

SECOND EDITION

SPORTS FIELDS

Design, Construction, *and* Maintenance

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

Sports Fields

**Design, Construction,
and Maintenance**

Second Edition

James C. Puhalla

Jeffrey V. Krans

J. Michael Goatley, Jr.



SportsTurf
MANAGERS ASSOCIATION

Experts on the Field, Partners in the Game.



WILEY

John Wiley & Sons, Inc.

This book is printed on acid-free paper. ∞

Copyright © 2010 by John Wiley & Sons, Inc. All rights reserved.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey

Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 646-8600, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at www.wiley.com/go/permissions.

Limit of Liability/Disclaimer of Warranty: While the publisher and the author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor the author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information about our other products and services, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books. For more information about Wiley products, visit our web site at www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

Puhalla, Jim.

Sports fields : design, construction, and maintenance / by James C. Puhalla, Jeffrey V. Krans, and J. Michael Goatley, Jr. – 2nd ed.

p. cm.

Includes index.

ISBN 978-0-470-43893-0 (cloth)

1. Athletic fields—United States—Design and construction. 2. Athletic fields—United States—Maintenance and repair. 3. Sports facilities—United States—Design and construction. 4. Sports facilities—United States—Maintenance and repair. 5. Turf management—United States. I. Krans, Jeff. II. Goatley, Mike. III. Title.

GV413.P85 2010

796.4206'8—dc22

2009049254

Printed in the United States of America

10 9 8 7 6 5 4 3 2

About the Authors

Jim Puhalla is the president of Sportscape International, Inc., a firm specializing in the design, construction, renovation, and maintenance of sports fields and related facilities. From its headquarters in Boardman, Ohio, Sportscape designs and builds fields throughout North America by working with engineers, architects, and subcontractors from all areas of the country. The company's reconstruction of the Boardman High School field won them the "Baseball Diamond of the Year" award from the Sports Turf Managers Association and *SportsTurf* magazine.

Jim has worked in the sports field industry since 1978. His experience includes sports field project management and coordination, consulting, construction drawings and specifications, on-site inspections, and overall construction administration. He has been engaged as a speaker for sports turf conferences throughout the United States and has written many sports field magazine articles.

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 has conducted research in turfgrass breeding and physiology. He has developed and patented four turf-type bermudagrass cultivars: MS-Pride, MS-Choice, MS-Express, and MS-Supreme. Jeff is a member of the Crop Science Society of America.

Mike Goatley is the Extension Turfgrass Specialist 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 is very active in advisory capacities for the Virginia Turfgrass Council and the Virginia Sports Turf Manager's Association and received STMA's William H. Daniel Founder's Award in 2008.



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+ 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**, provides the reader with 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 basic turfgrass and soil science, cultural practices, and stresses placed on turf 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 fields, turf paints and covers, field quality and evaluation, and environmental stewardship.

Throughout the text, we have worked to make this book as useful as possible to those who are charged with keeping sports fields 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 laboratory study 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.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions of many academic and professional leaders whose advice and counsel have contributed to the completion of this book.

We are appreciative for the advice of the following academic colleagues: Dr. Donald Waddington of Pennsylvania State University, Andrew McNitt of Pennsylvania State University, and Dr. Coleman Ward (Professor Emeritus) of Auburn University.

Thanks to James Thompson, Mukundray Patel, Victor Maddox, Wayne Philley, Dr. Don Blasingame, Dr. Pat Harris, Dr. John Byrd, Dr. Euel Coats, Dr. Paul Meints, and Dr. David Nagel, all of Mississippi State University, for providing photographs, information, and manuscript reviews. Thanks to Dr. Shawn Askew, Mr. David McCall, and Mr. Jason Bowers of Virginia Tech for manuscript review and providing multiple photographs. Thanks to Bart Prather of Mississippi State University, and Tra Dubois of World Class Athletic Surfaces for advice on painting athletic fields.

Thanks 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.

