Summary of Research and Recommendation for Weight and Distance for Powerlines and Towers

Improvement Recommendation

Disturbance Type	Disturbance Subtype	Weight	Distance
Powerlines	Distribution – Monopole, no cross members	25%	6km
Powerlines	Transmission – High Voltage	75%	6km
Towers	--	75%	6km

Summary of Transmission Line Research

Reference	Sage-grouse Avoidance of PLs	Impact on Sage-grouse Demographics
Gillian et al. 2013	SG avoidance within **600m** of transmission lines (138kv) in ID	
Pruett et al. 2008	Prairie chickens avoided PLs by at least **100m**	
Braun 1998	Avoidance of TLs within **600m** based on pellet transects	
Hanser et al. 2011	Avoidance of TLs within **500m** based on pellet transects in WY	
Hansen et al. 2013	SG Home ranges were negatively influenced (avoided) by presence of 345-500kv transmission lines	
Gibson et al. 2015	Nest site selection was lower within **10.5km** of the FG line	Nests within **8km** of FG line had reduced nest success
Gibson et al. 2015		Population growth rate declined by 3% within **10km** of the FG line
Gibson et al. 2015		Pre-fledging chick survival increased by 1.7% for every 1km increased distance from FG line
Dinkins et al. 2014		Increased female mortality with increased density of powerlines
Wisdom et al. 2011		Distance to TLs and cell towers strongly associated with SG extirpation – within **6km** of TLs and **12km** of cell towers
LeBeau et al. 2014		Did not find a negative impact of PLs on nest success, nest success increased closer to PLs, but with very large confidence intervals

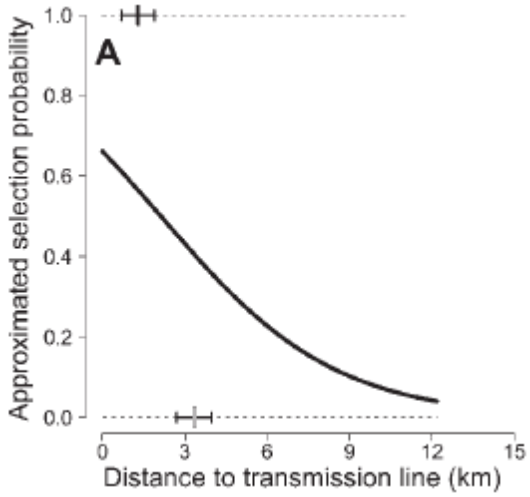
Reference	Raven Impact – Distance	Probability of Occupancy (Nesting/Resident)
Howe et al. 2014		31% decrease in probability of raven nest for every 1km increase in distance from TL
Coates et al. 2014a,b	Within **2.2km** of powerline was the most significant effect of raven presence, but observed increased raven occurrence out to **27km**	**80%** (53% TLs; 17% cell towers; 4% nesting platforms)
Bui et al. 2010	**3km** - Relative to Anthropogenic disturbance, most influence distance	**90%** (78-98%) – Relative to Anthropogenic disturbance
Gibson et al. 2015	Linked impacts on sage-grouse behavior and demographics to indirect effects of raven colonization and population increase of the FG line out to **10km**	

Literature Referenced

Raven Abundance/Occupancy on or Near Powerlines

Howe, K.B., Coates, P.S., and Delehanty, D.J. 2014. Selection of anthropogenic features and vegetation characteristics by nesting common ravens in the sagebrush ecosystem. The Condor 116: 35–49.

- Found that ravens selected nest sites in close proximity to transmission lines. They found 31% decrease in odds of nesting by ravens for every 1 km increase in distance away from a transmission line.



Coates, P.S., Howe, K.B., Casazza, M.L., and Delehanty, D.J. 2014. Common raven occurrence in relation to energy transmission line corridors transiting human-altered sagebrush steppe. Journal of Arid Environments 111: 68-78.

- Determined the probability of raven occurrence in relation to transmission had the most significant effect within approximately 2.2km of transmission lines, but the effect was seen out to 27km.

