Abstract

You have spent months, if not years, working on your research project, and you are finally ready to share it with the world. Next that high-impact journal article needs to be accompanied by high-impact figures. In this 30-minute presentation, we will introduce you to some tips and tricks to create journal-ready figures. While we won't cover all topics related to figure design, we will discuss the technical issues involved with turning your results into something that can be proudly displayed in print or on a computer screen.

How to Create Publication-Quality Figures

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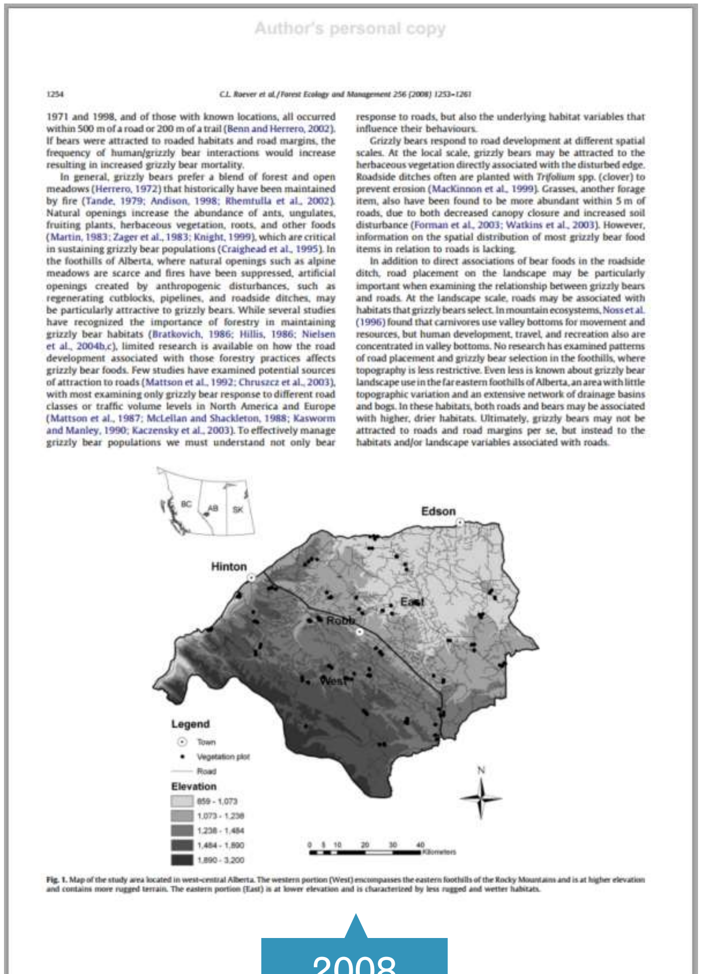
Northwest Knowledge Network, Library 4th Floor

25 April, 2018

My Journey



1971 and 1998, and of those with known locations, all occurred within 500 m of a road or 200 m of a trail (Benn and Herrero, 2002). If bears were attracted to roaded habitats and road margins, the frequency of human/grizzly bear interactions would increase resulting in increased grizzly bear mortality.

In general, grizzly bears prefer a blend of forest and open meadows (Herrero, 1972) that historically have been maintained by fire (Tande, 1979; Andison, 1998; Rhemtulla et al., 2002). Natural openings increase the abundance of ants, ungulates, fruiting plants, herbaceous vegetation, roots, and other foods (Martin, 1983; Zager et al., 1983; Knight, 1999), which are critical in sustaining grizzly bear populations (Craighead et al., 1995). In the foothills of Alberta, where natural openings such as alpine meadows are scarce and fires have been suppressed, artificial openings created by anthropogenic disturbances, such as regenerating cutblocks, pipelines, and roadside ditches, may be particularly attractive to grizzly bears. While several studies have recognized the importance of forestry in maintaining grizzly bear habitats (Bratkovich, 1986; Hillis, 1986; Nielsen et al., 2004b,c), limited research is available on how the road development associated with those forestry practices affects grizzly bear foods. Few studies have examined potential sources of attraction to roads (Mattson et al., 1992; Chruszcz et al., 2003), with most examining only grizzly bear response to different road classes or traffic volume levels in North America and Europe (Mattson et al., 1987; McLellan and Shackleton, 1988; Kasworm and Manley, 1990; Kaczensky et al., 2003). To effectively manage grizzly bear populations we must understand not only bear response to roads, but also the underlying habitat variables that influence their behaviours.

Grizzly bears respond to road development at different spatial scales. At the local scale, grizzly bears may be attracted to the herbaceous vegetation directly associated with the disturbed edge. Roadside ditches often are planted with *Trifolium* spp. (clover) to prevent erosion (MacKinnon et al., 1999). Grasses, another forage item, also have been found to be more abundant within 5 m of roads, due to both decreased canopy closure and increased soil disturbance (Forman et al., 2003; Watkins et al., 2003). However, information on the spatial distribution of most grizzly bear food items in relation to roads is lacking.

In addition to direct associations of bear foods in the roadside ditch, road placement on the landscape may be particularly important when examining the relationship between grizzly bears and roads. At the landscape scale, roads may be associated with habitats that grizzly bears select. In mountain ecosystems, Noss et al. (1996) found that carnivores use valley bottoms for movement and resources, but human development, travel, and recreation also are concentrated in valley bottoms. No research has examined patterns of road placement and grizzly bear selection in the foothills, where topography is less restrictive. Even less is known about grizzly bear landscape use in the far eastern foothills of Alberta, an area with little topographic variation and an extensive network of drainage basins and bogs. In these habitats, both roads and bears may be associated with higher, drier habitats. Ultimately, grizzly bears may not be attracted to roads and road margins per se, but instead to the habitats and/or landscape variables associated with roads.

