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Investigating the Challenges of Managing Natural Turfgrass and Synthetic Turf on Community Sports Fields

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Abstract. **Both natural turfgrass and synthetic turf fields have distinct advantages and disadvantages and present unique challenges. The challenges evolve over time because of climate change, players' ever-changing needs, and the development of technologies. It is imperative to identify these challenges and devise effective solutions to overcome them. We conducted a survey of 97 administrators and managers from various organizations in the United States who were responsible for managing community sports fields. Our findings identified budget constraints as the biggest challenge for natural turfgrass field management, followed by issues related to use/scheduling and weather/climate. For synthetic turf field management, the top three challenges included budget constraints, use/scheduling, and other challenges (mainly safety issues). Additionally, administrators and managers consistently indicated increased funding as a solution for addressing challenges of both natural turfgrass and synthetic turf field management. We discuss the implications of these findings and provide potential ways to address these challenges.**

Community sports fields at public facilities such as parks and schools (grades kindergarten–12) can host a variety of sports, and these facilities are often shared. The main purposes of community sports fields are to increase participation in physical activities that are both beneficial to individual health (Lee et al. 2012) and community-level public health (Eime et al. 2015) and to act as a conduit for social inclusion (Chen and Liu 2020). The two major types of sports fields are natural turfgrass fields and synthetic turf fields. Natural turfgrass fields were the only option until the introduction of synthetic turf in 1960 by David Chaney at North Carolina State University (The Associated Press 2004). Synthetic turf became adopted for recreational use in 1964 for the first time at the Moses Brown School in Providence, RI, USA (Brady 1972). In 1966, AstroTurf became prominent as a major substitute for real grass fields, with approximately 11,000 synthetic turf fields installed throughout the United States (Weeks 2015). Synthetic turf comprises a composite of synthetic fibers that mimic the texture and look of natural turfgrass blades that do not require photosynthesis. Originally designed with no infill, modern versions of synthetic turf comprise longer fibers (i.e., blades of grass) and recycled crumb rubber with sand as infill between the fiber to maintain the shape of the turf and reduce wear and tear. The frequency of usage of outdoor sports field facilities and indoor facilities is often influenced by weather patterns. For example, inclement weather may discourage outdoor exercise and increase indoor participation (Hug et al. 2009). The immediate attraction of synthetic turf was influenced by its artificial nature that allows sports fields to be created both indoors and at high altitudes, which are two major limitations of natural turfgrass fields.

Although there are advantages and disadvantages of both field types, facility administrators have concerns regarding cost, and the initial cost of installation is sometimes prohibitive. Studies have reported that the cost of synthetic turf, including upfront costs and infill costs, is higher than that of natural turfgrasses (Cheng et al. 2014; STMA 2009). However, synthetic turf eliminates the need for inputs such as fertilizer and herbicides required for natural turfgrasses, which can lower the labor and material costs (TURI 2016). Another benefit is that synthetic turf surfaces can be used more frequently, without the need for recovery periods between events because of their durability, thus making high-use areas, such as sports fields, more cost-effective (Serensits et al. 2013). More comprehensive studies of the life cycle costs of installing, maintaining, and disposing of both types of grasses are necessary to perform meaningful cost comparisons.

In addition to the cost, there are several advantages and disadvantages of selecting synthetic turf over natural turfgrass for sports fields. Specifically, the two main areas of concern associated with synthetic turf and natural turfgrass are the health risks and environmental impacts of synthetic turf (Brooks and Francis 2019; Cheng et al. 2014; Dragoo and Braun 2010). Synthetic turf is associated with the risks of injury and health; for example, friction created by synthetic turf, especially among older generations, can lead to higher rates of abrasions and burns (Twomey et al. 2019). Furthermore, increased temperatures can occur on turf during prolonged exposure (Fleming 2011; Jim 2017; Liu and Jim 2021; Williams and Pulley 2008). However, for the average participant, and even for professional athletes, there does not appear to be an increased risk of health risks with the use of synthetic turf (Cheng et al. 2014). This is especially true for younger athletes, who do not appear to be at increased risk for injury when using synthetic turf (Fuller et al. 2007; Steffen et al. 2007; Williams et al. 2013). A review of 53 articles published between 1972 and 2020 indicated that foot and ankle injury rates were slightly higher with the use of synthetic turf, whereas the rates of knee and hip injuries associated with natural and synthetic surfaces were indistinguishable (Gould et al. 2023). One notable distinction was that higher rates of knee injuries were observed with the use of synthetic turf for American football played at high levels of competition.

There is no evidence that the rubber infill adds to the presence of per- and polyfluoroalkyl chemicals in the surrounding environment that could lead to concerns regarding potential carcinogens (Lerner 2019). An additional concern related to synthetic turf is that the crumb rubber used as infill would lead to contamination through air and water pollutants. However, this concern appears to have been overstated. One study found that concentrations of heavy metals and organic contaminants in field drainage and concentrations of volatile and semi-volatile organic compounds near artificial turfs were below regulatory limits (Cheng et al. 2014). In contrast, natural grasses were believed to consistently contribute to improved air quality and reduce heat island effects (Nowak and Heisler 2010). However, there have been concerns about the perceived high demand for resources. The maintenance of natural turfgrasses requires inputs such as fungicides, insecticides, and fertilizer, which can negatively impact the environment and human health. For example, inappropriate use of fertilizer and pesticides can lead to nutrient and pesticide

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pollution, thus harming water quality and human health (Easton and Petrovic 2004; Gilliom et al. 2006). Maupin et al. (2014) found that 40% to 75% of domestic water is used for landscape irrigation in arid US regions, thus exacerbating water scarcity concerns associated with heat waves and droughts (US Drought Monitor 2020).

