Turf Lifecycle Assessment

Goal and Scope Report

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Background

The turf industry is well established in all states of Australia with an estimated production area of 4,400 Ha spread over 250 growers (Turf Australia, 2018). Natural turf grass is produced from a variety of cultivars for home lawns, landscaping, recreational areas and sports fields. Turf growers cultivate the soil and grow turf which is harvested as rolls or slabs for the various types of installations.

As an accountable industry the turf growers have commissioned the study: *Environmental Assessment of the Australian Turf Industry*. Horticulture Innovation Australia has established this study using grower funds and support from the Australian government. This study includes a lifecycle assessment of turf.

Turf production requires sun water, soil and nutrients that are managed by the turf grower. There is a balance between inputs and outputs, both of which generate environmental impacts to be assessed in this study. The first two inputs from nature are variable from season to season and produce an inherent variability in the output of turf from a particular turf farm as with all agricultural products there are good and poor seasons for growth. These have been taken into consideration by examining the turf farms over a two year period.

A two stage approach has been used where the growers have been assessed followed by an examination of installations to cover the full lifecycle of turf.

Goal and intended application of the study

The intent of this study is to quantify material movements and energy use over the lifecycle of turf and from this to determine the related environmental impacts of the lifecycle as defined herein. This data will then be used to define the environmental impacts in a form suitable for publication as an Environmental Product Declaration.

Reasons for carrying out the study

The environmental impacts of turf grass are a topic of discussion and potentially of mis-interpretation. There are fragments of information about water and energy consumption in the maintenance of turf. There is a need to bring all of the environmental data together so that myths can be revealed and a clear understanding of the nature and extent of environmental impacts can be gauged.

Provision of environmental impact data for turf will enable those considering turf installations to take these impacts into consideration, potentially in comparison to alternative surfacing solutions or in the context of larger overall projects.

Lifecycle assessment

Awareness of the environmental impacts of products manufacture, consumption and end-of-life has increased interest in methods to better comprehend and compare these impacts. One of the methods developed for this purpose is lifecycle assessment (LCA).

LCA is a technique for assessing the environmental aspects and potential impacts associated with a product or service by:

- compiling an inventory of relevant inputs and outputs of the product or service system
- evaluating the potential environmental impacts associated with those inputs and outputs
- interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.

LCA models the environmental impacts from each stage of a lifecycle across raw materials acquisition, manufacture, use and end-of-life.

