Artificial Turf and Safer Alternatives

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Collaborative on Health and the Environment
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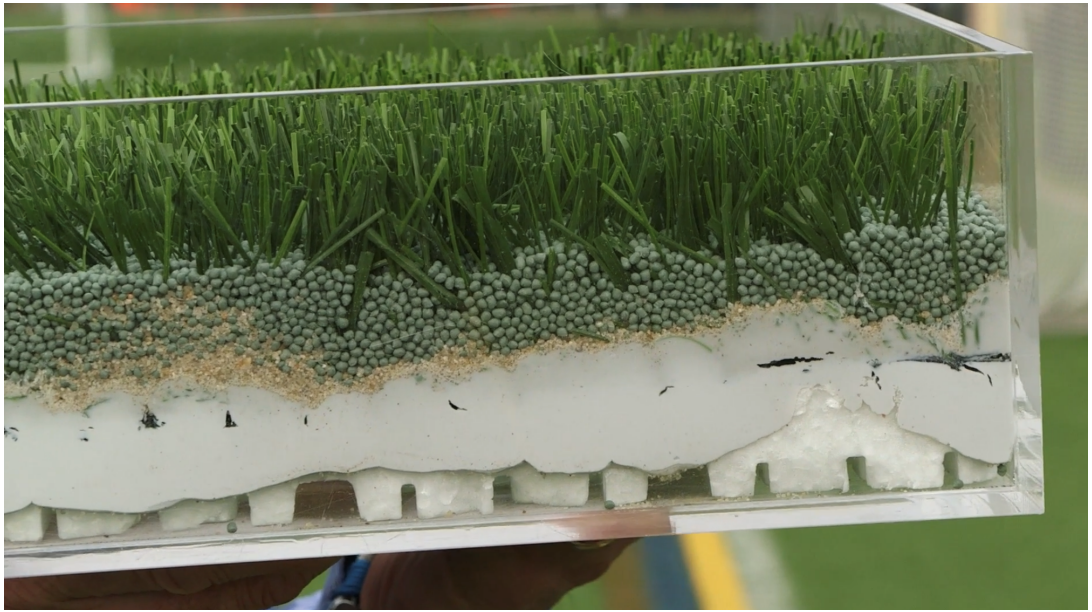
- **Principles of toxics use reduction**
  - Work with businesses & communities to reduce the use of toxic chemicals
    - Primary prevention of disease
  - Focus on inherent hazard
  - Assess alternatives
    - Avoid regrettable substitutions
    - Identify efficiencies & cost saving opportunities

Overview

- Artificial turf – chemicals
  - Infills – tire crumb
  - Infills - alternatives
  - PFAS in artificial turf carpet
- Additional concerns related to artificial turf
- Safer alternative – Sustainably managed natural grass fields



Tire crumb


Source of image: EHHI


Source of image: Ohio EPA


Source of image: Ohio EPA

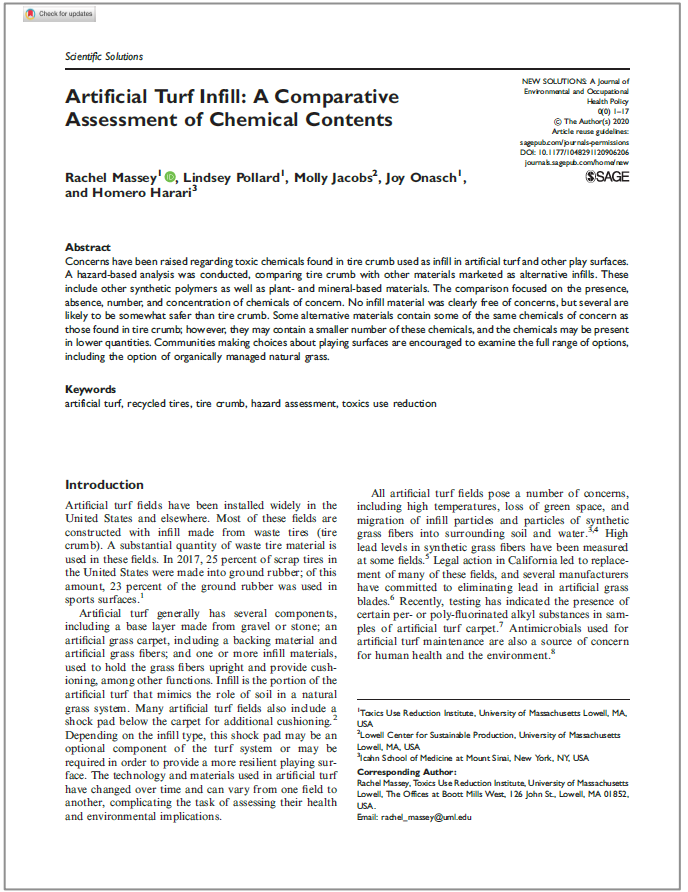
Tire ingredients include:

