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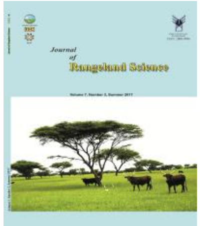

Review and Full Length Article:

A Conceptual Model on Relationship between Structure and Functions in Rangeland Ecosystems

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Abstract. One of the most important issues in structure-function relationship modeling is that each rangeland has numerous functions and each of them can provide the most benefits in a certain state of that ecosystem. In fact, relationship between structure and function can be varied in different states. After presentation of the Linear Structure-Function Model based on the Clementsian succession theory, another conceptual model was proposed to modify it based on more realistic State and Transition theory. While previous models mostly suppose one single function in their simulations, in this article, we suggest a conceptual model that summarizes the relationships between Ecosystem Structure and Multiple Functions (ESMF) in various states. The model can be useful for rangeland managers to get a rather correct understanding about multiple functions in rangelands. By this right understanding, the rangeland managers will be able to identify the best states for their ecosystems and try to reach to these states which can provide totally maximum benefits. This model shows that some functions in rangelands may conflict with or overlapped each other and some functions may not show a meaningful relationship with structure in ecosystems so that it is a very important task for managers to choose the states with the highest benefits and less conflict.

Key words: Ecological functions, Human well-being functions, ESMF model, Rangeland management

Introduction

Structure and function are two inherent attributes in any ecosystems. Structure refers to the constitutive physical components of ecosystem and also the style of their establishment (spatial distribution) (Bradshaw, 1984). But the concept of function may be very wider. In some references, function has been defined as goods and services that are provided by ecosystems (Millennium Ecosystem Assessment, 2005; De Groot, 1992; Costanza *et al.*, 1997; Daily *et al.*, 2000; De Groot *et al.*, 2002; Turner *et al.*, 2003; Ciais *et al.*, 2005). Some references in the definition of ecosystem functions put emphasis on ecological concepts (the ecological based view). In their view, the ecological characteristics such as stability, conservation, diversity, and carbon sequestration are more important (Tilman *et al.*, 1996; Bodin and Wiman, 2007; DSEWPC, 2011). Some of scientists that support this view even have known the stability of an ecosystem equivalent to its function (Walker, 1992; Tilman, 1999; Loreau, 2000; Loreau *et al.*, 2001; Hooper *et al.*, 2005; Srivastava and Vellend, 2005). This diversity of ideas about ecosystem functions is not resulted from personal ideas but rather it is resulted from the extreme diversity in the nature.

Recognition of indicators that can be easily evaluated and applied as pulses for managers to discover alarms is very important in rangeland management. Functions probably are the best indicators for this purpose (Tongway and Hindley, 2004) because they are the best criteria for the evaluation of sustainability. Ecosystem function can be defined as all benefits, services and goods which an ecosystem can provide (De Groot *et al.*, 2002). Also, human well-being functions in an ecosystem are very diverse. In a given state, these functions may not be fitted with the ecological function or even may not be fitted with each other. In fact, each ecosystem in a given state has special conditions and structure that make it more performing for some given functions. So, having a correct understanding about the relationship between structure and ecosystem functions is very important. However, the relationships among components in rangeland ecosystems (structure) are more complex in a way that we cannot evaluate them without a pre-designed model. Thus, presentation of a model that can simplify these relationships is very important. On the other hand, functions in rangelands are very diverse and it is necessary to have a presentation of a model which can reflect the performance of various ecosystem functions in a relationship with structure in rangelands.

In this paper, we discussed the differences between various rangeland ecosystem functions and emphasized that ecological and human well-being functions are different more specially. Since a certain ecosystem mostly has multiple functions, we also propose a conceptual model that shows a realizable relationship between structure and multiple functions of ecosystem in various states. Also, we introduced the ESMF model which shows a hypothetical pattern of rangeland ecosystem structure in a relationship with multiple functions in various states. In attention to dynamism in ecosystems, it is important for rangeland managers to specify their target functions and direct their ecosystems to the states that produce the highest benefits.

