IDENTIFICATION OF FUNCTIONAL MAINTENANCE REGIONS OF GOLF COURSES IN THE UNITED STATES

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PREFACE

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CHAPTER I

INTRODUCTION

The game of golf is a popular form of recreation in the United States today. The extensive use of land required for golf is clearly evident on the cultural landscape. Indeed, there are over 13,000 golf courses in the United States covering about 1 1/2 million acres of some of the most beautiful natural and artifically enhanced land in the world (Much, 1985). The typical regulation golf course covers from 125 to 175 acres of land. Perhaps one of the limiting factors to the expansion of golf in the United States is its spatially extensive nature and subsequent requirement for large tracts of land (Hegarty, 1985). Also, the large demand for water by golf courses in an atmosphere of diminishing supply is an increasingly serious problem that confronts golf courses in some parts of America.

Figure 1 represents the spatial distribution of golf holes by county in the United States. With the exception of certain resort areas, the distribution of golf holes mirrors the distribution of population in the United States. It is in the populous Northeast and Midwest where most of the golf holes are located. Likewise, it is in these areas where land availablity is most restricted and costs are highest.

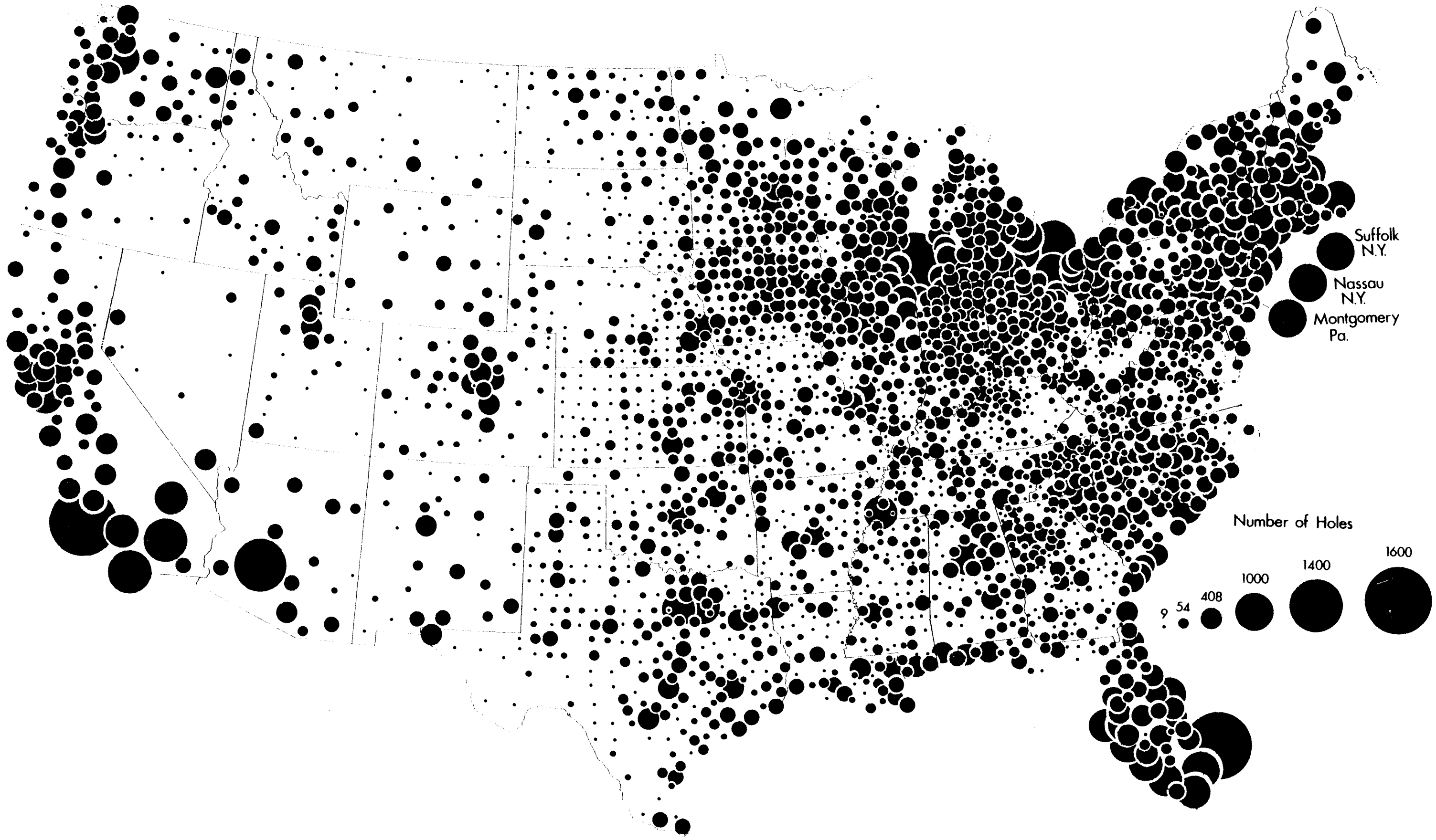

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Figure 1. Total Golf Holes by County (1984)

Maintenance and budget considerations are factors of great importance for potential golf course developers, as well as for superintendents of existing and future facilities. The time, money, and effort needed to maintain golf courses on valuable tracts of land can be extraordinary. For example, 50 percent of all private 18-hole regulation courses nationwide spend at least $207,000 per year on maintenance operating costs and 25 percent spend at least $291,570 (Golf Course Maintenance Report, 1985). The expenditures for maintenance have been shown to range from less than $50,000 a year to more than $800,000 a year (Golf Course Maintenance Report, 1985). The Golf Course Superintendents Association of America (GCSAA) and the National Golf Foundation (NGF) (1985) estimate that $1.7 billion is spent annually on golf course maintenance in the United States. Furthermore, the GCSAA and NGF estimate that the maintenance equipment inventory of all U.S. golf courses is valued at over $1.8 billion.

Golf course superintendents need a tool or method by which they can accurately estimate maintenance costs and requirements for golf courses so that justification of expenditures can be made to developers or operators. Moreover, the superintendent needs to know where his golf course stands among other courses in his region with respect to maintenance costs and requirements. This would allow for reliable comparison with other courses within a region. A superintendent could be able to accurately judge whether he was spending too much on maintenance or saving money.

Considerable study has been given to golf course enviroments at the individual level. For example, some sophisticated computerized irrigation systems are based on specific environmental conditions. The irrigation system is programed to turn on and off with regard to certain environmental conditions. Yet, no literature has ever explored the environments of golf at the national scale.

Obviously, maintenance requirements and costs will vary dramatically across a country as physically and environmentally diverse as the United States. This study will address the question of functional maintenance regions of golf courses in the United States by considering various environmental variables that are known to affect golf course maintenance requirements. It is expected that a new functional regionalization of golf could serve as an appropriate means for golf course maintenance and budget analysis. A new regionalization of golf could make estimation and comparison of maintenance and budget specifics much more reliable and easier.

Justification and Need for the Study

The National Golf Foundation (NGF) in cooperation with the Golf Course Superintendents Association of America (GCSAA) has prepared the first in a projected series of biennial reports on various aspects of golf course maintenance. Specifically, the 1985 Golf Course Maintenance

Report provides information on maintenance requirements, maintenance costs, maintenance staff, and other golf course characteristics (such as acreage, grasses, irrigation, etc.). Descriptive statistics based on the golf course maintenance data have been reported by United States Census regions (Figure 2). While U.S. Census regions are convenient to use, they fail to serve as appropriate divisions for environmental analysis and for the study of the geography of golf. U.S. Census regions are just too diverse with respect to the environment and the spatial distribution of golf facilities. Due to spatially varying maintenance requirements of golf courses across the United States, the NGF, GCSAA, and firms concerned with golf course management recognize a discrepancy between United States Census regions and functional maintenance regions of golf for statistical reporting. Joseph Beditz, Executive Vice President at the NGF, has expressed, in a personal conversation in the fall of 1985, the NGF's interest in developing more efficient regions for statistical reporting. The new environmentally-based regions could replace the perceived inadequacies caused by the use of United States Census regions for reporting areas. This study will develop functional maintenance regions for golf courses in the United States in order to enhance the reporting quality of future Golf Course Maintenance Reports and to improve the predictive capability of maintenance costs and requirements for existing and future golf courses. The study is aimed at

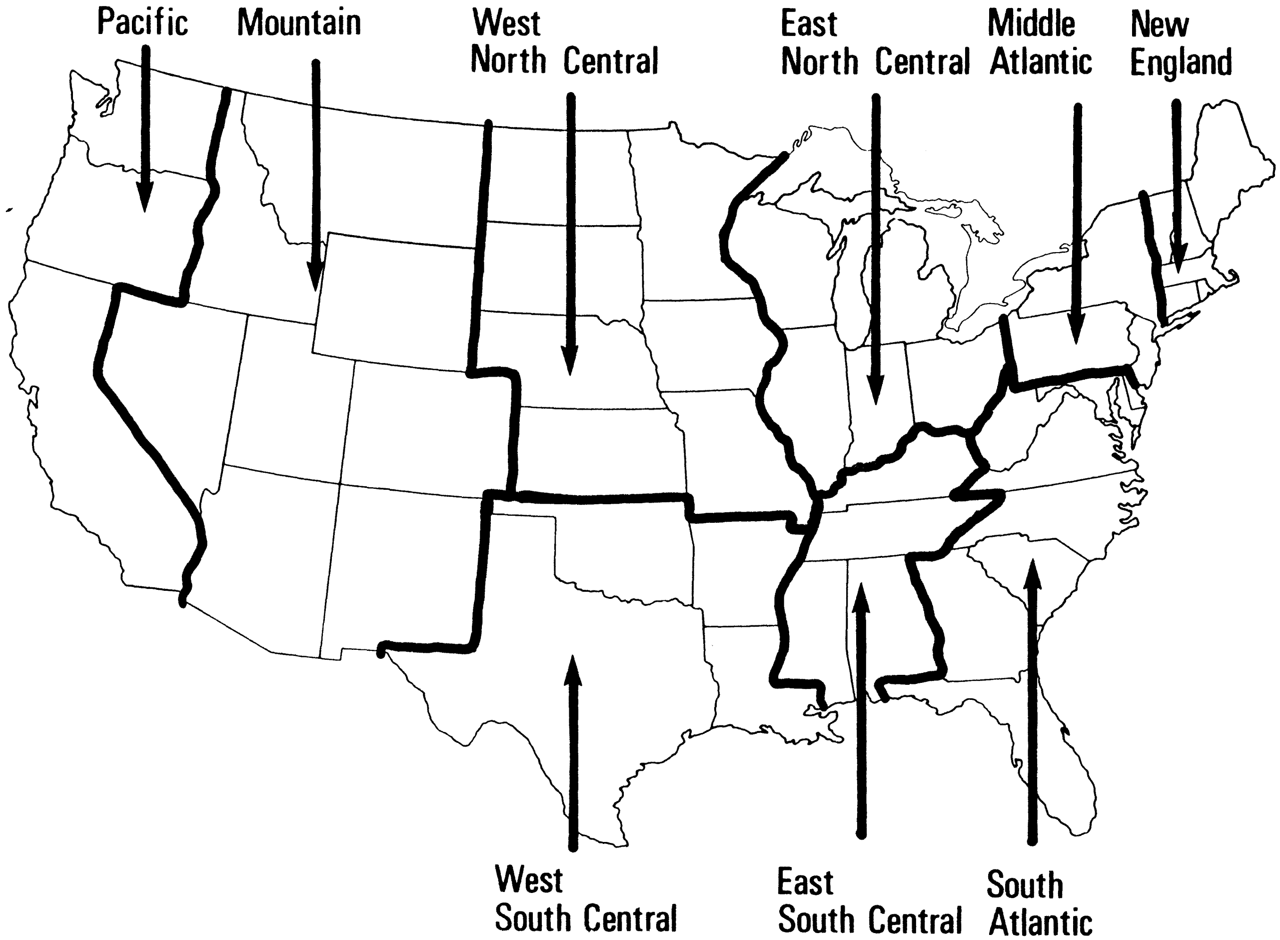


Figure 2. United State Census Regions

producing reliable data to assist superintendents in the preparation of budgets and to enable superintendents to see how their facilities compare to other courses with similar physical environments. This will make justification of expenditures to course owners or committees much easier (Schneider, 1985). Ideally, it can assist superintendents in determining where changes in maintenance and budget are needed based on requirements of other courses within a similar environmental region. Decreasing land and water availability and escalating maintenance costs warrant an investigation of alternate methods of predicting all aspects of golf course maintenance considerations.

Problem Statement and Hypothesis

The primary goal of the study is to achieve an environmental explanation of golf course maintenance costs through a functional regionalization of the golf environment. Specifically, the research question is can statistically objective functional maintenance regions of golf courses be identified for the United States by jointly considering various environmental factors known to be important in golf course management, and can this environmental regionalization provide a meaningful explanation into golf course maintenance costs?

The hypothesis is that statistically objective functional maintenance regions of golf courses can be identified for the United States by jointly considering various environmental factors and that these objective regions will correspond to sets of maintenance practices on actual golf courses. Based on a statistical analysis of the data, it is expected that within-region variance of maintenance costs and requirements will be minimal while between-region variance will be great.

Scope and Limitations of the Study

The objectively derived maintenance regions of golf courses will be compared to maintenance characteristics on actual golf courses as indicated from the results of the newest national survey of golf course maintenance. Approximately 1800 golf facilities from a population of about 13,000 responded to the new maintenance survey which was conducted in the fall of 1986 by the NGF and GCSAA. This study will be concerned only with golf facilities in the 48 contiguous United States. While golf facilities in Alaska and Hawaii could respond to the survey, they will not be included in the study since the NGF and GCSAA usually do separate analyses because of such vastly different environments. The results of the recent survey will be presented in the 1987 *Golf Course Maintenance Report*. It is hoped that the golf course maintenance regions from the present study will take the place of United States Census regions for the reporting of statistics in the 1987 biennial report.

Methodology

The golf course maintenance regions to be defined must be entities that represent relative uniform golf course maintenance characteristics. Cluster analysis will be used to objectively produce "natural" groupings or regions of conditions from similarities in the data. It is expected that the environmental variables to be selected will fall into several distinct maintenance regions.

Once the functional maintenance regions of golf courses have been identified from the environmental clustering, actual maintenance characteristics of golf courses will be examined by comparing statistics between and within the regions for validity. A multiple regression model will be constructed for each region to study which environmental factors are important in explaining the variation in annual cost per maintained acre. It is expected that certain unique maintenance charateristics will correspond to the various functional maintenance regions of golf courses.

Analysis of variance procedures will be employed to test the statistical validity of the regionalization. If the analysis of variance statistic is significant, between-region variation in annual cost per maintained acre will be greater than within-region variation, and thus, the variation in annual cost per maintained acre will be considered adequately explained by the regions developed in this thesis. Since golf course maintenance data will be in the form of point observations (golf facilities) with individual zip codes, the data will be aggregated to state resolution in order to allow for comparison with existing census region reporting units. Likewise, an analysis of variance test will be conducted on the United States Census regionalization to support the perceived notion of inadequacy. It is expected that the new, functional maintenance regions will be statistically significant and be proven superior to U.S. Census regions in characterizing the environmental aspects of golf.

CHAPTER II

LITERATURE REVIEW

Golf and Environment

Rees (1962) provides information on golf course design and maintenance considerations. Although the study is not geographical in nature, optimal environmental conditions for golf courses are discussed. Rees states that the most important factor to consider when planning a golf course is the question of future maintenance costs; faulty planning may create maintenance problems that require constant attention or reconstuctional work later.

Rees claims that rural settings are the best locations for golf courses since seclusion and quiet surroundings are enjoyable features. A golf course should be built in a rural setting it at all possible.

According to Rees (1962), hilly golf courses are not favored by players, and the best courses are constructed on "rolling undulating country." Also, hilly courses cost more to maintain. Perhaps the terrain type indicated by survey responses of golf courses in this thesis will help explain the variation of annual maintenance costs.

Rees recommends that a golf course be built on land that is free-draining. Obviously, money will be saved if installation and maintenance of a drainage system can be avoided.

The type of soils found on golf courses is considered to be an important factor in golf course design and maintenance (Rees, 1962). Rees (1962) describes a good soil as one that has suitable structure and texture with a relatively high natural fertility. Overall, soils should be resistant to compaction, fertile, and considerably retentive to moisture. If soils are not suitable, other soils must be introduced which is a costly but essential enterprise. Also, the introduction of fertilizers to poor soils adds to the maintenance bill. It is hoped that the natural fertility of the soil and fertilizer costs will help to explain annual maintenance costs in this thesis.

The maintenance of roughs is deemed important by Rees (1962) as a factor of good golf course management. The degree of rough maintenance depends on the type of vegetation growing there, but golf course policy regarding playing conditions is usually the overriding factor. Since Rees (1962) suggests that the intensity of rough maintenance varies from golf course to golf course because of individual course policy, it is expected that this variable will be of little help in explaining regional variations in annual maintenance costs in this thesis.

Rees (1962) realizes that climatic conditions make it essential to irrigate at some time or other during the year. Therefore, it is noted that a great deal of water and money can be saved if greens are placed so that more than one can be irrigated by a single outlet. Rees (1962) states that, in some cases, the position of a green might be determined by the availability of water. It some parts of the country, it is generally recognized that the cost and availability of irrigation water is one of the most important maintenance concerns confronting golf courses. It is expected that irrigation water will be an important factor in explaining reional maintenance costs in this thesis.

Finally, Rees (1962) makes the point that climatic conditions play the most important role in the overall management of golf course turf. No elaboration is offered. Because a wide variation exists in conditions between golf courses across the country, Rees (1962) does no more than outline the general principles of golf course management. This statement in itself suggests that the need exists for a national regionalization of golf course environments. It is hoped that this thesis will produce such a regionalization so that maintenance costs and requirements can be better explained.

Climate

Maunder (1962) begins by noting that most all climatic classifications have been based on either seasonal rainfall, annual or seasonal temperature, precipitation effectiveness and thermal efficiency, vegetation or agriculture. Few have considered humans in classifying climate.

Maunder (1962) believed that his human classification of climate was the first such attempt. His classification was based on an index which took into account thirteen aspects of the human climate: mean annual rainfall, mean annual duration of rain, percentage of rainfall from 9:00 p.m. to 9:00 a.m., mean annual duration of bright sunshine, mean winter duration of bright sunshine, mean annual degree-days, mean number of days with screen frost per year, mean daily maximum temperature of coldest month, mean annual maximum temperature, mean number of days with ground frost per year, humidity index, mean number of days with wind gusts 40 m.p.h. and over, and mean number of days with wind gusts 60 m.p.h. and over.

Nevertheless, Maunder (1962) recognized that no fundamental measure or index of climatic comfort exists, and that if one did exist, many people would not agree with it. Furthermore, Maunder acknowledged that his classification does not consider every aspect of the human climate since some variables are difficult or impossible to measure. Some aspects or climate such as days with snow, days with fog, days of high humidity, and days of high temperatures, are not readily available. Maunder states that these and other aspects of climate should probably be considered in analyzing the human climate of any location. While the model was applied to individual locations in New Zealand, no other examples were discussed nor were any regionalizations based on the climatic classification attempted.

If weather monitoring equipment were on the premises of a golf course, the climatic index and classification offered by Maunder (1962) could be easily determined. Indeed, some of the climatic variables mentioned by Maunder as being not readily available, such as days of high humidity, days with snow, days of high temperatures, etc., have been considered in the 1985 National Maintenance Survey (see question #37 on page 7 of survey, Appendix A). Other variables used in the climate index by Maunder, such as annual rainfall, are included in the survey. A variation of Maunder's ideas is incorporated in the present survey, and regional comparisons are made possible.

Terjung (1966) conducted a study on physio-climatic classification of the United States which was based on human comfort. Two indices were created: the Comfort Index which related dry-bulb temperatures to relative humidity, and the Wind Effect Index which accounted for the effects of solar rediation and wind chill. The indices were applied to about 300 stations in the conterminous United States for July and January, daytime and nighttime, respectively. The point observations were interpolated by Terjung (1966), and areas of differentiation were created. Nevertheless, Terjung (1966) warned that the lines of delimitations should not be considered as extremely accurate, and that the lines constitute areas of gradation in a continuum, changing from one type of condition into another gradually, not abruptly.

The results of the study indicated that no inconsistent distributions were apparent and that the classification seemed to be limited only by the reliability and availability of data. Terjung (1966) goes on to point out that the classification is applicable to any dimension, i.e. region or time. Although Terjung (1966) considers his classification to have implications for many fields of study, such as tourism, clothing, housing, etc., no specific examples were discussed. As for the implications of Terjung's (1966) work to this thesis, the regionalization considerations are the most important. Environmental golf conditions in boundary areas must be thought of as transitional and not as definite, sharp lines on a map.

Green (1967) offered a weather and outdoor comfort model to help the "holidaymaker" get more out of his leisure time. The comfort model was based on the heat balance of the body and atmosphere, and on the type of clothing worn. Based on these factors, Green (1967) calculated how much energy was expended by hiking a fixed distance and determined how long the hike should take at an exceptable level of comfort. While no other examples were given, it is plausible that the comfort model could be applied to golf. Certainly, the pace of a golf game should be relaxed slightly during the heat of the day to avoid heat exhaustion. Although Green (1967) constructed his model to apply to individual "holiday" locations, no specific geographic examples are discussed.

