VI. Synthetic Turf

1.0 Introduction

Synthetic turf has evolved considerably since it was first introduced in 1965 under the trade name *Astroturf*. *Astroturf* never really became popular with players (except perhaps in the sport of field hockey), who found the surface exceptionally hard (compared to natural turf), altering ball bounce characteristics in unfavorable ways, and also leading to more serious sports injuries. Successive innovations have thus been aimed at making synthetic turf resemble as much as possible the softness and ball handling characteristics of natural turf. The latest generation of synthetic grass uses a combination of synthetic fiber woven into a mat with sand/rubber infill to simulate the look and feel of natural turf, which is markedly superior to the earliest generation products.

Several organizations have approved the use of synthetic turf in their respective sporting activities. These include the Federation International Football Association (FIFA), the international governing body for soccer; Federation of International Hockey (FIH) for field hockey; and the International Rugby Association. These organizations have published detailed specifications (downloadable from their websites) for what characteristics an synthetic pitch should possess, as well as detailed testing protocols. In addition, the Synthetic Turf Council (www.syntheticturfcouncil.org), a trade association of synthetic turf manufacturers, also has a set of testing guidelines for synthetic turf products that could be used for applications outside the purview of specific sports governing bodies.

Why synthetic turf?

The world of sports has historically been the primary market for synthetic turf. In sporting applications, many factors enter into the decision to choose synthetic over natural turf. These include:

1. Climate. Some areas may not enjoy a climate conducive for growing natural turf on a year-round basis because of either severe summers or severe winters. Synthetic turf provides a more consistent playing surface.
2. Covered sports arenas. Often designed to increase spectator comfort, they also limit natural sunlight making cultivation of natural turf more difficult.
3. Reduced downtime. Although periodic maintenance and cleaning is necessary even in the case of synthetic turf, these surfaces are more available since they do not require seasonal fertilization and aeration as natural turf does. This is an important factor not only for professional sports, but also for expanding school districts where increasing uptime of existing playing fields through installation of synthetic turf may be more cost-effective than new land acquisition.
4. Cost. Although upfront costs of synthetic turf are many times greater than natural turf[56], over its life cycle synthetic turf may be cost-effective when one factors in reduced

[56] Irvine Ranch Water District reports that installed synthetic turf can cost between $6 and $9 per square foot (www.irwd.com/Conservation/synturf.php). The cost of sod is usually less than $1 per square foot. A do-it-yourselfer could thus install a natural turf landscape quite inexpensively, although professional installation would narrow the cost difference between natural and synthetic turf somewhat. Natural turf-based high-end sporting

maintenance, reduced downtime, and reduced irrigation bills. Unfortunately, reliable data about costs and benefits are not available at present to permit this assessment. Many of the synthetic turf manufacturers are privately held businesses that are loathe to sharing such data openly.

5. Optimization for multiple sports. Since the properties of the latest generation synthetic turf can be altered to some extent, it is possible to engineer a pitch that may be acceptable for many different sports. For example, football players may prefer natural turf, while field hockey players may prefer *Astroturf*, but both could perhaps find a properly optimized infilled synthetic pitch acceptable, obviating the need for two playing fields.
6. Recruiting. Choices made by competing institutions can play a part in whether a given institution chooses natural or synthetic turf ("perception is reality"). This bandwagon effect has probably worked both for and against synthetic turf at different points in time.[57]

Apart from sporting applications, synthetic turf is also suitable for residential and commercial applications assuming the cost benefit calculus is favorable. Again, anecdotal evidence suggests that residential applications are increasing rapidly in arid areas where water providers have taken aggressive measures to limit outdoor water use. An example is the Southern Nevada Water Authority (www.snwa.com), which limits residential turf to no more than 50 percent of landscaped area, limits summer watering to alternate days, and has inclining water rates. A recently completed synthetic turf study in the City of Anaheim[58], California, found that residential customers that replaced their natural turf with synthetic turf were quite satisfied with the result (mainly due to reduced maintenance and bugs), but the study included only five customers, so it is difficult to generalize to all residential applications. Of the two commercial sites included in this study (roadway median and public park) the park official was not enthusiastic about synthetic turf's appearance. The Anaheim Pilot Study estimated the cost of saved water to be $7,000 per acre-foot (savings were derived using engineering estimates, not billed data).