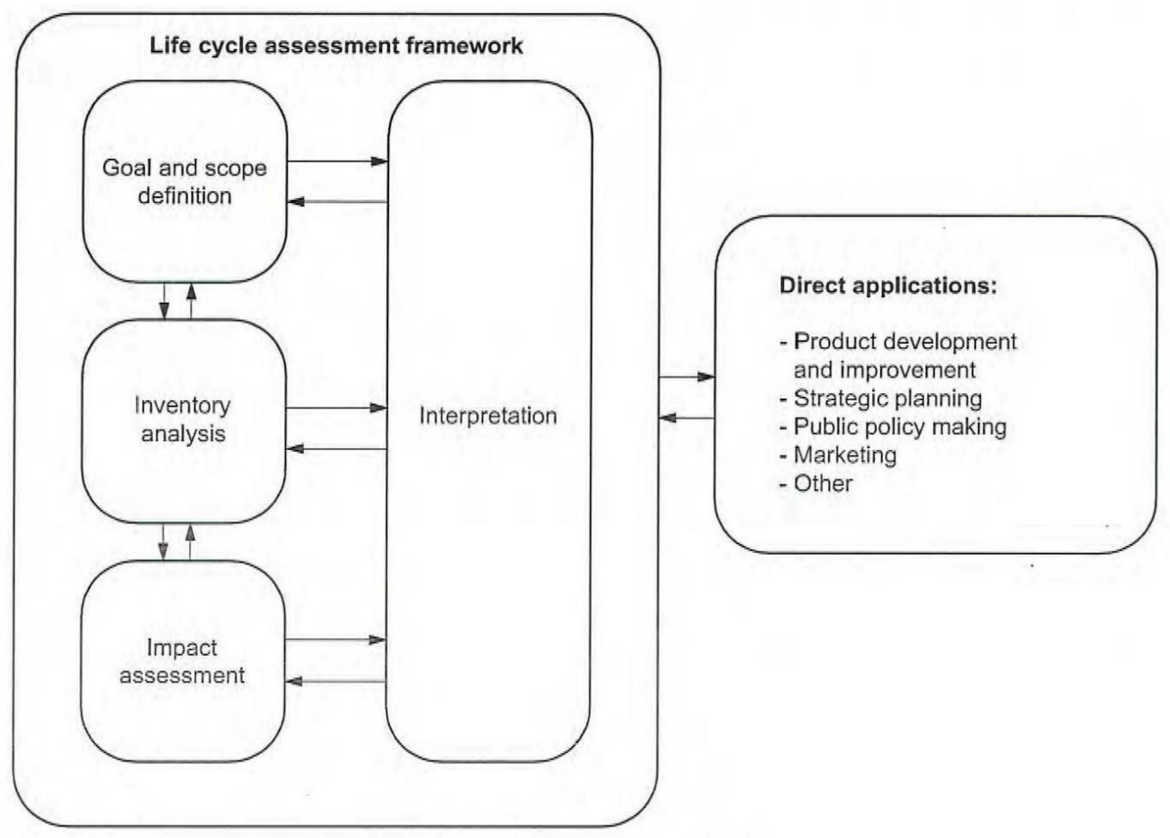

Figure 1. Stages in a lifecycle assessment

The key reference standards that will be utilised in undertaking the proposed LCA and Environmental Product Declaration (EPD) development are:

- International Standard ISO 14040:2006 Environmental management - Life cycle assessment - Principles and framework, Geneva: International Organization for Standardization.

- International Standard ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines, Geneva: International Organization for Standardization.
- ALCAS Best Practice Guide for Mid Point Lifecycle Assessment in Australia (M.A., 2018)
- International Standard ISO 14025:2006 – Environmental labels and declarations – Type III Environmental Declarations – Principles and Practice

Scope of the study

The data collected has been exclusively from the Australian turf industry for the application of the turf in Australia under the various conditions encountered. As turf has a life in an installation that is limited by changes in the use of the land. This may occur after a few or many years so the impacts of installation and maintenance will be reported separately to allow users of the EDP to calculate the annual impact based on an assumed lifespan for a specific installation.

Functional unit

Turf is sold by area of cover rather than weight of product, so the inputs are generally expressed and understood as the amount used per area of turf farm. In line with this practice the functional unit used is one square meter of finished product. The lifecycle inputs are expressed as those pertaining to the production of 1 m^2 of turf and its installation and maintenance over one year.

FUNCTIONAL UNIT = 1 m^2 turf installed/year (5 and 10 year default lifespan)

System description

Turf lifecycle can be split into three stages:

1. Growing and harvesting
2. Installation including transportation to site and
3. Maintenance

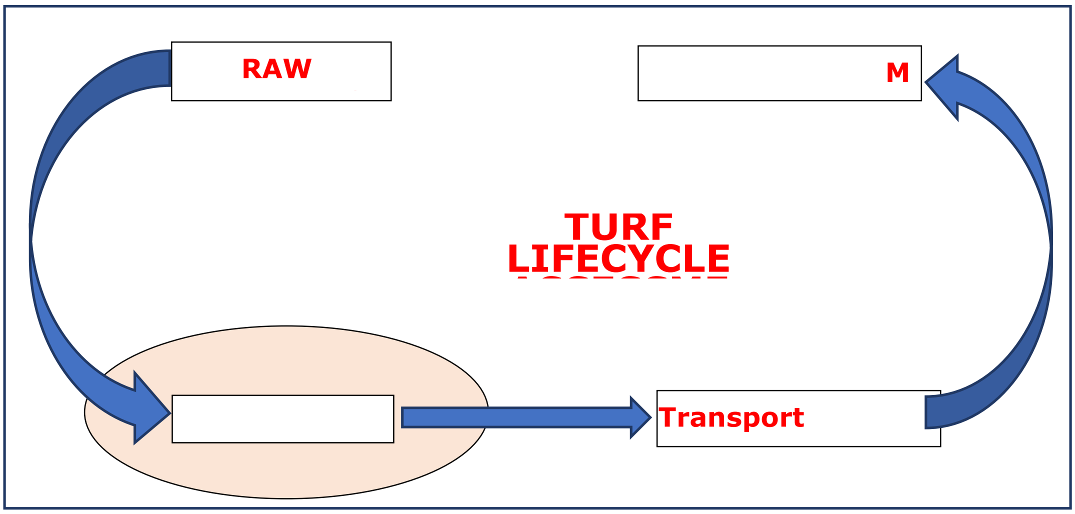

Figure 2. Lifecycle of turf

Growing

Turf grass may be grown from seed but is more commonly propagated from existing turf left remaining in the soil. The predominant varieties of Buffalo, Couch and Kikuyu are propagated in this way from strips of turf left after harvest or from turf grass roots left in the soil.

