

JAMES C. PUHALLA | JEFFREY V. KRANS
J. MICHAEL GOATLEY, JR.

SPORTS FIELDS

DESIGN, CONSTRUCTION, AND
MAINTENANCE

THIRD EDITION

SportsTurf
MANAGERS ASSOCIATION

Experts on the Field, Partners in the Game.

WILEY

Sports Fields

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**Design, Construction,
and Maintenance**

Third Edition

James C. Puhalla

Sports Field Consultant Boardman, OH, US

Jeffrey V. Krans

Mississippi State University – Retired Meridian, MS, US

J. Michael Goatley, Jr.

Virginia Tech Blacksburg, VA, US

WILEY

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About the Authors

Jim Puhalla of Boardman, Ohio, is a Sports Field Consultant who provides design, consulting, and construction supervision. His knowledge of sports field management came through hands-on experiences as a landscape and sports field design/build contractor. He owned and operated a company that specialized in sports field design, construction, and maintenance from 1990 through 2012, and a landscape company from 1977 through 2003. Although he retired from sports field construction and maintenance in 2013, he still enjoys sharing his experiences with others who have similar goals in creating safe, more useable sports facilities.

Jeff Krans is a former Professor of Agronomy at Mississippi State University in the Golf and Sports Turf Management program. He received his PhD from Michigan State University in 1975, an MS degree from the University of Arizona in 1973, and his BS degree from the University of Wisconsin–Stevens Point in 1970. Jeff taught and advised students in the Golf and Sports Turf Management program, and conducted research in turfgrass breeding and physiology from 1975 to 2002. Jeff remains an avid supporter of high-quality natural turf for safe sports for participants and spectators.

Mike Goatley is Professor and Extension Turfgrass Specialist in the School of Plant and Environmental Sciences at Virginia Tech. Mike received his PhD from Virginia Tech in 1988, his MS degree from the University of Kentucky in 1986, and his BS degree from the University of Kentucky in 1983. He taught and advised students in the Golf and Sports Turf Management program at Mississippi State from 1988 to 2003 before moving to Virginia Tech. Mike serves as the outreach coordinator for agronomic turf sciences in Virginia, and his research interests focus on turf selection and management strategies that promote environmental stewardship. He served as president of STMA in 2012 and 2013 and received STMA's William H. Daniel Founder's Award in 2008 and Harry C. Gill Founder's Award in 2016.



Experts on the Field, Partners in the Game.

About the STMA

STMA is the not-for-profit professional association for the men and women who manage sports fields. Since 1981, the association and its 30-plus local chapters have been providing education, information, and sharing practical knowledge in the art and science of sports field management. Its more than 2,500 members oversee sports fields and facilities at schools, colleges and universities, parks and recreational facilities, and professional sports stadiums. The membership's goal is to manage natural turf and synthetic surfaces to produce safe and aesthetically pleasing playing surfaces for athletes at all levels of playing abilities. STMA also has the support of commercial members that furthers the industry through continuous advancements in technology.

The STMA Mission:

To be the recognized leader in strengthening the sports turf industry and enhancing members' competence and acknowledgement of their professionalism.

Preface

Like so many aspects of contemporary life, our athletic and leisure pursuits are becoming increasingly influenced by economic and logistical factors. Construction and maintenance budgets are squeezed ever more tightly. The explosion in athletic opportunities for girls and women has doubled the use of some facilities, and sent planners scurrying off to build thousands of new ones. The popularity of personal injury lawsuits has forced insurance premiums higher and led insurers to insist on greater uniformity in the design and construction of sports facilities.

All of these factors have their impact on the construction and maintenance of sports fields. Tighter budgets mean less money for after-the-fact repairs and greater insistence on building it right the first time. Increased pressure on the facilities means that unplayable fields create twice as many rescheduling headaches as they used to. The threat of lawsuits demands greater attention to the safety of the facility itself.

