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MAAZ PUBLICATIONS

STATISTICAL ECOLOGY & POPULATION GROWTH MODELS

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ABSTRACT

The branch of biology dealing with the relations and interactions between organisms and their environment, including other organisms is called as ecology. Ecology is the scientific analysis and study of interactions among organisms and their environment. Population ecology studies the dynamics of species populations and how these populations interact with the wider environment. A population consists of individuals of the same species that live, interact and migrate through the same recess and habitat. Population ecology is a one of the field of ecology. It deals with the dynamics of species population and how these populations interact with the environment. It is the study of how the population size of the species living together in groups change over time and space, and was one of the first aspects of ecology to be studied and modeled mathematically. A basic law of population ecology is the Malthusian Growth Model which assumes that population will grow (or decline) exponentially as long as the environment experienced by all individuals in the population remains constant. The four variables death, birth, immigration and emigration regulate the changes in population. Statistical ecology and environmental statistics have numerous challenges and opportunities in the area of modeling and estimation. This paper shares some of the highlights in statistical ecology and estimation of population using growth models.

Keywords: Ecology; Statistical ecology; Data analysis; fitting of growth models.

INTRODUCTION:

We experience gradual changes in local and global climatic conditions and composition in animal kingdom. Imbalance of food production, unplanned growth of human population is main issue in ecological imbalance. Reduction in productivity of land and non availability of drinkable water is another serious problem. Ecologists have reported that there is destruction of wild species, flora and fauna. Ecology is branch of biology which deals with the study of interrelationships between organisms and their environment. Previously ecology was treated as descriptive science. Now it requires a deep knowledge of quantitative techniques based on mathematics & statistics. Applications of Statistical ecology are widely spread in fisheries, forest management & estimating population of wild animals.

Ecologists try to understand how natural processes determine the size and compositions of plant and animal populations. In this paper the mathematical models that is relationship between dependent variable (Population of Tigers) and independent variable (Year) is discussed. With the help of mathematical equations of the type linear, quadratic, exponential, logistic or logarithmic the equation of best fit is searched.

It was said that in 19^{th} century there were 45000 tigers in India. In the year 1972 for the first time census of Tigers is carried out & the number is approximately 1800 tigers. "Project Tiger" was launched by Indian Govt. in 1973.The aim of this mission is elimination of all forms of human exploitation and biotic disturbance from the core area and rationalization of activities in the buffer zone. Further to restrict the habitat management to repair the damages done to the eco-system by human and other interferences so as to facilitate recovery of the eco-system to its natural state.

Another function of Project Tiger is Monitoring the faunal and floral changes over time and carrying out research about wildlife. Because Tigers are at the top of the ecosystem chain as the top predators and the

entire ecosystem health is predicated on the health of the tiger population. If tigers die out, herbivores will overpopulate and denude vegetation leading to cascading detrimental environmental effects.
The various reasons behind decreasing population of tigers can be enumerated as 1. Various diseases like *Feline Panleucopania, tuberculosis, sarcosystis*, etc. have led to the decimation of many animals including tigers, including the predators. According to a recent study (2014) from the Wildlife Conservation Society (WCS), canine distemper virus (CDV) has the potential to be a significant driver in pushing the tigers towards extinction.
2. A tiger needs to eat about 50 deer-sized animals or 6,600 pounds of living prey every year. Wherever prey-base is adequate and good protection measures are in place tiger populations reach high numbers simply because the species breeds quickly.
3. Deforestation -Prey species itself depend on conditions of the habitat. 21 tiger reserves in India out of 28 had lost about 250 square km of forest from 1997 to 2002 because of urbanization and human encroachment.

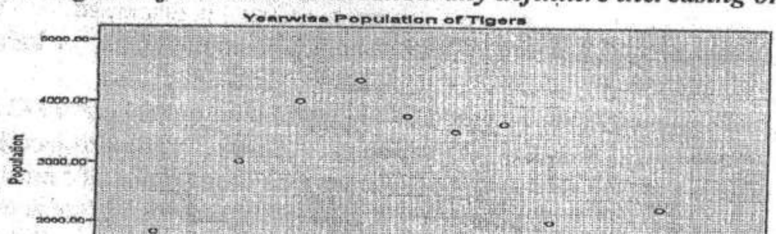
MATERIALS AND METHODS:

We have today 70% of world's tigers; further the number of tigers in Maharashtra has gone up by 66 from 103 in 2006, to 169 in 2010. The results of 2010 national tiger assessment, conducted nationally every four years, were declared by the National Tiger Conservation Authority (NTCA) and Wildlife Institute of India (WII). In 2006, the number of tigers was estimated to be 1,411, which increased to 1,706 in 2010. Because of special efforts of this mission Madhya Pradesh has recorded a 20% increase in tiger numbers.The tiger population has jumped in India from 1,706 in 2010 to 2,226 in 2014. In Karnataka it is increased from 257 in 2010 to 308 in 2014. India's tiger population rises 30% since 2010 to 2,226, according to the tiger census (All India Tiger Estimation 2014 National Tiger Conservation Authority) .Number tigers increase in Karnataka, Tamil Nadu, Uttarakhand and MP but decrease in Odisha, Jharkhand and Andhra Pradesh. The numbers mark a significant improvement from 2006 when the number of tigers in India was estimated at 1,411.

Table No. 1 The population of tigers in India from last 40 years

Year	Tiger population	Method of Census
1972	1,827	(pugmark method) (source: – Project Tiger India)
1979	3,015	(pugmark method) (source: – Project Tiger India)
1984	4,005	(pugmark method) (source: – Project Tiger India
1989	4,334	(pugmark method) (source: – Project Tiger India)
1993	3,750	(pugmark method) (source: – Project Tiger India)
1997	3,508	(pugmark method) (source: – Project Tiger India)
2001-02	3,642	(pugmark method) (source: – Project Tiger India)
2005	2,000	(based on pugmark method; considered to be flawed)
2006	1411	(1165 – 1657 min-max) (Nationwide census)
2010	1706	(First nationwide census by camera trap)
2014	2,226	(census by camera trap)

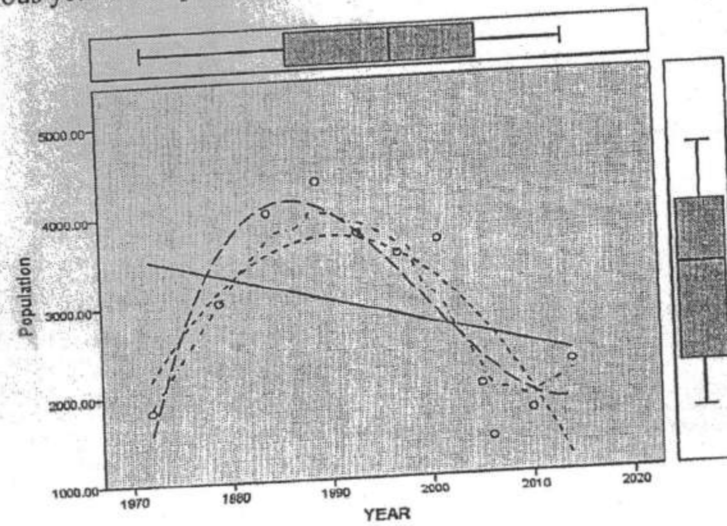
Fig. No 1 The Scatter Diagram of the data did not show any definitive increasing or decreasing pattern



In order to fit different growth curves, let N_t denote population size of tigers at time t . Let N_0 is population at initial stage of study then linear model will be
$N_t = N_0 + \beta \times t$. In this case as $t \rightarrow \infty$ $N_t \rightarrow \infty$ Which is not true. And the data shows declining population of tigers in last four decades.
Another model Exponential growth Model which is the the most basic way of modeling population dynamics is to assume that the rate of growth of a population depends only upon the population size at that time and the per capita growth rate of the organism. A population experiencing Malthusian growth follows an exponential curve, where N_0 is the initial population size. The population grows when $\beta > 0$, and declines when $\beta < 0$. The model is most applicable in cases where a few organisms have begun a colony and is rapidly growing without any limitations or restrictions impeding their growth (e.g. bacteria inoculated in rich media).
In other words, if the number of individuals in a population at a time t, is N_t, then the rate of population growth is given by:
$N_t = N_0 e^{\beta t}$. where β is the per capita growth rate, or the intrinsic growth rate of the organism. It can also be described as β = b-d, where b and d are the per capita time-invariant birth and death rates, respectively. Fortunately this equation does not properly fit to the given bivariate data. And the tiger population is decreasing in subsequent years.
Further neither quadratic curve $N_t = N_0 + \beta_1 t + \beta_2 t^2$ nor Logistic curve of the type fits good for given data sets.
The exponential growth model makes a number of assumptions, many of which often do not hold. A simple modification of the exponential growth is to assume that the intrinsic growth rate varies with population size. This is reasonable because the larger the population size, the fewer resources available, which can result in a lower birth rate and higher death rate. Hence, we can replace the time-invariant β with $\beta' = (b - a^*N_t - (d + c^*N_t)$ where a and c are constants that modulate birth and death rates in a population dependent manner. Both a and c will depend on other environmental factors which, we can for now, assume to be constant in this approximated model. The equation becomes

