Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Virginia Agricultural Experiment Station ***Bulletin 01-2***

The Economics of Turfgrass in the Commonwealth of Virginia

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December 2001

This publication is available at http://vaes.vt.edu/research/publications/index.html

ABSTRACT

This study provides an assessment of the economics of turfgrass in Virginia. Turfgrass production is defined as a demand item, and demand for turfgrass causes various economic activities such as provision of sod, seed, fertilizer, turfgrass equipment, labor, and turf services. Thus, turfgrass is viewed as a demand-pull system. An input-output model was applied using the IMPLAN system and data from a 1998 Virginia Agricultural Statistics Service survey. The results of the input-output estimates indicate that during 1998, turfgrass establishment, management, and maintenance activities added over $2.1 billion in economic output and over $1 billion in value added to the economy of Virginia. To put the economics of turfgrass production into a meaningful context, various industry professions were identified and surveyed. The survey to turfgrass professional inquired about past, present, and future trends in turfgrass production, management, and technology. Among other findings, the results indicate that turfgrass production is changing markedly because of increases in quality expectations, labor costs, and environmental and regulatory concerns. Turfgrass production appears to be shifting away from the use of semiskilled labor and is instead developing a smaller, more educated labor force that more extensively employs machinery and other technology. Spatial analysis is used to asses changes in various turfgrass demand factors (for example, population and housing starts) across the Commonwealth. The study results indicate that turfgrass demand has been increasing rapidly in northern and central Virginia while demand has been slowly increasing or even decreasing in the southern and southwestern portion of the Commonwealth.

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INTRODUCTION

Turfgrass can be found throughout the Commonwealth on roadsides, golf courses, home yards, and elsewhere. In fact, nearly 1.4 million acres of turfgrass are estimated to be maintained in Virginia, accounting for about 5.4 percent of the state's total land area. If turfgrass were considered a crop, it would rank first in the state in acreage (Table 1).

Table 1: Turfgrass and Ten Top Acreage Crops

Crop	*Acres in 1,000*	*Rank*
Turfgrass	1,369	n/a
Hay	1,260	1
Soybeans	480	2
Corn (for grain)	300	3
Wheat (winter)	245	4
Cotton (lint and seed)	91	5
Peanuts	75	6
Barley	70	7
Tobacco	45	8
Apples	17	9
Potatoes (summer)	6	10

Source: VASS

Undoubtedly, turfgrass provides many benefits by improving the appearance and functionality of both urban and rural environments. While turfgrass is often grown for aesthetic purposes, turfgrass production is best characterized as an economic process in which land, labor, fertilizer, and other inputs are used to produce an output. The procurement and use of these inputs will affect the economy of the Commonwealth—and the economy of the Commonwealth will affect turfgrass production.

The objective of this study is to describe many of the important economic attributes of turfgrass production in Virginia. The next section provides a description of turfgrass production in the Commonwealth, including a discussion of who produces turfgrass and how it is produced. The document continues with an analysis of the economic effects of turfgrass production on the Virginia economy. The final section provides a more dynamic description of how various economic factors are affecting turfgrass production.

In this report, turfgrass production refers to any activity that is performed for the purpose of directly establishing or maintaining turfgrass. Institutions that perform such tasks are considered to be turfgrass producers, regardless of their primary industry. For example, golf courses, sod farms, cemeteries, and many businesses are all turfgrass producers even though they are in different industries. Only the turfgrass production activities of these institutions are of concern.

Economic impact studies are typically concerned with the impact of a given firm or industry on an economy. Studies sometimes refer to the turfgrass industry and endeavor to derive the impact of the industry on a region's economy. However, this terminology can be confusing since the authors are generally referring to the turfgrass production activities of firms and institutions in a variety of industries. As defined by the MIT dictionary of Modern Economics, an "industry" is "a large number of firms competing with each other in the production of a homogeneous product." The important point is that the firms in an industry must compete. Competition implies not only that a common product is produced, but also that it is produced *for sale.* Thus, the turfgrass industry would refer to a set of firms engaged in turfgrass production and selling turfgrass in the market. However, most turfgrass producers do not sell turfgrass and, therefore, do not compete with each

other in their capacity as turfgrass producers. Such firms are not in the same industry even though they produce a common output. For example, golf courses and apartment complexes both produce turfgrass, but they clearly are not in the same industry.

This distinction reveals some important aspects of turfgrass production, most notably that turfgrass is produced by a variety of individuals and firms. Each type of agent will tend to employ different technologies and management practices to turfgrass production. Thus, turfgrass production cannot be characterized as a homogeneous process. In this study, production is assumed to be homogeneous within the various groups of agents; therefore, a description of turfgrass production is developed for each group.

TURFGRASS PRODUCERS IN THE COMMONWEALTH

Demand for turfgrass cannot be characterized in the same way as demand for most products. Generally, an agent demands a product and purchases it in the marketplace. However, turfgrass cannot be purchased as a single product. Rather, turfgrass demand results in the purchase of a set of goods and services such as seed, turfgrass maintenance, water, agricultural chemicals, and sod installation services. As such, turfgrass demanders are also viewed as producers although some or all of the production activities may be contracted to other agents. For example, when a homeowner demands turfgrass for her yard, she might purchase the necessary inputs and produce the turfgrass herself or she might hire a firm to produce it. In either case, this homeowner can be considered a producer, although in the latter case she has contracted the job to a firm.

Many types of economic agents demand turfgrass. The resulting heterogeneity of turfgrass production makes it impossible to describe turfgrass demanders as a single group. Instead, turfgrass demanders are grouped into categories within which individual agents are expected to display similar production characteristics. The turfgrass demand characteristics of agents can then be summarized by category to produce meaningful descriptions. In the present study, nine categories of turfgrass demanders were identified (Table 2).

Table 2. Turfgrass Users

Category
Home Owners (Home Lawns)
Airports
Golf Courses
Cemeteries
Churches
Highway System (VDOT)
Parks
Schools
General Areas (business and multifamily dwellings)

In addition to turfgrass demanders, other agents participate in turfgrass production. The present study also considers firms that produce (sod farms) or maintain turfgrass (turf service firms) as their primary economic activity. These firms are viewed as suppliers of turfgrass production inputs and contracted services, respectively. These firms can be considered turfgrass producers but not turfgrass demanders.

TURFGRASS SURVEY

Most types of turfgrass producers were represented in the 1998 Virginia Turfgrass Survey conducted by the Virginia Agricultural Statistics Service (VASS). The survey was distributed to individuals, firms, and institutions in each of the nine classifications. The survey forms sent to each type of respondent were modified to address differences in the attributes of each group. However, the survey forms were very similar, and most of the questions have a comparable counterpart on all survey forms. All of the survey forms have questions intended to provide the data necessary to estimate the following:

1. amount of turfgrass grown
2. employment
3. equipment expenses (purchases, depreciation)
4. area and cost of new turfgrass established during the year
5. spending in various categories, broken down by contracted and "own" expenses
6. proportion of spending out-of-state and in-state for various expenditure categories

Further, survey forms sent to turf service firms and sod producers included questions addressing sod related revenue. Overall, 3,381 surveys were completed (Table 3).

Table 3. Population, Sample, and Questionnaires by Category

Category	*Population*[1]	*Sample*[1]	*Questionnaires Returned*	*Percent Returned*
Home lawns	2,035,700	10,000	2,346	23.5
Airports	68	68	26	38.2
Golf Courses	318	333	202	63.5[2]
Cemeteries and Churches	8,528	630	206	2.4
VDOT	1	1	1	100.0
Parks	206	206	72	35.0
Schools	307	294	79	26.9
General Areas	25,950	2,872	233	8.1
Service Companies	2,205	2,023	206	10.2
Sod Farms	19	25	10	52.6[2]

[1] Numbers from VASS.
[2] Based on population, not sample size.
Source: VASS, 2000

Virginia's turfgrass demand sectors spent an estimated $1.74 billion on turfgrass establishment and maintenance activities during 1998. About a quarter of this expense was contracted through the turf service sector. The largest share (37 percent) of the demand sectors' direct (non-contracted) expense was for equipment purchase and leasing (Figure 1). This expense is followed by supplies and miscellaneous expenses (25 percent), labor (18 percent), parts and repairs (14 percent), and pesticides (6 percent).

The expenditure pattern was similar across the sectors (Table 4). Labor and equipment costs generally accounted for most turfgrass related expenditures. Expenditures on all other items tended to make up about a quarter to a third of total turfgrass expenses. However, the proportionate expenditure pattern of households differs from the other sectors due to a markedly lower labor expense. Assumably, this difference results from the substitution of unpaid family labor for paid labor.

Figure 1. Breakdown of Total Estimated Turfgrass Related Expenses (Demand Sectors)

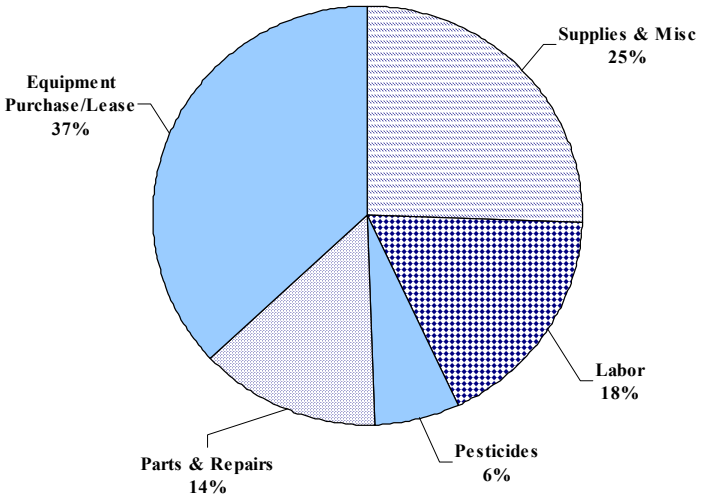


Table 4. Breakdown of Estimated Total Turfgrass Establishment and Maintenance Expenditure by Sector

Category	*Supplies & Misc.*	*Labor*	*Pesticides*	*Parts & Repairs*	*Equipment Purchase/ Lease*	*Contracted*
	----------%----------					
Airports	4.0	39.0	1.0	4.0	47.0	5.0
Cemeteries	5.0	44.0	1.0	9.0	21.0	21.0
Churches	9.0	18.0	1.0	9.0	14.0	49.0
General Areas	7.0	26.0	2.0	4.0	11.0	52.0
Golf Courses	12.0	52.0	8.0	10.0	17.0	1.0
VDOT	4.0	31.0	7.0	0.0[1]	12.0	46.0
Parks	14.0	39.0	1.0	8.0	27.0	0.0
Schools	9.0	68.0	3.0	10.0	9.0	0.0
Home Lawns	23.0	5.0	5.0	12.0	33.0	22.0
Sod Producers	29.0	43.0	3.0	5.0	20.0	0.0

[1] VDOT does not separate out repairs and maintenance by activity

While proportionate expenditures were similar across sectors, large differences occurred in per acre expenditures. Per acre expenditures were lowest for highways and airports while owners of single-family homes and golf courses spent the most. Per acre expenditures ranged from $76 on highways to $3,300 on golf courses (Table 5).

Table 5. Estimated Average Per Acre Turfgrass Related Expenditures by Sector

Category	*Non-contracted*	*Contracted*	*Total*	*Percent*
	----------$/acre----------			
Home Lawns	1,380	386	1,766	72.2
General Areas	594	635	1,230	15.1
Golf Courses	3,266	34	3,300	6.4
VDOT	41	35	76	1.3
Schools	524	n/a	524	1.3
Parks	807	n/a	807	1.2
Cemeteries	1,028	275	1,303	1.1
Churches	511	487	997	0.9
Sod Producers	1,535	n/a	1,535	0.4
Airports	112	5	118	0.1
Overall	**959**	**318**	**1,277**	

Source: VASS

Home lawns accounted for over half the Commonwealth's estimated maintained turfgrass acres in 1998. The Virginia Department of Transportation (VDOT) maintained about 290,000 acres along Virginia roads and highways, accounting for about 21 percent of the maintained turfgrass in the state. Most of the remaining amount could be found on general areas such as commercial properties and multifamily dwellings (Table 6).

Table 6. Estimated Turfgrass Acres, 1998

Industry	*----------Acres-------*	
	1,000	%
Home Lawns	714.0	52.2
VDOT	290.0	21.2
General Areas	215.0	15.7
Schools	43.2	3.2
Golf Courses	33.9	2.5
Parks	26.4	1.9
Cemeteries	15.4	1.1
Churches	15.6	1.1
Airports	10.2	0.7
Sod Farms	4.8	0.4
Total	**1,368.5**	**100**

Source: VASS.

Since per acre expenditures differ across sectors, the pattern of total turfgrass related expenditures differs from the breakdown of acreage. While home lawns account for about 52 percent of turfgrass acreage, about 73 percent of total turfgrass related expenditures were made to maintain these areas. About 15 percent of total turfgrass related expenditures went to the maintenance of turfgrass on general areas. Further, while golf courses account for only about 2.5 percent of the turfgrass acres in Virginia, about 6 percent of turfgrass related expenditures went toward establishment and maintenance of these areas (tables 5 and 6).

