大兴安岭东麓

旱作丘陵区耕地质量演变与可持续利用

◎郝桂娟 著

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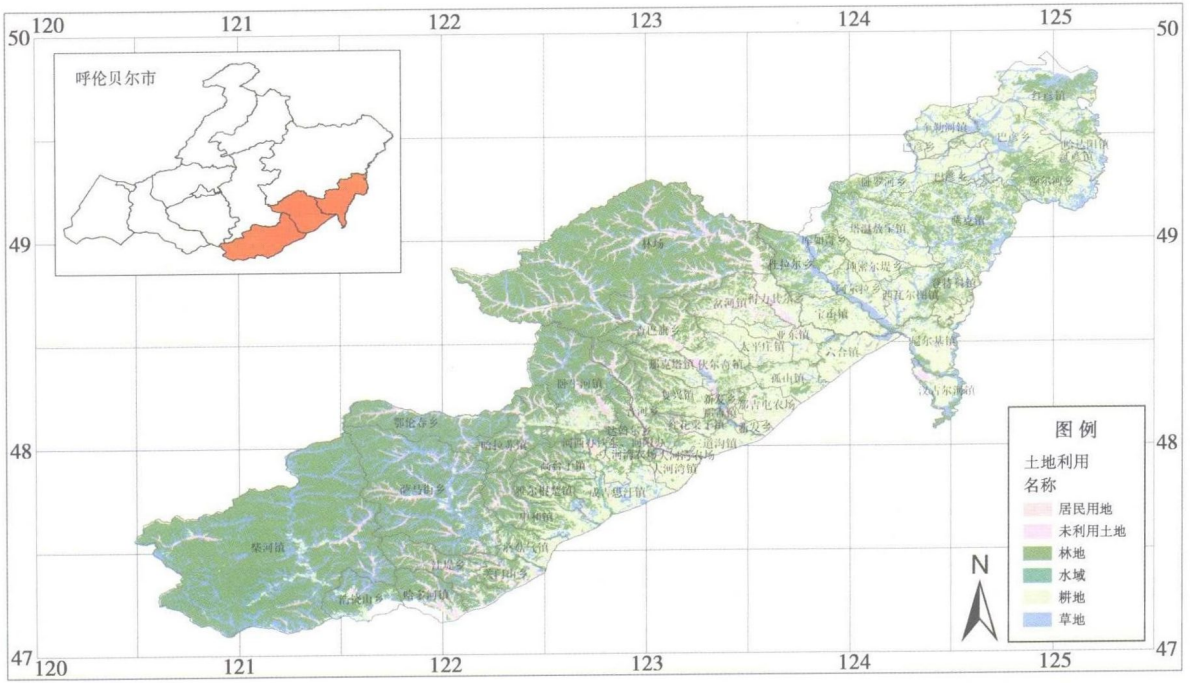