Fig. 1. Map of the study area located in west-central Alberta. The western portion (West) encompasses the eastern foothills of the Rocky Mountains and is at higher elevation and contains more rugged terrain. The eastern portion (East) is at lower elevation and is characterized by less rugged and wetter habitats.

2008

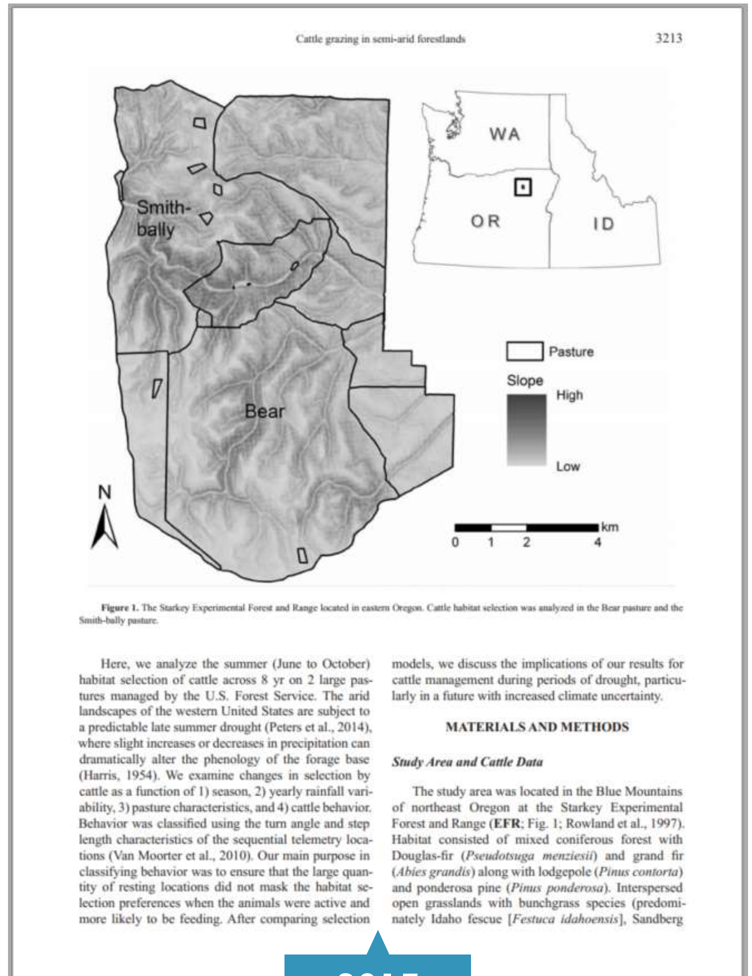


Figure 1. The Starkey Experimental Forest and Range located in eastern Oregon. Cattle habitat selection was analyzed in the Bear pasture and the Smith-bally pasture.

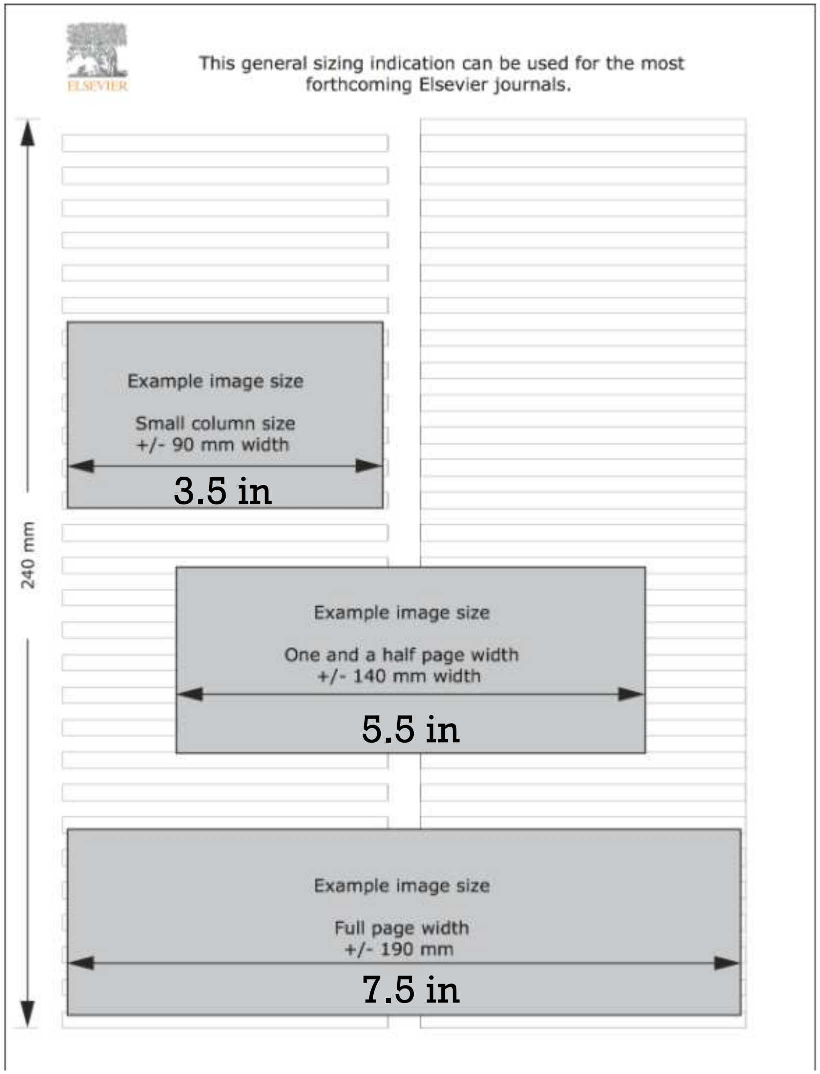
Here, we analyze the summer (June to October) habitat selection of cattle across 8 yr on 2 large pastures managed by the U.S. Forest Service. The arid landscapes of the western United States are subject to a predictable late summer drought (Peters et al., 2014), where slight increases or decreases in precipitation can dramatically alter the phenology of the forage base (Harris, 1954). We examine changes in selection by cattle as a function of 1) season, 2) yearly rainfall variability, 3) pasture characteristics, and 4) cattle behavior. Behavior was classified using the turn angle and step length characteristics of the sequential telemetry locations (Van Moorter et al., 2010). Our main purpose in classifying behavior was to ensure that the large quantity of resting locations did not mask the habitat selection preferences when the animals were active and more likely to be feeding. After comparing selection models, we discuss the implications of our results for cattle management during periods of drought, particularly in a future with increased climate uncertainty.

