

A COMPARISON OF TURF MANAGEMENT PRACTICES AT
TURF RUNWAY AIRPORTS IN THE SOUTHEAST

by

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ABSTRACT

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This pilot study investigated the turf management practices of turf airports in the Southeast United States. Turf runways account for 60% of the runways in the United States yet little prior research has been done to describe the turf management practices of these assets. This study surveyed turf airports in Georgia, Alabama and Florida to describe how turf areas are managed in order to ascertain commonalities and differences in these practices. The study concluded the maintenance practices of turf airports are greater than those used on turf surrounding highways yet less than residential lawns. Also, the environmental impact of turf airports due to irrigation and fertilizer or pesticide leach into water supplies is minimal.

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CHAPTER I

INTRODUCTION

Background of the Problem

The continental United States has 18,269 landing facilities, 12,609 of which are available to fixed wing aircraft. Of these 12,609 airports, only 4,333 have paved runways, with more than 8,000 – over 60% – having only unpaved runways, most of which are turf. The turf-only airports number 7,864 with 6,981 not only being privately owned but also categorized by their owners as “private use”. In total, turf runways account for 44,165 acres of land, not including taxiway and ramps (FAA Airport Data, n.d). By way of comparison, turf used on golf courses in Florida was estimated in 2002 by Haydu and Hodges at 147,000 acres, making the turf usage nationwide on runways 30% of that used on golf courses in Florida. A rough estimate of the investment in facilities alone on these 7,864 airports can be obtained by figuring an average of five dwellings at \$275,000 each yielding a valuation in excess of \$10 Billion. The turf quality of these airports is a direct reflection of the quality of the airport as a whole and thus is a factor in real estate value of the properties adjacent to the airports.

Turfgrass research is a mature science guiding the systematic management of turf assets. The University of Florida, IFAS, West Florida Research and Education Center estimates turf contributed over \$7.3 Billion to Florida’s economy alone in 2002 (Hodges, Haydu, van Blokland, & Bell, 1994). Turf research focuses on finding the optimum application of irrigation, fertilization, renovation, pesticides and mowing techniques. Turfgrass science calls this combination of techniques “cultural practices”. These cultural

practices are the key focus of sectors such as golf courses, athletic fields, sod farms and homeowners.

This pilot study attempts to determine how turfgrass research is being applied to turf runways. The descriptive research in this study will try to outline the turf species and cultural practices used at turf airports.

Perspective of Unpaved Airports and Turf

Unpaved Airports Perspective

As Dosch said in *Marking and Lighting of Unpaved Runways*:

The FAA has considerable control over large commercial airports primarily by virtue of certification requirements for air carrier operations and control over Airport Development Aid Program (ADAP) funding for development of these airports. However, the small general aviation airports, and in particular unpaved airports, do not come under the jurisdiction or control the FAA. These general aviation airports are generally under state control and in some states are licensed by state (1978, p. 1).

State and Federal control of private airport turf maintenance is simply not a feature of government regulation. The ownership of land for unpaved airports is predominantly private ownership.

Turf Science Perspective

In 1994, Hodges, Haydu, van Blokland, and Bell reported there to be an estimated 4.4 million acres of turfgrass maintained in Florida alone. The sectors of the economy using these 4.4 million acres are shown in Table 1. The authors note golf courses are

broken out separately “because of their prominent role in the industry as a provider of high-valued turf-based services” (Hodges, Haydu, van Blokland, & Bell, 1994, p. 3).

Table 1

Sectors of Economy Using Turfgrass in Florida

Sector	Thousands of Acres	Percent of Total
Sod Farms	46.1	1.0
Service Vendors	1,065.4	24.3
Golf Courses	131.3	3.0
Commercial Institutions	202.5	4.6
Non-Profit Institutions	336.2	7.7
Highways	329.1	7.5
Residential	3,306.6	75.3
Total	4,391.0*	100%

Note. From Hodges, A., Haydu, J., van Blokland, P., & Bell, A. (1994). *Contribution Of The Turfgrass Industry To Florida's Economy, 1991–92: A Value-Added Approach*. Gainesville, FL: University of Florida.