图 2 -1　2007 年研究区土地利用图

Fig. 2 -1　2007 Land use map

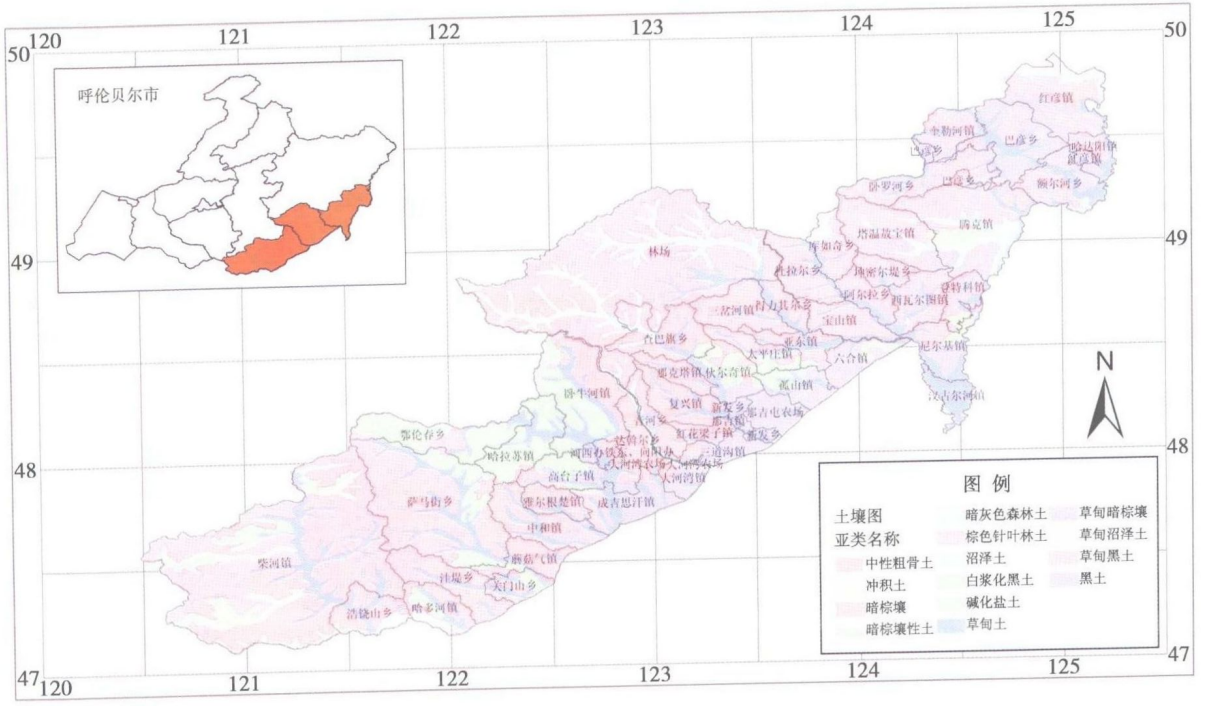

图 2 -2　2007 年研究区土壤图

Fig. 2 -2　2007 Map of soils type

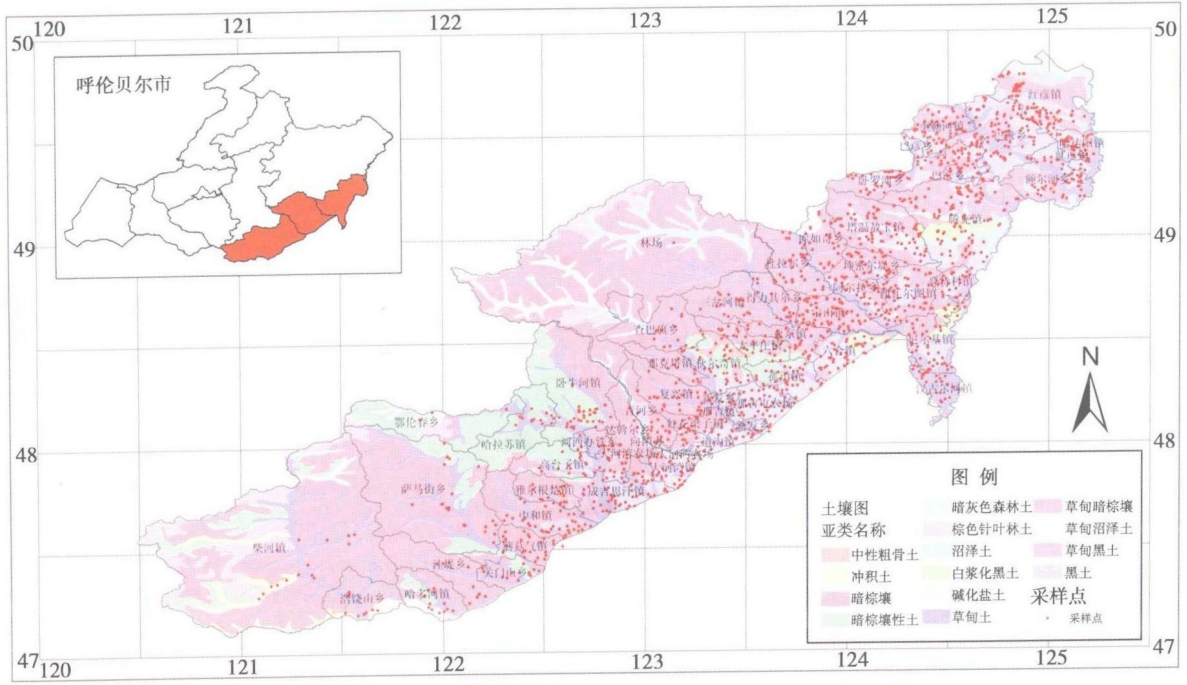

图 2 -3　土壤类型和土样采集点

Fig. 2 -3　Map of soil type and soil sampling place