Geography and Sport

Rooney (1974) has demonstrated that climate plays a role in the spatial distribution of high quality production of players of various sports. Rooney considers climate to be an important variable in regionalizing sports for the United States.

Rooney (1974) discusses the importance of long periods of cold and snow cover in the northern states. The climate is considered reliable enough to insure an excellent environment for outdoor sports such as skiing and ice hockey. One exception made by Rooney is the success of hockey in relatively warm eastern Missouri. The success of the St. Louis Blues is credited for the large demand for hockey equipment. While ice is very unreliable in this area, competition is, nevertheless, taking place on asphalt. While the "climatic barrier" of sport seldom seems to be broken, it has been in this instance.

Rooney (1974) claims that outdoor sporting activities thrive during all seasons of the year throughout the South. Yet, per capita indices of southern states decrease as winter temperatures increase. One example made by Rooney (1974) is of North Texas being much better in basketball than South Texas.

Climatic amenities are deemed responsible by Rooney (1974) for the advancement of outdoor sporting activity and for attracting people to Texas. One of the reasons for the success of football in Texas is attributed to the "fine autumn weather" which "provides ample time for a long season including playoffs" (Rooney, 1974).

Rooney (1974) has shown the spatial organization of golf tournament locations to be predominantly southern and western in nature. Rooney states that the spatial organization of professional golf is motivated by the desire for good weather at tournament locations. Thus, inhabitants of these areas have better access to professional golf than do other areas.

The production of professional golfers also indicates an apparent geographic variation which is based on climate. The Sun Belt states are by far the leaders in professional golfer production. Texas and California have the highest per capita production. The southern Plains and several southeastern states are also strong areas of professional golfer production. In the north, Minnesota is the best. The only other states that rank above the national average in the north are Connecticut, Massachusetts, New Hampshire, and Montana.

While Rooney's (1974) climatic explanations of sport regionalization are plausible, no statistical support is provided. The success of certain sports in various areas is apparent, yet no physical measure of climate is associated with the regionalization.

Yapp and McDonald (1978) have developed a recreation climate model based on the thermal balance of the body, perceived suitability of the weather, and climatic variables. The degree and frequency of comfort experienced in the course of recreation activities was identified as the best suitable basis for an index of recreation climate. Four classes of weather types and five classes of heat balance were used to derive comfort classes. The model was applied for a variety of activities, such as sunbathing, strolling, and boat fishing. The model used 9:00 a.m. and 3:00 p.m. daily observations for two study areas in southern New South Wales, one coastal and one inland. The most favorable months for the chosen activities were identified. The results indicated that the highest demand for recreational activities occurred outside the most favorable periods for participation.

While stating that the model could be applied to other activities, such as golf, Yapp and McDonald do not provide an example. It was concluded that the model has important implications for anyone, whether he be vacationer, recreation planner, or manager. Considering high demand periods, perhaps the model could be used in some way by golf course superintendents to aid in maintenance planning.

In a market analysis of golf facilities, McKay (1980) states that regional climate and weather patterns, such as wind direction and velocity, are important in decision making. The length of the playing season, and thus, the number of rounds played are directly associated with climate. Courses in warm southern states may appear more attractive to investors and developers because of year round play, but northern courses can be just as profitable. They are profitable because the playing season is limited, and expenses are minimized because the northern "off season" virtually precludes play. Southern courses' expenses continue throughout the year even though they also experience an off season.

The frequency of severe weather in an area can have a tremendous impact on a golf enterprise. For example, McKay (1980) states that the harsh winter and spring of 1978 produced a slowdown of golf facility development, player production, and the number of rounds played throughout the country. McKay emphasizes the importance of studying the effects of climate on golf in a region.

Beard (1983) offers a regionalization of the United States based on turfgrass climatic zones. He created the zones so that readers could get information on appropriate timing of individual turfgrass establishment and maintenance practices for specific locations. Although others have presented maintenance information for the United States in general terms with only an acknowledgement of the variation in requirements across the country (Rees 1962), Beard accounts for the variation by providing maintenance details for individual turfgrass climatic zones. While Rees only stated that climatic conditions play the most important role in the overall management of golf course turf, Beard recognizes the importance of determining appropriate maintenance practices for specific areas by incorporating the variation of climate into his turfgrass climatic zones.

Four major turfgrass climatic zones were presented; each major zone was further subdivided into two or three regions. While Beard (1983) refered to the zones as "turfgrass climatic zones", no specific information was given as to what climatic variables were considered in drawing the boundaries. Beard only stated the optimum temperature ranges for specific turfgrasses for each zone. The regional methodology was also not discussed. Yet, Beard cautions that boundary lines indicate general changes in turfgrass species, not absolute divisions. This notion should be kept in mind as the thesis progresses since this characteristic of regionalization is unavoidable.

Geography of Golf

Miller (1972) examined the spatial distribution of golf in the United States. The history and diffusion of golf in the United States were discussed. Golf regions were examined at the state level of resolution, and possible explanations for regional patterns were investigated. Miller explained the diffusion of golf from its American origin in the Northeastern United States to the South and Southwest. The Plains states were characterized as having a relative surplus of golfing facilities while the South was deemed as a deficit region. No climatic or environmental explanations were offered for regional golf facility development.

Spatial aspects of golf were presented by Rooney (1974). The origin and diffusion of golf in the United States were explained. Regional variations in the growth of golf facilities during the 1960's were examined at the state level of resolution. The shift in expansion from the Northeast to the Southeast and Southwest was emphasized. The trends in resort and real estate golf were discussed.

Spatial aspects of high school and professional competitive golf were also examined by Rooney (1974). The leading states of per capita high school golfer participation were Iowa, Kansas, and Minnesota. Close behind these states were Illinois, Texas, Nebraska, North Dakota, and Indiana. States with exceptionally low high school per capita participation were located in the Northeast or the South. Rooney (1974) attributed low high school golfer participation in the South to poor support for education and racial discrimination. High population density and urbanization were blamed by Rooney (1974) for low participation in some areas of the Northeast. Overall, Rooney (1974) considered participation to be a function of population density and settlement patterns.

Cornish and Whitten (1981) produced an interesting work on the history of notable golf course architects and their respective golf courses. However, geographic variation was considered only in the context that the game of golf has been played in many different locales and on widely differing terrains. Cornish and Whitten recognized that no standard playing field for golf has been adapted for all sites. No environmental or regional discussions are provided by Cornish and Whitten (1981).

The emergence of golf landscapes in America, with particular emphasis on real estate and golf, was examined by Adams and Rooney (1984). Real estate golf courses are those that are developed at the center of planned residential and resort communities. These residential and resort communities were coined "condo canyons" by Rooney and Adams (1984). The recent spread of the real estate course has been prevalent. Rooney and Adams (1984) state that over one-half of the courses being constructed today are real estate associated ventures. The traditional golf course is constructed to create golfing opportunities; the real estate course is constructed to enhance the value and aesthetic quality of the property where the subdivision is located. Traditional golf courses are increasingly employing cost saving strategies, such as the target golf concept versus the turf farm concept. Real estate courses usually consist of large, sprawling layouts. While many traditional golf courses are in financial trouble, real estate courses have proven to be profitable by attracting large numbers of golfers to create new communities. Rooney and Adams (1984) conclude by reiterating the significant impact of real estate golf upon the changing resort and residential landscapes of the United States, yet no regional explanation of residential golf is pursued.

Adams and Rooney (1985) have also explored the evolution of golf facilities in America. They provided a detailed account on the history of golf. Scotland was credited as being the birthplace of golf. It is believed that the Scots have been playing golf for more than five centuries. Scottish "links" golf courses are considered to be the "embryonic" form of golf courses. The links golf course is characterized by its coastal setting coupled with undulating terrain consisting of marine sands, but no other environmental or physical implications are given by Adams and Rooney (1985).

The origin of golf in America is considered by Adams and Rooney (1985) to coincide with the opening of the St. Andrews Golf Club in Yonkers, New York in 1888. By the end of the nineteenth century, there were more than 950 courses in the United States. The Northeast had 61 percent of the golf courses. The period between 1923 and 1929 was regarded as being the first golf boom in America. The emergence of Bobby Jones in the twenties contributed to the success of the sport. Over 600 new golf facilities were constructed during this period. By 1931, the Northeast's share of golf facilities declined to 25 percent while the North Central region climbed to more than 41 percent. The dominance of golf was still in the north, but the focus shifted to the interior of the country.

Adams and Rooney claim that the second boom of golf occurred in the late 1950's and 1960's with the advent of televised golf and such golfing heros as Arnold Palmer. Palmer related to the masses of the population, and new players flocked to already overcrowded courses. Adams and Rooney also point out that the 1960's experienced the development of resort and residential golf communities in the Sunbelt due to increased amounts of leisure time, disposable income, and earlier retirements. While Adams and Rooney (1985) note the development of golf in the Sunbelt region, no specific delineation is given nor is any enviromental description.

Growth continued in the early and mid 1970's (Adams and Rooney, 1985). The Northeast did not experience growth, however, because of high land values and densly urbanized population. Since the late 1970's, the growth rate of golf facilites has declined. The decline is blamed on increasing costs of land, course construction, maintenance, and generally unfavorable economic conditions. The Northeast continues to be dominant in golf facilities with over 54 percent of the total.

Private versus public golf facilities were also examined by Adams and Rooney (1985). Private facilities dominated until the late 1950's. Since then, public facilities have out numbered private facilities. Regional variations do exist. Adams and Rooney (1985) speculated that private facilities are dominant in the South due to racial and economic discrimination. Resort and residential communities in the South are also primarily private. Public facilities predominate in the North Central, Northeast, Pacific and Mountain states.

Other topics covered by Rooney and Adams (1985) include the availability of regulation golf courses and metropolitan versus nonmetropolitan availability. Metropolitan availability of golf continues to decrease as populations grow and available land for golf course development becomes harder to find in the urban environment.

Recent changes in the golf industry and future trends are explored. Overall, Adams and Rooney (1985) attribute the regional variation in access to golf courses to differences in income, population density, settlement patterns, land costs, availability of water, ethnic and racial constituency. A new relationship between golf and real estate ventures is attributed to changes in the economics of golf course development.

Although Adams and Rooney (1985) adequately explain the history and diffusion of golf in the United States through non-environmental factors, little attention is given to the role of climate or environment in explaining the regional variation of golf facility development. Aside from noting the increase in golf facility development in the Sunbelt area, no elaboration is presented. Adams and Rooney deem the the availability of irrigation water as an important factor in the regional variation of access to golf facilities, yet an explanation of which regions are affected by water supply is not attempted.

Hegarty (1985) has explored the question of where optimal locations should be for a new type of space-saving golf: the Cayman golf facility which employs a restricted-flight ball. Spatial analysis of golf supply was conducted at the county and SMSA level of resolution.

Hegarty ascertains that future Cayman golf facilities will be confined to SMSA locations since all other forms of space saving golf, ie. par 3, executive, are located within SMSA's. Hegarty (1985) bases optimal SMSA Cayman location decisions on four factors: 1. SMSA's with greater population densities require space saving golf facilities instead of regulation facilities. Cayman golf is deemed appropriate in these settings. 2. SMSA's with other existing forms of space saving golf will accept Cayman golf more readily because of familiarity with the concept. 3. Per capita availability of all golf is used as a measure. Two alternative location solutions are offered. One states that SMSA's that are not well served by golf are likely locations for Caymen golf. These SMSA's probably have a great latent demand for golf, but few facilities to serve them. Yet, a low per capita supply may also indicate a regional disinterest in golf. An example of this situation is poorly served SMSA's with high Hispanic populations. The low per capita index indicates Hispanic disinterest with golf rather than high latent demand for golf. Furthermore, a high per capita supply can also signal high regional interest in golf and thus, a high latent demand for the game. These locations are also considered prime for Cayman golf. 4. Finally, Hegarty (1985) states that Cayman golf will follow the public trend as have other space saving forms of golf. Again, arguments can be made as to decisions of low and high per capita supply of public golf.

Hegarty (1985) bases his decisions on the optimal locations of Cayman golf facilities entirely on non-environmental factors. Decisions are made primarily on the basis of demographics and on the geography of golf. Since Hegarty concentrated on SMSA locations, no regional solution was explored. The implications of Hegarty's work for this thesis are few. Perhaps a future analysis of golf environments at the SMSA level would be sufficient to provide a basis for regionalization by interpolating survey results between SMSA locations to create contour or proximal maps.

The National Golf Foundation compiles various statistics on golf. The Statistical Profile of Golf in the United States summarizes changes in the number of golfers, facilities, holes, rounds played, etc. A spatial summary is conducted at the state level.

Golf Market Today, which recently replaced The Wedge, is a monthly publication which provides articles and statistics on the latest golf information. Various information is sometimes presented for specific locations, states, and regions.

The NGF co-publishes the Golf Course Maintenance Report with the GCSAA. The biennial report provides statistics on golf course maintenance requirements, costs, staff, and other golf course characteristics. The next Golf Course Maintenance Report to be published will contain information from the maintenance survey on which this thesis is based.

The NGF also conducts many other assorted surveys and publications. One of the most recent projects is a joint effort by the NGF and Market Facts, Inc., a national marketing research and consulting organization. The National Golf Participation Study examined golf participation, golfer attitudes, and golfer behavior in the United States.

Although some NGF publications portray information through the use of regions, it is apparent that little attention has been given to the regionalization of golf. The spatial distribution of golf facilities in the United States is not accounted for, let alone national golf course environments. It seems logical that the geography of golf should be considered when determining reporting regions for some studies, such as market analyses and golfer participation analyses. Likewise, golf environments should be considered when presenting statistics for studies where the results are are partially affected by the influence of the physical environment, such as the national maintenance survey. Thus, the lack of efficient, environmentally-based reporting units for the national maintenance survey has inspired this thesis.

Regionalization

While some attempts and considerations of regionalization have been discussed in conjunction with previous studies above, an outline of concepts and methods of the process is now in order. Although methods of regionalization have changed over the years, the ultimate goal is still the same: to define an uninterupted area which possesses some kind of homogeneity based on specified criteria.

Whittlesey (1954) described the region as an area in which accordant areal relationships produce some form of cohesion. He goes on to state that the region is defind by specified criteria and is homogeneous only with respect to these criteria. Whittlesey believed that the search for accordant areal relationships among phenomena brought forth by specified criteria constitutes the regional method or the procedure for discovering order in earth-space. Indeed, the ultimate goal of this thesis is to regionalize golf environments based on specified environmental factors so that some sense of order can be achieved to improve the explanation of regional variations in maintenance costs.

Because of the need for regional delineation in a discipline that focuses on the variation of associated phenomena in earth-space, Whittlesey (1954) remarks that the attention of geographers has perennially been attracted to boundaries. With regard to regional cores and boundaries, Whittlesey (1954) describes two different situations. One situation is where regions are constructed out of a continuity, such as slope, where boundaries have precise definition. The main problem with this kind of delineation is deciding on the appropriate placement of isograms. Regions of this kind have no cores since transition is continuous. The second situation is where regions are defined by discontinuities, or areas of discontinuous distribution. Whittlesey (1954) points out that regional peripheries are likely to be "acutely troublesome" because the phenomena are "transitional" or "zonal." Regions that are based on discontinuities have distinct core areas, and the characterisitics that describe regions are most intensely expressed in the core. Obviously, golf courses are discontinous phenomena, and thus, the boundaries drawn in this thesis are to be considered as approximations since transitions of golf environments are rather broad.

As for the techinques of analysis in regional study, Whittlesey (1954) recognized four primary methods: analysis by expository methods, analysis by statistical methods, analysis by cartographic methods, and analysis by photo-interpretation methods. No detailed explanations of the four techniques were discussed. In this thesis, the primary technique of regional analysis will be statisitical.

The method of regionalization in this thesis will use the techniques of cluster analysis. Anderberg (1973) has provided theory and application of cluster analysis. He describes the objective of cluster analysis as the grouping of data units or variables into clusters such that the members within a cluster have a high degree of "natural association" among themselves while clusters are "relatively distinct" from one another. Anderberg (1973) asserts that cluster analysis is just a good or better than other methods of regionalization, such as discriminant analysis. Anderberg (1973) explains that cluster analysis can be effectively used to reveal structure and relations in data. He refers to cluster analysis as a tool of discovery. It is hoped that the use of cluster analysis in this thesis will lead to the discovery of naturally occurring maintenance regions of golf.

Anderberg (1973) makes the point that cluster analysis can be used to develop inductive generalizations. In most cases, the results of an analysis apply only to the sample on which they are conducted. Yet, Anderberg (1973) states that cluster analysis results can be extended to adequately describe the characteristics of other samples and ultimately the parent population. Thus, the results of the cluster analysis in this thesis, which are based on a sample of golf courses across the country, will be extended to characterize the environments of golf for the whole nation.

Anderberg (1973) provides some examples of fields of study that effectively employ cluster analysis in research, such as biology, sociology, marketing, geography, and many others. His remarks about the use of cluster analysis in geography are rather limited; he notes only that the technique has been applied to land and rock formations, river systems, soils, cities, counties, world regions, and land-use patterns. No elaboration is given. Nevertheless, it is expected that cluster analysis will be successful in finding "natural associations" in the maintenance data which will lead to the indentification of functional maintenance regions of golf.

Another examination of regionalization has been conducted by Smith (1975). He recognizes the identification of regions as a long-established method of geographical synthesis. Smith goes on to state that the regional approach has been improved by the introduction of quantitative analysis. Numerical methods have provided the means for analyzing much larger amounts of information than could be used in traditional methods of areal differentiation, i.e. map overlays, etc.

Smith (1975) makes the point that whatever kind of regionalization used, the primary objective of all good classifications should be to create relatively homogeneous categories which are well differentiated from one another. According to Smith, the best classification is one where within-class variations are minimized while between-class variations are maximized. This consideration is of prime importance in this thesis.

Smith (1975) states than when more than three criteria are needed in defining regions, conventional graphic methods cannot be used. Considering the large number of variables examined in this thesis, conventional methods are ruled out. Smith (1975) gives three alternative methodologies for regionalization: the activity combination method, the cross-boundary similarity technique, and factor analysis (principal components analysis).

The activity combination method is a variation of a technique orignally designed to classify agricultural areas but is especially applicable in economic geography (Smith, 1975). The technique classifies areas or places as "one activity, two activity, three activity, and so on." Smith (1975) states that its apparent utility is limited to situations where economies can be logically subdivided into at least four sectors and no more that six or seven. Considering the nature of this thesis with regard to subject matter and the number of variables to analyze, the activity combination method is not an appropriate regionalization technique for the study at hand.

The cross-boundary similarity technique develops a system of regions by measuring the similarity of adjoining areal units with respect to specified criteria (Smith 1975). Cross-boundary correlations are the statistical tests. These include Pearson's r, Spearman's r, and a general similarity index based on the Gini Coefficient (Smith 1975). Since applications of these tests have diminished in frequency since they were first used in the 1940's, they will not be employed in this thesis.

Smith (1975) claimed that most regional work was now based on packages of statistical methods where large number of criteria are considered simultaneously. The final method of regionalization discussed by Smith, factor analysis, was by far the most complex. Factor analysis has previously been used as a means of regional identification in the classification of cities and in urban social area analysis (Smith, 1975). The problem of measuring spatial variations in economic and social health in different areas of the world has also been addressed by factor analysis. Since it appears that most of the research using factor analysis has been cultural or social in nature, the methodology is deemed inappropriate for the environmental regionalization in this thesis.

Balling (1984) makes the point that although principle component analysis (factor analysis) is an excellent analytical tool for transforming raw data to a more efficient form, the best use of the technique is for preparing raw data for input to clustering algorithms. While Balling's work focuses on the application of cluster analysis in climatology, he states that all clustering is aimed at minimizing within-group variance while maximizing between-group variance.

Balling (1984) recognizes three kinds of clustering of increasing accuracy: single linkage analysis, complete linkage analysis, and average linkage analysis. The basic differences between the three methods are described by Balling as follows: single linkage analysis allows an observation to join a cluster when it is similar in some well defined aspect to any other member in the cluster. The other member could be the "farthest-neighbor" or the "nearest-neighbor". Complete linkage analysis is an opposite approach to the single linkage method whereby an observation can join a cluster only when it surpasses some "similarity level" with every other member of the cluster, not just one member. Average linkage cluster analysis permits an observation to join a cluster based upon the "average" similarity between the observation and other cluster members. Usually, the average similarity is defined by the average Euclidean distance. Balling (1984) claims that average linkage clustering is superior to single or complete linkage analyses in creating distinct groupings that minimize within-group variance and maximize between-group variance. Therefore, average linkage analysis will be used for a first approximation of regions, and other clustering procedures will also be examined.

Finally, a attempt at national, environmental regionalization has been done by Omernik (1987). His "ecoregions" were based on perceived patterns of several causal and integrative factors. A map of ecoregions of the conterminous United States was created to assist managers of terrestrial and aquatic resources "in understanding the regional patterns of the realistically attainable quality of these resourses." More specifically, the primary function of the regionalization was to provide a geographic framework from which ecosystem resource information could be organized.

