A comparison of indicator and poisson kriging of herbivore species abundance in Kruger National Park, South Africa

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Abstract – **This paper investigates the potential of indicator and Poisson kriging for populating gaps in aerial transect surveys of herbivore species abundance in Kruger National Park, South Africa. Indicator kriging does not perform well due to a lack of zero counts in the raw observations and due to poor variogram structure for rare large counts. Two Poisson approaches perform better than indicator kriging. Poisson approach (1), investigating spatial density, performed better than Poisson approach (2) which investigated the proportion each species was of all animals. However, Poisson approach (2) seems promising for mapping abundance of the rarer animals.**

Keywords: indicator kriging; Poisson kriging; species abundance

I. INTRODUCTION

Kruger National Park, South Africa, provides 19,485 km^2 of protected habitats for the unique species of the African savanna, several of which are endangered. For the last forty years annual aerial surveys to monitor large herbivore populations have been conducted. These have been used to understand population trends and the environmental factors and management actions that influence herbivore density and distribution patterns. From 1980-1993, the whole park was surveyed annually, but this was costly and time consuming. In 1998, the park-wide census approach was replaced by a sampling strategy whereby the number of animals is recorded along 800 m wide East-West transects, spaced at intervals of 2.5-5.6 km (Kruger et al. 2008). However, such strip transects leave "gaps" in the data spatially. The histogram of animal count data for the park is usually highly positively skewed and approaches the Poisson distribution. This hampers the estimation of the variogram by the traditional method of moments. Indicator and Poisson kriging (Monestiez et al. 2006) are explored as potential methods for populating the data gaps between transects and to create continuous surfaces of species abundance.

II. METHODS

Indicator variograms were computed and indicator kriging performed using the Auto-IK approach of Goovaerts (2009). This was done using both the raw count data (Fig. 1a) and the count data migrated to a regular grid (Fig. 1b). The former data has no zero counts whereas the latter does.

Poisson kriging of count data was performed using two types of denominator:

observational area (ratio = spatial density, Fig. 2a)

total number of animals in a given area (ratio = proportion, Fig. 2b).

Both Poisson approaches result in sightings of rare animals in sparsely populated areas being down-weighted for variogram computation and kriging. However, Approach (2) is only suitable for accurately mapping the distribution of individual species in the park. Leave one out (LOO) cross-validation was used to assess the relative performance of the different methods for estimating counts of all species, and of giraffes, impala and zebra for the whole park. These species are examples of the key feeding groups grazers, browers and mixed feeders, respectively.

III. RESULTS AND DISCUSSION

Cross-validation shows that using the Auto-IK approach with the raw count data produces the largest MAEs (Table 1). Maps show that using the Auto-IK approach with raw count data is not good at mapping low or high values (compare Fig. 3, a and b). The former occurs because in the raw data there are no zero counts. Using migrated data with the Auto-IK approach reduced MAEs (Table 1) and resulted in better mapping of areas of low counts (compare Fig. 1 a-c) but the high counts are still poorly estimated. This occurs because the number of thresholds used for Auto-IK had to be

(a) (b) (c) (d)

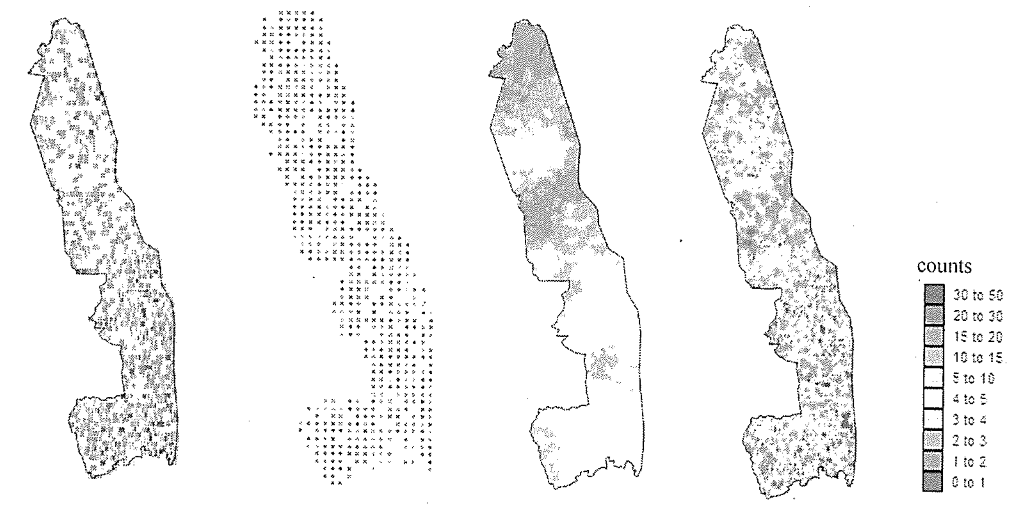

Figure 1. (a) Observed counts of all animals 2001, (b) counts migrated to a 5 km grid, (c) counts produced using Auto-IK and migrated data and (d) counts produced using Poisson approach (1).