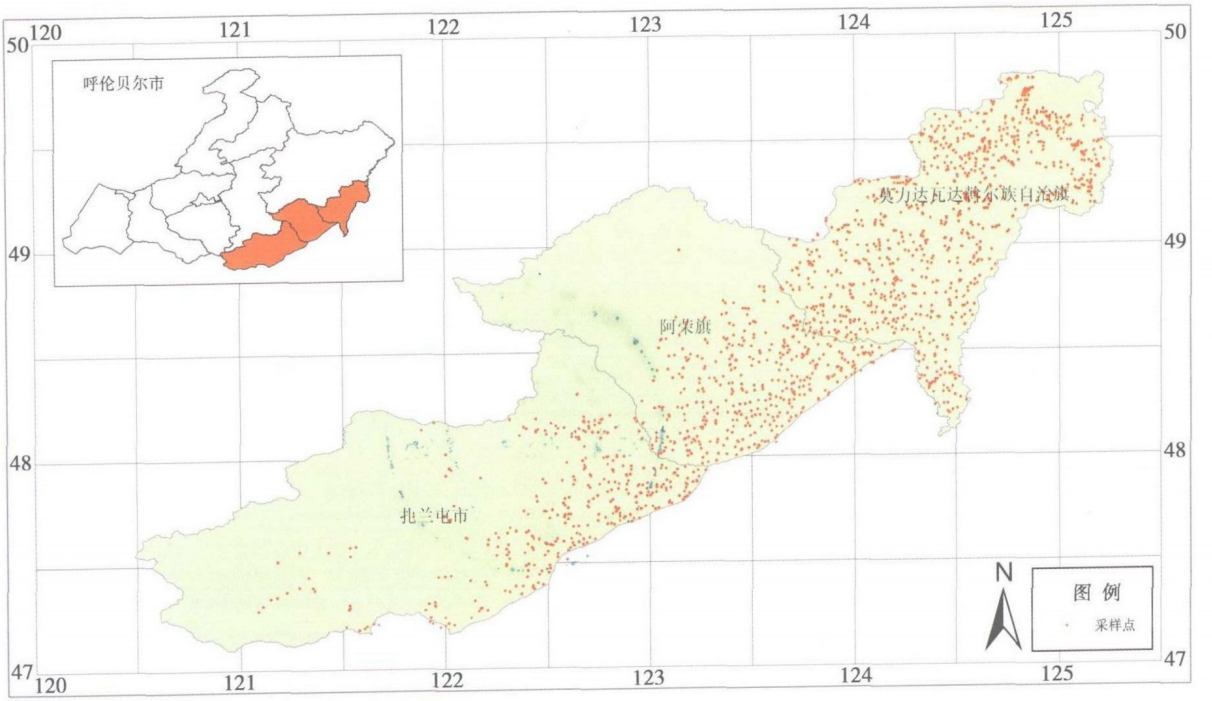

图 2 -4　研究区所属旗市行政区划和土样采集点

Fig. 2 -4　Administrative divisions of study area and soil sampling place

序

郝桂娟同志把自己多年研究成果撰写的博士论文，整编成《大兴安岭东麓旱作丘陵区耕地质量演变与可持续利用》一书，并在该书付梓前请我审阅并作序。作为导师，我对郝桂娟有较深入的了解。她是学者型领导干部，视野开阔、思维敏捷、办事条理清晰、果断干练，既体现了一名领导干部应具备的优秀品质，又展现了一名学者对科研事业的执着精神。