The diverse set of turf varieties have differing nutrition and water requirements. There was no attempt to split up the turf varieties as each farm produced a set of different products and differentiation of these was not practicable in this study.

Figure 2. Turf strips left for propagation after harvest

The process of propagation involves fertilisation and irrigation with due consideration of the season and growing patterns.

Growth rates are dependent on temperature, sunlight, nutrients and moisture in the soil. At temperate latitudes there is a growth season from Spring to Autumn and a dormant period over Winter. Subtropical regions can grow turf all year round.

During the growing period water and nutrients have to be supplied for optimal growth and weeds and pests have to be controlled. Each grower has an irrigation program along with fertilisation and chemical addition schedules.

Growers use energy predominantly in the form of diesel fuel. Tractors are used across the farm for most activities, diesel may also be used for irrigation pumps. If not, electrical pumps are used for irrigation that is the major use of electrical energy by turf growers.

Harvest and transport

Specialist equipment is used to harvest turf with most growers using automated harvesters that produce rolls or slabs. The rolls are placed on a pallet and wrapped to stabilise them on the pallet. They are then loaded onto a truck (usually a flat bed truck) for transport to the installation site.

As a living product turf is harvested on market demand and transported within a day to the installation site.

Installation

The site is prepared for the turf by levelling and adding top soil or sand if necessary. Fertiliser is added to aid the establishment of the turf. The turf is laid manually and watered in for the first week. A reticulated irrigation system may be used for larger installations. Smaller sites can use moveable sprinkler systems or can be hand watered.

Figure 3. Watering in a turf installation with a moveable sprinkler system

Maintenance

Once the turf is established a maintenance regime is employed. This involves mowing regularly over the growing season, fertilisation to maintain the required growth and watering as required by the turf grass.

It may be necessary to spot spray weeds and apply pesticides if they are having an adverse effect on the turf.

The end of life for a turf installation is dictated by land use rather than the lifespan of the turf which should go on indefinitely if appropriately maintained. As such there is no definite end of life scenario for turf grass and a one year period has been chosen for the installed lifespan.

System boundaries

The examination of environmental impacts considers the operations on the turf farm and the various inputs on farm being: energy, water, fuels, chemicals and other consumables such as netting. Farm infrastructure is not considered as it is not certain as to whether this was established with the purpose of turf growing in mind and may be utilised by other farming activities at the site. It is acceptable under the reference PCR to exclude infrastructure related inputs and outputs.

