

绿洲景观生态研究

贾宝全 慈龙骏 著



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OASIS LANDSCAPE ECOLOGICAL STUDY

by

Jia Baoquan and Ci Longjun



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内 容 简 介

本书从景观这一视角出发,利用景观生态学的理论和原理,全面系统地介绍了绿洲景观的基本概念与基本理论,并选择新疆石河子垦区 150 团场这一典型区域为研究靶区,在景观生态学理论指导下,对其景观格局、景观动态、耕地的自然潜力进行了系统研究。并以耕地自然潜力评价结果为基础,对其进行了景观规划设计。同时,考虑到水在绿洲开发及其稳定性维持上的作用,以及过去在水资源利用中过分强调其经济利用价值,而忽视其生态环境效应,进而导致干旱区严重的生态环境退化问题的现实,本书还对干旱区生态保护的原则、生态用水的概念和分类、生态用水机理及其计算模型等方面进行了系统研究。

本书可供从事干旱区生态学、地理学和环境科学以及有关应用学科的研究人员和教学人员参考,也可以作为有关专业的大学生与研究生的教科书或参考书。

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前 言

绿洲是干旱区集自然与人文为一体的特殊景观类型,也是干旱区的精华所在。虽然其面积仅占干旱区总面积的 4%~5%左右,但却集中了该区域 90%以上的人口与 95%以上的社会财富。在干旱区山地、荒漠、绿洲三大系统中,绿洲处于中心位置。不论是荒漠的开发还是山区资源的利用,均是以绿洲作为支撑点,并最终服务于绿洲的。在我国人口、资源和环境问题日益尖锐的今天,干旱区以其丰富的后备国土资源与矿产资源奠定了其在我国未来的国土资源开发战略中举足轻重的战略地位。而干旱区的开发,实则首先是绿洲的开发。

然而,就以往的绿洲研究而言,所做的工作主要集中在区域与生态系统两个尺度上。由于区域的概念比较宏观,所得研究成果的针对性与可操作性均不强;而生态系统水平的研究,又因视野所限,在解决较大尺度问题时又往往显得乏力。正是这两点限制,使得以往的许多研究工作留下了较大缺憾。针对这种研究现状,从一种全新的视角重新审视与研究绿洲便显得尤为必要。

景观生态学是现代生态学中的一个年轻分支,它以景观为研究对象,其研究尺度又恰好介于区域和生态系统之间。通过对它的研究,可以把区域与生态系统研究连接起来。因此,它可以视为目前进一步探索与研究绿洲的理想工具。而以前的许多研究成果也都承认绿洲是干旱区一种特殊的景观类型,然而,从这一角度对绿洲进行深入研究的工作却鲜有报道。

正是基于以上考虑,本书利用开展国家自然科学基金项目(40071004、39990490)与中国科学院资源与生态环境研究重大项目“新疆绿洲生态系统的生态过程与生态系统管理”(KZ951-B1-213)之“典型绿洲景观生态的结构、功能、演化及景观设计研究”专题工作的研究机遇,选取新疆石河子垦区 150 团场这一 20 世纪 50 年代开始开发建设的新绿洲为主要的研究靶区,并以甘肃的民勤绿洲和新疆的吐鲁番绿洲为辅助研究靶区,在景观生态学理论的指导下,在对绿洲基本理论问题的景观生态学探讨基础上,对其进行了景观生态学的系列研究,其内容分别涉及空间格局、景观动态、景观评价、生态用水、景观生态规划等诸多方面。

在课题的资料收集过程中,得到了石河子市土地管理局侯建荣科长的大力协助;在图件处理过程中承蒙中国科学院新疆生态与地理研究所绿洲生态系统开放实验室周克发助理研究员、罗格平副研究员的帮助;新疆大学地理系的孙林副教授在格局分析过程中做了大量工作;杨洁泉老师、蔡体久教授、张志强教授和高志海研究员在课题野外工作期间给予了大力协作。特别需要感谢的是中国科学院新疆生态与地理研究所张小雷所长,从课题立项之初一直到今天的出版,他都从行政、经费等方面为本书的完成给予了最大的关心与帮助。借本书出版的机会,向上述同志表示由衷的感谢。

最后有两点情况需要说明。首先,书中的部分内容已经在国内外相关的学术刊物中

正式发表,但受刊物版面的限制,许多内容均未充分展开讨论,同时也使得文章所反映的学术思想比较零散而不成系统,这次利用本书出版的机会对其均进行了较大的扩充与完善;其次,景观生态学是一门新兴的交叉学科,其理论与研究方法还处在不断的发展和完善当中,而绿洲研究又包容了生态、地理、社会经济等各方面的内容,将二者结合起来进行研究是一件十分具有挑战性,但却是非常有意义的研究方向,本书的出版即是该方向研究工作的一次尝试。虽然作者竭尽所能,力图完美,但由于水平所限,缺点和错误定当难免,恳请读者批评指正。

