Carbon Footprint Analysis of Operation and Maintenance of Northern California Golf Courses

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ABSTRACT

Golf course operations and maintenance involve energy and resource use to maintain consumer preferred conditions and these processes have an associated carbon footprint. As with any anthropogenic activity it is important to quantify the associated environmental effects in order to attain sustainable practices. By creating a golf course resource inventory and analyzing it using Carnegie-Mellon's EIO-LCA model, the WEST model, and LBNL's electrical generation model, I determined the overall carbon emissions of three Northern California golf courses. I compared these totals to the potential carbon sequestration from turfgrass growth on these courses, using the CENTURY model and then combined the figures to determine the carbon footprint. Agricultural chemicals, predominately fertilizers and pesticides, accounted for the largest annual source of carbon emissions with an average of 577 MT CO2e yr^{-1}. The greatest total carbon emission was 1337 MT CO2e yr^{-1} with a course average of 739 MT CO2e yr^{-1}. The largest individual footprint was Private Golf Club 1, with a net annual release of 1180.5 MT CO2e $yr^{-1}acre^{-1}$. The smallest individual footprint was Sunnyvale municipal, with a net annual release of 285.9 MT CO2e $yr^{-1}acre^{-1}$. The average footprint of those courses in this study was 739.2 MT CO2e yr^{-1}. I recommend reduced fertilization and pesticide use, fuel switching, and reduced water usage to reduce carbon emissions. Implementing these recommendations could affect course quality and may not be economically feasible, thus preventing adoption and carbon emission reduction.

KEYWORDS

Carbon sequestration, turfgrass, WEST model, CENTURY model, EIO-LCA

INTRODUCTION

Carbon accounting of sources and sinks of green house gases (GHG) can assist in identifying ways to reduce emissions in order to decrease the potential of further global environmental impacts (IPCC Synthesis report 2007). Land use change and land management have significant implications for reducing carbon sources and providing carbon sequestration sinks (West and Six 2007) and urban land management is an important factor that is often left out of global carbon estimates (Kaye et al. 2005). Life cycle analysis (LCA) of materials used in land management can be an important tool in defining the total carbon source associated with creating, using, and disposing of products in a particular land management regime (Rebitzer et al. 2004). Biogeochemical models that describe the net primary productivity of a plant species under variable environmental conditions, such as the CENTURY model, can assist in determining the potential of terrestrial carbon sequestration of a tract of land (Huh et al. 2008). LCA analysis combined with the CENTURY model can describe the overall carbon budget for urban land management procedures that will then help guide management decisions.

Introduction and management of turfgrasses in urban areas can create a terrestrial carbon sink (Pouyat et al. 2008). The CENTURY model, used in many studies addressing this sequestration phenomenon, evaluates biological parameters of growth, death, and decomposition of plant matter and has been adapted and applied to golf course turf. The potential carbon sink associated with the conversion of organic plant material into soil organic carbon (SOC) in a previous CENTURY model study shows that the rate of this process can be 0.9-1.0 t C ha^{-1} yr^{-1} on managed urban lands such as golf courses (Qian and Follett 2002). As managed turfgrass on golf courses encompasses approximately 1.5 million acres of land in the US these developed lands can offer a sizable terrestrial carbon sink to offset the carbon that is emitted in the managing of these lands (Environmental Institute of Golf 2007).

Terrestrial carbon sequestration potential depends on land management techniques. In agriculture, the management of inputs, such as fertilizers, herbicides, and pesticides, and tillage regime, factor heavily in creating a potential carbon sink (Sperow et al. 2003) and this is also true for urban land management (Pouyat et al. 2008). Golf course management practices also affect the carbon sink potential; types of grass used, turf grass clipping techniques, and age of the course are among some of the factors that affect its potential (Huh et al. 2008).

Golf course operations and maintenance can be highly energy and resource dependant and have a carbon footprint attributed to the upkeep of the land. The largest contributors to the carbon footprint are fossil fuels and electricity to power the landscaping machinery, water to maintain grass growth, fertilizers to increase and maintain turf health, and the imbedded carbon footprint in the landscaping machinery (Staples 2009). These factors vary depending on climate conditions like temperature and rainfall, utility energy mixture, grass type, and maintenance decisions. By creating an inventory of resources used for operations and maintenance for the upkeep of the golf course grass and then analyzing these inputs with an Economic Input-Output Life Cycle Analysis (EIO-LCA) model, a total carbon source inventory can be performed and recommendations for source reductions can be identified.

