

NORTHERN SPOTTED OWL MONITORING ANNUAL REPORT, FY 2016

1. Title:

Demographic characteristics of northern spotted owls (*Strix occidentalis caurina*) in the Klamath Mountain Province of Oregon, 1990-2016.

2. Principal Investigators and Organizations:

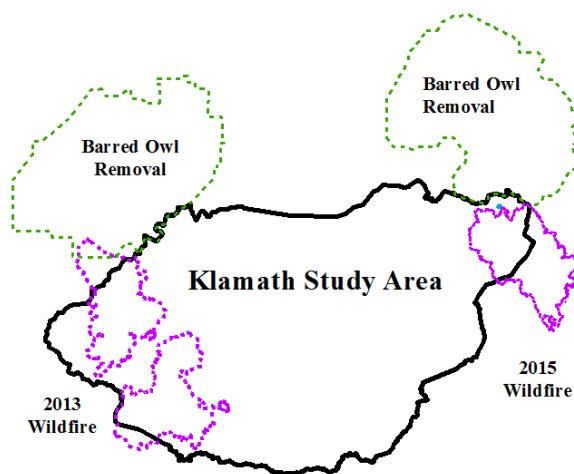
Damon Lesmeister (Principal Investigator); R. Horn (Lead Biologist); Biologists: R. Crutchley, K. Fukuda, T. Kaufmann, C. Larson, A. Price, H. Wise.

3. Study Objectives:

The study objectives are to estimate the population parameters of northern spotted owls on the Klamath Study Area (KSA) within the Klamath Mountain Province. These parameters include occupancy, survival and reproductive success. The lands are administered by the USDI Bureau of Land Management (BLM), Glendale Field Office of the Medford District and South River Field Office of the Roseburg District.

4. Potential Benefit or Utility of the Study:

Figure 1. Klamath Study Area boundary. Approximate boundaries of the 2013, 2015 wildfires and the experimental removal of barred owls.

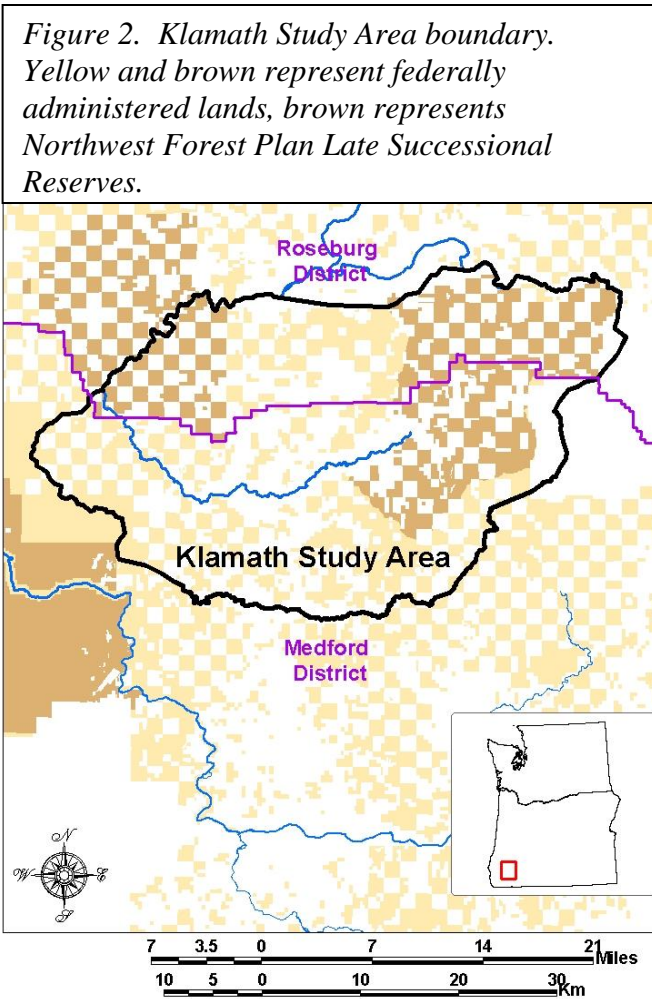


The KSA is one of eight long-term northern spotted owl study areas designed to assess the status and trends in northern spotted owl populations and habitat as directed under the Northwest Forest Plan (USDA and USDI 1994). The data from these studies are analyzed every 5 years as part of a range-wide meta-analysis workshop, and were most recently analyzed using data through 2013 (Dugger et al, 2016). The survival and reproductive data have been used in population modeling to assess the long-term stability of the population (e.g., Franklin et al. 1999). Data from several study areas have been used in the development of habitat suitability models and maps for spotted owl habitat (Lint et al. 1999, Anthony et al. 2000, Lint 2005, Davis et al. 2011, USFWS 2011).

An Environmental Impact Statement (EIS) has proposed experimental removal of barred

owls in four areas (USDI, 2013). The Union Myrtle Study Area (UMSA) is one of the four long-term northern spotted owl study areas designed to assess the effects of barred owl removal on the status and trends in northern spotted owl populations as directed under Recovery Action 29 in the Revised Recovery Plan (USDI 2011) (Figure 1). Surveys for barred owl presence began during the 2016 field season, and removal of barred owls began during fall of 2016. The KSA is considered the control area for this proposal, thus barred owl removal will not occur on the KSA.

5. Study Area Description and Survey Design:



The KSA was located within the Klamath Mountains Physiographic Province in Southwestern Oregon and was approximately 1422 km² (351,334 ac) in size (Figure 2). This province was characterized by mixed conifer forests dominated by Douglas-fir (*Pseudotsuga menziesii*) and incense cedar (*Calocedrus decurrens*). Other common species included pine (*Pinus* spp.), grand fir (*Abies grandis*), pacific madrone (*Arbutus menziesii*), golden chinquapin (*Castanopsis chrysophylla*), and oak (*Quercus* spp.) (Franklin and Dyrness 1973). Owl sites within the current boundaries of the KSA were systematically surveyed from 1997 to the present, with many opportunistic surveys done previous to that time. A smaller study area (about 466 km²; 115,138 ac) was systematically surveyed from 1990-1994 and was within the current study area boundary.

The KSA included portions of two BLM Districts in Western Oregon (Medford and Roseburg) and much of the intervening areas of private and state lands (Figure 2). The federal lands were primarily in an alternating “checkerboard” pattern of ownership with private lands. Of the eight long-term studies, two (Klamath and Tye) were composed almost entirely of this checkerboard pattern of ownership. Two types of study areas were included in the eight long-term studies: (1) density study areas, where all of the area within the boundary was surveyed each year, and (2) territorial study areas, where all known past and present owl territories were surveyed each year. The KSA was a territory based study area.