Omernik's (1987) method for defining the ecoregions was based on the hypothesis that spatially variable combinations of causal factors, such as climate, vegetation, physiography, and mineral availability (geology and soils), reflect regional patterns which are displayed by ecosystems and their components. Omernik (1987) analyzed a combination of small-scale maps of important causal factors and integrative factors, such as land-use, to differentiate regional patterns of perceived ecosystems.

Omernik (1987) began the process of defining the ecoregions by overlaying the maps, and then noting the predominant characteristics of each ecoregion. Evaluation for differences in generalities and accuracies among the maps was incorporated into the regionalization. Another consideration was the understanding of the interrelationships among the regional characteristics. Certainly, this is important in any exercise in regionalization.

As for the regional methodology employed by Omernik (1987), it has few implications for this thesis. Instead of manually overlaying component maps of different variables as did Omernik (1987), statistically "objective" methods are used to regionalize the environment. Since no *a priori* knowledge of what the regions should be based on the environmental data from the maintenance survey, statistical objectivity is required for the regionalization.

The importance of Omernik's (1987) environmental regionalization has potentially, great implications for studies beyond this thesis. Perhaps a study could be done which analyzed regional variations in maintenance costs by characterizing golf courses by Omernik-ecoregions or agglomerations of ecoregions. Considering the great detail such a study would require due to the large scale of the regions (ecoregions range in size from 15,000 square kilometers to 330,000 square kilometers), the end product would be invaluable to golf course superintendents.

Summary of Literature

Concluding, it becomes apparent that a scarcity of literature exists on the subject of regional golf environments. Indeed, little has been attempted at the environmental regionalization of any sport or outdoor activity. Certainly, the need for such a study is needed to better understand the regional variations in annual golf course maintenance costs.

Methods of regionalization have been varied, yet the ultimate goal has been the same: to define areas which are based on specified criteria where within-region variation is minimized and between-region variation is maximized.

Cluster analysis appears to be the newest and best objective classifier of the environment that is available. While the results of this study will have the most implications for golf course superintendents, it is hoped that this pioneer effort of applying cluster analysis to national environments of golf will produce results that will be of help to persons interested in the techiniques of environmental regionalization, the geography of sport, or the game of golf.

CHAPTER III

DATA COLLECTION AND ORGANIZATION, METHODOLOGY

The 1986 National Maintenance Survey

The 1986 National Maintenance Survey was sponsored jointly by the National Golf Foundation (NGF) and the Golf Course Superintendents Association of America. It was administered in late 1986 and early 1987. Administrative coordination was handled by Colin Hegarty of the National Golf Foundation and by John F. Rooney of the Department of Geography at Oklahoma State University (OSU).

The entire population of golf facilities in the United States was used as the sample population. Along with the maintenance survey, each golf facility was mailed a letter which requested full cooperation in the survey effort. Surveys were first returned to the GCSAA, and then the GCSAA shipped the surveys to me. Of the approximate 13,000 surveys mailed out, about 1800 usable surveys were received. This represented about 14% of all golf facilities in the United States. In addition, the number of each type of facility (private/public) from each region was determined. A telephone follow-up was initiated by the NGF to bring in more surveys from regions and types of courses that were lacking in the sample. This produced a more balanced sample distribution for data analysis.

The initial goal was to place the survey data into computer-compatible form. Each returned survey was individually opened and assigned an identification number. The ten page survey was quite thorough and extensive (Appendix A). It consisted of 156 questions and covered diverse topics such as irrigation, payroll, and budget.

Twelve people were hired to assist in data entry. Individual data sets were frequently checked for errors to preserve the integrity of the survey information.

The Statistical Analysis System (SAS) was the programming language employed in the study (SAS Institute, Inc., 1987). A SAS program was written which detected errors in the number of variables for each survey. Unfortunately, the actual value of each variable could not be individually checked because of the enormous size of the data set. However, another SAS program was written to filter out extreme or unreasonable variable values. Ranges of possible values and high standard deviations from the norm were considered. This was accomplished by first determining a frequency count of responses to each survey question. When an extreme or unreasonable response was encountered, the observation was deleted. For example, the frequency count indicated that one golf course was using over one billion gallons of irrigation water annually (many standard deviations from the mean). With a knowledge of golf course irrigation requirements, it was obvious that this was either an incorrect response or an error in typing. Likewise, some survey questions could have only one of several specified nominal categories as a response. When a deviation occurred, the observation was deleted. For example, the response for the question of intensity of rough maintenance can be only the numbers 1, 2, or 3. Any number other than 1, 2, or 3 is incorrect. Finally, all twelve data sets were merged into one master data set prior to the final data check. Once the data were checked and in proper order, data analysis proceeded.

The variables used in the study are responses to selected questions in the maintenance survey. A list of the selected questions in the survey indicates those used in the study (Appendix A). Some of the independent variables to be considered include terrain, soil type, annual rainfall, natural fertility of the soil, natural vegetation, and many others (Table I). Throughout the statistical analysis, annual cost per maintained acre was viewed as the dependent variable affected by environmental (independent) variables.

While some of the variables are not purely environmental (i.e., rounds played, private versus public, age of the course, etc.), they provide indications of physical influence on a golf course. For example, annual rounds played is an indicator of stress on a course, and maintenance practices are adjusted accordingly. The age of a course is considered because older courses generally must

TABLE I

INDEPENDENT VARIABLES USED IN MULTIPLE REGRESSION MODELING

Independent Environmental Variables	Independent Environmentally-Related Variables
- Annual Gallons Irrigation Water	- Public/Private Golf Course
- Gallons Water per Acre	- Resort/Non-resort Golf Course
- Source of Water	- Year Facility Opened (Age of the Course)
- Annual Inches Rainfall	- Months Annually Maintained
- Climatic Region	- GCSSA-Certified/ Uncertified Superintendent
- Elevation	- Total Annual Rounds
- Natural Fertility of Soil	- Grass/Seed/Sod Costs
- Dominant Soil Texture	- Fertilizer Costs
- Terrain Type	- Total Chemical Costs
- Dominant Natural Vegetation	- Intensity of Rough Maintenance
- Frequency Severe Weather Increases Maintenance Costs/Tasks	- Type of Green Irrigation
- Number of Days too Hot for Comfortable Play	- Type of Fairway Irrigation
- Number of Days too Cold for Comfortable Play	

TABLE I (CONTINUED)

Independent Environmental Variables
- Number of Days too Rainy for Comfortable Play
- Number of Days too Windy for Comfortable Play
- Number of Days too Humid for Comfortable Play
- Number of Days too Snowy for Comfortable Play

be more in equilibrium with their environments in order to have survived. Likewise, private or resort courses can be speculated to be more in equilibrium with their environments because of higher standards as well as budgets. Therefore, Table I is categorized by "pure" environmental variables and environmentally-related variables which might have a significant physical impact on maintenance costs and requirements.

Also, some variables were derived, such as gallons of water per acre and maintenance cost per acre. Cost per acre is created so that costs can be compared between courses of different sizes. Variables which were purely human or cultural in nature ie., union versus nonunion labor, superintendent's annual salary, etc., are purposely excluded from the study. Although golf course maintenance costs can be attributed to accomodations to human factors as well as to the environment, human factors were omitted from the study since the focus was primarily on an environmental explanation of golf course maintenance costs.

The data were managed in data matrix. framework. The spatial data resolution unit was five-digit ZIP codes. ZIP codes were aggregated to the state level for the research analysis. Manipulative operations on the data were executed through the use of (SAS). All environmental data required for the research were taken from the 1986 National Maintenance survey of golf courses.

Dr. Stephen Stadler and I were invited by the NGF to add formulate an environmental section to the 1986 maintenance survey. Also, a climatic regionalization of the United States based on Thornthwaite's first climatic classification (1931) was substituted for the U.S. census regions for exploratory purposes (see first page of maintenance survey, Appendix A). Specifically, these new regions were presented to superintendents in the maintenance survey to see if any improvement in the reporting of statistical results could be gained. Ideally, it was hoped that the new regionalization could provide a more efficient means for superintendents to compare how their golf facilities stand in relation to other golf facilities within their similar climatic region. This created an ideal medium for us to initially explore the geographic variation of golf environments at the national scale. The previous work with the survey data has set the stage for this thesis.

1984 Maintenance Survey Analysis

The work first focused on a preliminary environmental analysis of the 1984 maintenance survey data (Simone and Stadler, 1986). While the 1984 survey was designed prior to the OSU association with the NGF, it fortuitously contained several environmentally-related questions.

The building of a stepwise multiple regression model was the first step of analysis. A stepwise model is a method of choosing variables most important in explaining variance in total annual maintenance costs (SAS Institute, Inc., 1985). The stepwise multiple regression model was executed with all variables in the data set (non-environmental and environmental). The model provided some encouraging results. The "best four variable" equation chosen by the program included environmental variables (amount of irrigation water used, summer fairway grass type, annual number of rounds played, and annual precipitation) to the exclusion of the non-environmental variables on the survey. Other, supposedly important, non-environmental variables did not enter into the model to add significantly to the explanation of maintenance costs. For example, the size of the maintenance labor force and their wages did not contribute to the predictive capability of the model. While the amount of variation explained in total annual maintenance costs for all courses was only 35% when all variables were considered, we felt confident that further examination of the environmental variables alone would be worthwhile.

A model consisting of only environmental variables yielded a 49% explanation of maintenance costs. Thus, prediction of costs was improved by considering environmentally related variables only. It is obvious that environmental and non-environmental factors are interrelated with respect to golf course maintenance, yet the stepwise multiple regression model suggests that environmental variables (especially irrigation water) are the most important in explaining maintenance costs. This suggestion is also supported by the 14% increase in predictive power when non-environmental variables are excluded from the equation. The relationship between environmental and non-environmental factors is so complex that a distinction between the two types is needed to "clear up" the multiple regression equation, and thus, improve predictive capabilities.

Parallel multiple regression models based on categories of variables were also performed. Some of these models included private versus public courses, older versus newer courses, certified versus noncertified superintendent, size of the course, and climate type. Overall, the modeling appeared to produce multiple regression equations of moderate strengths (Table II). The amount of variation explained by the different models was in line with expectations. Furthermore, when a model was employed which considered U.S. Census regions, the doubts about the functionality of the regions were confirmed (Table III). The multiple R-square values were consistently lower than they were for the other models we ran. Unfortunately, lack of locational identifiers in the 1984 maintenance survey, such as ZIP codes, inhibited further detailed spatial analysis.

The implications from the analysis of the 1984 National Maintenance survey suggest that the environment does play an important role in explaining golf course maintenance costs.

TABLE II

PARALLEL MULTIPLE REGRESSION MODELS FOR 1984 GOLF COURSE MAINTENANCE SURVEY DATA

Model	R-square (Alpha=0.01)
<u>All Golf Courses</u>	0.49
<u>Type of Course</u>:	
Public Golf Courses	0.42
Private Golf Courses	0.59
<u>Age of Course</u>:	
Young Golf Courses	0.44
Old Golf Courses	0.54
<u>Age and Type of Course</u>:	
Old, Private Courses	0.56
Old, Public Courses	0.43
Young, Private Courses	0.66
Young, Public Courses	0.40
<u>Size of Course</u>:	
9 Hole Courses	0.17
18 Hole Courses	0.43
27 Hole Courses	0.44
36 Hole Courses	0.48

TABLE II (CONTINUED)

Model	R-square (Alpha=0.01)
General Climate Type:	
Mountain	0.39
Transition	0.43
Coastal Mediterranean	0.46
High Desert	0.49
Temperate	0.51
Sub-tropical	0.51
Low Desert	0.70
Tropical	0.73
Certified Superintendent	0.64
Non-certified Superintendent	0.50

TABLE III

MULTIPLE REGRESSION MODEL FOR U.S. CENSUS REGIONS USING 1984 GOLF COURSE MAINTENANCE SURVEY DATA

Census Region	R-square (Alpha=0.01)
Middle Atlantic	0.28
East North Central	0.29
East South Central	0.30
Mountain	0.31
West North Central	0.32
New England	0.35
South Atlantic	0.36
West South Central	0.37
Pacific	0.45

The environmental variables used in the multiple regression analysis produce equations with moderate, yet significant, predictive capabilities. Further insight into the costs of golf course maintenance is provided when golf courses are characterized by certain categories of variables ie., public/private, age, etc. The expectations about the categorization are supported by the results. For example, the notion that private courses are more in equilibrium with their environments is supported by a higher R-square value for private courses than for public courses.

The most important finding from this initial study was that an environmental regionalization of golf was a promising anvenue of research. As indicated from the R-square values (Table III), it is clear that United States Census regions are surpassed by some "environmental variables only" equations in explaining the regional variations in maintenance costs. An improvement in regionalization might be possible by considering the environments of golf courses instead of relying on politically-defined boundaries.

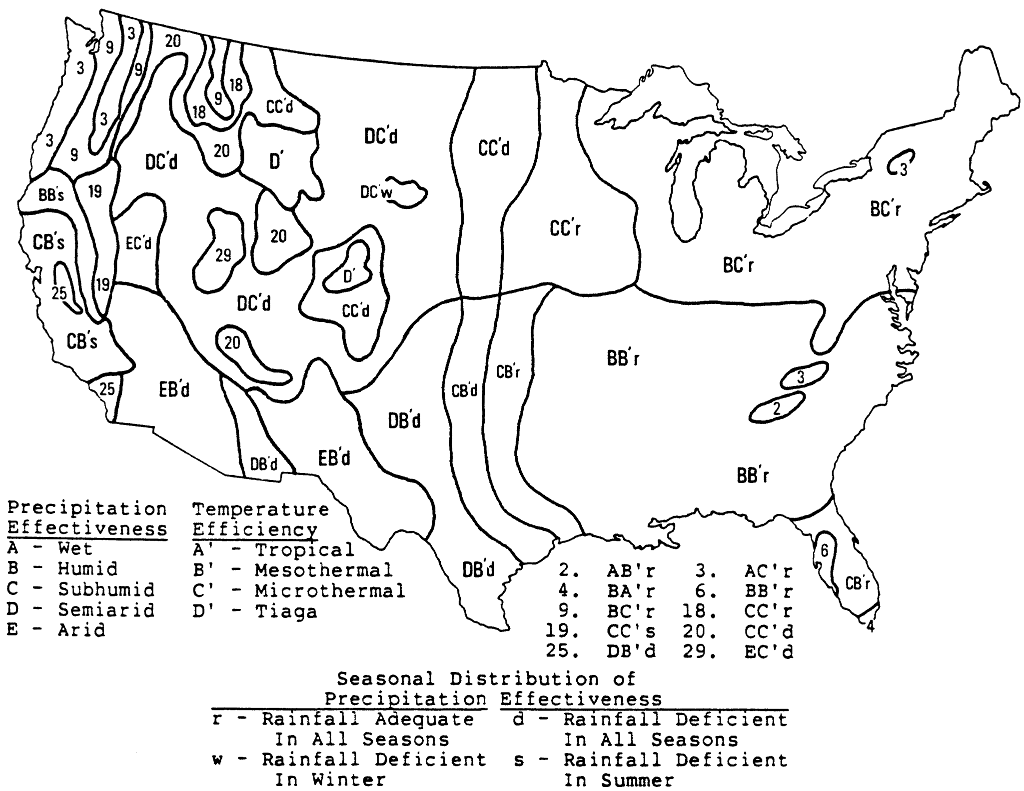
Thornthwaite-based Environmental Regionalization

The environmental analysis of the 1984 maintenance survey guided us in changing and adding the environmental questions in the 1986 survey. A ZIP code question was also added to the survey (Appendix A, question #2). The creation of new environmental regions based on Thornthwaite's 1931 climatic classification was also inspired from the initial analysis (see map on first page of survey, Appendix A).

The attempt at regionalization was guided by several considerations. First, we wished to keep region sizes on the same scale as U.S. Census regions. While the nine U.S. Census regions fail to function as environmental regions, they serve the purpose of representing data at a scale which tends to maintain some inter-region variation. Thus, it was decided that the environmental regionalization should consist of about nine or ten regions.

The second consideration of regionalization was the distribution of golf holes in the United States. The distribution of golf holes and golf facilities is largely a function of population distribution (Figure 1). Thus, the environmental regions had to be large enough so that the number of responses from any one region would yield statistically significant results. Furthermore, any one region should not contain an inordinately large percentage of the number of golf holes in the United States. Hence, the regionalization is based on environmental factors, but it also accounts for the spatial variation of golf holes.

Thornthwaite's Climatic Classification was used as the basis for the environmental regions (Figure 3). The Thornthwaite classification was based on the ratio of mean monthly temperature to mean monthly evaporation and the ratio of mean monthly precipitation to mean monthly



Source: Thornthwaite, C. W. "The Climates of North America According to a New Classification." <u>Geographical Review</u> 21 (1931): 633-655.

Figure 3. Thornthwaite Climatic Classification

evaporation (Thornthwaite, 1931). Elaborate irrigation systems at some individual golf courses are programmed to turn on and off according to conditions based on Thornthwaite calculations. Therefore, the use of modified Thornthwaite regions as environmental regions of golf appeared to be a reasonable initial regionalization scheme to explore.

As evidenced from Figure 3, the Thornthwaite classification has many sets of complex regions of different sizes. Therefore, similar Thornthwaite regions were agglomerated into larger, environmentally similar regions. The resultant map of environmental regions was included in the 1986 National Maintenance Survey (see map on first page of survey, Appendix A), and survey recipients were asked to indicate which regions their golf facilities were located.

Stepwise multiple regression models were constructed for each region to test the functionality of the environmental regions. Annual cost per maintained acre was the dependent variable in each model and Table I lists the independent variables.

While a full explanation of the results of each model is not presented here, it is sufficient to say that the multiple regression coefficients indicated that the regions did have some environmental integrity (Table IV). With the exceptions of regions 2 and 9, the predictive capability of the regionalization is moderate to high with respect to U.S. Census regions. For instance, the models for the

TABLE IV

MULTIPLE REGRESSION MODELS FOR THORNTHWAITE-BASED ENVIRONMENTAL REGIONS

Region	Best-Five Variable Model	R-square (Alpha=0.01)
1. South Florida	Irrigation Water Source Annual Inches Rainfall Days Too Cold (-) Days Too Humid	0.66
2. Southland	Rough Maintenance Terrain Type Severe Weather Soil Fertility Days Too Windy	0.10
3. Megalopolis	Irrigation Type Fairway Irrigation Terrain Type Elevation Days Too Humid	0.42
4. Eastern Interior	Total Chemical Expense Days Too Rainy Days Too Hot (-) Type Fairway Irrigation Annual Inches Rainfall	0.41
5. North Country	Rough Maintenance Type Green Irrigation Days Too Windy Months Maintained Days Too Rainy (-)	0.26
6. South Central	Days Too Windy (-) Soil Fertility Type Fairway Irrigation Days Too Humid (-) Days Too Snowy	0.53

TABLE IV (CONTINUED)

Region	Best-Five Variable Model	R-square (Alpha=0.01)
7. Empty Region	Irrigation Days Too Hot (-) Days Too Rainy Type Fairway Irrigation Annual Inches Rainfall	0.54
8. Southern California & Southern Arizona	Irrigation Days Too Humid Certified Superintendent Age of Course Terrain Type	0.75
9. Northwest Coast	Resort Course Annual Inches Rainfall Elevation Days Too Windy Days Too Cold	0.17

Thornthwaite-based regionalization produced multiple R-square values ranging from 0.26 to 0.75 (Table IV) while the U.S. Census regionalization produced multiple R-square values ranging from 0.28 to 0.45. The low R-square values for regions 2 and 9 are attributed to the possibility that these may be areas where the environments are mild enough so that cost per maintained acre is not dominated by environmental factors.

Again, irrigation water appears to be a significant factor in explaining annual cost per maintained acre. Indeed, irrigation was the single most important variable in regions 1, 3, 7, and 8. Recall that irrigation was the most important factor in the regression modeling of the 1984 Maintenance survey data.

The environmental variables chosen by the stepwise procedure for each region seem to make logical sense. That is, the "best five variables" selected for each region are mainly explainable through rational environmental characterizations.

The Thornthwaite-based regionalization serves as an acceptable division of the United States to explain maintenance cost per acre. Certainly, the percentage of variation explained is generally better than the U.S. Census region-based models. However, the regionalization is only suggestive and the boundaries are by no means absolute. It must be realized that environmental transition does occur over boundaries and that a golf course located near a boundary area could be typified by more than one environmental regional characterization.

While the regionalization produced multiple R-square values of satisfactory strengh, it was decided that room for improvement exists. This exploratory environmental regionalization led to still another concept of regionalization: cluster analysis.

ZIP Code Cluster Analysis

Another effort at regionalization was based on a cluster analysis of eight environmental dimensions utilizing ZIP codes (Stadler and Simone, 1987). Because five-digit ZIP codes were far more numerous than the number of golf courses in the sample, we agglomerated the data to three digit ZIP code zones. While ZIP codes are not environmentally based, they were used as building blocks to approximate broad environmental regions (Stadler and Simone, 1987).

