Temporospatial shifts in Sandhill Crane staging in the Central Platte River Valley in response to climatic variation and habitat change

Andrew J. Caven, Emma M. Brinley Buckley, Kelsey C. King, Joshua D. Wiese, David M. Baasch, Greg D. Wright, Mary J. Harner, Aaron T. Pearse, Matt Rabbe, Dana M. Varner, Brice Krohn, Nicole Arcilla, Kirk D. Schroeder, and Kenneth F. Dinan

Sandhill Crane Range and Migratory Corridor

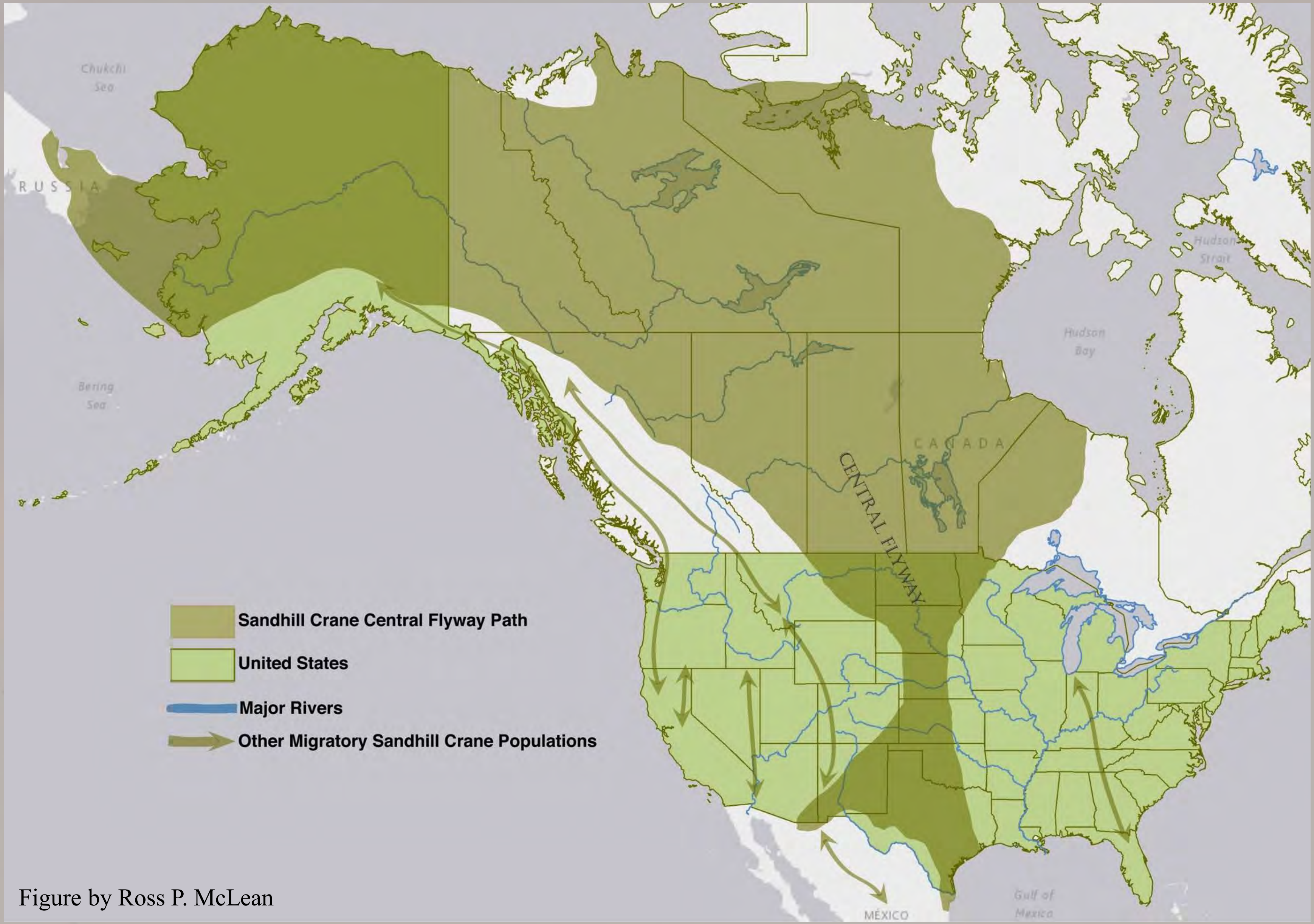


Figure by Ross P. McLean

Sandhill Crane Aerial Surveys

- Objectives: Track spatial and temporal changes in migration to better understand conservation needs of the CPRV
- Duration: 8-10 Weeks ~02/15 to ~04/15
- Start at first visible light (civil twilight ~20 before official sunrise)
- Flight path: 132 km from Chapman to Overton, NE. Central Platte River Valley (CPRV).
- Estimate Error: Based on photo subplots of counts made in the office for up to 10 roosts

Mental Polygons and Photo Based Error Estimates

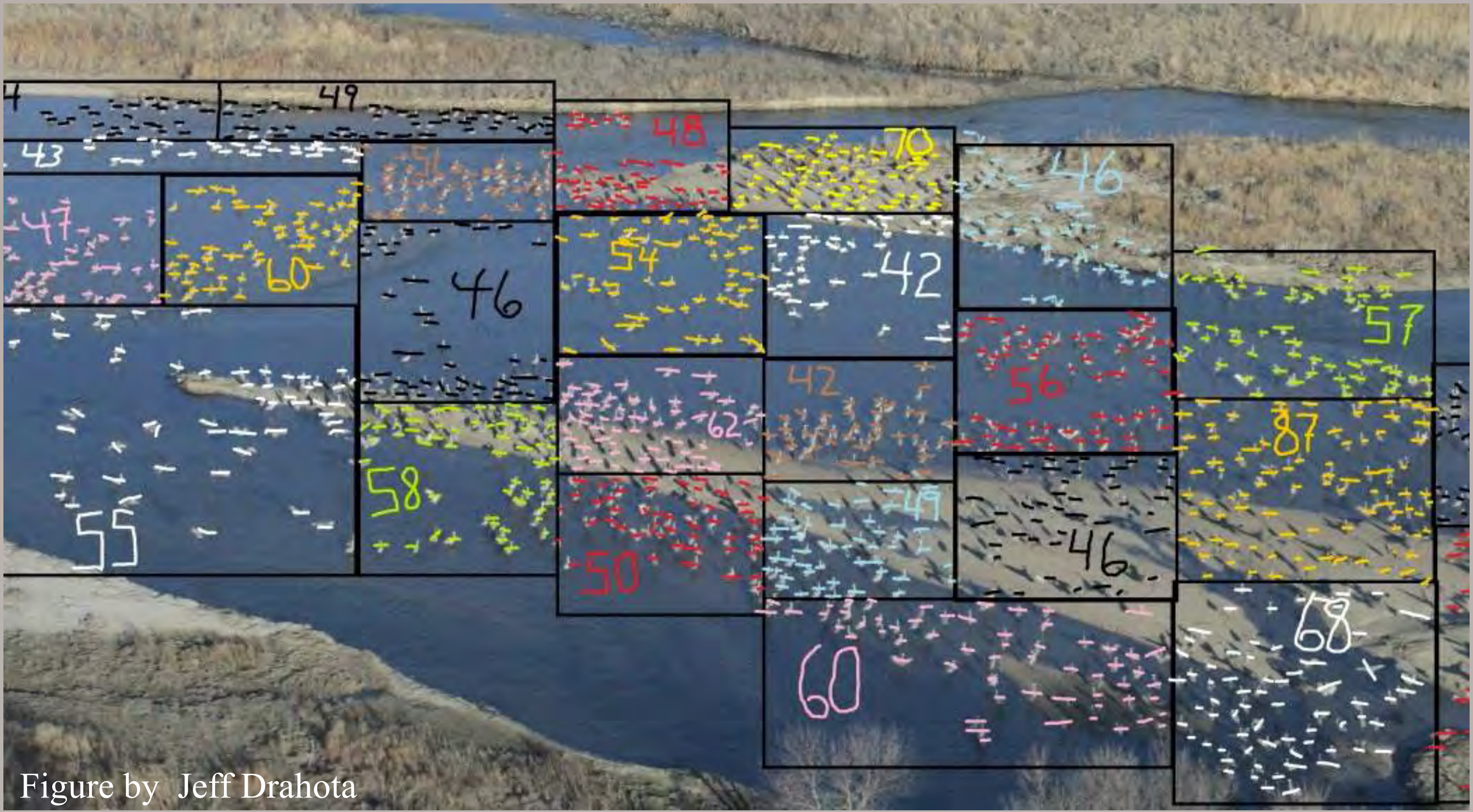
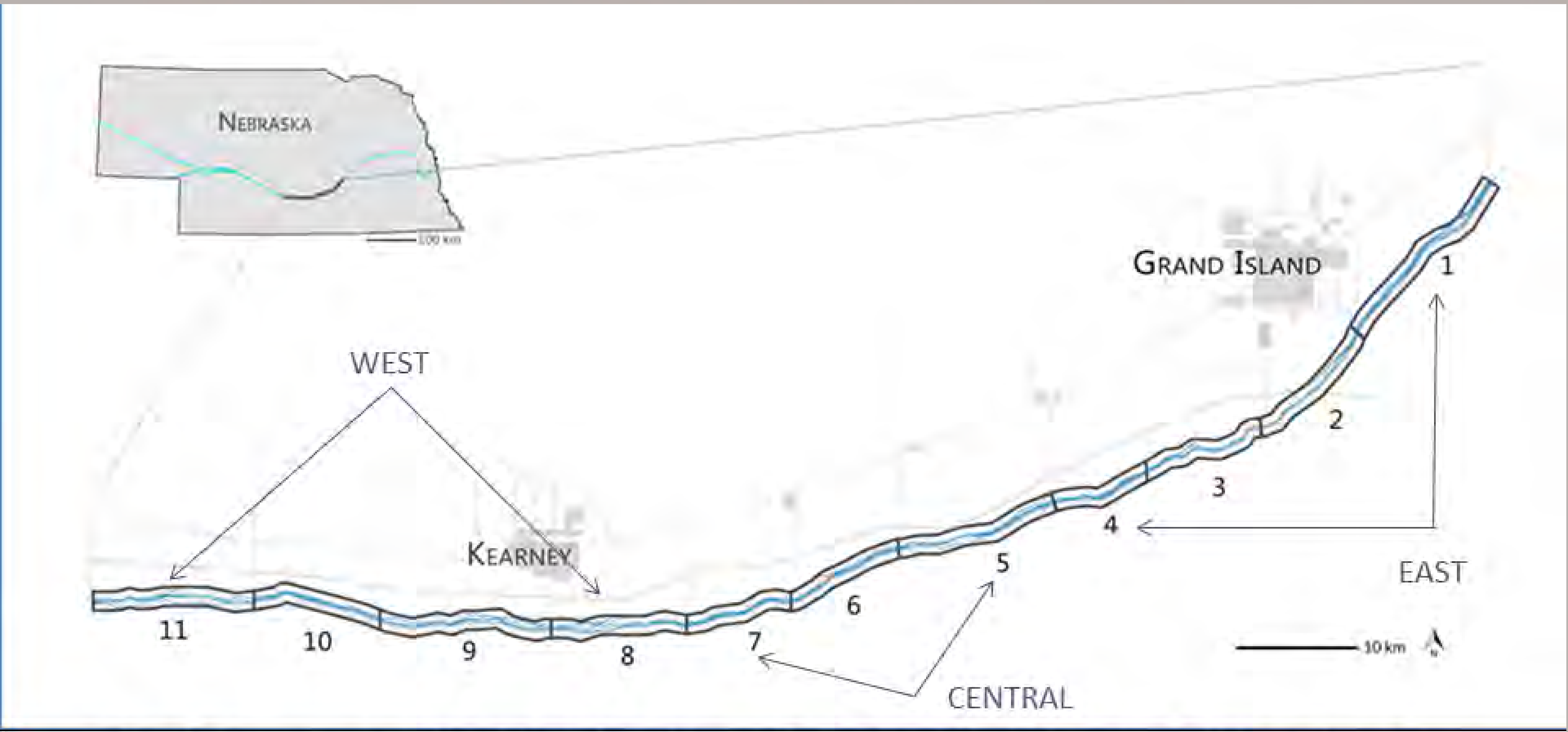