During July 2015, a wildfire (Stouts Creek Fire) of more than 10,000 ha (25,000 ac) impacted the eastern edge of the study area. In addition, during July 2013 another large wildfire (Douglas Complex Fire) of more than 16,000 ha (40,000 ac) impacted the western edge of the study area (Figure 1).

The study monitored demographic parameters including survival rates, reproductive rates, and annual rate of population change. The protocol used to determine site occupancy, nesting, and reproductive status for this study follows the guidelines specified by the Northern Spotted Owl Effectiveness Monitoring Plan for the Northwest Forest Plan (Lint et al. 1999). An attempt was made to uniquely color band all newly detected owls and re-observe all previously banded individuals within the study. The re-observation of banded owls was used for the calculation of survival rates and population trends (Burnham et al. 1996, Franklin et al. 1999, Anthony et al. 2006, Forsman et al. 2011a, Dugger et al, 2016).

6. Results for FY 2016:

Survey Effort

There are currently 159 known spotted owl sites within the KSA (Appendix A). During the period of study, it was determined that four sites previously considered separate sites, were different use areas of another site and have since been combined with other sites. Of the 159 sites surveyed during 2016; 25 were occupied by a pair, 11 by a single, and 10 were occupied by one or two owls with unknown status (Appendix A). At least one spotted owl was detected at 46 (28.9 %) of the sites (Appendix A).

Spotted Owl Occupancy

We identified 72 individual, non-juvenile, spotted owls (41 males and 31 females) in 2016, resulting in a male:female ratio of 1.32:1. Of the 60 non-juvenile owls where age was determined, 56 (93.3%) were adults and 4 (6.7%) were subadults (Appendix B). A total of 6 owls were newly banded during 2016; 4 (66.7%) were fledglings, and 2 (33.3%) were subadults.

About half of the Stouts Creek Fire was within the study area boundary. Eight demographic site centers were within the perimeter, approximately 4 of the sites had a substantial amount of suitable habitat severely burned. In addition, 2 of the Douglas Complex Fires were mostly within the study area boundary. Twenty seven demographic site centers were within the perimeter, approximately 5 of the sites had a substantial amount of suitable habitat severely burned. The small number of occupied sites with major impacts and the short time frame means any conclusions regarding occupancy or reproduction would be inappropriate.

Spotted Owl Reproduction

Yearly reproductive data (Appendix C, D) includes nesting attempts, nesting success, fecundity rate, and mean brood size. The proportion of nesting attempts is defined as the

number of females that attempted to nest versus the number where nesting status was determined. Nesting success is defined as the proportion of nesting females that fledged young. The fecundity rate is defined as the number of female young produced per female versus the number of sites where the number of young produced was determined. The mean brood size is defined as the average number of young produced per successfully reproducing pair.

Where appropriate, the data were split into four female age classes; 1-year old, 2-year old, adult, and unknown age.

There were a total of 25 sites where nesting status was determined in 2016, nesting was documented at 4 sites (16.0%) and not nesting was documented at 21 sites (84.0%). Two nesting attempts resulted in successfully fledged young and two failed, resulting in a nesting success rate of 50.0% (Appendix D).

The fecundity rate for all age classes in the KSA during 2016 was 0.074 (Appendix C). The fecundity rate for all sites during the years 1990-2016 was split into four female age classes. The rate for 1-year olds (0.063) was much lower than 2-year olds (0.302), adults (0.324), and unknown age class (0.260) (Table 1).

In 2016, the mean brood size was 2.00. The mean brood size for the years 1990-2016 was split into four female age classes, all known age classes resulted in similar values (Table 1).

Table 1. Fecundity rate and mean brood size by age class of female within the KSA (1990-2016).^a

Age class	Mean fecundity (N), 1990-2016	95% CI for fecundity	Mean brood size (N), 1990-2016	95% CI for brood size
1-yr	0.063 (96)	0.016-0.109	1.71 (7)	1.35-2.08
2-yr	0.302 (139)	0.235-0.369	1.50 (56)	1.37-1.63
Adult	0.324 (1523)	0.303-0.346	1.59 (621)	1.55-1.63
Unk	0.260 (51)	0.163-0.357	1.30 (20)	1.09-1.51
Total	0.307		1.57	

^a Preliminary data, values may change.

Spotted Owl Dispersal

Two owls originally banded as juveniles within the KSA were recaptured for the first time during 2016, one was an internal dispersal and one emigrated 17.2 km (10.7 mi) off the study area. In addition, one juvenile immigrated 22.9 km (14.2 mi) onto the study area from the barred owl removal area (Appendix E).

Figure 3. The annual average distance of non-juvenile movements within the KSA (1990-2016). All types of movements are included; immigration, emigration, and internal. A polynomial trend line is plotted ($r^2 = 0.608$).