MATERIALS AND METHODS

Study Area and Cattle Data

The study area was located in the Blue Mountains of northeast Oregon at the Starkey Experimental Forest and Range (**EFR**; Fig. 1; Rowland et al., 1997). Habitat consisted of mixed coniferous forest with Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) along with lodgepole (*Pinus contorta*) and ponderosa pine (*Pinus ponderosa*). Interspersed open grasslands with bunchgrass species (predominately Idaho fescue [*Festuca idahoensis*], Sandberg

2015



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Step 1

Define your width

Step 1.1

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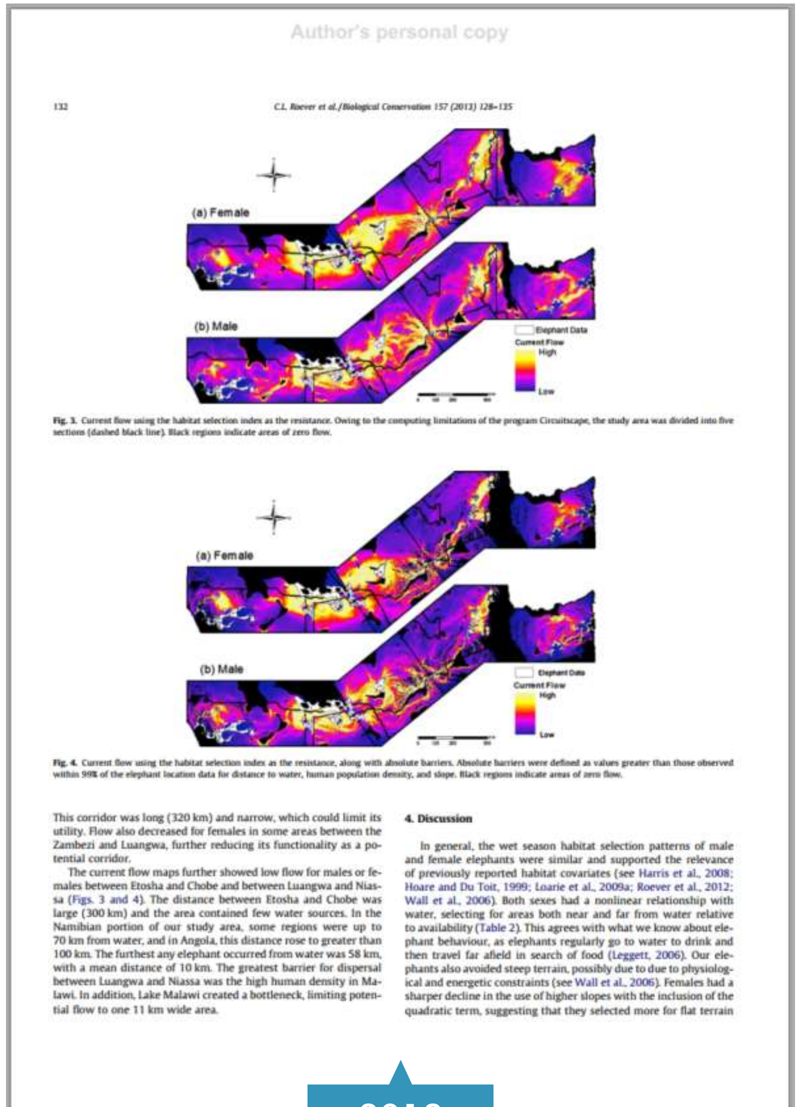


Fig. 3. Current flow using the habitat selection index as the resistance. Owing to the computing limitations of the program Circuitscape, the study area was divided into five sections (dashed black line). Black regions indicate areas of zero flow.

Fig. 4. Current flow using the habitat selection index as the resistance, along with absolute barriers. Absolute barriers were defined as values greater than those observed within 99% of the elephant location data for distance to water, human population density, and slope. Black regions indicate areas of zero flow.

This corridor was long (320 km) and narrow, which could limit its utility. Flow also decreased for females in some areas between the Zambezi and Luangwa, further reducing its functionality as a potential corridor.

The current flow maps further showed low flow for males or females between Etosha and Chobe and between Luangwa and Niassa (Figs. 3 and 4). The distance between Etosha and Chobe was large (300 km) and the area contained few water sources. In the Namibian portion of our study area, some regions were up to 70 km from water, and in Angola, this distance rose to greater than 100 km. The furthest any elephant occurred from water was 58 km, with a mean distance of 10 km. The greatest barrier for dispersal between Luangwa and Niassa was the high human density in Malawi. In addition, Lake Malawi created a bottleneck, limiting potential flow to one 11 km wide area.