- Natural & synthetic rubber
- Fillers
- Antioxidants, antiozonants, vulcanization compounds

Toxic chemicals in tire crumb include:

- Metals
  - E.g. lead, zinc, arsenic, barium, cadmium, chromium, nickel
- Polyaromatic hydrocarbons (PAHs)
  - E.g. fluoranthene, pyrene, naphthalene, etc.
- Phthalate esters
  - E.g. di(2-ethylhexyl)phthalate
- Phenols
  - E.g. 4-tert-octylphenol
- Volatile organic compounds (VOCs)
  - E.g. benzene, hexane, styrene, toluene, xylenes, benzothiazole
- Over 350 chemicals identified in EPA literature review; additional chemicals identified in subsequent studies.

- **Examination of infill materials**
  - Hazard-based comparison
  - Complex materials containing many chemicals
  - Lack of disclosure



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Scientific Solutions

Artificial Turf Infill: A Comparative Assessment of Chemical Contents

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Abstract

Concerns have been raised regarding toxic chemicals found in tire crumb used as infill in artificial turf and other play surfaces. A hazard-based analysis was conducted, comparing tire crumb with other materials marketed as alternative infills. These include other synthetic polymers as well as plant- and mineral-based materials. The comparison focused on the presence, absence, number, and concentration of chemicals of concern. No infill material was clearly free of concerns, but several are likely to be somewhat safer than tire crumb. Some alternative materials contain some of the same chemicals of concern as those found in tire crumb; however, they may contain a smaller number of these chemicals, and the chemicals may be present in lower quantities. Communities making choices about playing surfaces are encouraged to examine the full range of options, including the option of organically managed natural grass.

Keywords

artificial turf, recycled tires, tire crumb, hazard assessment, toxics use reduction

Introduction

Artificial turf fields have been installed widely in the United States and elsewhere. Most of these fields are constructed with infill made from waste tires (tire crumb). A substantial quantity of waste tire material is used in these fields. In 2017, 25 percent of scrap tires in the United States were made into ground rubber; of this amount, 23 percent of the ground rubber was used in sports surfaces.[1]

Artificial turf generally has several components, including a base layer made from gravel or stone; an artificial grass carpet, including a backing material and artificial grass fibers; and one or more infill materials, used to hold the grass fibers upright and provide cushioning, among other functions. Infill is the portion of the artificial turf that mimics the role of soil in a natural grass system. Many artificial turf fields also include a shock pad below the carpet for additional cushioning.[2] Depending on the infill type, this shock pad may be an optional component of the turf system or may be required in order to provide a more resilient playing surface. The technology and materials used in artificial turf have changed over time and can vary from one field to another, complicating the task of assessing their health and environmental implications.

All artificial turf fields pose a number of concerns, including high temperatures, loss of green space, and migration of infill particles and particles of synthetic grass fibers into surrounding soil and water.[3,4] High lead levels in synthetic grass fibers have been measured at some fields.[5] Legal action in California led to replacement of many of these fields, and several manufacturers have committed to eliminating lead in artificial grass blades.[6] Recently, testing has indicated the presence of certain per- or poly-fluorinated alkyl substances in samples of artificial turf carpet.[7] Antimicrobials used for artificial turf maintenance are also a source of concern for human health and the environment.[8]

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Alternative infills

Tire crumb

EPDM rubber

Athletic shoe material

Thermoplastic elastomer (TPE)

Acrylic-coated sand

Mineral-based (e.g. sand)

Plant-based (e.g. coconut fiber, cork)

Alternative infills

Table 1. Comparing Tire Crumb With Alternative Infills: Selected Categories of Chemicals of Concern.[a]