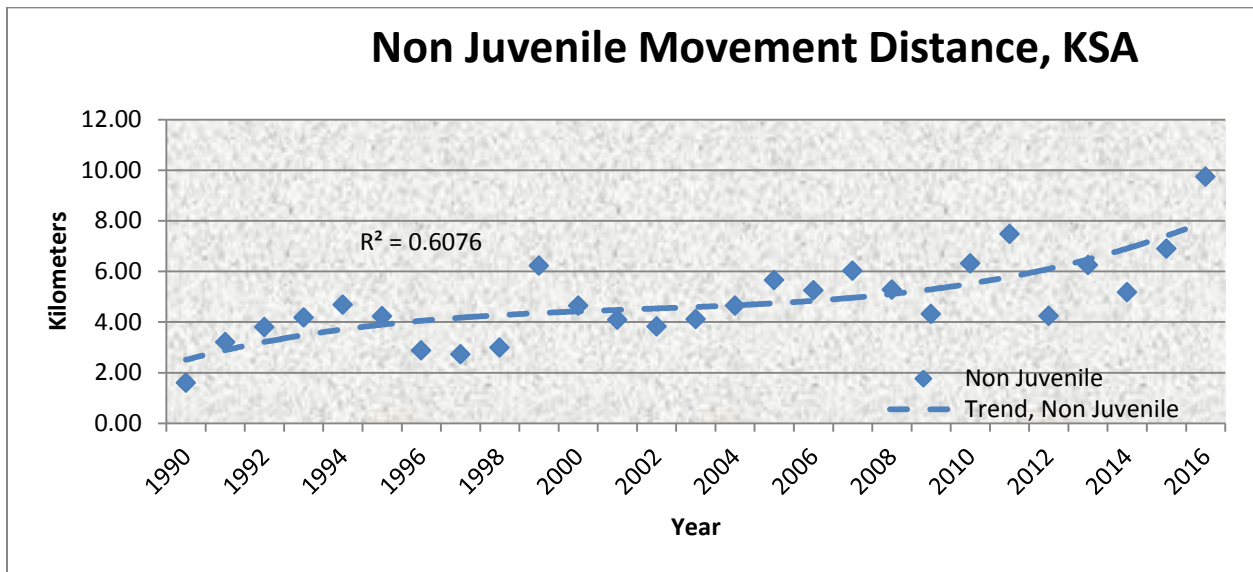
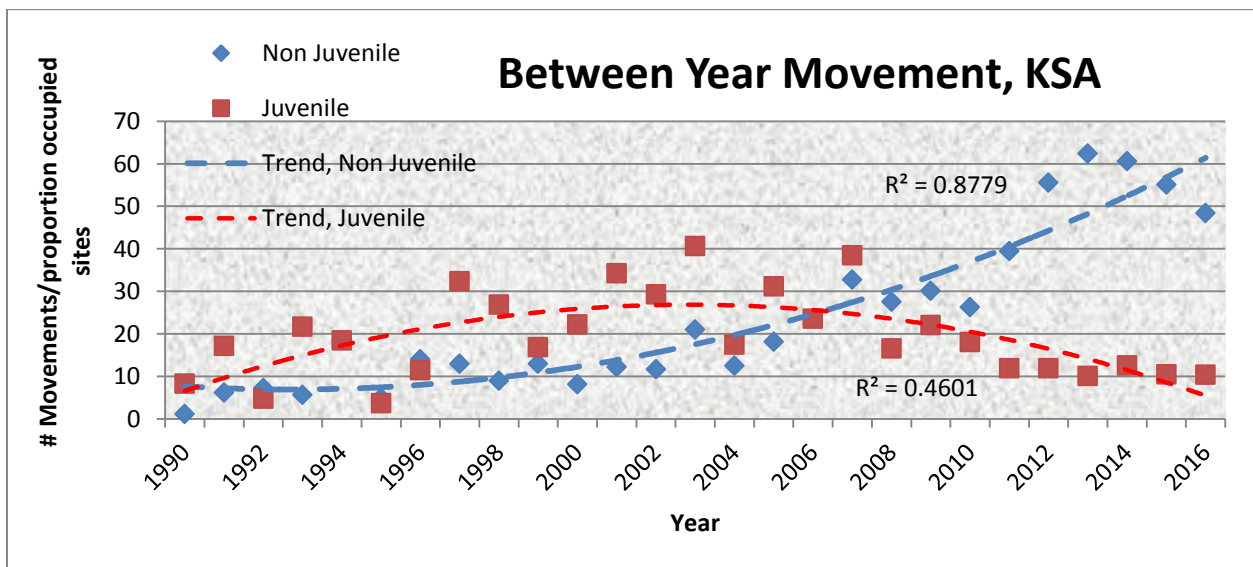


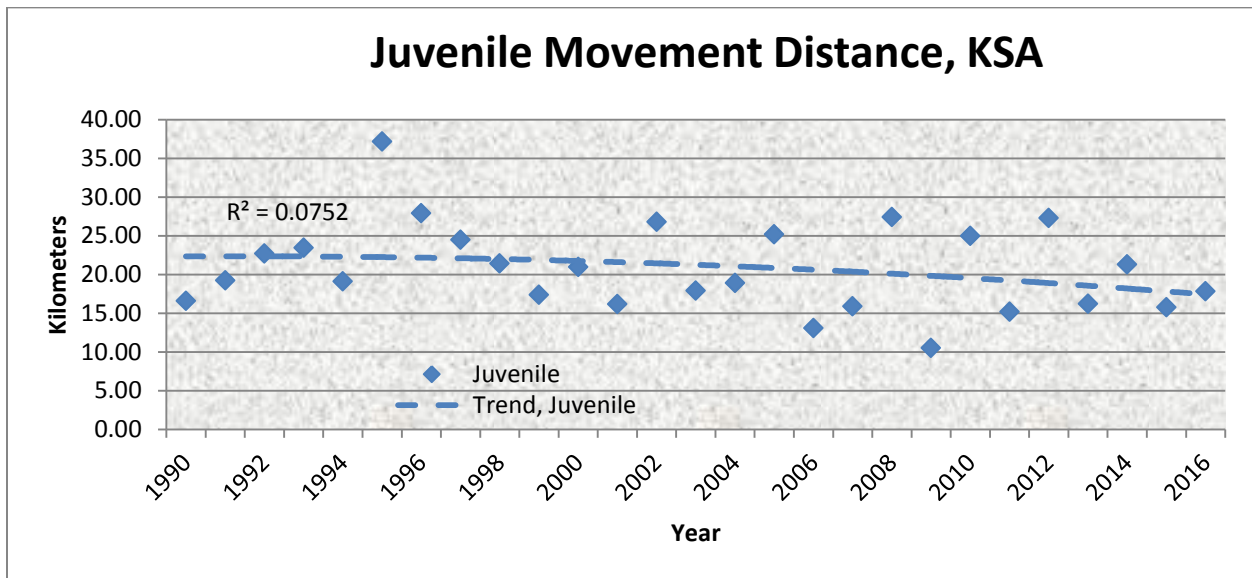
Figure 4. The annual number of movements/proportion of occupied sites within the KSA (1990-2016). All types of movements are included; immigration, emigration, and internal. A polynomial trend line is plotted for non-juvenile ($r^2 = 0.878$) and juvenile ($r^2 = 0.460$).



The average distance of between year movements for non-juveniles within the KSA, during 2016, was 9.7 km (6.0 mi); 9.3 km (5.8 mi) (N=7) for males and 10.2 km (6.3 mi) (N=7) for females (Figure 3). The number of movements (expressed as a proportion of occupied sites) have been steadily increasing and the trend line fits the data quite well ($r^2 = 0.878$)

(Figure 4). The number of between year juvenile dispersal movements rose steadily through the mid 2000's, and then has begun to decrease (Figure 4). The average distance of dispersal movements for juveniles within the KSA, during 2016, was 17.8 km (11.1 mi) (Figure 5).

Figure 5. The annual average distance of juvenile movements within the KSA (1990-2016). All movements including immigration, emigration, and internal are included. A polynomial trend line is plotted ($r^2 = 0.075$).