Figure by Jeff Drahota

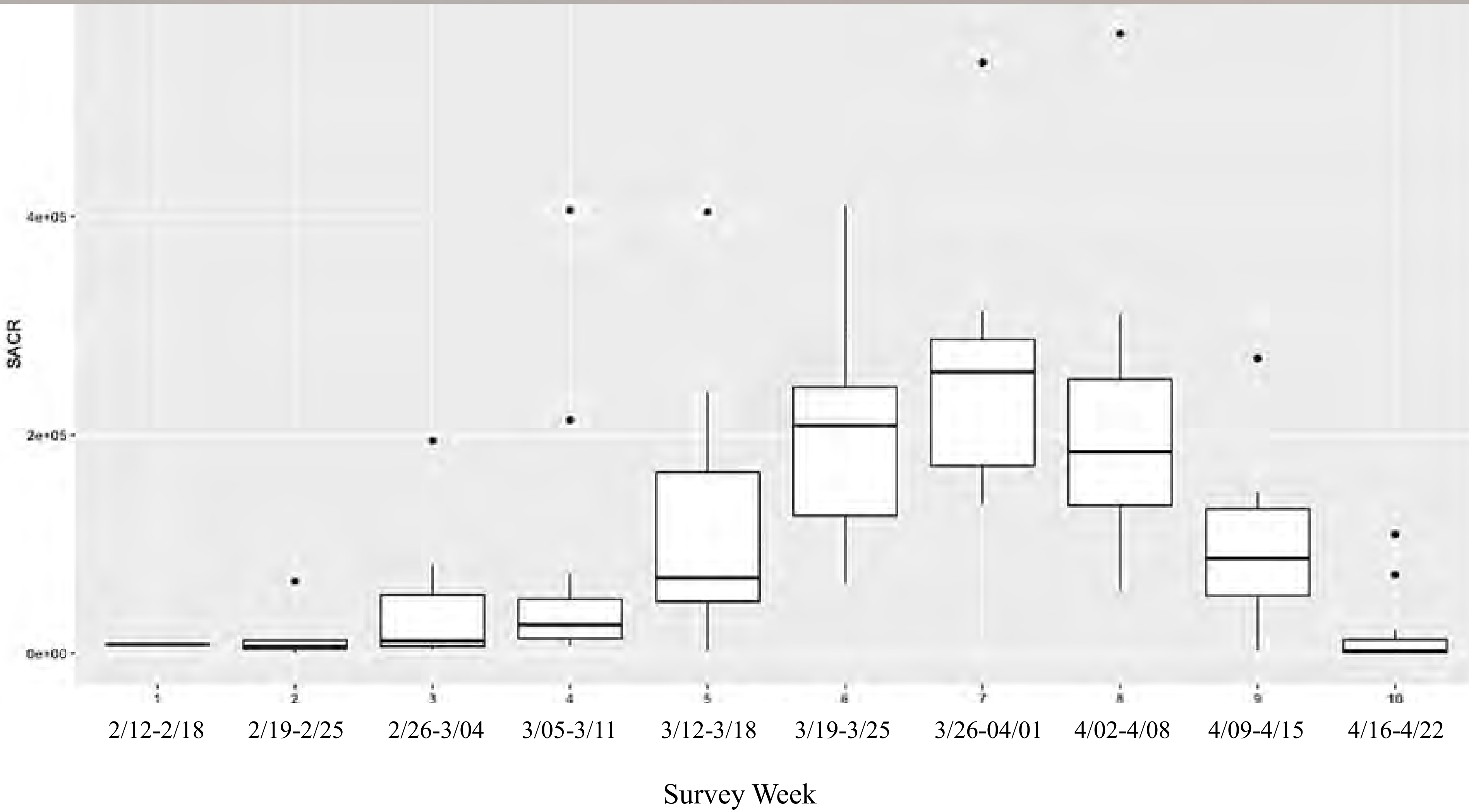
Study Area
Central Platte River Valley



EAST: 1- Chapman to HWY 34; **2**- HWY 34 to HWY 281; **3**- HWY 281 to Alda; **4**- Alda to Wood River
CENTRAL: 5- Wood River to Shelton; **6**- Shelton to Gibbon; **7**- Gibbon to HWY 10
WEST: 8- HWY 10 to Kearney; **9**- Kearney to Odessa; **10**- Odessa to Elm Creek; **11**- Elm Creek to Overton

Map by Emma Brinley Buckley

Sandhill Crane Aerial Counts per Survey Week

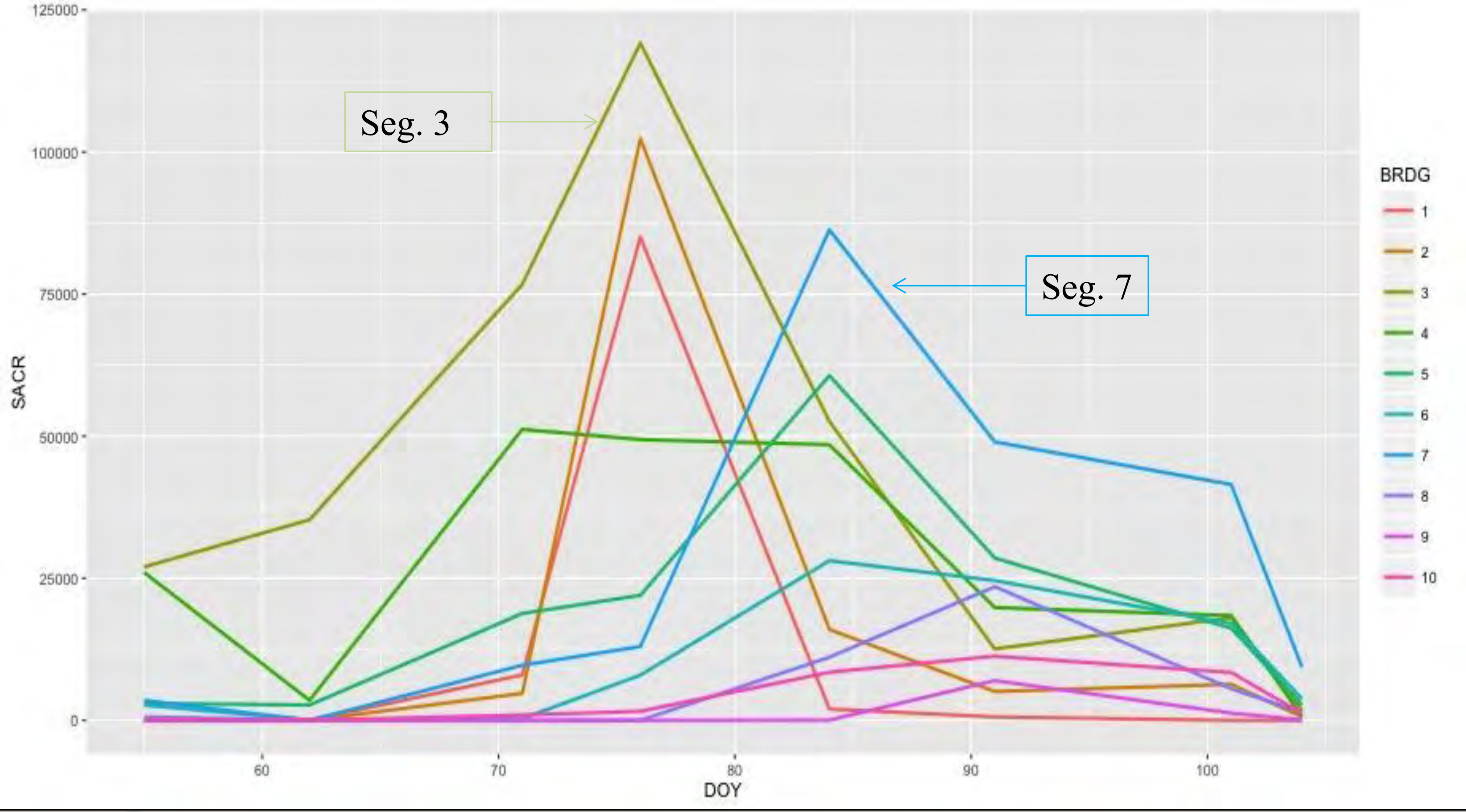


$\bar{x}$ = 25 Mar ± 9.2 days, **range** = 08 Mar – 08 April

Timing of Peak Sandhill Crane Count per Bridge Segment

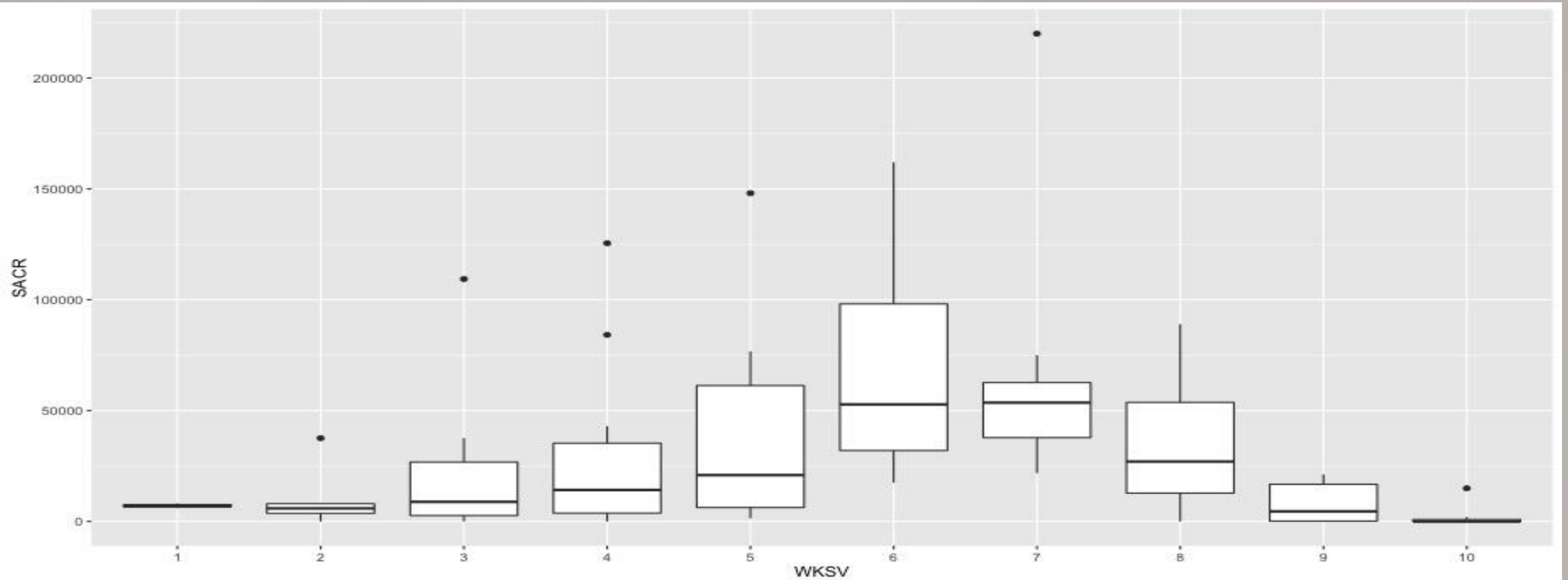
	Brg. Seg.	$\bar{x}$ Pk. SACR	$\bar{x}$ Pk. Density	$\bar{x}$ Pk. Surv. Wk.
1	Chapman	18,423	1,077	**6**, 3/19 - 3/25
2	HWY34	36,114	3,113	**6**, 3/19 - 3/25
3	HWY281	68,913	6,440	**6**, 3/19 - 3/25
4	Alda	39,561	4,654	**7**, 3/26 - 4/01
5	Wood River	38,180	2,747	**8**, 4/02 - 4/08
6	Shelton	25,046	2,480	**8**, 4/02 - 4/08
7	Gibbon	42,457	4,666	**8**, 4/02 - 4/08
8	HWY10	10,107	887	**8**, 4/02 - 4/08
9	Kearney	4,065	227	**8**, 4/02 - 4/08
10	Odessa	3,971	361	**8**, 4/02 - 4/08
11	Elm Creek	851	63	**8**, 4/02 - 4/08

