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'Greenness' in the Eye of the Beholder: Comparing Perceptions of Sustainability and Well-being Between Artificial and Natural Turfgrass

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Turfgrass lawns are a central component in urban green space and provide a variety of ecosystem services. Traditionally, natural turfgrass lawns can have substantial input requirements (e.g., water, herbicides), which if not managed properly can have harmful ecological effects. A proposed solution that has already been adopted in many cities are artificial turfgrass lawns which do not require some of the traditional inputs of natural lawns. However, understanding perceptions of the sustainability and well-being benefits between these two surfaces are unknown. We surveyed adults in the United States in order to understand perceptions of sustainability and well-being between artificial and natural turfgrass lawns. The survey utilized a pre-post design which presented participants with photos and information about each surface type with questions related to sustainability and well-being before and after the information was presented. Overall, participants perceived natural turfgrass lawns as more sustainable and better for human health and well-being than artificial turfgrass lawns. More work needs to be done to understand the specific reasons behind such perceptions and if perceptions change when in direct contact with the two lawn surfaces.

Keywords

artificial turfgrass, natural turfgrass, green space, sustainability, well-being

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INTRODUCTION

Globally, cities face pressure to balance the demands of increasing numbers of urban residents with a need to provide ecologically sustainable forms of urban green spaces (Tuyen and Xuan 2020; Gavrilidis et al. 2019; Aronson et al. 2017). Numerous studies have documented a wide range of cultural ecosystem services related to physical and mental health benefits that urban green spaces can provide to nearby residents while simultaneously providing critical additional ecosystem services (Hunter et al. 2019; Chang et al. 2017; van den Bosch and Ode Sang 2017; van den Berg et al. 2015). One form of urban green space, and in most cities the dominant form, turfgrass lawns provide a variety of ecosystem services (Monterio 2017). However, lawns have become increasingly scrutinized by residents and decision makers alike due to questions regarding the quantity of inputs (e.g., labor, water, fertilizer) needed to maintain such landscapes and the subsequent environmental impacts (Barnes et al. 2020a; Ignatieva et al. 2020; Monterio 2017; Wheeler et al. 2017). To balance the need for turf-like landscapes with environmental sustainability goals, some cities have turned to artificial turfgrass in public green spaces. While artificial turf can serve similar use functions as natural turf, little information exists whether the actual users of these public spaces perceive these two surfaces to be comparable to one another in terms of sustainability characteristics and elements of human well-being.

Urban green spaces across the globe are dominated primarily by natural turfgrass lawns that form a foundation for other types of vegetation (Wheeler et al. 2017). Grasses that are low growing, form a dense ground cover, and can tolerate traffic and mowing can be considered turfgrasses. Common species of natural turfgrasses include bermudagrass (*Cynodon dactylon* L.) and zoysiagrass (*Zoysia* spp.), most often found in warmer climates, and Kentucky bluegrass (*Poa pratensis* L.), tall fescue [*Schedonorus arundinaceus* (Schreb.) Dumort.], and fine leaf fescues (*Festuca* spp.), typically found in cooler climates (Christians et al. 2017).

The prominence of lawns as the foundation for urban vegetation was broadly adopted in the 20th century has continued due to a combination of both codified (i.e., ordinances) and non-codified practices (i.e., norms) alongside individual preferences (Jenkins 1994; Harris et al. 2013; Sisser et al. 2016). Preferences related to yards broadly, that include lawns, are driven by a multitude of factors including sociodemographic, psychological, and sociological factors. For example, gender, age, and household income have been associated with preferences for specific plant choices and broader yardscape styles (Cavender-Bares et al. 2020; Cubino et al. 2020; Kurz and Baudains 2012; van den Berg and van Winsum-Westra 2010). Psychologically, environmental attitudes are predictive of specific behaviors that might take place in a yard or lawn (e.g., fertilizing, watering) and can promote pro-environmental behaviors such was water conservation (Morera et al. 2019; Straus et al. 2016). Sociologically, norms situate individual behaviors and preferences in a broader social context and can predict specific behaviors (e.g., herbicide and fertilizer applications) alongside working to preserve the status quo of the lawn dominated yard (Fielding et al. 2016; Larson et al. 2009; Martini et al. 2015; Nassauer et al. 2009; Robbins 2007). Preferences related to turfgrass have been less widely studied, but findings have broadly mirrored those from broader yardscape studies. Specifically, eco-conscious individuals are generally willing to pay more for environmentally friendly attributes related to turfgrass (e.g., lower fertilizer and water requirements) (Yue et al. 2021). Interestingly an overlap exists between eco-conscious and time conscious individuals whereby both groups would prefer lower maintenance requirements for turfgrass lawns (Barnes et al. 2020a; Hugie et al. 2012; Ghimire et al. 2019) meaning lawns that require less mowing among other behaviors. Aesthetics are a key part of turfgrass preferences and usually center around color, texture, density, and weed presence, with individuals preferring dark, soft, dense and weed-free stands of turfgrass (Hugie et al. 2012; Yue et al. 2021).