Barred Owl

There were at least 192 non-juvenile barred owls (*Strix varia*) detected at 100 sites on the KSA during 2016 (Appendix A). We detected a pair of barred owls at 52 sites and a single at 48 sites. Fledglings were detected at 11 of the sites during 2016. One male hybrid was detected in 2016. We compared the percentage of sites that were surveyed where at least one spotted owl was detected versus at least one barred owl detected on the KSA and UMSA (Figure 6). The barred owl detections were incidental to spotted owl surveys; therefore the number of sites with at least one barred owl detection is probably underestimated. The percentage of spotted owl sites with barred owl detections is steadily increasing, from less than 10% in all years previous to 2003, to greater than 10% in all years beginning with 2003 (Appendix A).

We compared the fecundity rate of spotted owls at sites with barred owl detections and sites without barred owl detections (Figure 7). The fecundity rate during 2016 was 0.000 (N=10) at sites with barred owl detections, and 0.118 (N=17) at sites without barred owl detections. The average spotted owl fecundity rate from 1999-2016 was 0.172 (N=105) at sites with barred owl presence, and 0.274 (N=1167) at sites without barred owl presence. The beginning year of 1999 was chosen since it was the first year any barred owls were detected

at a site where spotted owl reproductive status was determined.

Figure 6. Percentage of sites surveyed with at least one spotted owl detection versus sites with at least one barred owl detection. Klamath Study Area (KSA) and experimental barred owl removal area (UMSA), 1990-2016.

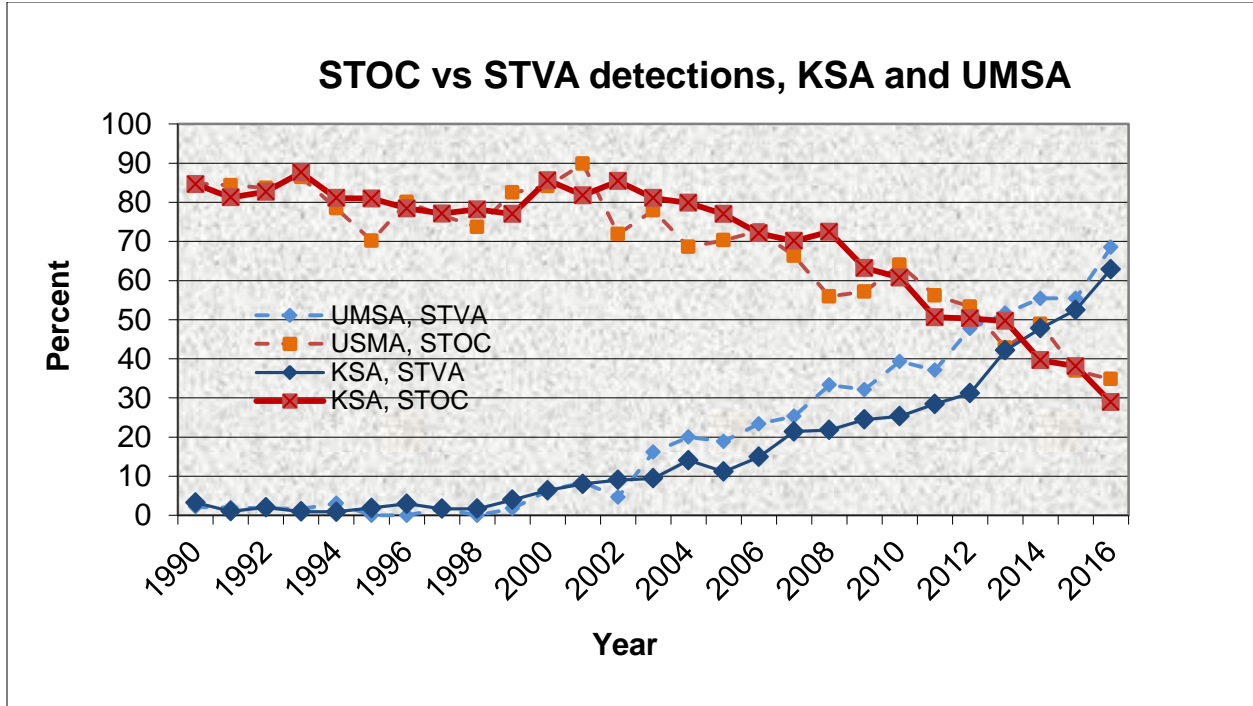
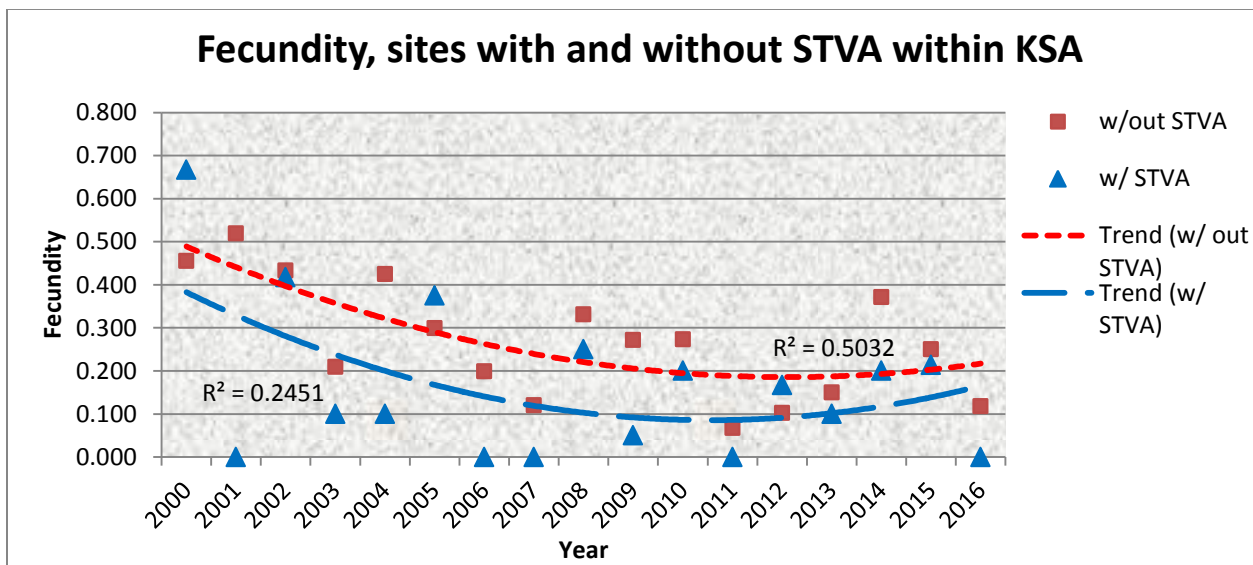


Figure 7. Spotted owl fecundity rate at sites with and without known STVA detections (1999-2016). Polynomial trend lines are plotted.