2009 Sandhill Crane counts by bridge segment (SACR) and Julian Date (DOY)

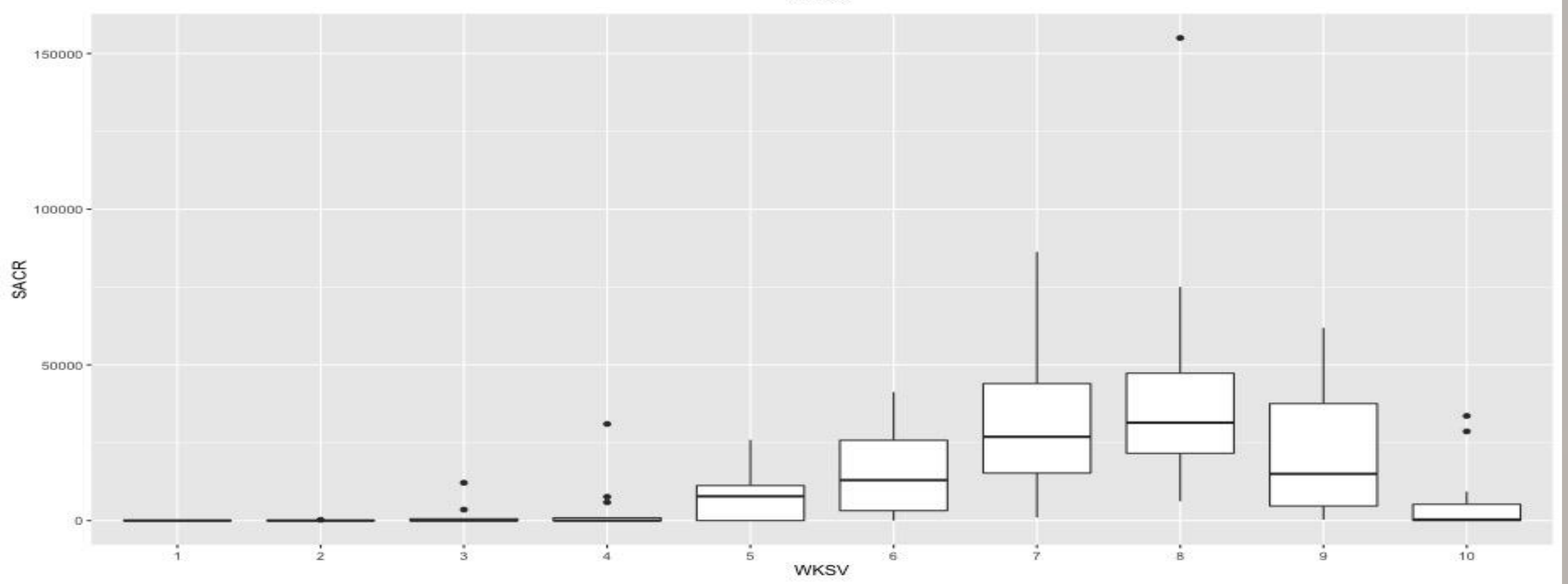


Weekly Sandhill Crane counts observed in bridge segments 3 (HWY 281 to Alda Rd.) and 7 (Gibbon to HWY 10).

Seg. 3

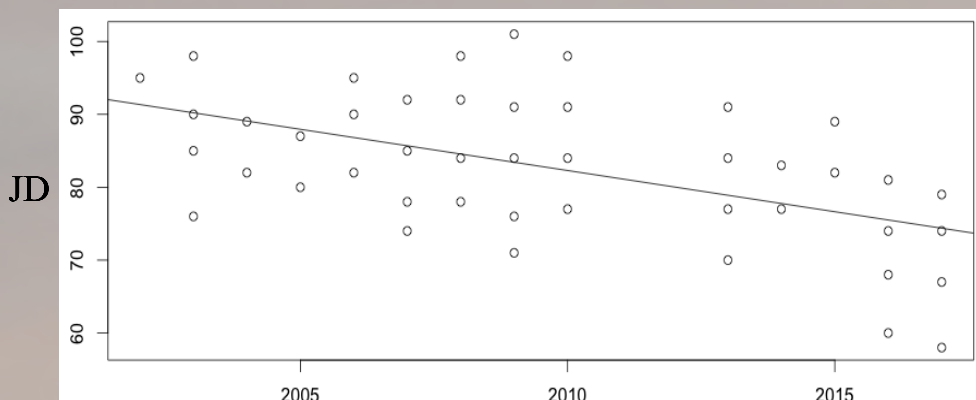


Seg. 7

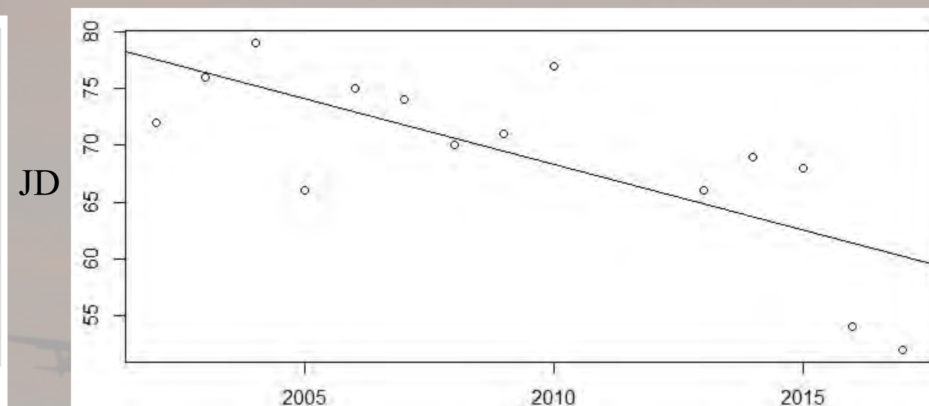


Sandhill Crane abundance and arrival metrics fit with ordinary least squares bivariate regression lines by survey year

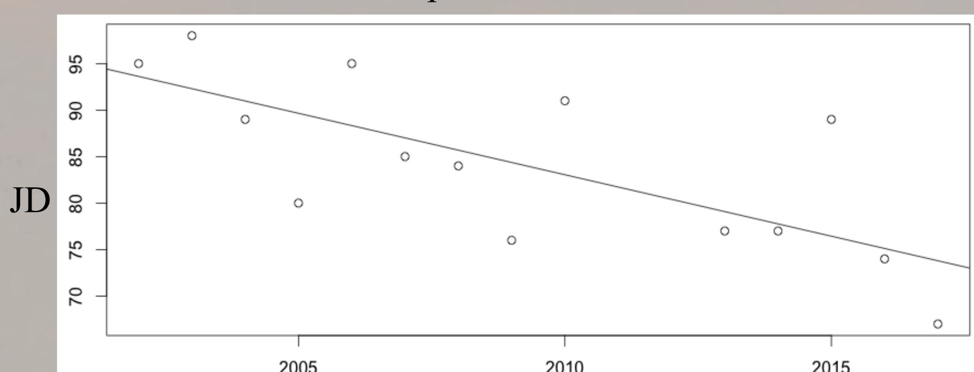
Julian dates of Sandhill Crane counts exceeding 125,000



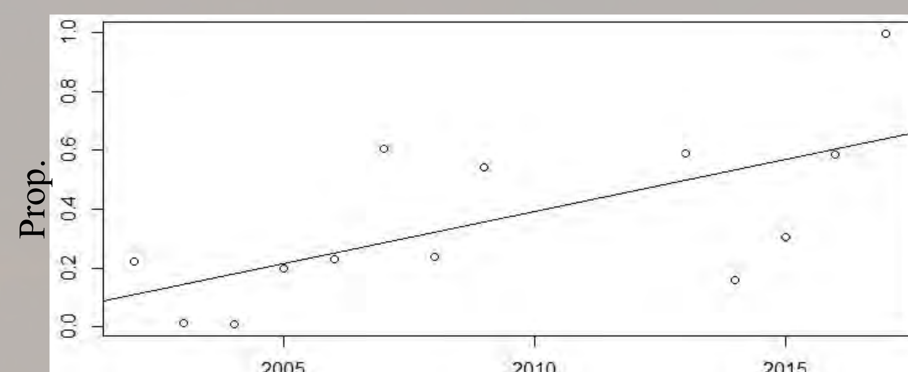
Julian date Sandhill Crane counts exceeded 15% of peak



Julian date of peak Sandhill Crane count



Proportion of the peak Sandhill Crane count observed in week five



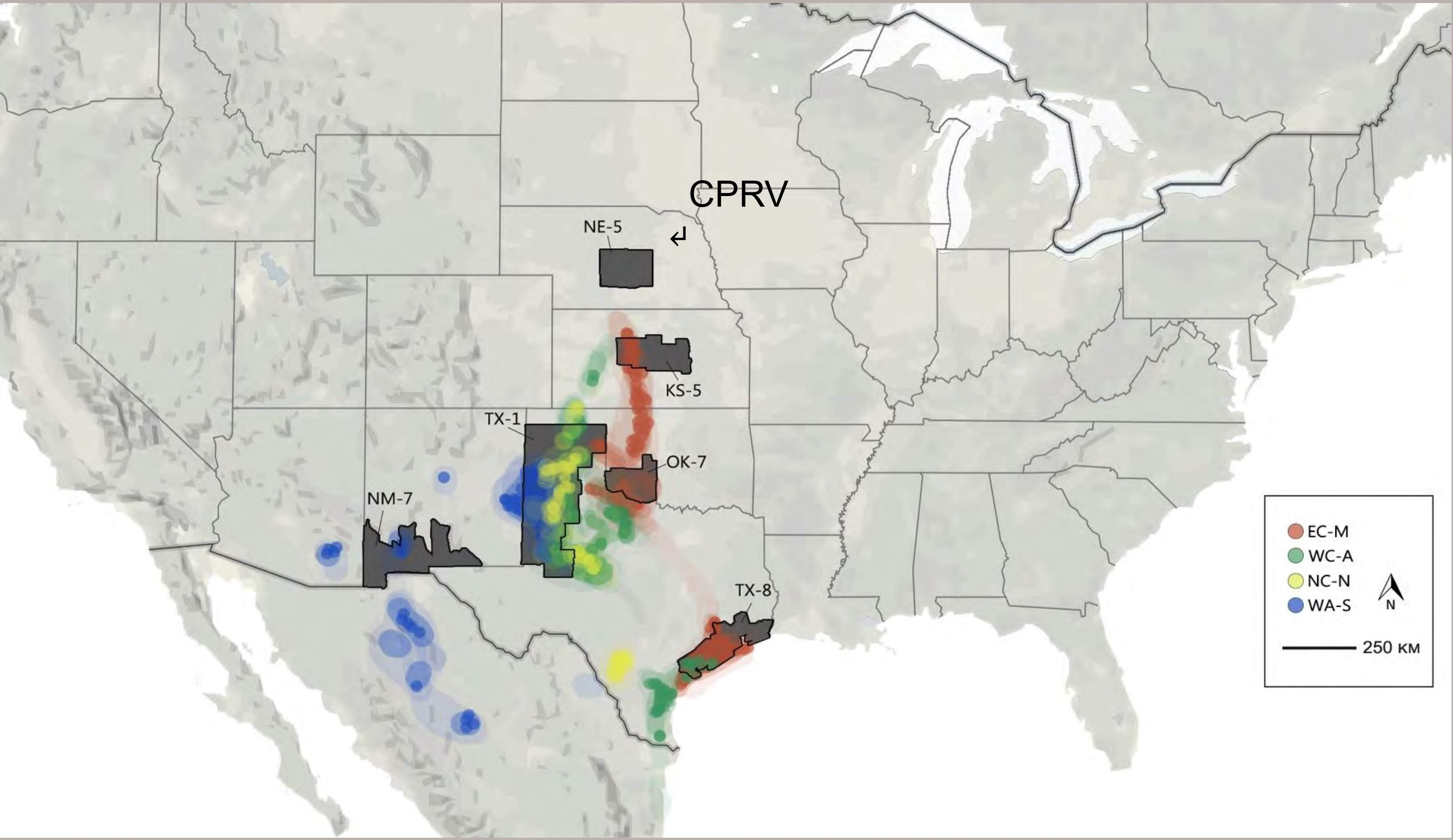
Bivariate ordinary least squares linear regression analyses Sandhill Crane abundance estimates by survey year (coefficient) from 2002 to 2017

Dep. Var.	Unit	β	SE	*t*	*p*	R^2	df
Peak	Julian Date	**-1.324**	0.364	-3.63	0.003**	0.524	12
> 125K	Julian Date	**-1.134**	0.277	-4.10	0.001***	0.281	43
> 5%	Julian Date	**-1.413**	0.428	-3.30	0.006**	0.476	12
> 15%	Julian Date	**-1.155**	0.309	-3.73	0.003**	0.537	12
> 25%	Julian Date	**-1.434**	0.334	-4.29	0.001***	0.605	12
% WK 4	Prop.	**0.034**	0.013	2.59	0.027*	0.402	10
% WK 5	Prop.	**0.035**	0.012	2.89	0.015*	0.430	11
% WK 8	Prop.	**-0.039**	0.016	-2.38	0.034*	0.322	12

Analysis of climatic variation's impacts on the arrival of significant percentiles of the midcontinent Sandhill Crane population to the CPRV

- Sandhill Crane arrival metrics (DVs):
  - Julian Date >30,000, >100,000, and >15% (of peak) SACRs detected in the CPRV
  - SACR counts in survey week 4 (3/05–3/11) and week 5 (3/12–3/18)
- Climatic variables (IVs): NOAA National Climatic Data Center, Climatological Divisions
  - $\bar{x}$ annual winter (Jan.-Feb.) temp. and PDSI for wintering locations (TX, OK, NM)
  - $\bar{x}$ annual late-winter and early-spring (Feb.-Mar./Apr.) temp. and PDSI for spring stopover locations (KS, NE)
  - Year as a control variable to account for long-term trends not driven by annual weather (i.e.- population growth, observer)
- Analysis:
  - Generalized Linear Models (GLMs) compared via Akaike Information Criterion for small samples (AICc)
  - $\bar{x}$ annual temps were not significantly correlated (r >0.50) with PDSI values
  - Thirty-five models:
    - Six locations: southwest OK, TX panhandle, TX coastal plain, southern NM, central KS, central NE
    - Five Sandhill Crane arrival metrics (>30k, >100k, >15%, WK4, WK5)
    - One null model (DV~1) for each DV

