

Environmental Health Impacts of Synthetic Turf and Safer Alternatives

CHE Partnership Webinar: January 27, 2022

(See [link](#) to webinar recording)

Research on the production, use, and disposal of artificial turf has brought to light concerns over environmental contamination, human health hazards, and adverse effects on wildlife. Researchers have studied a variety of contaminants found in artificial turf and different types of infill used to soften its surfaces. Concerns have been raised about polyaromatic hydrocarbons (PAHs), heavy metals, per- and polyfluoroalkyl substances (PFAS), 6PPD-quinone, and microplastics, among others. Studies have also examined heat related illnesses, skin infections, and other human health concerns. During this webinar **Rachel Massey, ScD, Lindsey Pollard, MS, Zhenyu Tian, PhD, and Sarah Evans, PhD**, discussed their work looking at environmental health impacts of artificial turf and safer alternatives.

Dr. Rachel Massey and **Lindsey Pollard** discussed the research they have conducted at the Toxics Use Reduction Institute (TURI) on health and environmental implications of artificial turf and safer alternatives. They described their research on materials used as artificial turf infill, including waste tire materials. They also touched upon emerging information on chemicals in artificial turf grass blades, as well as other health and environmental concerns associated with artificial turf, such as microplastic pollution and high surface temperatures. They briefly discussed their research on natural grass athletic fields as a safer alternative.

Dr. Zhenyu Tian summarized the identification of 6PPD-quinone as a lethal toxicant for coho salmon, and introduced the comprehensive screening of organic contaminants in urban stormwater and tire wear particle leachate. He discussed knowledge gaps and ongoing research about crumb rubber infill materials.

To conclude, **Dr. Sarah Evans** spoke from a pediatric environmental health perspective, touching on routes of exposure and concerns specific to children, with an emphasis on what families and communities can do to use safer alternatives.

Disclaimer: These are answers to questions posed informally during the webinar. Some of these questions were answered during the webinar, while others were answered afterwards. The answers are not intended to be exhaustive. Please see the respective sites below for more complete information:

[Toxics Use Reduction Institute: Athletic Playing Fields](#)

[Icahn School of Medicine at Mount Sinai: Artificial Turf Health Risks.](#)

[Northeastern University, College of Science: Zhenyu Tian.](#)

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PFAS

Question: What studies/resources/scientific opinions does TURI (or the panel here) have in regards to the PFAS containing dust shed from the blades themselves? This is a growing concern for field users and the EU Commission (using FIFA data on 3000 fields) has confirmed the microplastic shedding is in the hundreds of pounds per year per acre. Is this something that TURI is going to study and address in the future?

Answer: Thanks for this question on the interrelated issues of microplastics and PFAS. Microplastics are addressed in a separate section of this Q&A document. Regarding PFAS in artificial turf, this is an area of active research and it is likely that additional information on this topic will emerge over time. TURI is not doing any original research on this topic, but we expect to update our educational materials as additional information becomes available.

Question: I'm told by the committee and the engineers/planners tasked with the expansion of athletic fields in my town that there is no PFAS in artificial turf. Can you speak to that? Also that "safe" PFAS (I don't think that exists) used in production of artificial turf is inert so won't affect leaching or our sole source aquifer. Could you please speak to that?

Answer: Two nonprofit organizations that tested artificial turf carpet found evidence of the presence of PFAS in the material. They tested new turf; older, discarded turf; and samples of artificial grass blades. This is summarized in TURI's fact sheet, "Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet."
(https://www.turi.org/var/plain_site/storage/original/application/2af7f525abb175811f54b1dfb8ccc5c8.pdf)

There may often be some confusion about "PFAS free" claims, both for artificial turf and for other products. In some cases, a product may be incorrectly identified as "PFAS free," when in fact it is free of some PFAS but others are present.

There may also be confusion about polymeric PFAS (which may be what is being referred to in some cases as "inert"). PFAS polymers can break down into smaller molecules over time. In addition, residual processing aids may be present.

One other issue to be aware of is that the PFAS chemicals for which test methods are readily available are not necessarily the specific chemicals that may be used in a turf product. For more information, see TURI's fact sheet, linked above.

Question: Do you know of any more research about the boomerang effect where pfas in water enter the air from waves hitting the beach?

Answer: We have not researched this topic, but information is available in this article:
<https://pubs.acs.org/doi/10.1021/acs.est.1c04277>

Question: Please talk more about how the industry tries to mislead communities about pfas.

Answer: On this question, it's worth noting that information on PFAS can be confusing, and for many product categories, the absence of certain specific PFAS chemicals may sometimes be confused with the absence of all PFAS. There may not be an intention to mislead, but there may be room for error, so "PFAS free" claims for any product should be examined carefully.

In addition, even if PFAS are not used intentionally, in some cases they may be present as contaminants from the manufacturing process.

Heat/Drought

Question: Regarding temperature - is there a good range estimate established for surface temp across all infills? Like lowest increased temp to highest? We don't know what our school will chose yet though they won't choose crumb rubber. But its hard to argue when we don't know which of the other infills they will chose.

Answer: There is some variation across infills (some get hotter than others), although all artificial turf gets hotter than natural grass. The artificial grass blades play an important role in trapping heat. Resulting surface temperature will be a function of a variety of factors, including ambient temperature, sunlight, and materials used in the artificial turf.

The New York State Department of Environmental Conservation found that surface temperatures on an artificial turf field were 35 to 42 degrees F higher than on natural grass; up to 60.3 degrees F greater than natural grass; artificial turf fibers reached 156 degrees F under direct sunlight, while the crumb rubber infill reached 101 degrees F; measurements at Brigham Young University of surface temperature of artificial turf 37 degrees F higher than asphalt and 86.5 F hotter than natural turf, up to 200 degrees F on a 98 degrees F day.

Some information is available from Penn State at:

<https://plantscience.psu.edu/research/centers/ssrc/research/synthetic-turf-research-penn-state>

Detailed information is available in this report:

<https://plantscience.psu.edu/research/centers/ssrc/research/infill/temperature-and-color>

This report shows a range of surface temperatures alongside the air temperature when the readings were taken.

Question: There were at least 11 student athlete deaths over a short period of time recently from heat stroke. Do any of TURI's reports specifically speak to heat islands, water use on synthetic turf and how these plastic grass carpets impact Climate Action Plans, Zero Waste, and other plastic use reduction plans?

