# 气候和下垫面驱动下典型植物措施对径流和侵蚀的水土保持效应

胡彦婷[1,2] 张富[1*] 罗珠珠[1] Nasem Badreldinc[3], Glenn Benoyd[4] Zisheng Xing[4]

（1. 甘肃农业大学林学院 兰州 730070； 2. 西南林业大学湿地学院 昆明 650051； 3. Department of Soil Science, University of Manitoba, Manitoba, R3T 2N2； 4. Faculty of Forestry and Environmental Management and the Canadian Rivers Institute, University of New Brunswick, New Brunswick, E3B 5A3）

摘 要:【目的】典型植物措施气候（降雨量特征）、下垫面（坡度、前期土壤含水量）等综合对径流、侵蚀的定量分析仍然是半干旱地区具有挑战性的研究，在自然降雨条件下，定位监测了 1987—2019 年中国甘肃省的安家沟小流域不同措施（乔木林地、灌木林地、人工草地、天然草地和农地）不同坡度（10°、15°、20°）径流小区的降雨特征、前期土壤含水量、植被覆盖度、径流、侵蚀等。【方法】运用逐步回归模型和路径分析法，建立了主要驱动因子对径流量、土壤侵蚀最优评估模型，其评估结果较满意（$r_a^2$ ＞0.55）。【结果】结果表明：研究区降雨类型以中雨（10—25mm）为主，占比高于 60%，植物对径流和土壤侵蚀的影响随措施的不同而不同；在历时 24h 内发挥水土保持效益最好的植物措施是灌木林地，但在长历时（72h）降雨量条件下，天然草地是最易防治径流和侵蚀发生发展的地类。与农地（对照区）相比，侵蚀消减率（73%）约为径流消减率（37%）的 2 倍；坡度在控制径流和水土流失变化方面发挥了一定的作用，随坡度变化而变化，与 10° 和 20° 小区相比 15° 小区更易发生水土流失。因土地利用不同影响径流和侵蚀率的主要驱动因子稍有差异，但降雨量、最大 30min 雨强都是影响径流率的关键因子，径流和最大 30min 雨强均是驱动侵蚀变化的重要因子。【结论】半干旱区不同地形条件下典型植物措施的降雨特征、前期土壤含水量对径流和侵蚀量的耦合效应，有助于用典型植物措施对生态恢复中的径流和土壤侵蚀进行更准确的评估。

**关键词**：土壤动物；森林混交模式；群落结构；功能群；落叶松人工林

## Soil and water conservation effects of typical plant measures on runoff and erosion driven by climate and underlying surface

**Abstract:** 【Objective】The comprehensive quantitative analysis of runoff and erosion under specific climate (precipitation characteristics) and underlying surface conditions (slope, antecedent soil moisture) with different plant measures remains a challenging research topic in semi-arid regions. With a dataset from the Anjiagou watershed in Gansu Province, China, we conducted a comprehensive study on the soil and water erosion patterns under different plant measures. The research site was under long-term monitoring of precipitation conditions, antecedent soil moisture, and runoff and erosion rates through a set of modified standard erosion plots with different measures adopted (arbor forest land, shrub forest land, artificial grassland, natural grassland, and agricultural land) at three slopes (10°, 15°, 20°) from 1987 to 2019. 【Method】The collected data were subjected to analyses of path analysis and stepwise regressions to determine the main driving factors of runoff and soil erosion and proper input variables for modeling. 【Result】The results suggested that the models could be constructed with varying variables for different plant measures with satisfactory evaluations (P< 0.05, > 0.55). The analyses also showed that moderate rain (10–25 mm) accounted for more than 60%, and plant effects on runoff and soil erosion varied with the measures; Among plant measures, shrub forest had the best performance in reducing runoff and erosion for short-term precipitation event (shorter than 24 hrs), but under the long-duration (72 hrs) precipitation, natural grassland performed the best to prevent the occurrence and development of runoff and soil erosion. Compared with agricultural land, all the studied plant measures had an average erosion reduction rate of 73%, which was about twice the runoff reduction rate (37%). The slope was found to play some role in controlling runoff and erosion variation, varying with slope. Compared with at 10° and 20°, runoff and erosion reduction rates at 15° plots were lower. 【Conclusion】The key variables determining runoff rates under different plant measures included precipitation and maximum 30-minute precipitation intensity, followed by land use type. In contrast, erosion rates mostly depended upon runoff and maximum 30-min precipitation intensity. We also found that coupling precipitation characteristics with antecedent soil moisture in the modeling could help a more accurate assessment of runoff and soil and water conservation in ecological restoration with typical plant measures under different topographical conditions in semi-arid areas.

**Key words:** precipitation characteristic; antecedent soil moisture; runoff and erosion reduction rate; direct and indirect effects; Semi-arid area.