However, climate change can have a significant impact on natural turfgrass (James 2011; Straw et al. 2020). High temperatures increase water needs and stress, whereas cold temperatures can slow growth and make it more vulnerable to damage (Yue et al. 2023). Additionally, drought can lead to wilting and browning, whereas excessive rainfall can cause waterlogging (Liu et al. 2021; Murphy and Ebdon 2013). Although synthetic turf is designed to be more resilient to weather conditions than natural turfgrass, climate change can still affect its performance, but in different ways (Cheng et al. 2014; Petrass et al. 2015). Synthetic turf avoids issues like pooling, which can affect natural turf surfaces, especially those with improper drainage (Taylor et al. 2012). However, extreme heat can cause synthetic turf to become hotter, potentially leading to discomfort for players and an increased risk of injury (Jim 2017; Liu and Jim 2021).

In addition to the difference in cost and environmental and health concerns associated with the two types of grasses, users express distinct attitudes toward their appearance, feel, athletic performance, and durability (Barnes and Watkins 2022a, 2022b). Athletes often prefer natural turfgrass over synthetic turf because of its aesthetic and textural qualities. Natural turfgrass is perceived as safer and softer, thus providing a more comfortable experience for athletes (Stiles et al. 2009). In contrast, athletes may dislike synthetic turf because of the rigidity of the fibers, which can lead to a brighter surface and harsher perceived feel (Petrass et al. 2015). Yet, compared with natural turfgrass, synthetic turf is associated with more consistent athletic performance and a higher level of performance (Ataabadi et al. 2017). This is likely because of the consistent composition of synthetic turf compared with that of natural turfgrass, especially under certain weather conditions (Zanetti 2009). Although natural turfgrass fields are more sensitive to adverse weather conditions, synthetic turf can be used consistently under harsher weather conditions (Brocherie et al. 2015). Frequent use of natural turfgrass can lead to degradation, decreased playability, and longer recovery times, thus impacting both scheduling and usability of the field (Alabi 2023). In contrast, synthetic turf fields can endure more frequent use, which can increase playing time (Fleming et al. 2023; McLaren et al. 2012).

The challenges of managing synthetic turf fields and natural turfgrass fields have evolved over time because of climate change, players' ever-changing needs, and the development of technologies. It is imperative to identify the challenges and devise effective solutions to overcome them. The major objective of our research was to identify the specific challenges that administrators and managers encounter in their daily use, management, and maintenance of the fields and identify emerging challenges that may arise as climate, sports, and technology evolve. To achieve this goal, we conducted a survey of 97 US administrators and managers involved in the management and maintenance of community sports fields. These administrators and managers were from different organizations and represented different positions and roles. Specifically, we investigated their perspectives on the top three challenges faced when managing and maintaining natural turfgrass and synthetic turf. Additionally, we sought their input on potential solutions to address the biggest challenge. We also explored factors that may influence challenges faced by administrators and managers who manage synthetic turf fields and natural turfgrass fields, such as the number of natural turfgrass fields and synthetic turf fields, and the overall budget allocated for their management and maintenance.

Materials and Methods

Data collection. To identify the challenges and explore potential solutions to both natural turfgrass fields and synthetic turf fields in the United States, we conducted an online survey that targeted community sports fields managers and administrators in the United States during 2022–23 though Qualtrics™, a professional survey company. The survey was posted on social media (Twitter). Additionally, a flyer was published in *Sports Field Management Magazine*, and the flyer was emailed to all the Sports Field Management Association Chapter contacts on the Sports Field Management Association website. A total of 327 people responded to the survey, and 97 of them answered all the questions. Because our analysis necessitated complete questionnaire responses, we retained only those surveys with all questions answered. We acknowledge that the relatively small sample size might have limited the ability of our study to represent the nation. Therefore, we plan to recruit more participants for a more comprehensive and in-depth study and are considering strategies such as offering monetary incentives and sending follow-up reminders based on the implications reported by Avemegah et al. (2021) and Pennings et al. (2002).

The challenge of a smaller sample size has been common in other studies that focused on industry stakeholders because of factors such as the limited number of potential participants available within specific industries or sectors. Moreover, factors such as the length of the survey, reminders, and the use of monetary incentives can impact the response rate. Recently, Avemegah et al. (2021) implemented various practices and tested their effectiveness to increase response rates, including sending advance notifications and reminders and contacting participants multiple times and using multiple modes. During one of their surveys that achieved the highest response rate (30%), the sample was contacted up to four times via mail, and one-half of the selected participants were randomly chosen to receive a pre-incentive. Additionally, industry professionals often receive frequent requests from government agencies, the private sector, and academic institutions to complete surveys regarding various topics (Cycyota and Harrison 2006; Rogelberg and Stanton 2007). Therefore, their response rate is expected be low when their workload is high.

During our survey, the administrators and managers were from various organizations, including government agencies, schools, as well as other organizations such as nonprofit organizations [nongovernmental organizations (NGOs)]. They also had different titles, including administrators, managers, maintenance staff, and other roles such as athletic teachers or coaches. These varied backgrounds enriched the diversity of perspectives captured during our study. We surveyed a total of 97 administrators and managers responsible for natural turfgrass fields, synthetic turf fields, or both. We also gathered information regarding the number of natural turfgrass fields and synthetic turf fields for which they are responsible and the overall budget allocated to the natural turfgrass fields and synthetic turf fields.

To identify the challenges of natural turfgrass field and synthetic turf field management, the research team first compiled a list of challenges associated with both natural turfgrass fields and synthetic turf fields based on our knowledge and working experience with industry professionals. Additionally, we consulted with industry experts. In the survey, we asked administrators and managers to select from a list of options the top three challenges of both natural turfgrass fields and synthetic turf fields. These options included budget constraints, lack of administration support, weather/climate, use/scheduling, agronomic problems (excluded from the options for synthetic turf fields), construction problems, communications with users, and other challenges that administrators and managers could specify. Additionally, we collected their opinions regarding potential solutions that could help overcome the biggest challenges, thereby allowing for multiple selections. These options included more money for resources, more support, more information to justify needs, long recovery time/better scheduling, field reconstruction, synthetic turf (excluded from the options for synthetic turf fields), and an option for administrators and managers to specify their opinions. Additionally, the option of "no solution" was provided.