Answer: TURI has information on heat in our fact sheet:

https://www.turi.org/TURI_Publications/TURI_Chemical_Fact_Sheets/Artificial_Turf_Fact_Sheet

We also discussed some related issues in a recent blog (<https://www.go-gba.org/health-and-environmental-concerns-of-artificial-turf-fields/>), noting that building a healthy soil ecosystem helps to capture carbon, and that loss of green space can contribute to the urban heat island effect. We also noted that artificial turf does not necessarily eliminate the need for water; in some cases it is irrigated with water in order to temporarily bring down high surface temperatures. A recent article in *Architectural Digest* noted concerns about runoff water from turf being warmer than water running off from a natural grass field (<https://www.architecturaldigest.com/story/artificial-turf-installment>).

Climate change or sustainability plans will typically be relevant to athletic field decisions. The Denison University case study (<https://www.turi.org/content/download/13803/218956/file/Denison+University+case+study.pdf>) notes that its decision for all but one athletic field to be natural grass aligns with and is integrated into its campus environmental sustainability plan.

In terms of waste, it is important to keep in mind that synthetic fields are meant to be used 8 - 10 years and then require replacement. Infill also needs to be replenished during the useful life of the artificial turf field. (See our answers below to other questions regarding disposal and recycling issues.)

Question: NYC has teamed up with the Trust for Public Lands to install tire waste playgrounds and synthetic turf play areas that look nice but have all the toxic and heat problems and hardness too that you discussed. How can we counter this trend?

Answer: Some websites that provide information that community members and others can use in communicating with decision-makers are TURI's site, https://www.turi.org/Our_Work/Community/Athletic_Playing_Fields; the Partnership for Healthy Playing Surfaces, <https://www.healthyplayingsurfaces.org/>; and the Mount Sinai Institute for Exposomic Research website: <https://sinaisexposomics.org/artificial-turf/>. Also, each of the 10 federal regions has a Pediatric Environmental Health Specialty Unit (<https://www.pehsu.net/>) that provides information and support to pediatricians, community members, and others regarding children's environmental health issues. They can be a resource as well.

Question: I wanted to ask or request that there could be a case study done in California or other drought prone state to compare water use, benefits and drawbacks between grass and turf.

Answer: Some natural grass consultants are available to work in multiple parts of the country (see our fact sheet: https://www.turi.org/var/plain_site/storage/original/application/982fb1bc7bb561b4ce07072c5d26ab11.pdf). Consultants can sometimes consult remotely (e.g. guiding you through taking photos and collecting soil samples to diagnose the issues). You can also check the national listings of Accredited Organic Land Care Professionals (AOLCP's) ; <https://guide.organiclandcare.net/>

Regarding water use, organic land care decreases irrigation needs over time by building soil health.

Injuries

Question: My son contracted a strep infection from a bad turf burn from soccer.

Answer: Studies are mixed about whether or not artificial turf harbors more bacteria than natural grass, but outbreaks of infection have been shown following play on synthetic turf most likely due to the increased rates of turf burns (abrasions that occur when the skin comes in contact with turf materials). These skin abrasions/turf burns are a significant health and safety concern for athletes playing on artificial turf.

Human Health Impacts

Question: There must be epi studies.... i have heard data of increased in some cancers in children soccer players.

Answer: There have been efforts to initiate an epidemiological study of children exposed to artificial turf containing tire crumb infill, but to date, no well-designed study has examined this question. One ecological study was conducted to compare counties in California using a measure of "artificial turf density," and a Washington Department of Health report (addressed below) examined the question of whether to undertake a cancer cluster investigation in Washington. Neither study was designed to answer the question of whether athletes exposed to tire crumb have increased cancer risk.

Question: There was an epidemiological investigation of soccer players as a cancer cluster in Seattle.

Answer: The Washington Department of Health wrote a report on the question of a cancer cluster in Washington. The report stated, “Our investigation was not designed to determine if soccer players in general were at increased risk of cancer due to exposures from crumb rubber in artificial turf.” (See: <https://www.doh.wa.gov/Portals/1/Documents/Pubs/210-091.pdf>). Despite the narrow scope of the report, it has been cited misleadingly in the media as having investigated, and made a determination about, the relationship between tire crumb exposure and cancer risk. In fact, this question was not investigated.

Question: How could turf be isolated as an exposure factor in studying human health?

Answer: This is a question that could be answered in greater detail by an epidemiologist, but in general, a study can be designed to focus on a specific exposure in several possible ways. One option is a case-control study, in which cases (individuals with cancer) would be compared with controls (comparable individuals without cancer), with information gathered on individuals' exposure to tire crumb (including intensity and duration of exposure). Such a study would also require the collection of other information on exposures likely to affect cancer risk (e.g. exposure to radiation or smoking), and a statistical analysis would examine the role of all these factors.

The most informative way to study the health effects of turf would be through a prospective longitudinal cohort study in which study participants are followed over time and exposures and health outcomes are measured. As in a case-control study, it is important to measure as many other relevant exposures experienced by participants as possible so that you can determine the relative contribution that exposure to turf has on risk of developing disease. These studies can be costly and difficult to conduct because it can take several years to decades for diseases like cancer to develop following an exposure.

Question: Are there zeolite studies for the respiratory effects on children playing on this surface?

Answer: We are not aware of studies that have specifically examined respiratory effects of zeolite exposure among children playing on zeolite-containing infill. However, zeolite produces dust that may be inhaled and can pose respiratory hazards. The dust may be especially dangerous for children with asthma or who are prone to respiratory irritation.

In our comparison of infills

(<https://journals.sagepub.com/doi/full/10.1177/1048291120906206>), we note the following:

“Animal studies suggest that exposure to some types of zeolites may be associated with increased risk of developing mesothelioma. Erionite, one type of zeolite, poses particular concerns; its health effects can be similar to those of asbestos.” (References: Suzuki Y

and Kohyama N. Malignant mesothelioma induced by asbestos and zeolite in the mouse peritoneal cavity. *Environ Res* 1984; 35: 277–292. Weissman D. Erionite: An emerging North American hazard <https://blogs.cdc.gov/niosh-science-blog/2011/11/22/erionite/>.