Natural turfgrass provides ecological and social benefits when managed properly. Ecologically, natural turfgrasses are associated with a variety of critical ecosystem services. Healthy stands of natural turf, while sometimes less effective than other forms of vegetation, are a component of urban green infrastructure to manage stormwater via filtration, runoff mitigation, and erosion prevention (Elderbrock et al. 2020; Monterio 2017; Stier et al. 2013). Natural turfgrass is also an important component of vegetation mixtures to combat urban heat (Beard and Green 1994; Wu et al. 2007), which is critical given more frequent and intense urban heat events and their associated impacts (Heaviside et al. 2017). Additionally, properly managed turfgrass, especially low-input varieties, can be successful in sequestering carbon (Hamido et al. 2016; Zirkle et al. 2011). Natural turfgrass, as a component of broader urban greenspaces, can promote human health and well-being for urban residents (Pritchard et al. 2019; Nordh et al. 2009; van den Bosch and Ode Sang 2017). Specifically, whether public or private, natural turfgrass areas afford users a space to rest, relax, and recreate. Activities can be wide ranging, from picnicking to engaging in recreational sports like frisbee (Barnes and Watkins 2022). Additionally, natural turfgrass areas are places where people can gather and socialize with one another whether with friends, family, or neighbors (Barnes et al. 2020b). Individuals can also enjoy viewing turfgrass spaces for their beauty, especially when such spaces match individual aesthetic expectations (Barnes et al. 2020b; Ramer et al. 2019). Finally, urban residents simply like and want natural turfgrass lawns to be a part of their city's ecological landscape (Ignatieva et al. 2017, 2020) and in some cases even desire an increased amount of natural turfgrass lawns (Wheeler et al. 2020).

Although natural turfgrass has numerous benefits, the management of such spaces faces several environmental challenges when compared with other forms of vegetation. The most significant challenges faced by cities relate to the traditionally high inputs needed to maintain natural turfgrass areas in the form of water, fertilizer, herbicides, and the associated labor which is recognized by land managers, citizens, and decision makers (Barnes et al. 2020a; Reynolds et al. 2018). These input issues manifest themselves as distinct ecosystem service challenges that can hinder municipal environmental sustainability efforts. High input levels not only have direct effects on resource usage (e.g., water supplies) but also have secondary environmental effects such as runoff issues with improper application of herbicides and fertilizers (Barton and Colmer 2006; Carey et al. 2012; Hobbie et al. 2017), and higher CO_2 emissions due to increased maintenance frequencies (Kowalewski et al. 2014; Law et al. 2016). Intensively managed lawns, using significant amounts of herbicides and pesticides, can frequently be monocultures (Bertoncini et al. 2012; Wheeler et al. 2017), reducing floral and faunal biodiversity. Lawns can be problematic compared to alternatives (e.g., xeriscapes, urban forests) especially those with native plants which are less input intensive, can sequester more carbon, and can support increased biodiversity (Smetana and Crittenden 2014; Smith et al. 2015; Wang et al. 2016). In addition to ecological drawbacks, the often-high maintenance requirements impact municipal budgets and the labor required to maintain such spaces (Barnes et al. 2020a). A challenge of natural turfgrass management is that when such spaces are not managed properly, they can be rendered unusable or unsafe by weather events (Silva et al. 2017; Straw et al. 2020). For example, a natural turfgrass sports field with improper drainage can become waterlogged and require significant time to drain before being suitable for use, and if used to soon can be damaged requiring additional maintenance to repair the surface before future use (Murphy and Ebdon 2013).

With such concerns over the environmental aspects of natural turfgrass areas, cities and even some homeowners have turned to artificial turfgrass. The term 'artificial turf' encompasses man-made surfaces that are designed to "mimic the appearance and sports performance...of natural grass," while requiring little of the usual maintenance inputs of natural turfgrass (Cheng et al. 2014). Artificial turfgrass surfaces have undergone significant changes since their inception in the late 1960s, with fourth-generation artificial turf systems being the most recent iteration (Fleming 2011). An estimated 6,083 acres of artificial turf surfaces have been installed including sports fields and other applications in North America (Synthetic Turf Council 2021) and installations are expected to grow significantly with a projected 33% of total growth occurring in North America (Technavio 2021). Compared to natural turfgrass, artificial turf has several benefits. First and foremost, inputs normally required for natural turf, such as fertilizer and herbicides, are not necessary for artificial turf (Cheng et al. 2014). Lowering these inputs can reduce labor and material costs, which public land managers and associated municipalities often find desirable (Barnes et al. 2020a); it should be noted, however, that artificial surfaces still require regular maintenance, using specialized equipment as well as the required labor (Fleming et al. 2020). An additional benefit is that artificial turf surfaces can be used more frequently without the need for recovery periods between events due to their durability, which can make them more cost-effective for high-use areas such as sports fields (Serensits et al. 2013). Finally, the playing surface of the artificial turf grass itself can be more consistent especially in inclement weather, avoiding issues like pooling that can affect natural turf surfaces especially those with improper drainage (Fleming 2011; Serensits et al. 2013; Taylor et al. 2012).