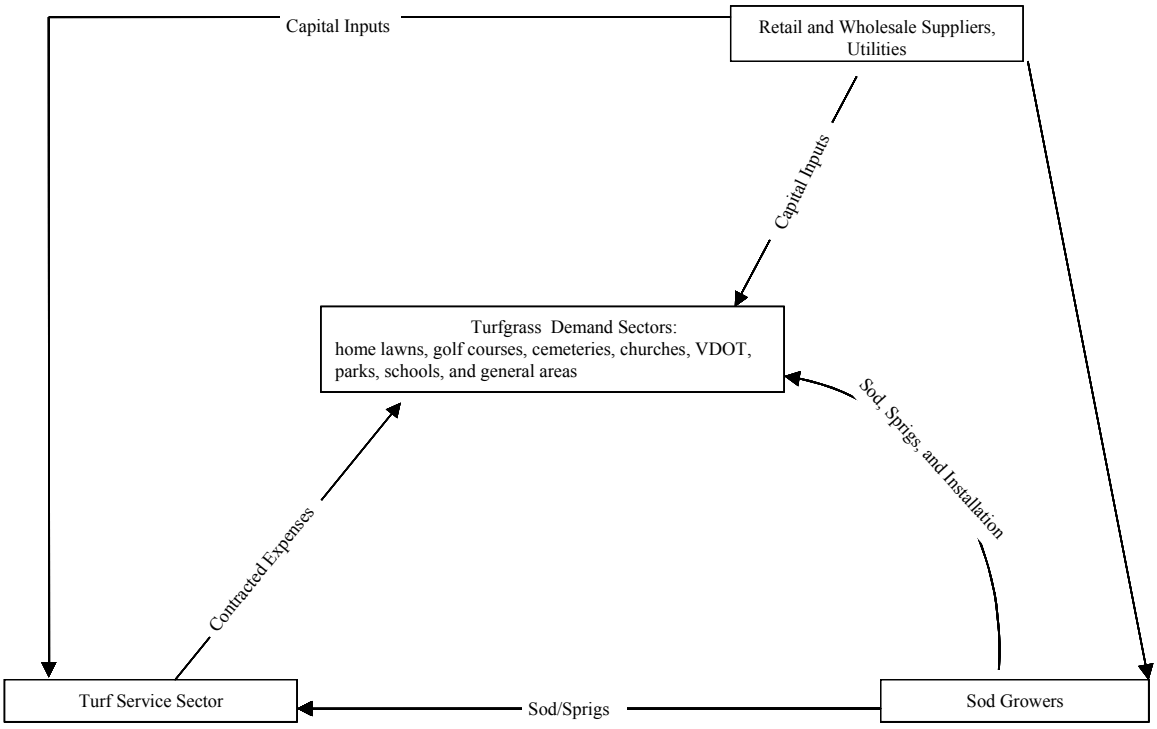
FLOWS OF GOODS AND SERVICES IN THE TURFGRASS SECTOR

Looking at individual categories is useful in understanding the production sector. However, the goal is to provide a description of turfgrass production overall. If no trade took place between the turfgrass production sectors, one could simply sum the expenditures of each type of producer to obtain an estimate of overall expenditure. However, trade does occur. Therefore, inputs purchased from other turfgrass producers must be netted out to avoid double counting. Specifically, sod, sprigs, installation services, and maintenance services are purchased from sod growers and the turf service sector.

When describing the flow of goods and services in turfgrass production, explicitly differentiating the turfgrass demand and supply sectors is useful. Turfgrass demand sectors produce turfgrass for their own use, and turfgrass production is not their primary economic activity. Turfgrass supply sectors provide turfgrass production inputs and services to the demand sectors.

Figure 2 represents the flow of goods and services among turfgrass producers. Generally, turfgrass demanders can either purchase inputs directly from sod growers and the retail sector or they can purchase inputs indirectly from the turf service sector. "Contracted expenses" in the VASS survey are assumed to represent such indirect purchases plus labor and value added by the service sector.

Figure 2. Flows of Goods and Services



Turfgrass Revenues and Expenses Reconciliation

If all turfgrass service firms properly represented their revenues, one would expect the sum of all estimated expenses in the demand sector to equal the estimated total cost of the turf service sector plus a reasonable margin. Turf service firms reported receiving an average of about $323,000 per firm in compensation for turfgrass related services. The survey data implied that this $665 million represents about 98 percent of their total income and came from customers located in the Commonwealth. However, the total estimated contracted expenses of the demand sectors is only about $436 million, leaving about $310 million unaccounted for. This difference implies that either or both of the values may be incorrect.

Two likely explanations can be given for this apparent discrepancy. First, turf service firms may have overrepresented their total receipts by including revenues from activities that are not directly related to turfgrass installation and management. For example, landscaping firms may have included revenues from

activities such as patio construction and installation and maintenance of trees and shrubbery. If this were the case, total revenue would not be expected to equal the turfgrass-related contracted expenses of the demand sectors. Second, contracted expenses may have been underestimated in the demand sectors.

The total estimated expenses of the turf service sector closely match the estimated contracted expenses of the demand sectors. One would expect the total expenditures of the service sector to be slightly less than the contracted expenses of the demand sectors because the service sector adds value.[1] Based on the survey data, the turf service sector has an approximately 22 percent profit margin on turf service activities. This margin is more reasonable than the 87 percent profit margin estimated from the total revenue figures reported by the turf service sector. Based on national survey data, turf service firms had an average profit margin of about 21.3 percent in 1998 and 22.9 percent in 1999 (*State of the Industry, 1999)*. Thus, contracted expenses of demand sectors and the reported expenses of the service sector appear to reconcile (Table 7).

Table 7. Reconciliation of Service Sector Revenues, Costs and Demand Sector Contracted Expenses

Source	*Value*
Total Turf Service, Virginia Receipts	$664,715,000
Total Contracted Expense from Demand Sectors	$435,514,000
Total Turf Service Costs	$357,896,000
Receipts Less Costs	$309,819,000
Return % Based on Estimated Receipts	86.6%
Demand Sector Contracted Expense Less Turf Service Costs	$77,618,000
Return % Based on Estimated Total Contracted Expense	21.7%

However, the expected correspondence between demand sector contracted expenses and total revenue of the service sector is not apparent in the data. Since the demand sector's estimated contracted expense seems to reconcile with the costs of the turf service sector, it is used as the estimate for turf service revenues in this study.

Similarly, one would expect the estimated value of sod and sprig production by Virginia sod producers to equal estimated sod purchases by the demand sectors. Based on the data provided by sod producers, sod and sprigs valued at about $9.1 million were sold to Virginia buyers. Based on data from the demand and service sectors, the estimated value of sod and sprigs purchased from Virginia sod producers was about $11.1 million. These figures deviate by about 21 percent, perhaps due to value added in the distribution system (Table 8).

Table 8. Reconciliation of Sod Purchases

Agent	*Total Direct (Non-Contracted) Virginia Sod and Sprig Purchases ($)*
Airports	0
Cemeteries	16,941
Churches	0
General Areas	692,616
Golf Courses	936,425
VDOT	0
Parks	481,282
Schools	101,129
Home Lawns	4,994,260
Sod Farmers	207,774
Turf Services	3,634,755
Total Virginia Sod and Sprig Purchases	11,065728
Total Sales Sod and Sprig to Virginia Buyers	9,127,230,
Purchases Less Sales	1,938,498
Estimated Value Added in Marketing System	21.0%

[1] That is, the demand sectors are paying "retail" prices for services. These retail prices must be higher than the cost of providing such services if the service sector is to make a profit.

Reconciling inter-sector exchanges provides some evidence that the demand and supply sectors are well represented by the VASS data. Further, this reconciliation provides evidence that the data are accurate, at least with respect to the expenditure items assessed above. However, turf service revenues do not seem to match the costs of that sector, thus raising questions of what respondents included in their revenues. Therefore, data on turf service revenues will not be used in this study.

TURFGRASS PRODUCTION IN THE VIRGINIA ECONOMY

The turfgrass production activities of turfgrass producers only represents part of the economic effects of turfgrass production. In addition to the primary (direct) effects of turfgrass production, the secondary effects are significant.

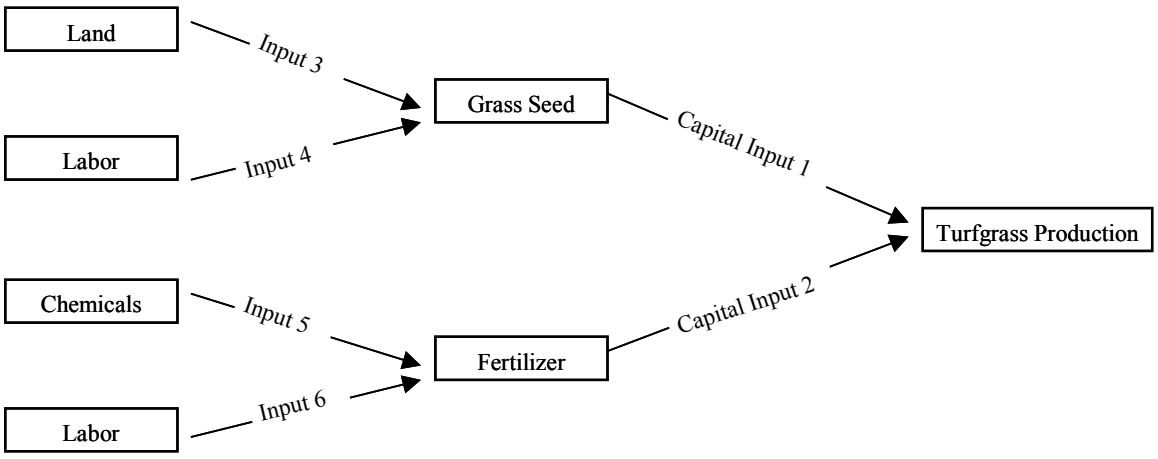
Input-Output Analysis

In the present study, the turfgrass production process is viewed as a "demand-pull" system in which an economic agent's demand for turfgrass causes a chain of economic events that ripple through the economy. The initial purchase of goods and services by turfgrass demanders is viewed as the cause of other activity in the economy. The cause of the initial demand is simply taken as given.

Economists typically view the production of goods and services as a process in which inputs (for example, labor, machinery, and supplies) are transformed into outputs. Purchases of these inputs results in **direct effects** on the economy. Thus, the direct effects of turfgrass production include the goods and services purchased and the employment necessary to produce the turfgrass.

Examination of the direct effects does not provide a complete picture of the economics behind a production process because there are often significant secondary (indirect) effects. When a turfgrass producer purchases an input, the input has to be produced, resulting in indirect effects. When the economy is viewed as a demand-pull system, such indirect effects are attributed to the initial cause—in this case, turfgrass production. For example, if turfgrass producers require only two capital inputs to produce turf: grass seed and fertilizer, and if capital inputs also require only two capital inputs in their production, then even in this simplified case, turfgrass production affects many firms (Figure 3).

Figure 3. Propagation of Backward Linkages in a Demand-pull Model



In reality, these indirect effects continue indefinitely and involve complex interactions among producers. Production also requires payments to labor (households), which result in a similar stream of **induced effects** when the households use these earnings to purchase other goods and services. To understand the context of a production process within an economy, it is important to estimate the direct, indirect, and induced effects that can be traced to it. Unfortunately, the problem quickly becomes empirically intractable, and a number of simplifying assumptions are required. The present study employs input-output analysis and a corresponding set of assumptions to trace the effects of turfgrass production through the Virginia economy.

The primary assumption of input-output (I-O) analysis is that the economy can be segregated into a set of industries, each of which produce only one output. Given this assumption, each intermediate good or service is uniquely associated with an industry. This assumption greatly simplifies the modeling process since a given purchase can be associated with the input transformation function of the industry that produced the good or service. Second, I-O models assume that the proportion of inputs to output is constant for each industry. This assumption is often represented as

$$y_j = {}_{1j}x_1 + {}_{2j}x_1 + \ldots + {}_{nj}x_n = \sum_{i=1}^{n} {}_{ij}x_i$$

In this equation, $_{ij}$ represents the amount *spent* on input i (x_i) to produce a dollar's worth of output in industry j. The $_{ij}$ coefficients (the technical coefficients) are assumed to remain constant for all levels of production and for all input prices. The implicit assumptions of this are

1. *Constant returns to scale*: if the level of *all* inputs is changed by a factor, the level of output will change by the same factor.
2. *Inputs cannot be substituted*: the same proportionate mix of inputs must always be used.
3. *The ratio of input to output is constant*: a change in output requires a proportionate change in all inputs.

Given these simplifying assumptions, an economy can be represented in the form of an ***input-output table***. An I-O table is a simple way to represent the production functions for all industries in the economy. For example, consider the sample input-output table presented in Table 9. This example is for a hypothetical economy with only three industries: agriculture, manufacturing, and services. The table shows that agriculture requires inputs valued at $0.10 from the service sector, $0.30 from the manufacturing sector, and $0.40 of its own outputs for each dollar's worth of output it produces.

Table 9. Sample Input-Output Table

	Purchases		
Sales	Agriculture	Manufacturing	Services
	----------$----------		
Agriculture	0.40	0.60	0.30
Manufacturing	0.30	0.20	0.20
Services	0.10	0.10	0.30

The input-output table is used to derive the indirect and induced effects of a given activity. In an actual analysis, the I-O table may model the flow of goods and services between hundreds of industries in a region. Further, actual analyses consider the activities of households and other institutions, interregional trade, taxation, and other factors.

Often, the goal of an I-O analysis is to estimate the effect of an activity on a variety of economic measures, usually **industrial output**, **value added, employment,** singly or in combination.

Total Industrial Output (TIO) measures the gross value of production in a region. TIO includes the total revenue of firms in the region and is not adjusted for payments to other firms. Thus, TIO counts products at each stage in the production process. Further, TIO includes payments to non-local businesses for inputs and services. Economic activity of a region is overstated by TIO since it double counts goods produced for use by other firms and since imported inputs are included.[2] TIO is closely related to **total output**, which measures the amount of money changing hands in an economy.

To provide a more meaningful measure of economic activity, modifying TIO by removing payments for products used in the production of other goods is necessary. This modification leaves only the portion of total revenue used to pay for interest, taxes, wages, salaries, and profits. Each of these payments is usually assumed to accrue to individuals in the local economy and their sum, therefore, represents the overall value added to goods and services by local firms. As such, this measure is referred to as **total value added**. A region's value added is analogous to a nation's Gross Domestic Product and is sometimes referred to as Gross Regional Product.

The economic activity of a region can also be measured by the number of jobs in the regional economy. Such **employment effects** are usually measured by permanent full-time jobs. Since some jobs are seasonal or part-time, employment is usually reported in terms of full time equivalent (FTE) jobs by converting part-time and seasonal positions to FTE jobs.

Comparing the Turfgrass Economy to the Virginia Economy

I-O models implicitly compare the state of the economy both with and without the activities under analysis. In the present case, the goal is to compare the actual Virginia economy with a hypothetical state of the economy in the absence of turfgrass related activities. In this sense, the goal is to measure the impacts of Virginia turfgrass production on the economy of the Commonwealth. However, the results are more appropriately viewed as descriptive of the relationship between turfgrass production and the larger economy than as a true impact.