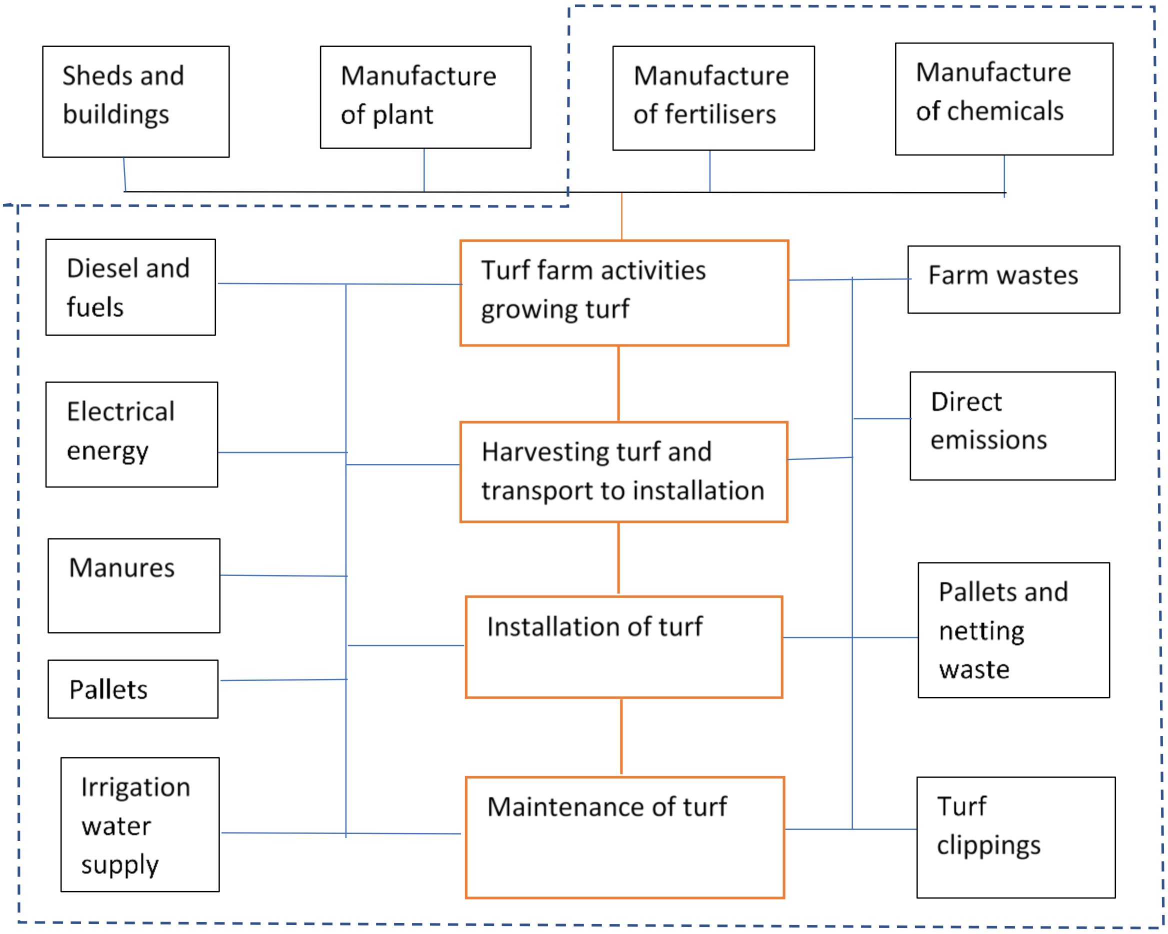

Figure 4. Boundaries of the life cycle assessment of turf (blue dotted line)

Geographical boundaries used were the limits of the Australian continent and Tasmania. The time boundaries used for the study are the financial years 2016-17 and 2017-18 for growing data. However, the installation data collection has been undertaken from January 2018 to March 2019.

The study is intended to cover all turf varieties together and growers in all sizes and Australian locations. Installation studies have been restricted to the Melbourne and Sydney regions.

System inventory data

Growing

Studies of 20 growers across Australia, over two annual periods, and a series of 6 installations have produced data on material flows and energy consumption through the lifecycle of turf. This is presented as the industry mean with high and low limits to cover the performance of 80% of growers. As the application of turf varies from recreational to specialist sporting facilities these are split into categories.

Regional variation in growing conditions has been accounted for by the high and low limits of the data. For instance irrigation water use is considerably higher in the sand belt of Western Australia than it is in clay loam conditions encountered elsewhere.

As data has been collected for the turf growers over two years the data presented represents the average of the 2016-17 and 2017-18 financial years.

Turf grower data (n=30-40)			**Median**	**Average**	**Top 90%**	**Bottom 10%**
Land use	m^2 of land / m^2 turf produced per year		1.67	1.5	2.86	0.93
Electricity	kWh/m^2 turf produced		0.25	0.38	0.95	0.05
Diesel	L/m^2 turf produced		0.12	0.15	0.29	0.06
Energy used	MJ/m^2 turf produced		5.5	6.91	14.5	2.39
Greenhouse	Direct emissions kg CO_2/m^2		0.51	0.74	1.2	0.26
	Net emissions kg CO_2/m^2		-1.63	-1.68	-2.31	-0.9
Water used	L/m^2 turf produced		1078	1497	3563	621
Nitrogen	kg(N)/m^2 turf produced		0.047	0.071	0.16	0.02
Phosphorus	kg(P)/m^2 turf produced		0.016	0.022	0.053	0.0023
Potassium	kg (K)/m^2 turf produced		0.021	0.027	0.061	0.00096
Ag chemicals	kg / m^2 turf produced		0.0019	0.0023	0.0061	0.00082
Lime +	kg / m^2 turf produced			0.092		