Econometric model. This study primarily focused on ranking the challenges that administrators and managers encounter when managing natural turfgrass fields and synthetic turfgrass fields. To improve the interpretability of the regression results, we redefined the values assigned to each ranking. For each participant, and for natural turfgrass and synthetic turf fields separately, the challenges were assigned values according to a scale of 1 to 4, with 4 indicating the biggest challenge, 3 indicating the second biggest challenge, and 2 indicating the third biggest challenge; all unselected options were given a value of

1, thus representing the smallest challenge they faced.

Because the dependent variable of interest was a discrete and ordinal variable, we used an ordered probit model to examine the ranking of these challenges and understand how the ranking was influenced by administrators' and managers' organization, titles, number of natural turfgrass fields and synthetic turf fields for which they are responsible, and the overall budget. Ordered probit models are frequently used to estimate models with an ordinal dependent variable (Greene and Hensher 2010). Examples of such variables are rating systems (e.g., poor, fair, good, excellent), opinion scales ranging from strongly disagree to strongly agree, rankings, grades, and others. The fundamental concept of the ordered probit model is that there is a latent variable underlying the observed ordinal outcome. This latent variable can be expressed as a linear combination of certain predictors and an error term with a standard normal distribution. Ordered probit models provide an approach to interpreting how predictors affect the latent variable.

Therefore, we estimated the following model for natural turfgrass fields and synthetic turf fields separately:

$$Y_{ic}^{*} = \beta_0 C_c + \beta_1 O_i + \beta_2 T_i + \beta_3 N_i + \beta_4 B_i + \varepsilon_{ic}$$

$$\varepsilon_{ic} \sim Normal\ (0, 1)$$

where Y_{ic}^{*} denotes the unobserved latent variable representing the true level of the reversed ranking of challenges c for participant i, C_c is a vector of challenge dummies, O_i represents the organization of the participant, T_i is a variable representing the title of the participant, N_i is the number of natural turfgrass fields and synthetic turf fields managed by participant i, B_i represents the overall budget allocated to manage the fields, and ε_{ic} is an error term that is assumed to follow a normal distribution with a mean of zero and a standard deviation of one.

The connection between the latent variable and the observed dependent variable is as follows:

$$Y_{ic} = j \ \ if \ \ \mu_{j-1} < Y_{ic}^{*} < \mu_j$$
$$j = 1,\ 2,\ 3,\ 4 \text{ and } \mu_o = 0, \mu_4 = \infty$$

where Y_{ic} is participant i's reversed ranking for challenge c, which is the observed dependent variable, j is the 4-scale ranking, and μ_j denotes threshold parameters. These thresholds divide the real line into intervals that align with different ordered categories and are estimated to match the probabilities associated with each ordered category. The probability that participant i will assign a reverse ranking of j to a specific challenge is as follows:

$$\begin{aligned}
&\Pr\left(Y_{ic} = \mathrm{j}\right) \\
&= \Pr\left(\mu_{j-1} < Y_{ic}^{*} < \mu_j\right) \\
&= \Pr\left(\mu_{j-1} < \beta_0 C_c + \beta_1 O_i + \beta_2 T_i + \beta_3\ N_i + \beta_4 B_i + \varepsilon_{ic} < \mu_j\right) \\
&= \Pr\left(\mu_{j-1} - \beta_0 C_c - \beta_1 O_i - \beta_2 T_i - \beta_3\ N_i - \beta_4 B_i < \varepsilon_{ic} < \mu_j - \beta_0 C_c - \beta_1 O_i - \beta_2 T_i - \beta_3\ N_i - \beta_4 B_i\right) \\
&= F\left(\mu_j - \beta_0 C_c - \beta_1 O_i - \beta_2 T_i - \beta_3\ N_i - \beta_4 B_i\right) - F\left(\mu_{j-1} - \beta_0 C_c - \beta_1 O_i - \beta_2 T_i - \beta_3\ N_i - \beta_4 B_i\right)
\end{aligned}$$

where F is the standard normal cumulative distribution function.

Table 1. Summary statistics of administrators and managers who participated in the national community sports field survey (N = 97). The frequency and percentage of each variable value are reported.

	Survey participants					
	Full sample		Natural turfgrass fields sample		Synthetic turf fields sample	
	No.	%	No.	%	No.	%
Organization						
1 = Government	71	73.2	69	72.63	16	76.19
2 = School	28	28.87	28	29.47	6	28.57
3 = Other	16	16.49	16	16.84	2	9.52
Title						
1 = Administrator	63	64.95	62	65.26	10	47.62
2 = Manager	17	17.53	17	17.89	5	23.81
3 = Maintainer	34	35.05	33	34.74	9	42.86
4 = Other	36	21.65	35	36.84	10	47.62
Number of natural turfgrass fields						
0 = ≤10			43	45.26		
1 = >10			52	54.74		
Number of synthetic turf fields						
0 = ≤10					19	90.48
1 = >10					2	9.52
Overall budget for managing sports fields						
1 = <$200,000	40	49.48	46	48.42	9	42.86
2 = $200,000–$599,999	30	30.93	30	31.58	7	33.33
3 = >$600,000	19	19.59	19	20.00	5	23.81
Observations	97		95		21	

Results

Summary statistics. Table 1 presents background information of the survey participants and includes summary statistics for the full sample and sub-samples representing those who worked with natural turfgrass fields and synthetic turf fields. The reported statistics include the frequency and percentage for each variable. Our survey comprised a total of 97 managers and administrators; 95 worked with natural turfgrass fields, 21 worked with synthetic turf fields, and, notably, 19 worked with both natural turfgrass fields and synthetic turf fields.

Participants' affiliations were important background information. We categorized their affiliations into government (comprising municipal and county government), schools [including independent school districts (ISDs) and private schools], and other organizations (such as NGOs). In our sample, government was the primary affiliation of participants who worked with natural turfgrass fields and synthetic turf fields, comprising 73% and 76%, respectively. Schools represented the second most common organization of participants who worked with natural turfgrass fields and synthetic turf fields, comprising 29% and 29%. The remaining participants were associated with other organizations.