Structure-function relations in ecosystems

Relationship between structure and ecosystem functions has been surveyed by many studies (Francis *et al.*, 1979; Hobbs and Norton, 1996; Zedler and Callaway, 1999; Lockwood and Samuels, 2004). The Linear Structure vs. Function (LSF) model that was presented by Bradshaw (1984) specified a linear relationship between structure and ecosystem function based on the succession theory (Clements, 1916). This theory assumed that no disturbances are influencing ecosystems so that their structures can be developed during the time, and as a result, their functions will be raised in the same rate (Fig. 1). However, the criticisms around the Clementsian theory challenged the LSF model too (Muller, 1940; Westoby *et al.*, 1989; Smith, 1989; Laycock, 1989 and 1991; Freidel, 1991; Rodriguez-Iglesias and Kothmann, 1997; Reitkerk and van de Koppel, 1997; Bestelmeyer *et al.*, 2003; Briske *et al.*, 2005). Cortina *et al.* (2006) reviewed the LSF model and tried to modify it. They illustrated that structure and function changes are not essentially symphonic in ecosystems.

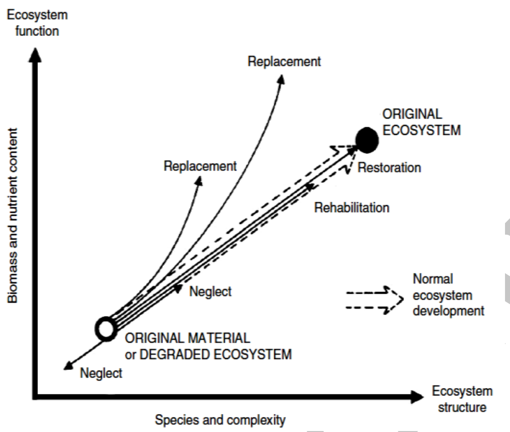

Fig. 1. Graphic representation of the structure–function model (Bradshaw, 1984)

According to state and transition theory (Westoby *et al.*, 1989; Stringham *et al.*, 2003), they expressed ecosystems during succession stages faced with various disturbances that can lead to the creation of new states. Similarly, various relationships can be established between structure and function but they essentially will not follow a similar path. By referring to some studies (Ostfeld and LoGiudice, 2003; Smith and Knapp, 2003), they explained that decreasing of species richness (as an index of structure) in ecosystems may not always lead to decreasing function, at least not in a same rate. They presented a conceptual model of ecosystem dynamics based on structure and function changes (Fig. 2). According to their model, various states that were generated by environmental or management factors show the points that are more probable in structure-function space and may be created by gradual or sudden changes in ecosystem characteristics.

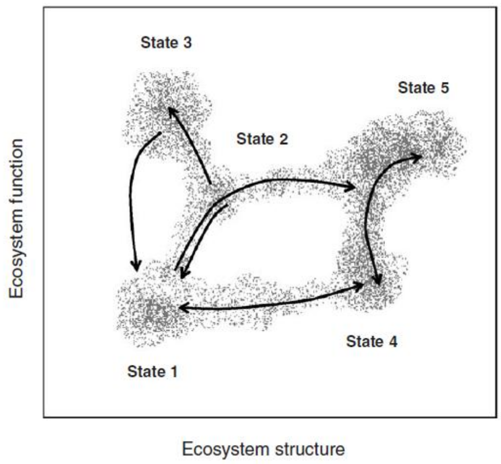

Fig. 2. A conceptual model of ecosystem dynamics based on changes in ecosystem structure and function (Adopted from: Cortina

Ecological and human well-being functions

Ecosystem function has a wide concept, thus before discussing about the relationship between structure and function, it is necessary to specify which concept we are talking about. We believe that there are fundamental differences between ecological and human well-being functions. In fact, these two types of functions may not coincide together in a rangeland. However, it is explicit that the nature does not coordinate its objectives with human's requests or profits but rather it has own rules. Natural systems inherently tend to get stability and are flexible versus disturbances (Farrell *et al.*, 2000; Walker and Del Moral, 2003; Stringham *et al.*, 2003; Bodin and Wiman, 2007). This trend is the factor that boost the ecosystem to climax in the Clementsian succession theory and also is the gravity in ball and bowl model that pull the ball down in the state and transition theory. We will not discuss about ‘what is this power?’ but it is noticed that ‘why is there this power?’ or on the other word , ‘what is the aim of nature from this trend? This issue can help us to get a better understanding about the concept of ecological function that we subsequently will discuss.