Table 1. Turf grower consumption data

Land use is an environmental impact category that may be considered in terms of its use over a set period of time. It also known as change of land use or biodiversity impact. The turf grower can use the same piece of land to produce turf for many years and this is commonly the case that the land has been used to produce turf for generations. The soil is incorporated into the turf product and hence soil is lost to the product. This may be replaced by the manures and other additives used by the grower and the soil develops through the plants an increase in organic matter. The situation is complex and the soil is not lost to the environment it is effectively transferred to another site, where it may also act to stabilise soil loss.

For these reasons we believe that the impact of land use is simply to be taken as the area of the turf farm for the total production of turf from that farm, expressed in m^2 of land / m^2 turf produced per year.

Energy is used as electricity and diesel with a minor amount of LPG used in forklifts to load trucks. The LPG usage is less than 1% of the total and has not been included in the lifecycle assessment. The total diesel used on farm as well as electricity have been used to calculate the usage per m^2 of turf produced. Where diesel is also used on farm for transport purposes a factor has been applied based on the trucks and product distribution mileage to gain an estimate of the total diesel used on the farm only. In most cases the growers used different accounts for on-farm diesel to the trucks.

For each grower the diesel and electricity usage was used to calculate the greenhouse gas emissions for the farm together with the greenhouse gas attribution of fertilisers and chemicals used. The net greenhouse gas emissions were calculated from a study of the carbon content of the product turf to gain a net Greenhouse emission per m^2 of turf. In all growers this was a net sequestration of carbon and negative Greenhouse emissions for turf products.

Turf growers use river water or bore water to irrigate turf. In some cases they collect run off from irrigation in dams and reuse this water. It was not possible to determine what the irrigation volume was recycled so the assumption is that all water is fresh. Some growers use waste water recycled from sewage treatment plants. While these growers can discount the water use impact for this waste water reuse this has not be done for the industry LCA.

Fertilisers and manures used by the growers were determined according to the NPK content (nitrogen, phosphorus and potassium) and these figures were used to estimate the environmental impact. The N, P and K were determined in the product turf of 6 growers and an average used to establish the amount of N, P and K held by the product turf and the that may be held up in the soil or lost to groundwater or surface run off.

A single grower may have used up to 40 different chemical products in addition to the fertilisers in a year. Most of these chemicals are not registered in the inventory used so it was assumed that they were a single common chemical and the total “Ag chemical” usage for the production of one m^2 of turf was calculated and used to determine the total environmental impacts.

The use of lime and other soil additives is haphazard and in response to particular issues on the farm. Lime and dolomite are the most common additives used, but these are not added to the soil regularly by most growers. An average over the two years of the study was 0.092 kg per m2 of turf produced.

Additional inputs come in the form of pallets and the netting used to stabilise the slabs or rolls of turf placed on them. The pallets are collected after installation and reused by the grower while netting wastes are assumed to be disposed to landfill through general waste bins at the point of installation. Each pallet holds about 80 to 100 m^2 of turf and is held by less than 10m^2 of netting (approx. 300g). Netting was discounted from the LCA calculations as a minor contribution of less than 1% of the material inputs (0.003 kg/m^2 of turf).

Transport and Installation

Typically a grower is involved in the marketing and delivery of product turf. Some growers are involved in installation and maintenance and others leave the whole marketing process to a third party.

Figure 5. A truck loaded with slabs of turf on pallets

Turf is palletised on the harvesting machine and dropped off at a storage location for truck loading and delivery.

Pallets are loaded and off-loaded from the truck using a forklift. Some were electric but most were either LPG or diesel forklifts.

Turf farms are scattered across the country positioned where irrigation water is available. The distance to market dictates the transport impacts in diesel fuel consumption. This was determined for 16 out of the 20 turf growers studied

Transport to installation diesel use

Fuel	Mean consumption	Average consumption	
	Litre/m2 produced	Litre/m2 produced	
Diesel	0.088	0.096	
LPG	<0.001	<0.001	

Table 2. Diesel consumption in transport

The installation site is levelled either by mechanical or manual means, fertiliser pellets may be added to the site before the turf is installed or fertiliser can be added to the irrigation water.

