The creation of “Ecosystem Core” hypothesis to explain ecosystem evolution

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Introduction

Humans have dramatically changed natural ecosystems around the world as their capacity to manage their environment for multiple uses has evolved in step with agricultural, industrial and green revolutions. Numerous natural ecosystems have been replaced by various semi-artificial or artificial ecosystems. So far, there is no definite theory about the mechanism for evolution of an ecosystem. Community ecology has a relatively well-described and comprehensive theory of succession, which is an environmental change caused by natural or human disturbance where the community composition, especially the dominant species, change. This is a phenomenon in which one community is replaced by another at different times in the same place. At the different research levels, is it the same mechanism for the ecosystem evolution and community succession? What is the factor that drives the ecosystem evolution? This abstract attempts to put forward the “Ecosystem Core” hypothesis, in order to scientifically address the above problems.

Example 1 Coexistence mechanism of different ecosystem types under the same climate and soil conditions

Emergy theory is an accounting tool that considers both the environmental and economic inputs that are directly or indirectly required by a process to generate a product and it measures real wealth, independent of financial considerations. Our results about natural emergy inputs for 12 ecosystems were the same, to 5.31×10^{14} sej/ha. But their average sum emergy inputs was more than 15 times different, and the average purchased emergy inputs was nearly 40 times the gap. It showed the rule roughly of “commercial crop > artificial forage > field crop > grassland” (Table 1).

Table 1. Emergy input of main ecosystems in Guyuan County of Hebei Province, China.

Ecosystem types	Ecosystems	Natural emergy input ($\times10^{14}$ sej/ha)	Purchased emergy input ($\times10^{14}$ sej/ha)	Sum of emergy input ($\times10^{14}$ sej/ha)
Commercial crop	Spinach greenhouse	5.31	146.35	151.66
	Chinese cabbage greenhouse	5.31	146.36	151.67
	Potatoes	5.31	147.67	152.98
	Cabbage	5.31	101.04	106.35
Artificial forage	Corn silage	5.31	12.09	17.40
	Oats	5.31	15.63	20.94
Field crop	Naked oats	5.31	6.94	12.25
	Wheat	5.31	6.89	12.20
	Flax	5.31	6.90	12.21
Grassland	Chinese leymus grassland	5.31	3.54	8.85
	Natural mowed grassland	5.31	3.53	8.84
	Free grazing	5.31	4.21	9.52

Under the natural condition without human disturbance, a specified ecosystem corresponds to a certain “ecosystem core”. When human’s disturb a natural ecosystem by increasing energy inputs or changing the output of the system’ state, the ecosystem changes or becomes a different ecosystem resembling the electronic transition of an atom; when a disturbance far exceeds the energy provided by the “ecosystem core”, it transitions from a natural system to an entirely artificial intelligent ecosystem that resembles an electron “escaping” in an atom (Fig.2).

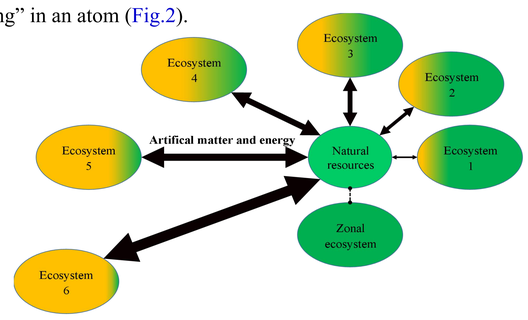
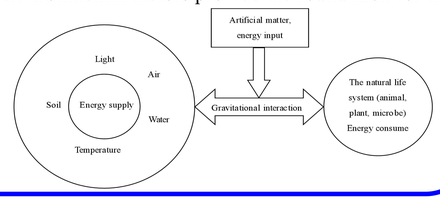


Figure 2. Conceptual model of ecosystem evolution

“Ecosystem Core” hypothesis

When compared with atomic structure, the relationship between organism and the environment in an ecosystem is similar. In the ecosystem, the environment is similar to the atomic nucleus. We call it “Ecosystem Core”, and all kinds of environmental factors provide the foundation for the existence and progress of the life form, including matter, energy and information (Fig.1).