Coates, P.S., Howe, K.B., Casazza, M.L., and Delehanty, D.J. 2014. Landscape alterations influence differential habitat use of nesting buteos and ravines within sagebrush ecosystem: Implications for transmission line development. The Condor 116: 341-356.

- Found that the probability of a raven nesting on anthropogenic structures was 80%, which consisted of transmission lines (53%), cooling towers, single radio-communication and cell towers (16.5%), and nesting platforms (4.1%)

- Transmission line structure ranged from 12.5 to 230 kv of primarily wooden poles with double cross arms ranging in height from 15 to 21 m. Distribution line poles were also wooden poles ranging in height from 15 to 16.8m. This is the same for the previously mentioned Coates and Howe studies. All results are based on both structure types.

Steenhof, K., Kochert, M.N., and Roppe, J.A. 1993. Nesting by raptors and common ravens on electrical transmission line towers. Journal of Wildlife Management 57(2): 271–281.

- Increased nesting by raptors (34%) and ravens (80%) following construction of a 500kv transmission line in Oregon and Idaho over 9 years, .22 nesting pairs/km.

Raven Predation on Sage-grouse Nests

Coates, P.S., Connelly, J.W., and Delehanty, D.J. 2008. Predators of Greater sage-grouse nests identified by video monitoring. Journal of Field Ornithology 79(4): 421–428.

Coates, P.S., and Delehanty, D.J. 2010. Nest predation of greater sage-grouse in relation to microhabitat factors and predators. Journal of Wildlife Management 74(2): 240–248.

- Identify ravens as the primary nest predator of sage-grouse nests.
- Nest depredation by ravens increased with less shrub cover (lower quality habitat) immediately surrounding the nest site
- Found that an increase of 1 raven per 10km of survey transects in sage-grouse nesting areas resulted in 7.4% increase in odds of sage-grouse nest failure

Coates, P.S. and Delehanty, D.J. 2008. Effects of environmental factors on incubation patterns of greater sage-grouse. The Condor 110:627–638.

- Recess duration and raven abundance were correlated, longer recesses increased chance of a nest being depredated by a ravens, especially during nautical twilight periods

Lockyer, Z.B., Coates, P.S., Casazza, M.L., Espinosa, S. and Delehanty, D.J. 2013. Greater sage-grouse nest predators in the Virginia Mountains of Northwestern Nevada. Journal of Fish and Wildlife Management 4(2): 242–254.

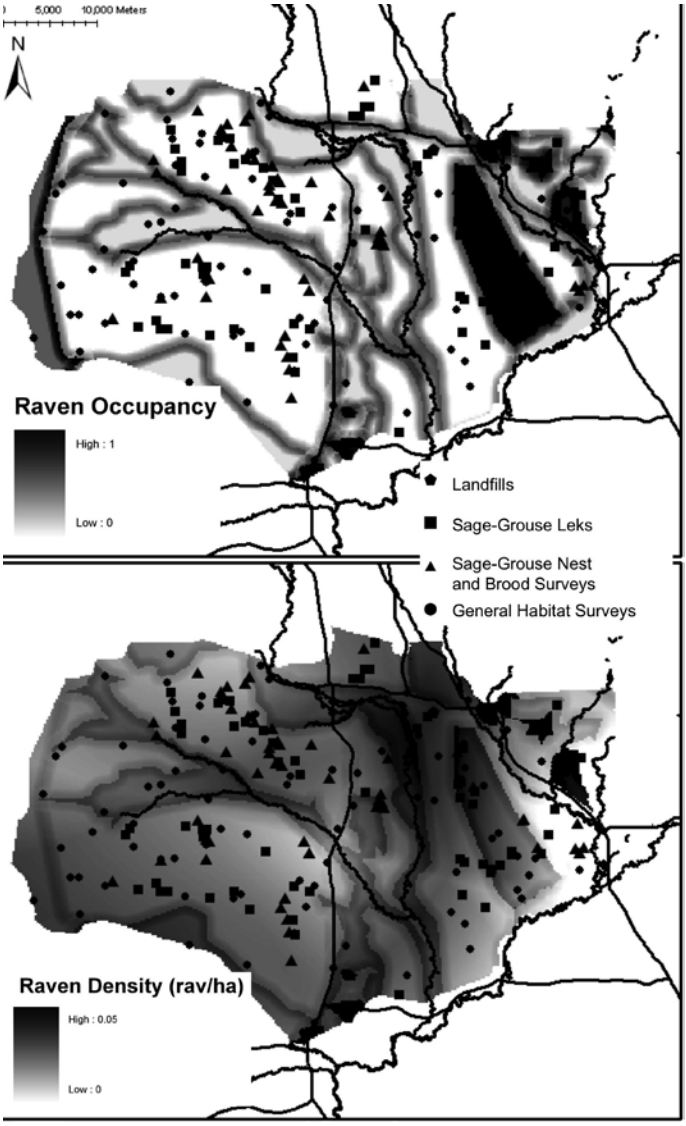
- 50% of sage-grouse nest depredations were by ravens in the Virginia Mountains study area in Northwestern Nevada