Overall, irrigation considerations do not appear to be a significant decision driver in sporting applications, but could be more so in other applications[59]. In other words, water providers probably enjoy very limited opportunity for influencing synthetic turf use in sporting applications (although they could still show support via rebates up to the value of saved water), but perhaps could have greater impact in residential and commercial applications.

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applications are likely to cost more than residential lawns. These are very rough figures based on anecdotal evidence, and a lot more investigation and history is required to really pin down these cost estimates across different settings.

[57] Rosenberg, B., "Greatest turf on show," NCAA news, September 29, 2003 (accessible at www.ncaa.org)

[58] *Astrolawn Synthetic Turf Pilot Project*, conducted by the City of Anaheim Public Utilities and H2O-Less Lawns and Turf, LLC, October, 2004 (under the auspices of MWDSC's Innovative Conservation Program).

[59] Anecdotal evidence indicates that, for summer sporting applications, water is used to "cool down" the synthetic turf prior to play.

Pros and cons of synthetic turf

Some of the key reasons why synthetic turf has found favorable reception in sporting applications were mentioned above (climate, covered arenas, reduced downtime, lack of land in urbanized areas). They may, in many circumstances, outweigh synthetic turf's considerably higher initial cost, and possibly its other technical deficiencies (such as a harder surface). But where the above factors are less important, synthetic turf may not turn out to be as cost effective as manufacturers claim. Here are some views offered by stakeholders within the natural turf industry:[60]

1. Natural turf advocates argue that synthetic turf is not maintenance free, and usually requires acquisition of specialized equipment to meet the manufacturer's maintenance specifications.
2. Synthetic pitches can become very hot during summer months and need to be sprayed with water to cool them down. They may also need to be regularly sanitized to reduce the possibility of viral/bacterial infections being transmitted to players when they suffer cuts and burns. All of these activities use water, making the irrigation savings perhaps not as large as one might think (especially in sporting applications).
3. Natural turf is friendlier for the environment. It effectively bio-filters rainwater as it moves from surface to aquifer. It also has a cooling effect on properties that it surrounds, reducing air conditioning related energy use, a factor that would need to be considered in residential/commercial applications.
4. While fertilizers and pesticides used with natural turf can run off into streams and rivers, synthetic turf uses infill materials (ground rubber tires) that could also leach toxic materials into the groundwater while in use[61]. Safe post-use disposal of synthetic turf also remains an issue.

Some of the above criticisms speak to the technical efficacy of synthetic turf relative to natural turf (such as greater chance of sports injuries, unusually hot playing surfaces, etc.); the others speak to whether a full accounting of direct and indirect environmental costs would still lead one to favor synthetic turf. As stated earlier, data to sort through these claims and counterclaims appear to be spread across multiple sources, many proprietary, which would need to be collated before one could draw any definitive conclusions. Given that synthetic turf has been approved by several sports governing bodies and that its penetration is steadily increasing in sporting applications, we would surmise that the negatives associated with synthetic turf are not so great in those situations.

However, the operational history of the latest versions of synthetic turf is limited. With useful lifetimes projected at as low as six years and as high as ten years, enough "real world"

[60] Several articles are cited at www.westcoastturf.com/architects/keepitreal.html and at www.turfgrasssod.org (click on "resources"). Also see a University of California, Riverside publication on this subject, "Davis, William, Natural versus Synthetic Turf: An Economical Alternative," *California Turfgrass Culture*, Vol. 31, No. 1, 1981 (ucrturf.ucr.edu/publications/CTC/ctc31_1.pdf).