Contents

About the Authors	ix
About the STMA	x
Preface	xi

Part 1 Principles of Sports Turf Culture 1

1	Turfgrasses	3
1.1	Introduction	3
1.2	Biology and Identification	4
1.3	Turfgrass Types	10
1.4	Turfgrass Selection	17
1.5	Using the Two-Map System to Select Turfgrass	20
1.6	Planting Times and Rates	24
1.7	Soil Preparation	28
1.8	Planting Techniques	29
1.9	Establishment	35
1.10	Overseeding Warm-Season Fields	37
2	Soils and Soil Science	45
2.1	Introduction	45
2.2	Soil as a Medium for Turfgrass	45
2.3	Soil for Hard Surfaces	54

3	Fertility and Fertilizers	57
3.1	Introduction	57
3.2	Nutrient Requirements	57
3.3	Nutrient Uptake	60
3.4	Soil Reaction	61
3.5	Fertilizer Analysis	63
3.6	Fertilizer Sources	65
3.7	Application Rates and Frequencies	68
3.8	Micronutrients	72
4	Mowing	75
4.1	Introduction	75
4.2	Types of Mowers	77
4.3	Turf Response	80
4.4	Height and Frequency	80
4.5	Pattern	82
4.6	Clipping Removal	83
4.7	Equipment and Safety	84
4.8	Chemical Growth Regulators	84
5	Irrigation	89
5.1	Introduction	89
5.2	Irrigation and Turfgrass Culture	89
5.3	General Principles of Turfgrass Irrigation	90
5.4	Portable Irrigation Systems	90
5.5	Installed Irrigation Systems	92
5.6	Wireless Sensor Technology	106
5.7	Subsurface Drip Irrigation (SDI)	107
6	Drainage	109
6.1	Introduction	109
6.2	Surface Drainage	109
6.3	Internal Drainage	114
6.4	Installed Drain Systems	119
6.5	Other Drain System Practices	130
7	Thatch	131
7.1	Introduction	131
7.2	Definition of Thatch	131
7.3	Advantages and Disadvantages of Thatch in Sports Turf	132
7.4	How Thatch Develops	134
7.5	Maintaining a Managed Thatch Layer	136
7.6	Reducing Excessive Thatch Buildup	137

8	Aeration	141
8.1	Introduction	141
8.2	Aerating for Optimal Turf Responses	141
8.3	Aeration Equipment	145
8.4	Topdressing	153
9	Turfgrass Stresses and Remedies	157
9.1	Introduction	157
9.2	Mechanical Stresses	157
9.3	Environmental Stresses	160
9.4	Weeds, Insects, and Diseases	164
10	Wise Use of Chemicals	239
10.1	Introduction	239
10.2	The Label Is the Law	239
10.3	Planning and Performing Applications	243
10.4	Record Keeping	256
11	Organic Field Management	257
11.1	Introduction	257
11.2	Definitions and the Controversy	258
11.3	Principles and Concepts of Organic Field Management	259
11.4	History and Materialization of Organic Field Management	260
11.5	Making the Mental Adjustment to Organic Field Management	261
11.6	Public Relations and Visibility of Organic Field Management	262
11.7	Timing and Site Conditions for Organic Field Management	262
11.8	Principles of Sports Turf Culture for Organic Field Management	263
11.9	Compost and Composting	277
11.10	Compost Applications on Sports Fields	279
11.11	Summary of Organic Field Management	280

Part 2 **Natural Turfgrass Sports Fields** **283**

12	Baseball and Softball Fields	287
12.1	Introduction	287
12.2	Design	287
12.3	Construction and Reconstruction	311
12.4	Renovation	319

12.5	Maintenance and Management Procedures	321
12.6	Warning Tracks	330
12.7	Rules and Regulations	334
13	Football Fields	339
13.1	Introduction	339
13.2	Design	340
13.3	Construction and Reconstruction	351
13.4	Renovation	351
13.5	Maintenance and Management Procedures	354
13.6	Rules and Regulations	363
14	Soccer, Lacrosse, and Field Hockey Fields	365
14.1	Introduction	365
14.2	Design	366
14.3	Construction and Reconstruction	372
14.4	Renovation	372
14.5	Maintenance and Management Procedures	375
14.6	Rules and Regulations	381