Major SACR wintering and migration locations overlaid with NOAA climatological divisions



Model selection table: GLMs of drought and temperature parameters at key SACR wintering areas and measures of early arrival in the CPRV

Model		**Model Coefficients**					
Dep. Var.	Location	Temp. β	PDSI β	Log Lik.	AICc	Δ	wt.
DY SACR > 30K	*TX Pan.*	-2.6848***	-0.4317	-36.72	90.9	0.00	0.59
	SW OK	-2.5137***	-0.4121	-37.11	91.7	0.78	0.40
DY SACR > 100K	*Cen. KS*	-1.2798**	-1.3338^	-37.32	92.1	0.00	0.90
DY SACR > 15%	*TX Coast*	-1.2768***	-1.1903*	-33.68	84.9	0.00	0.71
	SW OK	-1.2665**	-1.0991*	-34.90	87.3	2.43	0.21
SACR 3/05–3/11	*TX Coast*	21,624**	16910*	-145.80	311.6	0.00	0.84
	SW OK	21,035*	14572	-147.90	315.8	4.19	0.10
SACR 3/12–3/18	*TX Coast*	21,059**	15189^	-159.46	337.5	0.00	0.55
	Cen. KS	18,694**	10487	-159.93	338.4	0.94	0.35

Putting our results in context: A long trend

Harner et al. 2015. Wilson J. Ornithol. 127457-466.

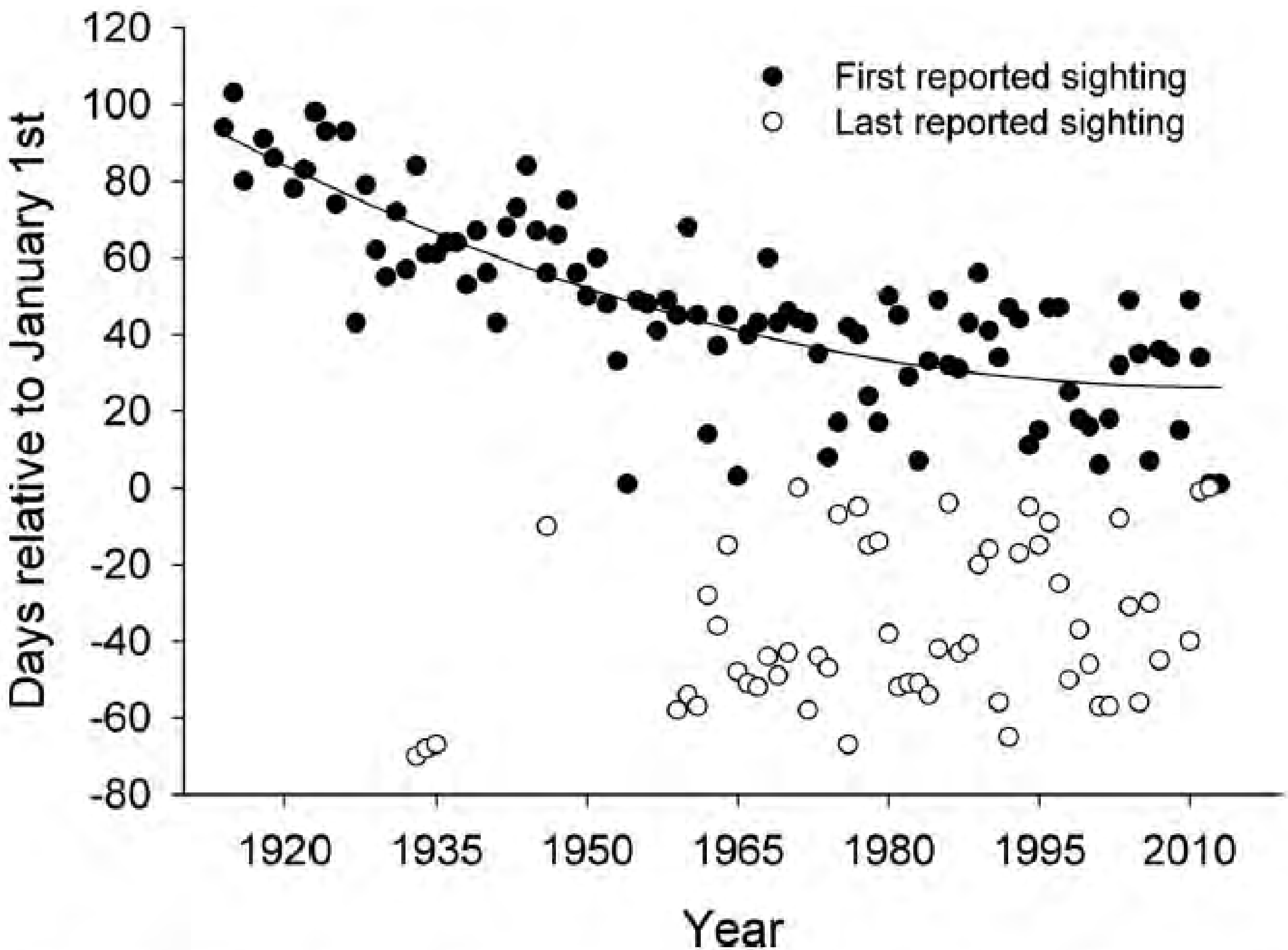
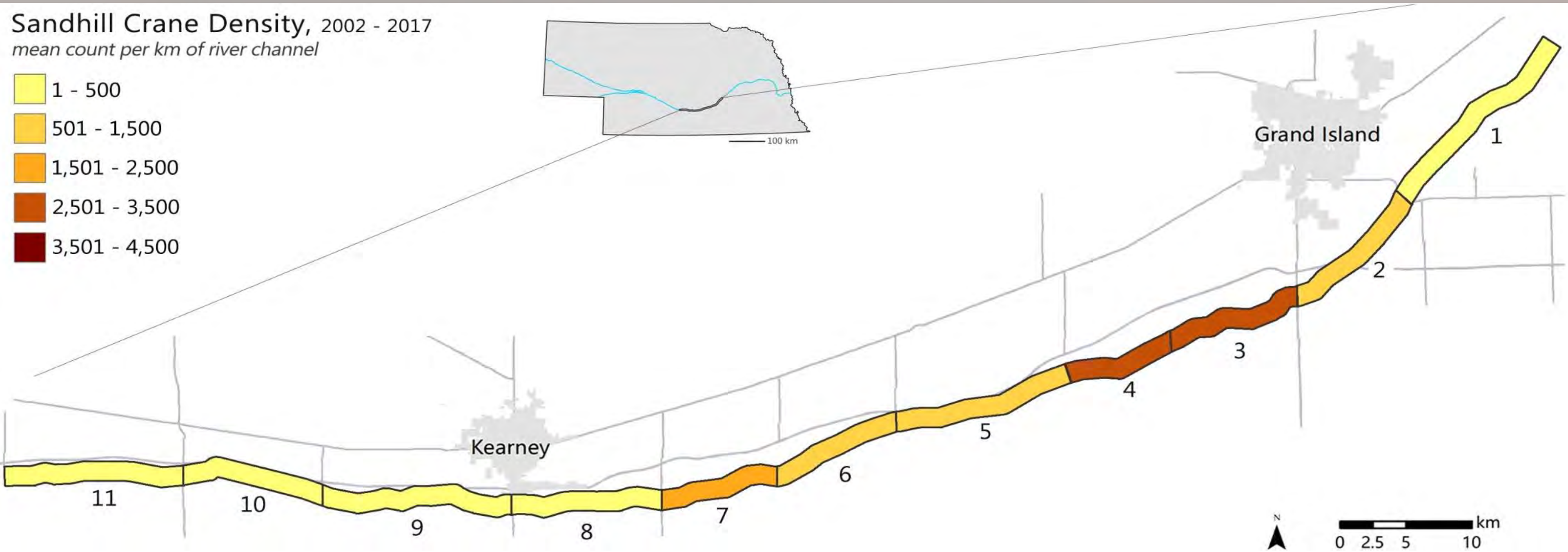
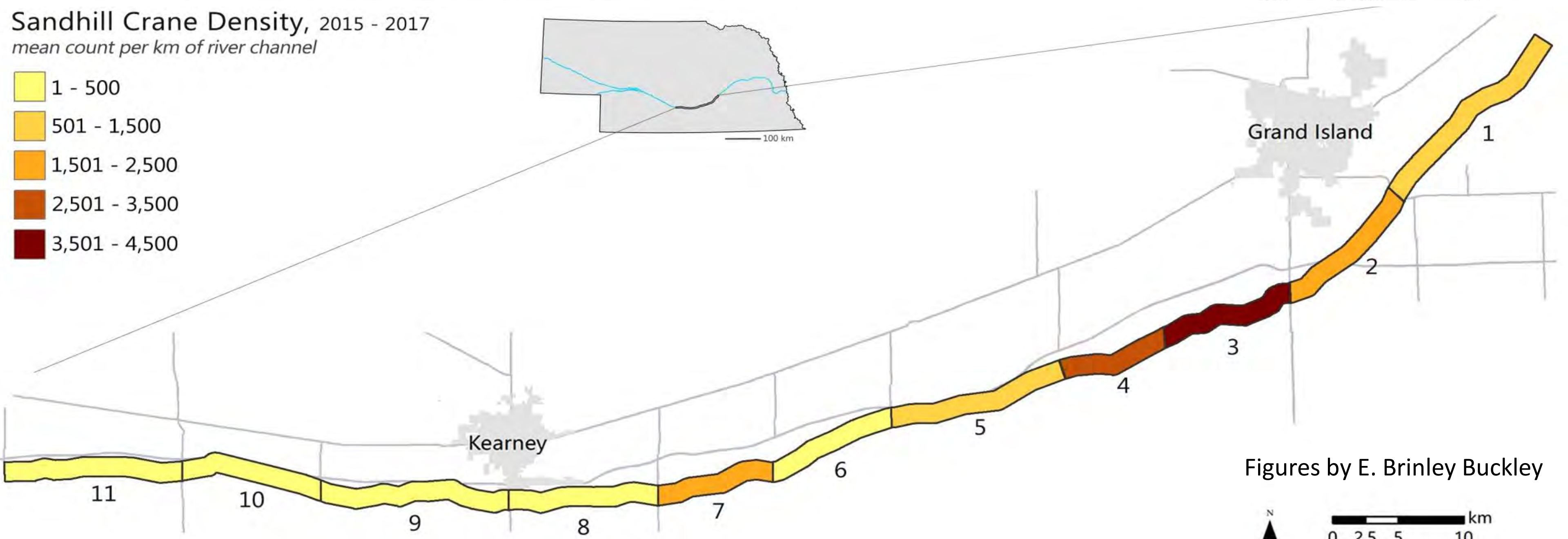


FIG. 2. First (filled circles) and last (open circles) observations of Sandhill Cranes (*Grus canadensis*) by year in Nebraska, USA, reported as days relative to January 1, between 1914 and 2013. Arrival dates show a significant, decreasing trend over period of record ($y = 2.829e{+}04 - (2.811e{+}01)x + (6.990e{-}03)x^2$; $r^2 = 0.62$; $P < 0.001$).

