第 24 卷第 5 期
2004 年 5 月

生 态 学 报
ACTA ECOLOGICA SINICA

Vol. 24, No. 5
May, 2004

繁殖体与微生境在退化草地恢复中的作用

张 荣,陈亚明,孙国钧,李凤民

(兰州大学生命科学学院,兰州 730000)

摘要:退化草地的成功恢复主要依赖于种子和母株无性繁殖幼苗的有效建植,即草地群落中可利用繁殖体是退化草地得以恢复的内在条件。此外,群落中那些提供种子发芽、幼苗生长发育的适宜微生境(safe sites/suitable microsites),构成了退化草地恢复的外在条件。由于严重退化草地群落缺乏可利用繁殖体和供繁殖体生长发育的适宜微生境,使得退化草地恢复受到很大限制,因而,同时满足繁殖体与微生境是退化草地恢复的先决条件。人为提供繁殖体和适宜微生境可以在很大程度上提高退化草地的恢复速度,即在缺乏繁殖体草地群落供给繁殖体,或者在缺乏微生境的草地群落中创造适宜微生境。不同植物种群建植需要的环境存在着显著差异,因此在人工恢复草地群落过程中,对这些植物的繁殖体和繁殖体着床环境给予特殊处理是必需的,使之同时满足多种植物种群建植需求。对退化草地植物繁殖体、微生境的重要性及其涵义进行讨论。

关键词:退化草地;安全位点;繁殖体;残留种群;自然恢复;人工恢复

The role of diaspores and microsites in restoring degraded grasslands

ZHANG Rong[1], CHEN Ya-Ming, SUN Guo-Jun, LI Feng-Min (*School of Life Science, Lanzhou University, Lanzhou 730000, China*). ***Acta Ecologica Sinica*, 2004, 24(5): 972~977.**

Abstract: Successful restoration of degraded grassland is mainly dependent upon the efficient establishment of seedlings both from available seeds and parental clones, i. e. available diaspores in grassland communities are the intrinsic requirements for the restoration of degraded grassland. Further more, safe sites in the communities that provide seeds, seedlings and even adult individuals with suitable resources, such as nutrients, water, light etc., for their normal germination, growth and development, constitute the extrinsic condition for the restoration of degraded grassland. The lack of available diaspores and safe sites in degraded grassland communities has limited the process of degraded grassland restoration, to meet the requirement for both available diaspores and safe sites simultaneously is the prerequisite for the restoration of degraded grassland. Artificial preparation of both available diaspores and safe sites in grassland communities could increase the speed of the restoration, i. e. additional diaspores should be provided in the communities that limited by diaspores limitation during natural restoration, and/or created safe sites for the additional diaspores. Different requirements of various plant species for efficient establishment in the process of restoration need specific treatment both in diaspores and habitats. The precent study aims at discuss the importance of diaspores and microsites and their implications in the restoration of degraded grasslands.

Key words: degraded grassland; safe sites; diaspores; remnant populations; natural restoration and artificial restoration

文章编号:1000-0933(2004)05-0972-06 **中图分类号**:Q346,Q948,S181 **文献标识码**:A

The importance of available diaspores and suitable safe sites in the establishment of individual plant species has long been recognized[1~3]. However, successful restoration of degraded grassland is not only reestablishment of one single plant species in

基金项目:国家重点基础研究发展规划资助项目(2000018603);国家自然科学基金重大研究资助项目(90102011);甘肃省自然科学基金资助项目(ZS031-A25-037-D)

收稿日期:2003-09-23;**修订日期**:2004-02-12

作者简介:张 荣(1963~),男,黑龙江省双鸭山市人,博士,副教授,主要从事种群生态学和恢复生态学研究。E-mail: rongz@lzu.edu.cn

Foundation item: The National Key Project for Basic Research in China (No. G2000018603), National Natural Science Foundation of China (No. 90102011) and Natural Science Foundation of Gansu Province (ZS031-A25-037-D)