In the state of Florida, turfgrass is supported through the U.S. Department of Agriculture’s Extension services. Extension services are partnerships between state government, industry and academia to promote sound turf practices aimed at benefiting the environment (IFAS, n.d.).

Turf Science and Turf Airports

It is not known how far the science of turf management has penetrated into the cultural practices of turf airports. There is an extensive body of knowledge available from research performed on turf which has benefited numerous industry sectors. This pilot

study seeks to find the existing relationship between turf science and turf airports and to identify areas where turf research may benefit turf runway maintenance.

Researchers Work Role and Setting

The author of this research project, Bill Tuccio, lives on a private airport community in Northwest Florida known as the Yellow River Airport in Holt, FL. He regularly attends meetings discussing the turf management needs of the 2,500 foot airstrip and participates in the maintenance of the airport.

The author collaborated with J. Bryan Unruh, Ph.D. who is a Florida turfgrass extension specialist and manages a 20+ acre turf research facility in Jay, Florida. Dr. Unruh was a contributing editor to *The Florida Lawn Handbook* (2003) and frequently speaks about turfgrass management in many venues across the country (Unruh, n.d.).

Statement of the Problem

This pilot study performed descriptive research of the turf management (cultural) practices of turf only airports. It focused on fixed wing airports in the Southeastern United States defined as Alabama, Georgia and Florida with a total 1,055 airports only 403 of which are paved.

Limitations

The pilot study was limited in time to one sample period. The environmental conditions of the Southeastern United States at the time of data collection effected the results and limited their applicability to reach trend based conclusions.

The study was limited by the expertise of the respondents in accurately answering the questions. There is a wide variety of turf expertise amongst the responders. The

respondent limitation increased the variability of the answers and limits the correlations which were reached by the study.

Delimitations

This study limited its geographic area to the Southeast, defined as the states Alabama, Georgia and Florida. Within these states, only unpaved, fixed-wing airports were considered. This delimitation made the study quantitatively applicable to Alabama, Georgia and Florida while having only qualitative value and extensibility to the rest of the United States.

This study made no attempt to draw any conclusions regarding safety of turf airports or financial values. This is an important delimitation to get the best response rate from airports who may be concerned about increased government oversight.

This study did not perform any chemical analysis of turf samples. This delimitation was made for economic reasons. It decreased accuracy in the areas of species identification as well as any disease observations.

Definition of Terms

Cultural Practices – The manner in which turf is maintained include irrigation, mowing, fertilization and pesticide applications.

Thatch – “The layer of undecomposed leaf blades, stolons, roots, and crowns intermingled with soil” (Trenholm & Unruh, 2003, p. 44).

(NTEP) – National Turfgrass Evaluation Program is designed to develop and coordinate uniform evaluation trials of turfgrass varieties and promising selections in the United States and Canada (National, n.d.).

CHAPTER II

REVIEW OF RELEVANT LITERATURE AND RESEARCH

The union of the modern turfgrass research industry to unpaved airports cannot be found in a literature review. It appears this study will be the first of its kind relating turf research to turf airports.

Victor Dosch of the FAA conducted a study in 1978, *The Marking and Lighting of Unpaved Runways*. As the title suggests, this research focused only on marking and lighting practices.

In 1942, the director of the United States Golf Association Green Section, John Monteith, Jr., published a wartime report “Turf for Airfields and Other Defense Projects”. This technical report described how to create airfields, including a discussion of various turf species and their characteristics.

Gene Leboeuf published in *Flying Safety*, “Airfield Turf”. This article spoke about the maintenance of turf surrounding paved runways and taxiways. The discussions in this brief article mention the advances in turf science, suggested mowing heights of buffer areas and the relation to wildlife safety issues such as bird strikes (2003).

A June, 2006 report by Connelly and Teubert of the FAA, “Airside Applications of Artificial Turf”, discussed how artificial turf could be used between runways and taxiways along with the economic and operational tradeoffs.

A report by U.S. Army Corp of Engineers, “Turf Runway Investigation, Fort Ruckman, Nahant, MA – Turf Evaluation”, is typical of a few research projects in that era. The projects were technical studies on test sections on specific turf runways to investigate fertilization techniques related to turf quality and weed growth. This study

and others of the time period are similar in intent to the type of modern turf research being conducted at places like the University of Florida and around the country (1950).