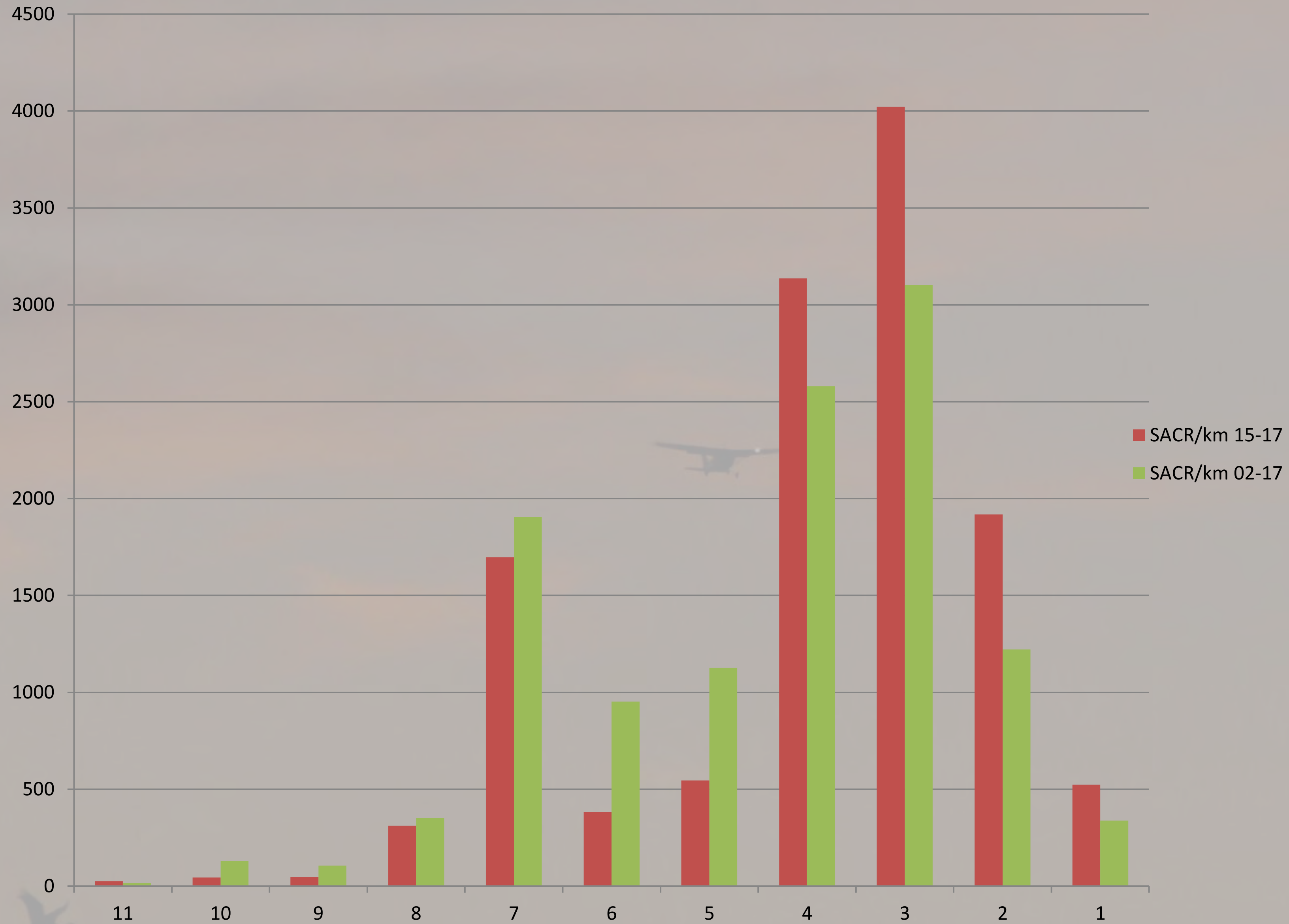
Sandhill Crane Density per km in the CPRV 2002-2017 and 2015 to 2017





Figures by E. Brinley Buckley

SACR density per km per bridge segment comparison between 2002-2017 and 2015 to 2017



Changing Densities of the Eastern, Central, and Western Reaches of the CPRV

Reach	Seg.	*x*/km 02-17	*x*/Prop. 02-17	*x*/km 15-17	*x*/Prop. 15-17
East	1-4	1,568	59.6%	2,107	75.8%
Center	5-7	1,288	33.8%	812	20.3%
West	8-11	141	5.7%	100	4.0%

Bivariate ordinary least squares linear regression models for trends in the proportion of Sandhill Cranes per bridge segments (1-11) and river reach, east (1–4), central (5–7), and west (8–11) by survey year

Reach segment	**DV**	***B***	**SE**	***t***	***p***	***R-square***	**Df**
East	Prop.	0.0233	0.0028	8.25	0.001***	0.850	12
1	Prop.	0.0049	0.0020	2.51	0.027*	0.344	12
2	Prop.	0.0023	0.0024	0.99	0.343	0.075	12
3	Prop.	0.0135	0.0029	4.63	0.001***	0.641	12
4	Prop.	0.0025	0.0018	1.39	0.190	0.138	12
Center	Prop.	-0.0200	0.0035	-5.76	0.001***	0.735	12
5	Prop.	-0.0116	0.0021	-5.56	0.001***	0.720	12
6	Prop.	-0.0072	0.0017	-4.15	0.001**	0.589	12
7	Prop.	-0.0011	0.0021	-0.54	0.601	0.023	12
West	Prop.	-0.0021	0.0010	-1.98	0.071	0.246	12
8	Prop.	-0.0007	0.0006	-1.19	0.256	0.101	12
9	Prop.	-0.0013	0.0004	-3.12	0.009**	0.449	12
10	Prop.	-0.0001	0.0005	-0.20	0.846	0.003	12
11	Prop.	0.00004	0.0002	0.28	0.784	0.006	12

Putting our results in context: Distributions constructed from the peak of migration, and with older data (here 2000-2003 and 2005), do not represent full use throughout the staging period.

Krapu et al 2014. Wildlife Monographs 189:1-41

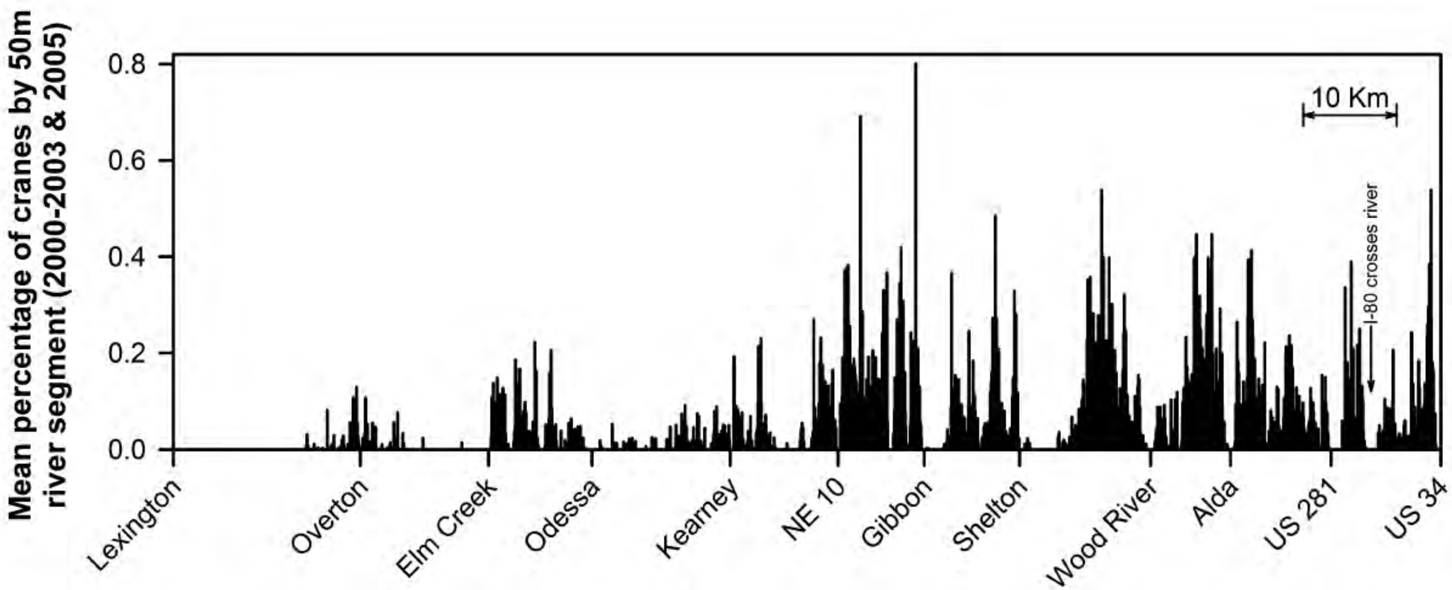


Figure 11. Average percentage of sandhill cranes of the Mid-Continent Population by 50-m intervals in the main channel of the Platte River during their spring stopover in the Central Platte River Valley, Nebraska, 2000–2003, 2005. We determined nocturnal roost distribution from aerial infra-red videography at night between 1200 and 0300 hours while cranes were on their nocturnal roosts during the last week of March at the peak of spring staging. Each tick mark shown on the *x*-axis above the location of a town, city, or highway identifies location of a bridge over the main channel of the Platte River.

Putting our results in context: A long trend

Faanes & LeValley. 1993. Great Plains Research 3:297-304.

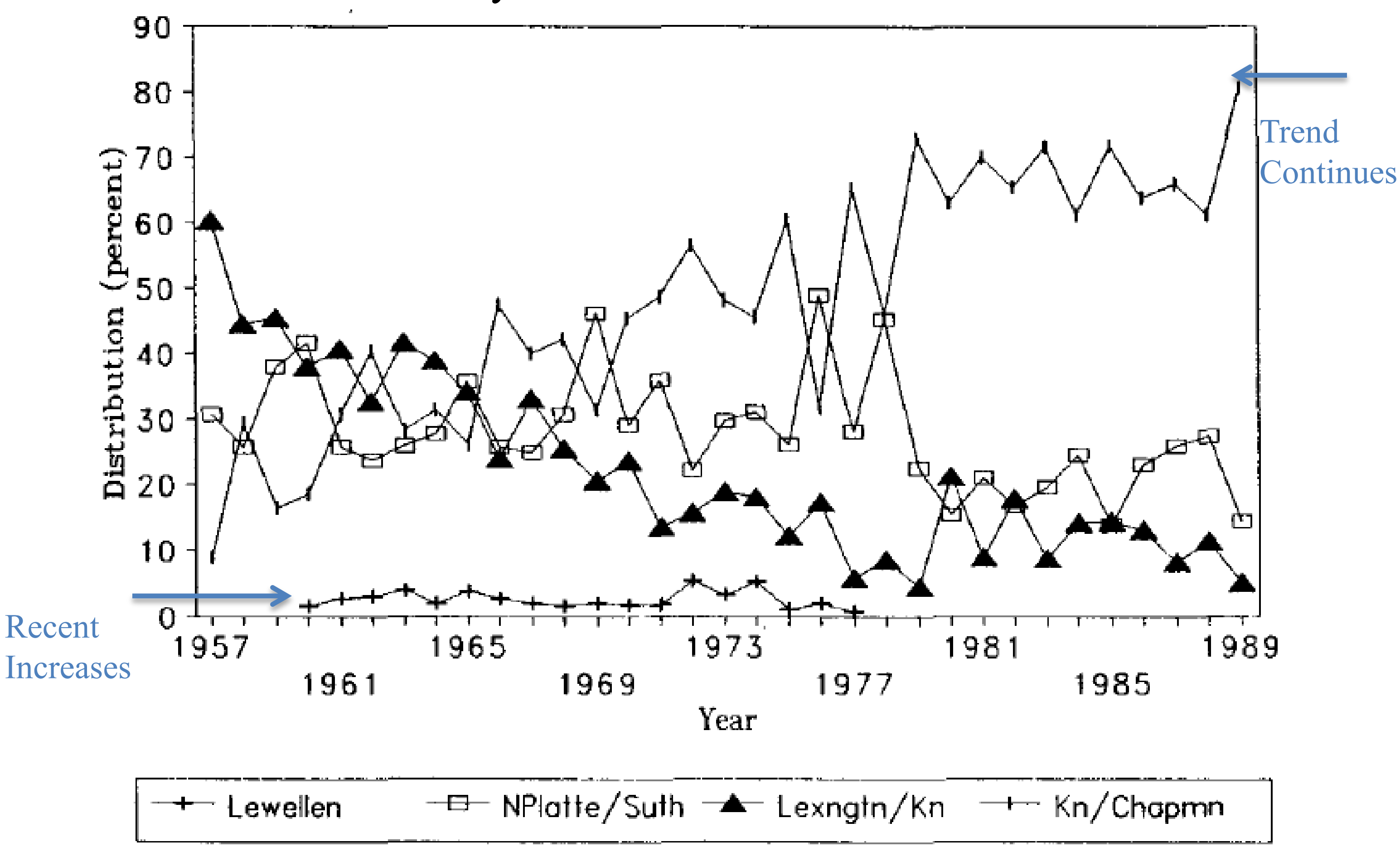
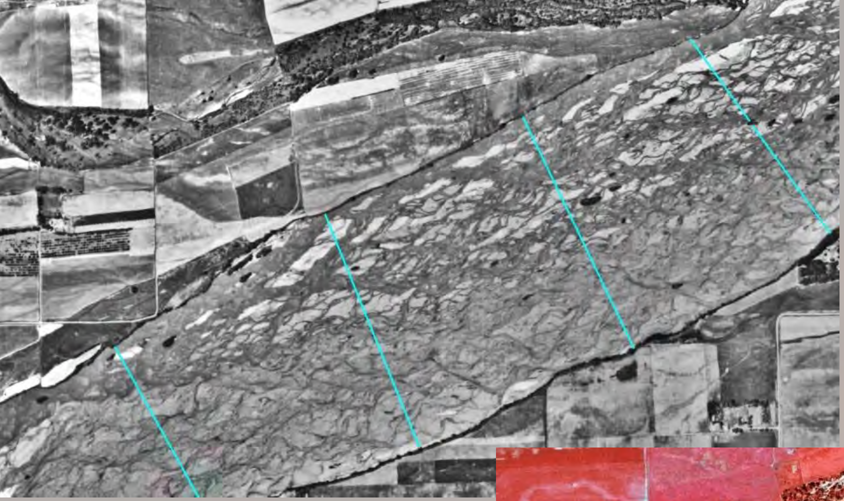
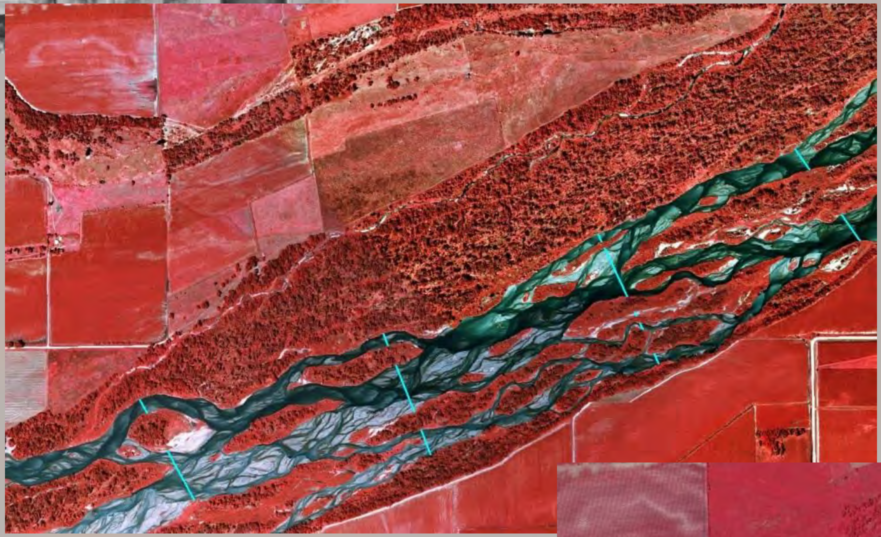