I-O studies are commonly used to describe the impacts of a given firm, industry, or set of activities on the economy of a region. As in the present case, these studies compare the state of the economy both with and without the events under assessment. However, such studies are often flawed since they fail to account for the next best use of funds or the opportunity cost of diverting funds to the activities under assessment.[3] In the present case, turfgrass production results in various positive effects on employment, value added, and output. However, if no turfgrass were produced in the Commonwealth, the funds used to produce turfgrass would not disappear. Rather, they would be diverted to their second best uses. In fact, since turfgrass is often produced for aesthetic rather than economic reasons, turfgrass production may be inferior to other uses

[2] Double counting occurs since the value of the final product *plus* the value of the inputs used in making it are both included in TIO. For example, assume that $15 worth of leather is used in the production of a pair of shoes valued at $30. Production of the pair of shoes would increase TIO by $45 although the total value of final sales is still only $30.

[3] Not all impact studies make this error. For example, the impact of a new factory on a community could be measured using an I-O model if the funds used to build the factory would have otherwise been invested in another community. However, one cannot assume that the funds used for turfgrass production would be sent out-of-state if turfgrass were not produced. The problem, therefore, relates to defining the counterfactual and in interpreting the results.

of funds in terms of the standard measures used in I-O studies (especially since no economic value is usually added in turfgrass production by demanders). In any event, it is impossible to determine how society would reorganize the economy if forced to cease turfgrass production.

Accounting for Flows of Goods and Services

The flows of goods and services are incorporated into the I-O model to avoid double-counting trade among turfgrass sectors. For example, a homeowner might purchase sod from a turf service firm, which purchased the sod on a sod farm. The sod is only properly accounted for once and must be removed from the expenditures of other agents. Generally, such purchases are included in either the final demand sector or at the lowest possible level of production. The former approach allows one to capture all of the value added by intermediaries. However, in the present case, the preferable choice is to include such purchases as a product of the lowest level producer.

Inputs

The expenditure summaries are very similar to direct expenditure items entered into the IMPLAN model. Since this report describes Virginia turfgrass production, the values presented included in-state and out-of-state expenditures. However, the I-O model is constructed to examine the relationship between turfgrass production and the Virginia economy. Therefore, estimated non-Virginia expenditures are removed for this portion of the analysis. Contracted expenditures are not directly included in the analysis but are assumed to be accounted for in the turf service sector. Each expenditure item was mapped to the appropriate IMPLAN sector, and labor expenditures were allocated to middle income households—incomes between $30,000 and $40,000 per year (Table 10).

In the I-O model, impacts are generated by the demand sectors while the service sector and sod farms are viewed as agents of the demand sectors. Thus, the impacts of the service sector and sod farms must be allocated to the demand sectors to properly trace impacts to the appropriate demand sector. Allocation was accomplished by distributing the impacts of the service sector and sod growers based on the proportion of output sold to each sector. For example, if a sector purchased 10 percent of the sod sold by Virginia growers, 10 percent of the sod sector's impacts were allocated to that sector.

First, the impacts of the sod farms were allocated to the other sectors:

$$SOD\_ALLOCATION_j = \frac{SODPURCH_j}{\sum_{i=1}^{k-1} SODPURCH_i} IMPACT_{SOD}$$

Where

- $SOD\_ALLOCATION_j$ = the amount of the impact of sod producers allocated to sector j
- $SODPURCH_j$ = the total amount of sod purchases made by demand sector j
- $IMPACT_{sod}$ = the impact of sod producers

Next, the impacts of the service sector were allocated to the demand sectors:

$$SRVC\_ALLOCATION_j = \frac{CONTRACT_i}{\sum_{i=1}^{n-1} CONTRACT_i} IMPACT_{SRVC}$$

Table 10: Model Inputs

IMPLAN Sector	*Sector*	*Airports*	*Churches*	*Cemeteries*	*General Areas*	*Golf Courses*	*VDOT*	*Parks*	*Schools*	*Home Lawns*	*Sod Production*	*Service*
Grass Seeds	14	3,061	109,738	80,944	2,693,853	2,497,950	325,000	751,289	300,978	33,376,416	582,715	22,110,591
Greenhouse and Nursery Products	23	1,391	81,528	24,845	728,385	556,447		177,132	110,625	16,517,783		1,946,120
Wood Products	147	10,852	278,997	37,467	1,619,100	279,226		42,258	193,221	45,529,215	4,275	5,517,484
Agricultural, Forestry, Fishery Services	26		12,854	2,551	51,146	142,720		4,216	10,363	335,114	1,587	262,365
Miscellaneous Repair Shops	482	39,527	550,242	854,399	5,262,770	8,494,143		1,309,482	1,431,432	53,299,339	390,149	11,918,239
Nitrogenous and Phosphatic Fertilizers	202	11,130	187,365	79,301	2,723,452	4,611,408	425,000	712,057	559,056	56,777,191	477,293	21,725,924
Agricultural Chemicals, N.E.C	204	14,664	182,414	204,377	2,808,127	9,115,152	1,633,200	282,558	651,253	69,557,489	197,076	19,099,577
Petroleum Refining	210	20,313	374,081	407,711	3,137,361	2,064,011		304,106	482,183	37,919,307	274,913	19,063,515
Lime	245		41,965	6,477	633,531	347,507	90,000	119,821	71,562	10,224,955	49,600	4,494,352
Hand and Edge Tools, N.E.C.	276	1,494	181,663	66,245	2,484,534	536,932		78,419	98,486	31,127,340	1,900	2,917,277
Farm Machinery & Equipment	309	564,466	2,835,681	4,900,358	30,903,539	15,397,431	2,600,000	5,978,372	2,824,808	471,698,761	1,399,016	42,190,311
Equipment Rental & Leasing	473	13,538	7,209	92,568	733,908	5,909,200		128,392	34,392	10,713,339	102,703	8,868,476
Water Supply and Sewerage Systems	445		304,506	44,312	5,313,919	779,848		288,009	267,555	84,423,098	2,850	405,381
Building Materials & Gardening			300	244,035	658	969,935		4,262	8,114	1,706,306	521,441	3,723,683
Median Income Households	10006	465,146	2,817,883	8,726,044	68,058,793	57,981,348	6,725,000	10,656,550	15,494,001	57,694,949	3,131,441	173,432,587
Sod and Sprigs (intersector transfer)				16,941	698,366	956,414		484,736	101,393	5,019,861	217,314	3,849,153
Service Sector (intersector transfer)		55,624	7,597,551	4,224,405	136,744,000	1,137,060	10,100,000			275,655,078		16,370,776
Total		**1,201,206**	**15,563,977**	**20,012,980**	**264,595,442**	**111,776,732**	**21,898,200**	**21,321,659**	**22,639,422**	**1,261,575,541**	**7,354,273**	**357,895,811**

Where

- $CONTRACT_i$ = the total contracted expense of sector i
- $IMPACT_{srvc}$ = the impact of the service sector
- $SRVC\_ALLOCATION_j$ = the amount of the impact of the service sector allocated to demand sector j

Finally, the impacts for each demand sector were calculated as

$$TOT\_IMPACT_j = IMPACT_j + SOD\_ALLOCATION_j + SRVC\_ALLOCATION_j.$$

The IMPLAN modeling system accounts for 535 economic sectors. Use of the IMPLAN system required that the expenditure items from the VASS survey be mapped to the corresponding IMPLAN sectors. For example, "seed" expenditure from the VASS data was mapped to IMPLAN sector 14, "grass seeds" (Table 11) .

Table 11. Mappings from Survey Variables to IMPLAN Sectors

Description of Survey Variable	*IMPLAN Sector*	*Sector Number*	*$ Amount*
Seed	Grass Seeds	14	67,969,121
Mulch	Greenhouse and Nursery Products	23	42,775,345
Topsoil	Greenhouse and Nursery Products	23	15,693,464
Soil Testing	Ag., Forestry, and Fishery Services	26	845,555
Parts and Repair, Installation Equipment	Maintenance and Repair, Other	56	1,691
Parts and Repair, Harvest Equipment	Maintenance and Repair, Other	56	76,932
Parts and Repair, Seeding, and Planting Equip.	Maintenance and Repair, Other	56	90,137
Parts and Repair, Irrigation Equipment	Maintenance and Repair, Other	56	12,783,741
Parts and Repair, Mowing Equipment	Maintenance and Repair, Other	56	92,209,088
Parts and Repair, Other Equipment	Maintenance and Repair, Other	56	3,839,182
Fertilizer	Nitrogen and Phosphorus Fertilizer	202	90,255,841
Crop Protectants, Disease Control	Ag. Chemicals, NEC	204	23,456,459
Crop Protectants, Insect Control	Ag. Chemicals, NEC	204	20,359,107
Crop Protectants, Other	Ag. Chemicals, NEC	204	4,002,347
Crop Protectants, Weed Control	Ag. Chemicals, NEC	204	49,201,239
Supplies, Growth Regulators	Ag. Chemicals, NEC	204	2,297,772
Supplies, Fuel	Petrol. Refining	210	60,932,323
Supplies, Lime	Lime	245	13,954,943
Equipment, Tools	Hand and Edge Tools, NEC	276	28,481,592
Equipment, Mowing Supplies	Farm Machinery and Equipment	309	98,359,246
Equipment purchases and Leasing	Farm Machinery and Equipment	309	505,957,056
Supplies, Water	Water Supply and Sewerage Systems	445	71,778,150
Supplies, Netting	Building Materials and Gardening	448	216,701
Supplies, Other	Building Materials and Gardening	448	5,670,899
Labor	Households	n/a	21,417,823
Labor, Fertilizer Application	Households	n/a	29,277,222
Labor, Irrigation	Households	n/a	17,961,102
Labor, Mowing	Households	n/a	529,175,112
Labor, Other Turf Maintenance	Households	n/a	42,126,137
Labor, Pesticide Application	Households	n/a	47,836,741
Labor, finished Turf Installation	Households	n/a	971,789
Labor, Harvesting	Households	n/a	1,092,550
Labor, Seeding and Planting	Households	n/a	37,292

Results of the Input-Output Analysis

The IMPLAN model estimated that about $2.2 billion of economic output in Virginia results from turfgrass establishment and maintenance activities. Further, turfgrass activities generate about $1.1 billion in value-added in the Commonwealth, accounting for about 0.5 percent of Gross State Product. These activities generated over 59,000 FTE jobs in the Commonwealth, thus accounting for about 1 out of every 70 FTE jobs in Virginia (Table 12).

Table 12. Estimated Effects of Turfgrass Production and Maintenance Activities on the Virginia Economy

	Output	*Value Added*	*Employment*	*Output*
	----------$----------		FTE	%
Airports	1,576,000	1,015,534	177	0.1
Cemeteries	25,724,178	19,999,003	3,504	1.2
Churches	19,451,132	12,327,141	2,836	0.9
General Areas	313,225,627	235,245,967	18,704	14.6
Golf Courses	150,514,180	114,784,786	4,282	7.0
VDOT	25,685,893	19,547,786	523	1.2
Home Lawn	1,556,366,691	603,078,446	25,631	72.3
Parks	28,422,220	21,042,731	1,571	1.3
Schools	31,050,077	27,957,811	2,115	1.4
Total	**2,152,015,998**	**1,054,999,205**	**59,343**	**100.0**

Turfgrass production and maintenance on home lawns accounts for about 72.0 percent of turfgrass related economic impacts on the Commonwealth's economy. General areas (14.6 percent) and golf courses (7.0 percent) account for most of the remaining impact.

Of the 535 sectors IMPLAN uses, turfgrass production activities were found to have meaningful effects on 453 economic sectors in Virginia. These impacts were highly concentrated in a few sectors. Based on the output effect, half the impact occurs in only ten sectors (Table 13) and about 75.0 percent of the impact is concentrated in the top 30 sectors.

Table 13. Top 10 Sectors Impacted by Turfgrass Production

Rank	*Sector*	*Impact ($1,000)*
1	Farm Machinery and Equipment	259
2	Miscellaneous State and Local Government Enterprises	100
3	Repair Shops	64
4	Owner Occupied Dwellings	50
5	Wholesale Trade	46
6	Real Estate	43
7	Doctors and Dentists[1]	34
8	Hospitals	34
9	Eating and Drinking Establishments[1]	30
10	Maintenance and Repair of Miscellaneous Facilities	8

[1] Offices, buildings, and grounds

Output: the total dollar value of the production of goods and services that would be lost to the state without the activity. It gives the overall economic impact on the state.
Value added: the value added to the final product after accounting for the cost of production. It includes proprietor income, employee compensation, interest, and indirect business taxes.
Employment: the number of FTEs that would be lost as a result of the absence of the industry. (Trupo, Alwang, and Lamie, p22)

In addition to impacts, I-O models provide estimates of multipliers. Output, value added, and employment multipliers were calculated for Virginia turfgrass production in each of the demand sectors (Table 14). Multipliers provide an estimate of the changes that will occur in an economy given a change in expenditures. For example, the output multiplier for golf courses was estimated to be $1.35. This multiplier implies that each additional dollar of turfgrass related expenditures by golf courses increases output in the Virginia economy by $1.35. Note that employment multipliers are presented as FTE jobs generated per $100,000 expenditure.

Table 14. Estimated Multipliers for Turfgrass Sectors

	Output	*Value Added*	*Employment*
	--Per $ Expenditure--		FTE/$100,000 Expenditure
Home Lawns	1.30	0.50	2.1
Airports	1.33	0.85	14.9
Golf Courses	1.35	1.03	3.8
Cemeteries	1.35	1.05	18.4
Churches	1.32	0.84	19.3
VDOT	1.30	0.99	2.7
Parks	1.34	1.00	7.4
Schools	1.37	1.24	9.4
General Areas	1.34	1.00	8.0
Overall	**1.31**	**0.64**	**3.6**

CHANGES AND CHALLENGES IN TURFGRASS PRODUCTION

The analysis thus far has been static. However, turfgrass production is not a static process. Rather, turfgrass producers respond to changes in the economy by changing how they produce turfgrass and how much turfgrass they produce. To understand the changes taking place in the turfgrass industry, industry professionals (sod growers, turf service providers, but not university faculty) were surveyed. Because industry trends are difficult to quantify as they depend on such diverse factors as changes in technology and management practices, the survey questionnaires relied mostly on open-ended, narrative type questions.

Prices and the Overall Cost of Producing Turfgrass

Most respondents indicated that input costs have changed enough over the past several years to require adjustments in management practices. Nearly all respondents who noticed such changes in costs indicated that labor costs had changed most noticeably. Many respondents also indicated that equipment and chemical costs were also increasing. However, respondents did not consistently indicate that the costs of other inputs such as water, fuel, sod, seed, and contracted services had increased enough to require a significant response in management practices.

