BURLEIGH DODDS SERIES IN AGRICULTURAL SCIENCE

Improving grassland and pasture management in temperate agriculture

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Introduction

Global demand for livestock products continues to increase as a consequence of population growth, changes in consumer preferences and income levels. Increased efficiency of food production to meet consumer demand must also focus on reducing the environmental impact of production and for the livestock sector there is also growing interest in the quality and traceability of products. In many countries, increasing demands on land use (production of food, fuel, industrial use, leisure) mean that its use for food production must compete with other land uses, and this has major implications for the grassland sector.

Improving the sustainable production of livestock products is a recurring research theme among grassland scientists, and provides many challenges but also opportunities for the grassland sector. These include increasing the utilisation of grasslands to improve nutritional quality for livestock production, increasing sustainability by using fewer inputs, and reducing the greenhouse gas emissions associated with agricultural production. Balancing these "traditional" objectives with delivery of ecosystem services and opportunities for exploiting grasslands for energy use is also required.

This volume reviews a range of research on the sustainable use of grasslands to optimise livestock nutrition whilst protecting biodiversity and delivering a range of broader environmental benefits. It assesses the latest research on how temperate grasslands function, surveys best practice in sustainable grassland management and considers wider aspects of sustainability, such as the maintenance of ecosystem services and biodiversity.

Part 1 Grassland functions and dynamics

The first part of the volume assesses grassland functions and dynamics, including plant-soil and plant-animal interactions, nutrient cycling and carbon capture.

The focus of Chapter 1 is the multifunctional role of grasslands in producing forage for animal production systems while providing a wide array of ecosystem services, including the regulation of biogeochemical cycles and the maintenance of biodiversity. The chapter provides an overview of current knowledge on the roles of grasslands in regulating the carbon (C) and nitrogen (N) cycles and conserving biodiversity and how the environmental roles of grasslands are driven by nutrient management, frequency and timing of grazing, the lifespan of the grasslands and their position and diversity in the landscape. The chapter also explains how different grassland types are necessary to target the services of food production, carbon storage in soils, regulation of the N cycle and biodiversity conservation at different levels of grassland intensification.

Chapter 2 moves on to examine the role of pasture in the diet of ruminant livestock. Grazed pasture is the single most important forage feed for ruminants due to its low unit cost and widespread global availability. The chapter describes how grazed pasture provides the energy, proteins, minerals and vitamins and other nutritional factors required by ruminants. It shows how the use of pasture and its by-products underpins the sustainable delivery of future ruminant livestock production systems and ensures its role in food security. Complementing the previous chapter's concentration on ruminant livestock, Chapter 3 examines plant-animal interactions in grazing systems. These interactions drive system performance. Central to this is the dry matter intake of animals grazing pasture, and the various factors influencing this are reviewed in detail.

Chapter 4 considers the principles of grazing management for sustainable grazing systems. As noted in Chapter 1, grasslands play a key role in soil, water and biodiversity conservation and deliver numerous other ecosystem and cultural services. The chapter defines and discusses key terms and strategies associated with sustainable grazing management and outlines current knowledge regarding major effects of grazing management on above- and below-ground plant responses.

Part 2 Management of grasslands

The second part of the volume reviews key aspects of grassland management, including strategies for sowing, soil health, irrigation and weed control.

Opening Part 2, Chapter 5 examines the planning and sowing of grasslands. The chapter provides an overview of species and cultivar selection, as well as the specific tolerances of different species and cultivars, along with other characteristics. The chapter then moves on to look at initial considerations to be taken into account with the establishment and renovation of grasslands and best practice for the sowing and initial management.

Chapter 6 focuses on grazing systems by providing an overview of grassland management for forage production. In temperate agriculture, grasslands play an important role in the provision of forage for livestock, and appropriate management of grassland is vital to ensure that high quality feed is available. The chapter reviews the short, medium and long term management of grasslands, including stocking rates, the day-to-day management of grazing and harvesting, planning for rotations and silage harvesting, renovation, drainage, reseeding and soil fertility improvement.

Chapter 7 turns to the theme of managing grassland systems to optimise livestock farming. High milk prices have encouraged intensive dairying systems using high inputs of chemical fertilizers, indoor feeding with high amounts of concentrate and imported protein at the expense of grazing. Consequently, grassland acreage has decreased considerably over the last 30 years and European dairy systems have become highly dependent on imported fossil energy and proteins. However, the various roles of grassland in providing regulating and supporting services are now widely recognized and grazing ruminants are highly appreciated by the public. The chapter reviews existing knowledge and tools for developing productive, efficient and environmentally-friendly dairying systems based on grazing and grassland utilisation.