Figure. 1. Changes in the number of sandhill cranes occupying various Platte River staging areas, 1957 - 1989.

Unobstructed (UOCW) and Maximum Unobstructed Channel Width (MUCW) measurements



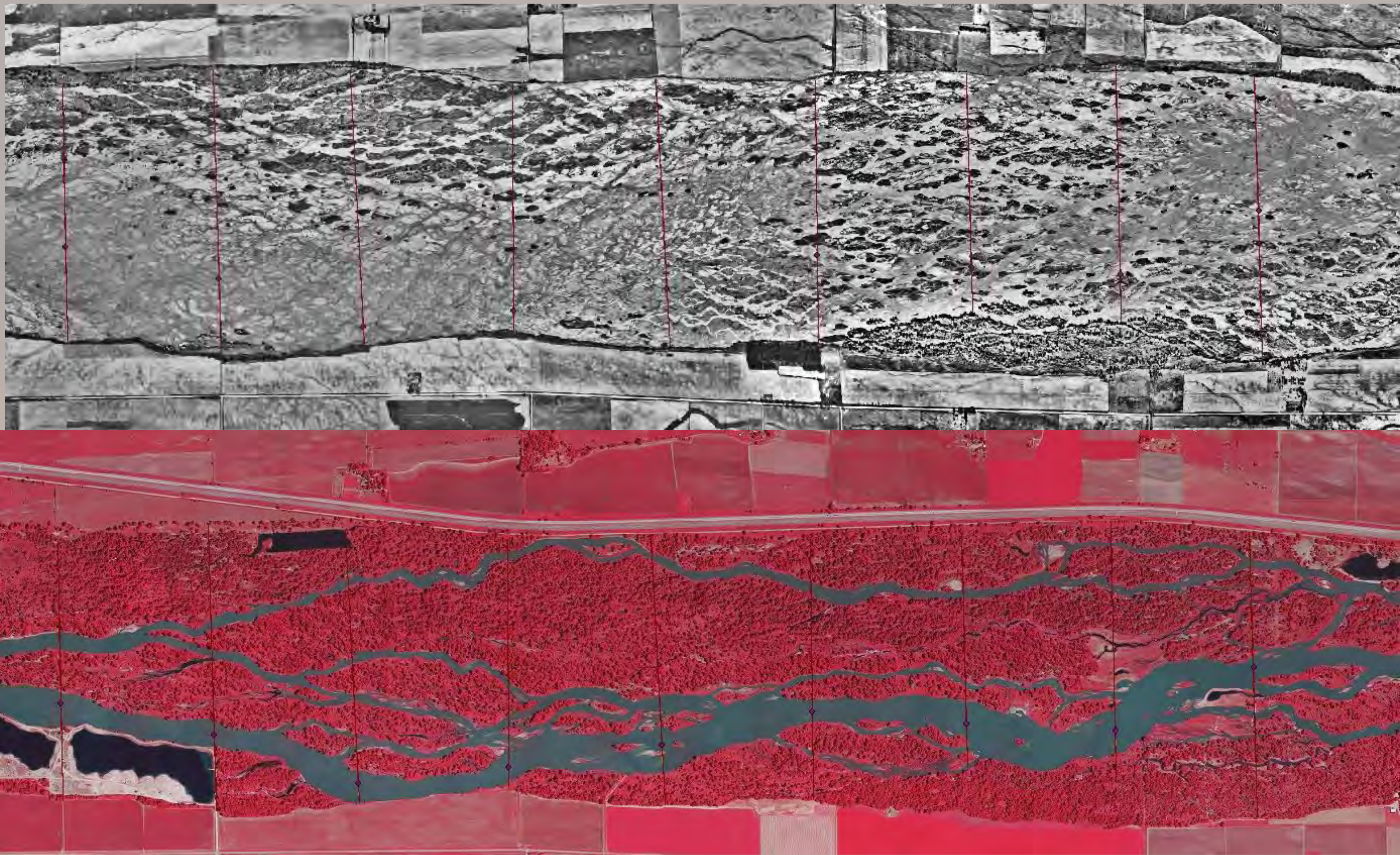
1938

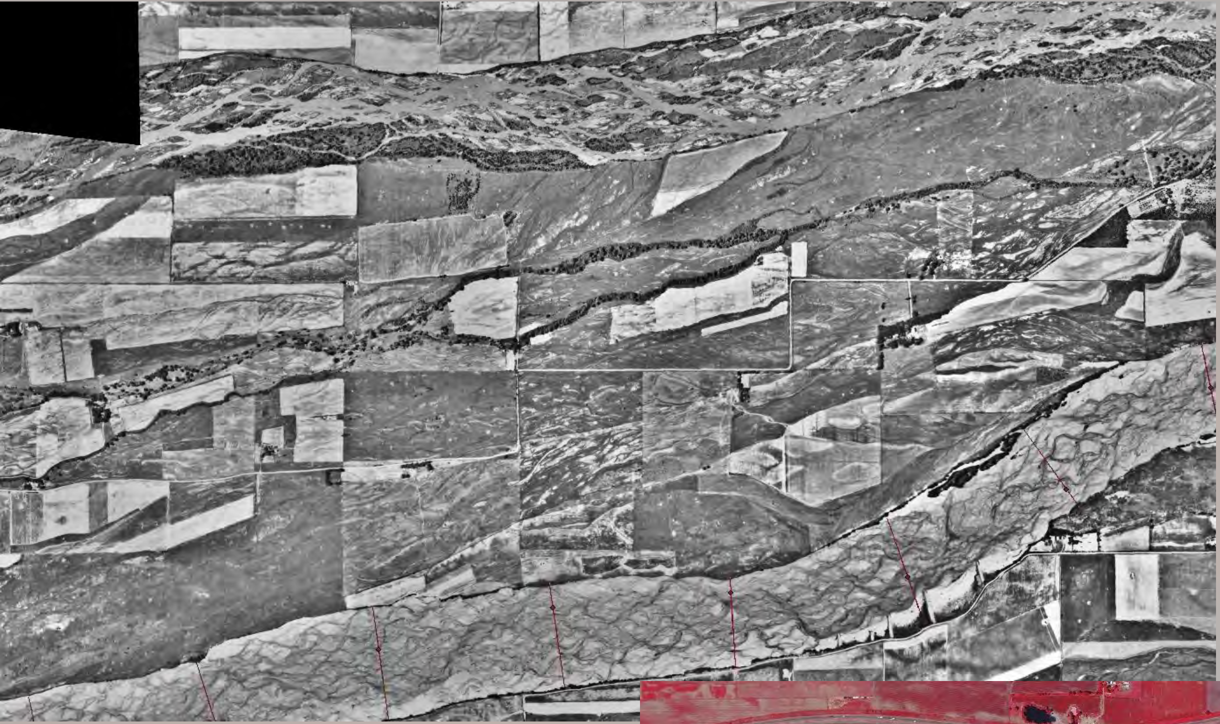


1998

2016

Increasing Number of Channels and Drastically Decreasing Unobstructed Channel Widths (e.g., Segment 9)





Decreasing Number of Channels and Moderate Decreasing Unobstructed Channel Widths (e.g., Segment 7)

Wet Meadow

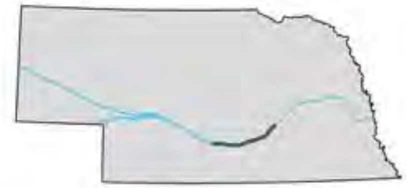
Foraging

Social Behavior

Proportion change in total and maximum unobstructed channel width

Wet Meadow-Tallgrass Prairie & Woodland Habitat
Central Platte River Valley, Nebraska

*Landcover classification from 2016 imagery within 800m of the main channel of the Platte River