Most respondents who noticed a significant change in input costs responded to the cost change by changing the mix of inputs used (for example, substituting machinery for labor). Many of these respondents were also forced to produce or maintain less turfgrass or reduce the amount of inputs used because of increasing costs or some combination of these activities. A few respondents were able to pass some or all the increased costs on to the consumer or have their budgets increased, thus allowing them to use the same mix of inputs at a higher cost.

Nearly all respondents indicated that the cost of establishing and maintaining turfgrass is increasing faster than the rate of inflation. Most professionals who felt that the cost was increasing attributed some or all the increase to changes in labor costs. Many respondents managing turfgrass on golf courses and home lawns felt that consumers expect higher quality turfgrass and that meeting such expectations is at least partially responsible for increased costs. More than half the respondents attributed some or all the change in production costs to changes in the price of capital inputs such as fertilizer, equipment, water, and seed. A majority of the respondents also cited increased concern for the environment or regulatory requirements or both as a cause of increasing turfgrass production costs.

Changes in Technology

When asked if they noticed changes in management techniques or technology over the past few years, about three-quarters of the respondents indicated that they had noticed significant changes. The goal of the question was to identify if technologies were significantly changing turfgrass production. The most often cited technological changes were plant growth regulators (PGRs) and new turfgrass varieties.

Several respondents indicated that PGRs have had a significant effect on turfgrass production and maintenance. PGRs have been used for over two decades on golf courses to control annual bluegrass. However, widespread use of Type II PGRs to reduce the need for mowing and clipping is a relatively new phenomenon on golf courses. Type II PGRs (for example, Primo) are better suited to general growth inhibition, and chemical companies did not initially market PGRs to golf courses (Branham). Since PGRs reduce growth of grass, mowing and clipping frequency is reduced. Given that many respondents noticed significant increases in labor costs, having PGRs become an important technology is not surprising.

Many respondents felt that new grass varieties have significantly changed turfgrass maintenance over the past few years. Apparently, the proliferation of new bentgrass varieties has affected management practices, particularly on golf courses. Over the past decade, many new bentgrass varieties have become available. These varieties are often tailored to a specific task or environment or both.[4] New varieties might mediate cost increases as increased quality expectations can be met with a smaller increase in the use of capital and labor inputs.

Turfgrass Management Practices during the Last Decade

The questionnaire to professionals asked respondents to describe "the most important ways in which turfgrass management practices have changed over the past decade." Responses to this question were varied, but some commonalities can be identified. First, many respondents indicated that they have had to respond to increased quality expectations by managing turfgrass more intensively. Second, turfgrass management appears to have become somewhat more complex, requiring more knowledge and education

[4] For a short history and description of newer varieties see David Huff and Peter Landschoot. "Comparing the new bents," *Grounds Maintenance.* Jan 02,2000 at *http://www.grounds-mag.com.*

among both managers and laborers. Such education has made management paradigms like IPM more common. Third, a variety of technologies, particularly in equipment, appear to have caused many changes in turfgrass management practices. Interestingly, respondents tended to attribute changes in management practices to new types of equipment even when they did not list the equipment as a technological change.

Expectations for Innovation during the Next Decade

The questionnaire also asked the professionals to predict innovations that are expected to change turfgrass production and maintenance during the next decade. Many respondents felt that turfgrass breeding and biotechnology programs will be very important. Some respondents were more specific in indicating that they expect herbicide resistant cultivars to become very important while others felt that pest resistance would be improved.

Expected Changes in Turfgrass Management over the Next Decade

Respondents were asked for their opinion on how turfgrass management practices will change during the next ten years. Many respondents predicted that consumers' quality expectations will continue to rise. Further, the experts do not anticipate any significant increases in labor availability.[5] To meet the increased quality expectations during a labor shortage, labor saving equipment and chemicals will become more important. Several respondents also pointed out that the effectiveness of labor or management or both will be increased through more intensive education. Thus, firms may begin to rely on a smaller amount of more highly skilled labor and management to meet their needs for scarce labor.

Several experts expect environmental or regulatory requirements or both to become more important in the coming decade. Some respondents expressed concern and uncertainty about future regulations and implied that they feel environmental regulation will likely be increased, although they do not know what such regulations might require. Clearly, issues such as pesticide runoff, chemical applications at reduced rates, water conservation, and ecosystem impacts are increasingly being considered by managers.

Supply-Side Factors

Economists generally view supply as a function of price. The law of supply indicates that, other things being equal, producers will supply more output as the output price increases and less output if the price decreases. However, factors other than price can also affect supply. These supply shifters cause changes in the nature of production rather than directly affecting the quantity produced. Three of the most important supply shifters are changes in input costs (inflation), labor availability, and technology.

Inflation

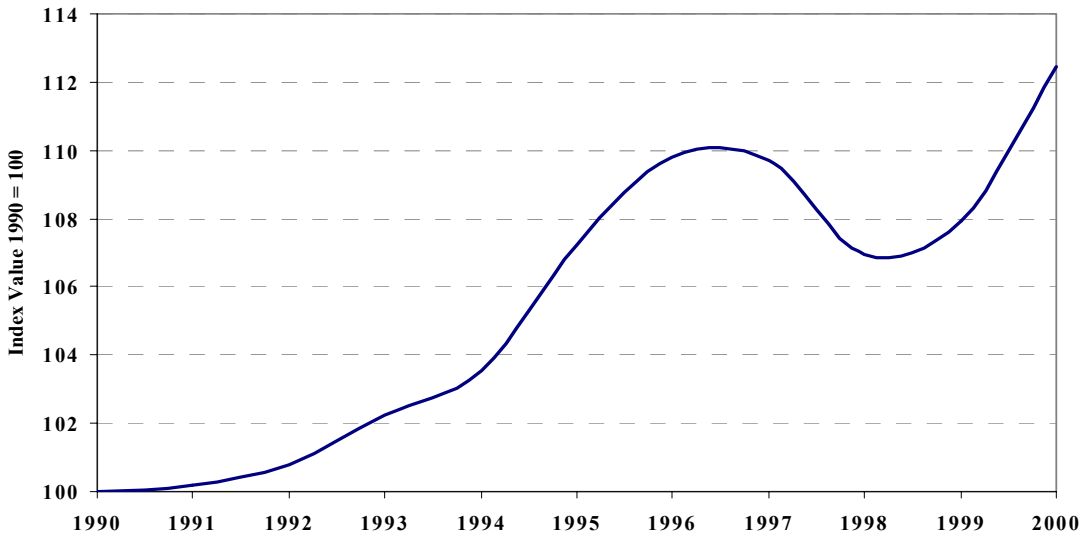
The price indices used are based on Bureau of Labor Statistics (BLS) data. Unless otherwise noted, indices have been adjusted from the BLS base year (generally 1982-1984) to 1990; that is 1990 dollars equal 100 and the index value for a given year will, therefore, represent the price level for that year as a percent of 1990 prices. Values for the year 2000 are calculated as the average of the monthly values of the corresponding index for the period January through June 2000 or as the average of quarterly data for first and second quarter of 2000 and are generally based on preliminary BLS estimates. All BLS data used in this analysis can be retrieved from the BLS website at *http://www.bls.gov* using the cited series numbers.

[5] Some areas of the country are using increasing numbers of migrant workers. What the availability and use of these workers is in Virginia is not known.

Some limitations are imposed when using a price index to measure price levels. Most notably, price indices measure the price of a basket of goods relative to the price of the same basket of goods in a base year. However, economic agents adjust to changes in price and quality over time and do not purchase the same basket of goods from year to year. For example, producers may purchase less gasoline as the price of gasoline increases; and they may purchase more equipment if the quality of equipment increases relative to its price. Thus, producers purchase a different basket of goods from year to year.

The Producer Price Index (PPI) for all commodities shows producer prices increased approximately 12 percent during the 1990s. Producer prices increased steadily through 1996, decreased briefly and began increasing again during 1999 (Figure 4). From January through June 2000, producer prices were still increasing at an annual rate of about 3.9 percent. This rate of increase is slightly higher than the average annual rate of change in the PPI over the past four decades. Although the PPI for all commodities provides interesting information about production, examining the price indices of individual commodities is also useful.

Figure 4. PPI for All Commodities, 1990-2000.



Turfgrass Production Price Index

Changes in the cost of individual inputs and the overall cost of production as shown by the individual indices do not provide enough information to understand how the overall price of turfgrass production has been changing. Consequently, an aggregated index of turfgrass production costs was developed to describe how the overall cost of turfgrass production has changed over time. The turfgrass production price index (TPPI) for a given year is calculated as

$$TPPI = \sum_{i=1}^{n} P_i(PI_i)$$

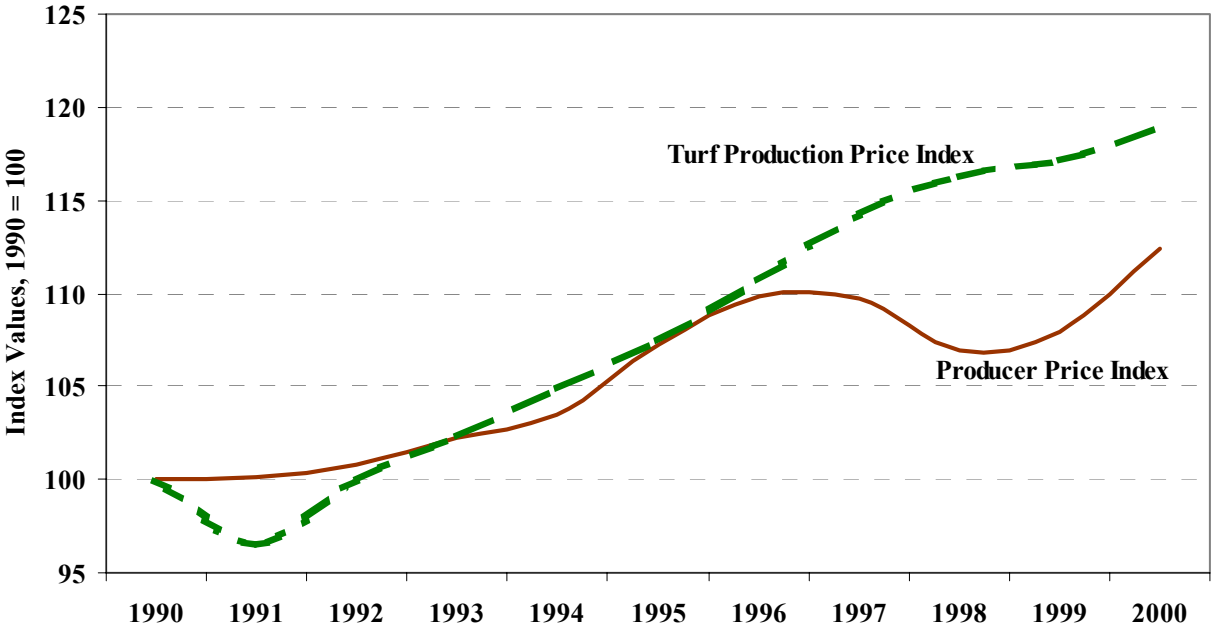
Where

- P_i is the (decimal) proportion of total expenditures spent on item i
- PI_i is the price index for item i

For the TPPI to be useful, turfgrass producers are assumed to always use the same proportionate mix of inputs. This assumption implies that turfgrass producers do not respond to changes in prices or technology by changing the mix of inputs used. Further, this assumption requires that production is linearly scalable. This assumption is required because the data needed to estimate the proportionate mix of inputs used are only available for 1998.

Based on the TPPI, the cost of producing and maintaining turfgrass in the Commonwealth increased by almost 26 percent between 1990 and mid-2000 (Figure 5). Turfgrass production costs increased 13.0 percent more than the price of all commodities. Note that the TPPI is not directly comparable with the PPI since the latter includes only producer prices of commodities; the PPI is considered only as a reference.

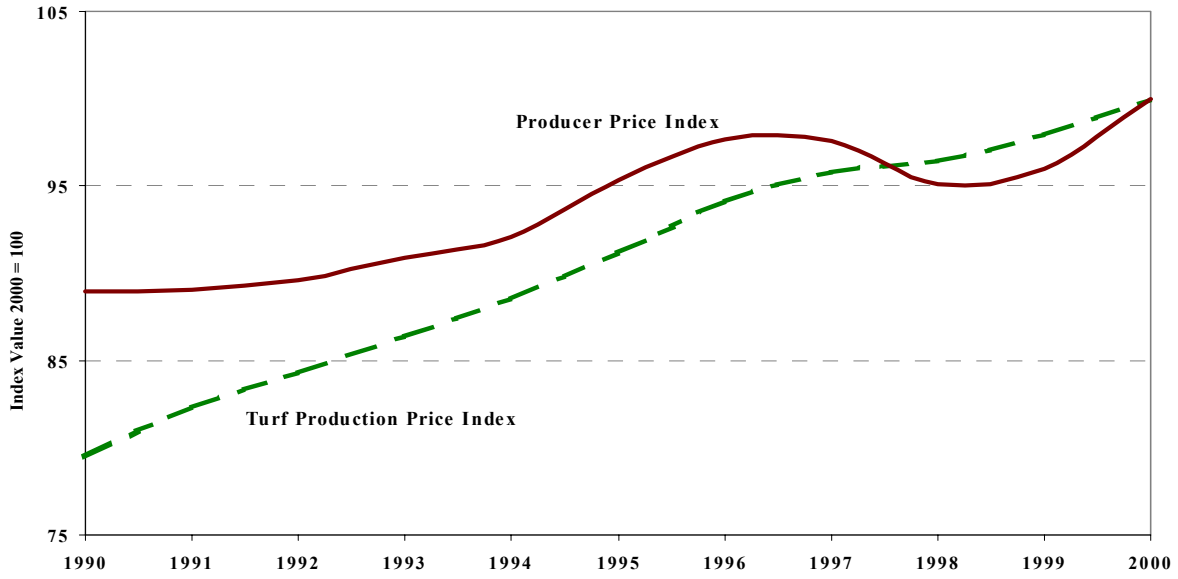
Figure 5. TPPI versus PPI, Base Year = 1990



Price indices give information *only* about average prices relative to prices in the base period. This limitation becomes very important when comparing values across indices. For example, two price indices exist: Index A and Index B with values of 110 and 120, respectively, in 1999. One might correctly conclude that prices of the items included in Index B increased proportionately more than those in Index A. However, the prices for items in Index B might not be "too high"—prices might have been low for these items during the base year or prices might have been high for the items in Index A during the base year. The important point is that the **only** valid conclusion is that prices of the items in Index B increased proportionately more than the prices for items in Index A. This distinction is very important when considering that the results of this study generally show that prices for turfgrass production inputs increased more than the price of all inputs, as measured by the PPI, over the past several years.