Question: What do you say to proponents of synthetic turf who say that it is safe because it has been in existence for over 50 years?

Answer: An assessment of safety depends on gathering relevant data, not on the number of years for which a product has been in use. Concerns have been raised about possible chronic health effects of playing on artificial turf fields, and these concerns have not been investigated systematically through a well designed epidemiological study. Thus, there continue to be open questions about safety, as EPA and other entities have noted. One exception is that there have been systematic studies of biomechanical injury rates.

More generally, we have seen an increase in the rate of chronic illnesses in children and adults over the past several decades that are not explained by genetics or changing diagnostics. This strongly suggests a role for environmental chemical exposures and given what we know about the chemical composition of turf we cannot rule out a contribution. The debate about safety of artificial turf centers primarily around varying estimates of the level of exposure of children and athletes during play.

Infill

Question: How would you rank the artificial infills in terms of safety? How concerning is the safest option?

Answer: It is difficult to create a clear hierarchy among infills, as there are many unanswered questions about the alternative materials. We have made hazard-based comparisons among infills in our report (see table 2) (https://www.turi.org/var/plain_site/storage/original/application/b9727dedf5860ae7e83e3226d058b7ee.pdf) and in our article (<https://journals.sagepub.com/doi/full/10.1177/1048291120906206>). In general, the alternative infills contain fewer toxic chemicals, or lower concentrations of toxic chemicals, compared with tire crumb. Zeolite is a particular concern due to respiratory hazards. From an environmental perspective, using plant-based materials avoids concerns related to microplastic pollution from infills. Armada et al. (2022) note that cork may be an environmentally preferable choice based on the criteria they examined. In making choices, it's also important to consider performance factors such as resiliency; we did not assess these factors in our analysis.

It's also important to remember that additional components of a turf field including the grass blades contain chemicals of concern that can pose a health risk. Likewise, from a

heat exposure standpoint, all synthetic turf fields reach higher temperatures than natural grass, regardless of infill type. In summary, even communities that make careful choices about infill still face a variety of open questions about hazards of the artificial turf system.

Question: What is known about possibility of mold in organic infills and do they need to be treated with fungicide to avoid mold?

Answer: This is an important question to pose to a vendor when discussing a possible purchase. Some artificial turf products are sold with a requirement to use disinfectants and cleaners as part of the maintenance process. Also note that another individual posting in this Q&A series mentioned that their community experienced problems with mold growth on a plant-based infill product. Some plant-based products may be more naturally mold-resistant than others.

Question: Mount Sinai slide titled “Chemicals of Concern in Turf” is that specifically referring to artificial turf with crumb rubber or artificial turf with any alternative infill? Thanks!

Answer: This slide lists a small subset of the hundreds of chemicals that may be present in the various components of turf including the infill, grass blades, and padding. As the studies conducted by TURI have shown, many of the chemicals of concern present in crumb rubber infill can also be found in other infill types, although the alternative infills may contain fewer numbers of chemicals or lower concentrations of many of the chemicals of concern.

Question: Does TURI conduct tests to screen alternative chemicals for use in consumer products or does TURI just guide/recommend certain tests to industry? If testing is done in house, how do you overcome a lack of commercial standards for many chemicals?

Answer: TURI does not do any of our own testing in-house. In some limited cases, TURI sends materials out to either academic or commercial laboratories for testing. The lack of standards for many chemicals can create significant limitations.

The Ecology Center (<https://www.ecocenter.org/>) and the Center for Environmental Health (<https://ceh.org/>) have expertise on product testing.

For PFAS testing specifically, there are some general comments in TURI’s fact sheet (<https://www.turi.org/content/download/12963/201149/file/TURI+fact+sheet+-+PFAS+in+artificial+turf.pdf>) and you may also find it useful to look at this fact sheet from the Cancer Free Economy Network (https://www.bizngo.org/images/ee_images/uploads/resources/CFE_PFAS_Testing_FactSheet_Final.pdf).

For an overview of TURI’s lessons learned with the limited testing we’ve had done by outside laboratories, see our report:

<https://www.turi.org/content/download/13556/206786/file/Report.TestingArtificialTurfMaterials.April2021.pdf>

Question: In order to be held in place, some organic infills are mixed with sand, which can lead to inhalation danger. Is there any information/studies to share on this concern? and are organic infills ever treated with flame retardants , antimicrobials, fungicides? there isnt' much out there on organic infills because they haven't been used much yet?

Answer: Regarding sand, here is a paragraph from our article comparing infills (available at: <https://journals.sagepub.com/doi/full/10.1177/1048291120906206>):

“If sand is used, the size and source of the sand particles can affect safety. Silica, the principal constituent of sand, is a carcinogen if inhaled in the form of crystalline silica dust. Industrial sand that is freshly fractured or that has been highly processed to contain very small particles can be a respiratory hazard when inhaled. Thus, it is important to understand the source and type of any sand used in a recreational setting.”

On the question of treatment of organic (plant-based) infills with flame retardants, antimicrobials, or fungicides, this is an important question to ask vendors. TURI has spoken with a vendor of one plant-based infill and that vendor stated that the material is not treated in any way. However, this may vary depending on the material and the brand.

Regarding the lack of data on possible health hazards of organic infills, this has not been a focus of any of the existing state or federal studies, so information availability has lagged.

Question: PFAS has been detected in wood chips used as a turf infill on Martha's Vineyard. Are you aware of this or if something similar happens with playground wood chips?

Answer: We have not done any research on PFAS in wood chips, and we do not know the source of PFAS detected in wood products used for artificial turf infill. So unfortunately we don't have further information to offer on this question at this point.

Question: When our county moved away from crumb rubber as an infill, one of our high schools went with cork-o-nut. The field grew weeds, mold, etc. and had to be treated with weed killers.

Answer: Thank you - this is helpful information. The need for chemical treatments is often overlooked when decisions to install artificial turf are made. Even “natural” materials may require maintenance chemicals; and even a field with plant-based infill will have synthetic components such as padding and artificial grass blades.

Question: How could any infill be recommended, knowing the harms of the plastic carpet?

