OPTIMIZING THE FRACTAL COMPLEXITY OF THE NATURAL ENVIRONMENT IN RUMINANT PRODUCTION

[1]*Johnny Mark M. Bolante*, [2]*Vincent T. Lapinig and* [3]*Reynaldo L. Aleman*
[1,3]Northwestern Mindanao State College of Science and Technology
[2]Governor Alfonzo D. Tan College

ABSTRACT

Meat and milk are the major products in the ruminant industry. Ruminant production can be harsh on the environment because it needs a large area to supply feed for this animal. This is the main cause of deforestation as the forest is converted into new pasture. This paper aims to characterize the agricultural ruminant production practices which either maintain or enhance the natural complexity of the environment. The study made use of a quasi-experimental design using computer-generated graphics. The pre-treatment design is a computer-graphic of a fractal figure called Seirpinski's carpet (dimension =1. 892789260) as referred to by Mandelbrot (1983). This fractal configuration is arbitrarily colored green for a representation of the dominant grass species and red-yellow-orange colors for the other species grass. The result revealed that a thirty percent increase in the number of replanted patches, increase the fractal dimension by .01 which is considered a significant alteration of the natural environment complexity. This also means that when the number of ruminants is increased by 30% of their current number, the natural landscape complexity will be significantly altered.

Keyword: fractal complexity, agriculture, ruminants, natural environment

Introduction

Modern agriculture practices ensure environmental sustainability while maximizing agricultural production (Bernardo, 1997). Thus, while traditional agriculture is characterized by exploitative practices, modern agricultural science stresses conservation and preservation constraints while finding ways of maximizing yields. This paper aims to characterize agricultural ruminant production practices which either maintain or enhance the natural complexity of the environment.

Environmental complexity is a measure of the extent of the ruggedness of the environment. Benoit Mandelbrot (1982) proposed fractal dimension as a measure of ruggedness in his book "The Fractal Geometry of Nature". Since the introduction of fractal geometry in the scientific literature, it has since found profound applications in almost all fields of inquiry. Macintosh et al (2013) studied temporal fractals in seabirds foraging behavior; Tremblay et al. (2007) used fractal landscape method as an alternative approach to measuring area-restricted searching behavior; Fuller et al. (2010) focused on the movement paths which revealed scale-dependent habitat decisions by Canada lynx; Bartumes (2007) wrote on Levy processes in animal movement as an evolutionary hypothesis, and Bartumes et. al (2008) linked animal behavior to statistical patterns of search.

The literature cited focused on animal search behavior in relation to the fractal dimension of the habitat. Given this, it is logical to ask how the natural architecture of the environment can be modified to maximize the probability of a successful search for food of the animals. Thus, the study aims to optimize the fractal complexity of the natural environment for ruminant production.

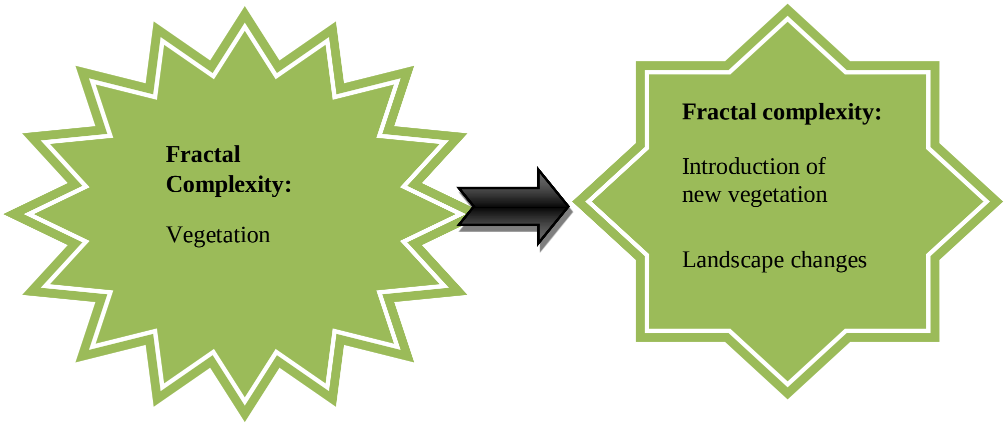
Conceptual Framework

The study is anchored on the theory that it is possible to maximize animal production without necessarily destroying the environment. Fuller et al. (2010) claimed that "Fractal dimension of movement paths was greater within preferred than in non-preferred habitats and corresponded with higher foraging success in preferred habitats. The Higher fractal dimension of movement paths reduced the number of transitions between patches of higher and lower foraging quality, resulting in individual movement patterns matching the scale of inter-patch variation in hare abundance and accessibility within home ranges". On the other hand, Tremblay et al. (2007) averred that "Quantifying spatial and temporal patterns of prey searching is of primary importance for understanding animals' critical habitat and foraging specialization". This information allows for the possibility of designing the entire environment into preferred patches and non-preferred patches of habitats to conform to the foraging patterns of ruminants. The design takes into consideration the original fractal complexity of the environment.