California golf courses offer a unique opportunity to perform a carbon footprint analysis. The Mediterranean climactic conditions in California create a relatively long vegetative growing season and low average annual precipitation. These conditions allow for a longer period for turf growth, allowing for lengthened carbon sequestration times, but also requiring more resources to maintain these grasses than in other parts of the country. Golf courses are highly water dependant and California golf courses, on average, demand three times more water than the national average (Environmental Institute for Golf 2009). Other regional factors affecting resource use, such as electrical energy mix, geography, and pesticide laws play a significant role in defining California as a unique area of interest in regard to golf course management practice.

By creating a golf course resource inventory and using EIO-LCA analysis to determine the overall carbon sources attributed to the operation and maintenance of golf courses and comparing it to the potential SOC sink of golf courses, using the CENTURY model, I have developed a model of carbon cycling related to golf course operations and maintenance in Northern California. I will determine if golf courses have the potential to be a carbon sink and I will identify the most significant sources for carbon used for the maintenance of these lands. I hypothesize that, under conditions of high annual precipitation, moderate temperature and a reduced carbon intense management regime, a golf course can be managed to become a potential carbon sink. I also hypothesize that the largest sources for carbon in the operation and maintenance of California golf courses will center on the acquisition, distributing and pumping of water.

METHODS

Study sites

California consists of many microclimates, and resource use on its 1,187 golf courses varies depending on land management practices. I gathered data on the operation and maintenance of 3 Northern California golf courses, which included public and private 18 and 36 hole courses. The survey was conducted from January to March 2010 and inquired about the previous five years of resource use and inventory data from each individual golf course. The golf course data was collected from the golf course superintendents who are responsible for the operation and maintenance of golf course grounds, including but not limited to the following: purchasing of equipment and fuel, allocation of fertilizers and pesticides, irrigation management, managing of golf course maintenance workers, and overall turf management.

Inventory Survey

I collected survey information from golf courses identified from a snowball sampling technique from January 2nd to March 30th 2010 by contacting a representative of the Northern California Superintendents Association, Jim Husting. He then referred me to other superintendents throughout California that were interested in participating in this study. Survey questions were determined by interviewing local golf course superintendents, personal golf course knowledge and reviewing relevant maintenance literature.

Resource use and physical inventory data for the upkeep and maintenance of the golf course was requested for the previous five years in order to reduce year-to-year variance. I defined inventory categories into property, machines, fossil fuels, utilities, and agricultural chemicals, while further delineating each category in order to create a comprehensive inventory. The questions were framed to inquire about annual financial data and physical amount data (Appendix 1).

I created an online survey inquiring about the resources used for golf course operations and maintenance. This data was collected from course superintendents from available inventory and purchasing records. I used the web service Survey Gizmo to create the 5-part survey (Appendix 1). I then distributed the surveys to my sample pool via email and received the results on the Survey Gizmo website.

Spreadsheet model

I determined carbon emission totals by processing the summary statistics identified in the survey in an Excel spreadsheet model that converts the resource use data from the survey into the total carbon dioxide equivalents (CO2e). The carbon conversion factors used in the model have been determined using the Carneige-Mellon EIO-LCA that converts economic data into CO2e by analyzing exchanges in different industry sectors (Carnegie Mellon University Green Design Institute 2010), the Lawrence Berkeley National Laboratory (LBNL) electric utility emission factor (Marnay et al. 2002) and the Water Energy Sustainability Tool (WEST) that defines emission factors for municipal water in California (Stokes and Horvath 2009).

Total carbon sequestration data was calculated using Qian and Follet's 2002 findings regarding turfgrass sequestration potential and multiplying it by the area of the managed lands on each individual golf course. This finding was calculated by physical sampling of turfgrass soils and through the CENTURY computer model and shown to have statistical significance.

Survey data analysis

After survey data collection and processing in the spreadsheet model, I calculated carbon total summary statistics on the levels of individual golf courses and between the sample pool. Individual golf course statistics were summarized from the previous years and averages were determined. The individual averages were intended to be used at the regional and statewide statistics, but due to a low response rate the analysis reflected only the individual level.