However, despite such benefits, artificial turf surfaces have drawn criticism for costs, impacts on human comfort and health as well as environmental impacts. To begin, life cycle costs for installing, maintaining, and disposing of artificial turfgrass surfaces can be significant. This includes the manufacture, transportation, installation, maintenance, and disposal of artificial turf. This includes the upfront cost of the synthetic surface and infill itself, along with the required sub-surface and grading for proper drainage, stability, and for a level surface, such costs can be between 2-4 times higher than a natural turfgrass field installation (Cheng et al. 2014; Sports Turf Managers Association 2006). In addition, the installation of artificial turf surfaces and required sub-surfaces removes not only current living vegetation but potentially important topsoil (Cheng et al. 2014). In relation to human health and comfort, artificial turf has a significant impact on localized temperatures, with both surface and ambient air temperatures being higher on average by 20^{o}C and 4^{o}C respectively, compared to natural turfgrass (Jim 2017; Twomey et al. 2016; Yaghoobian et al. 2010). Increased surface and ambient temperatures associated with artificial turf can impact human comfort and athletic performance along with exacerbating existing urban heat issues (Jim 2017; Liu and Jim 2021). Environmental impacts are related to the leaching of heavy metals from aged crumb rubber infill material into aquatic and terrestrial ecosystems (Bocca et al. 2009; Halsband et al. 2020; Pochron et al. 2018; Xu et al. 2019). Preliminary research has also suggested the presence of other chemicals and volatile organic compounds (VOCs) which could be related to acute and chronic health issues in those who use artificial turf surfaces (Massey et al. 2020; Menichini et al. 2011). Yet, a significant amount of research is still needed to understand in detail the risks associated with artificial turf for both people and the environment especially now that these surfaces are being used by millions of people worldwide (Cheng et al. 2014; Watterson 2017).

While previous research has demonstrated how individuals generally feel about use differences between artificial and natural turfgrass (Barnes and Watkins 2022), to date no work has been done to understand how individuals perceive sustainability and well-being aspects of artificial turfgrass despite a significant need for it (Francis 2018). Additionally, few studies have gone beyond the niche population of athletes to understand what the public feels about artificial turfgrass (Barnes and Watkins 2022; Brooks and Francis 2019; Francis 2018). The current research attempts to fill this gap in the previous literature by understanding how the general population in the United States feels about the sustainability and well-being aspects of artificial turfgrass compared to natural turfgrass in public green spaces, given the estimated growth in artificial turf installations for sports and other uses in North America. Specifically, we asked two main questions via an online survey. First, how do individuals perceive the sustainability and well-being of artificial and natural turfgrass lawns? Second, does presenting information to individuals about each type of turfgrass change perceptions of sustainability and well-being? We generally expected natural and artificial turfgrass to be perceived as similar in the pre-information context due to the public's general perceptions around the high input uses of natural turfgrass surfaces coupled with the limited information available for artificial turf; in contrast we expect significant differences between the two surfaces to exist in the post-information context.