Received date: 2003-09-23; **Accepted date**: 2004-02-12

Biography: ZHANG Rong, Ph. D., Associate professor, mainly engaged in population ecology and restoration ecology. E-mail: rongz@lzu.edu.cn

the community, but also the recover of a combination of plant populations. Regeneration niches of each species in grassland community vary a lot among plant species[2], that is the microsites in plant community may be suitable for the restoration of species A, but not suitable for species B, and so on. Besides this, numbers of available diaspores of various plant species in grassland community may vary a lot, depending upon their previous statuses and characteristics of each species. Different environmental requirements for microsites and variation in numbers of available diaspores make the restoration of degraded grassland very difficult.

The lack of available diaspores and suitable safe sites is thought to be the limiting factors for restoration of degraded grasslands. Therefore, to meet the requirements of both available diaspores and suitable sites together simultaneously become the prerequisites for the restoration of degraded grassland[4~6]. For renewable grassland communities, clonal ingrowth is the major mode of gap colonization in grasslands, accounting for between 59 and 99% of colonizing ramets[7~9]. What sort of available diaspores of plant species are in insufficient supply and, what is species-specific requirement for the safe sites of various plant species? How to resume the degraded grassland efficiently has become a great challenge to the ecologists. Certainly, more information is required for successful restoration of degraded grassland. The key is to quantify available diaspores and suitable safe sites of all the component plant species in grassland communities, to meet them together and to use efficient methods to supply the degraded grassland with available diaspores and suitable safe sites.

1 The two factors in the restoration of degraded grassland

Available diaspores and suitable safe sites are two key factors in the restoration of degraded grassland, in which available diaspores are the intrinsic requirement[10~13], and safe sites constitute the extrinsic condition for the restoration of degraded grassland. Lack of any of them, it is not only impossible for the restoration of degraded grassland, but also impossible for maintaining of any plant populations in grassland community. It is never overemphasized the importance of available diaspores and suitable safe sites in the restoration of degraded grassland.

1.1 Importance of available diaspores in grassland community

Numbers of available diaspores in plant communities vary a lot due to plant species and fluctuating environmental conditions[10~13]. For the degraded grassland communities, the existence of available diaspores are mainly dependent upon degree of degradation[14~15]. Severely degraded grassland has got less chance to produce diaspores, due to overgrazing and alteration of land use, remnant populations for diaspores' production are especially deficient. Fast restoration of grassland is impossible without additional supply of diaspores because of seed and seedling limitation[10~13]. In the case, additional supply of diaspores is necessary for fast grassland restoration. Otherwise, the degraded grassland would keep the status for a long period of time, until the appearance of parental plant populations relying on various ways of natural dispersal of diaspores. If the land was used as arable land and then left aside as fallow through natural restoration, the complete restoration would require more time[15,16]. Under these situations, natural restoration of degraded grassland would mainly depend on natural succession of the vegetation, it means that lack of diaspores in the grassland community is the key limiting factor except the safe sites in the communities. The speeds of restoration of degraded grassland are mainly dependent upon the intrinsic resources from the very few remnant populations[14]. Generally specking, additional supply of diaspores is required for fast restoration of degraded grasslands. However, collection of diaspores in severely degraded grassland, and even in normal grassland is laborious, therefore artificial supply of diaspores is rarely applied for the restoration of degraded grassland.

Comparatively, the slightly degraded grassland maintains a potential of higher productivity of diaspores due to the existence of more remnant populations. After fencing of degraded grassland, diaspores and seedings from remnant plant populations usually increase quickly and sufficiently[16~21]. Herein, in slightly degraded grassland, the remnant populations within the community could provide lots of diaspores both in seeds and seedlings to be used for the restoration. Seeds and seedlings from the remnant parental plants have two quite different fates, they would germinate and develop into adult plants if the factors what they require are satisfied, or they will die due to various reasons[13]. The fates of the diaspores are mainly relied on the sites of their location.