THE PURPOSE OF THIS BOOK

This book is designed to provide a comprehensive technical reference source for those who are responsible for the design, construction, renovation, or maintenance of sports fields. In order to address these issues, the chapters that follow will illustrate specific design elements of all popular sports facilities and explain how those elements are integrated in a successful project; explore commonly encountered sports field problems and suggest appropriate solutions; and provide practical guidance for continuing maintenance programs.

While soil and climate variations will sometimes create unique local challenges for those charged with building or maintaining sports facilities, the principles shared on these pages should provide a basic plan of action and a set of practical design criteria usable throughout North America and in similar geographies throughout the world.

How to Use This Book

Part 1, **Principles of Sports Turf Culture**, offers information on which to base sound decisions regarding the nurture and maintenance of sports turf. This portion of the book deals with such matters as turfgrass and soil science, cultural practices, and stresses placed on turf year-round and during sports competition. To achieve the fullest possible value from this volume, it's advisable to begin by reading these chapters.

Part 2, **Natural Turfgrass Sports Fields**, provides guidance on the design, construction, renovation, and maintenance of particular types of sports fields. Each chapter combines similar facilities, based on the design and construction strategies and performance expectations of the turf. For example, Chapter 14 covers soccer, lacrosse, and field hockey fields. Field dimensions are provided at the end of each chapter.

Part 3, **Other Sports Surfaces**, provides guidance on other types of sports facilities for which a designer, contractor, or facilities manager might be responsible, like tennis courts, track and field, and synthetic turf. Proper design and construction techniques can be particularly important for these facilities, which must be easily maintained in a wide range of usage and weather circumstances.

Part 4, **Ancillary Information**, covers miscellaneous related topics, including surveying, sand-based fields, turf paints and covers, field evaluation and turfgrass assessment, environmental stewardship, safety, innovations to promote natural grass fields, and public relations and professionalism.

The **appendix** at the end of the book consists of two parts. The first part considers calculations that are most commonly used by designers, contractors, and maintenance personnel. The second part looks at examples of how the STMA helps sports field managers keep up with the latest trends.

Throughout the text, we have worked to make this book as useful as possible to those who are charged with keeping sports fields safe, playable, and beautiful, and to those students who are preparing for a career in this rewarding field. These pages share much of the latest in academic research and development of the science of sports turf, but present these latest findings in the form of practical advice for the real world. It is our fondest hope that the result of this book will be a new generation of safe, competitive, and easy-to-maintain sports facilities for people of all ages.

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Thanks also to the many sports organizations and sanctioning bodies for sharing their specifications and field construction information, which have helped to make this volume comprehensive. These organizations are listed individually at the ends of their respective chapters.

PRINCIPLES OF SPORTS TURF CULTURE

Sports turf fields and related facilities are designed to meet two basic requirements: they must be large enough and/or the necessary shape to allow the particular sport to be played according to its recognized rules and regulations, and they must have a surface that allows the players to compete safely and at a reasonable level of competition. Because many sports turf surfaces are also used for nonsports activities (like band practice), the surface must be durable enough to withstand the stresses associated with those nonsports functions.

As any sports fan will agree, player performance depends in large part on the quality of the turf surface. But a fields manager must also keep in mind that safety, as well as performance, is dependent on turf quality. Each of these important considerations is dependent on three turf characteristics: *traction*, *hardness*, and *evenness*.

Traction is obviously critical to generating and controlling speed, making sharp changes in direction, and stopping. In addition to reducing a player's ability to avoid or (in the case of contact sports) to control collisions, poor traction can lead to muscle pulls and a variety of other common injuries.

Hardness can allow players to perform at maximum speed, but can also affect players' ability to cut sharply and increase injury from falls and tackles.

Evenness, along with hardness, is a major factor affecting ball response, which includes the height and direction of bounce, as well as the trueness and speed of roll. In many turf sports—and perhaps in most—predictable ball response is necessary to support the desired level of competition.