Bui, T.D., Marzluff, J.M., and Bedrosian, B. 2010. Common raven activity in relation to land use in western Wyoming: Implications for greater sage-grouse reproductive success. The Condor: 112(1):65–78.

- Sage-grouse nest survival in a Wyoming study was more affected by occupancy (e.g. nesting territorial pairs) than raven density (e.g. non-territorial/breeding, nomadic ravens)
- Raven density highest in cities/urban areas and dropped sharply at about 3km
- Raven density was significantly greater at locations near nests and brood locations
- Suggests breeding resident ravens were responsible for the majority of sage-grouse nest depredations, and increased occupancy in areas with less human activity (oil fields and other

anthropogenic structures across the landscape) may negatively affect locally breeding populations

- Increased raven occupancy may be a factor lowering productivity in the study area where females did not reach 2.25 juveniles per female to ensure long term population persistence (Connelly and Braun 1997)
- Raven probability of occupancy (nesting) ranged from 78% - 98% (average 90%) within 400m of oil development, cities, and roads



This figure shows raven occupancy (nesting) closely associated with rights-of-ways (roads and powerlines) and urban areas.

Effects of Powerlines on Sage-grouse Populations - Avoidance

Gillian, J.K., Strand, E.K. Karl, J.W., Reese, K.P., and Laninga, T. 2013. Using spatial statistics and point-pattern simulations to assess the spatial dependency between greater sage-grouse and anthropogenic features. Wildlife Society Bulletin 37:301–310.

- Showed avoidance of sage-grouse within 600m of transmission lines (>138kv) in west-central Idaho, 150m avoidance of buildings and no detectable avoidance of minor and major roads. Did not collect demographic information, only based on movement patterns

Hansen, E.P., Stewart, A.C., and Frey, S.N. 2016. Influence of transmission line construction on winter sage-grouse habitat use in southern Utah. Human-Wildlife Interactions 12(2): 169–187.

- Studied effects of a 345 kv line construction on sage-grouse movement, an existing 500kv line ran parallel to the new line at about 450m distance.
- Found that power line presence negatively influenced sage-grouse winter habitat use, particularly with increases in salt-desert scrub cover
- Did not find a difference in use/avoidance between pre-construction data of the 345kv line and post construction.
- Did not look at demographic rates

Braun, C.E. 1998. Sage-grouse declines in western North America: what are the problems? Proceedings of the Western Association of State and Wildlife Agencies 78:139–156.

- Pellet transects surrounding powerlines showed sage-grouse use decline within 600m of powerlines

Hanser, S. E., C. L. Aldridge, M. Leu, M. M. Rowland, S. E. Nielsen, and S. T. Knick. 2011. Greater sage-grouse: general use and roost site occurrence with pellet counts as a measure of relative abundance. Pages 112–140 in S. E. Hanser, M. Leu, S. T. Knick, and C. L. Aldridge, editors. Sagebrush ecosystems conservation and management: ecoregional assessment tools and models for the Wyoming Basins. Allen Press, Lawrence, Kansas, USA.