The participants' titles were another important aspect of their background. Titles included administrator (which included roles like organization president, supervisor, and superintendent) manager (including sports fields manager and parks and recreation manager), maintenance staff (including facility and ground maintenance crew), and other titles (such as athletic director, coach, grounds foreman, and retired). Participants had different titles. Among all participants, administrator was the most prevalent title, comprising 65% of the full sample. Specifically, among participants who worked with natural turfgrass fields, 65% were administrators, 35% were maintainers, 18% were managers, and the remainder had other titles. In contrast, among participants who worked with synthetic turf fields, 48% were administrators, 43% were maintainers, 24% were managers, and 48% had other titles.

Regarding the number of turfgrass fields, more than half of the participants who worked with natural fields worked with more than 10 natural turfgrass fields (55%), whereas the majority (90%) of those who worked with synthetic

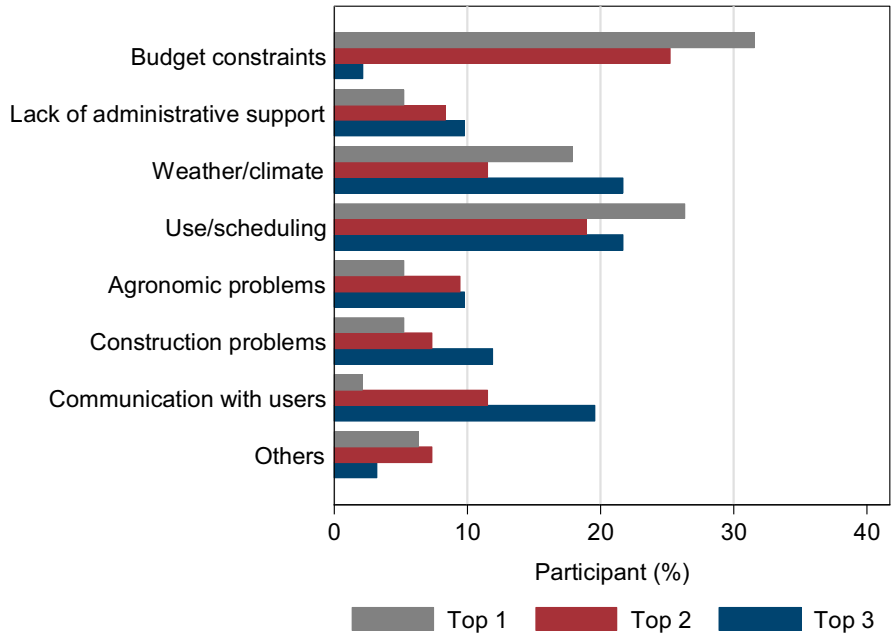

Fig. 1. Top 3 challenges faced by administrators and managers who manage natural turfgrass fields and participated in the national community sports field survey (N = 95). Other challenges were mainly related to the lack of labor.

turf fields worked with ≤10 synthetic turf fields. Moreover, in terms of the overall budget for managing turfgrass fields, the majority were in the "less than $200,000" category, accounting for 48% of the natural turfgrass field and 43% of the synthetic turf field sub-samples. Approximately 32% to 33% had budgets in the range of $200,000 to $599,999, and approximately 20% to 24% had budgets exceeding $600,000.

Challenges of working with community sports fields. Figures 1 and 2 display the percentages of the top three challenges faced by participants in the community sports field survey who worked with natural turfgrass fields and synthetic turf fields. For participants who worked with natural turfgrass fields, the primary challenges included budget constraints, with 32% ranking it as the biggest challenge and 25% ranking it as the second biggest challenge. Use/scheduling was also a common challenge; it was identified as the top challenge by 26% of the participants, the second biggest challenge by 19%, and the third biggest challenge by 22%. Weather/climate was another prevalent challenge, with 18% ranking it the biggest challenge, 12% ranking it as the second biggest challenge, and 22% ranking it as the third biggest challenge.

Other challenges were ranked lower compared with those mentioned by participants who worked with natural turfgrass fields. Communication with users was chosen as the second biggest challenge by 12% and as the third biggest challenge by 20%. Agronomic problems, which comprised challenges specific to natural turfgrass fields, were ranked as the top challenge by 5%, the second biggest challenge by 9%, and the third biggest challenge by 10%. Lack of administrative support was ranked by 5% as the top challenge, by 8% as the second biggest challenge, and by 10% as the third biggest. Construction problems were considered the top challenge by 5%, the second biggest challenge by 7%, and the third biggest challenge by 12%. Other challenges, mainly those related to the lack of labor, were also mentioned by participants.

Budget constraints were also identified as a challenge for participants who worked with synthetic turf fields; 19% and 35% ranked budget constraints as the biggest challenge and the third biggest challenge, respectively. Moreover, use/scheduling was identified by 29% as the biggest challenge for synthetic turf fields, by 15% as the second biggest challenge, and by 24% as the third biggest challenge. The other challenges mainly involved safety issues and were identified by 14% of participants as the top challenge, by 35% as the second biggest challenge, and by 12% as the third biggest challenge. Lack of administrative support was mentioned by 25% as the second biggest challenge. Additionally, construction problems were noteworthy; 24% and 12% ranked construction problems as the biggest challenge and the third biggest challenge, respectively. Communication with users was identified by 10% as the biggest challenge and by 10% as the second biggest challenge. Weather/climate was ranked lower compared with all other challenges.

Ordered probit model results. Table 2 presents the results of the order probit regressions that examined the ranking of challenges encountered by participants during their daily management of natural turfgrass fields and synthetic turf fields. The analysis also examined variations in challenge rankings based on participants' organizations, titles, number of fields, and overall budget. Interaction terms between influential factors and challenge dummies were introduced to allow for a more comprehensive examination. Overall, the results in Table 2 aligned well with the patterns observed in Fig. 1. For participants who managed natural turfgrass fields, the biggest challenge was budget constraints, followed by use/scheduling and weather/climate. However, for participants who managed synthetic turf fields, all challenges were not significantly different from safety issues (included in the "other challenges" category).

