Vegetation patches, spirals and arcs in arid landscapes

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Statement of the Problem: Dissipative structures have been observed in almost all field of the natural sciences where the appearance of order and structure involves nonequilibrium exchanges of energy and/or matter. Biological systems and population dynamics, in particular, are domains of applicability of dissipative structures [1,2]. Vegetation patterns considered in this contribution belong to this class of nonequilibrium systems. We report on the formation of vegetation patches, spiral, and arcs patterns in isotropic and under uniform environmental conditions. Isolated or interacting spirals and arcs observed in South America (Bolivia) and North Africa (Morocco) are interpreted as a result of curvature instability that affects the circular shape of localized patches.

Methodology & Theoretical Orientation: We consider the generic interaction-redistribution model [3,4] based on the relationship between the structure of individual plants and the nonlocal interactions existing within plant community. In this approach, vegetation pattern formation process is originated from interactions intrinsic to the vegetation dynamics (facilitation and competition), rather than from extrinsic, environmental causes. To simplify further the description of the system, we assume that all plants are mature. The state variable is the vegetation density, which is defined at the plant level. The resulting equation governing the space-time evolution of the vegetation density or biomass consists of an integro-differential model.

Findings: The results of numerical simulations of the generic interaction-redistribution model shown the formation of arcs and spirals like patterns that emerge as a transient behavior and are caused by the well know self-replication phenomenon. In the first stage, the curvature instability affects the circular shape of localized patches and leads spontaneously to the formation of arcs. In the second stage, the arcs transformed into non-rotating spirals that occupy the whole space available in a given arid landscape.