Just as good teams are created by careful attention to detail, good turf comes from practicing effective turfgrass cultural and management strategies. In the following chapters we will consider the underlying principles of turfgrass biology, selection, and establishment; soil science, including fertility and fertilizers; cultivation and thatch management; organic field management; irrigation and drainage; pesticide use and safety; turfgrass stresses; and even proper mowing techniques.

Whether reading sections of the text as a class assignment or flipping it open to address a particular sports turf concern, the reader will find that our advice is first to seek the health of the turf and its enfolding culture, and all the rest (playability, economy, aesthetics) will be added onto it. Manage the culture correctly, and pest problems will be minimized.

Turfgrasses

1.1 INTRODUCTION

Turfgrass is a designation given to a very small group of grasses that have a unique combination of plant morphology (form) and adaptation to a defined set of cultural practices. The morphology requisites of a turfgrass are prostrate or compressed stems at, near, and/or below the soil surface (tillers, stolons, and/or rhizomes), compressed leaf sheaths and blades (diminutive growth habit), tolerance to high plant compatibility (high stand density), and robust production and growth of branching stems (a knitted growth habit). In combination with these requirements, all turfgrasses must tolerate low and frequent shoot defoliation (withstand close and frequent mowing), have high vegetative plasticity (a plant's ability to contract or enlarge its shoot structure depending on mowing pressure), and control their vegetative to reproductive transformation (seedhead formation) regardless of mowing pressure, nitrogen level, irrigation, and chemicals that regulate plant growth, and the like.

Botanists have catalogued over 10,000 species of grasses worldwide. Within that classification, there are primarily 12 grass species that fall under the turfgrass label. Out of that number, only 6 grass species are recognized for sports turf application. This elite group of sports turf must possess the preceding turfgrass criteria plus three other important features. The sports turf species must have excellent traffic tolerance, rapid recovery from divoting and injury, and high tensile or sod strength. In some instances, a combination of turfgrass species are used to obtain all or most of these features.

To become better sports turf managers, we first need to familiarize ourselves with turfgrass biology, selection, and planting. In this chapter, we will begin by looking at turfgrass growth and development. Then we will turn our attention to the procedures of choosing, planting, and establishing the best sports turf possible. Finally, we will

discuss the overseeding of warm-season sports fields that are used during the fall and winter months. This information will set a foundation that will help the field manager to understand how maintenance practices, pest controls, and environmental stresses affect the quality of sports turf.

1.2 BIOLOGY AND IDENTIFICATION

Turfgrass biology is the study of the vital plant processes necessary for turfgrass growth and development. These processes are divided into the categories of morphology, anatomy, and physiology. Turfgrass morphology is the outward form or structure of the turfgrass plant. Turfgrass anatomy consists of the inner cell, tissue, and organ structures that combine to form the whole plant. Turfgrass physiology refers to the metabolic events and pathways that formulate the life processes of the plant. The underlying ability of grasses to survive and persist as turf is due to their specialized morphology, anatomy, and physiology.

Turfgrass cultural practices determine the grasses' ability to adapt as a turf. These practices include mowing and seasonal renovations practices, such as aeration, vertical mowing, and so on. An understanding of turfgrass biology and turf cultural practices allows us to predict a turfgrass response to these cultural practices, and to have a better understanding of how turf can be managed to help it tolerate injury by pests or by mechanical or environmental stresses.

Out of the 12 grasses commonly used as turfgrasses, the 6 species used in sports turf situations are cool-season species Kentucky bluegrass (*Poa pratensis* L.), tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons. syn. *Festuca arundinacea* Schreb.), perennial ryegrass (*Lolium perenne* L.), and creeping bentgrass (*Agrostis stolonifera* L. syn. *A. palustris* Huds.); and warm-season species bermudagrass (*Cynodon* spp.) and seashore paspalum (*Paspalum vaginatum* Sw.), as shown in Table 1.1. Two other warm-season species, buffalograss [*Bouteloua dactyloides* (Nutt.) J. T. Columbus, syn. *Buchloe dactyloides* L.] and zoysiagrass (*Zoysia* spp.), are sometimes used for sports turf, but infrequently.

