

# MOSAIC STRUCTURE OF BIOLOGIC DIVERSITY: A RESULT OF AUTOCONTROL AND SYNCHRONIZATION OF COMPLEX SPATIOTEMPORAL DYNAMICS OF BIOLOGICAL COMMUNITIES

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## Introduction

The principal difficulty involved in describing and studying biologic diversity lies in its more or less pronounced spatial structurization and strong heterogeneity. This is most clearly pronounced in phytocenoses, since the majority of plant species as a rule fill their habitats rather nonuniformly to form accumulations and voids that can far from always be convincingly explained by heterogeneity of the environment in the respective ranges. An impressive example here is clearly pronounced spottiness of tundra phytocenoses; yet, taiga plant communities, too, prove to be very spotty and heterogeneous as well. A successful description and analysis of the mechanisms of this heterogeneity within the framework of classic biological investigation methods are still pending. This communication suggests a mathematical model for spatial-temporal dynamics of plant communities to explain the occurrence of heterogeneous (spotty) spatial distribution by instability of community dynamics by phenomena of dynamic chaos and processes of chaotic self-adjustment. In plotting the given model, we accounted for interaction of plants situated close to each other and affecting both increase of biomass (new shoots, for instance) and restricted biomass growth caused by competition for resources needed for vital activity (Tuzinkevich, Frisman, 1990). The basic model version is as follows:

$$\dot{u}_i(x, t) = \int_M \alpha_i(x, y) u_i(y, t) dy - u_i^{\gamma_i}(x, t) \sum_j \int_M \beta_{ij}(x, y) u_j^{\rho_j}(y, t) dy, \quad (1)$$

where  $u_i(x, t)$  is the biomass density of the  $i$ -th species in point  $x$  in time  $t$ ,  $M$  the physical space, the community habitat range. Parameter  $\gamma_i$  characterizes the sensitivity of suppressed biomass to competitive impact; parameter  $\rho_j$  reflects the non-linearity of dependence of degree of competitive limitation on the density of the overwhelming biomass. Kernels  $\alpha_i(x, y)$  characterize the growth of the biomass of the  $i$ -th species from point  $y$  to point  $x$ . Kernels  $\beta_{ij}(x, y)$  characterize competitive impact of the biomass of the  $j$ -th species in point  $y$  for the biomass of the  $i$ -th species in point  $x$ . The kernels  $\alpha_i(x, y)$  and  $\beta_{ij}(x, y)$  depend on the distance between points  $x$  and  $y$ , and may be selected in the form of Gaussian curves.

In case of unispecific community, we have one dynamics equation

$$\dot{u}(x, t) = \int_M \alpha(x, y) u(y, t) dy - u^{\gamma}(x, t) \int_M \beta(x, y) u^{\rho}(y, t) dy \quad (2)$$

## Results and discussion

With sufficiently high values of parameter  $\gamma$  (and fixed values of other parameters) a solution of model (2) stationary in time and homogeneous in space would be asymptotically stable. Thus, with high  $\gamma$  values the plant population would fill its entire habitat space to cover it with a uniform "carpet" and stably preserve its spatial structure in time. Decrease of parameter  $\gamma$  (which may be interpreted as greater intensity of competitive suppression at low

densities of suppressed biomass) would lead to bifurcation in dynamic behavior of model (2) caused by loss in stability of spatially homogeneous solution and suppression of heterogeneous threshold distributions. With sufficiently low values of parameter  $\gamma$  (almost from any (heterogeneous) initial state, the population would no longer tend to homogeneous distribution and would be situated so that in some space points plant density would be substantially greater than in other points.

The present author performed a numerical study of the forms of extreme heterogeneous spatial distributions of solutions for equations (2) and (1). It turned out that with loss of stability in homogeneous spatial distribution equation solutions prove highly heterogeneous in space to represent in themselves a series of discrete peaks of zero density separated from each other by free space. Such heterogeneous distribution may be both stable and unstable.

We illustrate the simulation results showing the tree grouping structures (groups of trees with overlapping crowns) in the taiga site in the experimental forest situated in the north of Khabarovsk Region. A 400 by 1200-meter plot, about 48 ha in area, was studied. Tree data including species, breast height diameter, total height, wood quality, age and coordinates of each tree were collected from each tree on the plot. On the basis of evidence from the experimental plot and from the statistics calculated from that data, we simulated the parameters of mathematical model (1). The coefficients of intraspecific and interspecific competition were determined as values dependent on the correlation between the average total height and average crown diameters (Frisman, Faiman, Budzan, 2001). We examined many different choices of parameters and determined the plausible scenario for the dynamics of the principal species on the study plot. The prognosis for this scenario assumes gradual substitution of Korean pine by most likely hardwood species and a transition from stable dynamics to the variation in time of certain tree species.

An analogous mathematical model of evolution of a biological community with continuous variety of inherited properties was also suggested. The presence of selective densely dependent competition involving high individual adaptability of species was shown to lead to forming of discrete groups (taxons) in distribution of species in accord with inherited variables.

## **Conclusions**

It was shown that increased intensity of competitive for resources pressure leads to processes of chaotic self-organization and rise of complexly structured heterogeneous (spotty) spatial distributions.

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