pheasants in North America*.
10. Kansas Department of Wildlife and Parks. (n.d.) Reducing inputs and making pheasants in the wheat-fallow rotation. Promotional leaflet.
11. Rodgers, Randy D. 2002. Effects of Wheat-Stubble Height and Weed Control on Winter Pheasant Abundance. *Wildlife Society Bulletin (1973-2006)*, vol. 30, no. 4.
12. Pheasants Forever (n.d.). Retrieved from <https://www.pheasantsforever.org/Habitat/Pheasant-Facts/Effects-of-Predators.aspx>.
13. Riley, Terry & Schulz, John. 2001. Predation and Ring-Necked Pheasant Population Dynamics. *Wildlife Society Bulletin*. 29. 33-38.
14. Trautman, C. G. 1968. Gun harvest. In *Pheasant Seminar*. South Dakota Chapter, The Wild. 38.
15. Baxter, William L. and Wolfe, Carl W. 1973. *The Ring-necked Pheasant in Nebraska*. Nebraska Game and Parks Commission Publications. 44.
16. Pheasants Forever. (n.d.). Retrieved from <https://www.pheasantsforever.org/Habitat/Pheasant-Facts/Effects-of-Hunting.aspx>
17. Little, Andrew. 2020. University of Nebraska at Lincoln.
18. Photo. Benbennick, David. Otoe County, NE. 2006.
19. Environmental Working Group. (n.d.). EWG's Agriculture Conservation Database. Retrieved from <https://conservation.ewg.org/crp.php?fips=3113>
20. Nebraska Pheasants Forever. 2020. Chapters.
21. Pheasant Forever. 2020. Photo. Retrieved from <https://www.pheasantsforever.org/Habitat/Pheasant-Facts/Upland-Cover-Basics.aspx>.

## Figures List

1. Figure 1- Otoe County, Nebraska, 2020. Google Earth Pro, 2020.
2. Figure 2- Otoe County, Nebraska. Land Survey, 1855. (n.d.). Retrieved from <https://sso.nebraska.gov/index.html>
3. Figure 3- Otoe County, Nebraska, 1949. Google Earth Pro, 2020.
4. Figure 4- Powell, Larkin. 2015. Hitler's Effect on Wildlife in Nebraska: World War II and Farmed Landscapes. *Great Plains Quarterly*. 35. 1-26.
5. Figure 5- Otoe County, Nebraska, 1971. Google Earth Pro, 2020.
6. Figure 6- Environmental Working Group. (n.d.). EWG's Agriculture Conservation Database. Retrieved from <https://conservation.ewg.org/crp.php?fips=3113>
7. Figure 7- Otoe County, Nebraska, 2003. Google Earth Pro, 2020.
8. Figure 8- Otoe county, Nebraska, 2020. Google Earth Pro 2020.
9. Figure 9- Environmental Working Group. (n.d.). EWG's Agriculture Conservation Database. Retrieved from <https://conservation.ewg.org/crp.php?fips=3113>