It should be mentioned here that germination of some kinds of plant seeds requires special processes of treatment after shedding from remnant plant populations. For example, seeds of many kinds of grass species from temperate grassland require cold-wet stratification, while seeds of many legume species require softening, scarification etc., in order to break down both primary and secondary seed dormancy[22~24].

1.2 Importance of available safe sites in grassland community

Successful establishment of seedlings requires a series of ecological factors. However, the factors for successful establishment are usually not satisfied in the natural environment. Diaspores shedding from parental plants in grassland communities experienced different fates, most of them would die before germination because of animals, bacteria, virus and physical conditions. Many studies have showed that most seeds in grassland communities are attacked by various kinds of animals, such as pathogens, rodents etc[30~33]. Some diaspores that reached at safe sites could germinate, emerge and survive.

The safe sites provide all the suitable conditions to the seeds and seedlings required for survival, germination, growth and development, such as light, water, available nitrogen and phosphorus, and so on[25~29]. However, the sites in grassland may be suitable for some plant species, but not suitable for other plant species, i.e. the requirements for successful establishment of plant species are species-specific. No one site in a grassland community is suitable for all the plant species. On the other hand, the conditions of the sites in grassland community often change with time, i.e. they are dynamic, sometimes they are suitable for successful establishment of some plant species, at other times, they are not. So, there are some dormant seeds and seedlings in grassland community due to unfavorable physical conditions, some perhaps would loss their physiological activities before reaching suitable sites[25~29]. Suitable safe sites not only provide the seeds with the ecological factors what they require during germination, seedling emergence, and later development, but also provide the diaspores with refuges escape from herbivory and predation by animals[30~33].

Both available diaspores and suitable safe sites are essential for the restoration of degraded grassland, lack of any one would prohibit the processes of the restoration of grassland, no matter what process natural or artificial restoration is. For the artificial restoration of degraded grassland, prior to additional seed supply, preparation of safe sites is usually required[16,28].

2 Restoration of degraded grassland

The processes of restoration of degraded grassland depend mainly on available diaspores and suitable safe sites, which are subjected to the process of plant community succession. How to restore the degraded grassland in the regions has been caused considerable concerns over last century all over the world. Many practices on restoring grassland have been carried out in lots of regions[16]. However, restoration is not so easy as it is destructed by alteration of land uses by people and overgrazing by animals. Alterations of land use and overgrazing have changed the habitats more or less, and herein, the ways to restore degraded meadow grassland may be different. As mentioned above, the restoration of degraded grassland could be carried out by both natural and artificial ways.

2.1 Natural restoration of degraded grassland

Like other kinds of vegetations, grassland has the ability to renew itself after disturbance. This is the basic way of natural restoration by fencing the degraded grassland[15,16]. For example, fallow lands can be transformed into grassland through a long period of time, possibly 15 to 20 years or more. Due to lack of remnant meadow plant species and soil seed bank[5,14], the process of restoration are mainly dependent upon the dispersal and colonization of available diaspores from neighboring meadow communities, and therefore longer time is required[15,16]. For the degraded grassland caused by overgrazing, 3～5 years of time is required for restoration. Because of the differences of colonization ability among various plant species, in the processes of grassland natural restoration, the prerequisites for natural restoration is sufficient availability of seeds and safe sites which provide seeds and seedlings with the conditions of light, temperature fluctuations[31], nutrients and spaces etc[29~32]. The amount of these sources has significant effects on the speed of natural restoration[2,5,14]. Natural restoration is suitable to slight degraded grassland because of relative higher number of diaspores from remnant plant populations[5,14].

The speed of natural restoration is closely related to the degree of grassland degradation, the relationships between speed of natural restoration and the degree of grassland degradation could be expressed as figure 1 schematically. In figure 1, the axes x and y represent relative degree of grassland degradation and relative time required for the restoration, and in which the values of 1 on each axis of x and y coordinate, are the possible relative degree of most severely degraded grassland and the most longest time required for grassland restoration to its original status respectively.