- Probability of sage-grouse occurrence was negatively associated within 500m of powerlines based on pellet counts

Shirk, A.J., Schroeder, M.A., Robb, L.A., and Cushman, S.A. 2015. Empirical validation of landscape resistance models: insights from the greater sage-grouse (Centrocercus urophasianus). Landscape Ecology DOI 10.1007/s10980-015-0214-4.

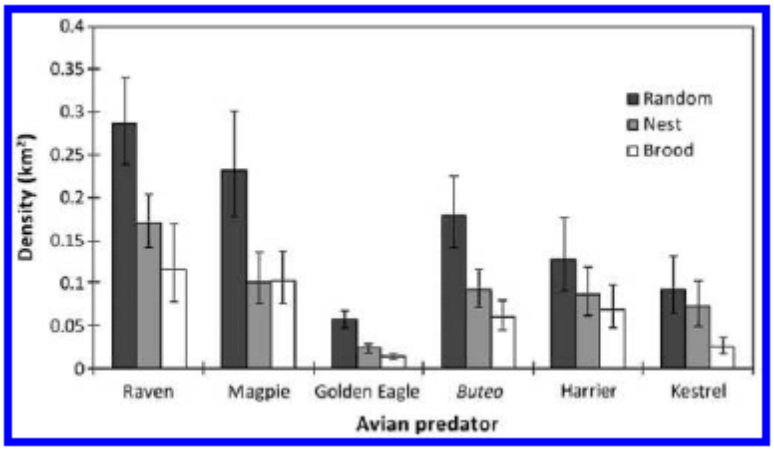
- Resistance models parameterized by expert opinion that were developed in Washington state predicted that powerlines would significantly affect sage-grouse movement, gene flow, and lek activity to distances beyond 500m.

Pruett, C.L., Patten, M.A., and Wolfe, D.H. 2008. Avoidance behavior by prairie grouse: implications for development of wind energy. Conservation Biology 23(5): 1253–1259.

- Greater and Lesser Prairie Chickens avoided power lines by at least 100m
- Both species crossed powerlines less often than if birds moved randomly. Closest nest was 201 m from powerline for Lesser and 2km for Greater
- Lesser prairie chickens home range overlapped with powerlines less than they would have randomly
- Suggests powerlines can lead to avoidance of previously suitable habitat and can act as barriers to movement
- Birds avoided powerlines more than roads in this study

Dinkins, J.B., Conover, M.R., Kirol, C.P., Beck, J.L. 2012. Greater sage-grouse (Centrocercus urophasianus) select nest sites and brood sites away from avian predators. The Auk 129(4): 600–610.

- Sage-grouse selected nest sites where there were lower densities of common ravens, golden eagles and Buteo hawks compared to random locations.



Effects of Powerlines on Sage-grouse Populations – Demographic Effects

Gibson, D, E.J. Blomberg, M.T. Atamian, S. P. Espinosa, and J.S. Sedinger. 2017. Effects of transmission lines on demography and population dynamics of greater sage-grouse (Centrocercus urophasianus).Wildlife Monographs: in review.

- Nest success increased 6% for each 5km increased distance from transmission line.
- Nests within 8km of FG line had reduced chances of hatching. Quadratic effect. Found interaction between a non-linear effect of distance to the FG transmission line and raven abundance on nest survival.

- Nest site selection increased as distance from any power line increased. Evidence of this avoidance effect (quadratic) dissipated at ~10.5km from the FG line
- Positive linear effect of distance from any power line on nest survival.
- Raven abundance – increased 5-fold since the construction of the FG line in 2004 (to 2012)
- First study that demonstrates that sage-grouse avoid nesting near PLs and that the avoidance is related to abundance of nest predators.