RESULTS

Survey response

Three golf courses in Northern California participated in this study. The largest area of maintained turfgrass was 173.6 acres and the average maintained area was 146.9 acres. The average number of rounds of golf played per year was 57,401. The different families of turfgrass that were used on the courses surveyed were poa, agrostis, and lolium commonly referred to as poa, bentgrass, and rye grass respectively. The average size specific maintained grass areas were: 3.7 acres of tee boxes, 39.6 acres of fairways, 3.7 acres of greens and 95.3 acres of rough, for a total average of maintain turfgrass of 146.9 acres. Survey results for individual course parameters are found in table 1.

Course	Tee box	Fairway	Rough	Green	Practice area
Private 1	2.5 acres	35 acres	130 acres	3.6 acres	2.5 acres
Sunnyvale	4.6 acres	34 acres	70 acres	4.6 acres	10 acres
Private 2	5.0 acres	50 acres	86 acres	3.0 acres	N/A

Table 1.Golf Course Turfgrass Land Use Parameters. Estimated golf course turfgrass land use types.

Carbon equivalent contribution

Equipment used for turfgrass maintenance accounted for the largest one time source of carbon contribution but the contribution is apportioned to an estimated 10yrs of use, yielding a course average of 25.6 MT CO2e yr^{-1}. This category was broken up into mechanical equipment and non-mechanical equipment, which included irrigation related materials, with an average carbon equivalent contribution of 25.6 MT CO2e yr^{-1} and 2.3 MT CO2e yr^{-1}, respectively. The greatest total carbon contribution value found was 29.3 MT CO2e yr^{-1} at Private course 2 (P2).

Municipal water use averaged 71.2 MT CO2e yr^{-1}. The greatest amount of municipal water used by a single course was by Sunnyvale at 171,166 m^3/yr resulting in a carbon equivalent of 213.0 MT CO2e yr^{-1}. Private Course 1 (P1) had water rights to an adjacent river so the only attributable carbon emissions for water use are imbedded in the fossil fuel use from pumping. P2 municipal water use carbon emission contribution was negligible at 0.7 MT CO2e yr^{-1}, as they too had water rights to a local aquifer.

Electrical utility usage contributed an average of 16.9 MT CO2e yr^{-1} to the overall carbon footprint. P1 had the largest amount of annual electricity use and the associated carbon emission accounted for 26.2 MT CO2e yr^{-1}.

Average annual fossil fuel use was, 18,320 gal/yr which accounts for a carbon emission rate of 46.1 MT CO2e yr^{-1}. Diesel is the primary fuel used to power the maintenance equipment, at an average of 57% of total fuel usage. Unleaded gasoline constitutes an average of 43% of fuel usage.

Agricultural chemicals such as fertilizers, insecticides, and pesticides showed the most course to course usage variance. P1 used the most annual fertilizer which had a carbon equivalent of 1176.3 MT CO2e yr^{-1}, whereas Sunnyvale had a carbon equivalent of 16.3 MT

CO2e yr^{-1}. Fertilizer usage accounted for the largest average annual course contribution at 482.3 MT CO2e yr^{-1}. Insecticides and pesticides accounted for an average annual course contribution of 94.7 MT CO2e yr^{-1}, see table 2.

Miscellaneous equipment, such as boundary stakes, rakes, and ball washers accounted for a negligible contribution to annual course carbon equivalent. The average annual course contribution was less than 0.02 MT CO2e yr^{-1}.

Course	Water	Electricity	Fossil fuels	Chemicals
P1	N/A	26.2 MT CO2e yr^{-1}	45.4 MT CO2e yr^{-1}	1240 MT CO2e yr^{-1}
Sunnyvale	213.8 MT CO2e yr^{-1}	13.9 MT CO2e yr^{-1}	17.6 MT CO2e yr^{-1}	144.3 MT CO2e yr^{-1}
P2	0.72 MT CO2e yr^{-1}	13.9 MT CO2e yr^{-1}	75.2 MT CO2e yr^{-1}	346.7 MT CO2e yr^{-1}

Table 2. Carbon Contribution for Maintenance Materials. Carbon dioxide equivalent emissions from spreadsheet model calculation

Carbon sequestration

Annual course carbon sequestration varied due to size of the maintained area. P1 had the largest maintained turf area, 173.6 acres, with a carbon sequestration potential of 156.6 MT CO2e yr^{-1}. P2 had the smallest turf area, 144 acres, with a carbon sequestration potential of 112.5 MT CO2e yr^{-1}. The course average for annual sequestration rate was 132.9 MT CO2e yr^{-1}.