[61] Although the Synthetic Turf Council's guidelines proscribe the use of toxic materials, it remains unclear exactly what each manufacturer is, in fact. using. The Santa Clara Valley Water District is examining this issue in greater detail, although no published report is as yet available from them.

experience is not yet available. To balance the picture, at present we can only suggest that interested readers also familiarize themselves with the generally favorable testimonials about synthetic turf included at the National Collegiate Athletic Association's (NCAA) website.[62]

[62] Search www.ncaa.org using keywords "synthetic turf" and "artificial turf".

2.0 Target Market

Synthetic turf's primary market is in sporting applications. While residential and commercial applications are also technically viable (and rapidly growing in Nevada according to anecdotal evidence), synthetic turf's cost-effectiveness in these latter applications will depend upon climate, water availability, and water rates. Certainly, one could envision the use of synthetic turf becoming more common in California's rapidly developing, hotter, inland regions.

Schools

Table 1 provides the total number of K through 12 public schools in California, which account for roughly 90 percent of all student enrollments (the remainder are enrolled in private schools). We were unable to find data about the size and type of playing fields that each type of school has, but school design is a highly regulated activity, subject to several codes and guidelines[63]. Thus, it is possible to develop estimates about synthetic turf's potential target market among K through 12 schools.

Table 1 California's Public Schools (FY 2004-05)

Type	Number
Elementary	5558
Middle/Junior High	1254
High	1128
K-12 (integrated)	96
Other‡	1339
TOTAL	9375

‡Includes alternative schools, special education schools, continuation schools, community day schools, etc.
SOURCE: California Department of Education (www.cde.ca.gov/ds/)

Colleges and Universities

Table 2 shows the total number of colleges and universities in California. Again, information about their athletic facilities is not available. It should be noted, however, that out of the 399 colleges located in California, only roughly 50 are members of the National Collegiate Athletics Association. These members include all the University of California campuses, the California State University campuses, and other well known private universities. Perhaps, only these 50 campuses have advanced athletic programs, and represent potential users of synthetic turf.

Table 2 California's Colleges and Universities (FY 2004-05)

Type	Number
2 year colleges	173
4 year colleges	226
TOTAL	399
Members of NCAA	50

SOURCE: National Center of Education Statistics (nces.ed.gov/programs/stateprofiles) and
National Collegiate Athletics Association (www.ncaa.org).

[63] For example, see California Department of Education's publication entitled, *School Site Analysis and Development, 2000 edition* (www.cde.ca.gov/ls/fa/sf/documents/schoolsiteanalysis2000.pdf). This document provides empirical guidelines about all aspects of school design, including playing fields, as a function of school size and enrollment.

Residential applications

Estimating synthetic turf's potential market in residential and commercial applications is extremely difficult. Given the price differential between natural and synthetic turf, only areas where water agencies aggressively aim to reduce outdoor use is synthetic turf likely to catch on. One can only construct "what if" scenarios at this stage. Which of these areas might be candidates in the future? To shed some light on this issue we present estimates of the indoor/outdoor split among single-family residences by County. Outdoor use as a proportion of total use varies considerably, exceeding 90 percent in Inyo County. If one focuses only on counties that are located in the southern district (since they are more dependent upon imported water), with very high outdoor water use (say, over 75 percent), one can shortlist San Diego, Imperial, Riverside, Ventura, San Bernardino, and Inyo counties as most promising markets for synthetic turf. According to the California Department of Finance, there were roughly 1.7 million single-family detached homes in these six short-listed counties.