Cluster analysis was employed in order to "objectively" classify the environment of each golf course as indicated from the respective survey responses. Again, region scale and the spatial distribution of golf facilities in the U.S. were considered in the regionalization process as they were in the development of the Thornthwaite-based environmental regions.

After experimenting with several different groups of environmental variables in the initial cluster analysis, the following eight variables were decided upon as the best combination which would have a high likelihood of identifying unique regions: annual inches of rainfall, number of days too cold for comfortable play, number of days to hot for comfortable play, number of days too windy for comfortable play, natural fertility of the soil, natural vegetation type, soil texture, and terrain severity. This combination of variables ultimately produced the regionalization scheme which made the most sense in terms of the environment. While the environmental survey responses can be considered as perceived information, it will be assumed that respondents have accurately characterized their golf course environments.

Eleven environmental cluster regions were decided upon (Figure 4). In drawing the boundaries of the regions, subjectivity entered into the process. Although the boundaries were based on mapped cluster type patterns of each 3-digit ZIP code zone, subjective decisions were made as to the exact definition of where boundaries should be drawn. Considering the regionalization scale, the spatial distribution of golf facilities, and the mapped cluster types, subjectivity was unavoidable.

Some of the regions were relatively uniform with respect to cluster type. For example, South Florida was a region in the country where one cluster type was dominant and spatially contiguous. On the other hand, some regions were characterized by several different cluster types. For

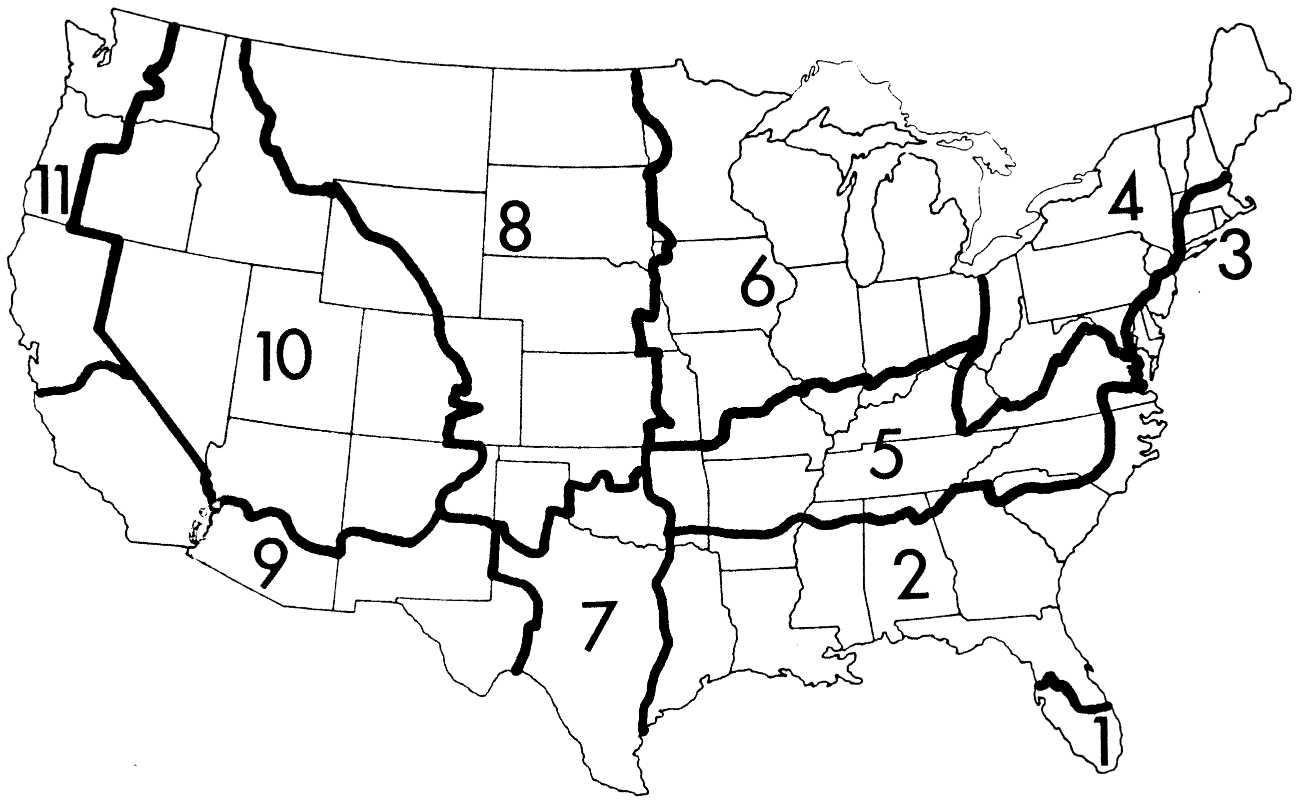


Figure 4. Agglomerated ZIP Code Cluster Regions

instance, cluster #6 was dominant on the South Atlantic Coast. In fact, cluster #6 could be found all along the coast to southern New England, but three other cluster types were also present in this area. Therefore, the decision was made to separate the northern coastal area from the more uniform southern coastal area. This made all the more sense in that this division reflected the spatial distribution of golf facilities by putting "Megalopolis" into its own region (Figure 4).

To examine the differences between the ZIP code cluster regions, parallel multiple regression models were generated. In all cases, annual maintenance cost per maintained acre was the dependent variable. Table I lists the independent variables. The amount of variance explained by the models indicated that the regionalization appeared to have some environmental integrity (Table V). With the exception of region 5, all R-square values were moderate to high. Region 5 had a considerably lower multiple R-square value than did the other regions (Table V). As for region 5, several different cluster types were represented in this area. One specific cluster type was not dominant. Hence, this is reflected in the low predictive power of the equation for this region.

A rational environmental explanation of the other regions is possible by examing the selected variables in the modeling. For example, South Florida is chararcterized by days too humid for comfortable play. The number of days too

TABLE V

MULTIPLE REGRESSION MODELS FOR ZIP CODE CLUSTER REGIONS

Region	Best-Five Variable Model	R-square (Alpha=0.01)
1. South Florida	Days Too Humid Water Source Days Too Windy Rounds per Acre Days Too Hot	0.46
2. Deep South	Type Green Irrigation Rounds per Acre Days Too Snowy Annual Inches Rainfall Severe Weather	0.34
3. Megalopolis	Rounds per Acre Type Green Irrigation Days Too Windy Soil Fertility Days Too Snowy	0.37
4. Eastern Uplands	Rounds per Acre Days Too Snowy Days Too Windy Days Too Humid Days Too Hot	0.99
5. Southern Interior	Days Too Snowy Type Green Irrigation Natural Vegetation Days Too Cold Elevation	0.17
6. Midwest	Rounds per Acre Annual Inches Rainfall Days Too Cold Water Source Severe Weather	0.37

TABLE V (CONTINUED)

Region	Best-Five Variable Model	R-square (Alpha=0.01)
7. Subhumid South Central	Terrain Type Days Too Humid Annual Inches Rainfall Days Too Windy Elevation	0.60
8. Subhumid North Central	Rounds per Acre Elevation Resort Course Days Too Cold Days Too Snowy	0.76
9. Dry Southwest	Irrigation Elevation Soil Texture Severe Weather Days Too Windy	0.51
10. Western Mountains and Desert	Soil Texture Days Too Windy Days Too Hot Rounds per Acre Terrain Type	0.69
11. Pacific Northwest	Natural Vegetation Soil Texture Annual Inches Rainfall Days Too Hot Days Too Windy	0.73

hot for comfortable play also enters the model. These characteristics are most typical of the tropical environment of South Florida. Likewise, it is not suprising that irrigation is the most important variable in explaining annual cost per maintained acre in the dry Southwest region. Rounds per acre is the most significant factor affecting annual maintenance costs in the Midwest, Eastern Uplands, and Megalopolis regions. The affect of the immense volume of play on maintenance costs is in line with explectations considering the highly dense population settlement patterns in these regions.

Overall, the ZIP code cluster regionalization is mostly explainable. Again, the boundaries are not absolute and the results only suggestive. In some cases, boundaries are "fuzzy", and boundaries could be justifiably shifted. Although subjective decisions had to be incorporated into the boundary drawing process, the cluster analysis did produce a regionalization which made reasonable sense in terms of the environment. While the ZIP code cluster analysis was satisfactory, an analysis at the state level was deemed appropriate to correspond to the familiar reporting units used by the NGF, GCSAA, and their audiences. Thus, based on previous analyses, a state-based cluster analysis was used to form the core of this thesis.

Thesis Methodology

The objective nature of cluster analysis makes it an attractive method of statistical regionalization. The basic underlying goal of cluster analysis is to create unique groups or regions from similarities in multi-dimensional data. Cluster analysis considers multiple variables at one time while it attempts to maximize between-region variance and minimize within-region variance (Balling, 1984). In this case, each region possesses certain distinct environmental characteristics.

Several different clustering methods were explored before deciding upon the best one to use for the study. Average linkage analysis (Sokal and Michener, 1958), the centroid method (Sokal and Michener, 1958), and Ward's minimum variance method (Ward, 1963) were the first methods used in the analysis. Each of these methods were rejected because they produced regions of highly disproportionate observation numbers. While ten regions were specified in the programming, each method always created a clustering scheme where two or three clusters contained a high percentage of the observations, leaving the remaining clusters with insufficient observations for statistical analysis.

Accordingly, the cluster method which produced the most reasonable end product is a method based on Hartigan's leader algorithm (1975) and MacQueen's k-means algorithm

(1967). The method is termed nearest centroid sorting by Anderberg (1973).

Specifically, the "FASTCLUS" procedure in SAS executed a disjoint cluster analysis where observations (golf courses) were sorted into regions such that each observation belonged to only one region. FASTCLUS attempted to minimize the sum of squared eight-dimensional Euclidean distances between cluster members and the cluster centroid while maximizing distance between cluster centroids (SAS Institute, Inc., 1985). Because of their proven utility in the previous analyses, the same eight environmental dimensions used in the ZIP code cluster analysis were employed here ie., annual inches of rainfall, number of days too cold for comfortable play, number of days to hot for comfortable play, number of days too windy for comfortable play, natural fertility of the soil, natural vegetation type, soil texture, and terrain severity. Ten environmental clusters were specified, and each observation (golf course) was classified into one of the clusters.

At this point, the dominant cluster type within each state was identified. The cluster type with the most observations (golf courses) was chosen as the characteristic type for that state. For almost every state, this was not a problem. One particular cluster type was almost always dominant for each state. On the other hand, some states were "cluttered" by more than one cluster type ie., New England states.

The dominant cluster types were recorded on a scratch map of the United States (Figure 5). Immediately, several distinct regional patterns emerged. Based on the environmental cluster types of each state, regional boundaries were constructed. The dominant cluster types of each state appeared to form a spatially contiguous pattern within each delineated region. That is, the regions were mostly homogeneous with regard to dominant cluster type.

For the most part, the regions that emerged were mainly products of the objective regionalization of the cluster analysis. Still, subjectivity was unavoidable. The plurality of cluster types, such as in the Middle Atlantic to New England region, created the problem of where to draw the best boundary. In that way, some of the boundaries where plurality occurred can be considered as fuzzy, and adjustment in regionalization by one or more states is purely a subjective matter. Two slightly different regional schemes are offered. One scheme consists of eight distinct regions while the other has nine (Figures 6 and 7).

The second scheme (Figure 7) differs from the first in that the North Central region is subdivided into two regions for two basic reasons. First, the sheer number of golf facilities in this region warrants a further breakdown of this region. This region contained the majority of the responding facilities. Nevertheless, the region does possess some environmental integrity if it is not subdivided.

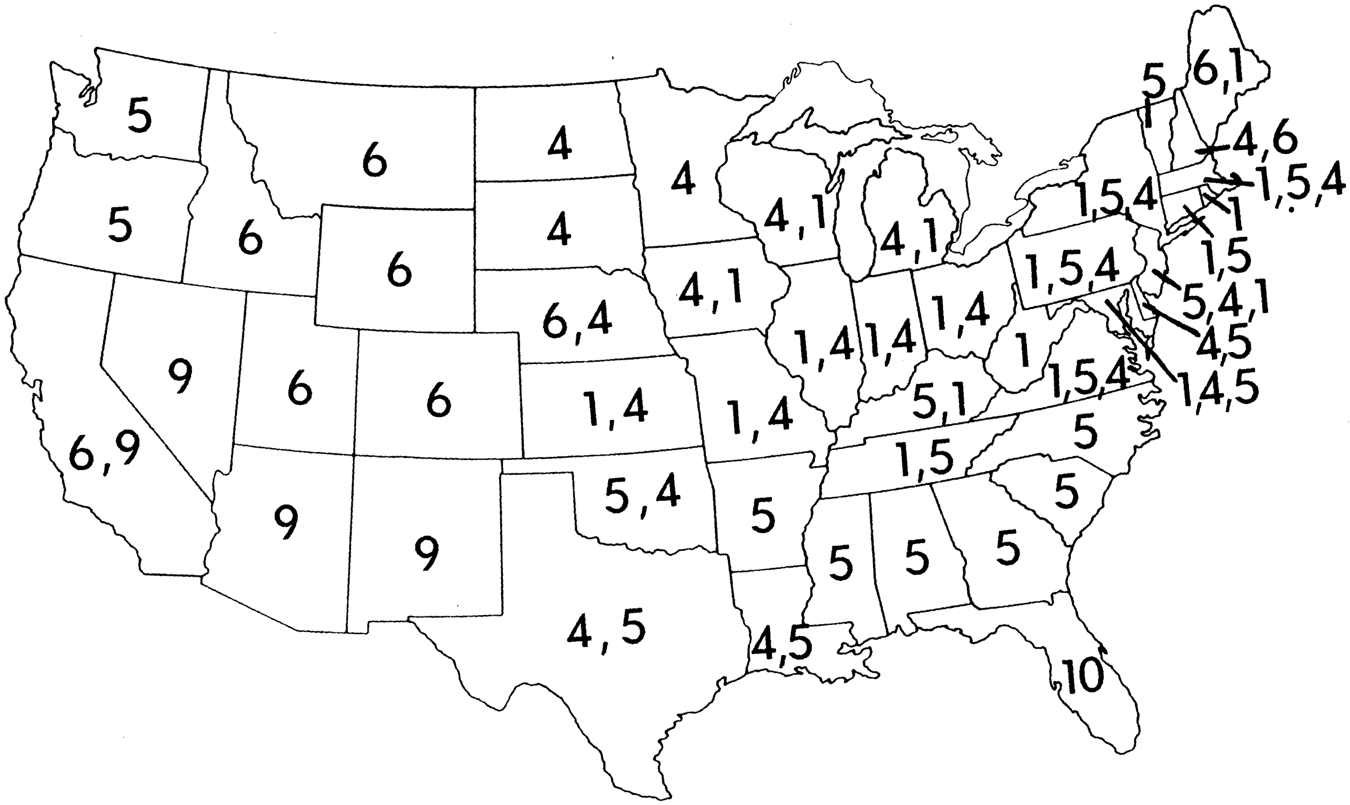


Figure 5. Dominant Cluster Types by State

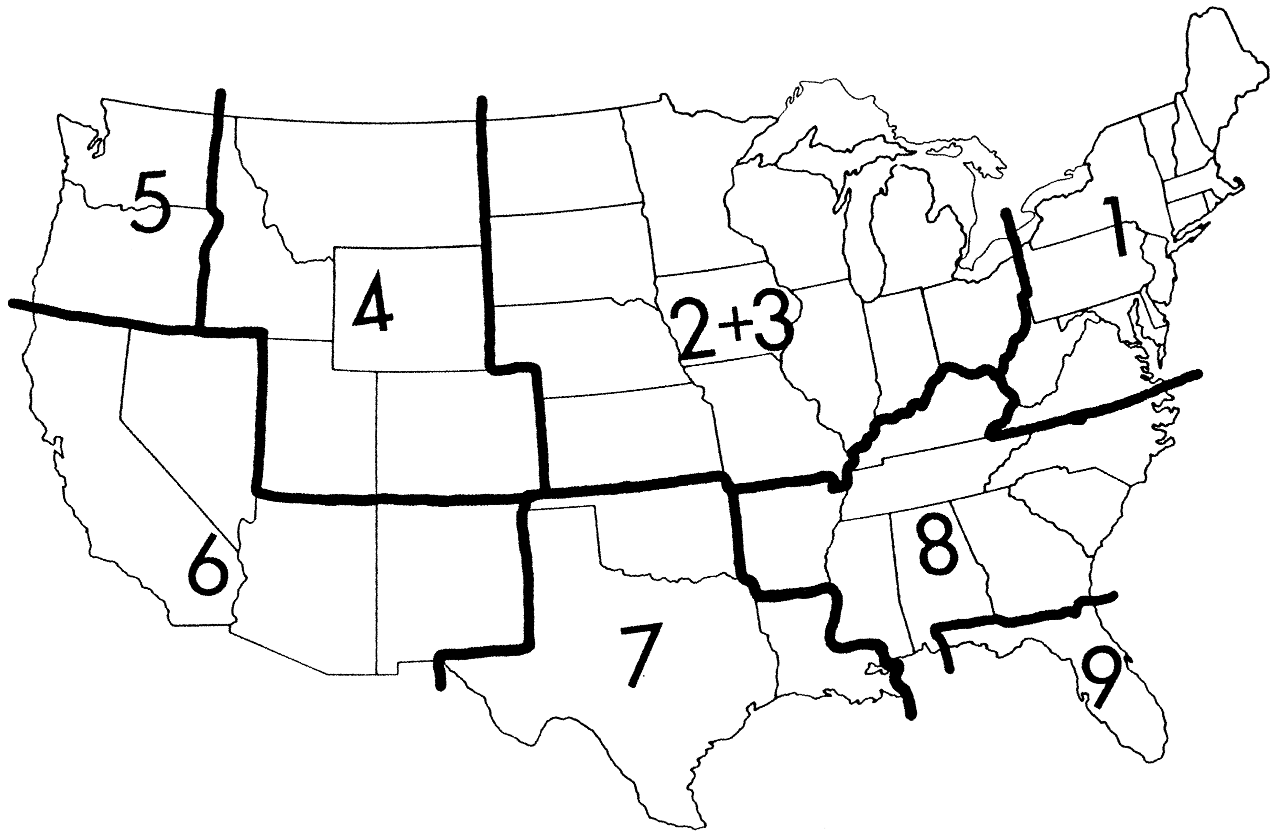


Figure 6. First State Environmental Regionalization Scheme

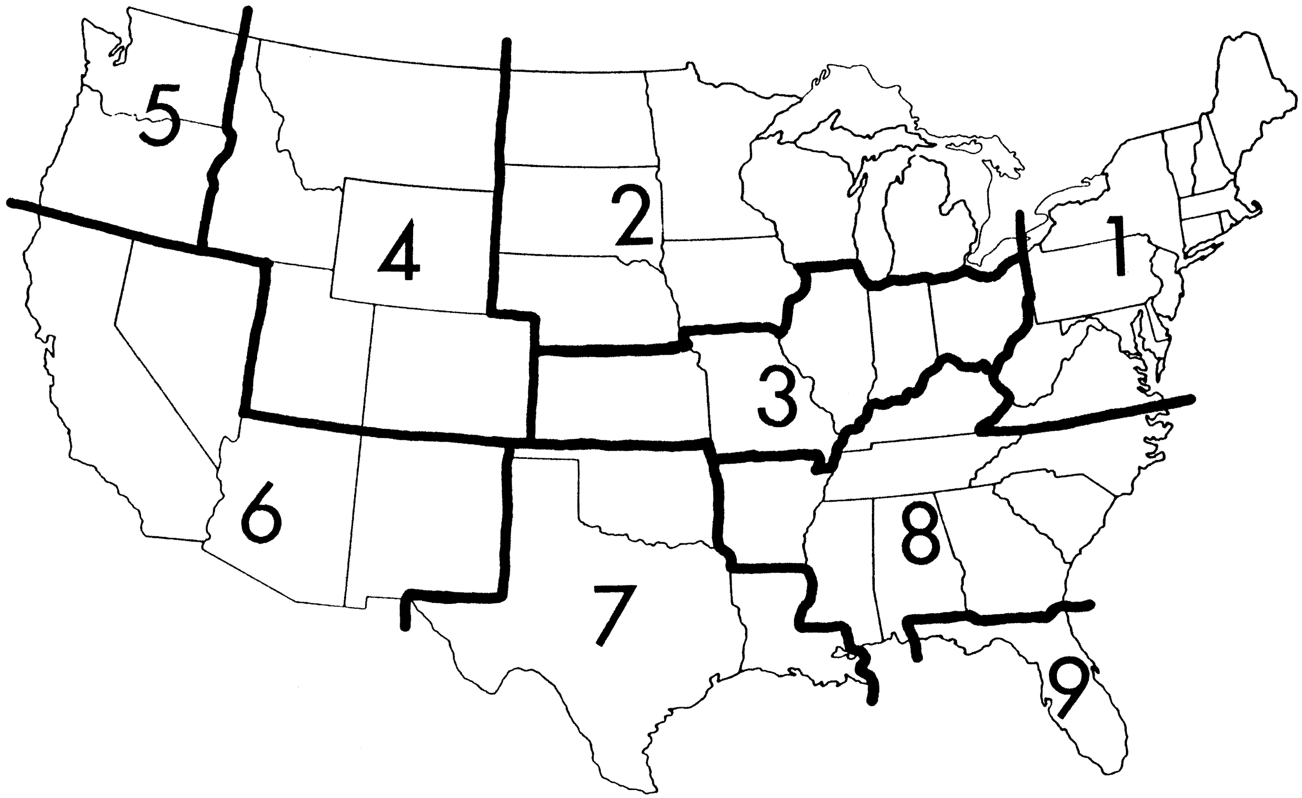


Figure 7. Second State Environmental Regionalization Scheme

Secondly, two different cluster types (#1 and #4) are dominant throughout the North Central region (Figure 5), and the subdivision further accentuates this relationship between the two cluster types. While both cluster types are apparent in the North Central region, cluster type #1 dominates in the Sub-North Central region and #4 dominates in the North-North Central region.