Changing the base year will change the appearance of a price index. If the base year is changed to 2000, the PPI will be above the TPPI in 1990. Figure 6 shows the PPI and TPPI with the indices adjusted so that 2000 equals 100. The conclusion must still be that turfgrass production prices have increased faster than the rate of inflation. However, if one simply looks at the graph, turfgrass prices appear low in 1990, rather than appearing high in the year 2000. This comparison underscores the fact that such normative conclusions are often inappropriate if they are based only on price index data.

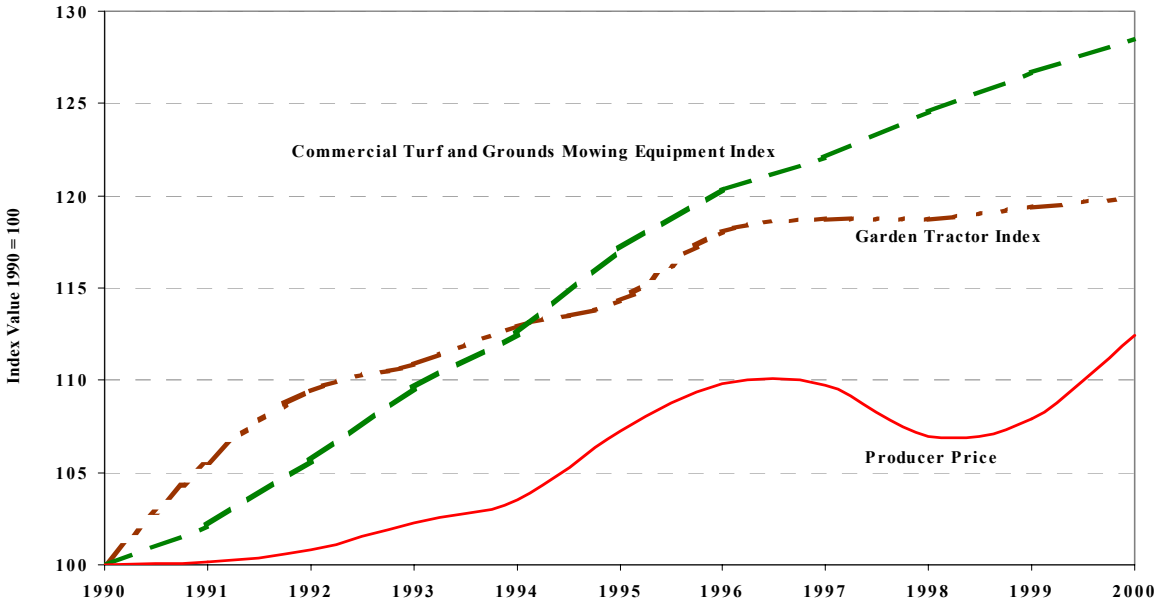
Figure 6. TPPI versus PPI, Base Year = 2000



Equipment

The price of turfgrass maintenance equipment appears to have increased more than other prices since 1990. Prices of garden tractors have increased about 20.0 percent[6] while the average price of commercial turfgrass and mowing equipment has increased nearly 29.0 percent[7] (Figure 7). Since equipment costs account for about a third of the total cost of turfgrass production,[8] this increase in prices has important implications for turfgrass producers.

Figure 7. Machinery Prices, 1990-2000.

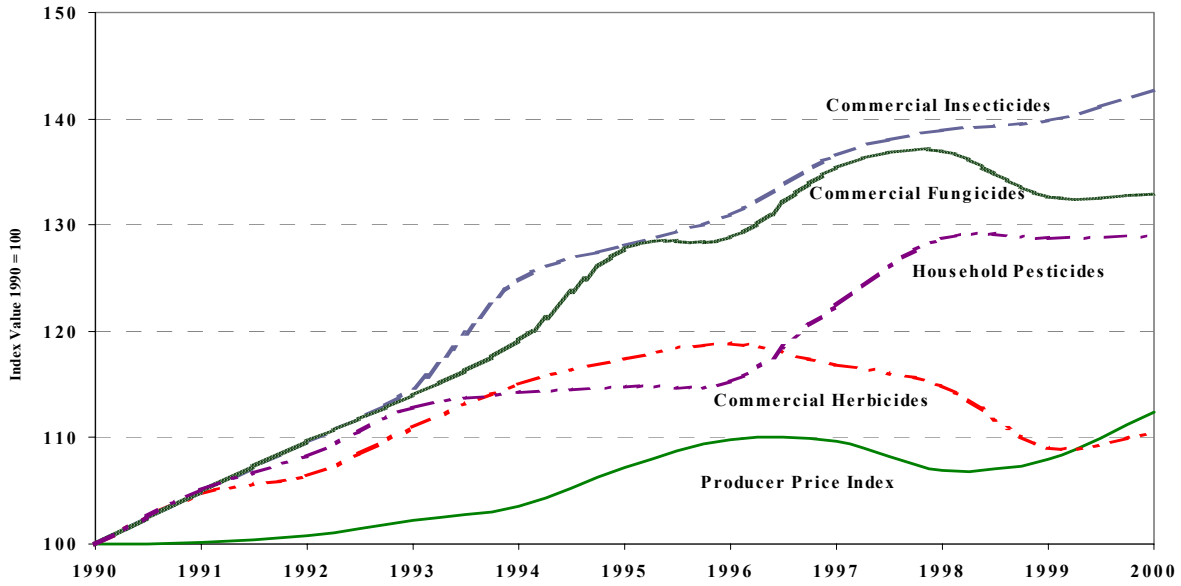


[6] BLS series WPU11110522.
[7] BLS series WPU11121211.
[8] 1998 VASS survey data. Calculated as a proportion of total non-contracted costs of the demand and intermediate sectors.

Pesticides

The average cost of all types of pesticides has increased in nominal terms since 1990. Further, the change in the price of all types of pesticides except commercial herbicides outpaced inflation during the period. The average cost of all household pesticides increased about 29.0 percent since 1990[9] while the cost of commercial fungicides and insecticides increased by 33.0 percent and 43.0 percent, respectively.[10] The average price of commercial herbicides increased by only about 10.0 percent.[11] Trends in the price of pesticides are presented in Figure 8.

Figure 8. Pesticide Prices



Employment

Nationally, the cost of unskilled and semiskilled labor has increased steadily since 1990. The average wage of general laborers has increased about 36.0 percent over 1990 wages.[12] Further, total compensation of blue-collar workers, which includes benefits as well as wages, increased by about the same amount during the period.[13]

Labor costs and unemployment rates are closely related. In general, as unemployment rates decrease, labor costs will increase as employers compete for increasingly scarce labor. Unemployment has been decreasing in Virginia since 1992, moving from about 6.4 percent to about 2.8 percent by 1999.[14] Virginia's unemployment rate has been consistently lower than the national average since 1990 (Figure 9).

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[9] BLS series WPU06530105.

[10] Fungicide price change BLS series WPU06530103; insecticide price change BLS series WPU06530101.

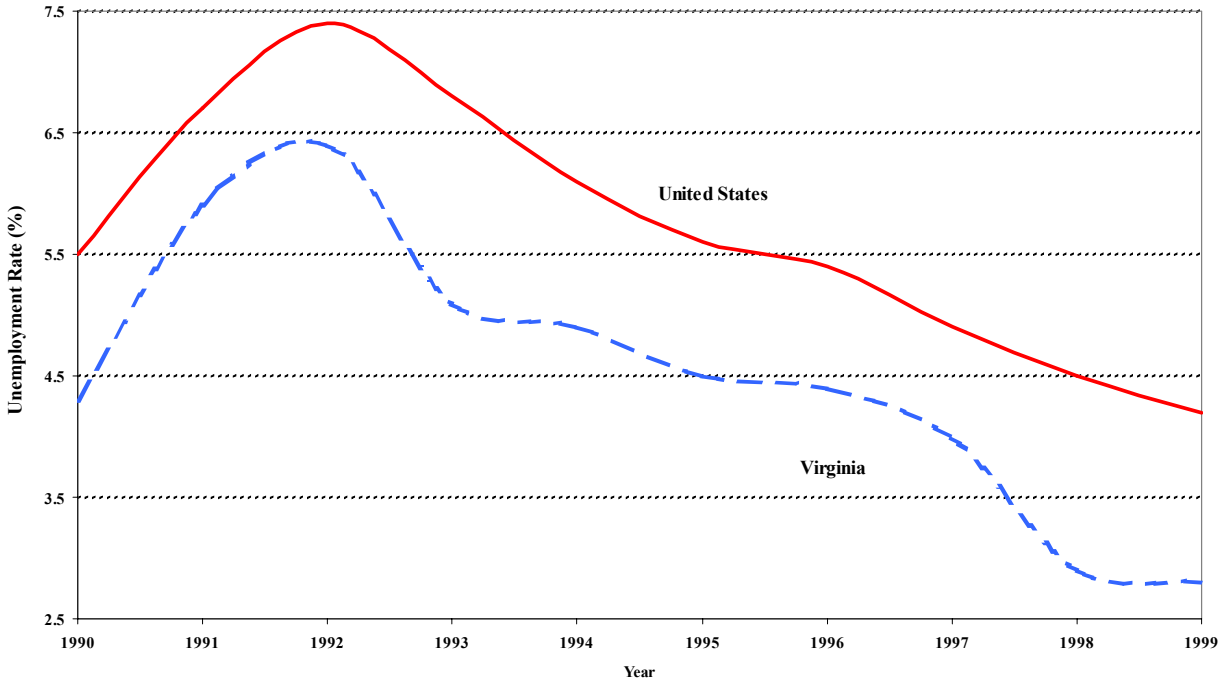
[11] BLS series WPU06530102.

[12] BLS series ECU21242I.

[13] BLS series ECU21201I.

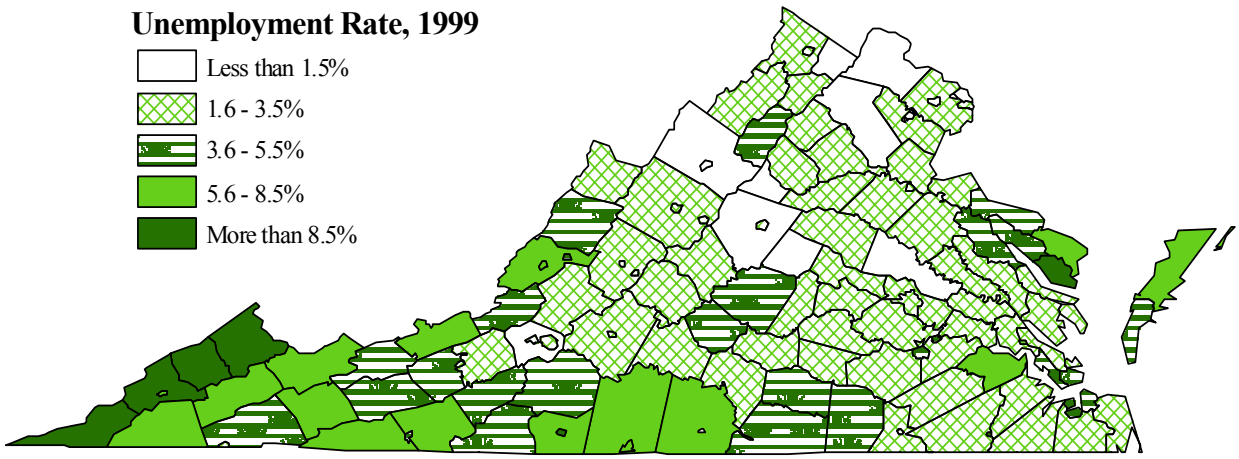
[14] Labor Force, Employment, Unemployment (LAUS), Annual; VEC see employment.readme.txt.

Figure 9. U.S. and Virginia Unemployment Trends



Employment trends are not homogeneous across the Commonwealth. Generally, unemployment rates are highest in the extreme southern and southwestern portions of the state, and the central and northern areas of the state have the lowest unemployment rates (Figure 10).

Figure 10. Unemployment in Virginia



Source: Virginia Employment Commission

Nationally, demand for landscaping and groundskeeping laborers is expected to increase at an annualized rate of about 2.1 percent through 2008, significantly faster than the 1.4 percent rate projected for all occupations.[15] Groundskeeping and lawn service jobs are sometimes difficult to fill because of relatively low

[15] Based on *ftp://ftp.bls.gov/pub/special.requests/ep/OPTDData/optd9808.txt*. Uses "matrix code" 3730110592: Laborers, landscaping, and groundskeeping: all occupations (last accessed 12 March 2002).

entry-level wages and the demanding nature of the work (US Dept. of Labor (d)). Consequently, turf service firms may suffer disproportionately from low unemployment as laborers are attracted to less demanding and better paying occupations. Further, increasing machinery costs may preclude firms from substituting machinery for labor, thus forcing costs to rise more than might otherwise be the case.

In 1998, the median United States hourly wage for landscaping and groundskeeping laborers was $8.24 (US Dept. of Labor (b)). Wages in Virginia metropolitan areas are somewhat higher, particularly in northern Virginia. The average hourly wage for nonfarm groundskeepers and gardeners was $10.42 in 1998 in the Baltimore-Washington metropolitan area (including portions of Virginia, Maryland, West Virginia, and Washington, D.C.). Hourly wages for landscaping and groundskeeping laborers in the urbanized areas of eastern Virginia (Norfolk, Virginia Beach, and Newport News) were much lower—about $8.68 in 1998 and $8.65 in 1999.[16] One would expect hourly wages to be even lower in southern and western portions of Virginia because of the relatively high unemployment rates in those areas.

Technology

Changes in technology also affect the supply side of production. Based on the survey to professionals, technology has changed the nature of turfgrass production over the past several years. The professionals reported that innovations such as new machinery, chemicals, and grass varieties have fundamentally changed the way they manage turfgrass. Interestingly, these technologies do not appear to be lowering the cost of production. Rather, new technologies are apparently being used to increase management intensity to meet increasing quality demands. Technological innovation could potentially offset increases in capital and labor costs by substituting for or complementing existing inputs, although this effect was not reported in the surveys.

Demand-Side Factors

Just as turfgrass producers respond to various changes in the economy, so do turfgrass users. The implicit assumption is that turfgrass demand changes with changes in the size of the production sectors.