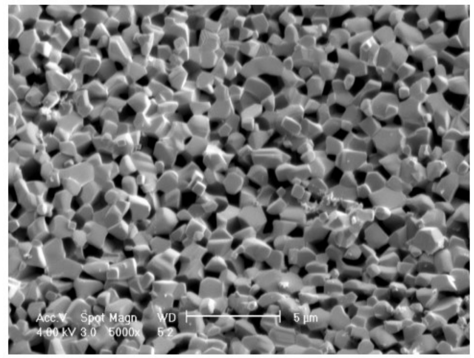
4. Discussion

In general, the wet season habitat selection patterns of male and female elephants were similar and supported the relevance of previously reported habitat covariates (see Harris et al., 2008; Hoare and Du Toit, 1999; Loarie et al., 2009a; Roever et al., 2012; Wall et al., 2006). Both sexes had a nonlinear relationship with water, selecting for areas both near and far from water relative to availability (Table 2). This agrees with what we know about elephant behaviour, as elephants regularly go to water to drink and then travel far afield in search of food (Leggett, 2006). Our elephants also avoided steep terrain, possibly due to due to physiological and energetic constraints (see Wall et al., 2006). Females had a sharper decline in the use of higher slopes with the inclusion of the quadratic term, suggesting that they selected more for flat terrain

2013

Step 1.2

When in doubt, be square



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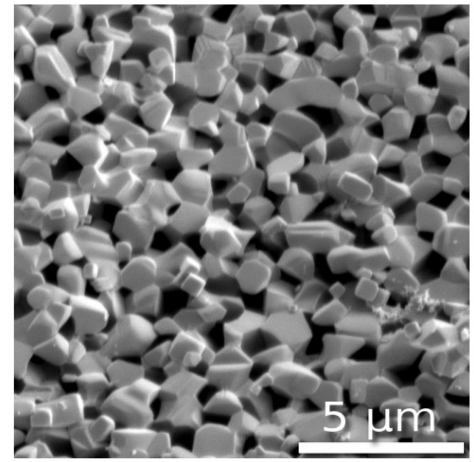

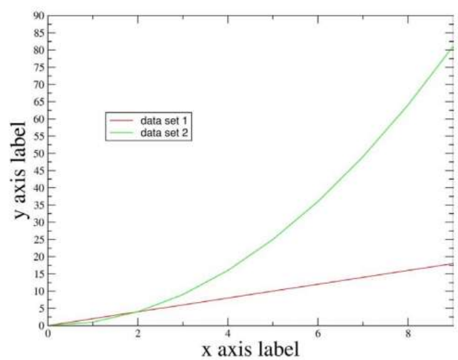

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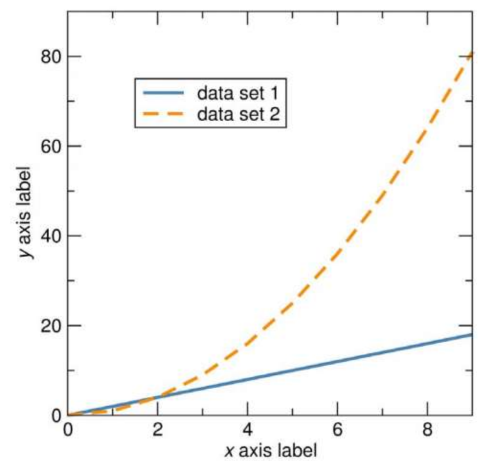
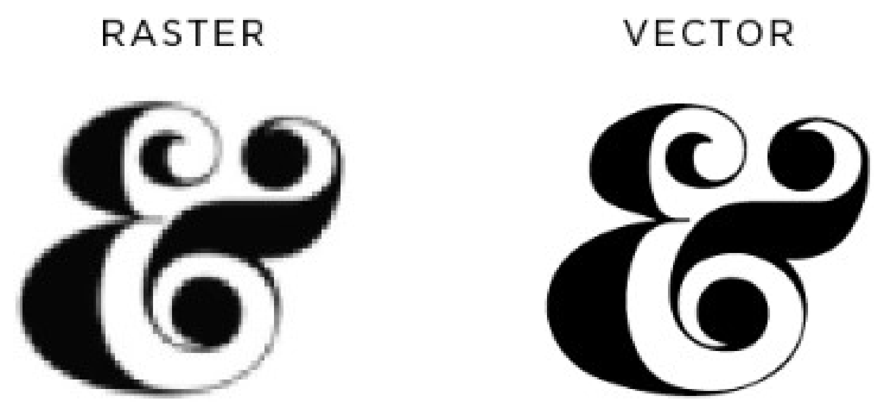


Step 2

Define your resolution

- Most journals → 300 – 600 dpi
- Aire with the higher end

- If possible, use scalable text and images (won’t pixelized)



Step 3

Consider your budget

- Color is costly ($150 - $1000 each)
- Is it absolutely necessary?