The warm-season species bermudagrass and seashore paspalum are usually planted and maintained alone (or as a “monostand”) except when overseeded with perennial, annual ryegrass (*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot) or intermediate ryegrass (*Lolium* × *hybridum* Hausskn.) for winter play. However, success is being achieved in some transition zone locations with a perennial two-grass turf where Kentucky bluegrass is established with bermudagrass (commonly referred to as “bluemuda”). The cool season species Kentucky bluegrass, tall fescue, and perennial ryegrass are planted and maintained as either monostands or in combination with one another (as “polystands”). Creeping bentgrass is usually planted as a monostand.

The limited use of buffalograss (*Buchloe dactyloides*) results from some of its special characteristics. Buffalograss is a warm-season grass used primarily in arid warm-season, transition, and cool-season regions in the United States. Its limitation is poor wear

Table 1.1 Characteristics of turfgrasses commonly used for sports turf.

Turfgrass Species	Strength as Sports Turf	Limitation as Sports Turf
Bermudagrass (<i>Cynodon</i> spp.)	Strong indeterminate rhizomes and stolons (excellent sod knitting), robust vegetative growth and recuperative ability, excellent wear resistance, and good surface resiliency.	Primarily warm climatic regions of United States, but cultivars with improved cold tolerance are rapidly expanding it into the transition zone, vegetative propagation only of most improved types, improved seeded cultivars now available touting enhanced density and superior cold tolerance for some cultivars.
Kentucky bluegrass (<i>Poa pratensis</i> L.)	Strong determinate rhizomes (excellent sod knitting), robust vegetative growth and recuperative ability, moderate wear resistance, good surface resiliency.	Cool climatic regions (including northern transition zone) of United States, with exception of new hybrid bluegrasses (<i>P. pratensis</i> x <i>P. arachnifera</i>) that show promise as monostands or when mixed with tall fescues and perennial ryegrasses in the southern transition zone; traditionally considered to have relatively slow establishment from seed but breeding efforts are now provided faster germinating cultivars, thus enhancing this grass's use on heavily trafficked sports fields.
Tall fescue (<i>Schedonorus arundinaceus</i> (Schreb.) Dumort., nom. cons. syn. <i>Festuca arundinacea</i> Schreb.)	Excellent wear resistance, robust primary and vegetative growth, good surface resiliency, adapted to transition zone of United States either alone or in combination with bluegrass.	Limited to transition or warmer regions of United States, weak determinate rhizomes (poor sod knitting).
Perennial ryegrass (<i>Lolium perenne</i> L.)	Excellent wear resistance, robust primary and vegetative growth, prolific tillering, rapid seedling growth, superior mowing aesthetics and good choice for winter overseeding of bermudagrass.	Limited to cool regions of United States (including northern transition zone), lacks rhizomes and stolons (very poor sod knitting), subject to damage from environmental and pest extremes.
Creeping bentgrass (<i>Agrostis stolonifera</i> L.)	Tolerates regular mowing at 1/4 inch, robust vegetative growth, strong stoloniferous growth habit provides recuperative potential.	Limited to cool regions of United States, drought tolerance is poor, slow seedling growth, lacks shear strength and resistance to divoting, primary use for low cut surfaces including tennis, croquet, etc.
Seashore paspalum (<i>Paspalum vaginatum</i> Sw.)	Strong indeterminate rhizomes, good surface resiliency, exceptionally salt tolerant, good visual mowing quality, better low-light performance than bermudagrass.	Limited to the warmest regions of United States, more sensitivity to many pesticides than most bermudagrasses, somewhat slow recuperative potential.

tolerance, obviously a problem for sports turf. The authors recommend the grasses listed in Table 1.1 as superior choices to buffalograss for sports turf use unless there is not sufficient water for irrigation to support these other choices.