The New England and Mid-Atlantic region is also represented by more than one dominant cluster type. However, clear subdivisional boundaries are not apparent. That is, the region is represented by so many different cluster types that no internal boundary can be drawn by considering the results of the "objective" regionalization. Any other boundaries imposed within this region would only serve to complicate statistical explanations. It was decided to leave this region whole to avoid a subjectively random division. The analytical statistics presented in Chapter IV support this decision.

The most noteworthy subjective decision occurred at the boundary between the Southeast, North Central, and Middle Atlantic to North Central regions (Figures 6 or 7). Cluster type #1 was present in all three regions (Figure 5). Cluster type #5 was shared by the Southeast and Middle Atlantic to New England regions, and cluster type #4 was shared by the North Central and Middle Atlantic to New England regions. The subjective boundary was drawn after careful examination was given to three overriding considerations: the objective spatial distribution of cluster types, the spatial distribution of golf facilities, and the possible environments that would be characterized by any one boundary placement. The resultant boundary placement between these regions appears to hold up under statistical analysis.

As for the rest of the country, boundaries were more easily drawn. Although Figures 6 and 7 represent some subjective decisions, the overall regionalization scheme has a reasonable objective environmental characterization given the crude spatial scale resulting from the use of states.

It must be understood that the utilization of political boundaries for environmental regionalization has its pitfalls. Some state boundaries encompass such large areas that many different environments can exist within state lines. Likewise, environments may straddle state lines. This risk of building environmental regions on the basis of states will be further examined in Chapter IV.

CHAPTER IV

ANALYSIS AND RESULTS

Regression Analysis

Parallel multiple regression models were constructed to analyze and characterize the environmental regions that were created. In all models, annual cost per maintained acre was the dependent variable, and Table I in Chapter III lists the environmental and environmentally-related independent variables. The ultimate goal was to explain cost per maintained acre by attributing cost to environmental affects on the golf course as well as to maintenance adjustments made to the environment.

A stepwise multiple regression model was first implemented to explore which environmental variables were important in explaining annual cost per maintained acre. Goodnight's maximum R-square improvement technique (MAXR) was utilized within the STEPWISE procedure of SAS for the modeling. The MAXR technique is considered "almost as good as all possible regressions " (SAS Institute, Inc., 1985). The MAXR technique begins by finding the "best one-variable model" which produces the largest R-square. The procedure then searches the remaining variables to find the best combination of two variables that produce the largest R-square. This process continues for all sizes of models. At each level of joining, MAXR determines if the R-square will be maximized by removing one variable and replacing it with another. After comparing all possible combinations at any one level in the modeling, MAXR generates the combination which produces the largest R-square for that model size.

The "best five-variable model" was selected as the level of analysis in the study. Five-variable models were preferred since that number proved to be optimal in the previous studies (Stadler and Simone, 1987). Models consisting of five independent variables appeared to sufficiently explain cost per maintained acre while minimizing the number of variables to consider. Also, the addition of more independent variables increased the multiple R-square only by small amounts (Stadler and Simone, 1987). Table I lists the independent variables from which the stepwise regression model could choose.

The order of importance of the best five variables in explaining annual cost per maintained acre was determined by comparing the "F" values of each variable. The F value is the ratio of the Type II Sum of Squares (SS) to the mean square error (MSE). The larger the F value for any one of the five variables, the greater the importance of that variable in explaining annual cost per maintained acre. Type II SS correspond to the R notation in that each effect is adjusted for all other effects possible (SAS Institute, Inc., 1985). For the regression model where

$$E(Y) = X1*B1 + X2*B1 + \ldots X5*B5 \qquad (1)$$

the Type II SS correspond to

Effect	SS
B1	R(B1 | B2, B3, B4, B5)
B2	R(B2 | B1, B3, B4, B5)
B5	R(B5 | B1, B2, B3, B4)

(2)

(SAS Institute, Inc., 1985). Less is added to the overall error term by a variable which has a large Type II SS, and the resultant ratio between the two is larger (high F). In other words, the variable with the largest F is the variable which accounts for the most explained variation in annual cost per maintained acre. Details of the regression analysis are provided (Tables VI through XVI, Appendix B).

To allow for comparison between models, R-square values have been adjusted for sample size. This was accomplished by submitting the best five-variables chosen by the stepwise model for each region to the "REG" procedure in SAS. The REG procedure considers regional sample sizes when computing multiple R-square values. Adjusted R-square values and descriptions of the best-five variables chosen in the stepwise regression model are provided (Table XVII).

All models, except for the Northwest region, were statistically significant at the 0.01 level of significance. The Northwest region model was not significant, possibly because of a small sample size from that area. Furthermore, SAS deletes observations that have missing values for selected variables. That is, when the SAS program

TABLE XVII

MULTIPLE REGRESSION MODELS FOR STATE CLUSTER REGIONS

Region	Best-Five Variable Model	R-square Alpha=0.01	N
1. Middle Atlantic to New England	Type Fairway Irrigation Gallons Water/Acre Age of Course Fertilizer Expense Irrigation Water	0.55	128
2. North-North Central	Total Chemical Expense Type Fairway Irrigation Water Source Fertilizer Expense Natural Vegetation	0.41	126
3. Sub-North Central	Gallons Water/Acre Total Chemical Expense Days too Snowy Grass/Seed/Sod Expense Climate Region	0.42	97
All North Central	Total Chemical Expense Gallons Water/Acre Days too Snowy Months Maintained Type Fairway Irrigation	0.41	223
4. Western Mountain States	Gallons Water/Acre Irrigation Water Fertilizer Expense Days too Windy Months Maintained	0.77	44
5. Pacific Northwest	Irrigation Annual Inches Rainfall Soil Fertility Type Fairway Irrigation	0.39	11
6. Arid Southwest	Gallons Water/Acre Terrain Type Type Green Irrigation Type of Course Certified Superintendent	0.35	57

TABLE XVII (CONTINUED)

Region	Best-Five Variable Model	R-square Alpha=0.01	N
7. OKTEXLA	Gallons Water/Acre Age of Course Severe Weather Annual Inches Rainfall Rough Maintenance	0.28	42
8. Southeast	Water Source Type Fairway Irrigation Fertilizer Expense Age of Course Grass/Seed/Sod Expense	0.23	107
9. Florida	Gallons Water/Acre Irrigation Water Total Chemical Expense Days too Windy Terrain Type	0.53	63
United States	Fertilizer Expense Gallons Water/Acre Grass/Seed/Sod Expense Irrigation Water Climate Type	0.40	675

encounters a missing value for a variable that is specified in the analysis, the whole observation is deleted even though other variables involved in the analysis may have valid numbers. This situation further diminished the size of the sample from this region, and the model has little significance.

The first model constructed was for the entire United States without regionalization (Table VI, Appendix B, and Table XVII). Clearly, one of the most important variables in explaining maintenance costs nationwide is gallons of irrigation water per acre. Aside from the availability of land for development, the supply of irrigation water may be the single most important limiting factor to the expansion of golf in America. While the model chose fertilizer expense as the single most important variable in explaining annual cost per maintained acre, it was found that gallons of water per acre totally dominated the modeling as the number of independent variables in the model was increased. Although fertilizer expense is important at the best five variable level, it is overshadowed by the primacy of irrigation water when all variables are considered. Climate type (Thornthwaite-based environmental regionalization) also appears to be an important consideration in explaining maintenance costs. The explanation here is that different climate situations require different maintenance practices, and thus, maintenance costs will vary across the country with changes in climate and associated maintenance practices. A 40% explanation of maintenance costs per acre at the national level confirms that environmental variables play an important part in golf course maintenance.

Region 1 - Middle Atlantic to New England

This region is characterized by high urbanization and dense population settlement (Table VII, Appendix B, and Table XVII). Land costs are at a premium in this region. Likewise, irrigation water is expensive throughout the region. Gallons of irrigation water per acre appears to be one of the most important environmental variables in explaining cost per maintained acre. This region is the hearth of golf in the United States. Golf began in this region almost a hundred years ago. It is not suprising to see the age of the golf course as an important variable in explaining cost per maintained acre. Older courses have had longer time to adapt to their respective environments, and hence, they are generally more in equilibrium to their surrounding conditions. The best-five model for the Middle Atlantic to New England region explains 55% in the variation of maintenance costs.

Region 2 - North-North Central

The model for this region is explained with 41% of the variation attibuted to environmental factors (Table VIII, Appendix B, and Table XVII). The effects of glaciation are apparent over much of this region. Lakes dot the landscape, and soils are usually quite infertile. Total chemical expense enters the model first, and fertilizer expense is also important. This accounts for the lack of fertile soils. The source of irrigation water is prominent in the model. Therefore, the major source of irrigation in this region is likely to be lake water. Much of this region is covered by forests. The natural vegetation variable enters the equation to explain the importance of forest growth in cost per maintained acre (some northern forest soils are also generally infertile).

Region 3 - Sub-North Central

Again, the fact that irrigation water is important in explaining annual cost per maintained acre is supported as gallons of water per acre enters the model first for this region (Table IX, Appendix B, and Table XVII). Like the North-North Central region, this is an area which experiences rather harsh winters. The number of days too snowy for comfortable play enters the model. Climate region (Thornthwaite-based environmental region), as shown on the map on the first page of the maintenance survey (Appendix A), enters the model second. The explanation here is that this region is centered over four of the nine Thornthwaite-based environmental regions. This reiterates the importance of climatic influence in explaining cost per maintained acre. Golf participation is high in this region, and this might account for the importance of grass/seed/sod and chemical expense in explaining cost per maintained acre. That is, the immense volume of play may warrant constant repair of the playing surface by the continual sodding or seeding of damaged areas. The best five model for the Sub-North Central explains 42% of the variation in cost per maintained acre.

All North Central Region

When the North-North Central and Sub-North Central regions are combined, the amount of explained variation in annual cost per maintained acre is still only 41% (Table X, Appendix B, and Table XVII). The total cost of chemicals is apparently the primary maintenance consideration in this region followed by gallons of water per acre. Again, the severity of winter in this region is highlighted by the number of days too snowy for comfortable play. To further accent the winter conditions in this region, the number of months the course is maintained enters the model. This reflects the shortened playing season throughout the region.

The advantage gained by dividing the North Central region into two parts seems to be minimal. The amount of explained variation in annual cost per maintained acre is virtually equal whether the region is divided or not. As indicated from the cluster analysis, the entire North Central region is relatively homogeneous with regard to cluster types (Figure 5). While cluster type #4 is dominant in the North-North Central region and cluster type #1 is dominant in the Sub-North Central region, the difference in the two cluster types is not great enough to produce any significant regional variation in the explanation of annual cost per maintained acre. The variables chosen by the model for the entire North Central region are a combination of the variables chosen by the models for each division (Table X, Appendix B, and Table XVII). The transition of environment is rather broad on either side of the boundary between the two divisions. Hence, the distinction of environment between the two divisions is not sufficient to provide any increase in the explanation of maintenance costs.

As mentioned earlier, the entire North Central region contains the majority of survey responses. Thus, dividing the North Central region primarily serves the purpose of reducing the number of golf facilities in the region. Considering all regions, a more balanced sample distribution is the end product. With respect to the spatial distribution of golf facilities in the United States, it is recommended that the division of the North Central region be maintained for statistical purposes.

Region 4 - Western Mountain States

The number of gallons of irrigation water used is the most important variable in explaining annual cost per maintained acre (Table XI, Appendix B, and Table XVII). Most of the water in this region originates from meltwater from mountain snows, and thus, the occurence is obviously seasonal. Indeed, over 63% of irrigation water originates from natural lakes and streams in this region (Table XVIII). When meltwater is not abundant, other sources are tapped which leads to increases in the maintenance budget. Groundwater is the second major source with a little over 20% of irrigation coming from wells (Table XVIII). The number of days too windy for comfortable play enters the model because of the relative location of mountain resort golf courses. Wind speed usually accelerates as air is forced up over and between mountains. Fertilizer expense figures into the model. Mountain soils are generally too coarse and infertile to support much low level vegetation. Finally, the number of months maintained reflects the long winter season present in mountain environments. Mountain resort courses are usually only maintained for a few months in late spring, summer, and early fall. The best five model for the Western Mountain States region is highly significant with 77% of the variation in the annual cost per maintained acre being explained by environmental factors.

Region 4 - Pacific Northwest

While the model for this region is not significant at the 0.01 or 0.05 level, the associated R-square value is 0.39 (Table XII, Appendix B, and Table XVII). Although the amount of variance explained is moderate, the results should be considered with caution. The equation for this model could only generate the best four variable model because no

TABLE XVIII

SOURCES OF IRRIGATION WATER
IN WESTERN MOUNTAIN
STATES REGION

Water Source	Percent	N
Effluent Water	3.8	3
Local Potable Water	12.7	10
Wells	20.2	16
Natural Lakes and Streams	63.3	50
Total	100.0	79

further improvement in R-square was possible. As mentioned previously, the small sample size for this region could be the possible explanation for the insignificance of the model (Table XII, Appendix B, and Table XVII). As was stated in Chapter III, another possible explanation lies in the problem of using state boundaries for environmental regionalization. The Pacific Northwest is characterized by two highly different environments. The western one-third of the region (west of the Cascades) is characterized by lush vegetation and moderate to heavy annual precipitation. The eastern two-thirds of the region (east of the Cascades) is characterized by large expanses of desert environment. While more golf courses are located west of the Cascades (Figure 1), combining the two dissimilar environments into one region may very well be affecting the statistical results. Although the two environments were recognized in previous studies (Stadler and Simone, 1987), it is impossible to account for the variations when using state boundaries. As for the environmental variables which are important in explaining annual cost per maintained acre, gallons of irrigation water, annual inches of rainfall, soil fertility, and type of fairway irrigation were chosen by the model. Any environmental explanation is only speculative considering the above problems.

Region 6 - Arid Southwest

As with the Pacific Northwest region, the southwest region has a problem with state boundaries. While most of the southwest region is arid, northern California is more like the Pacific Northwest region west of the Cascades. That is, lush vegetation and ample precipitation characterize northern California. Again, this unique environment was recognized in previous studies (Stadler and Simone, 1987), yet the use of state boundaries precludes the separation of northern California from the rest of the arid southwest. With this problem in mind, the following environmental explanation of the Southwest region should be viewed with caution.

As expected, one of the most important variables in explaining annual cost per maintained acre is gallons of irrigation water per acre (Table XIII, Appendix B, and Table XVII). Most of the region is characterized by high summer temperatures associated with very little precipitation and scarcity of irrigation water. In most cases, water is transported over many miles from other regions to meet the demands of a growing desert population. For example, an extensive canal network has recently been completed which transports water from the Colorado River to Phoenix, Arizona. Likewise, the Los Angeles area receives most of its water from the Colorado and from other northern sources located many miles away. Hence, water costs are at a premium. Type of green irrigation is also important in the regression model. The high sensitivity of greens in the desert environments of this region (excluding northern California) requires that constant care be given to the turf. Therefore, most of the irrigation systems in this region are automatic (Table XIX). Indeed, 85% of the survey responses from this region indicated that automatic was the most widespread type of green irrigation. Probably the most important reason for employing automatic green irrigation techniques is to efficiently maximize the benefits of the water through careful application and monitoring. Another possible reason is so that the system can be programmed to turned on and off every so often to syringe the greens, i.e. to apply shower-like light amounts of water. Syringing of the turf is not an irrigation technique but a method of cooling the surface of the green (Vengris, 1973). Syringing also serves the purpose of preventing wilt by reducing transpiration. Root irrigation is important for plant growth and health, but syringing of the surface during the heat of the day is just as important for turf survival in the desert environment.

The type of course also figured important in the explanation of annual cost per maintained acre. The Desert Southwest is a region of many private and resort courses. Private courses generally tend to have higher budgets and expenses than do other types of courses. It follows that annual cost per maintained acre is greater on private

TABLE XIX

TYPES OF GREEN IRRIGATION IN ARID SOUTHWEST REGION

Type of Green Irrigation	Percent	N
None	0.9	1
Manual	14.1	16
Automatic	85.0	96
Total	100.0	113

courses. Whether or not the superintendent of a golf course is certified by the GCSAA entered into the best-five regression model. It is assumed that certified superintendents have a greater knowledge of their golf course environments than do uncertified superintendents. The inclusion of this variable in the model makes sense in that private courses probably have certified superintendents since environmental mistakes in golf course management in the harsh desert environment can be devastating, both to the golf course and to the budget. Golf course turf can be lost or severely damaged in just a couple of hours without proper care. As seen from Table XX, annual cost per maintained acre is by far the greatest in the Desert Southwest. While the amount of variance in costs explained by environmental factors is only 35%, the most important variables chosen by the model make strong environmental sense in this region.

Region 7 - OKTEXLA

Although the amount of explained variance in annual cost per maintained acre is only 28% in the OKTEXLA region, the environmental variables selected by the model seem to have some validity (Table XIV, Appendix B, and Table XVII). The eastern part of this region is characterized by moderate to heavy precipitation amounts with the climate becoming progressively drier in western Texas and Oklahoma. Gallons of irrigation water per acre figures prominently in the model for this region as does annual inches of rainfall.

TABLE XX

REGIONAL AVERAGE COSTS PER
MAINTAINED ACRE ($)

Environmental Region	All Courses	Private Courses	Public Courses
1. Middle Atlantic to New England	2689	1973	4862
2. North-North Central	1196	1302	1079
3. Sub-North Central	1707	1653	1837
All North Central	1470	1507	1430
4. Western Mountain States	2276	2282	2278
5. Pacific Northwest	2124	2173	2069
6. Arid Southwest	4309	4460	4148
7. OKTEXLA	2525	2651	2078
8. Southeast	2075	2094	2009
9. Florida	3532	3786	2618
Overall Means	2390	2380	2440
Overall Means Without Regions #1 and #3	2438	2532	2214

How often severe weather increases the maintenance tasks and costs at golf courses in this region enters the regression model. Severe thunderstorm activity is not uncommon throughout this region. "Tornado Alley" is located in parts of central Texas and Oklahoma. Hurricane occurrences in the south and flooding problems throughout the region are well known in the climatic history of the region (Whipple, 1982). It is not suprising then that maintenance costs are escalated by the frequency of severe weather in this region.

The age of the golf course also appears to be important in explaining annual maintenance cost per acre in the region As mentioned earlier, newer courses generally have higher annual costs per maintained acre than do older courses since older courses are thought to be more in equilibrium with their environments. As seen from Table XXI, courses that have been built from 1970 to present have substantially higher average annual costs per maintained acre than do courses built before 1970. Furthermore, courses built from 1980 to present have even higher average costs per maintained acre than do courses built prior to 1980. One possible explanation considers the oil and petroleum boom in the region in the late 1970's and early 1980's. During that period of time, the region was economically prosperous because of high oil production and ceiling prices. This economic success probably spurred the rapid development of new golf facilities as well as other types of development. Since the golf courses are relatively young, they probably

TABLE XXI

COMPARISON OF AVERAGE ANNUAL COSTS PER MAINTAINED ACRE FOR OLD AND NEW GOLF COURSES IN THE OKTEXLA REGION

Course Age	Average Annual Cost per Maintained Acre ($)	N	Percent
Courses Opened Before 1970	2174	39	53.4
Courses Opened Since 1970	2924	34	46.6
Courses Opened Before 1980	2291	56	76.7
Courses Opened Since 1980	3363	17	23.3

have not completely adjusted to their environments. Indeed, almost half of the courses responding to the survey from this region have opened for business since 1970, and almost a quarter of the courses have opened since 1980 (Table XXI). Thus, this situation is reflected in Table XX as relatively high costs per maintained acre.

Region 8 - Southeast

Only about a quarter of the variation in annual cost per maintained acre is explained by environmental factors in this regional model (Table XV, Appendix B, and Table XVII). Even though the model is significant at the 0.01 level, the predictive power of the equation is relatively weak. In previous studies (Stadler and Simone, 1987), it was stated that the Southeast may represent a situation where the environment is mild enough so as not to dominate in determining annual costs per maintained acre. The Southeast region delineated in this study could be typified in the same manner (Figure 6 or 7). The Southeast region is characterized by a humid sub-tropical climate which is ideal for vegetation growth. Mild winters and an abundance of precipitation over evaporation also contribute to favorable conditions for vegetation growth in the Southeast (Stadler and Simone, 1987).