2008

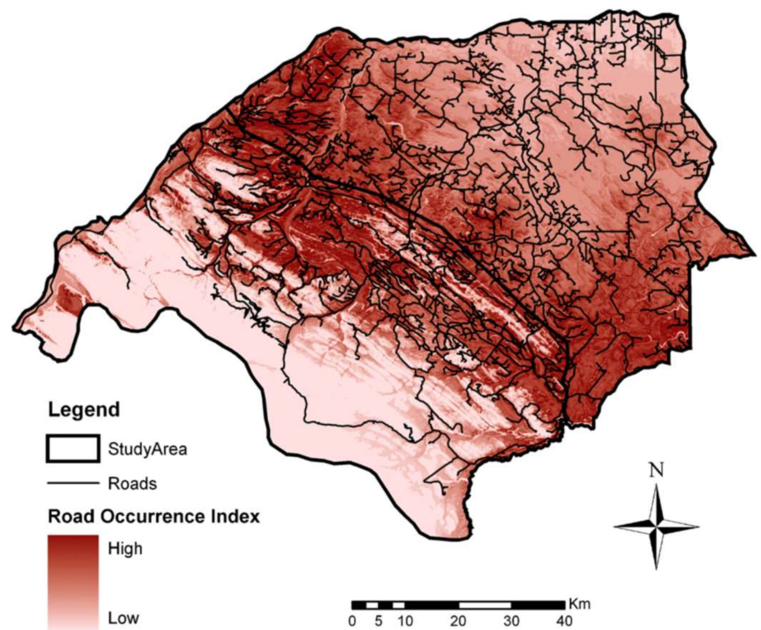


Fig. 3. Relative index of road occurrence created using data from the *western* portion of the study area, but applied to the entire study area. High values indicate that roads are more likely to be constructed in these areas.

Step 3.1

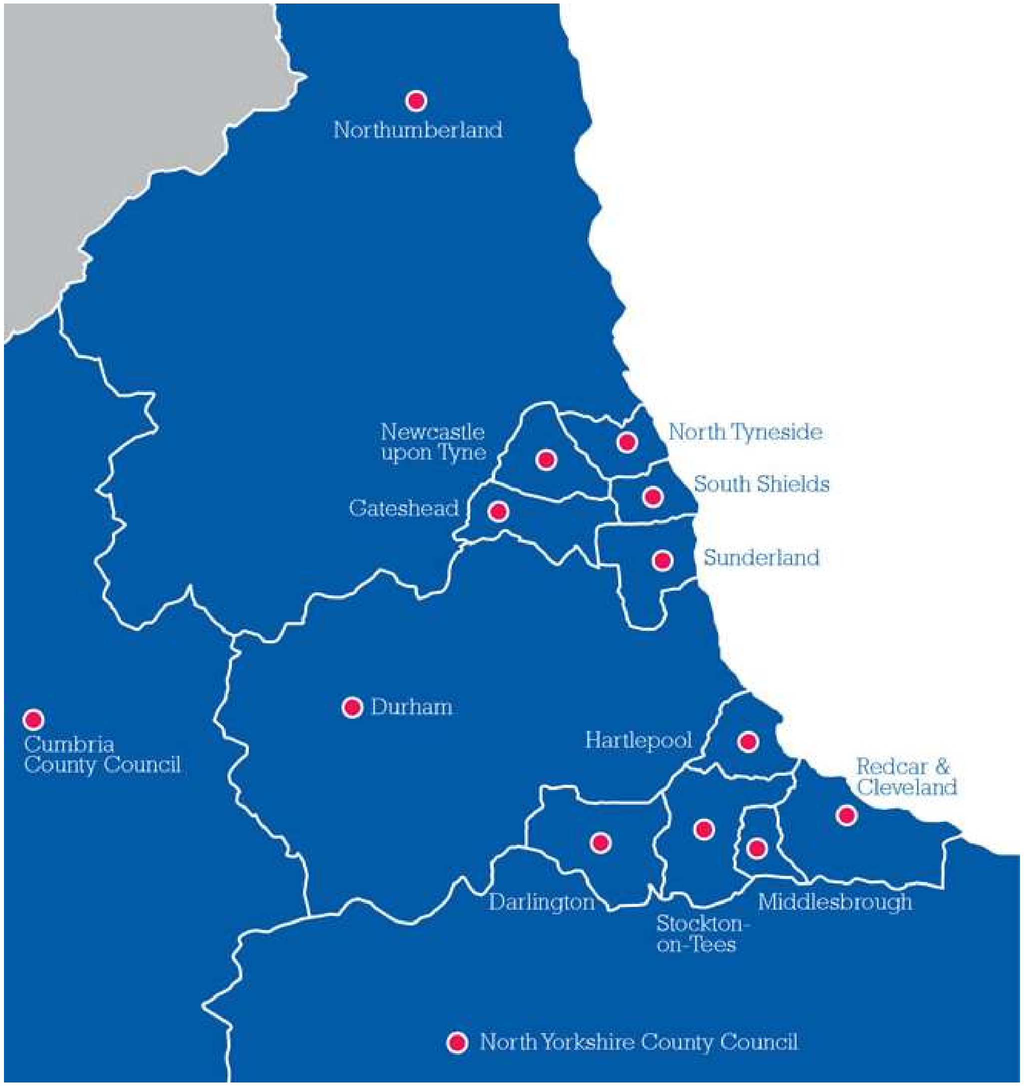
Accommodate disabilities

Full-color Vision

Red/Green Colorblindness

Step 3.2

Color and Emotion



Step 3.3

Color and Associations

Step 3.4

Color and Temperature

Table 1
Structure of the AIC candidate models evaluating elephant habitat use (elephant location vs. random location), elephant mortality risk (mortality location vs. random location), and difference in selection (mortality location vs. elephant location). Distance to water and distance to road were correlated; therefore, they could not be used in the same model.

Model name	Model
1. Null	
2. Water	Distance to water[a]
3. Nutrients	Distance to water[a] + Proportion tree[a]
4. Water, food, and slope	Slope + Distance to water[a] + Proportion tree[a]
5. Human presence	Distance to humans[b,c] + Distance to road[b]
6. Cover and humans	Proportion tree[a] + Distance to humans[b,c] + Distance to road[b]
7. Global model with water	Slope + Distance to water[a] + Proportion tree[a] + Distance to humans[b,c]
8. Global model with roads	Slope + Proportion tree[a] + Distance to humans[b,c] + Distance to road[b]

[a] Quadratic in all analysis.
[b] Quadratic in the elephant vs. random analysis.
[c] Quadratic in the mortality vs. elephant analysis.