Regarding the number of fields, the results suggest that compared with managing ≤10 fields, managing more than 10 natural turfgrass fields is associated with a higher likelihood of facing greater challenges. Moreover,

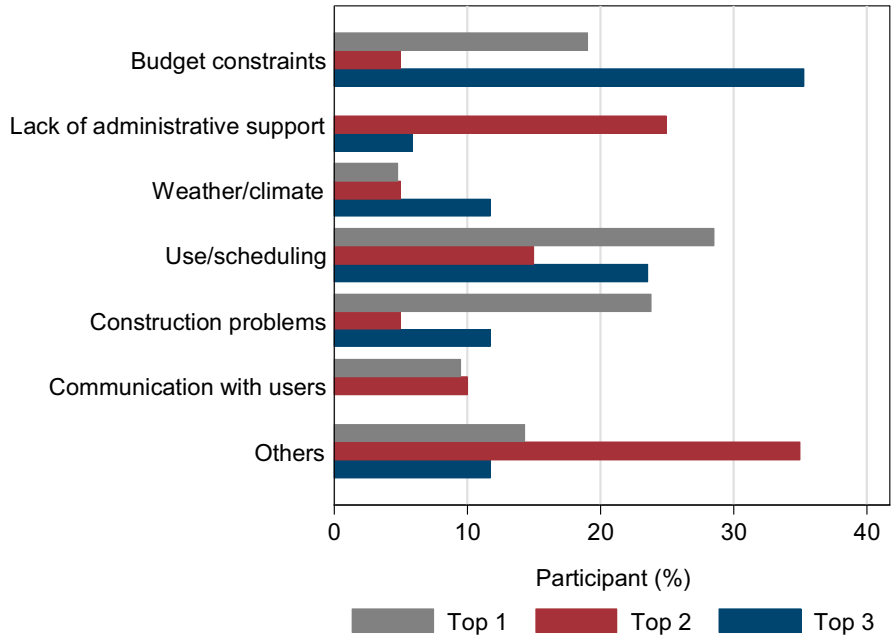

Fig. 2. Top 3 challenges faced by administrators and managers who manage synthetic turf fields and participated in the national community sports field survey (N = 21). Other challenges mainly involved safety issues.

Table 2. Ordered probit model results of ranking challenges associated with natural turfgrass and synthetic turf fields that are encountered by administrators and managers who participated in the national community sports field survey (N = 97).

Dependent variable: rank of the challenge (values 1–4)	Natural turfgrass fields	Synthetic turf fields
	Coefficient (*SE*)	
Challenges (base group: other challenges)		
Budget constraints	2.63***[i]	0.77
	(0.67)	(0.77)
Lack of administrative support	1.04	0.12
	(0.71)	(0.77)
Weather/climate	1.43**	−1.41
	(0.67)	(0.97)
Use/scheduling	2.00***	0.04
	(0.66)	(0.76)
Agronomic problems	1.12	
	(0.70)	
Construction problems	0.85	−0.62
	(0.72)	(0.79)
Communication with users	1.08	−1.33
	(0.70)	(1.02)
Number of turfgrass fields (base group: ≤10)		
More than 10 natural turfgrass/synthetic turf fields (dummy)	0.88**	0.43
	(0.42)	(0.60)
Budget constraints × more than 10 natural turfgrass fields	−0.55	
	(0.51)	
Lack of administrative support × more than 10 natural turfgrass fields	−0.66	
	(0.54)	
Weather/climate × more than 10 natural turfgrass fields	−1.58***	
	(0.51)	
Use/scheduling × more than 10 natural turfgrass fields	−0.83	
	(0.50)	
Agronomic problems × more than 10 natural turfgrass fields	−1.30**	
	(0.54)	
Construction problems × more than 10 natural turfgrass fields	−0.34	
	(0.54)	
Communication with users × more than 10 natural turfgrass fields	−1.10**	
	(0.54)	
Overall budget for managing sports fields (base group: <$200,000)		
$200,000–$599,999	0.31	0.91
	(0.43)	(0.74)
More than $600,000	0.65	−0.84
	(0.45)	(0.88)
Budget constraints × $200,000–$599,999	−1.04**	−1.34
	(0.52)	(0.98)
Budget constraints × more than $600,000	−1.82***	−0.44
	(0.58)	(1.15)
Lack of administrative support × $200,000–$599,999	−0.19	−1.55*
	(0.56)	(0.86)
Lack of administrative support × more than $600,000	−0.32	0.63
	(0.60)	(1.10)
Weather/climate × $200,000–$599,999	−0.45	0.76
	(0.53)	(1.25)
Weather/climate × more than $600,000	−0.62	0.40
	(0.58)	(0.92)
Use/scheduling × $200,000–$599,999	0.00	−2.60**
	(0.52)	(1.04)
Use/scheduling × more than $600,000	−0.85	−0.73
	(0.57)	(1.10)
Agronomic problems × $200,000–$599,999	−0.16	
	(0.55)	
Agronomic problems × more than $600,000	−0.20	
	(0.61)	
Construction problems × $200,000–$599,999	−0.18	0.09
	(0.55)	(1.01)
Construction problems × more than $600,000	−0.48	1.50
	(0.60)	(1.10)
Communication with users × $200,000–$599,999	0.23	−0.37
	(0.54)	(1.12)
Communication with users × more than $600,000	−0.17	2.74**
	(0.60)	(1.24)

(Continued on next page)

in comparison with managing ≤10 natural turfgrass fields and facing "other challenges," managing more than 10 natural turfgrass fields was likely to be associated with a lower probability of encountering greater challenges related to weather/climate, agronomic problems, and communication with users. In contrast, the number of synthetic turf fields had no influence on the ranking of challenges.