Answer: It is difficult to make recommendations. For a community that has the option, it is generally preferable to invest in improved maintenance of natural grass fields. In cases where artificial turf installation is under way or an existing artificial field is in need of replacement infill, in general, the alternative infills contain fewer toxic chemicals, or lower concentrations of toxic chemicals, compared with tire crumb; yet all of them require careful research.

Tire Crumb/ 6PPD

Question: Do you know the source of tire rubber that contributed to higher coho mortality? Did it originate from artificial turf fields?

Answer: We know that the sources of tire rubber were nearby highways.

Question: 6PPD has been implicated in the mortality risk of one specific species. Are there studies to see if this chemical affects other types of fish and what the implications are on the food chain?

Answer: A few recent studies showed that 6PPD-Q was NOT very toxic to freshwater species. <https://pubs.acs.org/doi/10.1021/acs.estlett.1c00453>

There are also ongoing studies on other species, especially other salmon and trout. We will probably see the results in the near future.

Question: Is 6ppdq volatile? Over time is it released from the tire crumb so after a few years content and release is low...or not?

Answer: We have not measured the volatility specifically, but it could be volatile. While 6PPD-Q is released or degraded, its formation from 6PPD could be going on at the same time.

Question: Do we know how 6PPD-Q is toxic to Coho salmon? Does it attack the nervous system, specific receptors, vestibular senses, etc? If there are no significant studies, do you have an educated guess? **Related question:** Any thoughts on how 6PPD-Q causes the acute effects in Coho? Target organ?

Answer: No final conclusion yet, but our collaborator considered there are some effects on the brain-blood barrier. Details in this paper:
<https://cdnsiencepub.com/doi/full/10.1139/cjfas-2020-0240>

Question: Is 6ppd quinone degraded easily in the natural environment? or in wastewater treatment plants?

Answer: Studies are still going on about 6PPD-Q's behavior. We see that 6PPD-Q is stable, but might not be very persistent. There is a German study showing 6PPD-Q in WWTP: <https://www.sciencedirect.com/science/article/pii/S0043135422000859>

Question: Is it known why chub are not affected like coho salmon from the road runoff? Is there a specific molecular receptor that plays a role in exacerbation/protection of this toxicity response?

Answer: My knowledge in toxicology is limited, so it's hard to answer these later questions. sorry. Jen McIntyre (our collaborator) may know better.

Question: I wonder if the pink colour in the toxic compound is a dye?

Answer: It's not a dye. The pure standard of 6PPD-Q has that pink-magenta color.

Question: Is there an available LC-MS library for the known compounds present or related to tire rubber?

Answer: Thanks, and I don't know a specific one with everything. I remember the EPA CompTox Dashboard may have a "tire chemical" list. Also see: www.epa.gov/tirecrumb.

Question: We first saw pre-spawn mortality about 15 years ago. Did tires change before then?

Answer: Good question. 6PPD has been used for a few decades, so it's probably not the change of tires. It's more likely the increased population and traffic resulted in a higher level of stormwater pollution. I also heard that the salmon restorations in urban areas made the mortality more visible to the public.

Question: Are tire manufacturers making a real effort to look for alternatives to 6PPD or are they mostly greenwashing?

Answer: I think we need some more time to answer this question, because this is still a relatively new discovery. We have heard from the U.S.Tire Manufacturers Association that the industries are working on alternative antioxidants. We will see how it goes.

Microplastics

Question: Has anyone looked at the microplastics that could come off of the plastic grass blades: If that has been studied – who has done the study? **Related question:** Do you know of any scientific groups testing watersheds for the presence of microplastics coming off of synturf fields? On average, an ST field loses tons of infill each year to the environment.

Answer: Communities have observed informally that plastic particles are distributed widely around artificial turf fields (showing disintegration of both infill and artificial grass blades). This has been documented through photos and videos in many communities.

A 2021 article in *The New York Times* (<https://www.nytimes.com/wirecutter/reviews/best-artificial-grass/>) noted, “A few themes emerged as we read academic research out of Sweden, Denmark, and the UK...Researchers can’t pinpoint an exact measure of the microplastics entering waterways via runoff from synthetic pitches, but conservative estimates put the number well into the hundreds of kilograms per pitch per year, with some estimates reaching into the thousands. In Sweden, synthetic sports fields are believed to be the second-highest contributor of microplastics into waterways... [O]fficials in that country previously recognized the issue and took steps to mitigate it—yet researchers still believe there are hundreds of kilograms of microplastics emerging from each field. In Norway, one researcher found microplastics in 85% of the soil samples collected from the bottom sediments of streams near artificial-grass pitches. In the US, there is relatively scant research on this topic, and although the impact of runoff within the 265 million square feet of installed synthetic grass is uncertain, it’s clearly not nothing.”

The Norwegian study can be found at:

<https://static02.nmbu.no/mina/studier/moppgaver/2018-Korbol.pdf>

Also see these links:

“RAC backs restricting intentional uses of microplastics: (June 2020):

<https://echa.europa.eu/da/-/rac-backs-restricting-intentional-uses-of-microplastics>

Fidra. “Microplastic loss from artificial (3G) pitches in context of the ECHA proposed restriction of microplastics intentionally added to products”:

https://naturvernforbundet.no/getfile.php/13158471-1599144644/Bilder/Milj%C3%B8vennlig%20hverdag/Plast/Kunstgress/Fidra-Microplastic-loss-from-artificial-3G-pitches_v2-.pdf

Fidra. “Solutions to microplastic loss.” <https://www.fidra.org.uk/artificial-pitches/plastic-pitches/solutions/>

Master’s thesis: *Tracking Microplastics from Artificial Football Fields to Stormwater Systems*. <http://www.diva-portal.org/smash/get/diva2:1330304/FULLTEXT02>

Case study: “Dispersal of microplastic from a modern artificial turf pitch with preventive measures.” <https://www.genan.eu/wp-content/uploads/2020/02/MP-dispersal-from-Bergavik-IP-Kalmar-Report.pdf>

Question: Dr. Sarah Jeanne Royer, now at Scripps, did her dissertation on the decomposition of sea water. In the process she discovered that plastics in seawater offgas methane and

ethylene. By extension she determined that all plastics made from these compounds, once exposed to sunlight, begin the offgassing process and never stop. Has TURI been in touch with her?

Answer: We have not been in direct contact, but agree this is important research.

Grass

Question: What do you recommend for outdoor areas where growing grass is not feasible?