作 者

2003 年 4 月,中国林业科学研究院

Preface

Oasis is a special type of landscape in arid zone in which the nature and human factors are all included. Its area occupied only 4~5 percent of arid land, but there gathered 90 percent population and 95 percent social wealth. The past oasis research was all concentrated on regional and ecosystem scale rather than landscape scale, therefore, this book presents our research work in the 150 regiment, Shihezi Land Reclamation District in Xinjiang Autonomous Region, in order to reveal various landscape ecological profiles of oasis.

On the basis of previous studies of oasis concept, classification, basic characteristics and distribution, a new definition of oasis at landscape scale was presented. Oasis is one kind of azonal landscape developed under dry climate condition and surrounded by desert at small or medium scale, in which mesophytes or xero-mesophytes plants with relatively high primary productivity supported by runoff grows. Runoff dependency, two-way succession liability, and spatially scattered distribution on ecotone are major characteristics of the oasis. In addition, artificial oasis is geometrically more regular, biologically less diversified and economically more self-consumptive than the natural oasis. Geographical distribution of oasis in China is ranged from Helan Mountain and Usaoling Mountain westward to West Mountain of Xinjiang, which include Junggar Basin, Tarim Basin, Caidam Basin, Hexi Corridor and Alashan Plateau.

Four different hierarchical criterions were developed to fulfill landscape classification of oasis at global scale. Firstly, oasis could be divided into temperate zone oasis and tropical or sub-tropical oasis in terms of climate conditions all over the world. Secondly, it could be divided into natural oasis, artificial oasis and potential oasis according to human disturbances. Thirdly, vegetation factor was used as a criterion, because it is the most remarkable surface indicator. As the result, Natural oasis here was classified into four types: desert-riverbank forest (Tugari forest) oasis, swamp meadow oasis, salinized meadow oasis. Artificial oasis and potential oasis have agricultural vegetation and desert vegetation, respectively. Fourthly, oasis could be divided according to their landform locality. Because the vegetation of natural oasis reveals landform conditions to some degree, artificial oasis could be distinguished from potential oasis by landform characteristics easily. Subsequently, artificial oasis was classified into six types: valley oasis, dried delta oasis, lakeside delta oasis, alluvial fan oasis, and riverbank oasis.

In order to investigate the spatial pattern and regional variations, oasis landscape of research area was divided into three sub-regions and eight patch types. Three sub-regions are southern part, middle part, and northern part, which stretch from oasis core to desert. The eight patch types include vegetable land, forestland, orchard, cultivated land, residential area,

abandoned field, sand land and waste grassland.

Landscape pattern analyses show that some actual pattern indice such as dominance, fractal dimension, and fragment index increased while the others including evenness, contagion, patches elongation, and diversity, declined in comparison with the potential patterns. Four conclusions could be drawn from such changes: 1. From 1982 to 1995, the studied area had been more and more controlled by a few patch types; 2. The patch shape was changing toward geometrical regularity and simplicity; 3. The degree of oasis landscape fragment increased. All above are resulted from enlarged human activity impacts on the oasis, 4. The potential pattern could be adopted as the absolute criterion for evaluating pattern changes indicated by regular changes of all pattern indice from potential patterns to actual patterns in agricultural landscape.

The landscape change analysis of the studied area from 1982 to 1995 showed that the area changes of different patch types took place greatly, among which the waste grassland, forested land, and residential area increased, whereas the others decreased. In 1982, the landscape matrix was cultivated land, but in 1995, it was changed into the waste grassland. All these changes played a positive role in relaxing water resource pressure, improving microclimatic condition of oasis, and reducing sand creeping damages.

The result of cultivated land evaluation in 150 regiment indicated that the area of the 1st, 2nd and 3rd grade cultivated land reached up to 8150.15 hm^2 , accounting to 63.4% of all cultivated land. In different sub-regions, the middle part has the highest cultivated land quality and the northern part the lowest. Major limiting factors of cultivated land quality include soil texture, salt content, and soil nutrient to some degree.