In terms of the influence of overall budget on the ranking of challenges, we found that, intuitively, having an overall higher budget for natural turfgrass field management (not less than $200,000) likely resulted in facing fewer challenges related to budget constraints compared with having an overall lower budget (less than $200,000). Similarly, for synthetic turf field management, an overall budget in the range of $200,000 to $599,999 was unlikely to be associated with challenges such as lack of administrative support and use/scheduling issues.

Regarding participants' organizations, we found that participants experienced with natural turfgrass fields who were employed by the government were less likely to encounter challenges than participants employed by all other organizations. However, they were more likely to encounter challenges related to budget constraints, weather/climate, agronomic problems, and communication with users than participants employed by other organizations categorized under "other," including private and nonprofit organizations (NGOs).

The role of the participants' was a prominent factor that influenced the rankings of challenges. Natural turfgrass field administrators were less likely to face challenges related to communication with users than maintainers and those with other titles, whereas synthetic turf field administrators had a higher likelihood of encountering use/scheduling challenges during daily management compared with participants with other titles. In contrast, managers of natural turfgrass fields were less likely to encounter challenges related to use/scheduling and communication with users, whereas managers of synthetic turf fields were less likely to encounter challenges in general compared with participants with other titles; however, they had a higher probability of encountering challenges related to budget constraints and communication with users. On the contrary, maintenance staff members who worked with synthetic turf fields were more likely to encounter challenges in general compared with participants with other titles; however, they had lower probabilities of encountering challenges related to budget constraints, lack of administrative support, and communication with users.

Potential solutions to address challenges suggested by participants. Figures 3 and 4 show participants' opinions regarding potential solutions to overcome the biggest challenges associated with natural turfgrass and synthetic turf presented by the community sports field survey. For participants who managed natural turfgrass fields, the survey results showed that, on average, ∼55% believed that

Table 2. (*Continued*)

Dependent variable: rank of the challenge (values 1–4)	Natural turfgrass fields	Synthetic turf fields
	Coefficient (*SE*)	
Organization (base group: schools and other organizations)		
Government (dummy)	−0.72*	
	(0.38)	
Budget constraints × government	0.82*	
	(0.48)	
Lack of administrative support × government	0.76	
	(0.51)	
Weather/climate × government	0.99**	
	(0.47)	
Use/scheduling × government	0.50	
	(0.47)	
Agronomic problems × government	0.83*	
	(0.50)	
Construction problems × government	0.27	
	(0.51)	
Communication with users × government	1.22**	
	(0.52)	
Title (base group: other titles)		
Administrator (dummy)	0.45	−1.20
	(0.49)	(0.81)
Budget constraints × administrator	−0.94	1.06
	(0.58)	(1.07)
Lack of administrative support × administrator	−0.96	1.34
	(0.60)	(1.11)
Weather/climate × administrator	0.20	0.18
	(0.59)	(1.35)
Use/scheduling × administrator	−0.14	2.73**
	(0.57)	(1.11)
Agronomic problems × administrator	−0.62	
	(0.61)	
Construction problems × administrator	−0.37	0.99
	(0.61)	(1.07)
Communication with users × administrator	−1.05*	1.57
	(0.59)	(1.20)
Manager (dummy)	0.75	−1.56*
	(0.58)	(0.94)
Budget constraints × manager	−0.94	1.93*
	(0.70)	(1.04)
Lack of administrative support × manager	−0.71	1.32
	(0.73)	(1.31)
Weather/climate × manager	−0.40	1.50
	(0.70)	(1.42)
Use/scheduling × manager	−1.21*	1.90
	(0.70)	(1.23)
Agronomic problems × manager	−0.62	
	(0.73)	
Construction problems × manager	−0.55	1.39
	(0.74)	(1.23)
Communication with users × manager	−1.24*	2.84*
	(0.73)	(1.55)
Maintainer (dummy)		1.88**
		(0.73)
Budget constraints × maintainer		−2.72***
		(0.78)
Lack of administrative support × maintainer		−2.78**
		(1.09)
Weather/climate × maintainer		−1.13
		(1.08)
Use/scheduling × maintainer		−1.00
	(0.43)	(0.93)
Agronomic problems × maintainer	−0.63	
	(0.48)	
Construction problems × maintainer	0.04	−1.55
	(0.46)	(0.95)
Communication with users × maintainer	−0.07	−3.66***
	(0.45)	(1.27)
Observations	760	147

[1] *, **, ***Significance at 10%, 5%, and 1%, respectively.

having more money for resources and implementing field reconstruction could help address the biggest challenge of managing natural turfgrass fields. Moreover, allocating longer recovery time or having better scheduling was indicated by 42% of participants as a potential solution. Fewer participants considered the remaining options, such as receiving more support (25%), adopting synthetic turf (18%), providing more information to justify needs (16%), and other solutions such as having more fields (3%), as potential solutions. Approximately 2% of participants indicated that they perceived no viable solution to address the identified challenge.

The potential solutions differed among participants who managed synthetic turf fields. Survey results revealed that the majority (43%) identified having more money for resources as a potential solution, followed by having better scheduling (23%) and having more support (23%). Moreover, 19% of participants considered having more information to justify needs and implementing field reconstruction could help address the challenges. Approximately 19% expressed that there was no viable solution to address the identified challenge; this rate was much higher than that for natural turfgrass. Additionally, 9% suggested other solutions, specifically, expanding and adding more synthetic turf to prevent rapid wear on existing fields.

Discussion and Conclusion

Because challenges posed by natural turfgrass fields and synthetic turf fields continue to evolve, understanding the challenges faced by administrators and managers has become increasingly important to ensuring effective management and maintenance. This study investigated the challenges encountered by administrators and managers responsible for natural turfgrass and synthetic turf on community sports fields and the potential ways to address the primary challenges. This study also offers insights regarding how factors such as administrators and managers' organizations, titles, number of fields managed, and budget allocations influence these challenges.