Highway Miles

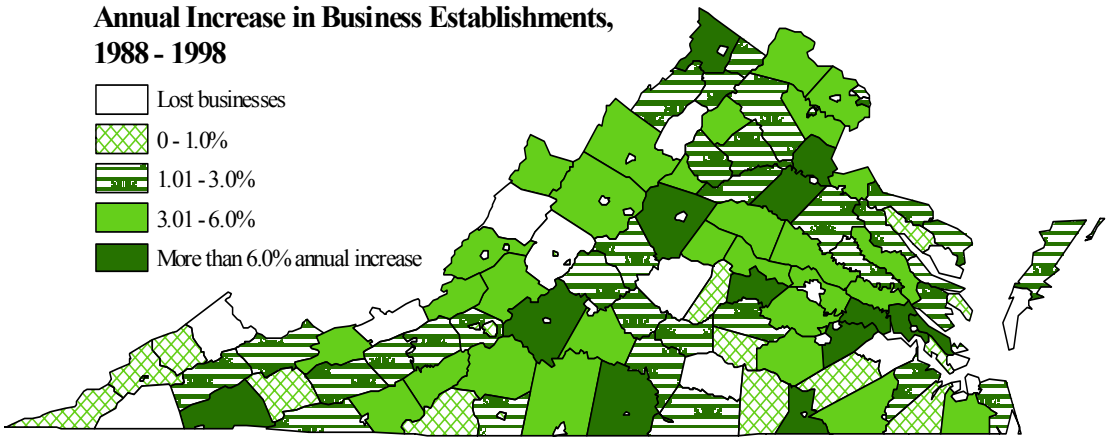
In 1998, the United States Department of Transportation (USDOT) reported 125,420 highway lane-miles administered by the Virginia Department of Transportation (VDOT). The total number of lane-miles managed by VDOT has increased about 2.4 percent since 1993, the first year that the data were reported. The annual increase in highway lane miles slowed over the period from 1.0 percent in 1994 to 0.1 percent during 1998 (USDOT). Although data on lane miles are not available by county, national data indicate that since 1995, 50.8 to 51.3 percent of the lane-miles were located in urban areas.

Commercial Facilities

Between 1987 and 1997, the number of commercial establishments in Virginia increased from about 139,400 to 172,600 at an annual rate of 1.9 percent (US Dept. of Commerce (a)). Most areas experienced moderate growth in commercial establishments. However, 18 areas experienced average annual growth rates in excess of 5 percent while 32 areas experienced negative growth rates (Figure 11). There was no noticeable regional trend in growth rates.

[16] BLS series NCU0099573048600, NCU5105643048600, and NCU5108653048600.

Figure 11. Percent Change in the Number of Business Establishments

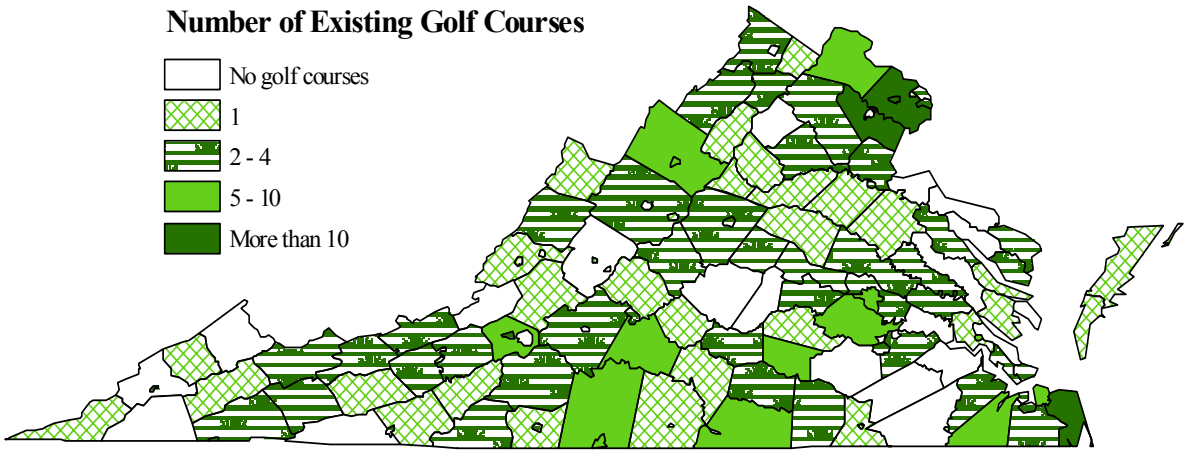


Source: US Dept of Commerce (b)

Golf Courses

By the end of 1999, 342 golf courses were operating in Virginia (NGF (b)). Figure 12 shows the location of these golf courses.[17] The number of golf courses has increased from 331 in 1998 (NGF (c)) and 320 in 1997 (NFG (a)). During the 15 year period between 1982 and 1997, the number of courses increased by 74 from 246 (4.9 per year). Thus, it appears that the number of courses in the Commonwealth is increasing at an increasing rate.

Figure 12. Location of Existing Golf Courses

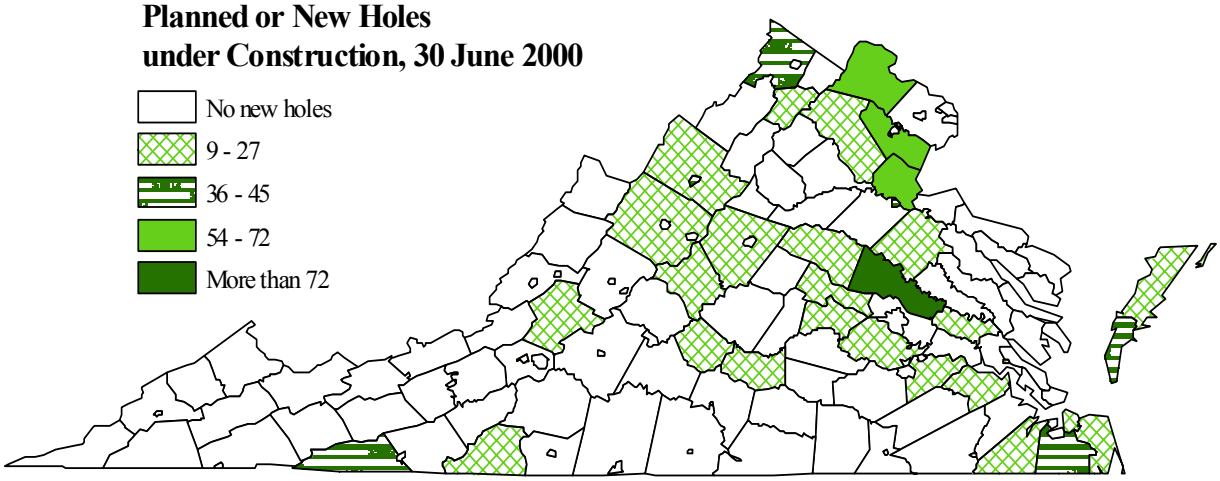


Source: Mailing List, Virginia Golf Association

[17] Figure 12 is based on zip codes for those golf courses belonging to the Virginia Golf Association. Richmond City, Danville, and Harrisonburg show an unusual number of golf courses for cities because mailing addresses for the gold courses are post office boxes in those cities rather than the actual location. Harrisonburg and Danville were combined with their surrounding counties. Not knowing whether those in Richmond were located in Hanover, Henrico, or Chesterfield made combining Richmond with the counties meaningless.

Turfgrass acreage in golf courses is more closely associated with the number of golf holes than the number of courses. Virginia's 342 golf courses had about 3,078 golf-holes at the end of 1999.[18] As of June 30, 2000, the National Golf Foundation reported that 369 new golf holes under construction on 21 courses. Twenty-seven of the holes were additions on four courses, the rest were new facilities (Figure 13). An additional 585 holes were in the planning stages on 30 courses. Forty-five of these holes on four courses represented additions to existing courses while the rest were planned new facilities. Thus, at least 954 new holes are either under construction or in planning as of this writing. This number probably represents the number of new golf holes that will be available in the Commonwealth over the next several years.

Figure 13. Golf Holes under Construction or in Planning as of 30 June 2000



Source: National Golf Foundation

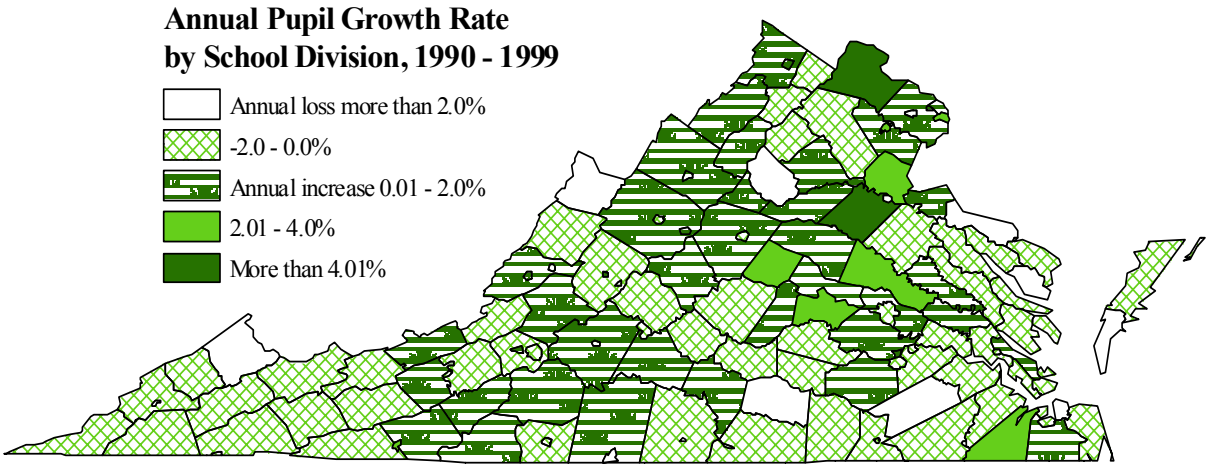
Schools

Between 1990 and 1999, the total number of students in Virginia K-12 schools increased from about 999,000 to 1,141,000. The annual rate of increase was about 1.5 percent (Figure 14), almost exactly the same as the national change over the same period (US Dept. of Ed). For the period 2000 to 2005, 15,344 new students are expected to enroll in Virginia schools. The rate of change in the number of students is expected to slow to 0.3 percent over the period.

Turfgrass is planted on a per-school basis, not on a per-student basis. Schools have a certain capacity for students. Thus, an increase in student populations may not necessarily imply an increase in the number of schools. Even if additional students cause a school to reach its capacity, it is more likely that the capacity of existing schools will be increased instead of building new facilities. Further, VASS reported estimates of turfgrass acreage and expenditure on a per-school system basis rather than on a per-school basis and the resulting estimates cannot be disaggregated. The rate of increase (0.3 percent) should, therefore, be viewed as a crude indicator of the growth in turfgrass maintained by schools systems.

[18] This figure is estimated based on the number of courses reported by the NGF and the breakdown of golf courses by size presented in the 1998 VASS survey data (22 percent 9 hole, 67 percent 18 hole, 8 percent 27 hole and 3 percent 36 hole) not including the "other" category.

Figure 14. Annual Pupil Growth by School District, 1990 – 1999



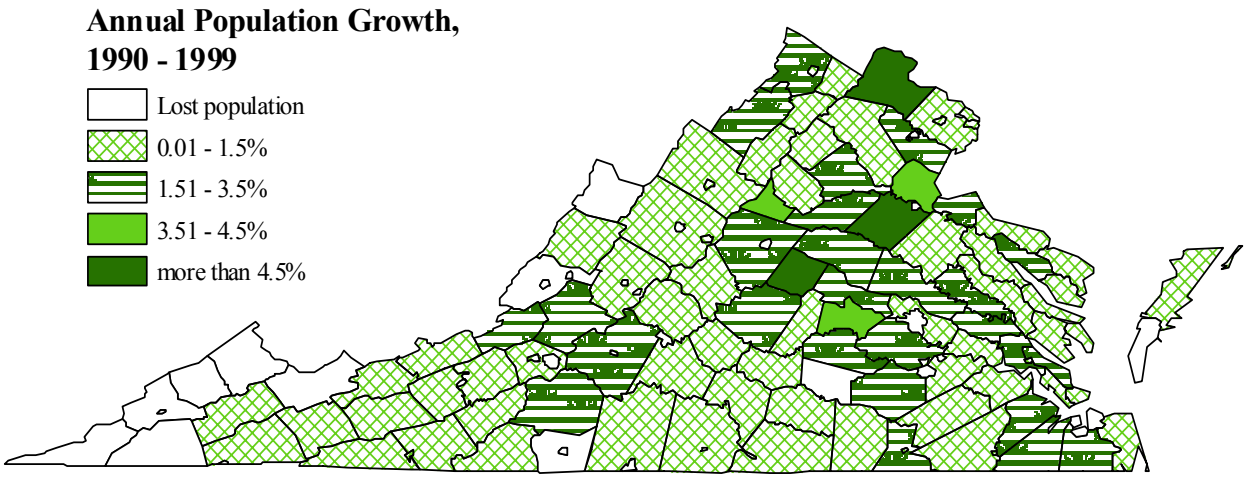
Source: US Dept. of Education

Population

Between 1990 and 1999, the population of the Commonwealth increased by about 684,000 or about 11.0 percent. During the same period, the United States population grew by about 9.3 percent (US Dept. of Commerce (c)) Virginia ranked 18th among states in the United States based on its rate of population growth and 10th in its absolute population change (US Dept. of Commerce (e)).

Population growth was not homogeneous in Virginia over the period. Between 1990 and 1999, the population of the Commonwealth increased at an annual rate of about 1.2 percent.[19] However, many areas in the eastern half of the state experienced annual growth rates above 2.0 percent. Growth rates were typically less than 1.0 percent in the western half of the state, and several western districts had population decreases during the period (Figure 15).