From Massey et al. 2020

Category	Tire crumb	EPDM	Shoe materials[b]	TPE	Acrylic-coated sand	Mineral- or plant-based
VOCs	Present[c]	Present; lower in some cases, higher in others[d]	Expected to be present but subject to RSL	Present, lower[e]	Expected to be low or absent	Expected to be low or absent[f]
PAHs	Present[c]	Present, lower[d]	May be present but subject to RSL	Present, lower[e]	Below detection limit[g]	Expected to be low or absent[f]
PAHs (TURI sample)[h]	Present, highest	Present, lower[L1]	Present, lower[L1]	Present, lowest[L2]	Present, lowest[L2]	Present, lowest[L2]
Phthalate esters	Present[c]	Present, lower[d]	May be present but subject to RSL	Present[e]	Expected to be absent	Expected to be absent
Vulcanization compounds[i]	Present[c]	Expected to be present	Expected to be present	Expected to be absent	Expected to be absent	Expected to be absent
Vulcanization compounds: benzothiazole only (TURI sample)[h]	Present, highest	Present, lowest detected[L3]	Present, lower[L1]	Not detected	Not tested	Not tested
Lead[j]	Present, wide range of values documented in the literature[c]	Present, lower in some cases, higher in others[d,j]	Present	Present	Below detection limit[g]	Below detection limit in some cases
Other metals[j]	Present	Present	Present	Present	Present[g]	Present in some cases
Fungi, allergens, or other biologically active dusts	Not known to be present	Not known to be present	Not known to be present	Not known to be present	Not known to be present	May be present in some plant-based materials
Pulmonary fibrogenic dusts (crystalline silica or respirable fibers)	Not known to be present	Not known to be present	Not known to be present	Not known to be present	Not known to be present	May be present in some mineral-based materials[k]

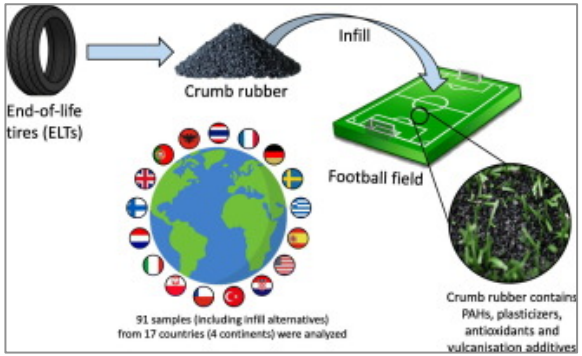
Summary

- No infill material was clearly free of concerns
- Some alternative materials contain some of the same chemicals of concern as those found in tire crumb
  - However, they may contain a smaller number of these chemicals, and the chemicals may be present in lower quantities.
- Infills are just one component of the artificial turf system, and other components also require careful examination

Massey, R., Pollard, L., et al. “Artificial Turf Infill: A Comparative Assessment of Chemical Contents.” *New Solutions* 2020.