While examining data collected from our survey of 97 administrators and managers in the United States, we consistently found that budget constraints were a prominent challenge for those who worked with natural turfgrass fields and synthetic turf fields. Specifically, natural turfgrass field administrators and managers identified budget constraints as the primary challenge, followed by challenges related to use/scheduling and weather/climate. In contrast, budget constraints, use/scheduling, and other issues (primarily safety concerns) were more substantial challenges for administrators and managers of synthetic turf fields.

The challenges of managing natural turfgrass fields and synthetic turf fields can be attributed to various factors related to their distinct characteristics and maintenance requirements. Challenges of natural turfgrass field management are largely associated with the costs and efforts required for maintenance and

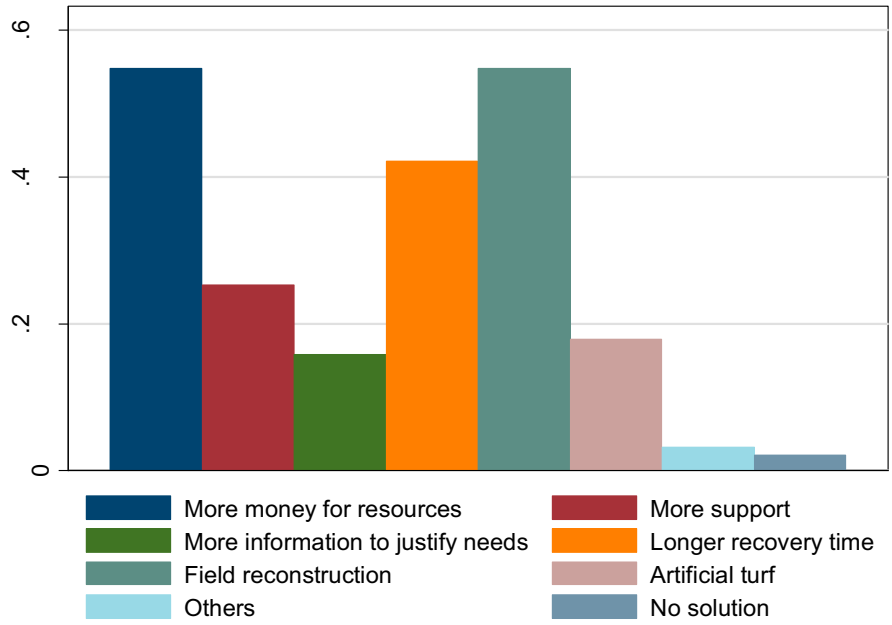

Fig. 3. Opinions of administrators and managers regarding potential solutions that could overcome the biggest challenges associated with natural turfgrass fields (N = 95). Other solutions included avoiding pest/animal destruction and having more fields.

recovery, which are exacerbated by weather sensitivity. Natural turfgrass fields require ongoing maintenance, including irrigation, fertilization, mowing, and pest control, and these activities incur significant costs, thus contributing to challenges associated with budget constraints for administrators and managers. However, synthetic turf fields are associated with challenges related to upfront installation costs, maintenance requirements, and safety concerns. Therefore, replacing natural turf with synthetic turf may not eliminate the primary cost concerns that managers of sports fields encounter. Another direct cost comparison between the two grass types is necessary, and it is essential to introduce other strategies to lower the costs and solve scheduling issues.

To address natural turfgrass field challenges, water conservation practices can be adopted to reduce irrigation costs, including the adoption of smart irrigation systems, scheduling watering times during optimal intervals, and increasing the use of drought-tolerant grass cultivars, such as hard fescue (*Festuca brevipila* Tracey) and colonial bentgrass (*Agrostis capillaris* L.), which have been shown to perform well with reduced water input (Braun et al. 2020; Hugie and Watkins 2016; Watkins et al. 2011). The development of efficient fertilization programs can help determine nutrient needs, thus reducing excess fertilization and associated costs. Optimizing mowing practices is helpful to balancing turf health and cost-effectiveness. For natural fields, adjusting mowing frequencies based on seasonal growth patterns and field usage to minimize wear and tear while reducing maintenance costs can be considered. Adopting integrated pest management can help minimize the need for chemical pest control, thus reducing the overall pest control costs. By combining these strategies, administrators and managers can work toward maintaining high-quality natural turfgrass fields while managing costs more effectively.

Moreover, the frequent use of sports fields, especially in high-traffic areas or during adverse weather conditions, can cause wear and tear, resulting in challenges associated with scheduling events and additional efforts required for maintenance and recovery. Natural turfgrass is also sensitive to weather conditions, such as extreme temperatures, heavy rain, and drought, which may lead to extended recovery times (Braun et al. 2020; Straw et al. 2020). To address these challenges, natural fields can implement a rotation schedule for high-traffic areas to allow for recovery (Kenney Machinery Crop 2024; Troderman 2024). For example, during periods of intense use, alternative fields or sections can be designated for use, thus allowing the primary areas time to recuperate. The natural fields can adopt field monitoring systems to track the usage patterns and control access during adverse weather conditions or when fields are in a vulnerable state to minimize wear and tear. Developing weather-responsive maintenance plans based on weather forecasts and adjusting maintenance activities based on upcoming weather events can help reduce the impact of weather on field conditions.

For synthetic turf fields, the initial investment can pose a significant challenge, especially for facilities with budget constraints. Although synthetic turf eliminates the need for inputs such as fertilizer and herbicides that are required for natural turfgrasses, which can lower labor and material costs (TURI 2016), artificial surfaces still require regular maintenance, which includes the use of specialized equipment and labor (Fleming et al. 2020). During the long term, the cost of replacement would also be significant. Without a direct comparison of the lifetime costs of natural and synthetic turf, drawing conclusions regarding the long-term costs would be challenging. Therefore, more comprehensive studies of the long-term maintenance costs for both grass types are necessary.