Answer: In our experience working with natural grass consultants, there are many options available for building a healthy, resilient grass playing field in a wide range of environments. Working with a consultant specialized in athletic fields, especially using organic or sustainable practices, would be a good start to learning how to build and maintain a field in a tricky area.

Question: Were there any case studies for schools facing drought situations? Our argument for grass rests with ability to water it in drought (california).

Answer: Our Martha's Vineyard case study (<https://www.turi.org/content/download/13432/205432/file/Natural+Grass+Playing+Field+Case+Study+MV+MA.Dec2020.pdf>) may be helpful to read. They are water limited as well and use irrigation systems that water sections of fields based on readings from moisture sensors. They also work to create a high organic matter content in soil to provide higher water retention and less need for irrigation.

Question: You talk about play time not being impacted by organic grass systems and cite statistics of play time during a season. What would be consider baseline hours for play time during a season?

Answer: Our approach was to document the number of hours for which fields were used in the communities for which we were able to do case studies. Springfield was our first case study, and we began that work without any prior assumptions about baseline levels of use. Communities' field use varies depending on the amount of sports activity they have scheduled as well as other factors.

One issue to be aware of is that estimates of usable hours are sometimes presented with an adjustment factor (e.g. an hour of a greater-impact sport may be counted as more than a single hour). We did not make any such adjustments in our case studies. When talking with vendors about playable hours, it may be useful to ask them whether they are making any of these adjustments (e.g. whether an hour of football is counted as a single hour, or as more than one hour).

Question: What is the best type of grass to use on a football or soccer field? Is there a difference across the US?

Answer: Yes, there can be different types of grasses that are best to use for athletic fields in different parts of the country. The National Turfgrass Evaluation Program can help identify the best turfgrass for a particular site. For example, TURI's Denison University natural grass playing fields case study notes how they used that program to choose a mix of grasses that would thrive in their particular climate and extend the length of the season during which the grass is growing.

Question: Thank you for an excellent presentation. I am wondering how you define and classify what you term as organic care? Do you think of grass field care as a dichotomy of organic versus non-organic approaches to grass care. It seems to me that there are many gradations (for instance, I saw a grass field in NJ that was very healthy and mostly organically maintained, though it did use occasional herbicides). Thank you.

Answer: Thanks for this good question. Yes, there are gradations. There are certain core practices that are essential to building soil health, and a community can adopt these organic land care practices even if they are not using all organic methods. A community can commit to sustainable land care even without using all organic practices. Also, a community can choose to use carbon-based/organic matter fertilizer, without using certified organic products.

Question: I am assuming that the 2 Massachusetts examples of grass fields only play 3 seasons (due to snow coverage)? here in the PNW the grass fields turn to mudpits in the long wet winter months and we have year-round soccer. I'd be curious to know if there are some examples in wet zones regarding the durability of the grass fields through the rainy season.

Answer: We have not done any case studies for the Pacific Northwest. Some of the findings in our MA case studies could be relevant in other climates -- for example, by choosing an appropriate mix of grass types it's possible to maximize the durability of the root system.

Our full set of case studies can be found here:

https://www.turi.org/Our_Work/Community/Organic_Grass_Care/Case_Studies

Additional information (as noted elsewhere in this question list) is available at

<http://www.nontoxiccommunities.com/>

<https://guide.organiclandcare.net/>

Question: Our community is saying grass must rest all summer and the artificial turf can only meet our usage needs. We are under 600 students. They are also saying the grass will be

overused and we will have to grow new grass and it will take 18 months to grow %0_ can grass be put on a field faster?

Answer: Hours of play is one of the most common questions that comes up in decision making about natural grass or artificial turf. TURI's case studies address this (https://www.turi.org/TURI_Publications/Case_Studies/Organic_Grass_Playing_Fields).

At TURI, we have learned that grass fields that are properly maintained do not need to be rested. Take a look at our case study on Martha's Vineyard (<https://www.turi.org/content/download/13432/205432/file/Natural+Grass+Playing+Field+Case+Study+MV+MA.Dec2020.pdf>). They were able to excavate and rebuild a field to playable condition in a few months. The grass and soil health continue to improve over time with the right kind of care.

The key to a well-functioning field is healthy soil and a healthy grass root system, and fields can be diagnosed and maintained to address specific issues and performance needs. The Springfield, MA case study includes the number of hours played at three organically managed grass fields. Its Treetop Park, a full-sized soccer field, is used for approximately 1,050 hours of practice, games, and informal activity annually. The Denison University natural grass playing fields case study notes that their field managers periodically move the play area and goals several feet, in order to ensure that wear and tear is not focused in one part of the field.

Question: Can you send resources for some of these grass consultants? Or how do different communities find them?

Answer: There are resources for this included in TURI's fact sheet, at <https://www.turi.org/content/download/13543/206640/file/Factsheet.BuildinganOrganicMaintenanceProgramforAthleticFields.April2021.pdf>. The National Turfgrass Evaluation Program can help identify the best turfgrass for a particular site.

As noted above, also see:

<http://www.nontoxiccommunities.com/>

<https://guide.organiclandcare.net/>

Question: As far as the Vineyard study, if organic fields have worked well for them, why are they trying to install turf fields at the public schools?

Answer: I believe the Martha's Vineyard discussion about artificial turf was in progress for some time before the organic management project started – so that debate may have its own history and dynamics that aren't directly tied to an evaluation of the organically maintained natural grass fields and their performance. You may be interested to learn more about The Field Fund (www.fieldfundinc.org), the nonprofit group that coordinates organic maintenance for the fields.

Accessibility

Question: Is organic turf safe for those in wheelchairs and who use other mobility aids? If not, how can we make it safe? I have seen artificial turf marketed as “disability-friendly” and inclusive and it worries me.

Answer: We don't have information on disability access with artificial turf, but would expect that the main issue is whether there is an even surface that a mobility aid can move across without difficulty. Many of the approaches to improving grass fields using sustainable techniques also lead to a smoother surface.

Turf Costs & Related Topics

Question: How much does it cost to put an artificial field on a football field? What maintenance is required? Is it necessary to replace the tire crumb? How long will it last, what is done with the old thrown away turf?