Zoysiagrass (*Zoysia* sp.) is a warm-season grass in the transition zone of the United States. It has excellent cold and wear tolerances and good adaptation to low-light situations like moderate shade. The most important limiting factor of zoysiagrass as a sports turf is its very slow recuperation from injury or wear. Zoysiagrass cultivars selected for faster lateral growth rates and shade tolerance were promoted for sports turf use for the first time in the late 1990s. However, the poor recuperative potential continues to limit widescale acceptance of zoysiagrass for sports field uses. Efforts continue in the development of new cultivars and management strategies that might broaden the use of zoysiagrass for sports turfs. As research and development in zoysiagrasses continues, it is anticipated that some cultivars will serve as sports turfs, especially for soccer, baseball, and softball. Where adapted for use, keep in mind that both zoysiagrass and buffalograss offer the potential as high-quality, low-maintenance turfgrasses that require minimal inputs (water, mowing, fertility, etc.). While these grasses might not always serve a sports turf use, sports facilities quite often have turf areas particularly suited for low-maintenance grasses.

1.2.1 Turfgrass Morphology

Turfgrass morphology is an important characteristic that allows these *grass plants* to form a dense, compact community when they are cultivated properly. The morphology of turfgrasses can be categorized into four types: (1) bunch-type, (2) stoloniferous, (3) determinate rhizomatous, or (4) indeterminate rhizomatous (see Figure 1.1). All morphological types are designed to keep the plant's growing points at or below the soil surface.

1.2.2 Turfgrass Anatomy

A critical aspect of turfgrass anatomy is the location of growing points or “meristem-atic” zones (i.e., zones of cell division). Localized growing points of turfgrass occur at the stem apexes or buds, leaf blade and sheath meristems, nodes, root apexes, and root pericycle (see Figure 1.2).

Buds are the origin of all leaf (including blade and sheath meristems) and stem tissue. *Apical buds* are located at the *apex* or tip of a turfgrass stem and *axillary buds* are located in the *axil* or internal fold of a leaf sheath. Blade and sheath meristems generate leaf blade and sheath structures, respectively, and the blade and sheath combine to make up the whole leaf. Turfgrasses tolerate close cutting because they are able to maintain their blade meristems close to the soil surface. Cutting too close damages the turf canopy by removing leaf tissue at or below their meristems.

Leaf shape is determined by differences in leaf anatomy among turfgrasses. Turfgrass leaves are either *rolled*, *folded*, or *filiform* (see Figure 1.3).

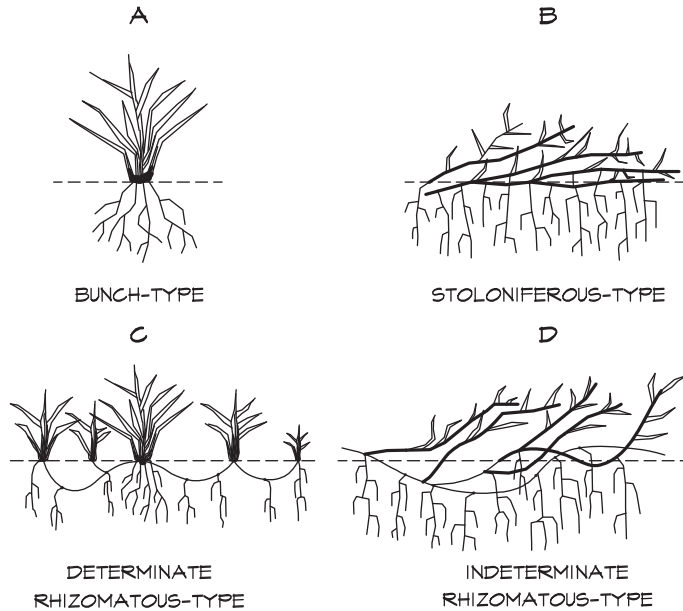


Figure 1.1 The four morphological types of turfgrasses: (a) bunch-type, (b) stoloniferous, (c) determinate rhizomatous, and (d) indeterminate rhizomatous.