In the case of sports fields drainage systems are in place and sand is laud over the substrate soil and levelled off. Manure or fertiliser is added prior to the turf installation.

Installation of the turf slabs or rolls is undertaken manually. The rolls are offloaded from the truck and set down by the installation from where they are rolled out or laid in position. When this has been accomplished the turf is watered in.

After installation the turf is watered in with an average daily application of 5mm of water for three weeks.

Input to installation	**Quantity**	**Explanation**
Top soil (sand) 150 mm	0.24 kg/m^2	Density assumed 1.6 kg/dm^3 -only applied for sports fields
Fertiliser	0.07 kg/m^2 total 0.005 kg N/m^2 0.006 kg P/m^2 0.006 kg K/m^2	Average usage rates from 5 installations studied of which two used no fertiliser
Water	0.047 m^3/m^2	Average of 5 installations studied watering in for three weeks in each case

Table 3. Inputs for turf installations

Maintenance of turf

The level of turf maintenance is dependent on the application. While recreational area turf or lawn provides a green and pleasant surface for human activities, sports field turf needs to function for the particular use(s) of the sports ground. Recreational turf surface smoothness and consistency is not critical for its use so the maintenance activities are much reduced when compared to sports turf. For this reason we have split the lifecycle assessment into the two areas:

- Recreational turf and
- Sport turf.

Recreational turf maintenance

There is variation in recreational turf maintenance from just the occasional mowing to serious attempts to maintain the turf in a good condition. In most cases recreational turf is maintained with adequate fertilisation, weed management and watering followed by mowing at regular intervals during the growing period.

In our study of recreational turf maintenance examples of lawn at a tennis centre and lawn in a landscape for a new housing estate were examined. These sites were maintained appropriately and according to the industry regimes.

The activities and inputs expected are given in Table 4.These activities and inputs are expected for a well maintained turf lawn that may be the responsibility of a maintenance contractor. In many cases of domestic lawn maintenance the inputs will be less than is given and it is unlikely that the inputs will be greater.

Maintenance				**Recreational turf lawn**
Inputs	**for one year**	**Expected**		**Comments**
Hand mowing	MJ/m^2	0.61		11.9 L of petrol per Ha (15 mows over the year – biweekly in Spring and monthly after 15 Dec)
	L/m^2	0.018		
Watering	L/m^2	100		Fortnightly watering to 5mm for 20 weeks per year
Fertilising	kg/m^2	0.024		4 kg All Purpose Fert per 500m2 = 0.008 kg/m^2 three times per year
Nitrogen	kg/m^2	0.0036		Nitrogen 15%
Phosphorus	kg/m^2	0.0012		Phosphorus 5%
Potassium	kg/m^2	0.0012		Potassium 5%
Mineral additives	kg/m^2	0.015		Assume ag lime or similar product addition at 150 kg/Ha (0.015 kg/m^2)
Ag chemicals	kg/m^2	0.00015		Weedicides at 150 g/Ha

Table 4. Inputs for recreational turf maintenance

Sports field maintenance

Sports fields require a clean cover of turf laid on top of a sand base to provide an even playing surface with sufficient resilience and consistency. The higher standard of surface requires an increased attention to the health of the turf and hence more inputs than for recreational turf

Maintenance activity	Sports fields			Data from maintenance schedule of a sports field
Mowing fuel consumption	L/m²/y	0.0128		Mowing 2x per week over growing season (32) at 0.4ml/m²/mow (diesel fuel)
Rolling, aerating	L/m²/y	0.0064		Once per week equivalent energy use of mowing
Watering	L/m²/y	140		23,300 L/Ha/day for 20 weeks over the growing period
Fertiliser	kg/m²/y	0.50		Regular fortnightly fertilisation at 48 kg/Ha of 15:3:15 plus one off additions.
Nitrogen	kg/m²/y	0.052		NPK 5-5-5 added
Phosphorus	kg/m²/y	0.014		Super phosphate added
Potassium	kg/m²/y	0.056		Granular slow release granular fertiliser
Mineral additives	kg/m²/y	0.082		Gypsum, kieserite, trace elements
Ag chemicals	kg/m²/y	0.00019		Weedicide, pesticides, fungicides, preventative herbicides

Table 5. Inputs for sports field turf maintenance

Outputs

Product turf is expected to continue to live at the installation and is assumed not to be wasted at the end of its life in the particular installation. Other material inputs may be lost to the system and are then potentially environmental pollutants.