Region 9 - Florida

Southern Florida is dominated by a tropical climate while the northern one third of the state approaches more of a subtropical environment. About half of the variation in annual maintenance cost per acre is explained by environmental factors (Table XVI, Appendix B, and Table XVII). Gallons of irrigation water per acre enters the model first. The inability of sandy soil to adequately hold moisture requires more irrigation to sustain turf growth in this region. Likewise, total chemical costs enter the model since greater treatment is needed on the relatively infertile sandy soils of the region. The number of days too windy for comfortable play also appears to be important. The strong land and sea breezes associated with coastal golf environments can increase maintenance costs and tasks by increasing clean-up operations of wind blown debris on the golf course. Finally, terrain type enters the model in explaining annual cost per maintained acre. This is logical because Florida is mostly characterized by flat coastal plains consisting of coral sands and limestone. Golf course developers are presented with the challenging problem of creating a golf course from a relatively uninviting golf environment. Terrain is almost always created on golf courses in Florida.

Analysis of Variance

An anaylsis of variance test was conducted to test whether the environmental cluster regionalization produced statistically dissimilar regions in terms of cost per maintained acre. A statistically significant "F" statistic indicates that between-region variance in annual cost per maintained acre is greater than within-region variance. In addition, an anaylsis of variance test was conducted on the United States Census regionalization to determine if it is, indeed, inferior to the environmental cluster regionalization.

Analysis of variance can be considered as a difference of means test. Specifically, it is a model in which the variance of a numeric variable "is related to, or explained by, the categories of the nominal scaled variable" (Clark and Hosking, 1986). In this case, cost per maintained acre is the numeric variable and region is the categorical, nominal variable.

The null hypothesis was that there is no difference of average cost per maintained acre between regions. The alternative hypothesis was that not all average cost per maintained acre values are equal between regions.

Clark and Hosking (1986) describe the underlying principle of analysis of variance: the total variance of a variable is divided into two parts. One part considers within-class variance while the other deals with between-class variance. The within-class variance is determined by computing the sum of the differences between individual data values within each individual category. The sum over all categories consists of the total within-class variance. The between-class variance is determined by computing the difference between each category mean and the grand mean. The between-class variance is then adjusted by the sample size of each category.

The test statistic used to determine whether variance is due to within-class variation or between-class variation is known as the F statistic. The F value is computed by the ratio of the mean square between-class variance to mean square within-class variance.

The general linear models procedure (GLM) in SAS was employed to conduct the analysis of variance. Nine different models were constructed (Tables XXII through XXX, Appendix C). Six models were for both regionalization schemes (Figures 6 and 7) and three were for the United States Census regions (Figure 2). Two of the models for each regional scheme considered whether the course was public or private, and one considered all courses. This strategy was used because of the fact that cost per maintained acre was better explained on private courses than on public courses.

In addition, Scheffe's test (1959) was performed to determine which regional means in annual cost per maintained acre were significantly different from other means.

Scheffe's test was used because it is generally considered to be the most conservative in the likelihood of rejecting the null hypothesis (Clark and Hosking, 1986). Also, Scheffe's test finds significant differences between pairs of regional means only if the F test is statistically significant (Clark and Hosking, 1986). Because Scheffe's test is so rigorous, it is suggested that a lesser significance level be used with the procedure (Ferguson, 1976). Therefore, all results are presented at the 0.05 level of significance (Tables XXXI through XXXVI, Appendix D).

The results of the analysis of variance for the environmental regionalizations provided some encouraging results. The models used all courses, regardless of type or environmental regionalization scheme (Tables XXII and XXV, Appendix B). For both regionalization schemes, the computed F statistic exceeds the critical value of F. Therefore, the null hypothesis can be rejected and the conclusion can be made that there are significant differences between regions when considering annual cost per maintained acre. In other words, between-region variation is greater than within-region variation. As for which regional means of annual cost per maintained acre are significantly different from others, only one relationship is apparent (Tables XXXI and XXXII, Appendix D). For the first regionalization (Figure 6), only the North Central and Arid Southwest regions are significantly different. For the second regionalization

(Figure 7), only the North-North Central and Arid Southwest region are significantly different. It might be noted that the Sub-North Central region becomes significantly different from the Southwest region if the significance level is lowered to 0.1. As seen from Table XX, the Southwest region has the highest annual average costs per maintained acre while the North-North Central and entire North Central regions have the lowest. Again, the high cost of irrigation water in the Southwest region is the overriding factor.

As for the model using United States Census regions, the analysis of variance test indicates that the regionalization is marginally significant (Table XXVIII, Appendix C). The null hypothesis is rejected, yet the differences between the regions are not as great as they are for the environmental cluster regions; the computed F value for the U.S. Census regionalization is not as strong as it is for the environmental cluster regionalizations. To further support the lesser significance of the U.S. Census regionalization, the Scheffe's test indicates that none of the regions are significantly different from each other (Table XXXIII, Appendix D). These results indicate the cluster regionalization is superior to the U.S. Census regionalization in terms of explaining costs per maintained acre.

The analysis of variance for public courses alone and private courses alone also provided some interesting results. For private courses, the analysis of variance test indicates that there is a strong significant difference between regions of cost per maintained acre (Tables XXIII and XXVI, Appendix C). Hence, between-region variation is far greater than within-region variation. Likewise, the model for public courses held up to expectations (Tables XXIV and XXVII, Appendix C). For public courses, the null hypothesis cannot be rejected, and it is concluded that there is no significant difference in cost per maintained acre between region.

The results here imply that variance in cost per maintained acre for public golf courses is not explained by regional differences, and thus, within-region variation is greater than between-region variation. The results suggest that public courses do not take the environment into account as much as private courses do in terms of maintenance practices. It is not that public courses totally neglect the environmental "health" of their golf courses, but it is due to the fact that private courses generally have higher standards as well as budgets.

When looking at the Scheffe's difference of means tests (Tables XXXIV and XXXV, Appendix D), it becomes apparent that a distinction between private and public is essential to highlight regional differences (tables are not generated for public courses since the analysis of variance test is not significant). Many significant regional differences emerge for private courses when the type of golf course is considered.

The analysis of variance test for public and private courses using the U.S. Census regionalization yields similar results (Tables XXIX and XXX, Appendix C). The model for private courses is highly significant while the public model is not. Even the Scheffe's difference of means test indicates that many differences exist between regions for private courses when the refinement is made to private and public courses (Table XXXVI, Appendix D).

While the model for private courses is highly significant when using U.S. Census regions, a comparison of F values indicates that the private models for the environmental regionalizations have far greater between-region variation and far less within-region variation than does the U.S. Census region private model (Tables XXIII, XXVI, and XXIX, Appendix C). Although the multiple regression models for all courses for the environmental cluster regions have only moderately larger strenghs than does the model for U.S. Census regions, an improvement in the regional explanation of annual maintenance costs is gained. Overall, the new environmental cluster regionalization seems to hold up to expectations; greater between-region variation and less within-region variation is achieved by replacing the U.S. Census regions with environmentally-based cluster regions.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The nine state-based functional maintenance regions of golf developed from the environmental cluster analysis appear to have utility in explaining maintenance costs. While state boundaries are rather broad divisions of the environment, the amount of variance explained by the multiple regression models suggest that the regionalization is appropriate for the purpose of improving the statistical presentation of golf course maintenance information. The environmental integrity of the regions is supported and mainly explainable by the variables which appear to be important in explaining annual cost per maintained acre. Furthermore, the analysis of variance confirms that annual maintenance costs vary substantially between the regions. Clearly, a regionalization based on environmental factors makes more sense than one that is based on ease of presentation, i.e. United States Census regions.

The environment plays such a variable role in determining maintenance costs between regions in the United States that consideration of regional environmental characteristics in preparing a budget is important to good golf course management. While human decisions and non-environmental variables dominate the total picture on the basis of variance explained in annual maintenance costs, it is clear from the results of the survey data that the environment cannot be ignored.

Although an analysis of golf environments is rather crude at the state level, it serves as an appropriate scale to present and convey information to a large audience. Thus, it is suggested that these environmentally-based functional maintenance regions of golf courses be employed in the presentation of results in the upcoming 1987 Golf Course Maintenance Report which will be published by the NGF and the GCSAA. It is expected that the results of the maintenance survey will be more meaningful to the users of the information in the survey, i.e. golf course superintendents. The results of the survey should be useful to superintendents because they will be able to more accurately compare how their environmental maintenance practices stand among other facilities in their region. Since the environmental golf regions were shown to be superior to the U.S. Census regions on the criterion of between-region variation, it makes sense to employ the new regionalization to improve the efficiency of survey result presentation.

Future research on golf course environments should be conducted at a scale larger than ever before. While reseach has been administered at the three-digit ZIP code level (Stadler and Simone, 1987), the next reasonable level of research should be done at the five-digit ZIP code level. This suggested research, of course, would require efforts beyond a mail survey to ensure viable numbers of courses are included. Regional research at the county level utilizing the very same data employed in this study is entirely possible at the present. While it would be extremely laborious, the considerable time required for such a study would be well worth the effort. Aside from studying individual golf courses, a magnification and refining of national golf course environments is needed to better identify geographic variation in explaining golf course maintenance costs.

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APPENDIXES

APPENDIX A

NATIONAL MAINTENANCE SURVEY

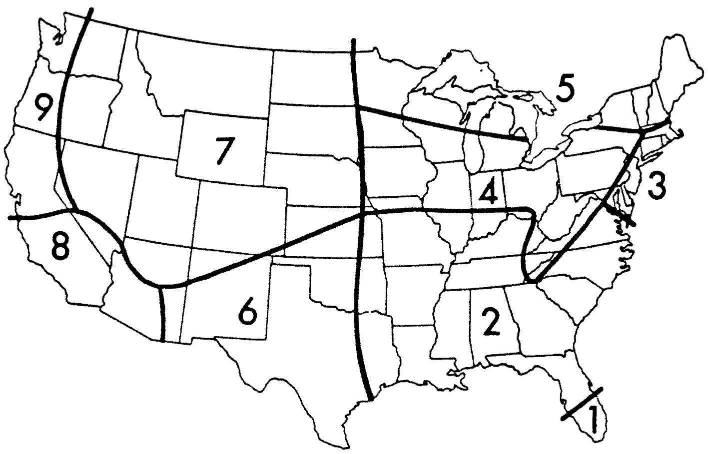
This is the subset of environmental questions on the national maintenance survey which were employed in the study: 1, 3, 4, 5, 8, 9(51), 14, 15, 16, 17(76), 17(78), 29(379), 29(391), 29(433), 29(470), 31, 32, 33, 34, 35, 36, 37(all), 38, and 40. The survey is reproduced in its original form on the following pages.

1986 NATIONAL MAINTENANCE SURVEY

Sponsored Jointly By
The National Golf Foundation
and
The Golf Course Superintendents Association of America

GOLF COURSE SUPERINTENDENTS ASSOCIATION OF AMERICA

NGF
NATIONAL GOLF FOUNDATION™



The map above shows maintenance regions that have been developed on the basis of climate, turfgrass type, facility density and cultural factors.

General Information

1. Using the map above, please indicate the region where your facility is located. region ________ (1)
2. Fill in your five digit zip code. ____________ zip (6)
3. What year did your golf facility open. 19 ____________ (8)
4. What is the total acreage of the course(s) you maintain: (only include the golf playing area, exclude bodies of water, include the driving range). ________ acres (11)
5. Please indicate the type of facility
   Private [ ] 1 (12)
   Daily Fee [ ] 2
   Municipal [ ] 3
6. Are you a **resort** course.
   Yes [ ] 1 (13)
   No [ ] 2

7. Indicate how many holes you have for each type of course.

Regulation	________	holes (15)
Executive	________	holes (17)
Par 3	________	holes (19)

8. How many months of the year is your facility maintained: ________ months (21)

9. Please estimate how many rounds of golf your facility carries in the following periods.

1st quarter	January-March	________	rounds (27)
2nd quarter	April-June	________	rounds (33)
3rd quarter	July-September	________	rounds (39)
4th quarter	October-December	________	rounds (45)
Total annual rounds		________	**rounds (51)**

10. What is your average green size: ________ sq ft (55)

11. What is your average tee size: ________ sq ft (59)

12. What is your average fairway size: ________ acres (60)

13. Indicate the acreage and number of tee stations of your driving range: ________ acres (62)
________ stations (64)

14. Indicate which statement most closely describes how your rough is maintained:

High Intensity (i.e. mowing once weekly at 1.5 inches)	[ ] 1 (65)
Medium Intensity (i.e. once every two weeks at 2.5 inches)	[ ] 2
Low Intensity (i.e. mowing once a month at 4 inches)	[ ] 3

Irrigation

15. How many gallons of irrigation water does your facility use per year? ________ gallons (74)

16. Indicate your major source of irrigation water (mark only one):

Wells	[ ] 1 (75)
Natural Lakes and Streams	[ ] 2
Local Potable Water	[ ] 3
Effluent Water	[ ] 4

17. Indicate the type of irrigation system used:

	Automatic	Manual	None
Greens	[ ] 1	[ ] 2	[ ] 3 (76)
Tees	[ ] 1	[ ] 2	[ ] 3 (77)
Fairways	[ ] 1	[ ] 2	[ ] 3 (78)
Rough	[ ] 1	[ ] 2	[ ] 3 (79)
Driving Range	[ ] 1	[ ] 2	[ ] 3 (80)

Pay

18. Indicate the total annual labor hours by Full Time (all season) employees. ______________ (86)

19. Indicate the total annual labor hours by Part Time employees. ______________ (92)

20. Is your golf course maintenance staff unionized? Yes [ ] 1 (93) No [ ] 2

21. Please fill in the hourly wages for the categories of staff listed below: (where several staff are employed in the same category indicate the highest and lowest wage as well as the average).

	Lowest	Average Hourly Wage	Highest
Mechanic		(101)$_____._____	
Full-time maintenance staff	(105)$_____._____	(109)$_____._____	(113)$_____._____
Part-time maintenance staff	(117)$_____._____	(121)$_____._____	(125)$_____._____
Foreman, Irrigation technician, chemical technician		(133)$_____._____	

22. Indicate which benefits are provided to your employees.

	Yes	No
Health Insurance	[ ] 1	[ ] 2 (138)
Dental Insurance	[ ] 1	[ ] 2 (139)
Paid Vacations	[ ] 1	[ ] 2 (140)
Paid Sick Leave	[ ] 1	[ ] 2 (141)
Pension Plan	[ ] 1	[ ] 2 (142)

Golf Cars

23. Are your staff responsible for maintaining the golf car fleet? Yes [ ] 1 (143)
If your answer is no skip this section and continue with the questions on equipment inventory. No [ ] 2

24. How many golf cars does your facility maintain.
__________ gas (146)
__________ electric (149)
__________ **total** (152)

25. If your staff maintain the golf cars, please estimate how many hours are spent on car maintenance annually. __________ hrs (158)

26. If you are responsible for maintaining the golf car fleet please fill in your annual budget for the items below:

(164)	$ ________	Payroll (covering labor relating to car fleet)
(170)	$ ________	Batteries
(176)	$ ________	Gas
(182)	$ ________	Parts
(188)	$ ________	Tires
(194)	$ ________	Electricity (for car recharging)
(200)	$ ________	Refurbishing

27. Which statement best describes your facilities' car paths:

Continuous Car Paths	[ ] 1 (201)
Some Car Paths	[ ] 2
No Car Paths	[ ] 3

Equipment Inventory

28. Please fill in the number of units, the estimated replacement value and the normal replacement frequency for the equipment categories listed below.

Total Units	Estimated Replacement Value	Normal Replacement Frequency	
(203)____	(209)$ ________	(211) ______ yrs.	Personnel Carriers & Utility Vehicles
(213)____	(219)$ ________	(221) ______ yrs.	Tractors
(223)____	(229)$ ________	(231) ______ yrs.	Triplex Mowers
(233)____	(239)$ ________	(241) ______ yrs.	Large Reel Mowers
(243)____	(249)$ ________	(251) ______ yrs.	Small Reel Mowers (hand units)
(253)____	(259)$ ________	(261) ______ yrs.	Rotary/Flail Mowers
(263)____	(269)$ ________	(271) ______ yrs.	Renovation/Construction Equipment
(273)____	(279)$ ________	(281) ______ yrs.	Ground Grooming Equipment
(283)____	(289)$ ________	(291) ______ yrs.	Chemical Application Equipment
(293)____	(299)$ ________	(301) ______ yrs.	Miscellaneous

Annual Budget

29. Please fill in figures from your 1986 budget in the generalized budget outline below. The line items in your budget will probably differ slightly from the items shown below. Please try and fit your budget into the line items below as best you can. If you do not have a budget for a particular item, (for example, meals, uniforms or administration overhead) **please fill in a zero.** Do not include budgets for the maintenance of non-golf playing areas (for example, facility entrance, clubhouse, swimming pool, tennis courts, etc.). Please do **not** include the budget for maintenance or operation of the golf car fleet.

(307)	$__________	Payroll (all labor costs including wages and salaries, casual labor and overtime.)
(313)	$__________	Payroll taxes
(319)	$__________	Employee Benefits (pension, insurance, etc.)
(325)	$__________	Meals
(331)	$__________	Uniforms and Rain Gear
(337)	$__________	Repairs and Maintenance to golf course equipment
(343)	$__________	Irrigation system repairs
(349)	$__________	Irrigation water
(355)	$__________	Irrigation pumping/energy costs
(361)	$__________	Electricity (not including irrigation electricity)
(367)	$__________	Tools
(373)	$__________	Equipment Rental
(379)	$__________	Fertilizer
(385)	$__________	Sand/fill/soil
(391)	$__________	Grass/seed/sod
(397)	$__________	Golf Course Supplies (signage, ropes, flags, marking paint)
(403)	$__________	Disposal expense/refuse removal
(409)	$__________	Gas, Oil, Grease
(415)	$__________	Fungicides
(421)	$__________	Herbicides
(427)	$__________	Insecticides/nematicides
(433)	$__________	Total Chemicals
(439)	$__________	Dues, Subscriptions, Publications
(445)	$__________	Travel Expenses
(451)	$__________	Consultant Fees
(457)	$__________	Administration Overhead
(463)	$__________	Miscellaneous
(470)	$__________	Total (excluding 1986 capital expenditures)

Capital Budget

30. Estimate total capital expenditure, for the categories listed below, for the last three years (1984-86).

Total Spent

1984-86

(477)	$____________	New Capital Equipment (trucks, mowers, etc.)
(484)	$____________	Landscaping and Beautification (flower beds, plants, treeplanting, etc.)
(491)	$____________	Contracted Projects (bridges, streams, major tree pruning, etc.)
(498)	$____________	Lakes (dredging, rebanking, etc.)
(505)	$____________	Car Paths (construction)
(512)	$____________	Course Replanning/Reconstruction (e.g., rebuilding tees, greens)
(519)	$____________	Drainage
(526)	$____________	Irrigation system upgrading/installation

Environment

31. How would you describe the general terrain of your golf course?

Very Flat	[ ] 1 (527)
Gently Rolling	[ ] 2
Rolling	[ ] 3
Hilly	[ ] 4
Very Hilly	[ ] 5

32. Indicate the general soil type on which your facility is located:

Heavy Clay	[ ] 1 (529)
Clay Loam	[ ] 2
Sandy Loam	[ ] 3
Sand	[ ] 4
Coarse Sand	[ ] 5

33. What is your average annual rainfall? __________ inches (531)

34. What is the approximate elevation above sea level of your facility?

0-1000 ft	[ ] 1 (532)
1000-3000 ft	[ ] 2
3000-5000 ft	[ ] 3
5000 plus ft	[ ] 4

35. How would you rate the natural fertility of your dominant soil type:

Very low	[ ] 1	(533)
Moderate	[ ] 2	
Moderately high	[ ] 3	
Very high	[ ] 4	

36. Which natural vegetation type was probably in the area before your course was built:

Broadleaf evergreen forest	[ ] 1	(534)
Narrowleaf evergreen forest	[ ] 2	
Broadleaf deciduous forest	[ ] 3	
Prairie/grassland	[ ] 4	
Desert scrub	[ ] 5	
Grasses/short trees (chaparral)	[ ] 6	

37. During the operational months of your facility **estimate** the number of days your facility is:

Too hot for comfortable play	________ days (536)
Too cold for comfortable play	________ days (538)
Too rainy for comfortable play	________ days (540)
Too windy for comfortable play	________ days (542)
Too humid for comfortable play	________ days (544)
Too snowy for comfortable play	________ days (546)

38. Please estimate how often does severe weather (i.e., thunderstorms, flooding, ice storms, etc.) increase the maintenance tasks/costs at your facility:

Frequently	[ ] 1	(547)
Occasionally	[ ] 2	
Seldom	[ ] 3	
Never	[ ] 4	

THE SUPERINTENDENT

39. Please indicate your class of GCSAA membership:

Class A	[ ] 1	(548)
Class B	[ ] 2	
Associate	[ ] 3	
Affiliate	[ ] 4	
Not a member of the Golf Course Superintendents Association of America	[ ] 5	

40. Are you a GCSAA Certified Course Superintendent?

Yes	[ ] 1	(549)
No	[ ] 2	

41. Please indicate how much expense per year your course reimburses you for professional business expenses (such as dues, superintendents meetings, national conferences, etc.):

Less than $100	[ ] 0 (550)	$2,001-2,500	[ ] 5
$100-500	[ ] 1	$2,500-3,000	[ ] 6
$501-1,000	[ ] 3	$3,001-3,500	[ ] 7
$1,000-1,500	[ ] 4	3,000	[ ] 8
$1,501-2000	[ ] 5	None	[ ] 9

42. Please indicate what describes your base annual salary:

Base annual salary: ________________ (555)

43. Please indicate your age group.

Under 25	[ ] 0 (556)	46-50	[ ] 5
26-30	[ ] 1	51-60	[ ] 6
31-35	[ ] 2	61-65	[ ] 7
36-40	[ ] 3	66-70	[ ] 8
41-45	[ ] 4	Over 70	[ ] 9

44. Please indicate the highest degree you hold:

AA	[ ] 0 (557)	MS	[ ] 5
AS	[ ] 1	MBA	[ ] 6
BA	[ ] 2	PhD	[ ] 7
BS	[ ] 3	Post Doctoral	[ ] 8
MA	[ ] 4	Not Applicable or High School	[ ] 9

45. Taking into account your responsibilities, what would you like your job title to be:

Golf Course Superintendent	[ ] 1 (558)	Greenkeeper	[ ] 6
General Manager	[ ] 2	Superintendent of Buildings & Grounds	[ ] 7
Golf Course Manager	[ ] 3		
Green Superintendent	[ ] 4	Property Manager	[ ] 8
Director of Golf Operations	[ ] 5	Other	[ ] 9

46. Who is your immediate supervisor?

Self (I own course)	[ ] 1 (561)	President or CEO	[ ] 6
Golf Course Superintendent	[ ] 2	Golf Professional	[ ] 7
General Manager	[ ] 3	Director of Golf	[ ] 8
Green Chairman	[ ] 4	Other	[ ] 9
Course Owner	[ ] 5		

47. Please indicate your sex:

Male	[ ] 1 (562)			
Female	[ ] 2			

48. What percentage of your time do you spend on areas of management other than golf course maintenance (i.e., tennis, golf car, swimming pool, etc.)?