First, in the situation of early succession of natural restoration, if the pioneer species belongs to the dominant plant species in grassland community, the restoration time required may be shorten because of its ability of providing diaspores by the community itself, and the relationship between degree of grassland degradation and time required for the restoration of degraded grassland could be depicted as the concave line on the figure 1. it means that under certain degrees of degradation, relative shorter time is required for the restoration of degraded grassland, especially found in the slightly degraded grassland community, where the dominant plant species are not quite destructed and still has a higher diaspores' productivity, both in seeds and clonal seedlings.

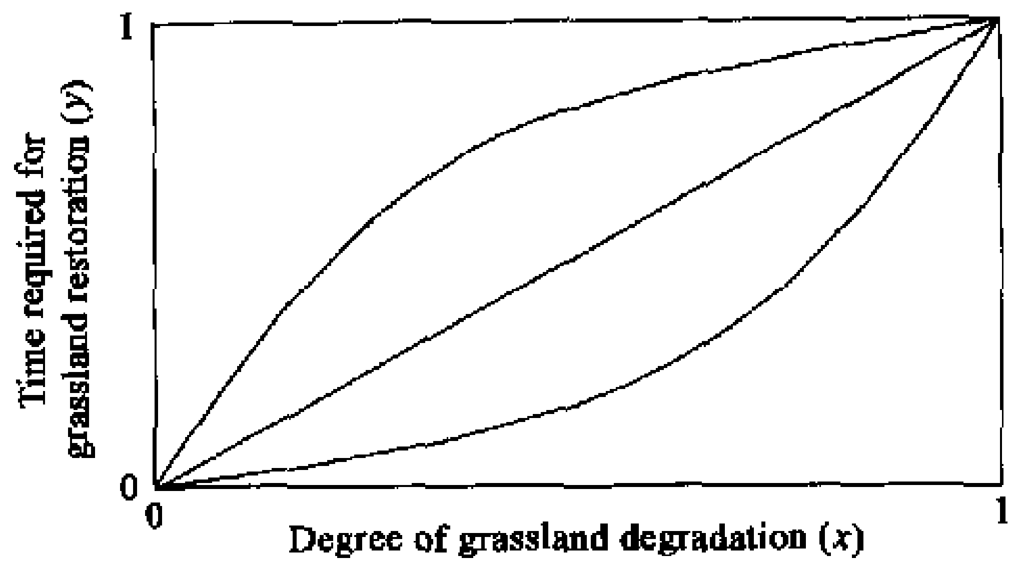

Fig. 1 Degree of grassland degradation(x)

Relationship between times required for grassland restoration and degrees of grassland degradation. For the detail see text

In the second case, conversely, if the pioneer species is not the dominant species, due to the existence of the pioneer species, e. g. *Ligularia virgaurea* after serious degradation[18], and severe lack of available diaspores of required remnant plant populations, the speed of natural restoration could be lingered significantly. The relationships between degree of grassland degradation and time required for the restoration of degraded grassland could be expressed as the convex line in figure 1. For most plant populations in degraded grassland, the processes of restoration are possibly belonging to this type shown as the convex line in the figure.

In the third case, the relationships between the time required for the restoration of degraded grassland and degree of meadow degradation is in positive correlation, could be expressed as diagonal in figure 1, is the counteracted result of the two cases expressed above. Here we thought that the case merely occur in real plant communities because of intra- and inter-competition and decrease of safe sites for same species and different species.

Growth of the plant populations in degraded grassland community will show sigmoid mode or logistic form during the process of restorations, but the possible relationships between the time required for the restoration of degraded grassland and degree of meadow degradation should not be ignored, in which restoration time required for each plant population will show a certain form in figure 1. Assuming that there are certain logistic growth forms for each plant population in grassland, for restoration of many plant species, but the most forms expressed as the relationship between degree of grassland degradation and time required for the restoration of degraded grassland are possibly the forms of concave and convex curves showed in the figure.