Water resource affects oasis development twofold. On one hand, it can accelerate the oasis economic development; on the other hand, it can become a limiting element on oasis development. At present, many environment problems are directly related with irrational utilization of water resource, especially without regard of eco-environmental water use. On the basis of integrated analysis of current research results of ecological or environmental water use studies, a new conceptual framework is outlined in Chapter 8 of this book by distinguishing ecological water use from environmental water use. We think that water consumed to maintain the stability of oasis environment and further support oasis existence and development as well as maintaining and improving oasis environmental quality should be called ecological water use. From this point of view, ecological water use could be divided into 8 kinds. In order to calculate the total quantity of ecological water use, we determined the quota for different kinds according to either field measurements or theoretically calculated data. The calculation showed that ecological water use reached $254.61 \times 10^8 \text{ m}^3$ in Xinjiang in 1995, in which the northern Xinjiang occupied 17.9%, the eastern 5.2%, and the southern 76.9%, respectively. Real quantity of ecological water use is $158 \times 10^8 \text{ m}^3$ in 1995 by subtracting repeatedly used water. In addition, it is projected that total ecological water use will reach $140 \times 10^8 \text{ m}^3$ and $141 \times 10^8 \text{ m}^3$ in 2010 and 2020, respectively.

Finally, according to the result of cultivated land evaluation, two land use schemes for major crops (spring wheat, corn, cotton, beet) in 2000 were optimized and proposed by linear program method. The target function for the optimization was the highest economic benefit and the restrain conditions were maintaining soil ecological balance, planting different crops in its suitable area, rotation of crops and grass, meeting the social need. In scheme A, economic benefit will be greater than that of 1995, but the planting area of beet and corn decrease in large, and shortage of organic fertilizer will reach up to 6890.5 tons, so this scheme was only proposed as alternative scheme. In scheme B, the economic will be declined in comparison with that of 1995, but its shortage of organic fertilizer will be only 584.7 tons and the crop evenly distributed in different graded cultivation land. As the result, the scheme B was recommended for local policy-making department as the most optimum scheme from sustainable development point of view.

Authors

Apr. 2003 in the Chinese Academy of Forestry

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第一章 绿洲研究的现状与问题

一、绿洲研究现状

绿洲存在于干旱区,干旱区研究是绿洲研究的基础。但二者在研究的深度与广度上均存在有很大差异。干旱区人类活动的历史虽然较长,但大规模、高强度开发利用的历史却较短。由于在其地域之内潜藏了更多的还未为世人所认识的自然之谜以及大量的后备性自然资源,因而在工业化社会日益发展的今天,伴随着自然资源稀缺性程度的加深,国内外学者都对干旱区自然资源、环境及开发利用进行了大量研究工作,这个领域正吸引着更多的研究者来关注这一领域。从时间上讲,真正推动干旱区研究在全球范围内展开的,当属 1977 年在肯尼亚首都内罗毕召开的世界沙漠化会议。此次会议以后,各国(尤其是受沙漠化影响程度较深的国家)学者在世界范围内,就对干旱区影响程度最大、危害最深的荒漠化过程进行了研究;而作为干旱区与荒漠化相对立的另一过程——绿洲化,以及绿洲化载体的绿洲景观本身的研究工作,总的说来,进展不大。但这里需要强调的是,我国学者在绿洲研究领域的工作,不论是数量上还是质量上,在世界同类研究中都是名列前茅的。早在 20 世纪 40 年代,周立三先生即对新疆哈密绿洲的形成、历史变迁进行了深入研究(周立三 1948)。之后随着新中国建设事业的需要,从 20 世纪 50 年代至 80 年代,国家相继组织了各种大型的科学考察活动,开展了干旱区农、林、牧、水、土、矿产等资源调查、评价、开发工作,虽其并未直接以绿洲为主旨,但各方面的工作都对绿洲有所涉及,这为以后的绿洲研究工作的进一步开展奠定了基础。进入 20 世纪 90 年代之后,随着黄盛璋先生建立“绿洲学”倡议的提出,以及围绕绿洲的各种课题的展开,才真正迎来了绿洲学研究的热潮(黄盛璋 1990)。尽管绿洲是干旱区众多景观中的一小类,面积只占干旱区总面积的 4%~5%左右,但“麻雀虽小,五脏俱全”,尤其是其与经济、社会等要素的紧密结合,大大增加了绿洲系统的复杂性。本章不可能就其研究的所有方面都做一回顾,仅就所获得的国内外相关文献,分若干重要方面对绿洲研究的现状做粗线条的描述。

1. 绿洲形成、演变过程研究

绿洲景观的形成是在干旱气候条件、水文地貌、人类活动等诸多因素的综合影响下形成的,其中水是第一位的(樊自立 1993,韩德麟 1995)。Pankova 等对前苏联南部戈壁绿洲的研究表明,自然绿洲仅形成于具有弱矿化度地表水的地带。在这一地带内,土壤上植被盖度的大小完全取决于地下水的出现深度与矿化度。但当人类影响进入时,绿洲水资源便趋于减少,土壤-植被盖度也发生了改变,土壤变得盐碱化,而且风蚀过程也得到了发展(Pankova 1994)。刘亚传从水文地质角度出发,在植被生长、土壤次生盐渍化、