Wastes

Any material that comes off the site of a growing or installation site is lost to the turf system and may be considered as a waste. These wastes can have significant environmental impacts particularly fertiliser components that are predominantly emitted to the atmosphere as nitrous oxide (a potent Greenhouse gas) or discharged to surface and ground waters as nitrate.

Key wastes and predicted fate are given in table 6.

Material	Input rate kg/m²/y	Maintained in soil or turf	Lost to surface and ground waters	Lost to the atmosphere
Fixed carbon dioxide	1.61 (fixed by turf)	0.51 (soil organic carbon)	-	1.10 (CO_2)

Fertiliser nitrogen	0.0036	0.0021	0.0014	<0.0001 (N_2O)
Fertiliser phosphorus	0.0012	0.0007	0.0005	-
Fertiliser potassium	0.0012	0.0007	0.0005	-

Table 6. Estimated wastes from turf maintenance of lawns

The sequestration of carbon dioxide was an average result from our intensive study of six turf growers in Australia (Cumming, 2018). A study of urban turf greenhouse emissions provided the figures for organic carbon build up in the soil and the fate of fertiliser nitrogen (Townsend-Small & Czimczik, 2010). Fertiliser inputs given in this table are an average of lawn fertilisation rates measured in this study. Potassium and phosphorus have been assumed to behave in a similar manner to nitrogen.

Assumptions

The LCA outputs rely on the use of industry mean data being representative of a particular case of growing conditions cultivar use and installation geography and climate conditions. The variations in growing conditions can be allowed for with particular data for growing conditions. The installation location of the turf is not known and may vary significantly.

It has been the intent of this study to be conservative in estimation of material and energy use across the lifecycle of turf so that the environmental impacts provided are also conservative and reflect the potential for all significant material inputs.

The boundary conditions have excluded the impacts associated with infrastructure on the turf farm including the plant and equipment used. This avoids allocation issues as the farm and plant may well be used for functions other than turf growing. Farm infrastructure is likely to have a lifespan of 20–50 years or more and, other than land use, the impact associated with it is assumed to be minor.

Agricultural chemical use has been aggregated into the one of two categories: ag chemicals and mineral additives. The latter is likely to be a soil additive to correct for soil inadequacies such as pH or cation exchange capacity. Ag chemicals are many and varied and most of these have not been characterised in inventories so the impacts associated with their manufacture, transport and marketing have been consolidated into the few that have been characterised in the inventories used as a single chemical product.

Herbicides are the most common ag chemical applied to turf. These are synthetic chemicals generated from petrochemicals, one of the most common of these is MCPA (2-methyl-4-chlorophenoxyacetic acid), another is Simazine a triazine derivative. Nicotinoids are commonly used as pesticides on turf but the application rate is significantly lower than with herbicides.

Mineral additives are used in certain circumstances at a much greater application rate to improve the characteristics of the soils. Common minerals used are lime, dolomite and clay. As the use of minerals is sporadic the total minerals consumption was determined across the 20 growers studied and an average figure used.

	Total additions kg	Total additions / Total m^2 kg / m^2
Ag chemicals (n=17)	10,940	0.0012
Mineral additions (n=20)	329,324	0.071

Table 7. Other chemical additions

The fate of fertiliser additions is of concern as these present as nutrients for eutrophication of particularly water bodies. Studies of installations for sports fields and grower sites in this project has given a figure of an average loss of nitrogen of 60% of the total amount of N applied. 40% of the N applied is taken up and incorporated into the turf plant while the remaining 60% is lost to the system predominantly by water movement to drains or groundwater bodies. Individual circumstance vary such as sandy sites where the loss of water is rapid through the soil structure and clay based sites where an effective barrier holds the water in the soil and the predominant mechanism is run-off to surface water bodies.