With the increase of plant population sizes, the effects of buffering resistance of natural restoration will also increase, which are resulted from: (1) safe sites decreases with the increase of plant populations and their sizes, the rate of re-colonization and establishment of both grasses and forbs decrease[27], many seeds can not find suitable sites remain dormant; (2) common resources taken up by individual plant will reduce because of intra- and inter-competition with the increase of plant population densities. Herein, in later stage of natural restoration, the speed of natural restoration will be slowed down, and the new establishment of seedling will be mainly from clonal ingrowth[5,21], most seeds from seed rains will be stored as soil seed bank until next gap disturbances occur or die from various reasons[5,13,25,26]. Hereon, we are sure that the relative importance of seeds and ramets in the restoration of degraded grasslands alters with the stages of restoration, or in different degree of degradation of grassland.

2.2 Artificial restoration of degraded grassland

Natural restoration of meadow grassland is mainly limited by a lack of number of diaspores and safe sites, especially those of fallows and overgrazing. Therefore, artificial restoration of degraded grassland is essential and can be considered as an additional method.

2.2.1 *Recreation of microsites for successful restoration of degraded grassland* Seeds of some plant species from temperate grassland require specific conditions for example cold stratification, light conditions, temperature fluctuating, weak competition etc., in the ecological factors, some could get through adjusting the time of sowing. For example, requirements for higher temperature, sowing time can be selected in later spring or summer; some species require gaps in the communities, laceration of meadow sod, can improve temperature fluctuations, light conditions; germination of some species is sensitive to nitrogen content in soil, therefore, additional supply of nitrogen is required. However, the requirements for environments of different plant species are sometimes different, i.e. there are species-specific requirements for their successful establishment, if there is contradiction among individual plant species, how to meet the different requirement for all the plant species which constitute meadow community is one great challenge to all the restoration ecologists.

2.2.2 Pretreatment of sowing seeds Characteristics of seed dormancy prevent seed from germination and seedling emergence under non-favorably environments and time, therefore, it is an important ecological strategy for the seeds and seedlings to escape from unfavorable conditions. For the successful establishment of some kinds of plant species in one region, breaking of seed dormancy breaking is a prerequisite, however, seeds of some plant species require induction of different factors for germination. If the factors could not meet the requirement, seeds would remain dormant. For example, seed germination of some temperate grassland needs pre-chilling treatment for a period of time before germination, such as *Pastinaca sativa*[6], seeds of some plant species need scarification or softening because of their hardness and impenetrability of seed capsule, for example, seeds of many legume species. Many studies showed that creation of gaps in grassland can improve light conditions and temperature fluctuations, the factors that are required by some plant species for their seed germination and later successful survival and growth[5,6].

3 Gaps open to further study

Differences among species in their requirements for microsites in which they germinate and grow are one mechanism that has been hypothesized to maintain competing species in a community, that is to make their coexistence possible[2,3]. However, species-specific requirements for seeds to germinate and later development have made the restoration of degraded grassland more difficult by artificial restoration. There is a long way to go to understand different detailed ecological mechanisms underlies for the restoration of degraded grassland. What are status of seed and seedling banks located in grassland communities? Whether present biological and physical environment of degraded grassland limited seed germination, seedling emergence and seedling growth? When grasses and forbs could grow and develop better? What factors or combinations of factors could break down dormancy of seeds or dormant buds of different plant species? Whether is there conflict among the requirements of plant species that coexisted in grassland communities or not, how to solve the problems? Could fast restoration be realized through the pretreatment of seeds, such as cold-wet stratification and/or preparation of seedbeds, such as harrowing meadow and supply of nitrogen?

Better understanding through exploring the statuses of seed germination of, survival rates, later growth and development of dominant forage species and toxic plant species, ecological responses to several main ecological factors, in comparison with different plant species under different treatments, to discover the response of dominant plant species and poisonous weeds to the variation of environmental factors, further to reveal the effects of seedling emergence and clonal growth on renewing and maintaining population process, and regulation of eat and flow of the two ways of reproduction during process of grassland restoration. The topics mentioned above are open and in instance to study for the restoration of degraded grassland.

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