Figure 15. Annual Population Growth in Virginia, 1990 to 1999

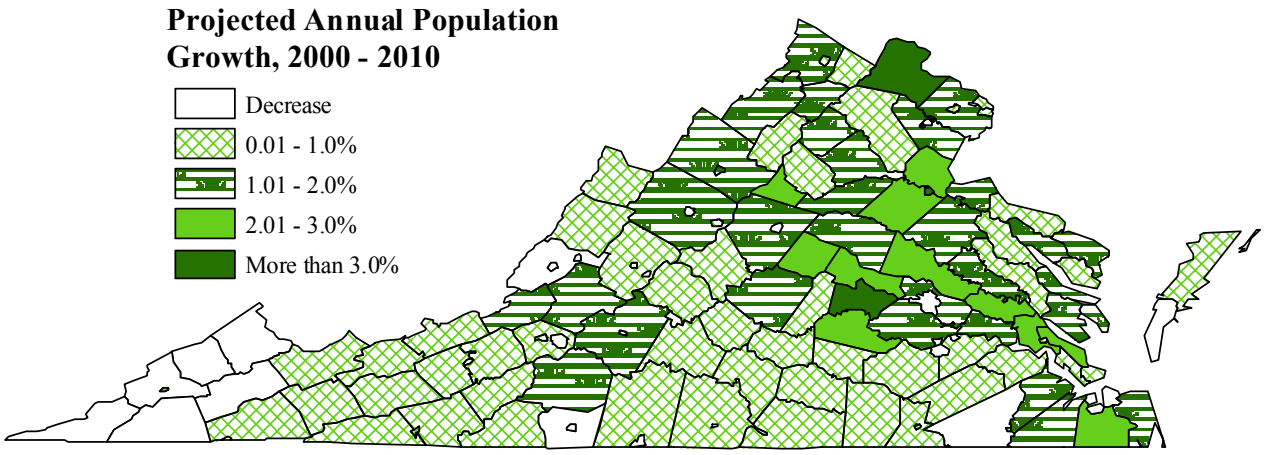


Source: University of Virginia

[19] Unless otherwise noted, the rates of change are derived statistically. See Appendix 2 for details. The annual percentage change for the variables are presented in Appendix 3.

Population projections suggest that population of the Commonwealth will continue to grow at an average rate of about 1.0 percent through 2010 (UVa). The rate of growth will be markedly faster in the northeastern quadrant of the state in contrast to extreme southwestern Virginia where most areas are expected to grow at less than 1.0 percent per year and several areas are expected to have negative growth rates (Figure 16). No areas are expected to experience annual growth rates above 3.1 percent through 2010.

Figure 16. Projected Annual Population Growth, 2000 – 2010



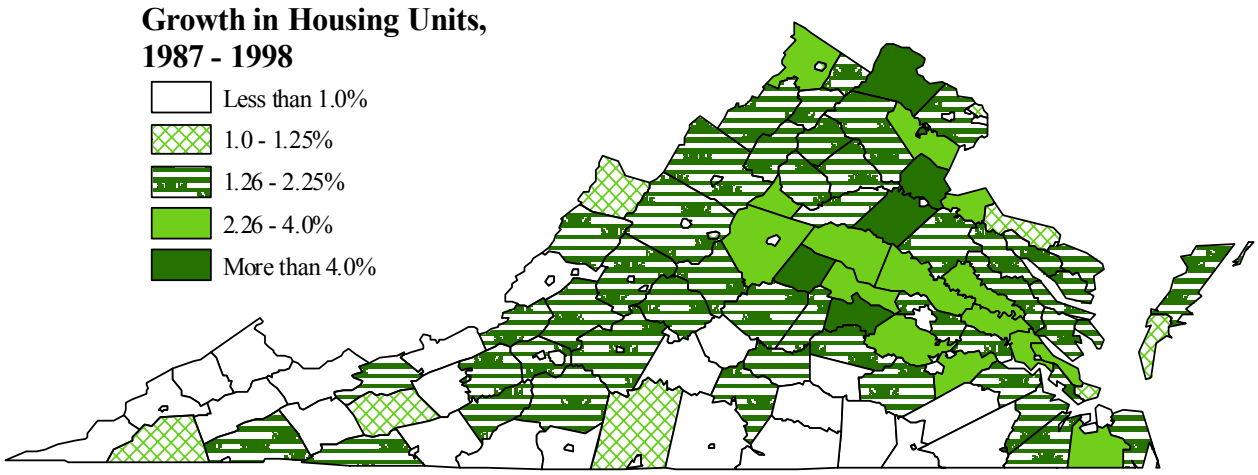
Source: Virginia Employment Commission

Housing Starts

Between 1988 and 1998, over 517,0000 building permits were issued in the Commonwealth for the construction of new housing units (US Dept. of Commerce (d)). About 410,000 (79.0 percent) of these permits were for construction of single-family housing units. The remaining permits were issued for construction of multifamily housing such as apartment complexes, townhouses, and duplexes. Since nearly all housing permits result in the construction of the permitted dwelling, a reasonable assumption is that the number of permits issued is a good indicator of the number of new units constructed (Figure 17). Given this assumption, the total number of housing units in Virginia grew at an annual rate of about 1.7 percent over the period (1.6 percent for single family dwellings, 2.1 percent for multifamily dwellings).

The location of housing starts are highly correlated with the location of population increases. Between 1990 and 1998, the average population change was 95.0 percent correlated with the average number of housing permits issued. Thus, one would expect the growth rate of housing units to be very similar to population growth as can be seen by comparing figures 15 and 17. Southern and extreme southwestern Virginia grew very slowly while northern and eastern Virginia grew quickly.

Figure 17. Average Annual Growth in Housing Units



Source: U. S. Dept of Commerce (d)

Consumer Income

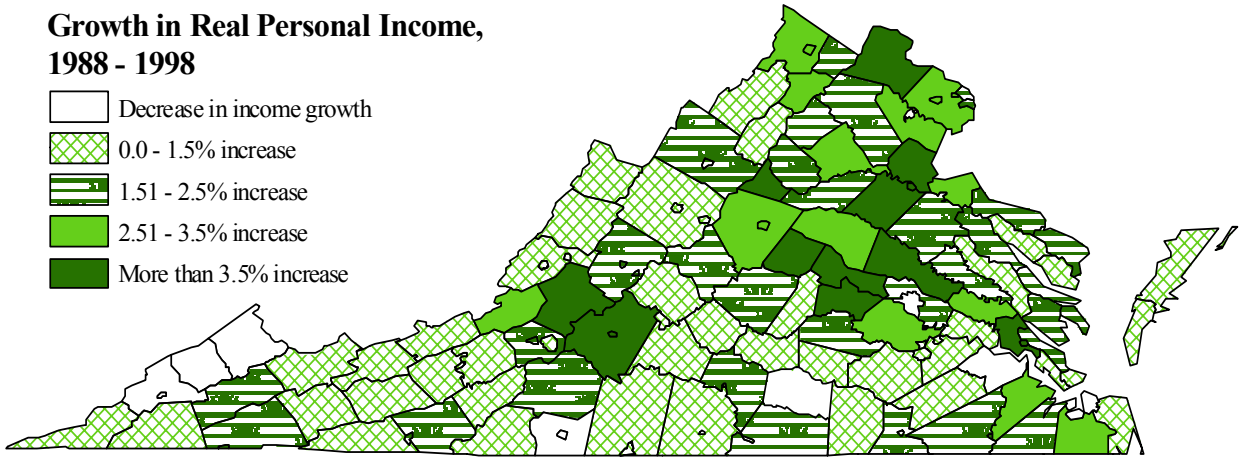
Consumer income is a very important factor in turfgrass demand. For most goods and services, increases in income are accompanied with a corresponding increase in demand. Homeowners likely consider turfgrass production to be a luxury item. Thus, an increase in income would cause a more than proportionate increase in turfgrass demand. Further, household income is an indicator of the general health of an economy. Increased household income implies increases in business and tax revenues, all of which positively affect the demand for turfgrass.

Increases in household income imply increased demand for turfgrass products (seed, pesticides, equipment) and turf services, although it is not clear how much a given income increase will increase turfgrass production demand. Arguably, turfgrass establishment is a by-product of new homes, and demand for turfgrass establishment will be more closely related to the number of new homes than the income of consumers. However, increased income might result in increased reliance on the turf service sector as homeowners can increasingly outsource their turfgrass maintenance activities. Thus, more economic activity would occur in the turfgrass sectors even though per household demand for turfgrass might not increase.

Total real income measures the amount of money earned by a population, corrected for inflation. Thus, total income[20] provides a useful summary of relevant trends by summarizing population, average income, and price levels into a single value. From 1988 to 1998, the real (inflation adjusted by CPI-U) total income of Virginia residents increased an average of 2.0 percent per year (Figure 18). The real total income earned in many southwest Virginia districts grew very slowly or decreased over the period while most northern Virginia areas experienced real growth rates in excess of 2.0 percent.

[20] The Bureau of Economic Analysis collects data on income. However, it does not separate some cities from their surrounding counties. Values for the following independent cities were reported with their respective counties: Bedford City, Bristol, Buena Vista, Charlottesville, Clifton Forge, Colonial Heights, Covington, Danville, Emporia, Fairfax City, Falls Church, Franklin, Fredericksburg, Galax, Harrisonburg, Hopewell, Lexington, Lynchburg, Manassas Park, Martinsville, Norton, Petersburg, Poquoson, Radford, Salem, Staunton, Waynesboro, Williamsburg and Winchester.

Figure 18. Annual Growth in Total Real Personal Income, 1988-1998



Source: US Dept. of Commerce (b)

STRATEGIC PLANNING

Two important conclusions can be reached from the discussion of the supply side factors. First, the increase in turfgrass production cost is clearly outpacing inflation. Second, various labor saving technologies are becoming important in production. While the increased use of labor saving technologies may offset cost increases, more likely they are being used to improve the ability of existing labor to meet consumers' increasing quality expectations. In any case, such technologies are unlikely to completely offset increased input costs.

Generally, one would expect increased labor costs to result in partial substitution of machinery for labor. However, machinery costs are increasing at about the same rate as general labor wages. Thus, only a slight decrease in average production costs could be achieved even if labor and machinery were perfect substitutes, which certainly is not the case.

On the demand side, demand for turfgrass has been increasing. One should be somewhat circumspect about any predicted trend as such predictions are notoriously inaccurate. On the other hand, there is no reason to believe that demand for turfgrass will not continue to grow.

Table 15 presents a summary of the estimated annual change in several factors which impact turfgrass demand. These changes appear relatively small on an annual basis. The largest changes occurred in the annual increase in golf courses from 1997 to 1999, 3.3 percent, and in median household income from 1990 to 1997, also 3.3 percent.

Most of the demand factors are functions of population growth. Thus, population growth provides a good proxy variable for other factors. The value of population as a proxy becomes particularly important when predicting future trends since population growth is fairly predictable, and credible population growth estimates are generally available at the county and city level. However, population growth is expected to slow slightly over the next decade, and this slowing might be expected to lead to a general slowing in demand for turfgrass, especially since turfgrass demand is probably more population-dependant than income-dependant.

Table 15. Estimated Annual Rate of Change for Various Demand Factors

Sector	*Item*	*Period*	*Yearly Change (%)*
Schools	Student Population	1990-1999	1.5
		2000-2005	0.3
Highways	Lane Miles	1993-1998	0.4
Home Yards	Single Family Dwellings	1988-1998	2.0
General Areas	Number of Multi-Family Dwellings	1988-1998	2.1
	Number of Commercial Facilities	1987-1997[1]	1.9
Golf Courses	Number of Courses	1982-1997	1.8
		1997-1999	3.3
All	Population	1990-1999	1.1
		2000-2015[1]	1.0
	Median Household Income	1990-1997	3.3
	Total Real Income	1988-1998	2.0

[1]Rate of change based on two data points

The results of the spatial analyses clearly show that the economy of Virginia is not homogeneous. Southwest and southern Virginia tended to show signs of having a generally slower economy than northern and eastern portions of the state. For example, unemployment rates in southwest and southern Virginia were generally high while growth rates in population, income, and housing units were markedly slower. Since demand for turfgrass is a function of these factors, a logical conclusion is that turfgrass demand has been growing faster in northern and eastern Virginia than in southern and western Virginia.

Comparing the annual growth rates in the population (Figure 15) and income (Figure 18) across counties shows that most of the growth has occurred in the "Golden Cresent." The Golden Cresent includes the counties and cities closest to Washington, DC, south along I-95 to Richmond and south and east along I-64 to Chesapeake and Virginia Beach. Since population is a good proxy for turfgrass demand and since projected population growth generally follows the Golden Cresent, the growth in turfgrass demand can be expected to also follow the Golden Cresent.

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APPENDIX

Appendix 1. Economic Effects

Appendix Table 1: Breakdown of Economic Effects by IMPLAN Sector

Sector	*Name*	*Output ($1,000)*	*Employment (FTE)*	*Value Added ($1,000)*
14	Grass Seeds	1,171,957	129	470
23	Greenhouse and Nursery Products	8,644,390	154	4,447
26	Agricultural, Forestry, Fishery Services	448,641	21	227
147	Wood Products	17,223,553	216	8,382
202	Nitrogenous and Phosphatic Fertilizers	4,446,051	9	587
204	Agricultural Chemicals, N.E.C	5,251,761	16	1,640
210	Petroleum Refining	7,986,098	5	1,316
245	Lime	333,804	2	101
276	Hand and Edge Tools, N.E.C.	3,077,727	27	1,984
445	Water Supply and Sewerage Systems	3,381,520	33	2,448
448	Building Materials & Gardening	10,117,965	263	8,455
473	Equipment Rental and Leasing	22,029,317	235	10,439
482	Miscellaneous Repair Shops	64,340,288	980	28,473
309	Farm Machinery and Equipment	258,759,162	1,506	80,747
10006	Median Income Households	n/a	n/a	n/a
N/A	Turfgrass Production	n/a	44,860	405,183,742
	Total	**407,211,234**	**48,456**	**405,332,458**

Appendix 2. Rates of Change

The rates of change were derived based on the assumption that the variables increase exponentially over time. Thus, the following model was assumed to represent the data:

$$Y = \alpha e^{\beta t}$$

Where

- Y is the variable under consideration
- α is an intercept term
- e is the base of natural logarithms
- â is a coefficient for the annual rate of change
- t is a time series index

Parameter estimates were derived using the linear (semi-log) form of the equation.