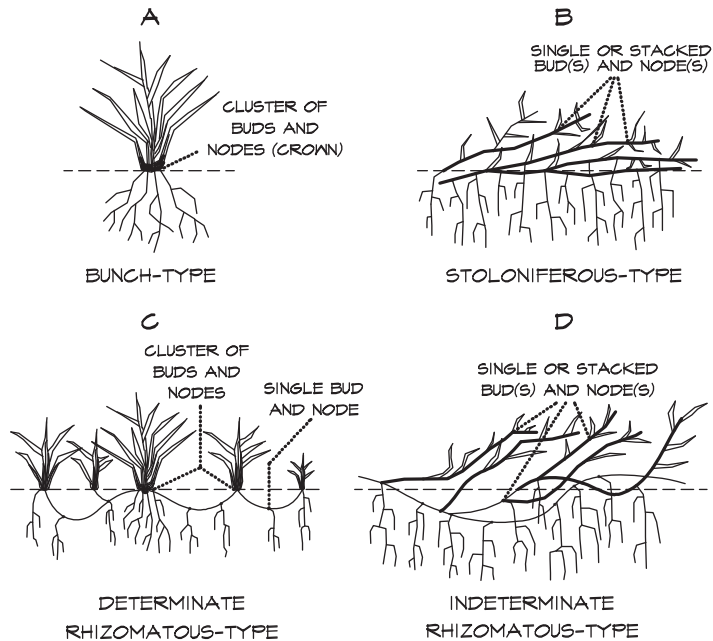


Figure 1.2 The location of turfgrass growing points: (a) bunch-type turfgrasses, (b) stoloniferous-type turfgrasses, (c) determinate rhizomatous-type turfgrasses, and (d) indeterminate rhizomatous-type turfgrasses.

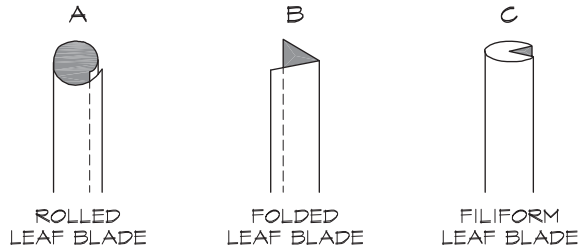


Figure 1.3 The variation in turfgrass leaf anatomy: (a) rolled leaf, (b) folded leaf, and (c) filiform leaf.

Rolled leaves have an anatomy of equally distributed and sized vascular bundles, and equally distributed zones of cells with thickened secondary cell walls transecting the turfgrass blade. Folded leaves have equally distributed but different-sized vascular bundles and different-sized zones of cells with thickened secondary cell walls transecting the turfgrass blade. Filiform leaves have equally distributed and sized vascular bundles, but scattered zones of cells with thickened secondary cell walls distributed throughout the leaf.

Nodes are the points of attachment of the axillary stem apices or buds, leaf blade and sheath structures (including meristems), and adventitious roots. Turfgrass nodes are part of the stem apex in turfgrasses having compressed stems and/or separated by internodes in turfgrasses with elongated stems (see Figure 1.4).