Carbon footprint

The totals for individual course carbon emission contributions and sequestrations were combined to show the overall carbon footprint for each individual course, see figure 3. Sunnyvale municipal had the smallest footprint, with a net annual release of 285.9 MT CO2e yr^{-1}. The largest individual footprint was P1, with a net annual release of 1180.5 MT CO2e yr^{-1}. The average footprint of those courses in this study was 606.3 MT CO2e yr^{-1}, see table 3.

Course	Carbon contribution	Carbon sequestered	Net annual carbon
P1	1337.1 MT CO2e yr^{-1}	156.6 MT CO2e yr^{-1}	1180.5 MT CO2e yr^{-1}
Sunnyvale	415.5 MT CO2e yr^{-1}	129.6 MT CO2e yr^{-1}	285.9 MT CO2e yr^{-1}
P2	465.0 MT CO2e yr^{-1}	112.5 MT CO2e yr^{-1}	352.5 MT CO2e yr^{-1}
Average	739.2 MT CO2e yr^{-1}	132.9 MT CO2e yr^{-1}	606.3 MT CO2e yr^{-1}

Table 3. Total Annual Carbon Flux. Calculated carbon equivalent from spreadsheet model.

DISCUSSION

Golf courses could be managed in a way that would approach carbon neutrality. Golf course 3 and 5 had net annual carbon emission rates that could be offset with relatively small management adjustments, such as switching from petroleum diesel to local biodiesel, reducing the amount of municipal water used for watering waste areas, and by implementing better fertilizer and pest management regimes. For example, P2 had a carbon emission of 64.3 MT CO2e yr^{-1} from diesel petroleum, if biodiesel replaced the current petroleum diesel used it could reduce that portion of the carbon footprint by up to 90% (Parikhit and David 2007). Irrigation strategies that reduced the overall watering regime by 20-40% of evapotranspiration rates have shown to still yield adequate turf conditions (DaCosta and Huang 2005), this reduction could account for 0.8 MT CO2e yr^{-1}. Optimizing fertilizer application techniques to reduce the overall usage would also effect the overall footprint but the turf quality may be impacted.

A study by a group of Cornell graduate students looked at the footprint of Bethpage Black, a course in New York State (Portnes et al. 2008). Using conversion factors for fuel combustion, to run the maintenance machines, and electricity generation to operate the irrigation pumps, they concluded that carbon neutrality is possible. They did not quantify the carbon footprint of the landscaping machines, agricultural chemicals, or municipal water use, resulting in a carbon footprint metric that was much closer to carbon neutrality than this study because it omitted a significant source of carbon associated with course operation and maintenance.

The EIO-LCA model used in this study is a comprehensive and conservative estimator for the transfer of economic units between industries and the associated GHG's tied to these transactions (Carnegie Mellon University Green Design Institute 2010). Each LCA analysis technique uses unique metrics for assessing the carbon emitted during the life cycle of a product, resulting in large differences in the end value for similar products assessed in different LCA analyses (Lee et al. 1995, Real et al. 2008). Therefore, this study should be interpreted as a conservative analysis to grasp the largest range for carbon emitted in the processes that were considered in operation and maintenance of golf course landscape. I recommend that in future studies that the most comprehensive estimates in order to account for the variance in EIO-LCA analysis.

Due to the small number of participants this study is limited to assessing these courses and does not offer sufficient data to be representative of the region or all golf courses. The outcome of this study offers a conservative assessment of carbon emissions from operation and maintenance resource use and the imbedded CO2 sequestration potential to offset these emissions for these particular courses. As shown in the results, this offsetting potential can reduce the net carbon emission by 22% on average. This conservative calculation suggests that golf course operation and maintenance, if optimized, could approach carbon neutrality. In order make this claim on a large scale; a larger data set would be needed. Incentives to respond to resource use surveys have been shown to yield a stronger participation rate in other golf course resource use related studies, such as the Environmental Institute of Golf's study on water use and energy use (Throssell et al. 2008). Another means of obtaining a strong data set would be to recruit an organization, such as the NCGA, to back the project. Having an institution that is known by golf course superintendents would elicit a better response.

This study offers a look into the life cycle and carbon cycle of recreational activity, few of which have been conducted. This may be due to the limited economic incentive to make recreational activities more efficient or it could be a social dynamic that does not view these activities as having negative environmental potential. This study offers a look at how a resource intense recreational activity impacts the environment. It also creates an opportunity for further studies to be done on other turfgrass recreational activities such as baseball, football, and soccer.