她生在农村、长在农村，对农村、农业和农民有着深厚的感情，无论在什么岗位上、从事什么工作，她都重视对农业发展问题的研究。在走上领导岗位以前，她一直工作在农业推广与农业基础性研究第一线，其研究成果多次获得内蒙古自治区和国家农业部的奖励。2005 年担任内蒙古自治区呼伦贝尔市政协副主席，不久又兼任市工商联主席。

郝桂娟同志有较深的理论功底和丰富的实践经验。20 多年的农业工作实践，使她有了深刻的一线体验，并为其研究工作提供了坚实的基础；而 10 多年的从政经历，又开阔了她的研究视野。由于作者的特殊经历、所处的独特位置以及广阔的视野，使其从事农业相关领域的研究具有得天独厚的优势。郝桂娟走上领导岗位后，坚持对农业工作的研究。攻读博士期间，她不仅能做好工作，而且顺利

地完成了各门课程的学习任务。博士论文答辩会上，答辩委员会成员一致认为，《大兴安岭东麓旱作丘陵区耕地质量演变与可持续利用》不仅选题切合国家对农业发展重视的需要，而且内容全面、资料丰富，论据充分，论证有力，结论正确。既具有较高的学术理论价值，又具有较高的应用价值，是一篇优秀的博士学位论文。

通观全书，论著紧紧围绕服务“三农”，以全球和全国为视角，采用空间分析和统计分析相结合的方法，对大兴安岭东麓旱作丘陵区耕地土壤化学性状和物理性状的演变特征、环境质量演变特征、耕地土壤侵蚀的形成与演变，及耕地质量演变的驱动因素与影响，进行了系统的分析研究，提出了耕地可持续利用的对策和技术措施。正是因为郝桂娟同志不是在书斋里坐而论道，而是将自己丰富的工作实践与所作的研究很好地结合起来，使该书理论性和实用性都很强。相信此书的出版，将对促进区域农业可持续发展有积极的推动作用。

2010 年 3 月 1 日

摘　要

本研究采用定量分析与定性分析相结合的方法，对大兴安岭东麓旱作丘陵区耕地土壤化学性状和物理性状的演变特征、环境质量演变特征、耕地土壤侵蚀的形成与演变，及耕地质量演变的驱动因素与影响，进行了系统的分析研究，提出了该区耕地可持续利用的技术措施和区域农业可持续发展的典型模式与对策等。研究结果如下：

（1）经过20多年的演变，大兴安岭东麓旱作丘陵区耕地土壤有机质含量平均下降23.8%；土壤全氮含量下降31.9%；土壤碱解氮含量降低12%以上；土壤速效钾含量下降24.7%。土壤中交换性钙、交换性镁、有效硫、有效硅等中量元素含量较为丰富。微量元素中锌、铜、铁、锰等含量丰富。硼和钼呈现缺乏，其缺乏面积分别占总耕地面积的87.2%和78.2%。

（2）与20多年前相比，研究区耕地物理性状逐步恶化，主要表现在土壤结构变劣、容重增加、腐殖质层厚度和有效土层厚度减少、障碍层形成、地表砾石含量增多。该区耕地出现了明显的次生障碍层，形成5～10cm的犁底层并不断加厚变硬，并形成一个地表砾石层。目前，地表砾石度大于5%的面积比20多年前增加近20倍；耕地中有

1/3～1/2 以上的土壤，分布在薄体和薄层暗棕壤上，该土壤腐殖质层较薄（＜20cm），土体砾石含量高（＞30%），砾石层位浅，一般 20cm 土深就出现大量砾石。而且随着坡度升高，种植年限延长，表层土壤砾石含量显著增加。

（3）研究区耕地土壤综合污染指数均小于 0.7，达到Ⅰ级标准，符合绿色食品产地土壤环境条件。因自然因素成土母质和成土过程不同，各类型耕地土壤重金属元素的汞、铬、砷、铅、铜含量有一定差异，但土壤镉含量的差异较小。该区土壤 pH 值为 4.8～7.1，平均为 6.0，呈微酸性—中性，各土类间 pH 值变化不大。研究区的河水和地下水均达到了农田灌溉水质标准的极限值，符合农田灌溉和绿色食品生产的水质标准。