Appendix 3. Data for Maps

Appendix Table 3. Data Used to Create Maps

Location	*Unemployment rate, 1999*	*Annual Growth: Business Establishments*	*Existing Golf Courses (number)*	*Golf Holes Planned and Being Built (number)*	*Annual Growth: Schools, 1990-1999*	*Annual Growth: Population, 1990-1999*	*Annual Projected Growth: Population, 2000-2010*	*Annual Growth: Housing Permits, 1990-1998*	*Annual Growth: Real Income, 1988-1998*
Accomack	6.4	1.7	1	18	-0.9	0.3	0.2	1.3	0.7
Albemarle	1.1	6.1	2	18	1.3	2.1	1.6	2.7	2.6
Alexandria	2.2	1.5	4	0	3.0	0.7	0.5	0.9	1.9
Alleghany	5.9	5.2	1	0	0.5	-0.4	-0.2	0.7	1.2
Amelia	2.5	2.9	1	0	-0.5	2.1	2.1	2.2	2.1
Amherst	1.8	2.7	1	0	-0.5	0.7	0.7	1.7	1.2
Appomattox	3.9	2.7	1	18	-0.5	0.9	0.9	1.0	1.3
Arlington	1.5	1.7	2	0	1.0	0.6	0.5	1.0	2.0
Augusta	2.3	3.9	2	18	0.4	1.5	1.3	2.2	1.3
Bath	4.7	-0.4	3	0	-1.2	0.4	0.4	1.5	1.0
Bedford	2.1	8.4	4	0	0.9	2.6	2.0	2.2	3.9
Bedford City	2.2	-1.8	0	0	0.9	0.3	0.4	0.9	3.9
Bland	4.6	3.4	3	0	-0.9	0.7	0.8	1.6	1.2
Botetourt	1.8	5.6	1	9	0.8	1.9	1.4	1.8	3.9
Bristol	3.4	-2.7	3	0	-0.7	-0.7	-0.4	0.6	1.9
Brunswick	4.0	0.7	2	0	-0.9	1.1	0.3	0.7	1.4
Buchanan	13.9	-1.0	0	0	-3.2	-1.3	-0.4	0.2	-0.8
Buckingham	4.1	0.0	0	0	-1.6	1.9	1.3	1.3	1.6
Buena Vista	2.7	0.2	0	0	-1.1	0.0	-0.2	0.6	1.6
Campbell	2.2	4.8	6	0	0.4	0.5	0.6	1.0	0.2
Caroline	3.3	2.5	1	18	-0.4	1.2	1.3	2.3	2.2
Carroll	6.9	3.6	1	0	0.3	0.7	0.6	1.0	1.7
Charles City	2.8	7.5	0	0	-0.1	1.3	1.4	2.0	1.4
Charlotte	3.2	1.1	1	0	0.1	1.1	0.5	1.4	1.6
Charlottesville	1.7	-0.1	3	0	-1.5	-1.0	-0.1	0.5	2.6
Chesapeake	2.6	4.1	4	36	1.7	2.9	2.1	3.2	3.2
Chesterfield	2.0	3.7	9	18	0.1	1.9	1.7	2.6	3.1
Clarke	1.5	1.9	1	0	-1.2	0.7	0.9	1.4	2.2
Clifton Forge	5.0	1.1	1	0	-0.4	-0.7	-0.7	0.2	1.2
Colonial Heights	2.4	4.7	0	0	1.0	0.3	0.3	1.2	1.1
Covington	7.5	-1.5	1	0	0.5	-0.3	-0.1	0.1	1.2
Craig	4.4	4.0	0	0	-1.6	1.6	1.3	2.1	3.1
Culpeper	2.0	2.2	2	0	0.5	2.1	1.3	2.3	2.9
Cumberland	2.0	0.3	0	0	2.0	0.8	0.5	1.8	0.1

Appendix Table 3. Data Used to Create Maps (continued)

Location	*Unemployment rate, 1999*	*Annual Growth: Business Establishments*	*Existing Golf Courses (number)*	*Golf Holes Planned and Being Built (number)*	*Annual Growth: Schools, 1990-1999*	*Annual Growth: Population, 1990-1999*	*Annual Projected Growth: Population, 2000-2010*	*Annual Growth: Housing Permits, 1990-1998*	*Annual Growth: Real Income, 1988-1998*
Danville	6.6	-0.9	5	0	-2.8	-0.7	-0.2	0.3	0.6
Dickenson	11.9	0.3	1	0	-1.9	-0.6	-0.2	0.5	-0.4
Dinwiddie	2.6	3.8	0	0	0.8	1.9	0.7	2.1	1.1
Emporia	4.8	-2.2	1	0	-1.2	0.3	0.5	1.4	2.2
Essex	4.4	1.2	2	0	-0.9	0.6	0.9	1.3	1.6
Fairfax	1.6	3.6	23	0	1.8	1.5	1.2	2.0	2.8
Fairfax City	0.9	-0.3	23	0	1.8	0.3	0.4	0.7	2.8
Falls Church	1.3	-2.0	1	0	1.7	0.5	0.4	0.2	2.8
Fauquier	1.5	2.2	2	18	0.0	0.9	0.9	1.9	2.3
Floyd	4.4	3.3	1	0	1.5	1.1	0.9	1.4	1.0
Fluvanna	1.2	4.7	2	0	3.1	5.0	2.8	5.1	5.2
Franklin	4.1	3.3	3	0	0.4	1.7	1.4	2.1	2.4
Franklin City	4.2	-2.3	1	0	-4.3	0.2	0.6	1.5	1.7
Frederick	2.1	7.7	2	36	1.7	2.4	1.8	3.0	2.9
Fredericksburg	2.5	-2.3	3	36	-4.0	-0.2	1.1	0.8	4.6
Galax	4.3	-0.2	2	0	2.1	0.4	0.3	0.8	1.7
Giles	6.1	-0.2	2	0	0.4	0.2	0.2	0.7	0.4
Gloucester	2.3	2.0	1	0	-1.1	1.4	1.4	1.6	1.7
Goochland	1.7	3.4	4	18	0.6	2.5	2.1	3.0	4.1
Grayson	5.9	2.5	0	36	-0.7	0.4	0.4	1.4	1.3
Greene	1.5	4.6	1	0	2.0	3.7	2.6	3.9	3.7
Greensville	3.0	9.0	1	0	-1.2	2.3	0.8	0.7	2.2
Halifax	6.3	8.2	1	0	-0.4	0.3	0.3	0.9	0.9
Hampton	4.0	0.0	4	0	-0.9	0.1	0.2	1.2	0.4
Hanover	1.5	3.8	2	90	2.5	3.2	2.3	3.6	3.6
Harrisonburg	1.3	-0.2	5	45	0.3	1.3	1.2	2.4	2.1
Henrico	1.9	3.5	4	0	1.9	1.5	1.1	2.0	1.6
Henry	6.4	1.9	1	0	-1.1	-0.2	-0.1	0.9	-0.8
Highland	2.6	3.4	1	0	-4.7	-0.6	0.4	1.0	1.4
Hopewell	4.1	-0.2	0	0	-1.4	-0.5	-0.2	0.4	1.4
Isle of Wight	2.7	3.0	2	0	-0.7	1.8	1.4	2.4	3.0
James City	2.0	13.8	1	0	no data	3.1	2.2	3.9	4.5
King and Queen	3.0	3.2	0	0	-1.7	0.5	0.6	1.3	1.3
King George	1.9	5.1	0	0	1.5	2.5	2.0	2.7	3.2
King William	2.4	2.5	2	0	1.3	1.9	1.8	3.0	2.2

Appendix Table 3. Data Used to Create Maps (continued)

Location	*Unemploy-ment rate, 1999*	*Annual Growth: Business Establish-ments*	*Existing Golf Courses (number)*	*Golf Holes Planned and Being Built (number)*	*Annual Growth: Schools, 1990-1999*	*Annual Growth: Population, 1990-1999*	*Annual Projected Growth: Population, 2000-2010*	*Annual Growth: Housing Permits, 1990-1998*	*Annual Growth: Real Income, 1988-1998*
Lancaster	9.3	-0.1	3	0	-2.2	0.4	0.5	1.6	0.8
Lee	8.8	0.5	1	0	-1.2	-0.1	0.0	0.9	1.5
Lexington	1.4	0.7	1	0	1.8	0.1	0.3	0.9	1.6
Loudoun	1.2	5.1	10	72	8.4	6.7	3.1	6.5	6.7
Louisa	3.5	4.2	1	18	0.3	2.2	1.7	2.9	3.3
Lunenburg	4.8	-2.1	2	0	-2.4	1.1	0.3	0.8	0.8
Lynchburg	2.1	0.0	2	0	-1.9	-0.2	-0.1	0.5	0.2
Madison	1.8	1.3	1	0	-2.0	0.6	0.7	1.9	2.0
Manassas City	1.5	2.2	0	0	2.5	2.0	1.5	2.0	2.5
Manassas Park City	1.1	3.3	0	0	2.2	2.8	1.5	3.1	2.5
Martinsville	9.8	0.1	4	0	-1.7	-0.5	-0.1	0.5	-0.8
Mathews	2.2	0.2	0	0	-0.2	1.1	1.2	1.4	1.5
Mecklenburg	5.3	1.3	5	0	-0.1	0.8	0.4	1.0	1.7
Middlesex	2.2	2.4	1	0	-1.7	1.0	1.4	1.8	2.1
Montgomery	1.9	2.8	4	0	-0.4	0.7	0.6	1.5	1.4
Nelson	2.1	2.3	2	18	0.9	1.2	0.8	1.9	2.2
New Kent	2.0	4.2	2	18	0.9	2.6	2.2	3.0	2.8
Newport News	4.0	0.6	4	0	-1.0	0.5	0.5	1.4	0.5
Norfolk	5.5	-1.1	5	18	-2.1	-1.6	-0.5	0.4	-1.2
Northampton	4.5	-0.5	1	36	-2.3	-0.2	-0.2	1.1	0.1
Northumberland	7.5	2.9	3	0	-1.5	1.0	1.1	2.0	1.8
Norton	7.1	1.3	2	0	-4.7	-0.8	0.2	0.7	0.0
Nottoway	2.8	1.0	5	0	-1.0	-0.4	0.3	0.7	0.5
Orange	2.5	2.2	1	0	0.3	1.8	1.6	2.5	2.2
Page	3.9	-0.2	1	0	0.1	0.7	0.7	1.4	1.4
Patrick	5.4	0.9	2	18	1.0	0.8	0.4	1.0	1.2
Petersburg	5.2	-2.2	2	0	-1.2	-1.4	-0.6	0.2	1.1
Pittsylvania	5.8	5.0	5	0	1.4	0.7	0.3	1.2	0.6
Poquoson City	2.2	1.5	0	0	-0.6	0.3	0.6	1.0	2.2
Portsmouth	4.9	-0.9	3	0	-1.4	-0.8	-0.5	0.5	-0.3
Powhatan	1.6	6.1	2	27	3.4	4.2	3.1	4.8	4.5
Prince Edward	3.5	1.8	2	18	-0.1	1.1	1.0	1.4	1.1
Prince George	2.7	8.2	2	9	-0.3	1.2	0.9	2.5	1.4
Prince William	2.0	3.5	11	63	1.9	2.3	1.6	2.9	2.5
Pulaski	4.5	1.3	2	0	0.3	0.1	0.1	0.7	1.2

Appendix Table 3. Data Used to Create Maps (continued)

Location	*Unemployment rate, 1999*	*Annual Growth: Business Establishments*	*Existing Golf Courses (number)*	*Golf Holes Planned and Being Built (number)*	*Annual Growth: Schools, 1990-1999*	*Annual Growth: Population, 1990-1999*	*Annual Projected Growth: Population, 2000-2010*	*Annual Growth: Housing Permits, 1990-1998*	*Annual Growth: Real Income, 1988-1998*
Radford	2.8	-0.4	1	0	-1.8	-0.3	0.3	1.3	1.4
Rappahannock	2.0	4.2	0	0	-0.9	1.2	1.1	1.7	1.9
Richmond	4.4	0.7	0	0	-1.2	2.5	1.6	1.3	0.6
Richmond City	3.4	-1.1	9	0	-1.2	-0.7	-0.3	0.2	-0.6
Roanoke	1.3	2.4	5	0	-0.6	0.5	0.6	1.4	2.5
Roanoke City	2.6	0.1	0	0	-0.3	-0.4	-0.1	0.4	0.2
Rockbridge	2.1	-1.4	0	0	-1.2	1.0	0.7	1.7	1.6
Rockingham	1.3	3.8	5	18	0.6	1.3	1.2	1.9	2.1
Russell	8.1	2.2	1	0	-0.6	0.1	0.0	0.7	1.6
Salem	1.6	0.6	2	18	0.2	0.3	0.4	1.0	2.5
Scott	6.6	0.0	0	0	-0.6	-0.1	-0.1	1.0	0.3
Shenandoah	2.8	2.0	2	0	0.2	1.5	1.2	1.7	1.4
Smyth	6.1	0.8	2	0	-0.6	0.0	0.1	0.8	0.7
Southampton	3.3	3.3	0	0	-0.4	0.5	-0.2	0.8	1.7
Spotsylvania	1.6	11.5	1	0	4.3	4.7	2.5	5.2	4.6
Stafford	1.6	7.0	4	54	4.0	4.4	2.4	5.3	4.1
Staunton	2.4	-1.0	0	0	-1.9	-0.3	-0.1	0.5	1.3
Suffolk	3.5	0.5	5	27	2.7	2.3	1.6	2.4	2.5
Surry	7.7	-0.2	0	18	-1.9	0.4	0.7	1.6	-0.2
Sussex	2.9	0.9	0	0	-2.3	0.9	0.4	0.8	1.5
Tazewell	7.0	1.3	2	0	-1.8	-0.1	0.1	0.7	0.4
Virginia Beach	2.6	1.9	15	9	-1.4	0.6	1.4	1.4	1.4
Warren	2.6	2.0	4	18	-0.1	1.2	1.7	2.1	3.0
Washington	4.7	7.4	2	0	-0.8	1.0	0.5	1.6	1.9
Waynesboro	2.9	-0.2	1	0	0.3	0.2	0.4	1.1	1.3
Westmoreland	5.1	1.6	0	0	-2.5	0.2	0.7	1.1	1.7
Williamsburg	5.9	-6.2	10	9	no data	0.5	0.5	0.9	4.5
Winchester	2.5	-1.7	0	0	0.1	0.1	0.6	1.0	2.9
Wise	9.2	0.6	0	0	-0.8	-0.2	0.0	0.4	0.0
Wythe	4.1	2.6	1	0	-0.6	0.5	0.5	1.1	1.4
York	2.0	6.1	0	0	0.2	3.4	2.5	3.8	2.2