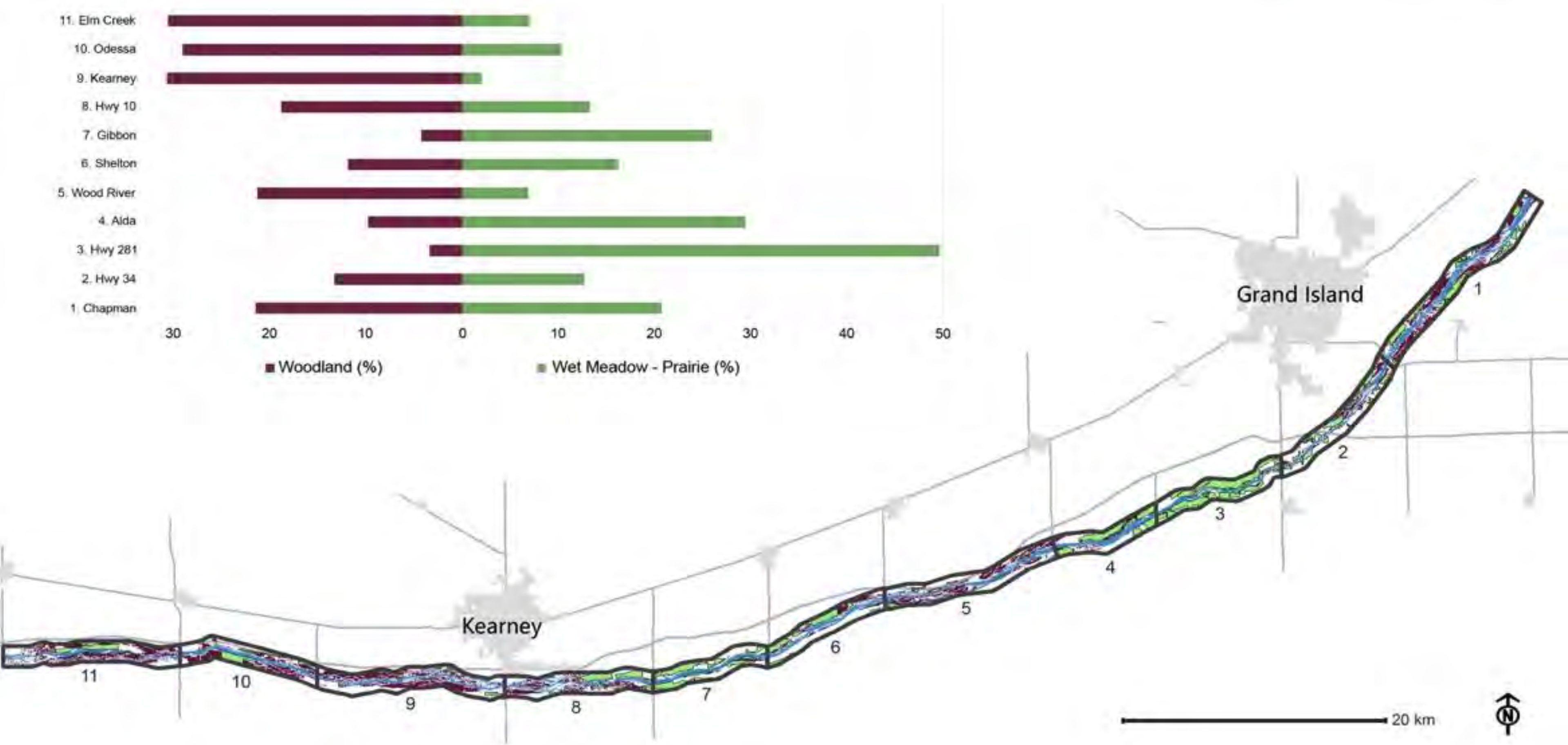
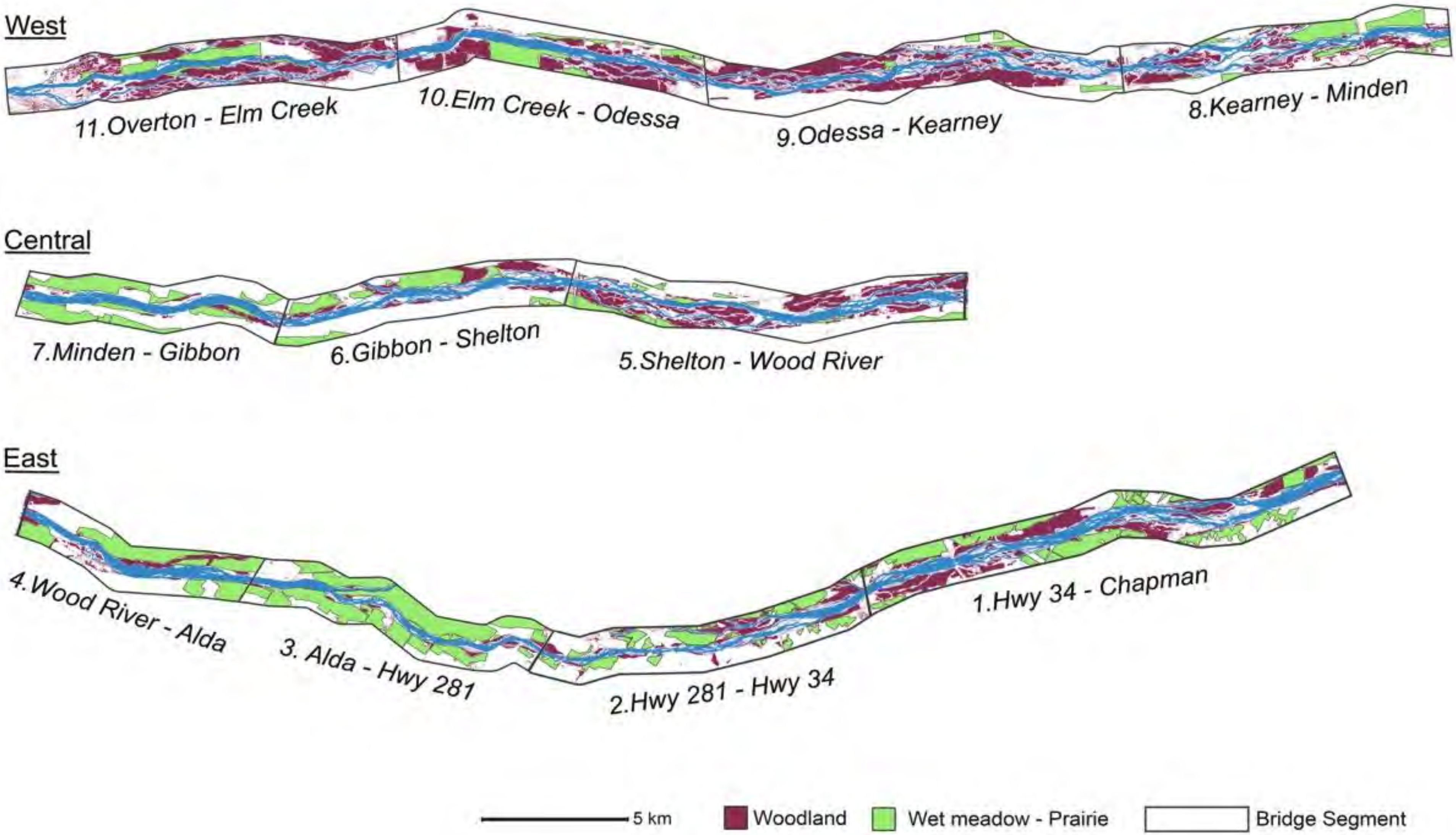


Figure by E. Brinley Buckley

Meadow-Prairie, Woodland-Forest, and River landcover classes within eastern, central, and western reaches of the CPRV



E. Brinley Buckley 2018

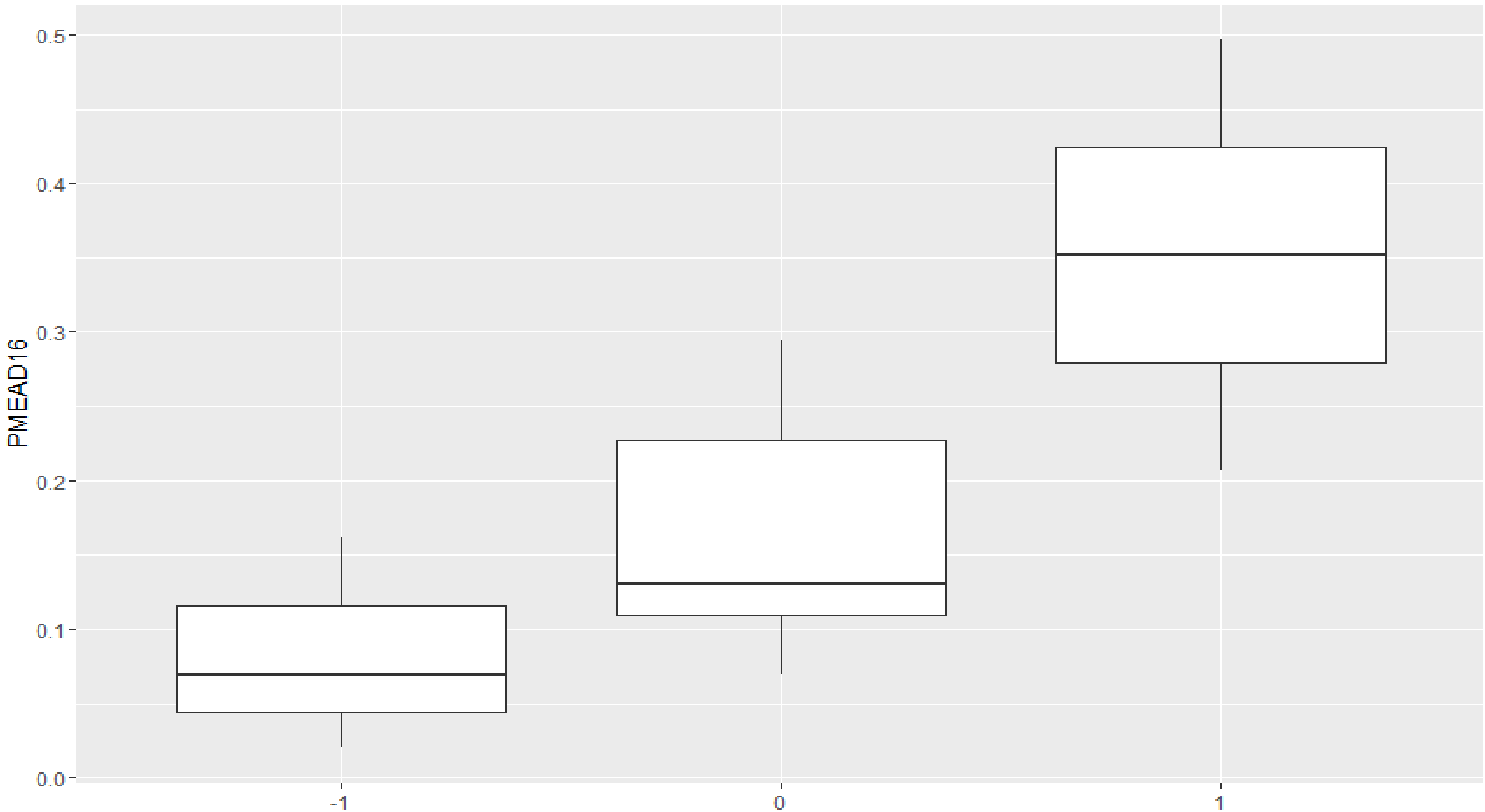
Analysis of land cover characteristics and channel width measurements on SACR habitat use

- Sandhill Crane abundance metrics (DVs):
  - Trend in proportional use per bridge segment from 2002–2017 (Trend)
  - $\bar{x}$ proportional use per bridge segment from 2015–2017 ($\bar{x}$ Prop.)
  - $\bar{x}$ density per km observed per bridge segment from 2015–2017 ($\bar{\bar{x}}$/km)
- Habitat Metrics: ArcGIS 10.5.1 (heads up and supervised classification)
  - Longitude (E-W): median longitude
  - Δ UOCW 1938-2016: % change in unobstructed channel width from 1938-2016
  - Δ MUCW 1938-2016: % change in maximum unobstructed channel width from 1938-2016
  - Δ No. Active Channels: % change in the number of active channels 1938-2016
  - Δ UOCW 1998-2016: % change in unobstructed channel width from 1998-2016
  - Δ MUCW 1998-2016: % change in maximum unobstructed channel width from 1998-2016
  - $\bar{x}$ UOCW 2016: mean unobstructed channel width in 2016
  - $\bar{x}$ MUCW 2016: mean maximum unobstructed channel width in 2016
  - % Woodland 2016: % woodland within 800 m of the main channel in 2016
  - % Meadow 2016: % meadow-prairie within 800 m of the main channel in 2016
  - Δ Meadow 1998-2016: % change in meadow-prairie from 1998-2016
  - % Conservation 2016: % of land managed by conservation organizations within 800 m of the main channel
- Analysis:
  - GLMs compared via AICc for proportional use and density analyses
  - Ordered logistic regression model with a cumulative "probit" link function used to predict SACR trend per segment from 2002-2017 (-1= negative, 0= no trend, 1= positive)
  - Thirty-nine total models including one null model for each DV; all models bivariate

Model selection table: GLMs and CLMs of channel width and landcover per segment in relation to the density, proportional use, and trend in SACR use.