7. Discussion for FY 2016:

Survey Effort

The KSA survey effort began in 1990 with the effort increasing until about 2003, and has remained relatively steady since (Appendix A). Although most of the area within this boundary is covered by territorial surveys, it is not a density study and some area may not be surveyed.

Spotted Owl Occupancy

The ratio of male:female 1.32:1 was highly skewed towards males during 2016. While the sex ratio has always favored males (Appendix B) and may be related to differential detection rates, the past 2 years have exhibited more highly skewed results than previous years.

In recent years there has been a steady decline in the number of non-juveniles detected (Appendix B), a decrease in the number of pairs detected, and an increase in the number of unoccupied sites (Appendix A). The number of non-juveniles detected in 2016 (72) was the lowest ever documented on the study area (Appendix B). The number of non-juvenile individual spotted owls during 2016 was 67.6% fewer than the high of 222 during 2002. The decline in the number of pairs was even more sizeable than the decline of individuals, with 74.5% fewer pairs detected in 2016 than the high of 98 during 2005. The number of pairs detected on the study area has declined every year since 2005. The 25 pairs detected during 2016 was the lowest number documented during the study period. The most recent data regarding individual and pair occupancy has shown a steady and rapid decline, which suggests the stability of the population may be in question. The recent meta-analysis (Dugger et al, 2016) indicated that the estimates of realized population change on the KSA was a 34% decline from 1992 through 2011, the numbers above may indicate this trend is continuing.

The decrease in the number of subadults is even more pronounced than the decrease within all non-juvenile age classes. The highest proportion of subadults ever documented in the KSA (25.1%) occurred during 2003 and the lowest proportion (0.0%) occurred during 2014. The proportion has been decreasing in recent years with subadults averaging 14.7% from 1990-2006, since 2006 they have accounted for just 5.9%. Some of this decline may be explained by an extended period of very low fecundity, resulting in fewer subadults recruited into the population in subsequent years. Another indicator of recruitment is the number of juveniles that successfully disperse and are recruited into the population. Three juveniles were initially banded within the KSA or immigrated into the KSA during 2016, one of the lowest numbers ever documented (Appendix E).

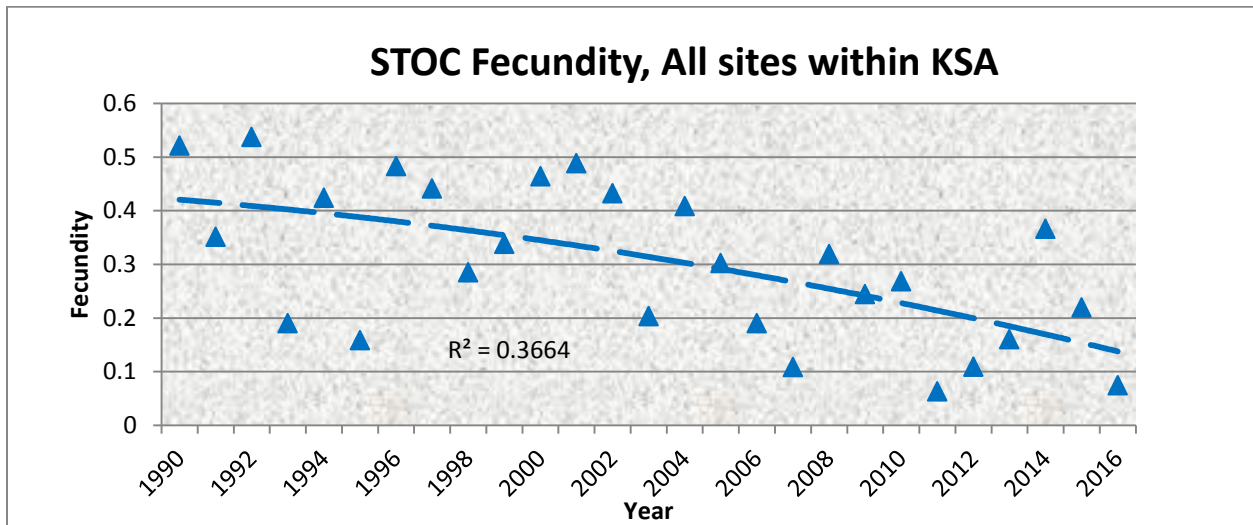
Spotted Owl Reproduction

Nesting status was determined at 25 sites during 2016, the lowest number ever documented.

The number of sites where nest status was determined has decreased every year since 2005, and appears directly related to the decrease in pair occupancy. The nest success rate for 2016 (50.0%) was lower than the 1990-2016 average of 73.3%. Nesting success has fluctuated above and below the 25 year average with no obvious trend (Appendix D), however the declining number of pairs available for reproductive output during those years has resulted in reduced total production. Mean brood size was 2.00 in 2016, much higher than the average for all years (1.57, Appendix C), however the sample size (N=2) was very small and was the lowest ever documented. The nest attempt rate and nest success rate during 2016 were both below the 1990-2016 average. This combined with the continuing decline in pair occupancy results in fewer fledglings produced than during earlier years when reproductive rates were lower but pair occupancy was much higher (Appendix B, C, D).

Fecundity increases from 1-year old to adult age classes on the KSA. Our most recent analysis shows a very low fecundity rate of 0.063 for 1-year olds, while the rate for 2-year olds was very similar to the adult rate (0.302 and 0.324, respectively) (Table 1). This is somewhat different than the most recent meta-analysis (Dugger et al, 2016), where the 2-year old fecundity rate (0.175) was midway between 1-year old (0.065) and adults (0.309). However, several study areas had a similar pattern to the KSA where the 2-year old rate was similar to the adult rate. In addition, the KSA had the largest proportion of 1 and 2-year olds with fecundity determined and may be related to the pattern observed above. The mean brood size within the KSA varied by age class, with the 1-year old age class actually having the highest rate (1.71), however the sample size was very small (N=7).

Figure 8. Spotted owl fecundity at all sites surveyed, KSA 1990-2016. A polynomial trend line is plotted ($r^2 = 0.366$).



The fecundity rate for 2016 was 0.074 (N=27), which was much lower than the average for the years 1990-2016 (0.300) (Appendix C). The only year with a lower fecundity rate was 2011 (0.063) which had more than twice the sample size (N=56). While the fecundity rate for spotted owls is known to fluctuate, we documented only 1 year during the most recent 8

years where the fecundity rate was above the overall average, and the rate appears to be in a downward trend (Figure 8). Dugger et al. (2016) noted that the fecundity rate on the KSA was declining and the most recent data agrees with this conclusion. The number of fledglings detected within the KSA during 2016 (4) was much lower than the overall mean (41.0) and the most recent 8 years all had a lower number of fledglings detected on the study area than the overall mean (Appendix B). A combination of the downward trend in fecundity rates, the downward trend in number of pairs, and the declining number of non-juveniles may indicate problems with maintaining a stable population.