The fractal complexity of a habitat is the composite effect of the diversity of the vegetation in the environment as well as its topography. The more diverse the vegetation is, the higher is the fractal complexity. Similarly, the more rugged the surface is, the higher becomes the fractal dimension

(Palmer, 1988), an information which allows agriculturists to re-design the natural environment. The conceptual framework of this study is schematically presented below:

NATURAL ENVIRONMENT **RE-DESIGNED ENVIRONMENT**



Natural Fractal Complexity = Re-designed Fractal Complexity

Figure 1. Schematic Diagram of the Study

Figure 1 shows a natural environment on the left with fractal complexity because of vegetation and topography. These vegetation and topography are natural. Thus, there are many animals living in this area.

Since, the purpose of this study is to raise different ruminants like cows, goats, etc. Therefore, we need to develop the natural environment in order to maximize the production of the ruminants present in this area without changing the fractal complexity. This can only be realized through maintaining the vegetation of natural environment and cultivate more forage for ruminants' survival.

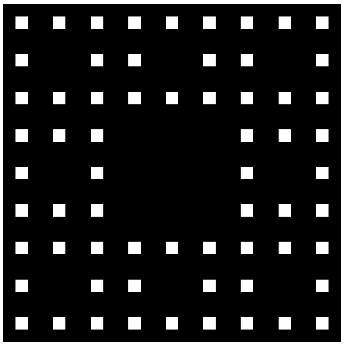
On the other hand, re-designing of the topography, which is suitable for the growth of the new-planted forages, is also helpful for maximizing the production of ruminants.

Research Design and Methods

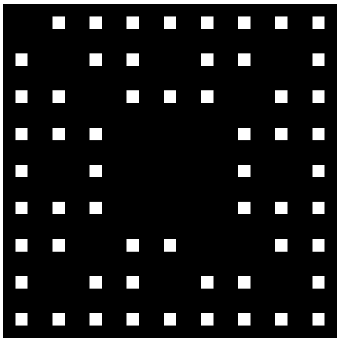
The study made use of a quasi-experimental design using computer-generated graphics. The pre-treatment design is a computer-graphic of a fractal figure called Seirpenski's carpet (dimension =1.892789260) as referred to by Mandelbrot (1983). This fractal configuration is arbitrarily colored green for a representation of the dominant grass species and red-yellow-orange colors for the other species grass. The colors represent vegetation patches which, according to Tremblay (2007), determine the fractal movement of the animals. The treatment consists of redesigning the environment by changing the red-yellow-orange patches to green color to accommodate ruminants to be raised in the environment. It is assumed that each patch is able to support the food requirements of two (2) ruminants for their entire life cycle. The addition of the green-colored patches effectively eliminates the other colors and the process of color-changing is continued until the fractal dimension of the original environment is proceeds significantly. The post-treatment design consists of the re-designed environment and the outputs are the new fractal dimension and the maximum number of ruminants accommodated.

Results and Discussion

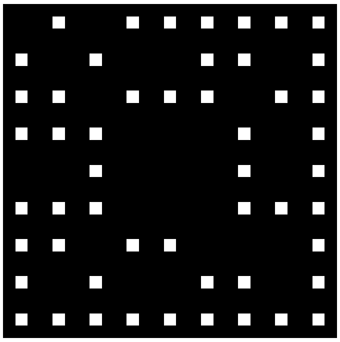
Figures 1 to 9 show the sequence of landscape re-engineering from the original fractal landscape structure (d = 1.879) represented by a Seirpinki's carpet layout to a smooth, totally reorganized agricultural ecology suitable for ruminants. In the original landscape, the black background denotes the dominant grass species. A successive colony of the white squares represents planting and replacing of the natural species with the dominant grass species. The redesigning of the environment through this process is resulting in the increase of fractal dimension (viz. more spaces filled by a black object) towards the "smooth" fractal dimension of two (2). There are sixty (60) small scales in the original configuration and each time, ten percent (or 6 squares) are "blackened".