Although many criticisms have been signed against succession theory, it is accepted by many scientists that ecosystems inherently tend to increase their diversity (ecologically, biologically and genetically) (Odum, 1969; Tilman *et al.,* 1996; Ives and Car-Penter, 2007; Karnani and Annila, 2009). Diversity helps rangeland ecosystems to complete their nutrition network and use maximum energies which are entered to them (Hoelzer *et al.,* 2006; Whitfield, 2007; Sharma and Annila, 2007; Wurtz and Annila, 2010). In fact, like other bio-systems, rangeland ecosystems tend to evolve.

In viewpoint of biology, it can be said that the aim of nature from dynamism and diversity is to get evolution (Pickering and Owen, 1994). From the initial creation of the universe, nature has been looking for evolution by creating new genes, species and ecosystems (Jaakkola *et al.,* 2008 a, b; Annila and Annila, 2008; Kaila and Annila, 2008). In order to have a comprehensive discussion about the ecological function, we also have to discuss the scientific concept of natural evolution. Evolution of organisms can be basically divided into two material (physiologic) and immaterial features. Physiologic evolution refers to the adaptation and speciation for seizing new environments (Annila and Salthe, 2010) but immaterial evolution implies to the intangible part of organisms. It is the thing that develops brain and mind and includes occasions such as authority, decision, social relations, culture, instrument usage, and ingenuity (Cziko, 2000). However, evolution in ecosystems can be defined as ‘ability to maximize the energy and sources consumption’. It may be the most fundamental characteristic in the ecosystems.

In this study, we do not aim to discuss the evolution and its inbreeding factors, but we aim to show that the development of an ecosystem is ecologically important even if it may not be valuable economically. So, the first step in modeling the relationships between structure and ecosystem functions is to divide the functions into two main groups: ecological and human well-being functions. As mentioned above, these two groups may be inconsistent with each other. Various human well-being functions may not be essentially fitted to each other as well; sometimes, some conflicts may be happened among them. For example, recreational function in a rangeland ecosystem may be in conflict with its provision functions. On the other hand, all functions in an ecosystem mostly have some overlap; for example, a certain plant species may be valuable in view of medicine and industry. Our studies have shown that when the amount of utilized functions in a rangeland is increased, their benefits get raised but not in a cumulative way (Fig. 3) because some functions may overlap or be in conflict with each other.

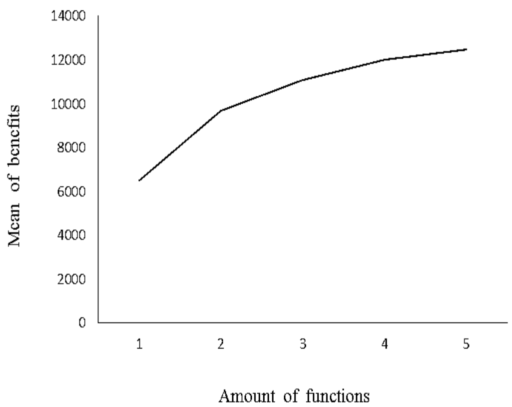

Fig. 3. Increased benefits as a result of increased multiple use of ecosystem functions (Ahmadpour *et al.,* 2016)

Presentation of a new model

According to the above discussions, we presented a new conceptual model to show the relationship between structure and multiple functions (ESMF model) in rangeland ecosystems (Ahmadpour, 2016). This model shows a hypothetical pattern of ecosystem structure associated with multiple functions. At first, the model is explained based on the succession theory. Fig. 4 shows the ESMF model under conditions that no disturbing factors are existed and ecosystems naturally go through succession stages toward the evolution. In this model, ecological function (the bold continued lines) is compared with some other types of ecosystem functions. As it has been shown, ecological function (the ability of maximum usage of energy) has a positive (but not essentially linear) relationship with structure. Generally, at the initial succession stages by the development of each structure unit, the amount of consumed energy increases at a greater proportion. But this proportion will be less in the last succession stages because residual energy sources are at the minimum at these stages. This increase will be continued until the unconsumed energy in the ecosystem reaches to its minimum level and ecological function will be fixed at a given level (the maximum entropy level) (Schneider & Sagan, 2005; Aoki, 2006; Meysman and Bruers, 2010).