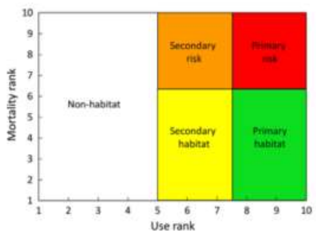


Fig. 2. Five habitat states categorized based on relative probability of use (10 ordinal bins from 1-low to 10-high) and relative probability of mortality (10 ordinal bins from 1-low to 10-high) for elephants. This figure was adapted from Nielsen et al. (2006).

regions (Fig. 1). Legal trophy hunting of elephant males was permitted in WMAs between the months of April and September, with a quota of 400 males in 2010 and 306 taken. Most of the terrain within the study area was flat, with the steepest slopes of eight degrees occurring along the Chobe River. The vegetation consisted primarily of deciduous dry woodlands and interspersed grasslands (Gaughan et al., 2012). Kasane, in the northeastern corner of the study area, was the largest town, and outside of this town, human settlements occurred in small villages along roadways mainly on the periphery of the study area. Permanent human settlements were prohibited in national parks; however lodges, campsites, and park offices were located within park boundaries. Roads also occurred throughout at a density of 0.073 km/km^2.

2.2. Elephant data

Aerial surveys to locate elephant carcasses and live elephants were conducted from June to December 2010. Aerial survey methodology followed procedures established by Norton-Griffiths (1978), whereby parallel strip-transects were systematically flown in a fixed-wing plane and animal locations were recorded. Transects were flown at a speed of 160 km/h and 300 feet above ground level. The study area was divided into 42 sampling units, and transects within each sampling unit where surveyed once over a period of 1 day to reduce duplicate counting of animals. The distance between strip-transects varied by sampling unit to minimize sampling effort (for detailed methods see Chase, 2011). Sampling units expected to have high to moderate elephant density were surveyed more intensively (2–4 km, $n = 38$) than those with low elephant densities (8 km, $n = 3$). However, NG26 was surveyed at a 1 km density at the request of local stake holders. The width of strip transects extended approximately 400 m (two observers covering 200 m); consequently, survey intensities of 1, 2, 4, and 8 km accounted for 40%, 20%, 10%, and 5% coverage of the sampling unit, respectively. The differing sampling intensities were not biased towards a particular habitat type or landscape feature and would, therefore, not bias habitat selection models (see Appendix A in Supplementary material). Orientation and spacing of flight paths were generated using DNR Garmin Sampling Extension in ArcView 3.2 (ESRI, Redlands, California).

The timing of aerial surveys coincided with the peak dry season to increase visibility through the tree canopy. The location, time, sex, and number of elephants were recorded. The sex and age

Table 2
Beta coefficients (β) and standard errors (SE) for the top-ranked AIC models. An asterisk (*) was used to indicate where the confidence intervals did not overlap with zero. Model fit using k-fold cross validation and the Spearman rank correlation coefficient (r_s) is also presented.

	Elephant vs. random		Mortality vs. random		Mortality vs. elephant	
	β	SE	β	SE	β	SE
Distance to water[a]	0.73	0.55	5.31	1.80*	4.29	1.90*
(Distance to water[a])^2	−0.15	0.02*	−0.28	0.06*	−0.12	0.06
Slope	0.15	0.04*	0.40	0.07*	0.27	0.09*
Proportion tree	6.24	0.67*	13.36	2.23*	4.38	2.48
(Proportion tree)^2	−17.98	2.28*	−38.83	8.01*	−14.86	8.34
Distance to humans[a]	2.92	0.46*	−4.52	0.46*	−8.05	1.45*
(Distance to humans[a])^2	−0.04	0.01*	–	–	0.05	0.03
Model fit (r_s)	1.00		0.96		0.87	

[a] Coefficient value and standard error multiplied by 100 for ease of interpretation.

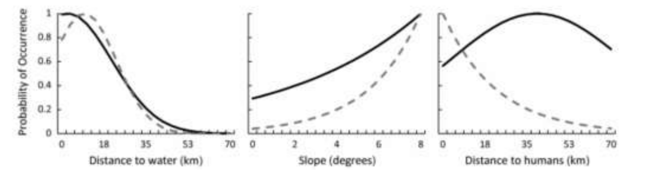


Fig. 4. Relative probability of occurrence for live elephant (solid black) and elephant carcass (dashed gray) locations as a function of distance to water, slope, and distance to humans.

Table 3
Percent composition of habitat states occurring within each study region.

	Non-habitat	Secondary habitat	Secondary risk	Primary habitat	Primary risk	Total area (km^2)
Chobe NP	14.6	14.5	26.1	14.8	30.0	10,751
Makgadikgadi NP	66.4	20.1	10.6	1.0	2.0	5018
Moremi GR	13.6	18.1	7.1	51.1	10.2	4889
Nxai Pan NP	35.8	27.9	8.1	9.5	18.7	2518
CH – east	42.1	9.8	19.3	9.0	19.7	6977
CH – north	39.1	0.5	43.2	0.1	17.2	2884
CT	84.1	3.0	11.2	0.4	1.3	10,002
NG – north	42.6	14.7	18.7	15.3	8.7	19,683
NG – south	10.4	33.1	7.0	36.5	13.0	8375
Total area	42.0	14.6	16.2	15.0	12.3	74,354