Less than 5%	[ ] 0 (563)	31-40%	[ ] 5
6-10%	[ ] 1	41-50%	[ ] 6
11-15%	[ ] 2	51-75%	[ ] 7
16-20%	[ ] 3	76-99%	[ ] 8
21-30%	[ ] 4	100%	[ ] 9

49. I have been employed in golf course operations for:

Less than three years	[ ] 1 (564)	20-30 years	[ ] 6
3-5 years	[ ] 2	30-40 years	[ ] 7
5-10 years	[ ] 3	40-50 years	[ ] 8
10-15 years	[ ] 4	Over 50 years	[ ] 9
15-20 years	[ ] 5		

50. I have been employed at my current golf course:

Less than three years	[ ] 1 (565)	20-30 years	[ ] 6
3-5 years	[ ] 2	30-40 years	[ ] 7
5-10 years	[ ] 3	40-50 years	[ ] 8
10-15 years	[ ] 4	Over 50 years	[ ] 9
15-20 years	[ ] 5		

51. Does your club/firm/school pay for your attendance at educational conferences, field days, equipment trade shows, professional meetings and professional dues?

Yes, 100%	[ ] 1 (566)
Yes, 75%	[ ] 2
Yes, 50%	[ ] 3
Yes, 25%	[ ] 4
No	[ ] 5

Tee Markers

To help offset the cost of this research project we have included some proprietary questions on behalf of a tee signage company. Although these questions are not part of the NGF/GCSAA research we would be grateful if you would take the time to complete them.

Tee signage is defined as the system at the tee bearing information as to the hole number, yardage and sometimes a diagram of the hole.

1. What type of tee signage system does your facility have:

Flat yardage plate on the ground	[ ] 1 (567)
Wooden sign with yardage	[ ] 2
Wooden sign with yardage & hole plan	[ ] 3
Metal sign with yardage	[ ] 4
Metal sign with yardage & hole plan	[ ] 5
Other	[ ] 6
None	[ ] 7

2. How old are your current tee markers. __________ Years old (565)

3. In what condition are your current tee markers:

Good condition	[ ] 1 (570)
Acceptable	[ ] 2
Poor Condition	[ ] 3

4. What was the approximate cost of your present tee signage for 18 holes: $ __________ (572)

5. When would you expect to replace your current tee signage:

Next year	[ ] 1 (573)
In two years	[ ] 2
In five years	[ ] 3
In ten years	[ ] 4
Longer than ten years	[ ] 5
Won't replace	[ ] 6

6. Would you like to see the tee signage system at your facility improved:

Yes	[ ] 1 (581)
No	[ ] 2

7. Does your current tee signage or tee benches include advertising messages:

Yes	[ ] 1 (579)
No	[ ] 2

APPENDIX B

REGIONAL MULTIPLE REGRESSION MODELS

The stepwise multiple regression models on the following pages indicate the results of the best-five variable equations for the United States and for the environmental maintenance regions of golf. The best-five variables are not listed in their order of strength in explaining annual cost per maintained acre because SAS prints the results in the order that the variables were specified in the original programming. The order of strength is determined by observing the F statistics, from the highest value to the lowest, for the variables in each model. Descriptions of variable names are indicated on Table XVII in Chapter IV which lists the variables in order of strength. An explanation of the F statistic as well as of the regression are also provided in Chapter IV.

TABLE VI

MULTIPLE REGRESSION MODEL FOR THE UNITED STATES

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	361618149.18677200	72323629.83735430	43.36	0.0001
ERROR	321	535442288.46235300	1668044.51234378		
TOTAL	326	897060437.64912400			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	806.54312965				
V23	-0.00000754	0.00000129	56814735.32984680	34.06	0.0001
V2	140.94208011	35.05095346	26970519.82195790	16.17	0.0001
V101	0.04092488	0.00527307	100474341.96389400	60.23	0.0001
V103	0.06352528	0.00995118	67975321.60244860	40.75	0.0001
GALPER	0.00092695	0.00012113	97681525.47179170	58.56	0.0001

TABLE VII

MULTIPLE REGRESSION MODEL FOR MIDDLE ATLANTIC TO NEW ENGLAND REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	40211428.33334260	8042285.66666852	20.34	0.0001
ERROR	61	24119660.10457430	395404.26400941		
TOTAL	66	64331088.43791690			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	24658.46684347				
V23	-0.00003438	0.00001007	4610169.20775451	11.66	0.0011
V4	-11.34669957	2.82062237	6398682.58908552	16.18	0.0002
V27	-785.22043475	124.25408521	15790765.43293890	39.94	0.0001
V101	0.05438462	0.01575000	4714467.29505282	11.92	0.0010
GALPER	0.00438999	0.00106610	6704645.16692174	16.96	0.0001

TABLE VIII

MULTIPLE REGRESSION MODEL FOR NORTH-NORTH CENTRAL REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	10576612.45690950	2115322.49138189	12.80	0.0001
ERROR	29	4790775.84130740	165199.16694163		
TOTAL	34	15367388.29821690			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	631.93546931				
V24	394.58951297	129.33668853	1537642.78916444	9.31	0.0048
V130	184.19904706	93.18629906	645473.59878973	3.91	0.0577
V27	-550.99232301	132.75882568	2845588.80968612	17.23	0.0003
V101	-0.05740601	0.02077566	1261283.73982307	7.63	0.0098
V110	0.04247872	0.00696950	6136872.94586975	37.15	0.0001

TABLE IX

MULTIPLE REGRESSION MODEL FOR SUB-NORTH CENTRAL REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	12319236.06035550	2463847.21207110	8.38	0.0001
ERROR	56	16471268.41146390	294129.79306186		
TOTAL	61	28790504.47181940			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	1289.29004890				
V136	4.17510714	1.81638737	1554022.56064943	5.28	0.0253
V2	-73.88801789	60.61750488	437009.56021141	1.49	0.2280
V103	0.02600218	0.01839176	587911.38909878	2.00	0.1630
V110	0.01770721	0.00563392	2905476.95906829	9.88	0.0027
GALPER	0.00011923	0.00003304	3830590.08390428	13.02	0.0007

TABLE X

MULTIPLE REGRESSION MODEL FOR ENTIRE NORTH CENTRAL REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	22607976.34595250	4521595.26919049	16.18	0.0001
ERROR	91	25426923.22393200	279416.73872453		
TOTAL	96	48034899.56988440			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	626.56807375				
V136	2.90911867	1.30519292	1388116.36955203	4.97	0.0283
V11	57.41999725	30.28337518	1004546.85870601	3.60	0.0611
V27	-132.32054543	84.44325240	686083.66580628	2.46	0.1206
V110	0.02416888	0.00408364	9787481.24522905	35.03	0.0001
GALPER	0.00009657	0.00003121	2674821.86619044	9.57	0.0026

TABLE XI

MULTIPLE REGRESSION MODEL FOR WESTERN MOUNTAIN STATES REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	182537041.09778200	36507408.21955630	37.57	0.0001
ERROR	18	17492702.11719980	971816.78428888		
TOTAL	23	200029743.21498100			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-878.66758889				
V23	-0.00004466	0.00000411	114749131.83045100	118.08	0.0001
V134	-34.66656214	9.67249756	12483279.31852870	12.85	0.0021
V11	196.17862408	90.78613886	4537834.70451089	4.67	0.0444
V101	0.13409161	0.02182205	36694110.75158950	37.76	0.0001
GALPER	0.00567571	0.00045274	152729701.79034600	157.16	0.0001

TABLE XII

MULTIPLE REGRESSION MODEL FOR
PACIFIC NORTHWEST REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	3317684.54847962	829421.13711991	999999.99	0.0001
ERROR	0	0.00000000	0.00000000		
TOTAL	4	3317684.54847962			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4964.91937153				
V23	-0.00016997	0	1272.54925573	999999.99	0.0001
V127	-52.75704495	0	206.38865216	999999.99	0.0001
V129	-268.55391666	0	45.53031570	999999.99	0.0001
V27	3314.40863809	0	839.92995854	999999.99	0.0001

TABLE XIII

MULTIPLE REGRESSION MODEL FOR
ARID SOUTHWEST REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	102598099.50554000	20519619.90110800	10.70	0.0001
ERROR	24	46007892.41476240	1916995.51728177		
TOTAL	29	148605991.92030300			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	2604.80018298				
V125	733.84785078	266.32607276	14554784.53176420	7.59	0.0110
V6	-743.31358017	362.85150620	8044654.03272055	4.20	0.0516
V25	-2195.00066229	826.81474886	13510579.53579950	7.05	0.0139
GALPER	0.00134990	0.00023239	64683493.17583190	33.74	0.0001
V139	868.90600326	666.78228140	3255356.76702119	1.70	0.2049

TABLE XIV

MULTIPLE REGRESSION MODEL FOR OKTEXLA REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	17305774.57365160	3461154.91473033	10.43	0.0002
ERROR	14	4647733.30143254	331980.95010232		
TOTAL	19	21953507.87508420			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-91581.06772654				
V127	14.11268357	7.17051738	1285971.62496142	3.87	0.0692
V137	-876.35378409	294.12807751	2947128.87471875	8.88	0.0099
V4	47.70744483	10.63799533	6676761.86202114	20.11	0.0005
V22	746.79722275	394.50546257	1189631.64911593	3.58	0.0792
GALPER	0.00157222	0.00026496	11689476.67705900	35.21	0.0001

TABLE XV

MULTIPLE REGRESSION MODEL FOR SOUTHEAST REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	30329904.35727820	6065980.87145563	17.83	0.0001
ERROR	28	9525331.75720042	340190.41990001		
TOTAL	33	39855236.11447860			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	16815.07714188				
V24	1010.02152019	174.97250340	11335579.38766110	33.32	0.0001
V4	-8.27990633	5.07677998	904890.94328897	2.66	0.1141
V27	-686.53125078	178.20260127	5049107.56399757	14.84	0.0006
V101	0.01885495	0.01119840	964407.89216144	2.83	0.1034
V103	0.02574669	0.01777973	713369.32585932	2.10	0.1587

TABLE XVI

MULTIPLE REGRESSION MODEL FOR FLORIDA REGION

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	33812630.42250750	6762526.08450150	5.42	0.0018
ERROR	24	29944866.74498250	1247702.78104094		
TOTAL	29	63757497.16749000			
	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4006.08521541				
V23	-0.00000877	0.00000209	21932532.22859890	17.58	0.0003
V125	-665.48026935	324.22307524	5256463.69336946	4.21	0.0512
V134	-38.35731653	17.06663665	6302483.12141185	5.05	0.0341
V110	0.02207899	0.00815839	9138205.12868928	7.32	0.0123
GALPER	0.00176391	0.00040030	24226301.40753590	19.42	0.0002

APPENDIX C

ANALYSIS OF VARIANCE TESTS

TABLE XXII

ANALYSIS OF VARIANCE SUMMARY FOR FIRST REGIONALIZATION SCHEME (ALL COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	7	813979840.8701900	116282834.4100270	3.83	0.0004	0.025233	231.8483
ERROR	1037	31444619538.3443000	30322680.3648450		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	1044	32258599379.2145000			5506.6033419		2375.08873795

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CLUSREG	7	813979840.8701890	3.83	0.0004	7	813979840.8701890	3.83	0.0004

TABLE XXIII

ANALYSIS OF VARIANCE SUMMARY FOR FIRST REGIONALIZATION SCHEME (PRIVATE COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	7	521922145.76952900	74560306.53850420	56.28	0.0001	0.373443	51.0780
ERROR	661	875671666.33841400	1324768.02774344		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	668	1397593812.10794000			1150.98567660		2253.38973529

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CLUSREG	7	521922145.76952900	56.28	0.0001	7	521922145.76952900	56.28	0.0001

TABLE XXIV

ANALYSIS OF VARIANCE SUMMARY FOR FIRST REGIONALIZATION SCHEME (PUBLIC COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	7	607284360.7615010	86754908.6802145	1.00	0.4341	0.019747	360.3967
ERROR	346	30146109263.3264000	87127483.4200186		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	353	30753393624.0879000			9334.2103801		2589.98234457

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CLUSREG	7	607284360.7615010	1.00	0.4341	7	607284360.7615010	1.00	0.4341

TABLE XXV

ANALYSIS OF VARIANCE SUMMARY FOR SECOND REGIONALIZATION SCHEME (ALL COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V
MODEL	8	837019636.0528760	104627454.5066090	3.45	0.0006	0.025947	231.8752
ERROR	1036	31421579743.1616000	30329710.1767969		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	1044	32258599379.2145000			5507.2416123		2375.08873795

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CLUSREG	8	837019636.0528750	3.45	0.0006	8	837019636.0528750	3.45	0.0006

TABLE XXVI

ANALYSIS OF VARIANCE SUMMARY FOR SECOND REGIONALIZATION SCHEME (PRIVATE COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	8	528307529.71968900	66038441.21496110	50.14	0.0001	0.378012	50.9299
ERROR	660	869286282.38825500	1317100.42786099		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	668	1397593812.10794000			1147.64995877		2253.38973529

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CLUSREG	8	528307529.71968900	50.14	0.0001	8	528307529.71968900	50.14	0.0001

TABLE XXVII

ANALYSIS OF VARIANCE SUMMARY FOR SECOND REGIONALIZATION SCHEME (PUBLIC COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	8	626714285.114775C	78339285.6393468	0.90	0.5190	0.020379	360.8023
ERROR	345	30126679338.9732000	87323708.2289078		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	353	30753393624.0880000			9344.7155242		2589.98234457

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CLUSREG	8	626714285.1147740	0.90	0.5190	8	626714285.1147740	0.90	0.5190

TABLE XXVIII

ANALYSIS OF VARIANCE SUMMARY FOR UNITED STATES CENSUS REGIONS (ALL COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	8	635761670.9556990	79470208.8694624	2.60	0.0080	0.019708	232.6166
ERROR	1036	31622837708.2587000	30523974.6218714		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	1044	32258598379.2144000			5524.8506425		2375.08873795

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CENSUS	8	635761670.9556990	2.60	0.0080	8	635761670.9556990	2.60	0.0080

TABLE XXIX

ANALYSIS OF VARIANCE SUMMARY FOR UNITED STATES CENSUS REGIONS (PRIVATE COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	8	328370544.22951100	41046318.02868890	25.34	0.0001	0.234954	56.4841
ERROR	660	1069223267.87844000	1620035.25436127		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	668	1397593812.10795000			1272.80605528		2253.38973529

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CENSUS	8	328370544.22951100	25.34	0.0001	8	328370544.22951100	25.34	0.0001

TABLE XXX

ANALYSIS OF VARIANCE SUMMARY FOR
UNITED STATES CENSUS REGIONS
(PUBLIC COURSES)

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	8	912124330.7283680	114015541.3410460	1.32	0.2331	0.029659	359.0892
ERROR	345	29841269293.3595000	86496432.7343755		ROOT MSE		COSTPER MEAN
CORRECTED TOTAL	353	30753393624.0879000			9300.3458395		2589.98234457

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
CENSUS	8	912124330.7283670	1.32	0.2331	8	912124330.7283660	1.32	0.2331

APPENDIX D

SCHEFFE'S DIFFERENCE OF MEANS TESTS

The names of the environmental maintenance regions for the abbreviations on the following pages are: SW (Southwest), FL (Florida), NE (Middle Atlantic to New England), OK (OKTEXLA), RO (Western Mountain States), NW (Pacific Northwest), SE (Southeast), SU (Sub-North Central), NC - First Environmental Regionalization (All North Central Region), and NC - Second Environmental Regionalization (North-North Central).

The names of the United States Census regions for the abbreviations on the following pages are: PC (Pacific), NE (Northeast), MA (Middle Atlantic), SA (South Atlantic), MT (Mountain), WS (West South Central), ES (East South Central), WN (West North Central), and EN (East North Central).