Golf is a game that has a high per capita resource use, which should encourage environmentally conscious superintendents and managers to take a look at their overall environmental footprint. While study shows that golf courses could be carbon neutral, it represents a very small portion of the larger sample pool of golf courses and even in this small sample size it would be hard to identify the correct action to achieve carbon neutrality. The trade off of reducing resource use also may have a negative impact to the quality of the turfgrass playing conditions which may further reduce the likelihood of resource reduction. It is important to further this type of study and expand a similar survey to the greater golf community, as groups like the Environmental Institute of Golf have done. It is everyone's responsibility to monitor his or her own resource use and practice environmental responsibility both on and off the course.

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APPENDIX 1

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Carbon Cycle Survey for Golf Course Operation and Maintenance
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Introduction
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1. Would you or your company like to remain anonymous?
   ( ) Yes
   ( ) No

2. Would you be interested in a copy of the final product?
   ( ) Yes
   ( ) No

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Course Infrastructure
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Course Information
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3. First Name

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4. Last Name

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5. Title

   ____

6. Company Name

   ____

7. Street Address

   ____

8. Apt/Suite/Office

   ____

9. City

   ____

10. State

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11. Postal Code

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12. Country

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13. Email Address

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14. Phone Number

____

15. Fax Number

____

16. Mobile Phone

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17. URL

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18. Course Land Use Types (area)

Please include information on land use types on the golf course.

Can be expressed in any form- acres, hectares, meters/feet squared

Tee _________________
Fairway _________________
Green _________________
Rough _________________
Bunker _________________
Trees and Shrubs _________________
Water _________________
Driving Range _________________
Practice Area _________________
Cart Path _________________

19. Grass types

Please include information on both the perennial grass used and any type of filler grass used.

Tees _________________

Fairways ________________
Greens ________________
Rough ________________

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Maintenance Equipment
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20. Mowing Equipment (make, model and number in fleet)

Please include information on all types of mowers used for maintenance.

Fairway Mower ________________
Rough Mower ________________
Green Mower ________________
Trim and Surrounds Mower ________________
Landscape Mower ________________
Miscellaneous Mower 1 ________________
Misc. Mower 2 ________________
Misc. Mower 3 ________________
Misc. Mower 4 ________________
Misc. Mower 5 ________________

21. Tractors (make, model and # in fleet)
Tractor Type 1 ________________
Tractor Type 2 ________________
Tractor Type 3 ________________
Tractor Type 4 ________________
Tractor Type 5 ________________

22. Utility Vehicles (make, model, and # in fleet)

Please include information on all non-mowing utility vehicles, including but not limited to: golf carts, turf vehicles, and trucks.

Vehicle Type 1 ________________
Vehicle Type 2 ________________
Vehicle Type 3 ________________
Vehicle Type 4 ________________
Vehicle Type 5 ________________

23. Specialty Equipment- Mechanical (make, model and # in fleet)

Please include information on powered machinery that is used in course maintenance.
Aerator Type 1 ________________
Aerator Type 2 ________________
Aerator Type 3 ________________
Liquid Sprayer Type 1 ________________
Liquid Sprayer Type 2 ________________
Liquid Sprayer Type 3 ________________
Liquid Sprayer Type 4 ________________
Bunker Rake Machine ________________
Bunker Rake Attachment ________________
Sweeper ________________
Debris Vacuum ________________

Debris Blower ________________
Seeding Machine ________________
Sod Cutter ________________
Misc. Machine 1 ________________
Misc. Machine 2 ________________
Misc. Machine 3 ________________
Misc. Machine 4 ________________

24. Miscellaneous Powered Hand Tools (make, model and # in use)

Please include all information on powered equipment that is used in maintenance.
Leaf Blower ________________
Chainsaw ________________
Weed Whacker ________________
Miscellaneous 1 ________________
Misc. 2 ________________
Misc. 3 ________________
Misc. 4 ________________
Misc. 5 ________________
Misc. 6 ________________

25. Non-powered Hand Tools (type and # in use)

Please include information on all non-powered hand tools that are in use for landscape maintenance, including but not limited to; rakes, shovels, green rollers, ect.
Type 1 ________________
Type 2 ________________
Type 3 ________________
Type 4 ________________
Type 5 ________________
Type 6 ________________
Type 7 ________________
Type 8 ________________
Type 9 ________________
Type 10 ________________
Type 11 ________________
Type 12 ________________
Type 13 ________________
Type 14 ________________
Type 15 ________________