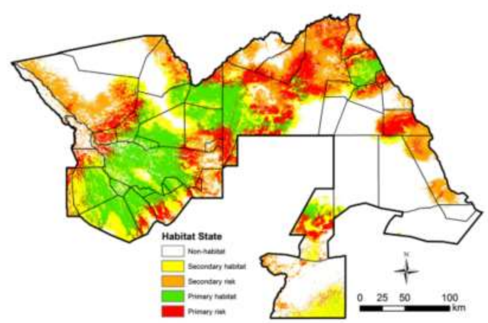


Fig. 5. Habitat states for elephants in northern Botswana. Non-critical habitats represent areas of low use by elephants. Primary and secondary habitats represent areas with low mortality and high to moderate use, respectively. Primary and secondary risk areas represent regions with high mortality and high to moderate use, respectively.

factors as independent variables. We used a design I approach because individual animals were not uniquely identified and were only sampled once (Manly et al., 2002). A design I approach is made at the population level, where used resources units are sampled for the entire study area (Manly et al., 2002). We then developed three habitat-based models. First, using the live elephant observations, we estimated habitat selection by elephants. Each elephant herd accounted for one observation, resulting in 3040 live elephant observations. We compared these to random points generated at a density of 1 point per 3 km^2 across the study area, for a total of 24,785 random locations. Next, we estimated the habitat-specific probability of elephant mortality using the 341 elephant carcass observations. The same set of random points was used for the mortality model as in the elephant habitat selection model. Finally, we compared elephant carcass locations to live elephant locations. This model accounts for the reality that elephants can only die in areas where they occur (Nielsen et al., 2004).

2013

Step 3.5

Accommodate B&W printing of color figures

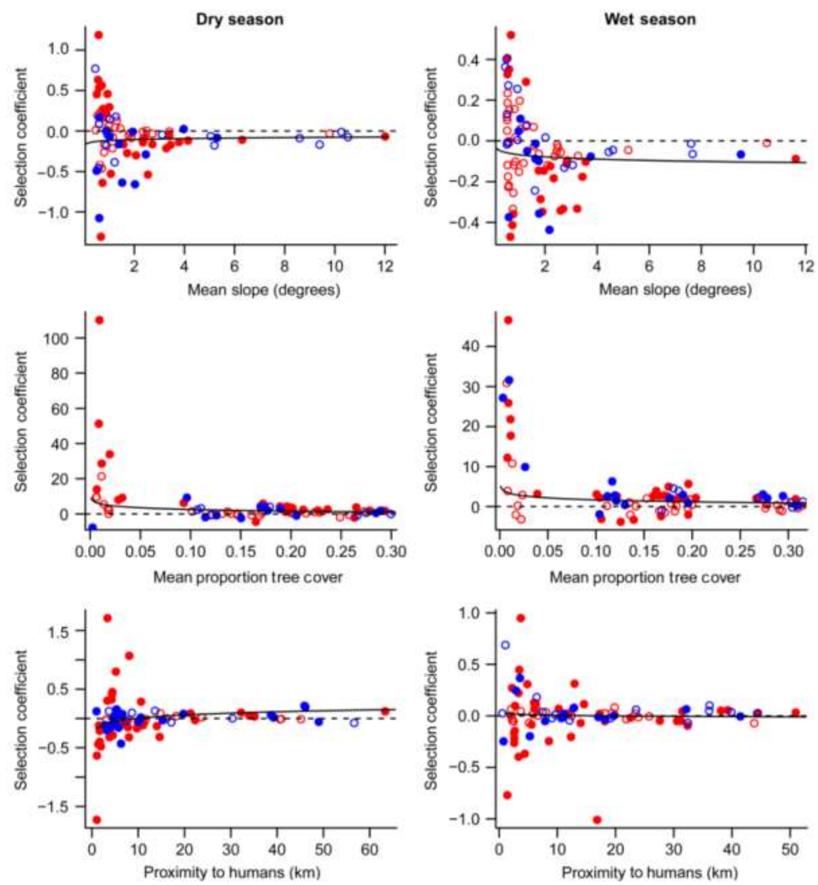
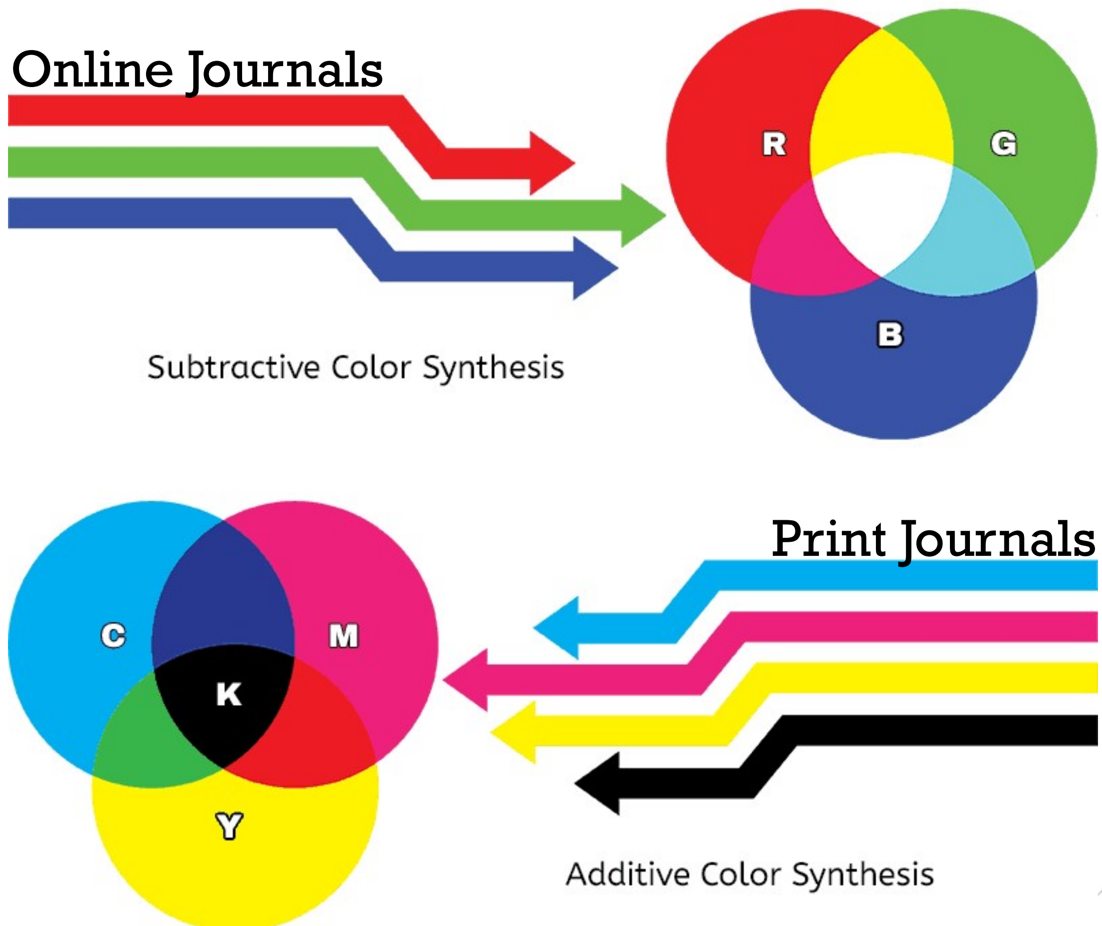