Figure 1. Atomic structure (David et al., 2011) and “Ecosystem core” hypothesis model



Example 2 The emergy of metabolism in the same ecosystem under different environmental conditions

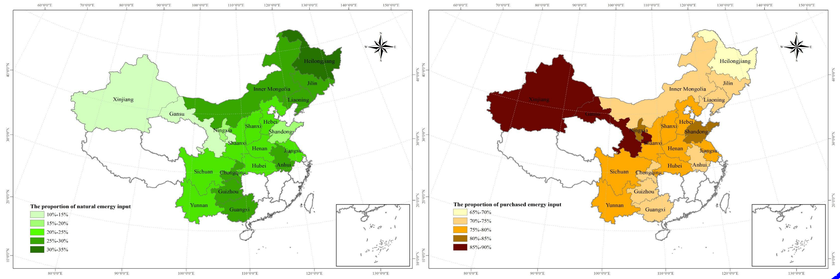
In the case of wheat ecosystem (Table 2), the purchased emergy input in Northeast and Southwest of China accounts for about 59% and 73% of the total input respectively, while other areas are more than 80%.

Table 2. Natural and purchased emergy input in major wheat planting areas of China.

Ecological zones	Natural emergy input ($\times10^{14}$ sej/ha)	Purchased emergy input ($\times10^{14}$ sej/ha)	Natural emergy input ratio (%)	Purchased emergy input ratio (%)
Northeast of China	9.55	13.80	41%	59%
Huang-Huai-Hai Plain	5.91	36.95	14%	86%
Loess Plateau	8.80	39.55	18%	82%
Northwest of China	7.20	41.98	15%	85%
Southwest of China	9.13	25.24	27%	73%

Maize production is similar, these ratios are close to 70% to 75% in the Northeast and Southwest respectively, while the Loess Plateau, the Huang-Huai Hai Plain and the Northwest area are 78-85% (Fig.3). Under normal conditions, the yield of maize and wheat mainly depends on the amount of natural and auxiliary energy input, and the input of auxiliary energy is closely related to the water and heat conditions of each climatic zone and the soil fertility.

Figure 3. The proportion of natural and purchased emergy input in the main maize growing provinces.



Conclusions

Fig.4 shows that when the structure of the natural ecosystem becomes weaker, its function will also be degraded. The artificial reconstruction ecosystem is the structure of the natural ecosystem that has been partially or completely destroyed, and it also exhibits different system functions.

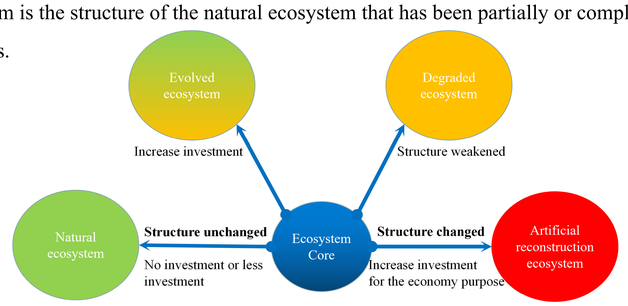


Figure 4. The mechanism of ecosystem evolution

Overall, the “Ecosystem Core” hypothesis reveals the quantitative relationship between life system and environment, the input of artificial auxiliary energy is the fundamental cause of ecosystem evolution. The evolution of an ecosystem is related to human economic purpose, and the input-output ratio affects the goal of system reconstruction.

References

〖1〗. Brown et al, 2016. The geobiosphere emergy baseline: A synthesis. *Ecol. Model.* 339, 92-95.

〖2〗. David W. Ball, John W. Hill, Rhonda J. Scott. 2011. The Basics of General, Organic, and Biological Chemistry. Saylor Academy.

〖3〗. Odum, 1988. Self-organization, transformity, and information. *Science*, 242, 1132-1139.