Answer: We have some cost and maintenance data summarized in documents on our website, including:

Fact sheet:

https://www.turi.org/TURI_Publications/TURI_Chemical_Fact_Sheets/PFAS_in_Artificial_Turf_Carpet

Also see our 2016 "costs" document

(<https://www.turi.org/content/download/10395/173557/file/Cost%20Artificial%20Turf.%20September%202016.pdf>) and our Marblehead case study

(<https://www.turi.org/content/download/12705/198916/file/Natural+Grass+Playing+Field+Case+Study+Marblehead+MA+revised.Nov2020.pdf>), which includes a comparison to artificial turf costs.

Maintenance for artificial turf includes fluffing, redistributing infill, seam repairs, replacing infill that is lost from the field over time, disinfecting, and other activities.

The typical useful life of an artificial turf field is 8 to 10 years, though some last longer; the vendor can provide information on the expected life of the product. Discarded turf materials are often stockpiled, and are generally not recycled.

The Sports Field Managers Association (STMA) estimates \$6.00-\$10.25 per square foot for construction and an average of \$5,000 – \$8,000 per year in material costs and approximately 300-500 hours of labor cost per year to maintain an artificial turf field. (<https://www.stma.org/synthetic-turf-or-natural-grass-sports-fields/>)

Question: How does the synthetic turf industry usually push back against the kinds of research findings that you all are presenting?

Answer: The synthetic turf industry has largely responded to concerns about tire crumb through the marketing of alternative infills made from materials such as rubber, plastic, and plant-based materials. (The term “virgin” rubber is used to describe rubber that is not a waste material.) Greenwashing terms include “green”, “natural”, “enviro”, and “safe”; in fact, these newer products have not been tested for safety, and may also contain chemicals of concern. Industry points to a lack of studies on the health effects of turf and inherent difficulties in proving causality in epidemiological studies (e.g. long disease latencies, difficulty in accurately measuring exposure, recall bias) to support safety claims.

Question: In our community, there seems to be a fight between parents of athletes who are convinced they will get more play time out of artificial turf and environmentalists who feel the product is toxic. Any advice?

Answer: Hours of play is one of the most common questions that comes up in decision-making about natural grass or artificial turf. TURI’s case studies address this (https://www.turi.org/TURI_Publications/Case_Studies/Organic_Grass_Playing_Fields). The key to a well-functioning field is healthy soil and a healthy grass root system, and fields can be diagnosed and maintained to address specific issues and performance needs.

For example, the Springfield, MA case study includes the number of hours played at three organically managed grass fields. Its Treetop Park, a full-sized soccer field, is used for approximately 1,050 hours of practice, games, and informal activity annually. The Denison University natural grass playing fields case study notes that their field managers periodically move the play area and goals several feet, in order to ensure that wear and tear is not focused in one part of the field.

In TURI’s natural grass case studies, we document the annual amount of play on example fields. These were not the maximum amount of hours the fields could accommodate, they simply document the number of hours for which the communities were actually using the fields. All of the play needs were being met in these case study communities.

Community

Question: Used tire crumb is used extensively in playground mats and tiles. We even have them on beaches in CA. They frequently break down. CA Coastal Commission in San Diego County recently turned a blind eye to one of these on the beach in Oceanside, CA. We have a big battle ahead of us to get rid of these toxic and carcinogenic materials that kids roll and play on. Is TURI actively helping communities with these battles, or do you have a more neutral stance and provide info via publications only?

Answer: We primarily provide information via publications, though we're happy to do our best to field questions from community members and decision makers. Our colleagues at this webinar at the Icahn School of Medicine at Mount Sinai are available to provide evidence-based guidance on the potential health effects of artificial turf to individual communities.

Question: Do you write letters of support for communities?

Answer: In general, TURI does not write letters or support or attend community meetings. Instead we have created a number of videos and documents that communities can use during decision making. We have two short videos in particular with community meetings in mind: a four-minute video about our organic grass case studies (<https://www.youtube.com/watch?v=Cmjv1qteLho>) and a five-minute video about artificial turf and safer alternatives (<https://www.youtube.com/watch?v=jHgN11fxzaU>). There are also some helpful short videos of interviews with Dr. Phil Landrigan (https://youtu.be/_sijvzkc73w and https://youtu.be/rT4jKG_88pl).

Mount Sinai health professionals are also available to provide evidence-based guidance on the potential health effects of artificial turf to individual communities. See, for example: <https://villagegreennj.com/wp-content/uploads/2021/07/Mount-Sinai-Letter-to-Maplewood-Township-June-2021.pdf>

Question: In your experience, who is the best entry point in school districts to talk about these issues? Principals? Athletic directors? Facility managers?

Answer: This is really a question that community members would need to answer, but as a starting point, we would suggest that it can be helpful to offer information to all of those stakeholders within a school system.

Disposal/Recycling

Question: Can/will anyone speak to the issue of synthetic turf disposal?

Answer: Artificial turf fields typically only last around 8 to 10 years, at which time they need to be removed and disposed of. However, there are no state or federal regulations related to the disposal of artificial turf, which contains a complex mix of plastics, rubbers, and other materials. Many fields are placed in landfills or dumped in forests and wetlands at the end of their life, where chemicals continue to leach into the environment. For more information on this topic see:

The Atlantic: “The Dangerous Pileup of Artificial Turf”
(<https://www.theatlantic.com/science/archive/2019/12/artificial-turf-fields-are-piling-no-recycling-fix/603874/>)

Environmental Health News: “Hidden Gotcha in Artificial Turf Installations”
(<https://www.ehn.org/hidden-gotcha-in-artificial-turf-installations-2641507579>)

Zembla (public broadcasting program in The Netherlands - investigative reporting on artificial turf recycling): <https://www.youtube.com/watch?v=Y5o3J7uy4Tk>

York Daily Record: “Running out of Room: How Old Turf Fields Raise Potential Environmental Health Concerns”: <https://www.ydr.com/in-depth/news/2019/11/18/old-artificial-turf-fields-pose-huge-waste-problem-environmental-concerns-across-nation/2314353001/>

Seattle Times: “Rubber debris litters miles of Puyallup River after artificial turf was used in dam project without permit” ([https://www.seattletimes.com/seattle-news/environment/rubber-debris-litters-miles-of-puyallup-river-after-artificial-turf-was-used-in-dam-project-without-permit/?utm_source=facebook&utm_medium=social&utm_campaign=article_inset_1.1&ct=\(RSS_EMAIL_CAMPAIGN\)](https://www.seattletimes.com/seattle-news/environment/rubber-debris-litters-miles-of-puyallup-river-after-artificial-turf-was-used-in-dam-project-without-permit/?utm_source=facebook&utm_medium=social&utm_campaign=article_inset_1.1&ct=(RSS_EMAIL_CAMPAIGN)))

Question: Is the state of New York currently evaluating regulation for disposal of synthetic turf? Can rolls of used turf currently be put in landfills or is there a temporary pause on disposal until regulations are put in place?