26. Irrigation Use (producer, material type, annual length/amount, annual cost)

Please include information on the annual irrigation equipment used. Can be expressed as any metric- ft/yr, lbs/yr, $/yr, ect.
Irrigation Pump 1 ________________
Irrigation Pump 2 ________________
Irrigation Pump 3 ________________
Irrigation Pump 4 ________________
Irrigation Pump 5 ________________
Irrigation Pipe 1 ________________
Irrigation Pipe 2 ________________
Irrigation Pipe 3 ________________
Irrigation Pipe 4 ________________
Irrigation Pipe 5 ________________

Sprinkler Head 1 ________________
Sprinkler Head 2 ________________
Sprinkler Head 3 ________________
Sprinkler Head 4 ________________
Sprinkler Head 5 ________________
Miscellaneous Irrigation Equipment 1 ________________
Misc. Irrigation Equipment 2 ________________
Misc. Irrigation Equipment 3 ________________
Misc. Irrigation Equipment 4 ________________
Misc. Irrigation Equipment 5 ________________
Misc. Irrigation Equipment 6 ________________
Misc. Irrigation Equipment 7 ________________
Misc. Irrigation Equipment 8 ________________
Misc. Irrigation Equipment 9 ________________
Misc. Irrigation Equipment 10 ________________

27. Miscellaneous Machinery (type, producer, make, model and # in fleet)

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Resource Use
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28. From what year is the data being drawn from?

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29. Utility Usage (provider, annual usage, and annual cost)

Please include information on utilities used. Can be expressed in any metric- kW/yr, gal/yr, $/yr, ect.

Electricity ________________
Natural Gas ________________
Municipal Water ________________

30. Fuel (annual amount and annual cost)

Please include information on annual fuel usage. Can be expressed in any metric- gal/yr, lbs/yr, $/yr, ect.

Unleaded Gasoline ________________
Diesel Gasoline ________________
Motor Oil ________________

31. Fertilizer Types (producer, annual weight, and annual cost)

Please include information on annual fertilizer use. Can be expressed in any metric- lbs/yr, kg/yr, $/yr, ect.

Type 1 ________________
Type 2 ________________
Type 3 ________________
Type 4 ________________
Type 5 ________________
Type 6 ________________
Type 7 ________________

Type 8 ________________
Type 9 ________________
Type 10 ________________

32. Insecticide, Herbicide, and Fungicide Use (producer, annual weight, and annual cost)

Please include information on annual pesticide use. Can be expressed in any metric- lbs/yr, kg/yr, $/yr, ect.
Type 1 ________________
Type 2 ________________
Type 3 ________________
Type 4 ________________
Type 5 ________________
Type 6 ________________
Type 7 ________________
Type 8 ________________
Type 9 ________________
Type 10 ________________

33. Miscellaneous Chemicals (producer, annual amount, and annual cost)

Please include information for miscellaneous chemicals used. Can be expressed in any metric- lbs/yr, gal/yr, $/yr, ect.
Miscellaneous Chemical 1 ________________
Misc. Chemical 2 ________________
Misc. Chemical 3 ________________
Misc. Chemical 4 ________________
Misc. Chemical 5 ________________
Misc. Chemical 6 ________________
Misc. Chemical 7 ________________
Misc. Chemical 8 ________________
Misc. Chemical 9 ________________
Misc. Chemical 10 ________________

34. Landscaping materials

Please include all materials used in maintaining the physical landscape of the golf course. Can be expressed in any metric- lbs/yr, ft3/yr, $/yr, ect.

Grass seed type 1 ________________
Grass seed type 2 ________________
Grass seed type 3 ________________
Grass seed type 4 ________________
Sod ________________
Concrete ________________
Mulch ________________
Sand ________________
Stone ________________

35. Tee and green supplies
Please include information regarding the equipment used for tee boxes, boundaries and greens. Can be expressed in unit amount or monetary cost amount
Flag poles ________________
Flags ________________
Cups ________________
Cup/hole puncher ________________
Tee markers ________________

Ball washers _________________
Divot mix containers _________________
Boundary stakes _________________
Yardage stakes _________________
Yardage markers _________________
Misc. _________________
Misc. _________________
Misc. _________________

36. Miscellaneous Resources (type, producer, annual amount used)

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____
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********This section was repeated five times to capture five years of data********