New research on infills: Armada et al., 2022

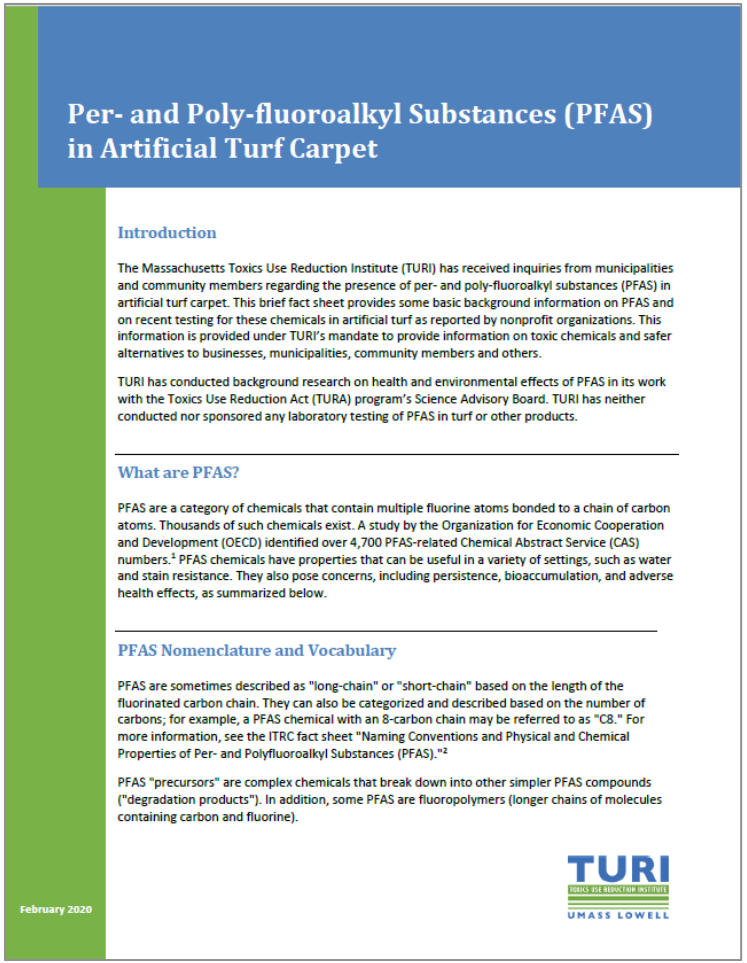
- 91 infill samples
  - PAHs, plasticizers, antioxidants, vulcanization compounds
    - Toxic chemicals in all samples
    - Some exceeded ECHA limits for PAHs
- Alternative infills
  - TPE:
    - PAHs lower
    - Plasticizers higher
  - Cork:
    - PAHs and other chemicals of concern low or absent
- Concerns for microplastic pollution.



Source of image: Armada et al. 2022

Reference: Armada, D et al. 2022. Global evaluation of the chemical hazard of recycled tire crumb rubber employed on worldwide synthetic turf football pitches. *Science of the Total Environment 812: 152542.*

PFAS in artificial turf carpet



Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet

Introduction

The Massachusetts Toxics Use Reduction Institute (TURI) has received inquiries from municipalities and community members regarding the presence of per- and poly-fluoroalkyl substances (PFAS) in artificial turf carpet. This brief fact sheet provides some basic background information on PFAS and on recent testing for these chemicals in artificial turf as reported by nonprofit organizations. This information is provided under TURI's mandate to provide information on toxic chemicals and safer alternatives to businesses, municipalities, community members and others.

TURI has conducted background research on health and environmental effects of PFAS in its work with the Toxics Use Reduction Act (TURA) program's Science Advisory Board. TURI has neither conducted nor sponsored any laboratory testing of PFAS in turf or other products.

What are PFAS?

PFAS are a category of chemicals that contain multiple fluorine atoms bonded to a chain of carbon atoms. Thousands of such chemicals exist. A study by the Organization for Economic Cooperation and Development (OECD) identified over 4,700 PFAS-related Chemical Abstract Service (CAS) numbers.[1] PFAS chemicals have properties that can be useful in a variety of settings, such as water and stain resistance. They also pose concerns, including persistence, bioaccumulation, and adverse health effects, as summarized below.

PFAS Nomenclature and Vocabulary

PFAS are sometimes described as "long-chain" or "short-chain" based on the length of the fluorinated carbon chain. They can also be categorized and described based on the number of carbons; for example, a PFAS chemical with an 8-carbon chain may be referred to as "C8." For more information, see the ITRC fact sheet "Naming Conventions and Physical and Chemical Properties of Per- and Polyfluoroalkyl Substances (PFAS)."[2]

PFAS "precursors" are complex chemicals that break down into other simpler PFAS compounds ("degradation products"). In addition, some PFAS are fluoropolymers (longer chains of molecules containing carbon and fluorine).

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February 2020

- Per- and poly-fluoroalkyl substances (PFAS) have been found in artificial turf grass blades & other components
- PFAS pose concerns including persistence and adverse health effects

Understanding PFAS testing

- Thousands of individual PFAS chemicals
  - Many break down into a common set of degradation products
- EPA methods include
  - Test methods for 29 PFAS in drinking water
  - September 2021 – draft test method for 40 PFAS in 8 media
- Options include:
  - Total Fluorine or Total Organic Fluorine Analysis
  - Total Oxidizable Precursor (TOP) Assay
- Greater information can be obtained by using more than one test method

Other concerns include:

- **Heat:** In warm, sunny weather, artificial turf becomes hotter than natural grass, regardless of infill materials or carpet fiber type
- **Environmental concerns:** Microplastic pollution, chemical run-off and water and soil contamination, habitat loss, use of antimicrobials
- **Disposal:** Based on current evidence, most artificial turf is not recycled
- **Injuries:** Particular concerns for **s**kin abrasions

Rubber infill particles in the Puyallup River, WA- (Source: *Seattle Times)*

Photo: Steve Ringman/*Seattle Times*

Studies of tire crumb

- Materials characterization & leaching
- Limited exposure studies
- Limited *in vitro* and *in vivo* toxicity studies
- Numerous risk assessments
  - Variations in set of chemicals considered and assumptions about exposure
- Limited human health studies
  - No well-designed epidemiological study

Safer alternative:
Organically or sustainably managed natural grass athletic fields

Maintenance

Natural grass – building a healthy soil and grass ecosystem:

- Aeration
- Soil testing
- Fertilizers/soil amendments
- Compost/addition of beneficial soil microorganisms
- Irrigation
- Mowing
- Using appropriate grass seed

Artificial turf:

- Fluffing, redistributing, & shock testing infill
- Periodic static control & disinfection of materials;
- Seam repairs & infill replacement
- Organic matter removal
- Watering to lower temperatures on hot days

Case Studies

Natural Grass Playing Field Case Study: Springfield, MA

Organic Grass Fields Meet Athletes' Needs and Protect Connecticut River Watershed

THE CITY OF SPRINGFIELD, Massachusetts, manages 12 properties, or a total of 67 acres, organically. This includes sports fields, park areas, and other public properties. Springfield's organically managed fields fully meet the community's needs for sports and other recreational activities, with high quality grass and soil.

Since starting the organic program in 2014, the city has doubled the number of properties in the program and experienced an increase in overall recreational use due to the improvement in soil and grass conditions.

This case study provides detailed information on the number of hours played at three parks in Springfield: two large complexes and one single, full-sized soccer field. Communities wishing to estimate the number of playable hours on a soccer field can use Treetop Park, the full-sized soccer field, as the most relatable model of the three parks discussed here. Treetop Park is used for approximately 1,050 hours of practice, play, and informal activity annually.

Children playing a pick-up soccer game on an organically-managed field in Springfield.

Aeration of the fields is a central element of successful organic maintenance. Other key elements include product application plans based on performance needs and soil testing for each field. Field management costs in 2018, including products, irrigation maintenance, and all labor costs, were just under $1,500 per acre across all the properties.

Springfield's organic management of natural grass has eliminated the need for pesticides, while providing a practical playing surface that fully meets the needs of athletes and others who use the parks. The Parks Department also notes that their field management choices help to protect water quality in the Connecticut River.

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Natural Grass Playing Field Case Study: Martha's Vineyard, MA

Improving the quality of grass playing fields with data collection and organic management

COMMUNITIES ON THE ISLAND of Martha's Vineyard, Massachusetts – Chilmark, Edgartown, Oak Bluffs, and West Tisbury – have chosen to work with a non-profit group, The Field Fund, to manage their natural grass playing fields. The Field Fund was formed in 2017 with a goal of providing quality grass playing fields that can support the full demands of local youth and adult recreational activities, and increase community access to pesticide-free play spaces. This case study provides information on maintenance practices, costs, use, successes, and challenges for three natural grass field complexes managed by The Field Fund.

Children playing soccer at West Tisbury School field

In its work with towns and schools, The Field Fund has chosen to use a combination of established organic management techniques and innovative technologies to pinpoint the needs of each field and allocate resources with precision. The Field Fund worked with a consultant to design the project and to create individualized maintenance plans for the fields. The Field Fund places a high priority on maximizing availability of the fields for play. Their techniques are designed to ensure that fields are never closed for maintenance.

Elements of organic management include frequent aeration, frequent mowing, soil testing, and the use of organic fertilizer and soil amendments. These practices are designed to create a healthy ecosystem with an active soil microbial community and a strong root system. In addition to these organic techniques, The Field Fund uses technologies such as drone photography and soil moisture mapping to assess field maintenance needs. Information collected through these techniques makes it possible to target the field areas needing additional maintenance, and to reduce total maintenance costs. The Field Fund also chose a mixture of grass types that are resilient in the Massachusetts climate and provide maximum root stability to withstand sports activity.