Table 3. Outdoor Water Use Patterns By County

County	District	Single-family internal use	Single-family external use
Santa Barbara	SD	61.17%	38.83%
San Luis Obispo	SD	56.71%	43.29%
Humboldt	ND	55.00%	45.00%
Monterey	SJD	51.10%	48.90%
Siskiyou	ND	46.86%	53.14%
Kern	SD	41.60%	58.40%
Kern	SJD	37.51%	62.49%
Tulare	SJD	37.03%	62.97%
Orange	SD	37.00%	63.00%
Los Angeles	SD	36.45%	63.55%
Lake	ND	36.33%	63.67%
San Benito	SJD	35.15%	64.85%
Madera	SJD	34.31%	65.69%
Santa Cruz	SJD	34.07%	65.93%
Butte	ND	33.00%	67.00%
Del Norte	ND	32.00%	68.00%
Kings	SJD	30.45%	69.55%
Santa Clara	CD	30.12%	69.88%
Alameda	CD	30.10%	69.91%
Contra Costa	CD	30.08%	69.92%
Calaveras	CD	30.04%	69.96%
Yuba	CD	30.04%	69.97%
Marin	CD	30.02%	69.98%
Amador	CD	30.02%	69.98%
San Francisco	CD	30.01%	69.99%
Placer	CD	29.73%	70.27%
El Dorado	CD	29.67%	70.33%
Fresno	SJD	29.64%	70.37%
Nevada	CD	29.54%	70.46%
Mono	SD	29.00%	71.00%
Mono	CD	28.57%	71.43%
Sonoma	CD	26.22%	73.78%
Modoc	ND	26.00%	74.00%
Sacramento	CD	25.00%	75.00%
Mendocino	CD	24.82%	75.18%

County	District	Single-family internal use	Single-family external use
Solano	CD	24.01%	75.99%
San Diego	SD	23.17%	76.83%
Tuolumne	CD	22.57%	77.43%
Shasta	ND	22.50%	77.50%
Sierra	CD	22.15%	77.85%
Imperial	SD	22.08%	77.92%
Merced	SJD	21.52%	78.48%
San Joaquin	CD	21.46%	78.54%
Yolo	CD	21.45%	78.55%
Sutter	CD	20.04%	79.96%
Napa	CD	20.01%	79.99%
San Mateo	CD	20.01%	79.99%
Tehama	ND	19.75%	80.25%
Stanislaus	SJD	19.72%	80.28%
Mariposa	SJD	19.50%	80.50%
Lassen	ND	18.11%	81.89%
Riverside	SD	18.04%	81.96%
Alpine	CD	17.74%	82.26%
Ventura	SD	17.25%	82.75%
Plumas	ND	17.00%	83.00%
Colusa	ND	15.20%	84.80%
San Bernardino	SD	12.50%	87.50%
Trinity	ND	10.00%	90.00%
Glenn	ND	6.86%	93.14%
Inyo	SD	6.21%	93.79%

SOURCE: Indoor/Outdoor splits were obtained from the California Department of Water Resources website. The data are for 2001: www.landwateruse.water.ca.gov/docs/annualdata/2001/Urb_IO_2001_by_Co.xls
Housing units data can be obtained from the California Department of Finance's website. These are for 2006: http://www.dof.ca.gov/HTML/DEMOGRAP/E-5a.xls
Finally, CIMIS maps California by climate zone based upon annual ET, a potentially useful tool for identifying target markets: wwwcimis.water.ca.gov/cimis/images/etomap.jpg

3.0 California Potential

Estimating residential and commercial water conservation potential at this stage is very difficult. So we do not attempt it. Instead, we focus only on sporting applications and provide rough estimates of that potential. As noted earlier, we lack rigorous estimates about how much acreage ought to be considered viable for synthetic turf installation in schools and colleges. In order to approximate the savings, however, we have relied on anecdotal evidence provided to us by a knowledgeable conservation professional, who suggests that an average estimate of three acres per school site may be reasonable.[64] These water savings are very uncertain for two reasons: (a) school playing fields often are deficit irrigated and (b) some amount of water is usually necessary to cool as well as clean synthetic turf. We assume that irrigation savings may only be in the range of 3-4 acre-feet per acre per year. We also assume product life to be roughly 10