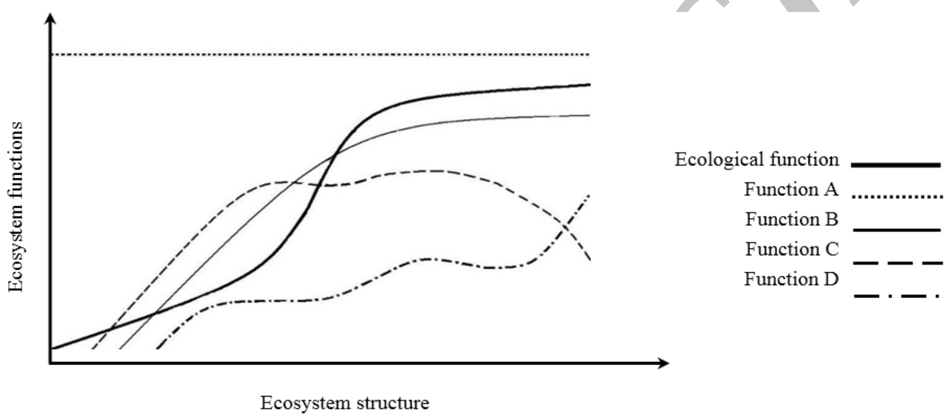

Fig. 4. Graphical ESMF Model based on succession theory (Ahmadpour, 2016)

It must be noticed that the growth of ecological function curve in the initial stages is not necessarily similar for all ecosystems; it can be convex in some types of rangelands or concave in some others. In contrast, human well-being functions in ecosystems may show various patterns. Some of them may not show a significant relationship with ecosystem structure (function B). One example of these functions is aesthetic function. Actually, nobody can assert that a productive rangeland is certainly more pleasant than a bare desert. Other functions that are in relationship with structure can be noticed from two points of view: i) almost all of them need at least a minimum of structure development, ii) these functions increase by increasing the structure development, but some of them continue this procedure until they reach to the maximum level at the climax stage (function D) (for example utilization of timber that is more suitable on the dense forest). Some functions may even show an inverse relationship with structure development (function C) (for example, forage production in rangelands mostly is maximized at the pre-climax stage of vegetation succession and rangeland managers are mostly interested in maintaining their ecosystems at this stage).

However, the Clementsian succession is known as a visionary concept among the ecologists who believed that the real macrocosm is influenced by many natural and man-made factors. So, the models which are presented to explain the relationship between structure and ecosystem functions must be based on more realistic theories to be more applicable in view of ecosystem management. Fig. 5 shows the modified ESMF model based on the state and transition theory. In this model, various states have been assumed for a rangeland ecosystem and we have named them by numbers 1, 2, 3 and 4 (these numbers may be more). Disturbing or restoring factors can convert these states to each other (although conversion from state 1 to state 4 and vice versa may be very difficult). Slumping and rising in the ecological function curve respectively refer to disturbing and restoring activities and show their effects on ecosystem structure and functions. As it has been observed, when a disturbance occurs and the structure development curve shifts to the left, the ecological function curve descends. Other functions may be independent and fluctuate through various states. The presented model actually is a hypothetical pattern that has been made based on the existing knowledge about the relationships among rangeland ecosystem components.

It is explicit that neither of the states or functions that have been presented in the model refers to a real state or function. Also, arches at the curves never try to show the real amounts but they served just to show that the relationship is not linear necessarily.

Conclusion

Although the number of functions that each ecosystem can provide is very much, we can categorize them into two main groups: ecological and human-wellbeing functions. Some studies have tried to present a model simulating the relationship between structure and function in ecosystems (Bradshaw, 1984; Cortina *et al.,* 2006). While a given ecosystem may have numerous functions, these studies mostly suppose just a single function in their simulations. In this paper, we introduce the ESMF model which shows a hypothetical pattern of ecosystem structure in the relationship with multiple functions. The ESMF model shows that the ecological function always has a direct (but no linear essentially) relationship with the development of ecosystem structure. In fact, when the structure develops during the sequence process (movement of graph to the right), the ecological function (evolution of energy chain) is raised too and when the structure goes through a retrogression process (movement of graph to the left), the ecological function gets fall (Ahmadpour, 2016). The sequence process or any restoration operations may push the graph foreword, and against any disturbing actions such as overgrazing or drought, they can return it backward.