潜水矿化度等与地下水埋深关系探讨的基础上,提出了绿洲最佳水文地质环境的概念,认为绿洲最佳水文地质环境取决于最佳地下水位埋深,并给出了确定这一最佳水位的关系:即最佳水位埋深=临界深度+植物根系密集深度(刘亚传 1984)。赵建新认为,绿洲规模大小与绿洲依托的河流间距有一定关系,河流间距越大、流量及引水规模越小,越能形成分散、单独的绿洲体系;而河流间距越小、流量及引水规模越大,越有可能形成连片成带的绿洲体系(赵建新 1993)。

正是由于水在绿洲形成中的主导作用,以及绿洲规模与水资源间存在的相关关系,使得人们能够在抓住主要矛盾的基础上,通过数学关系式来预测绿洲的规模大小。邓永新利用系统动力学方法为研究手段,建立了两种方案下的绿洲规模回归预测模型:在绿洲内引用地表水量不变的情况下,关系式为 $Y = -98.732 - 7.294X_1 + 396.478X_2$, 式中 Y 为绿洲规模, X_1 地下水开采量, X_2 为渠系综合利用系数;但当绿洲内部水资源利用水平有很大提高、地表水引用量明显减少情况下,所建关系式为 $Y = -158.375 + 3.112X_1 + 5.789X_2$, 式中 Y 为绿洲规模, X_1 为绿洲内引用地表水量, X_2 为地下水开采量(邓永新 1992)。汤奇成利用塔里木盆地绿洲与河川径流之间的关系,在耕地面积与水资源总量之间建立的回归方程为: $Y = -18.06 + 5.89X$ ($r = 0.90$, $n = 11$), 式中 Y 为耕地面积, X 为水资源总量, r 为相关系数, n 为项数(汤奇成 1989)。姜德华、王国清则在新疆库车县 12 个乡灌溉面积与引水量定量回归的基础上,得到下列数学模式: $Y = -175 + 870X$ ($R = 0.9978$)。式中 Y 为年引水量, X 为灌溉面积, R 为相关系数(姜德华、王国清 1991)。而陈昌毓的确定方法则稍有不同,他首先从生态平衡的角度出发,确定研究单元绿洲和农田的生态需水量,然后再用研究单元实际年水资源量与其年生态需水量的供求差,来衡量研究单元绿洲及农田面积是否适中(陈昌毓 1995)。当然,这些绿洲规模的预测模式在人工绿洲中有很大的应用成功率,但对于天然绿洲而言,由于其内在控制机制复杂,加之内部有许多尚未解决的研究难点,因此还有更多的工作要做。

对于绿洲演化阶段的划分,不同学者之间尚有一定差别。樊自立以人类引水利用过程为线索,把绿洲的演变发展阶段划分为:下游简易引水阶段、引水移向山前地带阶段、平原水库调蓄阶段等三个阶段(樊自立 1993)。张林源、王乃昂则以人类对绿洲利用的时序划分为:原始绿洲阶段、古绿洲阶段、老绿洲阶段、新绿洲阶段等四个时期(张林源等 1994)。周劲松则以绿洲产业结构演变过程将甘肃的高台绿洲划分为:原始牧业绿洲(公元前 1300~前 121 年)、传统农牧绿洲(公元前 121 年~公元 2000 年)、新型产业绿洲(公元 2000 年以后)三个阶段,并指出,绿洲产业化是其发展演化的必然趋势(周劲松 1996)。

绿洲空间演化规律主要有三点,一是绿洲溯源迁移,即绿洲由河流下游向河流上游发展;二是由河岸向高阶地发展,即由沿河纵向绿洲向横向绿洲群发展(张林源等 1994)。此外还有一点——绿洲下移扩展,即在水源条件允许的条件下,它可以不断地向下游发展,新疆玛纳斯河流域的绿洲开发即是此规律的集中反映(中国科学院新疆地理研究所 1986)。就目前的绿洲演变现状而言,以溯源迁移为主,在溯源迁移的同时,横向发展也比较突出;而下移发展仅出现于局部地区的局部地段。

绿洲演化的动因或促其演变的原因,归纳起来,大致有自然因素与人为因素两个方面。就自然因素方面而言,目前普遍为大家接受的因子包括:风沙活动、盐碱化、河流改道(樊自立 1993, 张林源等 1994, 李兰维 1992),此外还有气候变迁。不过对于气候