The Field Fund tailors maintenance to the use needs of each field. Some fields need only simple maintenance; others benefit from more support, including use of innovative technologies, to match their usage demands. Annual costs per acre range from $4,900 to $10,600. These costs are about 30% higher than would be faced by mainland communities for the same activities, due to additional costs associated with transporting materials and equipment to an island, as well as higher labor costs overall.

Fields maintained by The Field Fund are fully meeting the needs of their communities. None of The Field Fund partner fields were closed due to field conditions in 2019. By using organic maintenance practices, they are protecting their limited water resources and creating quality fields both for general use and for organized sports.

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Springfield, MA – organic program since 2014

- Eliminated pesticide use to help protect Connecticut River watershed
- Maintenance costs, including labor, just under $1,500 per acre
- Fields never shut down during open hours
- Game cancellations are rare

Forest Park in Springfield, MA

Table 6: Treetop Park soccer field (117,771 sq. ft.): Hours of use for sports practice and games, 2018

Sport	Age Group	Season	Total Use: Hours per Week*	Total Use: Hours per Season
Soccer	Adult	Spring	11	160
	Youth	Spring	12	170
Soccer	Adult	Fall	20	280
	Youth	Fall	18	245
Total documented sports team use – all seasons			**61**	**855**
Estimated informal recreation hours			7	196
Estimated total hours – all seasons			**68**	**1,051**

*Soccer is played year-round at Treetop Park. Spring and fall seasons were 14 weeks each. Informal use hours were calculated for 28 weeks.

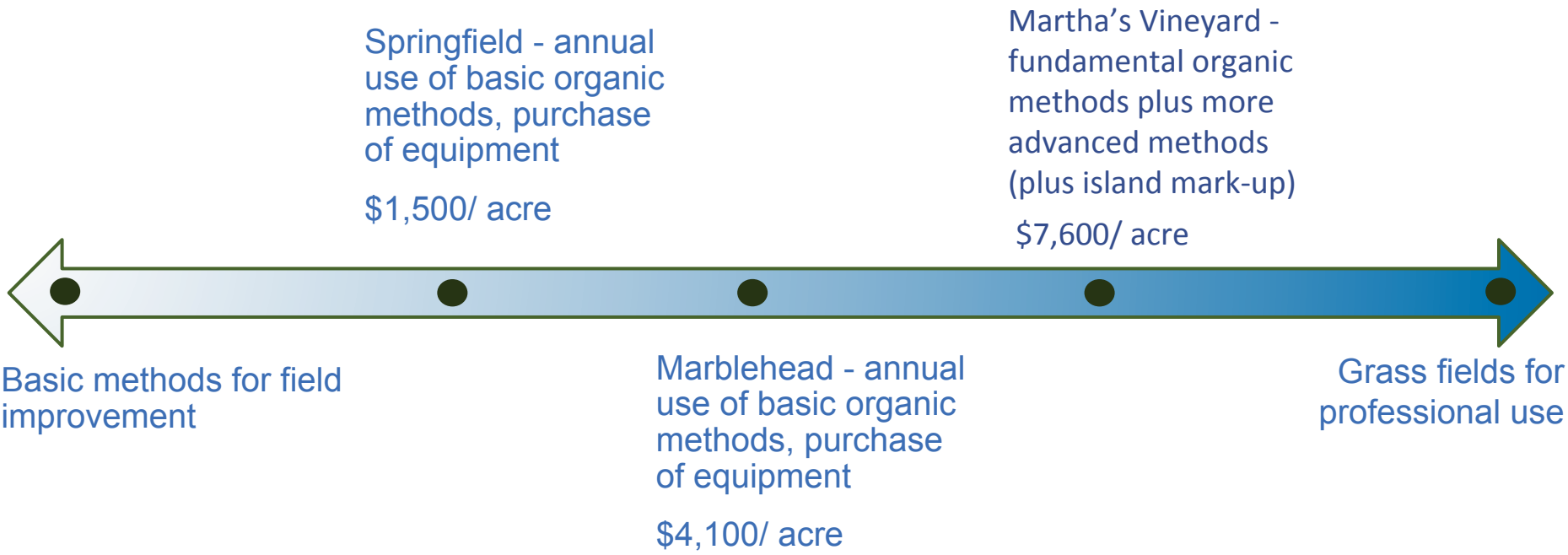
Hours do not account for cancellations. There were approximately 24 hours of soccer cancellations in 2018.