In the model, we have noticed the ecosystem state which has extracted from the state and transition concept. Each state in this model can include various functions with given situations while these situations may be varied at the other states. The ESMF model implies that the states (1, 2, 3 and 4 numbers) can be converted to each other by some factors such as restoration or disturbing actions although the converting of state 1 to state 4 may be more difficult. Also, rangeland managers by applying management operations can direct their ecosystems to the desired states which provide the highest benefits for them.

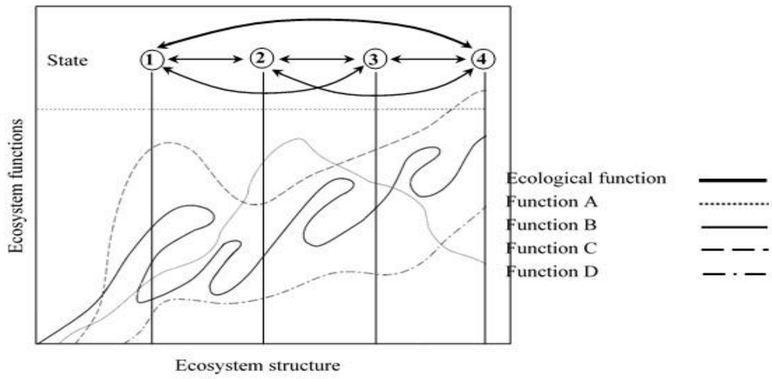

Fig. 5. Graphical ESMF Model based on state and transition theory (Ahmadpour, 2016)

Rangelands in many countries are not in a good condition that mostly results from overgrazing (Moghaddam, 2000). So, it is important for rangeland utilizers to change their strategies into multiple utilization procedures. It can moderate the utilization pressure on the ecosystems. In this way, they need to have a relatively right understanding about the relationships between various functions in rangelands. The ESMF model shows that some functions in rangelands may not have a meaningful relationship with ecosystems structure whereas some others may be completely correlated with it. Thus, managers need to focus on the functions which are more sensitive against the structure variations.

Also, at a given ecosystem with different states, each function may show a different behavior in the relationship with structure. It means that by changing the condition at a rangeland, the functions which provide the highest benefits may change; therefore, rangeland managers need to identify the functions with the best benefits in each state. The ESMF model can be useful for them to understand these behaviors of functions in rangelands. The model shows when the structure of a rangeland develops during the sequence process, how various functions can be changed on it. By this knowledge about the functions behavior in the rangelands, managers will be able to predict the benefit changes in the future and direct their ecosystems to the states that provide the highest benefits. However, directing a rangeland ecosystem to a state that maximizes a given function may result in adverse effects on other functions in long time. So, the establishment of an equilibrium among several functions seems to be better than considering a single function alone.

It is must be noticed that decision making about the target function(s) is an important task for rangeland managers. They can direct their rangelands to a given state by applying the restoration or other management operations. The ESMF model just simulates the variations of benefits provided by multiple functions in ecosystems and in relationship with structure.

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References

Ahmadpour, A., 2016. A new approach in assessment of rangeland ecosystems based on ecological and economic view. Ph.D. thesis. Gorgan University of Agricultural Sciences and Natural Resources. (In Persian).

Ahmadpour, A., Heshmati, G.A., Joulaie, R., 2016. Rangeland Condition Assessment Based on Economic Criteria. Jour. Landsc. Ecol., 9(2), 83-96. (In Persian).

Annila, A., Annila, E., 2008. Why did life emerge? Int. Jour. Astrobi., 7, 293-300.

Annila, A., Salthe, S., 2010. Physical foundations of evolutionary theory. Jour. Non-Equilib., Thermodyn., 35, 31-321.

Aoki, I., 2006. Min–max principle of entropy production with time in aquatic communities. Ecol. Complex. 3, 56–63.

Bestelmeyer, B.T., Brown, J.R. Havstad, K.M., Alexander, R., Chavez, G., Herrick, J.E., 2003. "Development and use of state-and transition models for rangelands." Jour. Range Manage., 56(2), 114-126.