(a) (b)

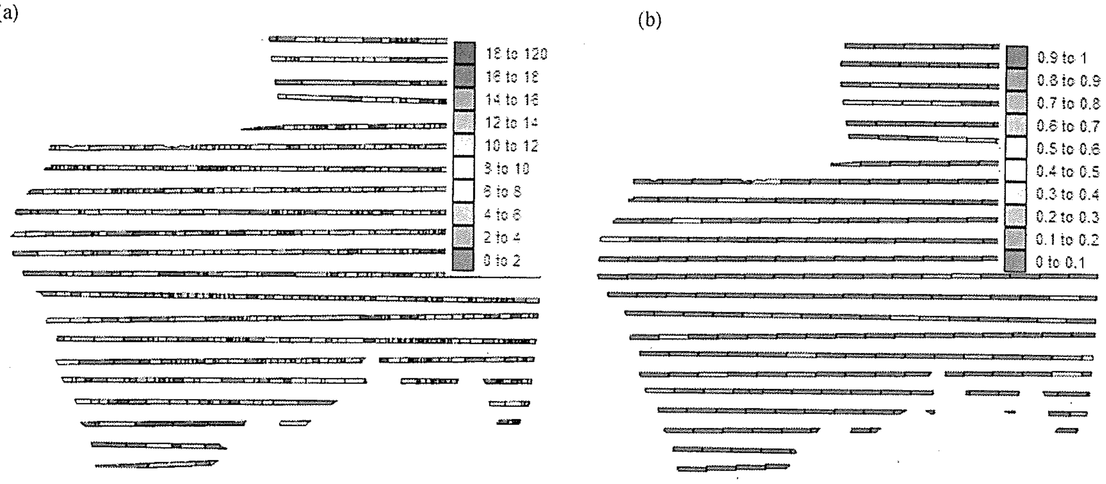

Figure 2. Calculation of (a) spatial density from 800 m wide transect data for Poisson approach (1) and (b) proportion of each animal from 5 km long blocks of the 800 m wide transect data for Poisson approach (2)

TABLE I. MEAN ABSOLUTE ERRORS (MAES) FROM LEAVE ONE OUT (LOO) CROSS-VALIDATION USING AUTO-INDICATOR KRIGING WITH RAW COUNT DATA AND DATA MIGRATED TO A GRID AND FOR POISSON KRIGING USING: APPROACH (1) SPATIAL DENSITY AND APPROACH (2) PROPORTION OF ANIMALS

	MAEs			
Data	***Auto-IK migrated data***	***Auto-IK raw count data***	***Poisson approach (1)***	***Poisson approach (2)***
All animals 1998	4.788	8.120	0.0528	b
All animals 2000	a	4.950	0.0401	b
All animals 2001	3.980	6.432	0.0463	b
All animals 2005	4.146	5.495	0.0448	b
Giraffe 2000	0.698	1.639	0.1337	0.1481
Giraffe 2001	a	1.890	0.1112	0.1929
Impala 2000	4.673	7.388	0.1668	1.3791
Impala 2001	a	8.410	0.2655	1.1053
Zebra 2000	2.561	5.711	0.2630	0.3909
Zebra 2001	a	6.454	0.2770	0.4698

a. variable not investigated,
b. not possible to do this method when considering all animals