METHODS

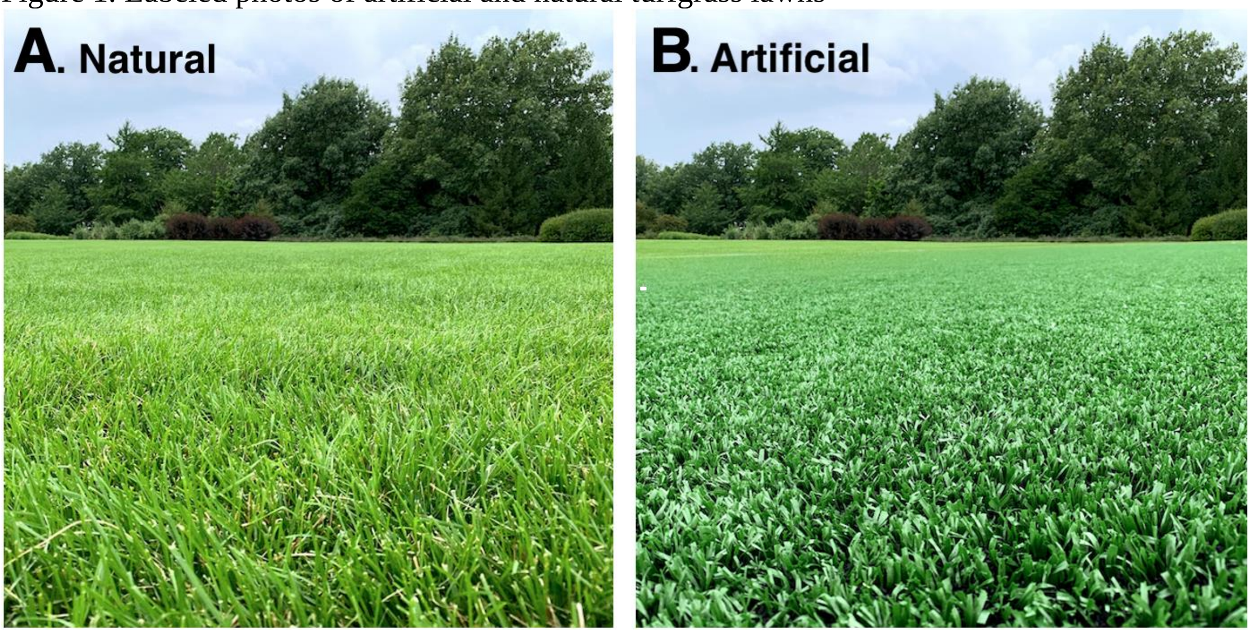
Participants & Procedures

An online survey was designed on the Qualtrics™ platform and distributed via Amazon Mechanical Turk (MTurk) to gather responses in September of 2020. MTurk has been found to provide equal data quality and are often more attentive participants compared to in-person samples (Hauser and Schwarz 2016; Paolacci et al. 2010). Individuals were compensated $0.50 for completing the survey. Several inclusion criteria were used to establish the final sample. Respondents had to be 18 years of age or older, consent to participate, and be in the United States. Three data integrity measures were used in addition to the inclusion criteria described above. First, reCAPTCHA v3 (Completely Automated Public Turing Test to tell Computers and Humans Apart) from Google was utilized to assess potential bot behavior (Google Developers 2020). The reCAPTCHA v3 script compares user behavior to bots and produces a per user score ranging from 0.0 to 1.0, scores closer to 0.0 possibly indicating bot-like behavior. Survey responses with a reCAPTCHA v3 score < 0.5 were manually reviewed for response variety and completion as recommended per Google guidelines (Google Developers 2020). Second, total survey time was investigated with a predefined threshold of 2 minutes, survey responses with a completion time less than the 2-minute threshold were manually reviewed for response variety and completion. The manual check for variety included a predefined threshold of 50% or more of participants responses being the first response selected, while the check for completion used a 75% total completion threshold. Finally, an attention check was presented halfway through the survey which asked respondents to select a specific response. If respondents failed to select the specified option, they were informed that they could not complete the remainder of the survey and the reason why.

Turfgrass Lawn Photos

Two photographs were used to create the figure presented to respondents. The two photos presented broad views of both a natural turfgrass lawn and an artificial turfgrass lawn, labeled as A and B respectively (Figure 1). Original images were taken by the authors and then digitally edited by a graphic designer to have the same background as well as to be color balanced. This was to assist participants in only focusing on the lawns themselves and less on background landscapes or significant color differences between the photographs.

Figure 1. Labeled photos of artificial and natural turfgrass lawns



Survey Questions

After consenting to participate, respondents were presented with basic definitions of artificial and natural turfgrass lawns. Artificial lawns were defined as, “a non-living synthetic (man-made) surface manufactured to mimic the look and performance of natural turfgrass lawns,” (Cheng et al. 2014). Natural lawns were defined as, “low-growing species of grasses that form a dense ground cover of living plants that can be mown and can tolerate traffic,” (Christians et al. 2017). Participants then were presented with Figure 1 and asked a series of questions related to their perceptions of the sustainability of each type of lawn with the following prompt: “Considering the lawn in photo A/B only, how do you perceive it in terms of the following items.” Sustainability questions were measured on a 1-7 Likert type scale ranging from 1 being ‘Strongly disagree’ to 7 being ‘Strongly agree’ and included the following five items: ‘Made of Sustainable Materials’, ‘Environmentally Friendly’, ‘Uses Less Natural Resources’, ‘Contributes to Human Health and Well-being’, and ‘Contributes to Ecosystem Health’. Participants then were presented with an information table that described three pros and cons for both artificial and natural turfgrass lawns (Table 1). All items included in the information table were created from previous literature on each surface type (Cheng et al. 2014; Elderbrock et al. 2020; Fleming 2011; Hamido et al. 2016; Jim 2017; Serensits et al. 2013; among others). After reading the information table participants were asked the same five sustainability questions as described above to assess changes in perceptions of sustainability between lawn types. Finally, participants completed a section of sociodemographic items that included state of residence, race/ethnicity (open-response), age, gender (open-response), if they owned a pet and their type (cat, dog, other), and if they had a child(ren) and identified their age ranges (under 5, 5-11, 12-17, older than 17).