Answer: The New York State Department of Environmental Conservation (DEC) does not regulate artificial turf as solid waste so these materials can be placed in landfills. There is an active bill in the 2021-2022 legislative session that would conduct a comprehensive public health study that would include health and environmental impacts of turf disposal. Additionally, an act to amend the environmental conservation law has been proposed that would establish a carpet collection and recycling program, including artificial turf.

See below for the full text of the proposed legislation:
<https://www.nysenate.gov/legislation/bills/2021/s3269>

<https://www.nysenate.gov/legislation/bills/2021/A9279>

Question: Is there any actual recycling for artificial turf and its components?

Answer: To the best of our knowledge, most artificial turf used in the US is not recycled, although individual portions may be used a second time in another location (e.g. in an animal care facility). These temporary re-use options simply delay the longer-term disposal problem, however.

A 2019 article in *The Atlantic* reported that scrap tires used in synthetic turf were continuing to be disposed of in landfills, urban and rural stockpiles, and natural areas (<https://www.theatlantic.com/science/archive/2019/12/artificial-turf-fields-are-piling-no-recycling-fix/603874/>). It said that the technology “to recycle this complex product - separating the plastic grass and backing from the sand-and-rubber infill - still isn’t fully developed in the United States, or is deemed too expensive.” It refers to a 2016 report focused on California, finding that landfill disposal in that state is “by far the most common method for managing field components after removal.”

An artificial turf recycling facility is being established in Pennsylvania:
<https://dced.pa.gov/newsroom/gov-wolf-announces-artificial-turf-recycler-establishing-first-north-american-facility-in-luzerne-county-creating-approximately-40-jobs/>

See the Zembla reporting, linked above, for more information on some of the technical limitations related to recycling.

Playgrounds

Question: Poured in place playgrounds (PIP) are a very concentrated point source of tires, too. These are playgrounds that are paved with tire materials, often with a layer of "virgin" synthetics on top. If you haven't had a chance to test these (which are similar to turf fields), they are worth a look, both for PAH levels, phthalate, and other toxicological questions.

Answer: Thank you for this comment. TURI has collected some information on playground surfacing in this report:
[www.turi.org/Our Work/Community/Playground Surfacing](http://www.turi.org/Our_Work/Community/Playground_Surfacing).

The Ecology Center has also done research on playground surfacing (www.ecocenter.org).

Question: Similarly, could the research discussed here today be applied to the related poured-in-place rubber surfaces used in playgrounds and running tracks (many of which are virgin rubbers)?

Answer: Yes. Poured in place surfaces and running tracks can contain many of the same materials that turf infills are composed of (e.g. recycled tire rubber, EPDM). In addition they may contain other components with chemicals of concern such as coatings and solvents. When assessing these products it's important to also consider the different types of usage and who will be using them. For example, a young child crawling in a field of EPDM infill may experience different exposures and risk than an adult athlete running on an EPDM track.

Question: Is PIP made of used tires?

Answer: That is correct; poured-in-place (PIP) playground surfacing is often made with waste tire material. For more information, see TURI's report:
https://www.turi.org/Our_Work/Community/Playground_Surfacing

Children

Question: For each speaker, would you allow your 5 yo or 12 yo kid (if you have/had them) play on these fields regularly?

Answer: It's important for children to have the opportunity to engage in structured and unstructured activities with their peers, yet parents need to ensure the children's physical safety. For both cases you mention – a five-year-old and a twelve-year-old – there are concerns, including the risk of skin exposure and incidental ingestion of tire crumb particles, as well as exposure to excessive heat. Our suggestion would be to try to minimize a child's time on these fields, educate the child about minimizing exposure to tire crumb or other materials on the field, and certainly to avoid exposure on hot days. In addition, we would suggest being very attentive to any skin abrasions that occur and treating them promptly to minimize infection risk.

Question: What do you think of installing synthetic turf fields where middle school children (grade 5-8) have recess? How can the kids wash and change clothes after recess? We don't have time for that. Is it really necessary?

Answer: Artificial turf where schoolchildren have recess raises concerns about exposure to toxic chemicals in the turf. Children are especially vulnerable to health impacts from both toxic chemicals and excess heat. A natural grass field, ideally managed organically, provides a safer play surface.

TURI's case studies include communities that manage their natural grass fields organically or using organic techniques (https://www.turi.org/Our_Work/Community/Organic_Grass_Care/Case_Studies).

If artificial turf is the only available area for recess, Mount Sinai recommends that children should brush any visible turf material off of their clothing and wash their hands immediately afterwards. Play should not be permitted on hot days.

Question: Like the Westport advisory. I'm not understanding how turning clothes inside out helps though.

Answer: The small pieces of tire crumb and grass blades can be carried home inside clothing and socks. Changing immediately and turning clothing inside out and shaking it over a garbage can is one approach to prevent bringing turf particles into your home.

Policy

Question: Thank you for these excellent talks. Curated, integrated, and actionable insights are quite hard to come by . . . but this session provided many of them. Are the speakers aware of any emerging policies or zoning laws that could help?

Answer: Here are some examples of policies and zoning regulations:

European Union policy on PAHs: As of August 2022, eight PAHs in tire crumb infills will be subject to new limits in the European Union (https://echa.europa.eu/hot-topics/granules-mulches-on-pitches-playgrounds?utm_source=echa-weekly&utm_medium=email&utm_campaign=weekly&utm_content=20210728&cldee=d2FsdGVycEByc2Mub3Jn&recipientid=lead-b4715268b1e0e71180fa005056952b31-9a5cf698ed30497abcf8243d6266869a&esid=76a5ab12-80ef-eb11-812e-005056b9310e).