TABLE XXXI

SCHEFFE'S DIFFERENCE OF MEANS TEST FOR FIRST ENVIRONMENTAL REGIONALIZATION (ALL COURSES)

ALPHA=0.05 CONFIDENCE=0.95 DF=1037 MSE=30322680
CRITICAL VALUE OF F=2.01839

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

CLUSREG COMPARISON	SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT	
SW - FL	-2274.2	776.9	3828.0	
SW - NE	-873.2	1619.8	4112.7	
SW - OK	-1536.5	1783.4	5103.3	
SW - RO	-1256.6	2032.6	5321.7	
SW - NW	-2787.9	2184.9	7157.7	
SW - SE	-546.1	2233.8	5013.6	
SW - NC	486.9	2838.7	5190.5	***
FL - SW	-3828.0	-776.9	2274.2	
FL - NE	-1778.0	842.9	3463.8	
FL - OK	-2410.5	1006.5	4423.5	
FL - RO	-2131.5	1255.7	4642.8	
FL - NW	-3630.1	1408.0	6446.1	
FL - SE	-1438.3	1456.9	4352.0	
FL - NC	-425.2	2061.8	4548.8	
NE - SW	-4112.7	-1619.8	873.2	
NE - FL	-3463.8	-842.9	1778.0	
NE - OK	-2765.8	163.6	3093.0	
NE - RO	-2481.8	412.8	3307.3	
NE - NW	-4155.9	565.1	5286.2	
NE - SE	-1685.5	614.0	2913.4	
NE - NC	-539.1	1218.9	2977.0	
OK - SW	-5103.3	-1783.4	1536.5	
OK - FL	-4423.5	-1006.5	2410.5	
OK - NE	-3093.0	-163.6	2765.8	
OK - RO	-3382.0	249.2	3880.3	
OK - NW	-4803.8	401.5	5606.8	
OK - SE	-2726.8	450.4	3627.5	
OK - NC	-1754.9	1055.3	3865.6	
RO - SW	-5321.7	-2032.6	1256.6	
RO - FL	-4642.8	-1255.7	2131.5	
RO - NE	-3307.3	-412.8	2481.8	
RO - OK	-3880.3	-249.2	3382.0	
RO - NW	-5033.4	152.3	5338.1	
RO - SE	-2943.9	201.2	3346.3	
RO - NC	-1967.8	806.2	3580.1	
NW - SW	-7157.7	-2184.9	2787.9	
NW - FL	-6446.1	-1408.0	3630.1	
NW - NE	-5286.2	-565.1	4155.9	
NW - OK	-5606.8	-401.5	4803.8	
NW - RO	-5338.1	-152.3	5033.4	
NW - SE	-4829.8	48.9	4927.5	
NW - NC	-3994.2	653.8	5301.9	
SE - SW	-5013.6	-2233.8	546.1	
SE - FL	-4352.0	-1456.9	1438.3	
SE - NE	-2913.4	-614.0	1685.5	
SE - OK	-3627.5	-450.4	2726.8	
SE - RO	-3346.3	-201.2	2943.9	
SE - NW	-4927.5	-48.9	4829.8	
SE - NC	-1540.7	605.0	2750.6	
NC - SW	-5190.5	-2838.7	-486.9	***
NC - FL	-4548.8	-2061.8	425.2	
NC - NE	-2977.0	-1218.9	539.1	
NC - OK	-3865.6	-1055.3	1754.9	
NC - RO	-3580.1	-806.2	1967.8	
NC - NW	-5301.9	-653.8	3994.2	
NC - SE	-2750.6	-605.0	1540.7	

TABLE XXXII

SCHEFFE'S DIFFERENCE OF MEANS TEST FOR SECOND ENVIRONMENTAL REGIONALIZATION (ALL COURSES)

ALPHA=0.05 CONFIDENCE=0.95 DF=1036 MSE=30329710
CRITICAL VALUE OF F=1.94732

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

CLUSREG COMPARISON	SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT	
SW - FL	-2427.3	776.9	3981.1	
SW - NE	-998.3	1619.8	4237.8	
SW - OK	-1703.1	1783.4	5269.8	
SW - RO	-1421.7	2032.6	5486.8	
SW - NW	-3037.4	2184.9	7407.2	
SW - SE	-685.6	2233.8	5153.1	
SW - SU	-89.7	2602.3	5294.2	
SW - NC	349.0	3112.4	5875.8	***
FL - SW	-3981.1	-776.9	2427.3	
FL - NE	-1909.5	842.9	3595.3	
FL - OK	-2582.0	1006.5	4594.9	
FL - RO	-2301.5	1255.7	4812.8	
FL - NW	-3882.9	1408.0	6698.9	
FL - SE	-1583.5	1456.9	4497.3	
FL - SU	-997.4	1825.4	4648.1	
FL - NC	-555.4	2335.5	5226.5	
NE - SW	-4237.8	-1619.8	998.3	
NE - FL	-3595.3	-842.9	1909.5	
NE - OK	-2912.8	163.6	3240.0	
NE - RO	-2627.0	412.8	3452.6	
NE - NW	-4392.8	565.1	5523.1	
NE - SE	-1800.9	614.0	3028.8	
NE - SU	-1151.8	982.5	3116.8	
NE - NC	-731.1	1492.6	3716.4	
OK - SW	-5269.8	-1783.4	1703.1	
OK - FL	-4594.9	-1006.5	2582.0	
OK - NE	-3240.0	-163.6	2912.8	
OK - RO	-3564.2	249.2	4062.5	
OK - NW	-5065.0	401.5	5868.0	
OK - SE	-2886.2	450.4	3787.0	
OK - SU	-2320.6	818.9	3958.4	
OK - NC	-1871.9	1329.0	4530.0	
RO - SW	-5486.8	-2032.6	1421.7	
RO - FL	-4812.8	-1255.7	2301.5	
RO - NE	-3452.6	-412.8	2627.0	
RO - OK	-4062.5	-249.2	3564.2	
RO - NW	-5293.6	152.3	5598.3	
RO - SE	-3101.7	201.2	3504.1	
RO - SU	-2534.0	569.7	3673.4	
RO - NC	-2086.0	1079.9	4245.7	
NW - SW	-7407.2	-2184.9	3037.4	
NW - FL	-6698.9	-1408.0	3882.9	
NW - NE	-5523.1	-565.1	4392.8	
NW - OK	-5868.0	-401.5	5065.0	
NW - RO	-5598.3	-152.3	5293.6	
NW - SE	-5074.6	48.9	5172.3	
NW - SU	-4580.0	417 4	5414.7	
NW - NC	-4108.7	927.5	5963.7	
SE - SW	-5153.1	-2233.8	685.6	
SE - FL	-4497.3	-1456.9	1583.5	
SE - NE	-3028.8	-614.0	1800.9	
SE - OK	-3787.0	-450.4	2886.2	
SE - RO	-3504.1	-201.2	3101.7	
SE - NW	-5172.3	-48.9	5074.6	
SE - SU	-2126.2	368.5	2863.2	
SE - NC	-1693.0	878.7	3450.3	
SU - SW	-5294.2	-2602.3	89.7	
SU - FL	-4648.1	-1825.4	997.4	
SU - NE	-3116.8	-982.5	1151.8	
SU - OK	-3958.4	-818.9	2320.6	
SU - RO	-3673.4	-569.7	2534.0	
SU - NW	-5414.7	-417.4	4580.0	
SU - SE	-2863.2	-368.5	2126.2	
SU - NC	-1800.1	510.2	2820.4	
NC - SW	-5875.8	-3112.4	-349.0	***
NC - FL	-5226.5	-2335.5	555.4	
NC - NE	-3716.4	-1492.6	731.1	
NC - OK	-4530.0	-1329.0	1871.9	
NC - RO	-4245.7	-1079.9	2086.0	
NC - NW	-5963.7	-927.5	4108.7	
NC - SE	-3450.3	-878.7	1693.0	
NC - SU	-2820.4	-510.2	1800.1	

TABLE XXXIII

SCHEFFE'S DIFFERENCE OF MEANS TEST FOR UNITED STATES CENSUS REGIONALIZATION (ALL COURSES)

ALPHA=0.05 CONFIDENCE=0.95 DF=1036 MSE=30523975
CRITICAL VALUE OF F=1.94732

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

CENSUS COMPARISON	SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT
PC - MA	-2409.3	538.9	3487.0
PC - MT	-2313.5	885.1	4083.7
PC - SA	-1502.7	1163.7	3830.1
PC - WS	-2138.2	1282.8	4703.7
PC - NE	-2426.0	1582.0	5590.1
PC - ES	-2315.3	2042.6	6400.5
PC - EN	-523.0	2167.3	4857.7
PC - WN	-379.1	2507.2	5393.5
MA - PC	-3487.0	-538.9	2409.3
MA - MT	-2639.0	346.3	3331.5
MA - SA	-1781.5	624.8	3031.1
MA - WS	-2478.5	743.9	3966.3
MA - NE	-2796.7	1043.2	4883.1
MA - ES	-2700.1	1503.7	5707.5
MA - EN	-804.4	1628.4	4061.3
MA - WN	-679.6	1968.4	4616.3
MT - PC	-4083.7	-885.1	2313.5
MT - MA	-3331.5	-346.3	2639.0
MT - SA	-2428.8	278.5	2985.9
MT - WS	-3055.3	397.6	3850.6
MT - NE	-3338.5	696.9	4732.3
MT - ES	-3225.7	1157.4	5540.5
MT - EN	-1448.8	1282.2	4013.1
MT - WN	-1302.1	1622.1	4546.3
SA - PC	-3830.1	-1163.7	1502.7
SA - MA	-3031.1	-624.8	1781.5
SA - MT	-2985.9	-278.5	2428.8
SA - WS	-2847.6	119.1	3085.8
SA - NE	-3209.7	418.4	4046.4
SA - ES	-3132.3	878.9	4890.1
SA - EN	-1078.8	1003.6	3086.1
SA - WN	-986.6	1343.6	3673.7
WS - PC	-4703.7	-1282.8	2138.2
WS - MA	-3966.3	-743.9	2478.5
WS - MT	-3850.6	-397.6	3055.3
WS - SA	-3085.8	-119.1	2847.6
WS - NE	-3914.5	299.3	4513.1
WS - ES	-3788.1	759.8	5307.7
WS - EN	-2103.8	884.5	3872.8
WS - WN	-1941.4	1224.4	4390.3
NE - PC	-5590.1	-1582.0	2426.0
NE - MA	-4883.1	-1043.2	2796.7
NE - MT	-4732.3	-696.9	3338.5
NE - SA	-4046.4	-418.4	3209.7
NE - WS	-4513.1	-299.3	3914.5
NE - ES	-4543.9	460.5	5465.0
NE - EN	-3060.4	585.3	4231.0
NE - WN	-2867.4	925.2	4717.8
ES - PC	-6400.5	-2042.6	2315.3
ES - MA	-5707.5	-1503.7	2700.1
ES - MT	-5540.5	-1157.4	3225.7
ES - SA	-4890.1	-878.9	3132.3
ES - WS	-5307.7	-759.8	3788.1
ES - NE	-5465.0	-460.5	4543.9
ES - EN	-3902.5	124.8	4152.0
ES - WN	-3696.0	464.7	4625.3
EN - PC	-4857.7	-2167.3	523.0
EN - MA	-4061.3	-1628.4	804.4
EN - MT	-4013.1	-1282.2	1448.8
EN - SA	-3086.1	-1003.6	1078.8
EN - WS	-3872.8	-884.5	2103.8
EN - NE	-4231.0	-585.3	3060.4
EN - ES	-4152.0	-124.8	3902.5
EN - WN	-2017.6	339.9	2697.4
WN - PC	-5393.5	-2507.2	379.1
WN - MA	-4616.3	-1968.4	679.6
WN - MT	-4546.3	-1622.1	1302.1
WN - SA	-3673.7	-1343.6	986.6
WN - WS	-4390.3	-1224.4	1941.4
WN - NE	-4717.8	-925.2	2867.4
WN - ES	-4625.3	-464.7	3696.0
WN - EN	-2697.4	-333.9	2017.6

TABLE XXXIV

SCHEFFE'S DIFFERENCE OF MEANS TEST FOR FIRST ENVIRONMENTAL REGIONALIZATION (PRIVATE COURSES)

ALPHA=0.05 CONFIDENCE=0.95 DF=661 MSE=1324768
CRITICAL VALUE OF F=2.02342

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

CLUSREG COMPARISON	SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT	
SW - FL	-157.9	674.3	1506.4	
SW - OK	929.3	1809.4	2689.5	***
SW - RO	1091.5	2178.3	3265.1	***
SW - NW	836.1	2287.0	3737.9	***
SW - SE	1586.0	2365.5	3145.1	***
SW - NE	1772.7	2487.0	3201.4	***
SW - NC	2255.3	2953.1	3650.9	***
FL - SW	-1506.4	-674.3	157.9	
FL - OK	317.5	1135.1	1952.7	***
FL - RO	467.2	1504.1	2540.9	***
FL - NW	198.9	1612.8	3026.6	***
FL - SE	983.0	1691.3	2399.6	***
FL - NE	1177.0	1812.8	2448.6	***
FL - NC	1661.7	2278.8	2896.0	***
OK - SW	-2689.5	-1809.4	-929.3	***
OK - FL	-1952.7	-1135.1	-317.5	***
OK - RO	-706.8	368.9	1444.6	
OK - NW	-965.0	477.6	1920.2	
OK - SE	-207.9	556.1	1320.2	
OK - NE	-19.7	677.6	1375.0	
OK - NC	463.3	1143.7	1824.1	***
RO - SW	-3265.1	-2178.3	-1091.5	***
RO - FL	-2540.9	-1504.1	-467.2	***
RO - OK	-1444.6	-368.9	706.8	
RO - NW	-1468.5	108.7	1685.9	
RO - SE	-807.9	187.2	1182.4	
RO - NE	-636.2	308.7	1253.6	
RO - NC	-157.7	774.8	1707.3	
NW - SW	-3737.9	-2287.0	-836.1	***
NW - FL	-3026.6	-1612.8	-198.9	***
NW - OK	-1920.2	-477.6	965.0	
NW - RO	-1685.9	-108.7	1468.5	
NW - SE	-1305.1	78.5	1462.1	
NW - NE	-1147.9	200.0	1547.9	
NW - NC	-673.1	666.1	2005.3	
SE - SW	-3145.1	-2365.5	-1586.0	***
SE - FL	-2399.6	-1691.3	-983.0	***
SE - OK	-1320.2	-556.1	207.9	
SE - RO	-1182.4	-187.2	807.9	
SE - NW	-1462.1	-78.5	1305.1	
SE - NE	-443.8	121.5	686.8	
SE - NC	43.3	587.6	1131.8	***
NE - SW	-3201.4	-2487.0	-1772.7	***
NE - FL	-2448.6	-1812.8	-1177.0	***
NE - OK	-1375.0	-677.6	19.7	
NE - RO	-1253.6	-308.7	636.2	
NE - NW	-1547.9	-200.0	1147.9	
NE - SE	-686.8	-121.5	443.8	
NE - NC	20.3	466.1	911.8	***
NC - SW	-3650.9	-2953.1	-2255.3	***
NC - FL	-2896.0	-2278.8	-1661.7	***
NC - OK	-1824.1	-1143.7	-463.3	***
NC - RO	-1707.3	-774.8	157.7	
NC - NW	-2005.3	-666.1	673.1	
NC - SE	-1131.8	-587.6	-43.3	***
NC - NE	-911.8	-466.1	-20.3	***

TABLE XXXV

SCHEFFE'S DIFFERENCE OF MEANS TEST FOR SECOND ENVIRONMENTAL REGIONALIZATION (PRIVATE COURSES)

ALPHA=0.05 CONFIDENCE=0.95 DF=660 MSE=1317100
CRITICAL VALUE OF F=1.95242

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

CLUSREG COMPARISON	SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT	
SW - FL	-197.0	674.3	1545.5	
SW - OK	887.9	1809.4	2730.9	***
SW - RO	1040.4	2178.3	3316.2	***
SW - NW	767.8	2287.0	3806.2	***
SW - SE	1549.3	2365.5	3181.8	***
SW - NE	1739.1	2487.0	3235.0	***
SW - SU	2031.3	2807.3	3583.4	***
SW - NC	2340.0	3157.8	3975.6	***
FL - SW	-1545.5	-674.3	197.0	
FL - OK	279.1	1135.1	1991.2	***
FL - RO	418.4	1504.1	2589.7	***
FL - NW	132.4	1612.8	3093.2	***
FL - SE	949.7	1691.3	2432.9	***
FL - NE	1147.1	1812.8	2478.5	***
FL - SU	1435.9	2133.1	2830.2	***
FL - NC	1740.2	2483.6	3226.9	***
OK - SW	-2730.9	-1809.4	-887.9	***
OK - FL	-1991.2	-1135.1	-279.1	***
OK - RO	-757.4	368.9	1495.2	
OK - NW	-1032.9	477.6	1988.1	
OK - SE	-243.9	556.1	1356.2	
OK - NE	-52.5	677.6	1407.8	
OK - SU	239.0	997.9	1756.9	***
OK - NC	546.8	1348.4	2150.0	***
RO - SW	-3316.2	-2178.3	-1040.4	***
RO - FL	-2589.7	-1504.1	-418.4	***
RO - OK	-1495.2	-368.9	757.4	
RO - NW	-1542.8	108.7	1760.2	
RO - SE	-854.8	187.2	1229.2	
RO - NE	-680.7	308.7	1298.1	
RO - SU	-381.8	629.0	1639.8	
RO - NC	-63.7	979.5	2022.7	
NW - SW	-3806.2	-2287.0	-767.8	***
NW - FL	-3093.2	-1612.8	-132.4	***
NW - OK	-1988.1	-477.6	1032.9	
NW - RO	-1760.2	-108.7	1542.8	
NW - SE	-1370.2	78.5	1527.2	
NW - NE	-1211.3	200.0	1611.4	
NW - SU	-906.1	520.3	1946.8	
NW - NC	-578.8	870.8	2320.4	
SE - SW	-3181.8	-2365.5	-1549.3	***
SE - FL	-2432.9	-1691.3	-949.7	***
SE - OK	-1356.2	-556.1	243.9	
SE - RO	-1229.2	-187.2	854.8	
SE - NW	-1527.2	-78.5	1370.2	
SE - NE	-470.4	121.5	713.4	
SE - SU	-185.2	441.8	1068.8	
SE - NC	114.2	792.3	1470.3	***
NE - SW	-3235.0	-2487.0	-1739.1	***
NE - FL	-2478.5	-1812.8	-1147.1	***
NE - OK	-1407.8	-677.6	52.5	
NE - RO	-1298.1	-308.7	680.7	
NE - NW	-1611.4	-200.0	1211.3	
NE - SE	-713.4	-121.5	470.4	
NE - SU	-214.8	320.3	855.4	
NE - NC	76.7	670.8	1264.8	***
SU - SW	-3583.4	-2807.3	-2031.3	***
SU - FL	-2830.2	-2133.1	-1435.9	***
SU - OK	-1756.9	-997.9	-239.0	***
SU - RO	-1639.8	-629.0	381.8	
SU - NW	-1946.8	-520.3	906.1	
SU - SE	-1068.8	-441.8	185.2	
SU - NE	-855.4	-320.3	214.8	
SU - NC	-278.6	350.5	979.5	
NC - SW	-3975.6	-3157.8	-2340.0	***
NC - FL	-3226.9	-2483.6	-1740.2	***
NC - OK	-2150.0	-1348.4	-546.8	***
NC - RO	-2022.7	-979.5	63.7	
NC - NW	-2320.4	-870.8	578.8	
NC - SE	-1470.3	-792.3	-114.2	***
NC - NE	-1264.8	-670.8	-76.7	***
NC - SU	-979.5	-350.5	278.6	

TABLE XXXVI

SCHEFFE'S DIFFERENCE OF MEANS TEST FOR UNITED STATES CENSUS REGIONALIZATION (PRIVATE COURSES)

ALPHA=0.05 CONFIDENCE=0.95 DF=660 MSE=1620035
CRITICAL VALUE OF F=1.95242

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

CENSUS COMPARISON	SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT	
PC - MT	-243.9	888.9	2021.6	
PC - SA	340.8	1158.6	1976.4	***
PC - WS	270.8	1254.8	2238.8	***
PC - NE	618.1	1784.2	2950.4	***
PC - MA	951.2	1831.4	2711.5	***
PC - EN	1397.5	2242.5	3087.5	***
PC - ES	1007.9	2279.4	3550.8	***
PC - WN	1650.6	2551.0	3451.3	***
MT - PC	-2021.6	-888.9	243.9	
MT - SA	-689.0	269.7	1228.5	
MT - WS	-738.0	365.9	1469.8	
MT - NE	-373.6	895.4	2164.3	
MT - MA	-69.9	942.5	1954.9	
MT - EN	371.6	1353.6	2335.7	***
MT - ES	24.1	1390.5	2756.9	***
MT - WN	632.1	1662.1	2692.2	***
SA - PC	-1976.4	-1158.6	-340.8	***
SA - MT	-1228.5	-269.7	689.0	
SA - WS	-681.2	96.2	873.5	
SA - NE	-372.3	625.7	1623.6	
SA - MA	32.0	672.8	1313.6	***
SA - EN	492.2	1083.9	1675.6	***
SA - ES	1.6	1120.8	2240.0	***
SA - WN	724.1	1392.4	2060.7	***
WS - PC	-2238.8	-1254.8	-270.8	***
WS - MT	-1469.8	-365.9	738.0	
WS - SA	-873.5	-96.2	681.2	
WS - NE	-608.6	529.5	1667.6	
WS - MA	-266.1	576.6	1419.2	
WS - EN	181.8	987.7	1793.7	***
WS - ES	-221.2	1024.6	2270.4	
WS - WN	432.4	1296.2	2160.0	***
NE - PC	-2950.4	-1784.2	-618.1	***
NE - MT	-2164.3	-895.4	373.6	
NE - SA	-1623.6	-625.7	372.3	
NE - WS	-1667.6	-529.5	608.6	
NE - MA	-1002.5	47.1	1096.7	
NE - EN	-562.1	458.3	1478.6	
NE - ES	-899.0	495.1	1889.3	
NE - WN	-299.9	766.7	1833.4	
MA - PC	-2711.5	-1831.4	-951.2	***
MA - MT	-1954.9	-942.5	69.9	
MA - SA	-1313.6	-672.8	-32.0	***
MA - WS	-1419.2	-576.6	266.1	
MA - NE	-1096.7	-47.1	1002.5	
MA - EN	-264.1	411.1	1086.3	
MA - ES	-717.5	448.0	1613.5	
MA - WN	-23.6	719.6	1462.9	
EN - PC	-3087.5	-2242.5	-1397.5	***
EN - MT	-2335.7	-1353.6	-371.6	***
EN - SA	-1675.6	-1083.9	-492.2	***
EN - WS	-1793.7	-987.7	-181.8	***
EN - NE	-1478.6	-458.3	562.1	
EN - MA	-1086.3	-411.1	264.1	
EN - ES	-1102.4	36.9	1176.1	
EN - WN	-392.9	308.5	1009.8	
ES - PC	-3550.8	-2279.4	-1007.9	***
ES - MT	-2756.9	-1390.5	-24.1	***
ES - SA	-2240.0	-1120.8	-1.6	***
ES - WS	-2270.4	-1024.6	221.2	
ES - NE	-1889.3	-495.1	899.0	
ES - MA	-1613.5	-448.0	717.5	
ES - EN	-1176.1	-36.9	1102.4	
ES - WN	-909.2	271.6	1452.5	
WN - PC	-3451.3	-2551.0	-1650.6	***
WN - MT	-2692.2	-1662.1	-632.1	***
WN - SA	-2060.7	-1392.4	-724.1	***
WN - WS	-2160.0	-1296.2	-432.4	***
WN - NE	-1833.4	-766.7	299.9	
WN - MA	-1462.9	-719.6	23.6	
WN - EN	-1009.8	-308.5	392.9	
WN - ES	-1452.5	-271.6	909.2	

VITA

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Master of Science

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