[64] Maddaus, William, 2006. Personal communication. Mr. Maddaus states that "elementary schools normally have about 3 acres of turf, enough for one soccer field. Middle schools have about 7 acres and high schools about 15 acres. Colleges show a wide variation since many colleges are small urban campuses. We've used 10 acres in the past as an average. This is the amount of turf we feel is being irrigated now. But for replacement with artificial turf, because of the high cost, it will probably be limited to playing fields. So to be conservative you could use 3 acres per school and have a figure that is not too overly optimistic."

years in sporting applications based upon anecdotal evidence that synthetic turf manufacturers generally offer an eight year product guarantee[65]. Table 4 shows the results, suggesting the gross conservation potential (from turf replacement in all schools in the state) may roughly lie in the range of 88 to 117,000 acre-feet per year, and over the product lifetime between 880,000 and 1,170,000 acre-feet. For reasons cited earlier, the potential "capture" rate of that savings cannot be determined at this time.

Table 4 Water Conservation Potential in School Sporting Applications

Site type	No. of sites	Potential for synthetic turf replacement per site on average	Annual savings potential		Lifetime savings potential (10 year product life)	
			At 3 AFY per acre	*At 4 AFY per acre*	*At 3 AFY per acre*	*At 4 AFY per acre*
K-12 schools	9,375	3 acres	84,375	112,500	843,750	1,125,000
2 and 4 year colleges	399	3 acres	3,591	4,788	35,910	47,880
TOTAL			87,966	117,288	879,660	1,172,880

4.0 Cost effectiveness

Given lack of reliable data and unresolved environmental issues, we are unable to provide comparative cost-effectiveness analyses to evaluate how natural and synthetic turf would fare against one another in similar settings. Instead, we only provide illustrative estimates of what the cost of saved water would be from a synthetic turf installation. Once again we assume product life to be 10 years, water savings to range between 3 and 4 acre feet per acre per year, and the cost of installed synthetic turf to vary anywhere between $6 and $10 per square foot. Table 5 shows that the cost of saved water could vary anywhere between $6,000 and $15,000 per acre foot, which significantly exceeds the current cost of water in most, if not all, California jurisdictions.

Table 5 Cost of Water Saved Through Synthetic Turf Installation

Savings per acre per year	Product life	Installed cost of synthetic turf per square foot	Installed cost per acre	Total lifetime water savings per acre	Cost per acre-foot saved
3 acre-feet	10	$6	$261,360	30 acre feet	$8,712
3 acre-feet	10	$8	$348,480	30 acre feet	$11,616
3 acre-feet	10	$10	$435,600	30 acre feet	$14,520
4 acre-feet	10	$6	$261,360	40 acre feet	$6,534
4 acre-feet	10	$8	$348,480	40 acre feet	$8,712
4 acre-feet	10	$10	$435,600	40 acre feet	$10,890

[65] However, anecdotal information also suggests that where heavy sporting use exists (e.g., school playfields shared with local municipal recreation programs), the physical life of the synthetic turf may be as short as six years.

5.0 Conclusions

Our brief survey of the literature on the topic of synthetic turf shows that at present information about this technology is distributed across many sources, and that these disparate pieces of information have not been collated in a way that would allow one to observe trends, offer general guidelines about product suitability in different applications, estimate the size of potential markets for this product in California, and ultimately assess its broader impact on water use and the environment. It is feasible to generate this information, especially in the context of sporting applications, since the user community is fairly well defined.[66] While some of this information would also translate to residential and commercial applications, identifying the target market in these latter applications will remain very difficult. Decisions to go synthetic or natural in the residential and commercial sector are much more dependent upon water agency policies, and the cost differential between natural and synthetic turf, than appears to be the case in the sporting sector. The only estimate of the cost of saved water in residential and commercial applications that we were able to find (City of Anaheim Pilot Study cited earlier) suggests that this may be as high as $7,000 per acre-foot. Much more research is needed to refine this estimate to fully account for all the costs and benefits associated with natural vis-à-vis synthetic turf.

[66] The Metropolitan Water District of Southern California also has roughly 10 pilot projects underway under the auspices of their synthetic turf program. However, no reports are available from these projects at present to shed light on the various issues surrounding synthetic turf.