Wisdom, M.J., Meinke, C.W., Knick, S.T., and Schroeder, M.A. 2011. Factors associated with extirpation of sage-grouse. Chapter 17 in S.T. Knick, Connelly, J.W., Braun, C.E., eds. Ecology and conservation of greater sage-grouse: a landscape species and its habitats. Studies in Avian Biology 38, University of California Press, Berkeley, CA.

- Found that mean distance to transmission of historical sage-grouse locations in extirpated range was ~6km compared to ~15km for historical locations in currently occupied range; the mean distance to cellular towers of historical sage-grouse locations in extirpated range was ~12km compared to ~21km for historical locations in currently occupied range

Johnson, D.H., Holloran, M.J., Connelly, J.W., Hanser, S.E., Amundson, C.L., and Knick, S.T. 2010. Influences of environmental and anthropogenic features on greater sage-grouse populations, 1997–2007. Chapter 17 in S.T. Knick, Connelly, J.W., Braun, C.E., eds. Ecology and conservation of greater sage-grouse: a landscape species and its habitats. Studies in Avian Biology 38, University of California Press, Berkeley, CA.

- No effects of powerlines on lek attendance were detected on a long term trends throughout sage-grouse distribution. However, this study evaluated powerlines where the majority were in place before the 1997-2007 lek trend analysis. Short term effects may have already taken place and not detected in the long term analysis.

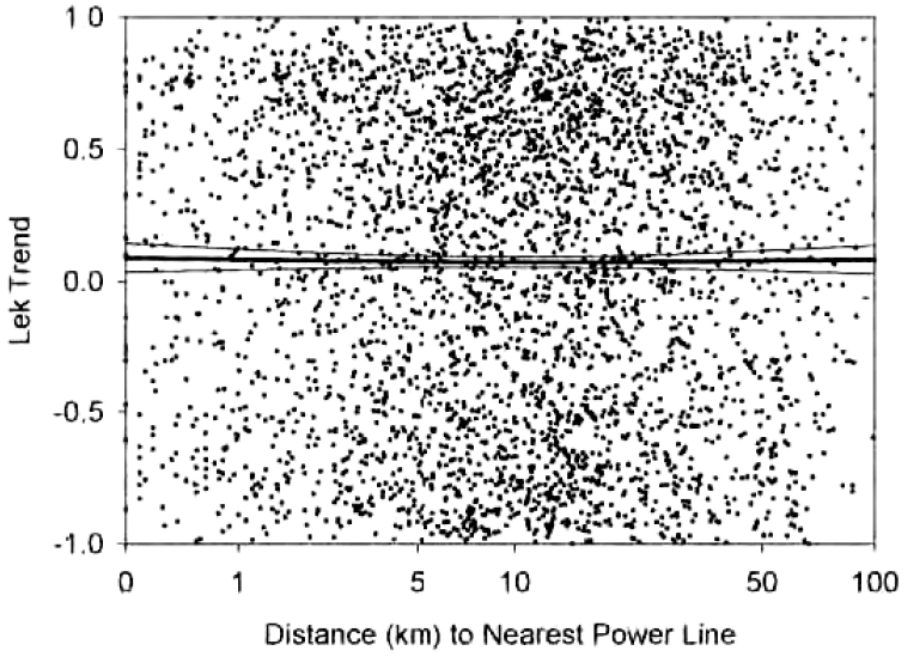


Fig. 3. Trends in annual male attendance at greater sage-grouse leks in North America between 1997 and 2007 in relation to distance to the nearest power line (Johnson et al. 2010).

LeBeau. C. W., J. L. Beck, G. D. Johnson, and M. J. Holloran. 2014. Short-term impacts of wind energy development on greater sage-grouse fitness. Journal of Wildlife Management 78:522-530.