Table 1. Artificial and natural turfgrass lawn information presented to participants

Artificial Lawns	**Natural Lawns**
Pros	
Made from recycled tires and other recycled rubber products	Cooler surface temperature than the ambient air temperature*
Provides consistent playing surface despite weather conditions	Sequesters carbon in leaves and root systems
Can be used more frequently since no recovery period for turf is necessary	Provides runoff and filtration of water if properly managed
Cons	
Recycled tire infill (used on sports fields) and other materials can leach heavy metals into soil and water	Needs inputs of water, fertilizer, and herbicide to maintain high quality
Surface can be significantly hotter than the ambient air temperature	Regular maintenance activities such as mowing often require fossil fuels resulting in carbon dioxide release
Can have an increased risk for certain types of athlete injuries	Usually needs time to recover after heavy use

**can vary depending on specific conditions (e.g., full sun vs. cloud cover, and length of conditions) and the subsequent temperature measurement timing (Jim, 2017).*

Analysis

Open-ended question responses were cleaned and organized along with numerical data to categorize missing values. All descriptive statistics along with t-tests and graphs were compiled using Stata v.16. Paired sample t-tests were conducted to assess significant differences between participants pre-test and post-test scores on sustainability items. Items related to sustainability were also averaged to create an index and overall differences were tested in the same way as described above for individual items. All t-tests used α = .01 and the Bonferroni correction for multiple comparisons. Significant t-tests include effect sizes calculated using Cohen's *d* values. Interpretation of such values follows general guidelines where: 0.15 as small, 0.25 as medium, and 0.35 as large (Gignac and Szodorai 2016).

RESULTS

After inclusion and integrity checks, 931 responses were included in the final sample out of 1,012 total recorded responses. Survey responses were excluded due to individuals not consenting to participate (n = 5) and failing the attention check (n = 76). Thirty-three (33) responses fell under the < .05 reCAPTCHA v3 threshold; upon manual review all were included in the final sample. No survey responses under the 2-minute completion threshold were not already excluded by other criteria. Sociodemographics for the sample are presented in Table 2. Overall, the total sample provided broad representation of the United States population (United States Census Bureau 2019). Where the sample did differ, it tended towards traditionally underrepresented groups in survey research with slight overrepresentation for individuals who identify as African American/Black and Asian American/Asian as well as the sample being slightly younger (35.6) than the overall population (38.5). No significant differences were found related to geographic regions related to artificial or natural turf sustainability items, as such all further analyses were conducted on the combined sample.

Table 2. Sample sociodemographic characteristics

Variable	**n**	**%**	**Variable**	**n**	**%**
*Race/Ethnicity**			*Geographic Region****		
Caucasian/White	513	57.8	South	314	33.7
African American/Black	189	21.3	West	291	31.3
Asian American/Asian	115	13.0	Midwest	165	17.7
Hispanic/Latino	55	6.2	Northeast	161	17.3
Native Am./Indigenous	10	1.1	*Have Child(ren)*	692	74.3
Mixed/Biracial	5	0.6	Younger than 5 yrs. old	263	38.0
*Gender***			Child(ren) 5 - 11 yrs. old	348	50.3
Male/Masculine	619	66.6	Child(ren) 12 - 17 yrs. old	146	21.1
Female/Feminine	310	33.3	Older than 17 yrs. old	95	13.7
Non-binary	1	0.1	*Have Pet(s)*	748	80.5

	Mean	**SD**			
			Dog(s)	631	84.3
Age	35.6	10.6	Cat(s)	258	34.4

**Race/Ethnicity categories were created from terms used by survey respondents.*
***Gender categories were created from terms used by survey respondents*
****Geographic region designations follow US census regions as follows. South: AL, AR, DC, DE, GA, FL, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV. West: AK, AZ, CA, CO, HI, ID, MT, NM, OR, UT, WA, WY. Midwest: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI. Northeast: CT, MA, ME, NH, NJ, NY, PA, RI, VT.*

Artificial Turfgrass Sustainability Pre- & Post-Tests

The combined index of the five-item sustainability inventory held no significant difference between the pre- and post-tests (Table 3) for artificial turf. There were three significant changes on individual items. Two items had significant increases including ‘Sustainable Materials’ from 5.09 in the pre-test to 5.21 in the post-test with a non-consequential effect size of d = .08, and ‘Uses Less Natural Resources’ from 4.88 pre-test to 5.01 post-test with a large effect size of d = .87. ‘Ecosystem Health’ had a significant decrease from 4.92 pre-test to 4.79 post-test with a large effect size of d = .81. The items ‘Environmentally Friendly’ and ‘Human Health & Well-being’ did not significantly change from pre- to post-test for artificial turfgrass.