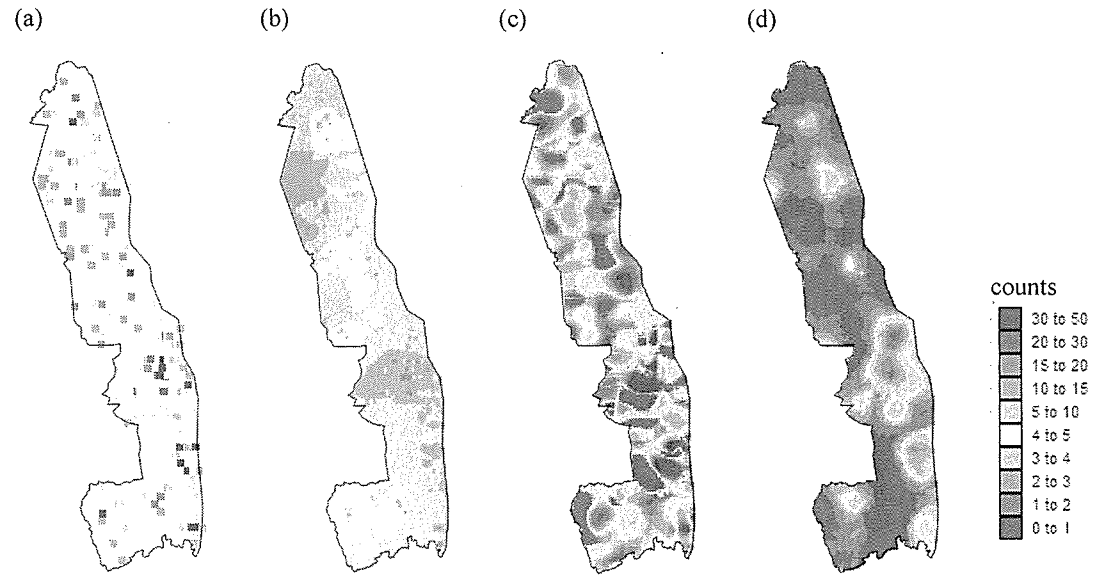

Figure 3. (a) Observed counts of zebra in 2000 and kriged maps of counts produced by (b) Auto-IK and raw data, (c) Poisson approach (1), and (d) Poisson approach (2).

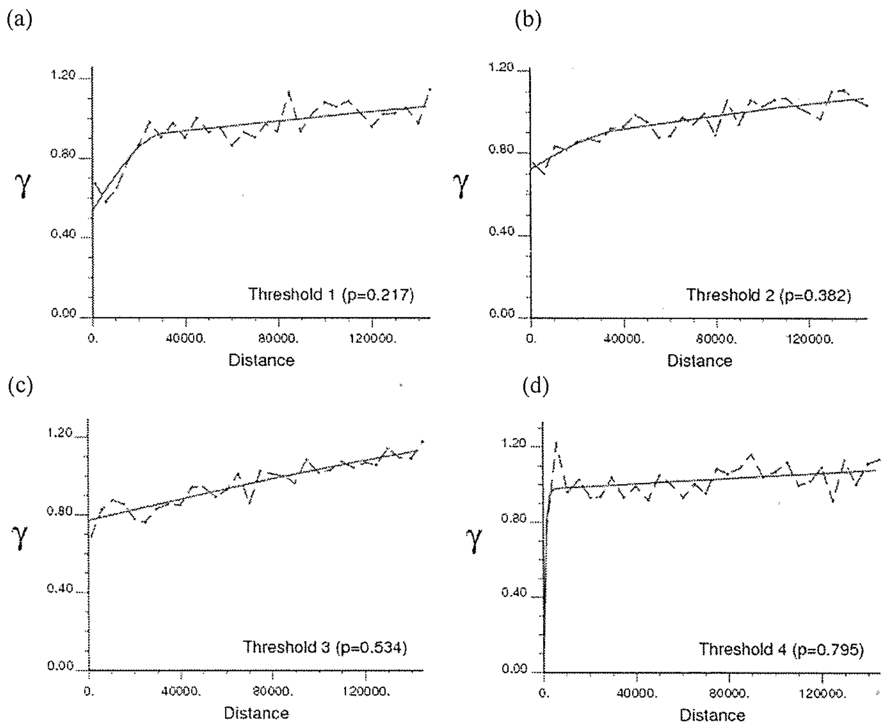

Figure 4. Indicator variograms computed and modelled for 4 thresholds of (a) 2, (b) 3, (3) 6 and (d) 10 for Zebra 2000 using Auto-IK.

limited due to lack of structure in the indicator variograms for observation points with rare high counts (Fig. 4).

Both Poisson approaches produce MAEs that are markedly lower and often an order of magnitude smaller than indicator kriging (Table 1). For estimating numbers of giraffe, impala and zebra, Poisson approach (1) produced smaller errors. Maps of counts for both Poisson approaches confirm the patterns shown by the MAEs. The MAEs show that Poisson approach (1) produces its best estimates when there are more animals i.e. looking at counts of all animals. Poisson approach (2), however, produces its best estimates for the rarest animals. Of the animals studied here impala are most abundant, followed by zebra and then giraffes. These observations suggest that Poisson approach (2) might be effective with some rarer species like warthog and waterbuck which are particularly difficult to map.

Incorporating environmental data such as biomass, tree cover, geology and ecotypes into a simple 0/1 indicator approach (results not shown here) improved estimation, therefore future research should involve incorporation of environmental data into one or both of the Poisson approaches used here.

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