Compressed stems are found on bunch-type and aboveground stems of determinate rhizomatous type turfgrasses. Elongated stems are characteristic of stoloniferous, indeterminate rhizomatous, or belowground stems (rhizomes) of determinate rhizomatous-type turfgrasses. Compressed stems are usually less than 1/8 inch long and are found on perennial ryegrass, Kentucky bluegrass, and tall fescue. Elongated stems (multiple nodes with internodes) can range in size from 1/8 inch to 4 to 6 inches long and are found in Kentucky bluegrass (rhizomes only), bermudagrass (stolons and

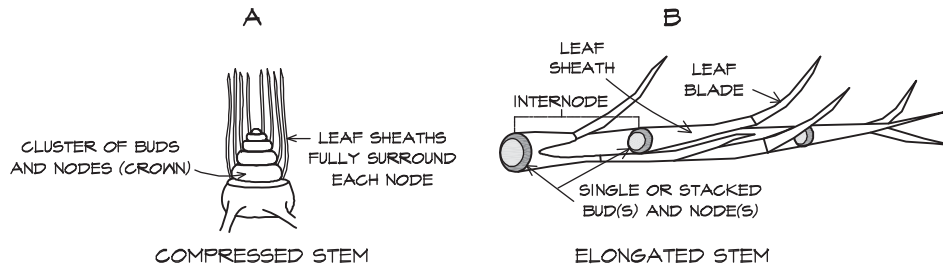


Figure 1.4 Nodes on turfgrasses with (a) compressed stems or (b) elongated stems.

rhizomes) seashore paspalum (stolons and rhizomes), and zoysiagrass (stolons and rhizomes). A collection of compressed stems located in a central core is called a node cluster or crown. Therefore, crowns are found only in bunch-type and aboveground stems of determinate rhizomatous species only.

1.2.3 Turfgrass Physiology

Turfgrasses are divided into two groups based on their temperature requirements for optimum growth. Turfgrasses are grouped as *warm-season* (80–95°F optimal growth) or *cool-season* (60–75°F optimal growth) plant types. Of the six common sports turf species, bermudagrass and seashore paspalum are classified as warm-season types, and tall fescue, perennial ryegrass, Kentucky bluegrass, and creeping bentgrass are cool-season types. These two groups of grasses differ in their physiology and anatomy.

Turfgrass physiology is a complex series of metabolic events. These events can be summarized as *energy capture*, *energy conversion*, and *energy utilization*.

Energy capture is the absorption by the turf of solar radiation through its canopy or leaves. To capture sufficient energy, the turf must have a minimum canopy density. Mowing defoliates the turf's canopy, and if the mowing height is too low, the turf can't capture enough energy. In some situations, the canopy of the turf is sufficient to capture adequate energy, but the level of solar radiation is insufficient (e.g., shaded environments). Sunlight-deprived turf may be due to stadium design or the presence of nearby trees that shade the field. In sports turf, canopy density may become limited on baseball infields, grass tennis courts, lacrosse, and other areas where close mowing heights are used (see Figure 1.5).

Energy conversion includes the processes of photosynthesis and respiration. In both of these processes, the high-energy compound *adenosine triphosphate* (ATP) is formed. If canopy density and level of sunlight are adequate, the turf can form ATP – provided all the metabolic pathways are stocked with the key substrates. These key substrates include chlorophyll, nicotinamide adenine dinucleotide phosphate (NADP), and electron transport pathway metabolites. For sports turf, adequate levels of these key substrates are maintained by supplying a proper balance of nitrogen, phosphorus, magnesium, manganese, and iron.

The conversion of carbohydrates to ATP is the *respiration* process. In this process, key substrates include nitrogen, phosphorus, copper, and zinc. Failing to maintain the proper balance or levels of these nutrients can restrict this portion of the energy conversion process (see Figure 1.6).

Energy utilization consists of the metabolic events that comprise the growth and development of the turfgrass plants. This component of turfgrass physiology is complex and interdependent on many diverse processes. Key substrates include nitrogen, sulfur, calcium, phosphorus, and potassium.