Bodin, P., Wiman, B.L.B., 2007. The usefulness of stability concepts in forest management when coping with increasing climate uncertainties. Forest Ecol. Manage., 242, 541-552.

Bradshaw, A.D., 1984. Ecological principles and land reclamation practice. Landsc. Plan., 11, 35–48.

Briske, D.D., Fuhlendorf, S.D., Smiens, F.E., 2005. State-and-transition models, thresholds and rangeland health: a synthesis of ecological models and perspectives. Range Ecol. Manage., 58, 1-10.

Ciais, P.H., Reichstein, M., Viovy, N., Granier, A., Oge´e, J., Allard, V., Aubinet, M., Buchmann, N., Bernhofer, Chr., Carrara, A., Chevallier, F., De Noblet, N., Friend, A.D., Friedlingstein, P., Gru¨nwald, T., Heinesch, B., Keronen, P., Knohl, A., Krinner, G., Loustau, D., Manca, G., Matteucci, G., Miglietta, F., Ourcival, J.M., Papale, D., Pilegaard, K., Rambal, S., Seufert, G., Soussana, J.F., Sanz, M.J., Schulze, E.D., Vesala, T., Valentini, R., 2005. Europe-wide reduction in primary productivity caused by the heat and drought in 2003. Nature, 437, 529-533.

Clements, F.E., 1916. Plant succession: an analysis of the development of vegetation. Carnegie Inst., Washington Pub., 242, 1-512.

Cortina, J., Maestre, F.T., Vallejo, R., Baeza, M.J., Valdecantos, A.L., Pe´rez-Devesa, M., 2006. Ecosystem structure, function, and restoration success: Are they related? Jour. Natu. Cons., 14, 152-160.

Costanza, R., d'Arge, R., de Groot, R.S., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature, 387, 253-60.

Cziko, G., 2000. The Things We Do: Using the Lessons of Bernard and Darwin to Understand the What, How, and Why of Our Behavior. Massachusetts Institute of Technology. US. 290p.

Daily, G.C., Soderquist, T., Aniyar, S., Arrow, K., Dasgupta, P., Ehrlich, P.R., Folke, C., Jannson, A., Jansson, B.O., Kautsky, N., Levin, S., Lubchenco, J., Maler, K.G., David, S., Starrett, D., Tilman, D., Walker, B., 2000. The value of nature and the nature of value. Science, 289, 395-396.

De Groot, R.S., 1992. Functions of Nature: Evaluation of Nature in Environmental Planning, Management and Decision-Making. Wolters Noordhoff BV, Groningen, The Netherlands.

De Groot, R.S., Wilson, M., Boumans, R., 2002. A typology for the description, classification and valuation of ecosystem functions, goods and services. Economics, 41, 393-408.

DSEWPC, Department of Sustainability, Environment, Water, Population and Communities., 2011. ACRIS Landscape Function Update 2006-2010: Updated Information to That Provided in Rangelands 2008– Taking the Pulse. Commonwealth of Australia. 37p.

Farrell, E.P., Fu¨hrer, E., Ryan, D., Andersson, F., Hu¨ttl, R., Piussi, P., 2000. European forest ecosystems: building the future on the legacy of the past. Forest Ecol. Manage., 132, 5-20.

Francis, G.R., Magnuson, J.J., Regier, H.A., Talhelm, D.R., 1979. Rehabilitating Great Lakes Ecosystems. Great Lakes Fishery Commission. Technical Report 37, Ann Arbor, MI., pp. 1–107.

Friedel, M.H., 1991. Range condition assessment and the concept of thresholds: a viewpoint. Jour. Range Manage., 44, 422-426.

Hobbs, R.J., Norton, D.A., 1996. Towards a conceptual framework for restoration ecology. Restor. Ecol., 4(2), 93-110.

Hoelzer, G.A., Smith, E., Pepper, J.W., 2006. On the logical relationship between natural selection and self-organization. Jour. Evol. Biol., 19, 1785-1794.

Hooper, D.U., Chapin III, F.S., Hector, A., Inchausti, P., Lavorel, S., Lawton, J.H., Lodge, D.M., Loreau, M., Naeem, S., Schmid, B., Seta¨la¨, H., Symstad, A.J., Vandermeer, J., Wardle, D.A., 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecol. Monogr., 75, 3-35.