（4）按照全国土壤侵蚀类型区划，研究区属于东北黑土区的低山丘陵区，存在不同程度的侵蚀现象，主要分为水力侵蚀、冻融侵蚀两种类型，其中水力侵蚀占耕地侵蚀的 99.8%。与第二次土壤普查期间比较，现有耕地面积比 20 多年前增加了 3.3 倍，耕地土壤侵蚀强度由微度发展到轻度。耕地土壤二级以上的明显侵蚀面积由 12.2 万 hm^2 增加到 52.7 万 hm^2，增加了 3.3 倍；平均侵蚀模数由第二次土壤普查前的小于 500t/（km^2·年），增加到 1 935.7 t/（km^2·年）；沟壑密度由 0.06 km/km^2 增加到 1.87km/km^2；30% 左右的耕地因土壤侵蚀已经产生严重或比较严重的水土流失。耕地自开垦以来，表土层流失厚度总量为 3.0～16.8cm，平均为 8.4cm，年均流失厚度为 0.2～1.1cm，严重地区个别年度表土层的流

失量达 5cm 以上。其中，暗棕壤表土层的总流失厚度为 11.3cm，占腐殖质层厚度的 51.3%；黑土土类的总流失厚度为 9.5cm，占该土类腐殖质层厚度的 28.83%；草甸土流失厚度为 4.4cm，占该土类腐殖质层厚度的 6.2%。根据土壤侵蚀程度分级标准，黑土土类的土层厚度占 A 层的 6.2%，属轻度侵蚀；暗棕壤的侵蚀厚度占 A 层的 51.8%，属中度侵蚀；草甸土土类的侵蚀厚度占 A 层的 4.4%，属轻度侵蚀。研究区的总体侵蚀厚度为 8.4cm，占 A 层的 17.8%，属于轻度侵蚀程度。耕地土壤受侵蚀后，一方面造成水土流失，物理性状恶化，另一方面还存在养分流失的问题。平均每年流失土壤总量为 916.7 万 t，流失有机质总量为 42.5 万 t，流失的 N、P、K 养分相当于 40% 高浓度含量的复合肥 5.9 万 t，是该地区年均化肥施用量的 1.4 倍。

（5）耕地土壤 <0.01mm 颗粒的含量、孔隙度、团聚体含量、田间持水量，随坡度增大而减小，容重随坡度升高而增大。土壤有机质、全氮、有效磷、有效钾、有效铜、有效锰、有效硼、有效硅，随着坡度的升高而明显下降；土壤有效铁、有效钼、有效硫含量随着坡度的升高而增加；随着坡度升高土壤的酸性增强。降水的季节性分布不均、蒸发量上升加重土壤侵蚀；气温的变化和灾害性天气频率的增加也导致耕地质量向退化方向演变。在人为因素中，不合理的垦荒种植，难以改变的小型四轮拖拉机表土翻耕方式，以及不科学的肥料使用、管理方式，及人口增长和经济社会发展的负面影响，都促使耕地质量在演变

中逐步形成退化。

（6）提出了分区改良、合理布局、防止水土流失、科学施肥培肥地力、改革耕作制度等耕地可持续利用的技术措施和建立耕地可持续利用的立法机制、开发保育监督机制、政府专题议事规则、加强人才培养，发展区域特色经济等政策建议。针对该研究区的实际情况，提出区域农业可持续发展的典型配套模式。

关键词：大兴安岭；旱作丘陵区；耕地质量；演变；可持续利用

Abstract

Based on the method of quantitative and qualitative analysis, this study was conducted to investigate the evolution of soil fertility characteristics, soil physical properties, soil environmental quality, soil erosion status of hilly dryland on the eastern slope of the Greater Khingan Mountains and then the reasons for those changes were comprehensively investigated. At last, the technical and strategically pathways were put forward for sustainable utilization and agricultural sustainable developmental model in this area. The results were list as follows:

(1) Compared with the parameters at 20 years ago in the studied regions, the soil organic matter content decreased 23.8%, soil total nitrogen content decreased 31.9%, alkali-hydrolysable nitrogen content decreased more than 12%, and soil available potassium decreased 24.7%. Soil medium elements and microelements remain consistently, such as exchangeable calcium, exchangeable magnesium, available sulfur, available silica and zinc, copper, iron, manganese, while 87.2% and 78.2% of the soils were short of boron and molyb-

denum, respectively.