Table 3. Results of paired t-tests between artificial turfgrass pre-test & post-test sustainability items

	Pre-test		Post-test		t(df)	Cohen’s d
Index or Items	*M*	*SD*	*M*	*SD*		
Index of Items	5.00	1.27	5.00	1.29	0.09(921)	NS
Sustainable Materials	5.09	1.52	5.21	1.52	2.49(929)*	.08
Environmentally Friendly	5.13	1.55	5.05	1.56	1.61(927)	NS
Uses Less Natural Resources	4.88	1.59	5.01	1.61	2.64(926)**	.87
Human Health & Well-being	4.93	1.56	4.92	1.55	0.18(930)	NS
Ecosystem Health	4.92	1.66	4.79	1.66	2.84(929)**	.81

*Notes: NS = non-significant, Cohen’s d not calculated, * $p < .01$, ** $p < .001$*
Scale: 1 = Strongly disagree to 7 = Strongly agree

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Natural Turfgrass Sustainability Pre- & Post-Tests

The combined index of the five-item sustainability inventory held no significant difference between the pre- and post-tests (Table 4) for natural turfgrass. There was only one significant difference for the item 'Uses Less Natural Resources' which had increased from 4.81 pre-test to 4.85 post-test with a large effect size of *d* = .92. All other items had no significant differences between pre- and post-tests.

Table 4. Results of paired t-tests between natural turfgrass pre-test and post-test sustainability items

Index or Items	Pre-test *M*	Pre-test *SD*	Post-test *M*	Post-test *SD*	*t*(df)	Cohen's *d*
Index of Items	5.29	1.15	5.31	1.16	0.57(919)	NS
Sustainable Materials	5.32	1.50	5.30	1.55	0.48(927)	NS
Environmentally Friendly	5.55	1.39	5.53	1.41	0.41(925)	NS
Uses Less Natural Resources	4.81	1.67	4.85	1.68	3.00(927)**	.92
Human Health & Well-being	5.36	1.43	5.37	1.42	0.27(925)	NS
Ecosystem Health	5.40	1.50	5.37	1.50	0.58(926)	NS

*Notes: NS = non-significant, Cohen's d not calculated, * p < .01, ** p < .001*
Scale: 1 = Strongly disagree to 7 = Strongly agree

Artificial vs. Natural Sustainability Pre- & Post-Tests

The combined index as well as pre-test and post-test indices comparing artificial and natural turfgrass conditions are presented in Table 5. The natural turfgrass surface was rated significantly more positively than the artificial surface in the pre-test index (Natural *M* = 5.29, Artificial *M* = 4.99), with a large effect size *d* = .64. Significant differences persisted in the post-test, however mean values were nearly unchanged (Natural *M* = 5.31, Artificial *M* = 5.00), with a large effect size *d* = .62. Finally, the combined index between pre and post conditions followed the previous conditions with natural turfgrass (*M* = 5.30) rated significantly more positively than the artificial surface (*M* = 4.99), with a large effect size *d* = .47. Related to individual items, all variables except for 'Uses less natural resources' were significant with small to moderate effect sizes.

Table 5. Results of paired t-tests between artificial & natural pre-test and post-test sustainability indices & items

	Artificial		Natural		t(df)	Cohen's d
Indices or Items	*M*	*SD*	*M*	*SD*		
Combined Index	4.99	1.19	5.30	1.07	9.55(910)**	.47
Pre-test Index	4.99	1.27	5.29	1.16	8.47(920)**	.64
Post-test Index	5.00	1.29	5.31	1.15	8.13(919)**	.62
Sustainable Materials	5.15	1.35	5.31	1.36	3.58(930)**	.12
Environmentally Friendly	5.09	1.40	5.55	1.24	10.10(929)**	.33
Uses Less Natural Resources	4.95	1.42	4.88	1.49	1.27(930)	NS
Human Health & Well-being	4.92	1.38	5.37	1.26	9.68(930)**	.31
Ecosystem Health	4.85	1.49	5.38	1.34	10.88(930)**	.36

*Note: * p < .01, ** = p < .001. Scale: 1 = Strongly disagree to 7 = Strongly agree. Individual item statistics refer to combined index values.*

Sociodemographic Factors in Artificial vs. Natural Turfgrass Sustainability

A few significant differences emerged as related to sociodemographic factors. First, pet owners rated artificial turf as more sustainable than non-pet owners (Pet owners M = 5.0, non-pet owners M = 4.5) using the combined index. This difference was significant with a large effect size (t = 4.49, p < .001 Cohen's d = .37) and was not dependent on the type of pet (e.g., cat or dog). Second, individuals who identified as African American/Black rated artificial turf as more sustainable than individuals who identified as Caucasian/White (African American/Black M = 5.4, Caucasian/White M = 4.8). This difference was significant with a large effect size (t = 5.89, p < .001 Cohen's d = .51). Third, individuals who identified as African American/Black rated natural turf as more sustainable than individuals who identified as Caucasian/White (African American/Black M = 5.5, Caucasian/White M = 5.2). This difference was significant with a large effect size (t = 3.50, p < .01 Cohen's d = .31). No significant differences were found related to the sociodemographic factors of region, gender, kids, or age.