Martha's Vineyard, MA

- Focus on maximizing play time with no field closures
- Combination of established organic management techniques plus innovative technologies
- Core practices: aeration, soil testing, organic fertilizer & soil amendments
- Additional techniques: drone photography, soil moisture mapping

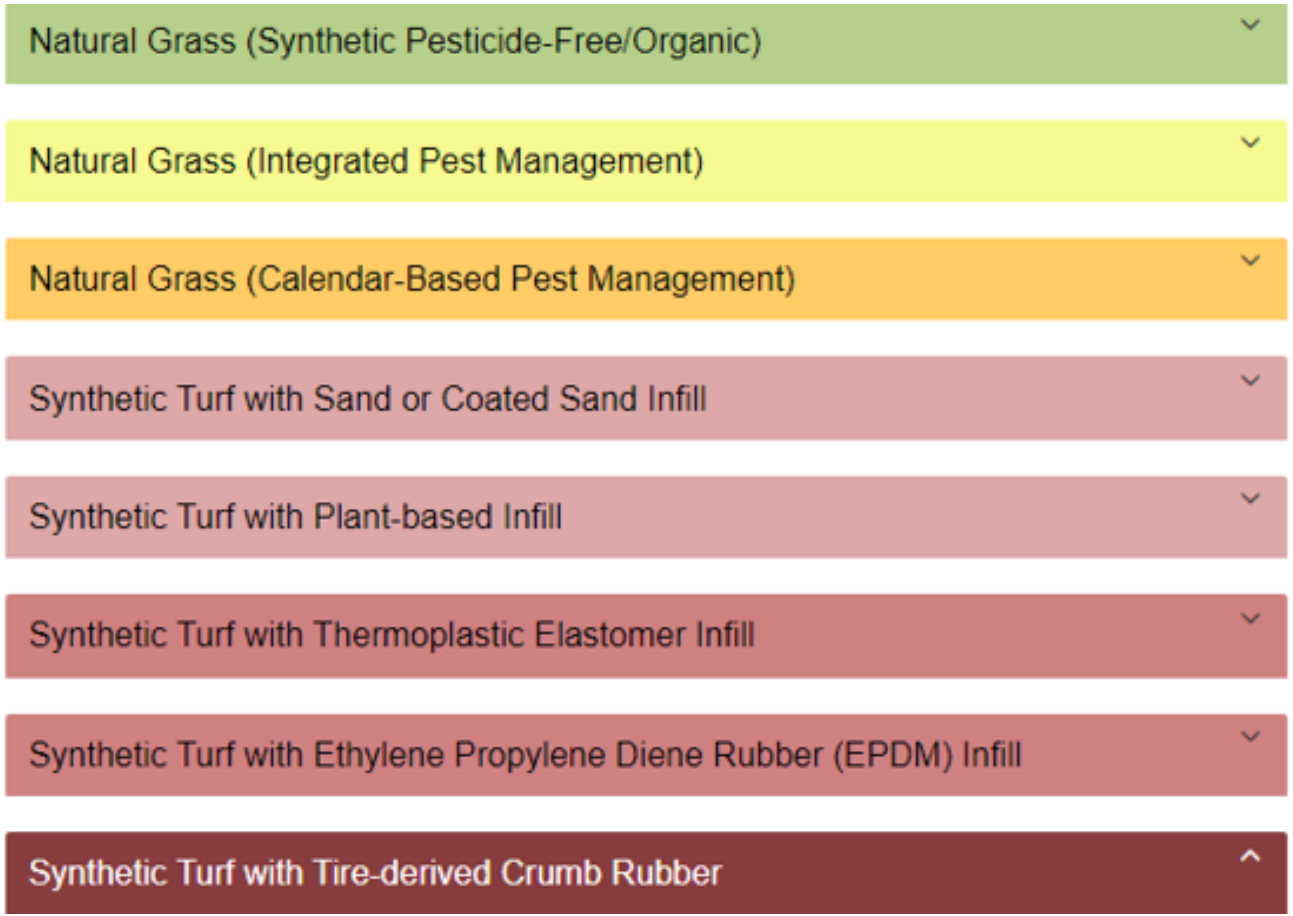
West Tisbury School field in Martha's Vineyard, MA