(2) The soil physical properties had a trend of depravation in the recent 20 years in the studied area, which representing in the decrease of soil structure quality, the increase of soil bulk density, the decline of humus and availability soil layer, the form of obstacle layers and the increase of surface gravel contents. Secondary soil obstacle layers were formed in the studied 20 years, which resulted in a surface gravel layer and a 5 ~ 10cm hard ploughpans. The surface areas with gravel contents $\geqslant 5\%$ were increased by 20 times compared with 20 years ago. One third to half of the farmland were distributed in thin dark-brown soil, which has thinner humus layer (<20cm) and higher gravel content ($>30\%$) and the gravel appeared under ground 20cm in general. With the increasing of the slope and cultivation years, the gravel content in soil surface increased significantly.

(3) The integration pollution index of soil in studied areas were below 0.7 in general, which reached to the I class standard, belonging to soil standard for green food production. Due to the different of natural factors and soil parent material and soil pedogenesis process, soil heavy metals such as mercury, chromium, arsenic, lead, copper contents in different types of soils had certain differences while soil cadmium contents had no such obvious difference. Soil pH values in the areas were on

the average of 6.0, between 4.8 ~ 7.1, was slightly acidic to neutral response. The water quality from river and ground had reached the limits of quality standards for irrigation in the studied areas, which accorded to the water quality standards use for green food production.

(4) In term of the national divisions of soil erosion type, the studied areas belonged to north-eastern hilly areas of black soil zone. There were different degrees of erosion, which mainly fall into two categories including water erosion and freeze-thaw erosion. Water erosion accounted for 99.8% of arableland erosion in this area. Freeze-thaw erosion only accounted for part of areas which called "land split" (2 ~ 5cm in width, 5 ~ 50cm in depth) in the near Great Xingan Mountains forest due to the formation of frozen-thawed 20 years ago, while the area enlarged to 3.3 times more than before. The soil erosion intensity of arableland turned to micro-developed from mild. The soil erosion area above second class increased from 12.2×10^4 hm^2 to 52.7×10^4 hm^2, which increasing 3.3 times; The average soil erosion modulus were increased by 1 935.7 t/km^2/year from less than 500 t/km^2/year. Gully density were increased by 1.87 km/km^2 from 0.06 km/km^2; 30% of the arableland has been subjected to serious soil erosion. The total thickness of soil loss for the 3.0 ~ 16.8cm, with an average of 8.4cm, an average annual loss of thickness 0.2 ~ 1.1cm, serious areas of individual annual soil loss amounted to more than

5cm since the reclamation of land, in which 11.3cm thickness soil layer was loss in dark brown soil, accounting for 51.3% of humus layer; 9.5cm thickness soil was loss in black soil, accounting for 28.8% of humus layer thickness; 4.4cm thickness soil was loss in meadow soil, accounting for humus layer thickness by 6.2% of the same soil type. In terms of the classification standards of the degree of soil erosion, black soil layer thickness accounts for 6.2% level of Class A, which is mild erosion; dark brown soil erosion accounts for 51.8% of A level, which is moderate erosion; meadow soil erosion thickness accounted for 4.4% of A level, which is slightly eroded. The overall erosion of the study area is a thickness of 8.4cm, accounting for 17.8% of A level, with a degree of slight erosion. Investigation of the studies showed that soil erosion resulted in, both deterioration of physical properties and nutrient loss. Average annual soil loss of the total amount is 9 167 000 t. The loss of organic matter reached 425 000 t. The loss of N, P, K nutrients equivalent to 59 000 t compound fertilizers with 40% content, 1.4 times of the total amount of chemical fertilizer use in this areas.

(5) The soil particles <0.01mm content, porosity, aggregate content, field capacity decreased with the increase of slope, while bulk density increased with the slope. Soil pH value, organic matter, total nitrogen, available phosphorus, available potassium and effective copper, effective manga-