Part 3 Other Sports Surfaces 387

15	Tennis Courts	389
15.1	Introduction	389
15.2	Design	389
15.3	Construction and Reconstruction	394
15.4	Renovation	396
15.5	Maintenance	398
15.6	Rules and Regulations	400
16	Track and Field Facilities	401
16.1	Introduction	401
16.2	Design	402
16.3	Track Construction and Reconstruction	409
16.4	Track Renovation	410
16.5	Track Maintenance	410
16.6	Rules and Regulations	410
17	Synthetic Turf	419
17.1	Introduction	419
17.2	History and Innovations	420

- 17.3 Choosing the Right Manufacturer
and Installer 421
- 17.4 Care and Maintenance 422

Part 4 Ancillary Information 427

- 18 Surveying 429**
 - 18.1 Introduction 429
 - 18.2 Surveying Equipment 429
 - 18.3 Using Surveying Equipment to Establish
Elevations 432
 - 18.4 Interpreting the Contour (Grading) Plan 436
- 19 Sand and Sand-Based Fields 437**
 - 19.1 Introduction 437
 - 19.2 Critical Considerations in Sand-Based Growing
Media 438
 - 19.3 Sand Field Amendments 443
 - 19.4 Practical Considerations for Sand-Based
Fields 447
 - 19.5 Design 448
 - 19.6 Methods of Construction 448
 - 19.7 Reconstruction 453
 - 19.8 Maintenance 453
 - 19.9 Sand Field Testing 455
- 20 Paints and Covers 457**
 - 20.1 Introduction 457
 - 20.2 Paints 458
 - 20.3 Covers 464
- 21 Field Quality and Evaluation 469**
 - 21.1 Introduction 469
 - 21.2 Components of Field Quality 469
 - 21.3 Aesthetic Appeal and Quality 470
 - 21.4 Ball and Player Response as Affected by Surface
Characteristics 471
 - 21.5 Hardness Evaluation Equipment 472
 - 21.6 Traction Evaluation Equipment 473
 - 21.7 Surface Pace Evaluation Equipment 474
 - 21.8 Safety Considerations 475
 - 21.9 The Playing Condition Index 479

22	Environmental Stewardship, Resource Conservation, and Sustainability	481
22.1	Introduction	481
22.2	Environmental Stewardship	482
22.3	Resource Conservation	483
22.4	Sustainability	492
	Glossary	499
	For Additional Reading	510
	Index	511

Helpful Hints

Checking the Operating Pressure at the Heads	102
How to Tell When the Field Needs Water	106
Aerate and Topdress with Sand to Assist Internal Drainage	111
Sand Depth Requirements for Sand-Based Fields	120
Correcting a Muddy Field Problem	126
Off-Season Management Programs	142
The 1/128th Acre Method for Calibrating Sprayers	253
Common Design Errors and Solutions	284
Setting Elevations at Critical Points	312
Installing Bases	315
Manage the 'True' Playing Area	356
How to Keep Grass in High-Traffic Areas of a Practice Soccer Field	373
Establishing a Benchmark	433
Setting Proposed Elevations	434
An Innovative Storm Water Retention System	488
Designing and Implementing Sustainability in a Professional Sports Facility	495

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 to seek first 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 word label 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, etc. 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 need to first 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 (*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 others 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 planted and maintained alone (or as a “monostand”) except when overseeded with perennial or annual ryegrass for winter play. 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 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 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 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. One single limiting factor of zoysiagrass is its very slow recuperation from injury. Zoysiagrass cultivars selected for faster lateral growth rates and shade

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; and slow establishment from seed.
Tall fescue (<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> L.)	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.