$$N_t = \frac{K}{1+e(N0+\ \beta' t)}$$

where β' = b-d and K = (b-d)/(a+c)
The biological significance of K becomes apparent when stabilities of the equilibrium of the system are considered. It is the maximum carrying capacity of the population. The equilibrium of the system are N = 0 and N = K. If the system is liberalized, it can be seen that N = 0 is an unstable equilibrium while K is a stable equilibrium
Tiger population in various years with possible Curve fittings are shown below



CONCLUSION:

All the above discussed growth curves are unable to fit the population of tigers in India. (The curve fittings by SPSS software.) The techniques presented here yields estimates of variances of the curve parameters & growth curves of different types are compared.

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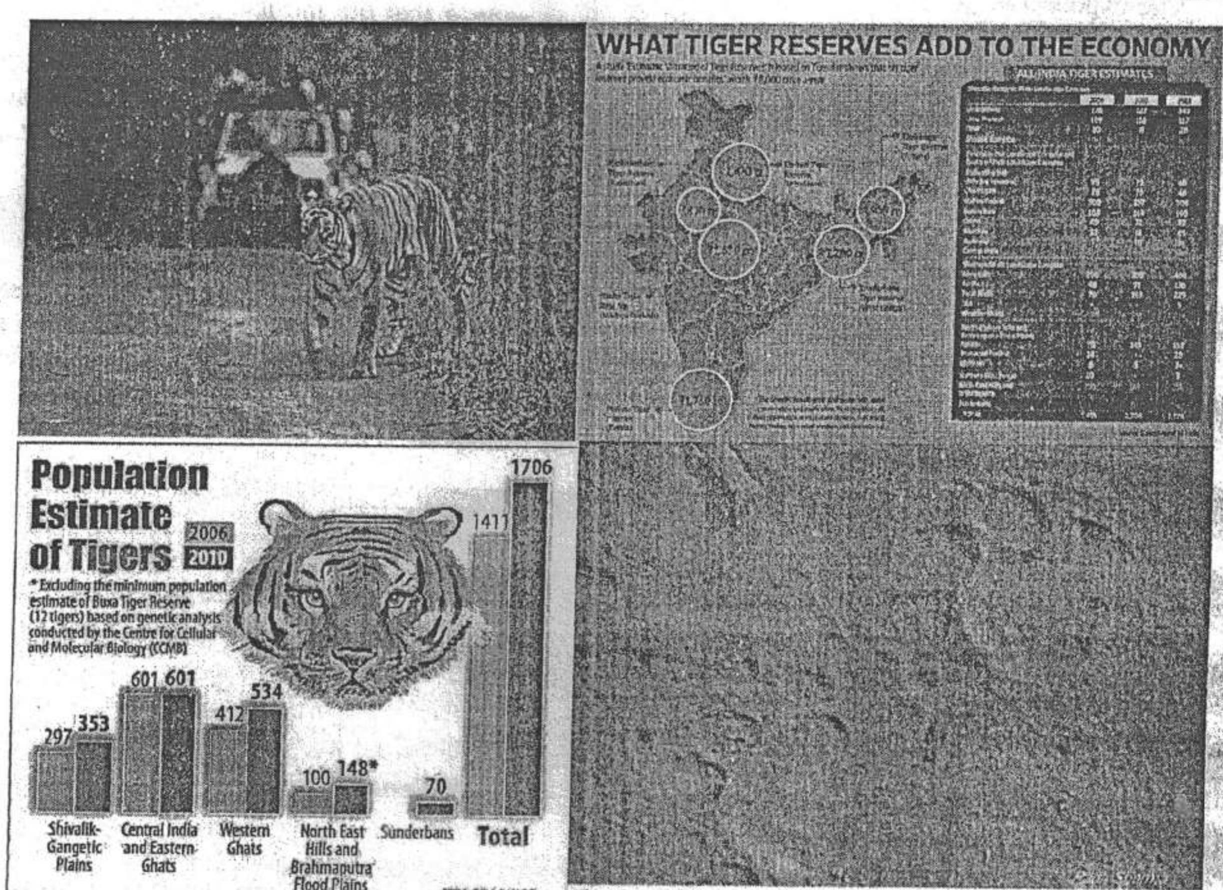

PTI GRAPHICS — Tiger Pugmarks (photo Parth Sharma)