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DISCUSSION

Turfgrass lawns are foundational landscapes within urban ecosystems located in built environments. Multiple pressures converge on municipalities to deliver urban green spaces that are functional for residents, ecologically sustainable, as well as budget friendly. Considering those pressures cities have looked to alternatives to traditional turfgrass lawns, one such alternative has been artificial turf. While the adoption of artificial turf has increased, research into how residents feel about such surfaces has not kept pace leading to a significant gap in our understanding of how the users of such spaces perceive this newer form of urban landscape. The current study investigated how individuals felt about the key aspect of sustainability as related to artificial turf compared to natural turfgrass.

The current study has shown a divergence among participants' perceptions of the sustainability and well-being between artificial and natural turfgrass lawns. At the broadest level individuals viewed natural turfgrass lawns more favorably than artificial turf across all but one sustainability item, 'uses less natural resources,' where no significant difference was found between surface types. This suggests support for natural lawns as preferable to artificial lawns as related to sustainability and well-being. Despite often being labeled as fabricated anthropocentric landscapes, natural lawns in the minds of individuals seem to indeed be 'greener' than artificial turfgrass lawns. While artificial and natural turfgrass lawns might serve the same purposes for individuals, the difference, as Brooks and Francis (2019) argue is that "living rather than a dead material is replaced," which could lead to the more favorable views of natural turfgrasses sustainability compared to artificial. Individuals therefore are perhaps making judgements based on the living vs. nonliving nature of natural and artificial lawns. Such comparisons between the living and nonliving landscapes should be investigated in future work comparing multiple landscape types that encompass a range of living and nonliving elements, potential uses, and ecosystem services and disservices. While a handful of these comparative pieces exist (Francoeur et al. 2021; Smetana and Crittenden 2014; Smith et al. 2015), a more comprehensive approach is needed to understand the diverse needs of users alongside environmental implications for urban ecosystems. For example, understanding perceptions of and preferences for artificial turf, hardscape, traditional turfgrass lawns, low input turfgrass lawns, low/no-mow areas, and urban meadows would be useful for public land managers, and policy makers who aim to manage urban landscapes more sustainability while delivering urban green spaces that meet the needs of residents and visitors.

On the broad scale, the information intervention (Table 1) impacted perceptions of artificial turf more than natural turf. Two factors might be at work related to this finding. First, natural turfgrass lawns are still far more common than artificial ones, especially considering the proportion of artificial turf installed in private green spaces (Francis 2018). Second, due to the ubiquity of natural lawns, the information available and transfer of that knowledge between individuals is a frequent occurrence (Martini et al. 2014). Taken together, individuals could be learning specific information about artificial turf for the first time compared to adding to previous information related to natural turf. Individual attitudes regarding natural turfgrass are more likely to be entrenched and thus harder to change compared to attitudes related to artificial turf which could be loosely held or novel (Albarracin and Shavitt 2018). This presents a situation in which more sustainable forms of natural urban lawns (e.g., low inputs, flowering lawns), might be more difficult to promote due to entrenched beliefs, attitudes, and emotions (Harris et al. 2013). In contrast, the alternative of artificial turf could seem more attractive as a solution that “meets the cultural expectations of a ‘good’ lawn more effectively than a real lawn ever could,” (Francis 2018), while not being laden with the weight of previously held attitudes and beliefs. It is critical then for future work to understand perceptions of individuals with previous experiences with artificial turfgrass surfaces, to assess whether direct experiences shift perceptions.

Underlying the broader differences between artificial and natural lawns were specific differences among individual sustainability and well-being items. First, the lack of divergence between artificial and natural turf related to the perceptions use of natural resources aligns with previous work identifying natural lawns as needing significant inputs (Reynolds et al. 2018). The need for high-input use, especially related to traditional turfgrass lawns, is combined with a strong desire among homeowners and public land managers to have lower input requirements (Barnes et al. 2020a, Ghimire et al. 2019). The comparison then for individuals is between natural turf which require often require multiple inputs (e.g., water, fertilizer, herbicides), and artificial turf which doesn’t require these traditional forms of inputs. Future work should compare management requirements which could include both traditional inputs used by natural turf and alternative inputs used by artificial turf to understand if perceptions of individuals shift. This would be a critical area to study given the potential for individuals not previously familiar with artificial turf who may believe it is input or maintenance free.