Chapter 8 examines the use of temperate grassland legumes for sustainable animal production. Forage legumescan play a key role here, but their positive environmental and economic effects can only be realized if they also show persistence and yield stability. These are complex traits which depend on the interaction of different biotic and abiotic environmental factors with the genetic background of the sown species/cultivar. The chapter surveys the global cultivation of forage legumes and considers important challenges to achieving persistence and yield stability. It includes a case study on the improvement of persistence in red clover by recurrent selection, and then discusses physiological studies on drought stress tolerance in white clover and broad-leafed birdsfoot trefoil.

Building on the insights of Chapter 8, Chapter 9 looks at efforts to develop new varieties of grasses and legumes. It highlights the challenge plant breeders face in developing high performing forage cultivars that maintain the profitability of temperate grassland farming systems while reducing the environmental footprint and taking account of animal health issues.

The subject of Chapter 10 is the challenge of managing soil health for grasslands. Soil health is a holistic concept that includes all the processes affecting the ability of soil to provide the ecosystem services required from grassland. The primary 'service' provided by grassland is forage for livestock production, but increasingly, scientists recognize a diverse suite of other 'benefits' such as effects on fauna and flora, avoiding off-site impacts, and many aesthetic qualities.

Chapter 11 looks at the management of water resources for grasslands. Grasslands support essential food and fiber production, biodiversity, and water function and other ecosystem services. Planted or native grasslands are typically located on drier, steeper, or less fertile areas of any region. The chapter discusses the topics of water requirements of temperate pastures, monitoring and modeling grassland vegetation and water use, drought monitoring and water resources management in grasslands.

Shifting the focus from the needs of grasslands to dealing with threats to their survival, Chapter 12 examines biological weed control in temperate grasslands. The chapter identifies the constraints to, and opportunities for, the effective biological control of weeds in the world's temperate grasslands.

Picking up issues from Chapters 3 and 4, the subject of Chapter 13 is restoring degraded grasslands. Grazed grasslands are complex ecosystems, and careful and responsible management is essential for their growth and maintenance. The chapter examines the inter-relationship of species, microbial activity, nutrients and environmental factors in restoring and maintaining their health, sustainability and productivity. It also outlines the key factors in restoration of degraded grasslands, such as promoting both the ecosystem's biogeochemical processes and physiological mechanisms in grasses that gradually alter grassland species composition.

The final chapter of the section, Chapter 14, examines advances in remote sensing (RS) for monitoring grassland and forage production. Achieving cheap, appropriate and timely information on vegetation will be essential for sustainable and economically viable management of grassland in the future. RS offers new possibilities to monitor vegetation repeatedly and at large scale. The chapter describes the most important sensor types, reviews recent developments in sensor performance and significant advances for grassland research and practice.

Part 3 Sustainability and wider uses of grasslands

The third and final part of the book considers wider aspects of sustainability such as protecting biodiversity as well as silage processing.

The focus of Chapter 15 is research challenges in adapting grasslands to climate change. Climate change poses many challenges to European grasslands, from droughts, heatwaves and changing precipitation patterns in the south, to warmer winters and wetter summers in the north and increasing frequency of extreme weather events. The chapter reviews the probable impacts of climate change and associated challenges and the adaptiveness of European grassland systems. The chapter includes a number of detailed case studies of climate change impacts and adaptation options from Finland, Italy and Austria and considers the challenges and limitations for climate change mitigation in grasslands and priorities for research.

Chapter 16 looks at issues associated with the protection of biodiversity in grasslands. The chapter summarises the conditions that facilitate biodiversity in permanent and semi-natural grasslands in temperate climates, explaining and giving examples of losses in the biodiversity of managed grasslands in recent decades. It describes some of the main factors influencing biodiversity, leading to discussion of appropriate management measures and how these might be integrated into livestock production systems.

Moving on to new developments in the uses of grasslands, Chapter 17 examines advances in feeding grass silage, the main forage source during indoor feeding periods in many temperate regions. The chapter reviews research on factors affecting nutrient supply from the digestive tract in animals fed a grass silage-based diet and the effects of energy and protein supplementation on production responses, taking into account nitrogen and methane emissions. It also highlights recent developments in the big bale system that has become popular especially in Northern Europe.

Continuing the theme of the use of grasslands for new purposes, Chapter 18 deals with the use of grassland for bioenergy and biorefining. The chapter reviews grassland types, categorizing them according to their potential for biomass production. It details options for the use of grassland biomass, and covers biogas, combustion, pyrolysis and gasification, enzymatic hydrolysis and fermentation to ethanol, and biorefining and future prospects for the use of grassland biomass in bioenergy applications.

The book's final chapter, Chapter 19, looks at the particular challenges associated with organic grassland. After considering the key characteristics of organic grassland, the chapter examines its multifunctionality and specific challenges, offering two detailed case studies which deal with the diversification of organic leys in Great Britain and skylark protection on organic grassland in Brandenburg, Germany.

We would like to express our sincere thanks to the authors. We hope this book contributes to a greater understanding of the complexities involved in managing grassland and a wider appreciation of its great value to society as a whole.

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