Phosphorus losses were also measured in this study as the difference between the applied amount and that taken up by the turf pants

In either case the potential for eutrophication of the water body is similar and dependent on the nitrogen or phosphorus losses. These were measured at 59% loss of applied N and an 86% loss of applied P. In the maintenance stage of the turf lifecycle the applied N and P are assumed to be lost at a rate of 40%. (It could be argued that there are other loss mechanisms for nitrogen and that nitrogen can also be taken up by soil organisms. Similarly phosphorus can be held up in the soil by biological and chemical adsorption mechanisms. As such this analysis presents a worst case scenario for eutrophication potential.

LCA impact categories

Local impacts such as dusts, noise and odour have been discounted in this study as they cannot be adequately accounted for in an industry wide study. In some cases these impacts may well be important.

The major impacts associated with energy inputs directly into the activities studied and indirectly through material inputs are given in table 8.

Environmental impact	**Applicability to turf**	**Environ mental significa nce**	**Risk to grower**	**Risk to environment**	**Included in LCA**
Local air pollution	Unlikely	No		Unlikely	No
Energy resource use	Yes	Yes			Yes
Greenhouse emissions	Yes	No		Yes	Yes
Dust emissions	Unlikely	No	Yes	Unlikely	No
Odour emissions	Possible	Possible	Yes	Possible	No
Carbon sequestration	Yes	Possible		No	Yes
Water resource use	Yes	Yes	Yes	Yes	Yes

Surface water pollution	Yes	Yes	Yes	Yes	Yes
Surface water eutrophication	Yes	Possible	Yes	Yes	Yes
Ground water loss	Possible	Possible	Yes	Yes	No
Ground water pollution	Possible	Possible	Yes	Yes	No
Soil loss / erosion	Possible	Possible	Yes	Yes	Yes
Soil contamination	Possible	Yes	Yes	Yes	No
Land use / Biodiversity loss	Possible (Greenfield sites)	No	No		Yes
Land contamination	Possible	Yes		Yes	No
Noise pollution	Unlikely	No	Yes		No
Biodiversity	No	No			No
Human health impact	Possible	No			Yes

Table 8. Environmental impacts

While the environmental impacts of some risk to the environment may be present it may also not possible to quantify these impacts for the turf industry in general. The impacts in some cases are particular to a micro-location and it is not possible to generalise some particular impacts across the Australian turf industry.

The impacts that have been excluded based on this criterion are:

- Dusts
- Odour
- Groundwater pollution
- Soil/land contamination
- Noise

The other impacts have been examined in the LCA through mid-point analysis as described in Table 9.

The chosen environmental impact categories have the following units and measurement systems.

Environmental Impact category	**Units**	**Explanation** (M.A., 2018)
Land use	m^2	Land area used for production of one square meter of turf. There is no change of land use as turf is produced on the same area of land continuously
Climate Change (Global Warming)	kg (CO_{2-eq})	This is a measure of the equivalent amount of carbon dioxide released into the atmosphere over a 100 year time period. A negative value indicates that there is a net loss of carbon dioxide in the atmosphere
Carbon sequestration	kg (CO_{2-eq})	This is a measure of the actual amount of carbon dioxide extracted from the atmosphere by the plant turf during photosynthesis
Ozone depletion	kg (CFC-11_{eq})	Ozone depletion potential is measured as the equivalent amount of refrigerant CFC-11 emitted
Water consumption	m^3 (H_2O_{eq})	This is the amount of water consumed multiplied by the Water Stress Index averaged over Australia (WSI = 0.5)
Eutrophication	kg (PO_{4eq})	Eutrophication is taken as the sum of the nitrogen and phosphorus lost through run-off from the turf farm and installation that impinges on surface water systems. This is measured in phosphate equivalents
Acidification	kg (SO_{2eq})	Simply the acidification potential associated with turf from emissions to land water and air of acidic chemicals express as sulphur dioxide equivalents
Photochemical Ozone formation	kg $C_2H_{4\ eq}$	Predominantly air emissions with photochemical oxidation potential that can convert oxygen to ozone in the troposphere measured as ethylene equivalents
Toxicity	CTU_e /CTU_h	Toxicity to human health and the environment measured using USEtox methods for acute and chronic toxicity
Resource depletion (minerals)	kg Sb_{eq}	Total mineral stock abiotic depletion allowing for current reserves and the rate of de-accumulation expressed as kg of antimony
Resource depletion (fossil fuels)	MJ	Fossil fuel abiotic use expressed as megajoules

Table 9. Mid-Point Environmental Impacts and measures