The strongest differences between the two surface types were related to natural turfgrass lawns being both more environmentally friendly alongside being positively related to ecosystem health. This finding could follow along with earlier reasoning related to the living/nonliving dichotomy as well as individuals recognizing some inherent ecosystem services and restorative benefits provided by natural lawns that are not present in artificial turf (Brooks and Francis 2019; Nordh et al. 2009) despite improvements in the aesthetic qualities of artificial turf over time. Perceptions of the ecological benefits of lawns, especially in areas where environmental issues are more prominent and where greenspaces are rarer could drive such preferences for natural compared to artificial turf (Bertram and Rehdanz 2015; Yang et al. 2019). Identifying specific aspects of sustainability should be investigated in the future, alongside understanding potential ecosystem disservices associated with both surface types (e.g., nuisance insects, crumb infill). Sociodemographics related to overall sustainably aspects were largely insignificant. While previous studies have found significant impacts of age, and the presence of kids and pets related to specific maintenance behaviors like fertilizing due to health concerns (Blaine et al. 2012; Carrico et al. 2013), the current study did not specifically address such health concerns directly and as such could be responsible for the lack of findings associated with those sociodemographic factors. There was however a significant difference between pet owners and non-pet owners whereby pet owners viewed artificial turf as more sustainable overall than non-owners. This could be due to the impact that pets, especially dogs, can have on natural turfgrass lawns in a variety of ways (Hobbie et al. 2017); pet owners are potentially expressing a higher rating for artificial turf due to less maintenance needed via reduced impact of pet behavior.

The current work also has significant implications for decision makers. While artificial turfgrass installations have increased due to concerns around wear and use of natural turfgrass lawns, most of these installations have been driven by a selective incorporation of ecological goals (e.g., saving water), without consideration of a complete assessment of ecosystem service tradeoffs (Francis 2018). Incidentally the water saving goal could be undone by watering requirements of artificial turf to keep it at a temperature which is usable and comfortable for individuals (Kanaan et al. 2020). More broadly though, the holistic effects on urban ecosystems need to be considered by decision makers at multiple levels regarding the installation of and conversation of natural to artificial turf surfaces. These decisions need to incorporate the full suite of impacts across ecosystem service categories, being attentive to cultural services related to use, health, and well-being as the current findings suggest. Specific management implications of the current work should focus on land managers prioritizing maintaining living turfgrass landscapes in ways that can reduce their overall use of inputs while still providing the qualities that make them useful for people to engage with. This is especially important given that lawns are generally well liked and are desired by urban residents (Wheeler et al. 2020). One way in which this could be achieved is transitioning to low input turfgrasses (e.g., fine fescues) which, once established, require fewer inputs of herbicides, fertilizer, and water (Diesburg et al. 1997; Watkins et al. 2010). A transition to the use of low-input turfgrasses is already supported by public land managers and homeowners and could help to maintain a more sustainable living surface that supports a variety of ecosystem services (Barnes et al. 2020a,b; Braun et al. 2020). In addition, other alternatives such as flowering lawns or bee lawns can be explored for lawn areas that are less trafficked to support pollinators and enhance urban biodiversity (Larson et al. 2022; Ramer et al. 2019; Wolfin et al. 2021).

The current study has three main limitations. First, the survey did not assess prior knowledge or experience with both natural and artificial turfgrass lawns. This also includes an assessment of whether individuals lived in a home with natural or artificial lawns at the present time. Knowing if an individual had prior experiences with or lived in a home with one or both surfaces might provide a more accurate assessment of both perceived and actual sustainability and well-being. This could be especially important among those living in arid areas where turfgrass replacement programs are common (Pincetl et al. 2019); in these locations' decisions about replacement or conversation of natural lawns are a present consideration compared to individuals in areas where water resources are currently plentiful. Future research should include measurements of prior knowledge and experiences with both surfaces to assess potential biases. Second, the existing study did not assess whether perceptions of the surfaces varied among use cases (e.g., sports, picnicking). Individuals might hold different views depending on their own uses for areas of turfgrass lawns. Finally, the sustainability index items could be more specific to assess individual attributes that might elaborate on differences between the two surface types. For example, the item "Uses Less Natural Resources," could be expanded into specific resource uses such as water, fertilizer, petroleum, etc. This expansion could allow for nuances to be assessed between artificial and natural turfgrass lawns and should be included in future research.

CONCLUSION

The current study addresses a significant gap within our understanding of how individuals perceive natural and artificial turfgrass lawns as related to sustainability and well-being. Natural turfgrass lawns were perceived to be more favorable overall and across all sustainability and well-being items other than related to their use of natural resources in which they were found to be not significantly different from artificial turfgrass lawns. With these types of surfaces playing a central role in many urban areas, understanding the comparative perceptions of these surfaces is important in balancing ecological and human well-being outcomes. Decision makers and land managers should take into consideration a holistic approach to assessing the potential benefits and drawbacks of the installation of artificial turf surfaces and their impacts on a broad range of ecosystem services.

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