- The risk of a nest failing decreased closer to transmission lines. However they state the relationship was not substantial due to very large 90% confidence intervals.
- Habitat quality also influenced and confounded results. Brood and nest survival were also negatively associated with a ruggedness index and lower variation in shrub cover

Dinkins, J.B., Conover, M.R., Kirol, C.P., Beck., J.L., and Frey, S.N. 2014. Greater sage-grouse (Centrocercus urophasianus) hen survival: effects of raptors, anthropogenic and landscape features, and hen behavior. Canadian Journal of Zoology 92: 319–330.

- Increased hen mortality with increased density of powerlines. Transmission and distribution lines were combined into one layer.

Avian Power Line Interaction Committee (APLIC). 2015 Best Management Practices for Electric Utilities in Sage-Grouse Habitat. Edison Electric Institute and APLIC. Washington, DC.

- Does not include any of Coates research regarding raven presence and occurrence on PLs and most recent findings from Gibson et al. (2015), however this paper is still in review and is subject to change
- Reported results from LeBeau et al. (2014) that female sage-grouse and brood survival were not influenced by distance to transmission lines
- Cited Utah Wildlife in Need (UWIN) paper " Contemporary knowledge and research needs regarding the potential effects of tall structures on sage-grouse" that reported overall there is not enough research to evaluate the impacts of tall structures on sage-grouse. However since, the publication of this report in 2010, multiple studies have been published addressing these questions.

Examples of Applied Science in Other States

U.S. Fish and Wildlife Service and Bureau of Land Management. 2015. Assessing indirect effects of transmission lines on greater sage-grouse for the Gateway West Interstate Transmission Line Project.

- Convened to assess the indirect effects of transmission lines and associated infrastructure
- Described three indirect impact zones:
    - Avoidance (600m impact zone) – recommended a 75-90% habitat services reduction
    - Increased Avian Predator Presence and Predation (600-1200m impact zone) – recommended a 20-50% habitat services reduction
    - Decreased Productivity and Survival (1200-5000m impact zone) – recommended a 5-40% habitat services reduction

Bureau of Land Management. Record of Decision for the Energy Gateway South Transmission Project, Utility Right-of-way and Resource Management Plan Amendments. December 2016.

Bureau of Land Management. Record of Decision for the TransWest Transmission Project and Resource Management Plan Amendments. BLM/WY/PL-15/012+5101, December 2016.

- Six members of a Technical Advisory Group were selected to develop a science based approach to quantify indirect effects to sage-grouse for two transmission line projects, the Energy Gateway South and TransWest. This updated the 2015 Whitepaper with latest available research
- Combined the Increase Avian Predator Presence and Predation and the Decreased Productivity and Survival zone to Decreased Population Growth, based on Gibson et al. (In Review)
    - Avoidance (600m impact zone)
    - Decreased Population Growth (0-10,000m impact zone)
- Determined habitat service loss decreased linearly from 75%

Additional Research

Raven Abundance on or Near Powerlines

Knight, R.L., Knight, H.L., and Camp, R.J. 1995. Common ravens and number and type of linear rights-of-way. Biological Conservation 74(1): 65–67.

Knight, R.L. and Kawashima, J.Y. 1993. Responses of raven and red-tailed hawk populations to linear right-of ways. The Journal of Wildlife Management 57(2): 266–271.