Barred Owl Influence on Spotted Owl Occupancy

It is clear that the barred owl population is increasing across the range of the northern spotted owl. There is strong evidence that barred owls are having a negative effect on spotted owl populations (Dugger et al. 2016). The most recent meta-analysis (Dugger et al., 2016) indicates that the spotted owl populations have declined across most of the range and that the annual rates of decline were accelerating in many areas. The most significant declines have occurred in Washington where the barred owl has been present the longest. Forsman et al (2011a) indicated an annual rate of population change (λ) of 0.990, (95% CI: 0.962-1.017) within the KSA during the 1992-2006 study period, the more recent analysis by Dugger et al. (2016) indicated an annual rate of population change (λ) of 0.972, (95% CI: 0.940-1.005) within the KSA during the 1992-2011 study period. Dugger et al. (2016) suggested that the presence of barred owls was negatively associated with apparent annual survival in 7 of 11 study areas, not including the KSA. Since the most recent meta-analysis, the KSA data continues to show trends where the numbers of barred owls continue to increase, while spotted owl occupancy and fecundity continue to decrease.

The number of individual barred owl detections was increasing during recent years and 2016 was the highest number ever detected. In addition, many of these detections appear to comprise more than one pair of barred owls within a single spotted owl site. Multiple detections at a site are estimated using a 500ha hexagon grid across the landscape, with each hexagon representing an approximate barred owl home range. Using this criteria, there were at least 192 non-juvenile barred owls detected on the KSA during 2016 compared to 179 during 2015. The numbers may be underestimated since barred owl detections were incidental during surveys where spotted owl calls were used, and Wiens (2011) noted that barred owls were more likely to respond to a conspecific call versus a spotted owl call (0.66/visit vs. 0.48/visit). However, as the numbers of spotted owl pairs decline, any underestimation may become lower since Bailey et al. (2009) noted that barred owls are often twice as likely to be detected if spotted owls are not present.

Using simple presence of at least one owl at a site, there has been an increase in the number of sites with barred owl detections during the past 10 years (Appendix A). This increase agrees with the increase in the number of individual detections noted above. Beginning in 2005, the number of barred owls detected has increased in each subsequent year (Figure 6). On the KSA, the number of sites where barred owls were detected exceeded the number of sites where spotted owls were detected for the first time in 2014 (Figure 6). Barred owls

were detected on the highest percentage of sites during 2016, and the percentage of sites where spotted owls were detected was the lowest of any year. The spotted owl and barred owl occupancy trends observed on the KSA (barred owl removal control) are similar to the trends on the barred owl removal area prior to removal (Figure 6).

Barred owls now co-occur with spotted owls throughout the range of spotted owls, and barred owls negatively affect spotted owl occupancy dynamics (Dugger et al. 2011, Kelly et al. 2003, Olson et al. 2005) and the probability of detecting spotted owls (Bailey et al. 2009, Ferber and Kroll 2012). Olson et al. (2005) determined that barred owl presence positively affected local-extinction probabilities or negatively affected colonization probabilities of spotted owls. They concluded that a further decline in the proportion of sites occupied by spotted owls is expected. Dugger et al. (2016) reported that the presence of barred owls resulted in an increase in local extinction rates for all 11 study areas analyzed, including the KSA. The steady decline in the number of pairs and the number of non-juveniles on the KSA since 2002 (Appendix A, B) indicates that the KSA population may be experiencing these effects.

It has been postulated that spotted owls increase inter-territorial movements in reaction to barred owl disruption of territories. Data on the distance of non-juvenile movements indicated a fairly strong upward trend in distance moved since 2003 (Figure 3). The annual number of inter-territorial movements shows this same strong upward trend (Figure 4). Forsman et al (2011b) noted an increase of non-juvenile movements as well as an increase in the number of individuals located at multiple sites during the same year on the Tye Density study area. There appears to be a trend of increasing numbers of between year movements of non-juvenile spotted owls within the KSA that seems to agree with Forsman et al. (2011b). These data indicate that a disruption of territorial fidelity within the KSA may be occurring.

Barred Owl Influence on Spotted Owl Reproduction

We compared fecundity rates at sites with and without barred owl influences. The method was a site specific rate that compares fecundity at sites with barred owl presence to sites where barred owls have not been detected. Because barred owl detections were incidental, the results from sites where spotted owl reproduction was determined may be biased low. However, any survey bias comparing reproductive versus non reproductive sites should be somewhat similar since most visits to occupied sites occur diurnally. The site specific fecundity rate from 1999-2016 at sites with known barred owl presence was 0.172 compared to 0.274 at sites where barred owls were not detected. Barred owl presence appears to reduce spotted owl fecundity rates. Yearly data comparisons indicate barred owl presence may be having a negative impact on spotted owl reproduction and is consistent with findings from Forsman et al. (2011a) which included analysis of the KSA through 2008. Dugger et al. (2016) noted only a weak negative effect of barred owl presence on fecundity. Glenn (2011) and Olson et al. (2004) also noted that there was a negative association with barred owl presence and reproduction in their respective analysis.

There is mounting evidence that barred owls may be negatively impacting the spotted owl population within the KSA. This is illustrated by several apparent population trends: (1)

spotted owl detections have been steadily decreasing (Figure 6) and reached the lowest point in 2016, when barred owl detections reached their highest level; (2) fecundity rates appear to be declining (Figure 8) and in only 2 of the previous 10 years was the rate above the 27 year average; and (3) the fecundity rate for sites with known barred owl presence was lower than at other sites and is continuing to decline. Forsman et al. (2011a) noted that the consistency of the negative associations between spotted owl demographic rates and the presence of barred owls supports the conclusion that barred owls are having a negative effect on spotted owl populations. The more recent meta-analysis (Dugger et al. 2016) was even more emphatic in stating that competition with barred owls may be the primary cause of spotted owl population declines. The recent KSA data, with the combination of decreasing occupancy and reduced fecundity, appears to reinforce this conclusion.

8. Acknowledgments:

Many people and organizations contributed to the success of this project. Without the dozens of dedicated people collecting the field data, none of this could have been accomplished. In addition, biologists from surrounding areas have contributed information regarding owl movements. Several private timber companies have been gracious enough to allow access to sites on their property. Funding for range wide demographic studies comes from BLM, USDA Forest Service, and the National Park Service.