Ives, A.R., Carpenter, S.R., 2007. Stability and diversity of ecosystems. Science, 317(5834), 58-62.

Jaakkola, S., Sharma, V., Annila, A., 2008a. Cause of chirality consensus. Curr. Chem. Biol., 2, 53-58.

Jaakkola, S., El-Showk, S., Annila, A., 2008b. The driving force behind genomic diversity. Biophys. Chem., 134, 232-238.

Kaila, V.R.I., Annila, A., 2008. Natural selection for least action. Proc. R. Soc. A., 464, 3055-3070.

Karnani, M., Annila, A., 2009. Gaia again. Bio Systems., 95, 82-87.

Laycock, W.A., 1989. Secondary Succession and Range Condition Criteria: Introduction to the Problem. In: W.K. Lauenroth, and W.A. Laycock (eds), Secondary Succession and the Evaluation of Rangeland Condition. Westview Press, Boulder, Colo.

Laycock, W.A., 1991. Stable states and thresholds of range condition on North American rangelands: a Viewpoint. Jour. Range Manage., 44, 427-433.

Lockwood, J.L., Samuels, C.L., 2004. Assembly Models and the Practice of Restoration. In V.M., Temperton, R.J., Hobbs, T., Nuttle, S., Halle, (Eds.), Assembly Rules and Restoration Ecology (pp. 34-54). Washington: Island Press.

Loreau, M., 2000. Biodiversity and ecosystem functioning: recent theoretical advances. Oikos, 91, 3-17.

Loreau, M., Naeem, S., Inchausti, P., Bengtsson, J., Grime, J.P., Hector, A., Hooper, D.U., Huston, M.A., Raffaelli, D., Schmid, B., Tilman, D.,Wardle, D.A., 2001. Biodiversity and ecosystem functioning: current knowledge and future challenges. Science, 294, 804-808.

Meysman, F.J.R., Bruers, S., 2010. Ecosystem functioning and maximum entropy production: a quantitative test of hypotheses. Phil. Trans. R. Soc. B., 365, 1405–1416.

Millennium Ecosystem Assessment: Synthesis Report, 2005. Strengthening capacity to manage ecosystems sustainably for human wellbeing. Millennium Ecosystem Assessment offices, 219p.

Moghaddam, M., 2000. Range and range management. Tehran University. 470 pp. (In Persian).

Muller, C.H., 1940. Plant succession in the Larrea-Flourensia climax. Ecology, 21, 206-212.

Odum, E.P., 1969. The strategy of ecosystem development. Science, 164, 262-270.

Ostfeld, R.S. LoGiudice, K., 2003. Community disassembly, biodiversity loss, and the erosion of an ecosystem service. Ecology, 84, 1421–1427.

Pickering, K.T. & Owen, L.A., 1994. An Introduction to Global Environmental Issues. Routledge: London, 390pp.

Reitkerk, M., van der Koppel J., 1997. Alternate stable states and threshold effects in semiarid grazing systems. Oikos, 79, 69-76.

Rodriguez Iglesias, R.M., Kothman, M.M., 1997. Structure and causes of vegetation change in state and transition model applications. Jour. Range Manage., 50, 399-408.

Schneider, E. D. and Sagan, D., 2005. Into the cool: energy flow, thermodynamics, and life. Chicago, IL: University of Chicago Press.

Sharma, V. and Annila, A., 2007. Natural process - natural selection. Biophys. Chem., 127, 123-128.

Smith, E.L., 1989. Range Condition and Secondary Succession: a Critique. In: W.K. Lauenroth, and W.A. Laycock (eds), Secondary Succession and the Evaluation of Rangeland Condition. Westview Press, Boulder, Colo.

Smith, M.D., Knapp, A.K., 2003. Dominant species maintain ecosystem function with non-random species loss. Ecol. Letters, 6, 509-517.

Srivastava, D.S., Vellend, M., 2005. Biodiversity-Ecosystem function research: Is it relevant to conservation. Annu. Rev. Evol. Syst., 36, 267-294.

Stringham, T.K., Frueger, W.C., Shaver, P.L., 2003. State and transition modeling: an ecological process approach. Jour. Range Manage., 56, 106-113.