Wide range of maintenance costs and options for grass athletic fields



Additional Resources

Healthy Building Network (HBN): Hazard Spectrum



See: https://homefree.healthybuilding.net/products/70-turf-hazard-spectrum

For more information, visit: www.turi.org/artificialturf

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Athletic Playing Fields and Artificial Turf: Considerations for Municipalities and Institutions

This fact sheet introduces some of the considerations that are relevant to evaluating natural grass and artificial turf playing surfaces. For more of TURI's research on artificial turf and natural grass, see www.turi.org/artificialturf.

Principles of toxics use reduction

TURI's work is based on the principles of toxics use reduction (TUR). The TUR approach focuses on identifying opportunities to reduce or eliminate the use of toxic chemicals as a means to protect human health and the environment. Projects to reduce the use of toxic chemicals often have additional benefits, such as lower life-cycle costs.

Children's environmental health

People of all ages benefit from a safe and healthy environment for work and play. However, special concerns exist for children. Children are uniquely vulnerable to the effects of toxic chemicals because their organ systems are developing rapidly and their detoxification mechanisms are immature. Children also breathe more air per unit of body weight than adults, and are likely to have more hand-to-mouth exposure to environmental contaminants than adults.[1] For these reasons, it is particularly important to make careful choices about children's exposures.

Other synthetic infills. Other synthetic materials used to make artificial turf infill include ethylene propylene diene terpolymer (EPDM) rubber, thermoplastic elastomers (TPE), waste athletic shoe materials, and acrylic-coated sand, among others. These materials also contain chemicals of concern, although the total number of chemicals and/or the concentration of chemicals of concern may be lower in many cases.[5] For more information on chemicals in these materials, see TURI's report, *Athletic Playing Fields: Choosing Safer Options for Health and the Environment*.[9]

Artificial Turf Concerns

Infills	Other Materials	Heat	Disposal	Environment
• Tire crumb contains chemicals that are known to be hazardous to human health and the environment • Other infills can also contain chemicals of concern	• Toxic chemicals have been measured in artificial grass fibers • Shock pads can be made with chemicals of concern • Maintenance may require application of hazardous antimicrobials	• On summer days, artificial turf temperatures have been measured over 150 degrees F • Can burn skin and increase the risk of heat-related illness among athletes	• In most cases artificial turf cannot be completely recycled • Most turf and infill is not recycled • Most waste artificial turf goes to landfills	• Synthetic particles migrate into the environment, contributing to microplastic pollution • Replacing natural grass reduces habitat for small organisms

Find more details on our research at: www.turi.org/artificialturf

Safer Alternative? Natural grass managed organically.
Visit: www.turi.org/organicgrass

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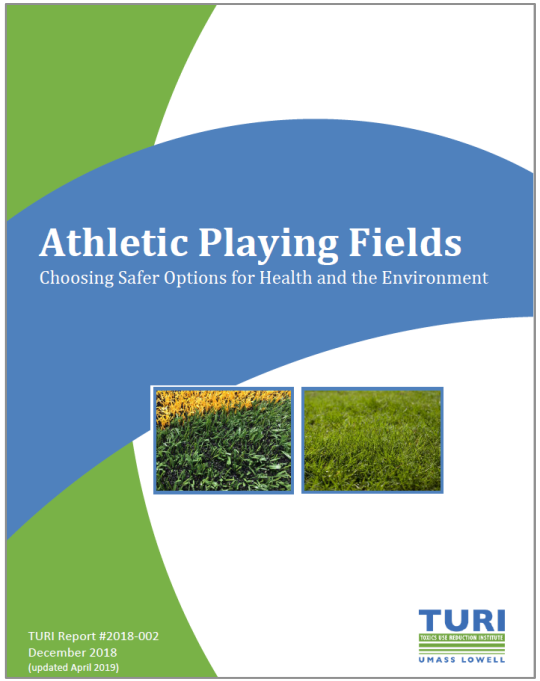

Athletic Playing Fields
Choosing Safer Options for Health and the Environment

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