Figure 3. Functional responses in habitat selection for female (red) and male (blue) elephants. Selection coefficients were estimated for each individual using a resource selection function model and were modeled as a function of the mean slope, tree cover, or proximity to humans within each home range. Both significant (filled circle) and non-significant (open circle) selection coefficients were modeled.

2012

Step 3.6

RGB vs CMYK



Conversion How-To: http://b.nanes.org/figures/

Step 3.6

RGB vs CMYK

Online Journals

Print Journals

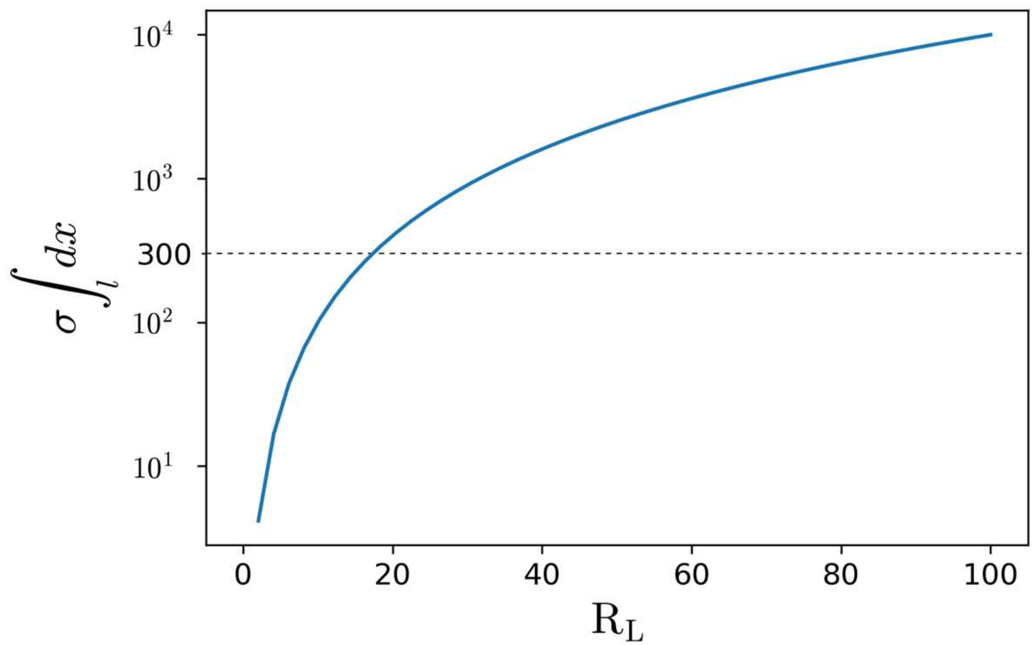
Check with the journal

Conversion How-To: http://b.nanes.org/figures/

Step 4

Standards for text

- If [Step 1: Width](#) is defined properly, this is straightforward
- Minimum size: 8 pt.
- Consistent use of fonts
- Use 0.2 instead of .2



Step 4.1

To serif or not to serif

SERIF - GOOD FOR PARAGRAPHS

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SAN-SERIF - GOOD FOR HEADERS

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Step 5

And the cheese stands alone

- Should be interpretable without any manuscript text
- No abbreviations unless defined therein

Step 6

Exporting & File Format

- Check with the journal
- Lossless (TIFF, PNG, BMP) > Lossy (JPG & GIF)
- Vector (PDF, SVG) > Raster (TIFF, PNG, JPG)

Resources

Free (mostly) alternatives to Photoshop & ArcGIS

- Inkscape (optimized for vector images)
- Photopea
- getPaint.net (developed by students at WSU)
- GIMP
- Affinity Photo ($40)

- QGIS
- R

Thank you!

Resources

- http://b.nanes.org/figures/
- https://www.mrl.ucsb.edu/~seshadri/PreparingFigures.pdf