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Appendix A. Territories surveyed and occupancy results by year within the KSA (1990-2016).^a

Year	Total Sites ^b	Sites w/ Pair ^e	Sites w/ single	Sites w/ undetermined status ^f	Total occupied sites	Sites w/ no occ ^g	Sites w/ incomplete survey ^h	Sites w/ STVA ^c	Total STVA ind ^d
1990	91	58	10	9	77	14	7	3	4
1991	96	61	11	6	78	18	9	1	1
1992*	98	59	13	9	81	17	9	2	2
1993*	105	65	14	13	92	13	9	1	1
1994*	111	74	4	12	90	21	9	1	1
1995*	105	62	11	12	85	17	16	2	2
1996	102	60	7	13	80	20	19	3	4
1997	118	61	13	17	91	25	8	2	2
1998*	119	76	9	8	93	22	10	2	4
1999*	126	74	9	14	97	26	5	5	7
2000*	125	71	16	20	107	14	7	8	14
2001*	137	86	12	14	112	20	1	11	17
2002	144	96	10	17	123	17	1	13	19
2003	148	96	11	13	120	20	0	14	24
2004	149	97	10	12	119	26	0	21	32
2005	152	98	12	7	117	31	1	17	33
2006	154	90	11	10	111	33	1	23	34
2007	154	82	15	11	108	37	1	33	61
2008	156	80	12	21	113	35	0	34	54
2009	155	76	8	14	98	51	2	38	69
2010	158	69	12	15	96	51	0	40	70
2011	158	52	13	15	80	57	1	45	69
2012	157	51	11	17	79	70	2	49	92
2013	159	48	14	17	79	69	0	67	117
2014	159	38	10	15	63	80	0	76	155
2015	159	33	10	18	61	82	0	84	179
2016	159	25	11	10	46	100	0	100	192

^a Preliminary data, values may change.

^b Sites surveyed to protocol.

^c STVA occupancy is opportunistic and is defined as any detection at the site.

^d Total STVA individuals is an estimate based biologist opinion if multiples occupy the same site.

^e Pair as defined in Lint et al 1999.

^f Undetermined status may include one or 2 owls, does not qualify as a pair or resident single.

^g No occupancy determined with at least 3 survey visits. The sum of this column and the total occupied sites column may not equal the total sites number since sites with the same individual located at 2 sites during the same year are not considered as occupied at one of the sites.

^h Incomplete survey is 2 visits or less (usually no visits, only includes sites surveyed in previous years).

* represents years with a site where the pair was comprised of a spotted owl and a barred owl which was included as a "site with single".

Appendix B. Sex and age composition of spotted owls located within the KSA (1990-2016). Non-juvenile owls where the sex could not be determined are not included. ^a

Year	Adult (M,F)	Subadult (M,F)	Percent Subadult	Age unk (M,F) ^b	Total non- juvenile (M,F)	Juvenile
1990	101 (58,43)	16 (10,6)	13.7	21 (10,11)	138 (78,60)	50
1991	111 (60,51)	18 (9,9)	14.0	13 (5,8)	142 (75,67)	40
1992	106 (61,45)	16 (7,9)	13.1	19 (11,8)	141 (79,62)	58
1993	112 (60,52)	23 (13,10)	17.0	27 (16,11)	162 (89,73)	22
1994	121 (66,55)	26 (12,14)	17.7	20 (10,10)	167 (88,79)	55
1995	118 (66,52)	9 (1,8)	7.1	21 (15,6)	148 (82,66)	18
1996	109 (60,49)	9 (4,5)	7.6	29 (15,14)	147 (79,68)	56
1997	112 (57,55)	21 (15,6)	15.8	26 (11,15)	159 (83,76)	52
1998	127 (69,58)	28 (15,13)	18.1	20 (9,11)	175 (93,82)	41
1999	133 (74,59)	17 (6,11)	11.3	29 (14,15)	179 (94,85)	44
2000	136 (74,62)	19 (10,9)	12.3	28 (18,10)	183 (102,81)	65
2001	151 (80,71)	35 (20,15)	18.8	17 (12,5)	203 (112,91)	82
2002	154 (85,69)	48 (21,27)	23.8	20 (13,7)	222 (119,103)	83
2003	152 (85,67)	51 (23,28)	25.1	14 (10,4)	217 (118,99)	39
2004	171 (93,78)	29 (11,18)	14.5	18 (13,5)	218 (117,101)	75
2005	190 (105,85)	19 (3,16)	9.1	8 (7,1)	217 (115,102)	61
2006	170 (91,79)	20 (5,15)	10.5	14 (11,3)	204 (107,97)	35
2007	162 (85,77)	16 (7,9)	9.0	12 (8,4)	190 (100,90)	19
2008	163 (83,80)	9 (4,5)	5.2	22 (14,8)	194 (101,93)	53
2009	150 (76,74)	10 (5,5)	6.3	14 (12,2)	174 (93,81)	38
2010	137 (71,66)	12 (7,5)	8.1	21 (13,8)	170 (91,79)	38
2011	111 (58,53)	8 (5,3)	6.7	17 (14,3)	136 (77,59)	7
2012	109 (53,56)	10 (8,2)	8.4	15 (10,5)	134 (71,63)	12
2013	105 (58,47)	2 (0,2)	1.9	26 (21,5)	133 (79,54)	15
2014	88 (45,43)	0 (0,0)	0.0	15 (10,5)	103 (55,48)	31
2015	74 (41,33)	5 (3,2)	6.3	17 (10,7)	96 (54,42)	14
2016	56 (32,24)	4 (2,2)	6.7	12 (7,5)	72 (41,31)	4

^a Preliminary data, values may change.

^b It is possible some of the unknown are auditory responses and the same individuals as included in another category.