Moreover, although synthetic turf can withstand adverse weather and more frequent use without the need for recovery periods between events because of its durability, scheduling concerns may still arise because of the need for regular maintenance, infill replacement, and occasional full-field replacement, thus disrupting

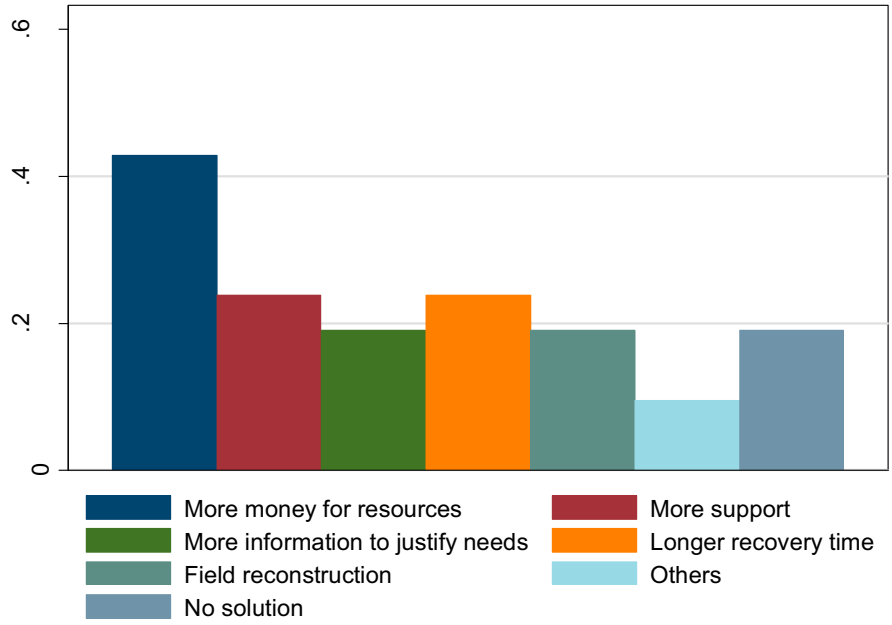

Fig. 4. Opinions of administrators and managers regarding potential solutions that could overcome the biggest challenges associated with synthetic turf fields (N = 21). Other solutions included expanding and adding more synthetic turf to prevent rapid wear on existing fields.

regular field use (Fleming et al. 2023). These requirements involve the use of specialized equipment as well as labor, thus adding to the challenge of budget constraints. To address these challenges, maintenance activities for synthetic fields can be planned during off-seasons or periods of less frequent field use, and a rotation schedule for infill replacement that is focused on specific areas rather than the entire field at one time can be implemented. These approaches allow for continuous use of parts of the field while maintenance is performed on other sections, thus minimizing the disruption of field use. Collaborating with neighboring facilities to share specialized equipment or rental equipment can help reduce the costs as well. Establishing volunteer programs within the community can help alleviate the need for additional paid labor and foster community engagement.

Additionally, although synthetic turf has been adopted as a replacement for natural turfgrasses on sports fields, the major concerns stem from safety issues related to the increased risk of injuries and exposure to chemicals (Cheng et al. 2014; Jim 2017; Liu and Jim 2021). Studies have indicated that, compared with natural grass fields, synthetic turf fields can lead to higher rates of certain injuries, such as turf burn, muscle strains, ligament sprains, and concussions (Olive 2023). These injuries are often attributed to the harder surface of synthetic turf and reduced shock absorption on turf (Brooks and Francis 2019; Cheng et al. 2014; Dragoo and Braun 2010). Exploring synthetic turf systems that incorporate cooling technologies can help mitigate elevated temperatures. Some advanced turf products are designed with cooling features, such as reflective materials or cooling infills. Installing shade structures or trees around the synthetic turf area to provide shade during hot weather can help reduce the risk of elevated temperatures on the playing surface. Additionally, there are concerns about potential exposure to harmful substances found in synthetic turf, particularly those comprising the infill material (Brooks and Francis 2019; Cheng et al. 2014; Dragoo and Braun 2010; Lerner 2019). Long-term health effects of these substances, especially for athletes who regularly use synthetic turf fields, are significant concerns. Although synthetic turf offers advantages such as durability and all-weather usability, addressing these safety concerns is crucial to ensuring the health and well-being of users.

This study further delved into the influence of various factors on the challenges faced by administrators and managers. For example, the number of fields, budgets, organizations, and titles all play pivotal roles in determining the nature and intensity of challenges faced by administrators and managers. Managing a large number of natural turfgrass fields was found to increase the likelihood of encountering challenges, especially those related to weather/climate, agronomic problems, and communication with users. Managing a larger number of natural turfgrass fields introduces more complexity. This complexity is likely attributable to the diverse set of challenges posed by weather and climate variations, agronomic issues, and the need for effective communication with users across multiple locations. Strategically allocating resources based on the criticality and frequency of use of each natural turfgrass field and establishing a centralized communication platform to streamline interactions with users can potentially help address such challenges.

Because budgets for the management of turfgrass fields play a crucial role, relatively higher budgets were associated with fewer challenges related to budget constraints, thus indicating that higher budgets enable administrators and managers to more easily overcome financial challenges. Similarly, higher budgets appeared to mitigate challenges associated with lack of administrative support and scheduling for synthetic turf field management. To address budget challenges, administrators and managers of sports fields can actively seek funding from various sources, including government agencies and private foundations, to supplement the budget. Additionally, organizing community-based fundraising campaigns can help generate additional funds for turfgrass field management. Exploring partnerships with local businesses, sports organizations, and community groups through public–private partnerships can potentially alleviate the difficulties associated with budget constraints.

In summary, our findings offer valuable insights regarding the ongoing challenges associated with turfgrass field management, thus providing a foundation for developing targeted strategies to address these challenges. Each type of field comes with specific trade-offs, thus necessitating careful consideration by field managers based on their unique needs and constraints. Further research should explore specific solutions and interventions to address the needs of management and maintenance and enhance the overall quality and sustainability of community sports fields. Additionally, studies should explore approaches to improving the performance of both natural and synthetic turf fields, explore approaches to overcome budget constraints, investigate the impact of technological developments on turfgrass field management, and consider the influence of climate and geographic location on natural and synthetic turf fields.

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