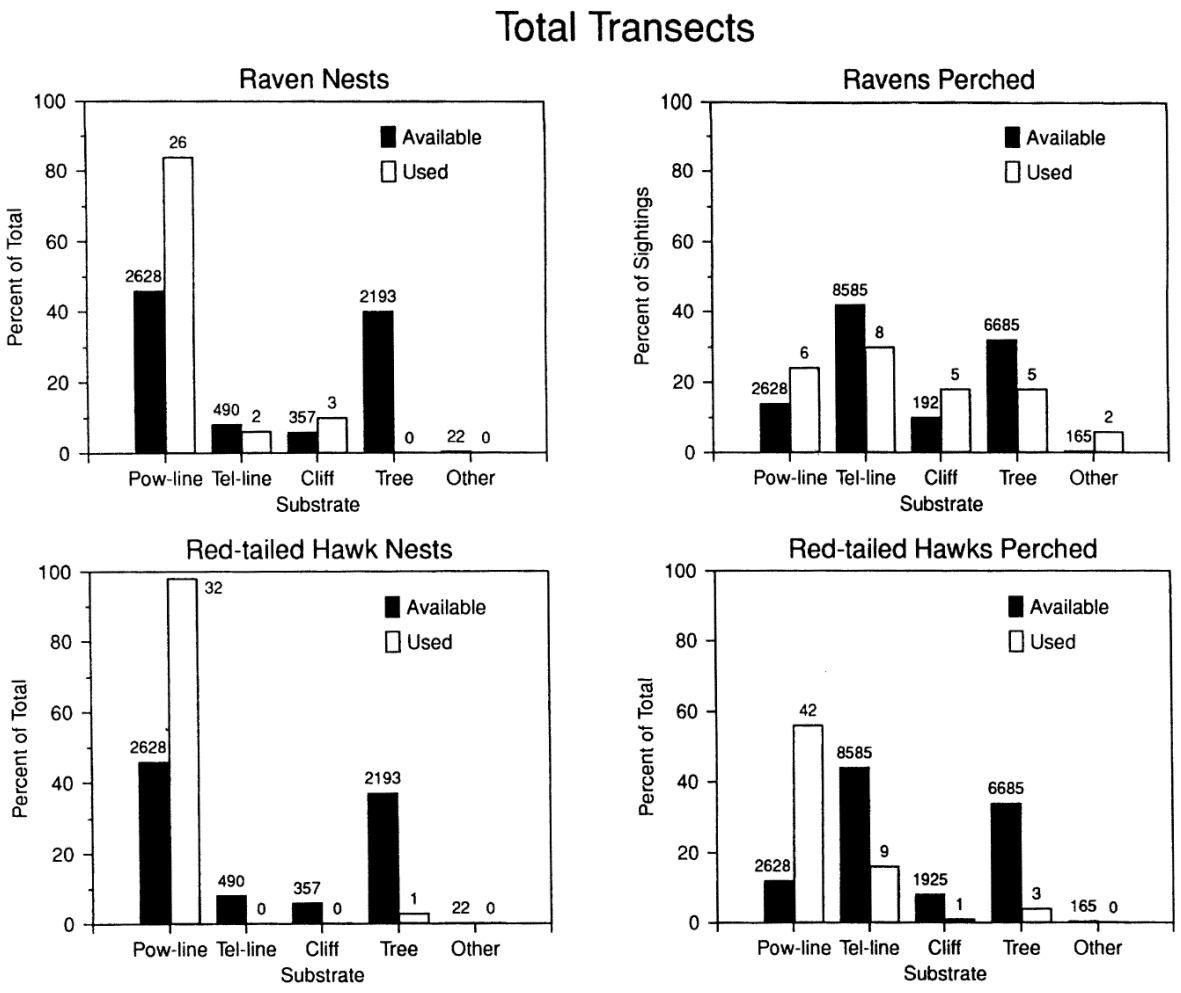


Fig. 2. Frequency distributions of common raven and red-tailed hawk nesting and perching on available nest and perch sites for all transects combined, Mojave Desert, California, 1989. Numbers above bars represent numbers of perch or nest sites available, or the number of sites used as perches or nests by ravens or red-tailed hawks.

Knight, R.L., Camp, R.J., Boarman, W.I., and Knight, H.L. 1999. Predatory bird populations in the east Mojave desert, California. Great Basin Naturalist 58(4): 331–338.

- All show a positive correlation with powerlines (higher densities on and near powerlines) and other anthropogenic subsidies in the Mojave Desert, CA

Knight, R.L. and Kawashima, J.Y. 1993. Consequences of human landscape perturbations on two bird species. Journal of Wildlife Management 57:266–271.