Local school board heat policy: The school board of Burlington, MA has taken additional steps to protect student athletes by ensuring that both WBGT and surface temperature are taken into account. Burlington's policy, "Utilizing Artificial Turf in the Heat," (https://www.burlingtonpublicschools.org/district/district_policies/utilizing_artificial_turf_in_the_heat) requires use of an infrared heat gun to determine field surface temperature. The policy includes information about the conditions under which athletes may use artificial turf fields and the conditions under which their activities must be moved to grass fields. For example, the policy states that if the National Weather Service issues a Heat Advisory, artificial turf cannot be used for physical education if the air temperature is higher than 85 degrees with humidity 60 percent or more. Under these conditions, only a grass surface may be used. **Policies on waste turf fields:** There have been some efforts to adopt requirements related to safer disposal of artificial turf fields at the end of the product life. See, for example: <https://www.marylandmatters.org/2020/02/20/proposed-legislation-could-see-more-environmentally-friendly-turf-removal/>.

Local moratorium on installation of new artificial turf fields: A number of communities have adopted moratoria on installation of new artificial turf fields. For example, the town of Wayland, Massachusetts adopted a moratorium and also allocated funds for natural grass fields as an alternative (see:

<https://patch.com/massachusetts/wayland/wayland-enacts-turf-field-moratorium-elects-grass-option>).

State wellhead protection rules: Some communities have made decisions about athletic field surfacing based on wellhead zoning. In Massachusetts, information on Zone 1 wellhead protection zones is available on MassDEP's website (www.mass.gov/service-details/wellhead-protection-tips-for-small-public-water-systems).

Question: What is the role of the federal, state, and local governments to address this?

Answer: Federal, state and local governments have engaged on this issue in several ways. In some cases government entities have actively supported the use of waste tire materials in recreational settings, as part of a larger effort to identify alternative uses for these waste materials. Government entities have also worked to identify and assess hazards.

- Federal agencies have undertaken a series of studies related to the possible health effects of tire crumb used in artificial turf fields. Federal agencies have also played a role in the development of the artificial turf industry by supporting the use of waste tire materials in a range of settings.
- Some state agencies have worked to assess potential health effects of playing on artificial turf fields containing tire crumb infill. In addition, a number of state agencies have programs to address tire waste, and in some cases, states provide subsidies for the use of tire waste in a range of settings.
- Many of the decisions about athletic fields are made at the local level. Town committees, athletic groups, parents, and taxpayers may be involved in decision making. Decision-makers at the local level are also able to make decisions about investing in rebuilding natural grass fields, shifting from conventional to organic management techniques, and making improvements to natural grass field management to improve the quality of the playing surface. Some municipal governments or school districts have adopted limits or moratoria on the installation of artificial turf subject to certain criteria (e.g. presence of tire crumb, presence of PFAS), and some have adopted requirements related to heat. Some also require signage to warn athletes and parents about hazards.

EPA study/infills/tire crumb

Question: Has the long-awaited EPA report on artificial turf and crumb rubber been completed and released yet?

Answer: The federal turf study is not complete. EPA, NTP and CPSC have released three reports as part of this study, in 2016 and 2019. These include a literature review, materials characterization, and a preliminary study to inform playground exposure assessments consisting of phone interviews of parents of young children. None of these studies included a risk assessment or biomonitoring to assess chemical exposures. Planned biomonitoring studies by the CDC to assess actual exposures by users of turf fields have been postponed due to the COVID-19 pandemic.

To read more about the study and access the reports: <https://www.epa.gov/chemical-research/federal-research-recycled-tire-crumb-used-playing-fields>

Safer Alternatives

Question: Are there any future artificial turf surfaces in development that address the many environmental and health concerns all of you have cited?

Answer: That's a good question. We are aware of a variety of innovations in artificial turf, but it's not clear whether any of these innovations address the full range of health and environmental concerns.

Question: How many of the chemicals are in the dust - have there been many studies into the dust coming off the crumb?

Answer: It's hard to give an accurate number of total chemicals, because manufacturers used different formulations in their products. Also, multiple transformation products can be generated from a single ingredient, making it more complicated. A rough estimate would be in the hundreds, according to the existing studies and reports.

Some studies have specifically examined dust, while others have focused on other aspects, such as offgassing to air, leaching to water, or material characterization.

Question: The Montgomery County Civic Federation publishes a monthly newsletter. May I share the presentations link and the recording link in the next issue? It will publish in the next 10-days at www.montgomerycivic.org. We have written numerous articles on the ST subject over the last 10 years.

Answer: Yes, you are welcome to share this material.

Question: Are you guys familiar with Organic Land Care Standards and AOLCPs (accredited organic land care professionals, there is a national database online). This could help you refer solution based offerings that further this discussion in a productive way. I'm with www.NonToxicCommunities.com; you can access those links on our site or contact us for a conversation. Excellent presentation and hope the recording will be made available?

Answer: Thank you for these useful links. The national database of AOLCPs mentioned in this query can be found at:

<https://guide.organiclandcare.net/>

Question: Let's not forget that the waste tire piles that plagued state governments for years have disappeared under the feet of children. Bush Administration in 2007 got together with Institute of Scrap Recycling Industries and Rubber Mfrs Association to pave the way for this corporate welfare program and the plastics industry was right there with them. No toxicologists were in the room.

Answer: Thanks for this comment. We can add that there have been several phases of decision-making related to tire waste at the federal level. As early as 1990, there were discussions in Congress about whether to create a regulatory framework for tire recycling; Congress ultimately did not take action. A 1991 report from EPA considered markets for waste tire materials, and focused largely on options for using waste tires in a variety of applications, rather than looking primarily at source reduction options (<https://archive.epa.gov/epawaste/conservation/materials/tires/web/pdf/tires.pdf>). State programs often provide financial support for use of waste tire materials in a variety of settings. We would agree that health and environmental hazards have not necessarily been prioritized in decision-making related to waste tire materials.

Question: Bloomberg Law mentioned recently something about EPA regulation on synthetic fields containing PFAS. Do you know where that is at? Will that cause a flood of lawsuits against schools and park districts installing them, knowing the hazards?

Answer: Thanks for this question. Unfortunately, this is not a topic we have looked into at this point.