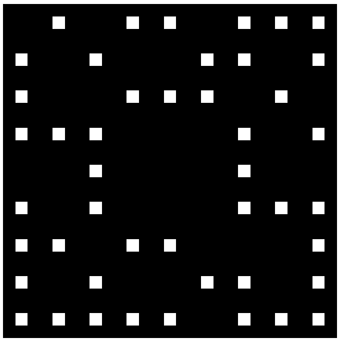
Fractal Dimension = 1.9078



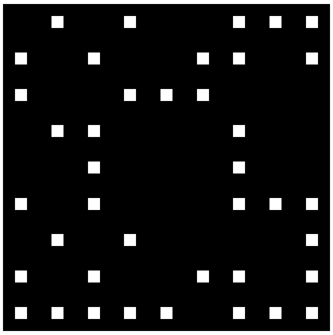
Fractal Dimension = 1.9106



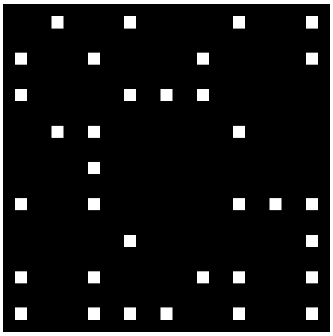
Fractal Dimension = 1.9134



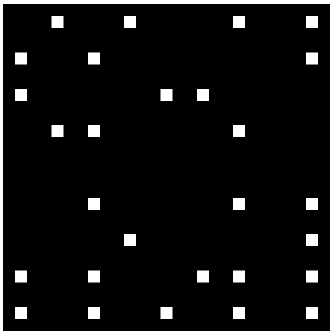
Fractal Dimension = 1.9161



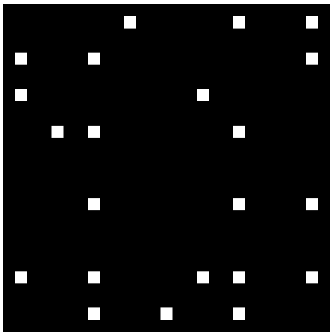
Fractal Dimension = 1.9188



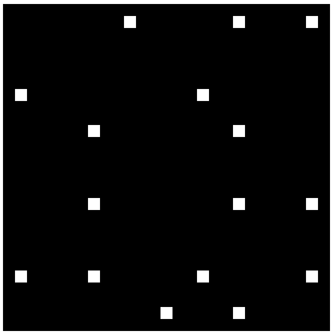
Fractal Dimension = 1.9215



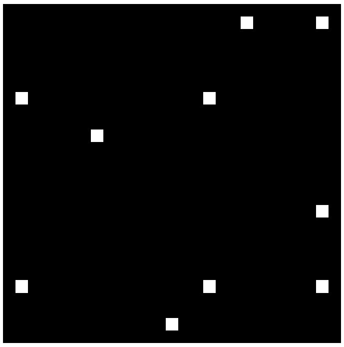
Fractal Dimension = 1.9241



Fractal Dimension = 1.9268



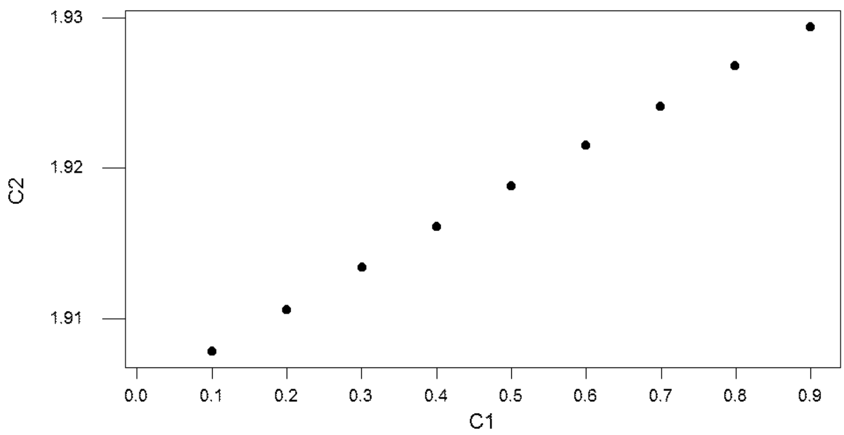
Fractal Dimension = 1.9294



Fractal Dimension = 1.9320

The result revealed that a thirty percent (30%) increase in the number of replanted patches, increase the fractal dimension by 0.01 which is considered a significant alteration of the natural environment complexity. This also means that when the number of a ruminant is increased by 30% of their current number, the natural landscape complexity will be significantly altered.

From an Ecofriendly agricultural management perspective, the study implies that sustainable and Ecologically-friendly animal production system needs to limit the number of animals raised to no more than 30 percent of the existing animal stock. While production can be maximized up to carrying capacity of the habitat, ecological consideration demands that this will be limited to no more than 30% re-designing of the natural ecosystem.



Conclusion

This study anchored on the theory that it is possible to maximize animal production without necessarily destroying the environment. The fractal dimension of movement paths was greater within preferred than in non-preferred habitats and corresponded with higher foraging success in preferred habitats. The higher fractal dimension of movement paths reduced the number of transitions between patches of higher and lower foraging quality, resulting in individual movement patterns matching the scale of inter-patch variation in hare abundance and accessibility within home ranges. The sequence of landscape re-engineering from the original fractal landscape structure (d = 1.879) represented by a Seirpinki's carpet layout to a smooth, totally reorganized agricultural ecology suitable for ruminants. The result revealed that a thirty percent increase in the number of replanted patches, increase the fractal dimension by .01 which is considered a significant alteration of the natural environment complexity. This also means that when the number of a ruminant is increased by 30% of their current number, the natural landscape complexity will be significantly altered.

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