- Found significantly more ravens along powerlines and highways than along secondary roads or locations farther away from linear right of ways

Kristan, W.B., and Boarman, W.I. 2007. Effects of anthropogenic developments on common raven nesting biology in the west Mojave Desert. Ecological Applications 17(6): 1703–1713.

- Ravens nested disproportionally closer to anthropogenic subsides supplying food and water resources and had higher chances of nest success
- Study suggests predatory impacts of ravens can be considered a significant indirect effects of anthropogenic development

Webb, W.C., Boarman, W.I., and Rotenberry, J.T. 2004. Common raven juvenile survival in a human augmented landscape. The Condor 106: 517–528.

- Identified increased juvenile raven survival , leading to increases in local raven populations, closer to anthropogenic subsidies (e.g. urban areas, powerlines, landfills, roads, etc) in the Mojave Desert, CA

Engel, K.A., Young, L.S., and Steenhof, J.A. 1992. Communal roosting of common ravens in southwestern Idaho. Wilson Bulletin 104:105–121.

- Observed large concentrations of communal roosting on varying sizes and structure of powerlines (138 to 500kv lines) and towers were observed in Idaho
- Maximum roost numbers throughout the study period ranged from 22 to 2103 ravens from a single roost point

Effectiveness of Perch Deterrents

Slater, S.J and Smith, J.P. 2010. Effectiveness of Raptor Perch Deterrents on an Electrical Transmission Line in Southwestern Wyoming. Journal of Wildlife Management 74(5): 1080–1088.

- Cross-arm spikes and Pole Cap (Zena, Inc., Odenville, AL) resulted in an 80% reduction in perching by ravens

Figure 1. Raptor perch-deterrent devices (Zena, Inc., Odenville, AL) used on cross-arms and pole-tops of H-frame power-line support structures in southwest Wyoming, USA, in 2007.

Dwyer, J.F. and Doloughan, K.W. 2014. Testing systems of avian perch deterrents on electric power distribution poles in sagebrush habitat. Human-Wildlife Interactions 8(1): 39–55.

- Cross arm spiked deterrents were most effective in reducing perching duration from raptors and ravens (only if all horizontal surfaces were covered with spikes)
- Perch deterrents most effective on hawks – they tend to sit and wait for longer periods while hunting. Deterrents reduce perch duration, so affected hawks more than falcons or ravens.

Dwyer, F.J. and Leiker, D.L. 2012. Managing nesting by Chihuahuan ravens on H-frame electric transmission structures. Wildlife Society Bulletin. 36(2): 336–341.

- Perch deterrents (nest diverters) reduced nesting Chihuahuan ravens on transmission line by 100% (untreated: 34%, treated: 0%) and reduced nest material placement by 84% (untreated: 43%, treated: 7%)

Lammers, W.M., and Collopy, M.W. 2007. Effectiveness of Avian Predator Perch Deterrents on Electric Transmission Lines. The Journal of Wildlife Management 71(8): 2752–2758.

- Type of deterrent was a unique and experimental design. Horizontal arm deterrent constructed of 16 gauge weather steel sheet, inverted Y design with leg of Y designed to exceed grip capability for large sized raptors.
- Found that the perch deterrents of the FG line discouraged perching, but overall were not very effective. Overall shorter duration of perching due to increased difficulty, but still preferred the higher elevation that the towers provide.

Prather, P.R. and T.A. Messmer. 2010. Raptor and corvid response to power distribution line perch deterrents in Utah. Journal of Wildlife Management 74:796-800.

- Evaluated 5 perch deterrents on low voltage (12.5kv) distribution lines in Gunnison sage grouse habitat and found no difference between controls and deterrents evaluated due to inherent design and placement flaws.

BLM. 2016. Record of Decision for the Energy Gateway South Transmission Project: Utility Right-of-Way and Resource Management Plan Amendments.

- BLM required use of tubular steel H frame structures because they have reduced horizontal cross arms and are easier to manage and construct perch deterrents. However, there is no evidence to show the H frame structures are more effective at reducing perching and nesting by raptors and ravens.