Appendix C. Fecundity rate and mean brood size by year within the KSA (1990-2016). Years with an * represent years when backpack transmitters were attached to females during the nesting season, these sites are excluded from the calculation. ^a

Year	Mean fecundity (N)	95% CI for fecundity	Mean brood size (N)	95% CI for brood size
1990*	0.521 (48)	0.397-0.644	1.61 (31)	1.44-1.79
1991*	0.351 (57)	0.233-0.468	1.67 (24)	1.44-1.89
1992*	0.537 (53)	0.425-0.650	1.49 (39)	1.30-1.68
1993	0.190 (58)	0.100-0.279	1.47 (15)	1.21-1.73
1994	0.424 (66)	0.308-0.541	1.81 (31)	1.64-1.97
1995	0.158 (57)	0.076-0.240	1.38 (13)	1.11-1.66
1996	0.483 (58)	0.378-0.588	1.47 (38)	1.34-1.61
1997	0.441 (59)	0.322-0.559	1.73 (30)	1.57-1.89
1998	0.285 (72)	0.198-0.371	1.37 (30)	1.19-1.54
1999	0.338 (65)	0.231-0.446	1.69 (26)	1.51-1.87
2000	0.464 (70)	0.366-0.563	1.51 (43)	1.36-1.66
2001	0.488 (84)	0.387-0.589	1.78 (46)	1.66-1.90
2002	0.432 (96)	0.344-0.520	1.60 (52)	1.49-1.70
2003	0.203 (96)	0.136-0.271	1.34 (29)	1.17-1.52
2004	0.408 (92)	0.319-0.496	1.56 (48)	1.42-1.70
2005	0.302 (101)	0.220-0.384	1.61 (38)	1.45-1.76
2006	0.190 (92)	0.116-0.264	1.59 (22)	1.38-1.80
2007	0.108 (88)	0.046-0.170	1.73 (11)	1.45-2.00
2008	0.319 (83)	0.234-0.404	1.43 (37)	1.27-1.59
2009	0.244 (78)	0.153-0.334	1.73 (22)	1.54-1.92
2010	0.268 (72)	0.181-0.355	1.41 (27)	1.22-1.60
2011	0.063 (56)	0.006-0.119	1.40 (5)	0.92-1.88
2012	0.109 (57)	0.035-0.183	1.50 (8)	1.13-1.87
2013	0.160 (49)	0.067-0.252	1.50 (10)	1.17-1.83
2014	0.366 (41)	0.229-0.503	1.67 (18)	1.44-1.89
2015	0.219 (33)	0.089-0.348	1.56 (9)	1.21-1.90
2016	0.074 (27)	0.000-0.175	2.00 (2)	
1990-2016	0.300		1.58	

^a Preliminary data, values may change.

Appendix D. Proportion of nesting attempts at sites with nest status determined, and proportion of nest success by year within the KSA (1990-2016). Years with an * represent years when backpack transmitters were attached to females during the nesting season, these sites are excluded from the calculation. ^a

Year	Nest Attempt Proportion (N)	95% CI for Nest Attempts	Nest Success Proportion (N)	95% CI for Nest Success
1990*	0.821 (39)	0.698-0.943	0.750 (32)	0.598-0.902
1991*	0.696 (46)	0.561-0.830	0.688 (32)	0.524-0.851
1992*	0.783 (46)	0.662-0.903	0.889 (36)	0.785-0.993
1993	0.391 (46)	0.249-0.534	0.722 (18)	0.509-0.935
1994	0.569 (57)	0.440-0.698	0.818 (33)	0.685-0.952
1995	0.462 (39)	0.303-0.620	0.667 (18)	0.443-0.891
1996	0.872 (39)	0.765-0.978	0.853 (34)	0.732-0.974
1997	0.540 (50)	0.400-0.680	0.963 (27)	0.890-1.036
1998	0.660 (53)	0.532-0.789	0.618 (34)	0.452-0.783
1999	0.472 (53)	0.336-0.607	0.880 (25)	0.750-1.010
2000	0.776 (58)	0.668-0.884	0.844 (45)	0.737-0.952
2001	0.716 (74)	0.613-0.820	0.849 (53)	0.752-0.946
2002	0.667 (90)	0.569-0.765	0.850 (60)	0.759-0.941
2003	0.506 (83)	0.398-0.614	0.595 (42)	0.445-0.745
2004	0.614 (88)	0.511-0.716	0.852 (54)	0.756-0.947
2005	0.600 (90)	0.498-0.702	0.611 (54)	0.480-0.742
2006	0.375 (88)	0.273-0.477	0.606 (33)	0.437-0.775
2007	0.224 (76)	0.129-0.318	0.647 (17)	0.413-0.881
2008	0.613 (75)	0.502-0.724	0.783 (46)	0.662-0.903
2009	0.449 (69)	0.331-0.568	0.677 (31)	0.510-0.845
2010	0.787 (61)	0.683-0.891	0.500 (48)	0.357-0.643
2011	0.208 (48)	0.092-0.324	0.500 (10)	0.173-0.827
2012	0.208 (48)	0.092-0.324	0.800 (10)	0.539-1.061
2013	0.267 (45)	0.136-0.397	0.833 (12)	0.613-1.054
2014	0.571 (35)	0.405-0.738	0.800 (20)	0.620-0.980
2015	0.433 (30)	0.253-0.614	0.692 (13)	0.431-0.953
2016	0.160 (25)	0.013-0.307	0.500 (4)	0.000-1.066
1990-2016	0.535		0.733	

^a Preliminary data, values may change.

Appendix E. Count and distance traveled between year movement within the KSA (1990-2016). The count of movements is weighted by dividing by the proportion of occupied sites. All juvenile and non-juvenile movements including immigration, emigration, and internal are included. ^a

Year	Count of juv move	Count/ proportion sites occ	Juv KmTravel	Count of non-juv move	Count/ proportion sites occ	Non-juv KmTravel
1990	7	8.3	16.57	1	1.2	1.60
1991	14	17.2	19.21	5	6.2	3.20
1992	4	4.8	22.68	6	7.3	3.80
1993	19	21.7	23.43	5	5.7	4.18
1994	15	18.5	19.11	15	18.5	4.68
1995	3	3.7	37.17	4	4.9	4.23
1996	9	11.5	27.89	11	14.0	2.88
1997	25	32.4	24.46	10	13.0	2.72
1998	21	26.9	21.43	7	9.0	2.99
1999	13	16.9	17.36	10	13.0	6.22
2000	19	22.2	20.94	7	8.2	4.64
2001	28	34.3	16.18	10	12.2	4.09
2002	25	29.3	26.79	10	11.7	3.82
2003	33	40.7	17.91	17	21.0	4.11
2004	14	17.5	18.88	10	12.5	4.64
2005	24	31.2	25.18	14	18.2	5.65
2006	17	23.6	13.05	17	23.6	5.25
2007	27	38.5	15.86	23	32.8	6.02
2008	12	16.6	27.40	20	27.6	5.27
2009	14	22.1	10.49	19	30.1	4.31
2010	11	18.1	24.95	16	26.3	6.31
2011	6	11.9	15.18	20	39.5	7.47
2012	6	11.9	27.27	28	55.6	4.24
2013	5	10.1	16.22	31	62.4	6.25
2014	5	12.6	21.30	24	60.6	5.18
2015	4	10.5	15.73	21	55.1	6.90
2016	3	10.4	17.83	14	48.4	9.74

^a Preliminary data, values may change.