Tilman, D., 1999. The ecological consequences of changes in biodiversity: a search for general principles. Ecology, 80, 1455-1474.

Tilman, D., Wedin, D., Knops, J., 1996. Productivity and sustainability influenced by bio-diversity in grassland ecosystems. Nature, 379, 718-720.

Tongway, D.J., Hindley, N.L., 2004. Landscape Function Analysis Manual: Procedures for Monitoring and Assessing Landscapes with Special Reference to Mine sites and Rangelands. Version 3.1 on CD Produced by CSIRO Sustainable Ecosystems, Canberra, Australia.

Turner, R.K., Paavola, J., Cooper, P., Farber, S., Jessamy, V., Georgiou, S., 2003. Valuing nature: lessons learned and future research directions. Ecol. Economics, 46, 493-510.

Walker, B.H., 1992. Biodiversity and ecological redundancy. Cons. Biol., 6, 18-23.

Walker, L.R., Del Moral, R., 2003. Primary Succession and Ecosystem Rehabilitation. Cambridge: Cambridge University Press.

Westoby, M., Walker, B., Noy-Meir, I., 1989. Opportunistic management for rangelands not at equilibrium. Jour. Range Manage., 42, 265-273.

Whitfield, J. 2007. Survival of the likeliest? Plops Biol., 5, 962-965.

Wurtza, P., Annila, A., 2010. Ecological succession as an energy dispersal process. Bio. Sys., 100, 70-78.

Zedler, J.B., Callaway, J.C., 1999. Tracking wetland restoration: Do mitigation sites follow desired trajectories? Restor. Ecol., 7, 69-73.

ارائه یک مدل مفهومی از رابطه بین ساختار و کارکردها در اکوسیستم‌های مرتعی

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چکیده. علیرغم آنکه داشتن یک درک صحیح در خصوص رابطه بین ساختار و کارکردهای اکوسیستم از اهمیت قابل توجهی برخوردار است در حال حاضر یک مدل جامع و مورد توافق در این زمینه وجود ندارد. پس از ارائه مدل رابطه خطی بین ساختار و کارکرد در اکوسیستم‌ها بر اساس مدل توالی کلیماکس، مدل مفهومی دیگری به منظور بهبود مفاهیم آن بر مبنای نظریه حالت و انتقال پیشنهاد شد. با این حال مسئله دیگرِ باقیمانده این است که اصولاً در یک اکوسیستم کارکردهای مختلفی وجود دارد و هر یک در وضعیت خاصی از ساختار اکوسیستم بیشترین منافع را ایجاد می‌کند. بنابراین برای مدیران اکوسیستم‌ها بسیار مهم است که وضعیت‌هایی را که بیشترین منافع را برای بهره‌برداران فراهم می‌سازند شناسایی کرده و اکوسیستم‌های تحت مدیریت خود را به سمت آن وضعیت‌ها هدایت کنند. این موضوع مدلسازی رابطه بین ساختار و کارکردهای مختلف اکوسیستم‌ها را پیچیده‌تر می‌سازد. در این مقاله در رابطه با تفاوت‌های بین کارکردهای بوم‌شناختی (کارکردهای مطلوب طبیعت) و کارکردهای مطلوب انسان بحث می‌شود سپس بر اساس آن مدلی مفهومی از رابطه بین ساختار و کارکردهای چندگانه اکوسیستم ارائه می‌گردد. این مدل به مدیران اکوسیستم‌ها کمک خواهد کرد تا درک بهتری از وضعیت‌های مختلف اکوسیستم و چگونگی ارتباط آن با کارکردهای متعدد و منافع فراهم شده توسط آنها بدست آورند. بر مبنای این درک صحیح، آنها قادر خواهند بود تا از بین حالت‌های متعددی که اکوسیستم‌های تحت مدیریت، می‌توانند به آنها برسند، بهترین حالت را انتخاب کرده و استراتژی‌های مدیریتی‌شان را جهت رسیدن به آن ساختار از اکوسیستم طرح‌ریزی نمایند.

کلمات کلیدی: کارکردهای اکولوژیکی، کارکردهای مطلوب انسان، مدل ESMF، مدیریت اکوسیستم