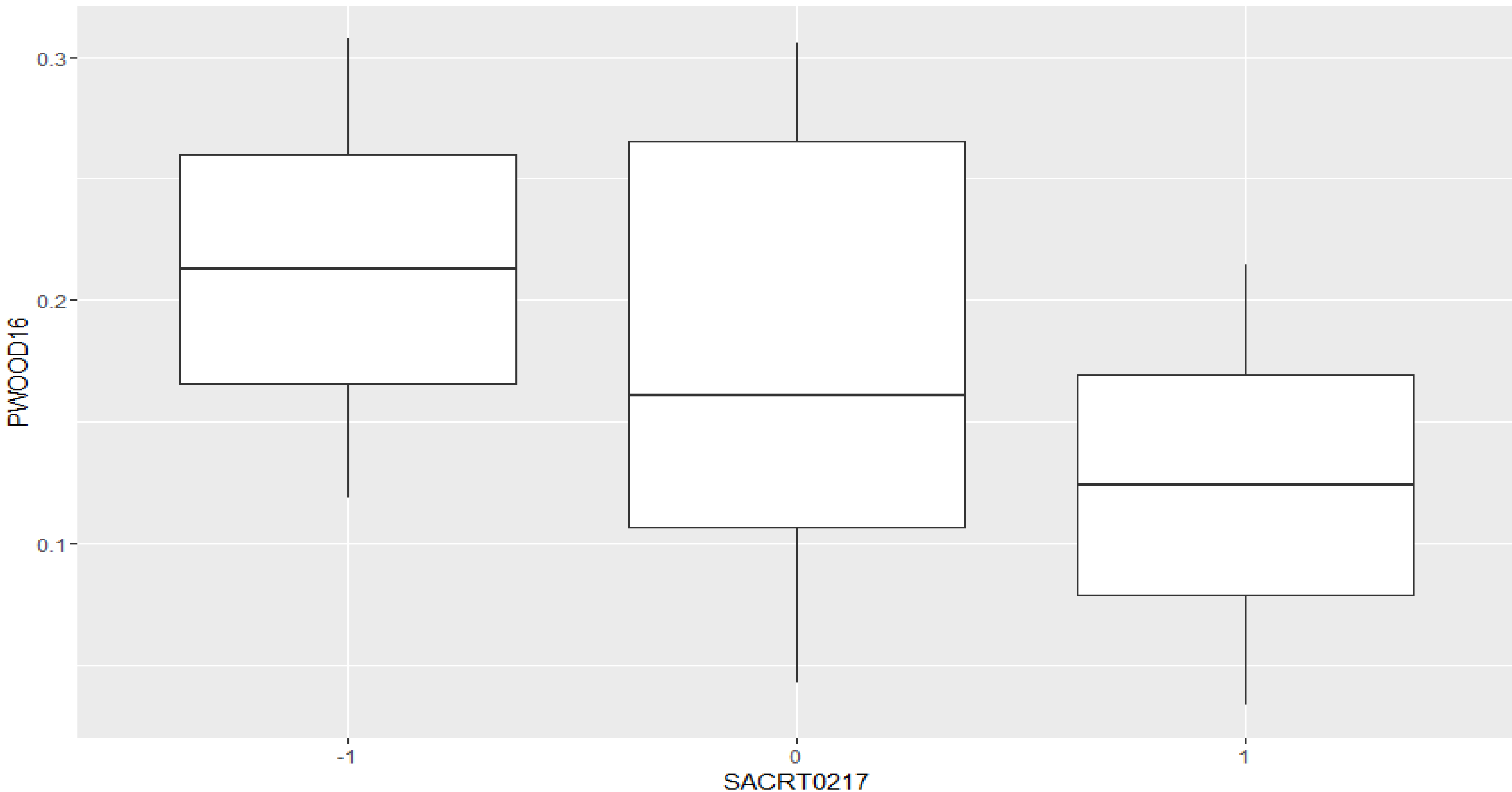
Dep. Var.	**Coef.**	***β***	**SE**	***t/z***	**Log Lik.**	**AICc**	**Δ**	**wt.**
$\bar{x}$ SACR/km$^{2015\text{-}17}$	Δ UOCW$^{1938\text{-}2016}$	5,840.2***	818.7	7.1	-84.1	177.7	0.00	0.81
	Δ MUCW$^{1938\text{-}2016}$	5,590.5***	988.4	5.7	-82.1	178.8	1.14	0.10
$\bar{x}$ Prop. SACR$^{2015\text{-}17}$	Δ UOCW$^{1938\text{-}2016}$	0.41***	0.07	5.5	18.2	-26.9	0.00	0.48
	p Meadow-Prairie^{2016}	0.66***	0.12	5.4	18.0	-26.6	0.30	0.41
Trend SACR$^{2002\text{-}17}$	*p* Meadow-Prairie^{2016}	1.27*	0.64	1.9	-7.6	24.7	0.00	0.42

Proportion of land cover within 800 m of the main channel of the Platte River classified as meadow-prairie (PMEAD16) by statistical trend in SACR proportional use (-1, 0, or 1).

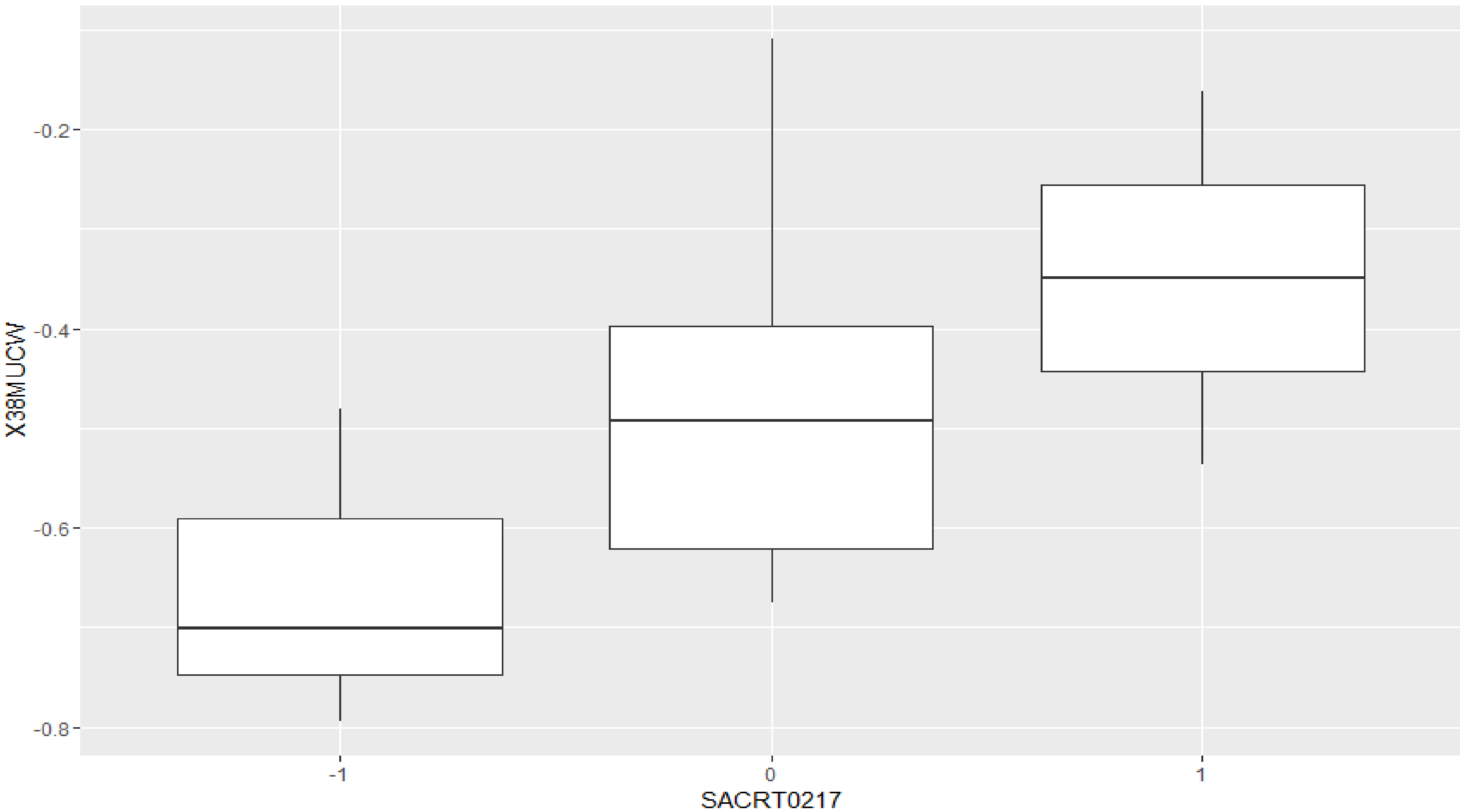


Trend in Proportional Use by Sandhill Cranes

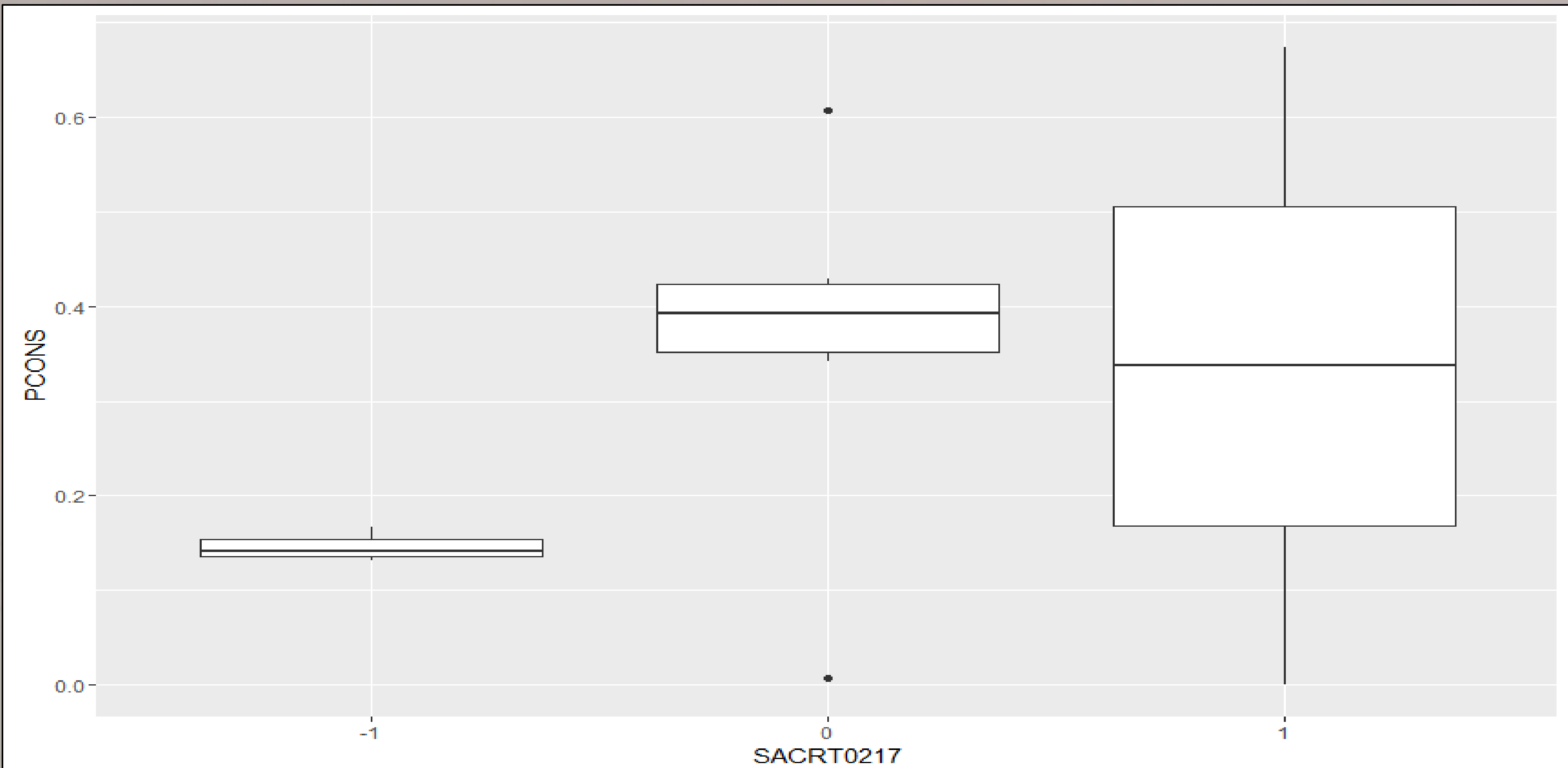
Proportion of land cover within 800 m of the main channel of the Platte River classified as woodland in 2016 (PWOOD16) by statistical trend in SACR proportional use (-1, 0, or 1).



Percent change in the maximum unobstructed channel width (X38MUCW) from 1938 to 2016 on the main channel of the Platte River by statistical trend in SACR proportional use (-1, 0, or 1).



Proportion of land within 800 m of the main channel of the Platte River owned or managed by conservation organizations (PCONS) by statistical trend in SACR proportional use (-1, 0, or 1).



Conclusions and Management Implications

- Temperatures and drought conditions at wintering locations heavily used by Greater Sandhill Cranes (*A. c. tabida*) best predicted migration chronology of the MCP to the CPRV

- The proportion of width reduction in the main channel since 1938 –not its absolute width in 2016– and the proportion of land cover as prairie-meadow within 800 m of the Platte River best predicted the spatial distribution of roosting Sandhill Cranes from 2015 to 2017 and the trend per segment from 2002 to 2017

- Sandhill Cranes advanced their migration just over one day per year from 2002 to 2017.

- Sandhill Cranes continued to shift east concentrating in eastern reaches of the CPRV and expanding their range eastward.

- Climate change, land use change, and habitat loss together have led to Sandhill Cranes coming earlier and staying longer in fewer reaches of the CPRV, increasing their site use intensity.

- Conservation actions (river disking, prairie restorations, etc.) may be maintaining Sandhill Crane densities in areas that would otherwise be declining in use.

- Management efforts since 1998 have likely not been large enough in spatial scale to redistribute Sandhill Cranes throughout the CPRV.

- Higher site use intensity will likely put additional pressure on agricultural foraging resources and increase the disease risk for cranes and other water bird species that overlap in wetland habitat use, including Whooping Cranes.

Questions?

Contributions From:

Research conducted by the Crane Trust. Financial support from the Crane Trust and the Rainwater Basin Joint Venture. Staff contributions from all organizations listed. A special thanks to G. Wright, R. McLean, B. Krohn, and K. King for their logistical support, and A. Bishop and the RWBJV for their continued financial support. Also, a big thanks to E. Brinley Buckley for support in data management and GIS analysis and R. Grosse for supplying imagery. Finally, thanks to all the pilots that have supported our efforts.

CRANE TRUST

RAINWATER BASIN JOINT VENTURE

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

USGS science for a changing world

UNK®