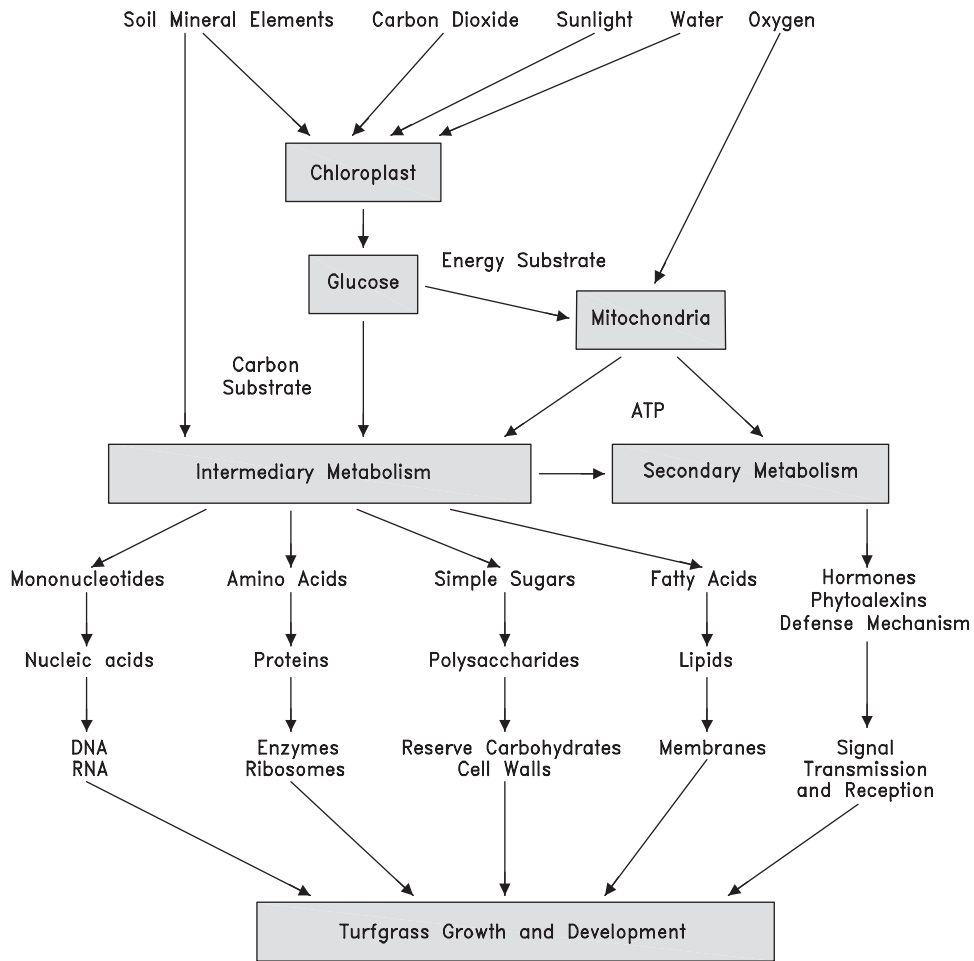


Figure 1.5 A schematic representation of turfgrass physiology.

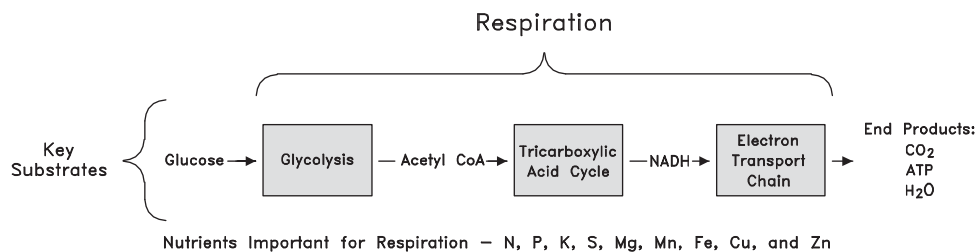


Figure 1.6 Key substrates and nutrients that support their formation and metabolism.