In 2003, Haydu, Satterthwaite, and Cisar surveyed sod producers in Florida, “An Economic and Agronomic Profile of Florida's Sod Industry in 2003”, to quantify the size and demographics of the sod industry in Florida. While introducing their research, the authors note Florida has an estimated 4 million acres of maintained turf. Consumers across all market sectors, including uses such as golf courses, spend on average \$1,200 per acre for turfgrass maintenance.

In 1994, Hodges, Haydu, van Blokland and Bell conducted a survey consisting of 916 mailed surveys and 629 phone interview surveys. Their study, “Contribution of the Turfgrass Industry to Florida's Economy, 1991–92: A Value-Added Approach”, outlined the economic extent of the Florida turfgrass industry. Among other things, they estimated 4.4 million acres of maintained turf and they broke usage down by sector. There was no specific breakdown for turf airports in Florida, which would have been less than 1%.

In 2007, the author of this proposal spoke with Dr. J. Bryan Unruh who also manages a 20+ acre sod research center in Jay, Florida. The discussions with Dr. Unruh included the kinds of research being conducted on turfgrass. A large area of research is technical, side-by-side comparisons of plots of turf comparing variants of species under the same cultural practices, or comparing different cultural practices on the same species.

One area of research described by Dr. Unruh centered on the turf used in the Super Bowl. For the last three years, the Super Bowl has been played on the same variant species of Bermuda grass. Three research facilities around the country are comparing a number of new variants of turfgrass to identify superior turf varieties.

Another research area discussed with Dr. Unruh included a \$3 million grant by the Florida Department of Environmental Protection to investigate the residual amount of fertilizer treatments which go through the soil and have the potential to leach into the water supply. This multi-year study is also a highly technical study with regular intervals of chemical analysis of a controlled experiment in north, central and south Florida.

Dr. Unruh also described the services of the University of Florida Agricultural Extension services. Dr. Unruh is a representative of these services in Florida and he responds to citizen and business inquiries regarding turf management practices. As part of these services, in April, 2007, Dr. Unruh visited the author's Yellow River Airport in Holt, Florida and offered consultation on the condition of the airfield. The discussions focused on how to best take soil samples and to use the results, methods for aeration, how to deal with pests and the nature of the best turf management approach. Dr. Unruh observed the airport management is not that of a golf course, but is somewhere between that of a pasture and a residential lawn.

Summary

The summary of prior research indicated no comprehensive, descriptive surveys of the large number of turf airports in the United States and none specifically targeted at turf management practices of turf runways. Aviation specific studies of turf focused on the areas of the airport not used by aircraft as opposed to the areas used by aircraft.

Statement of the Hypothesis

Based on the review of literature and personal experience, the following hypothesis was posited for this study. All results are reported to a level of significance of $\alpha=0.05$.

Primary Research Hypothesis

One measure of a managed, systematic, mature approach to managing a problem is measurement followed by action followed by measurement and so on in a recurring cycle. This suggestion of process leads to this hypothesis.

H_0 : Airports engaging in at least one soil sample every other year report better turf quality than those airports not conducting such tests.

H_N : Soil testing does not equate to a significant difference in turf quality.

Other Related Areas of Interest

The literature review revealed no prior, comprehensive survey of the turf airport population. While surveying the population, other areas of interest were surveyed as the basis of future research. These results are reported graphically and in tabular form with observations made on the collected information.

Acreage

The FAA maintains a database of turf airport runway lengths and widths. This information is sufficient to know the total runway acreage on turf airports but no data exists allowing estimates of total airport acreage. Questions were asked to discover relationships between runway acreage and total airport acreage.

Turf Species

The species of turf used on airports is an important variable discovered in the review of literature. Observations of many other parameters depend upon knowing the turf species.

Irrigation

Irrigation can have a dramatic effect on the health of turf. Under watering as well as over watering both have impacts. Environmental concerns for water preservation in all areas of society are very pressing. The literature review revealed the water used daily for turf irrigation only in the commercial sectors of Florida was 1.8 billion gallons per day (approximately 3 million gallons per day per 1,000 acres). Knowing the number of turf airports with installed irrigation systems is an important variable to understand their impact on water usage. The researcher's knowledge of turf airports indicates few airports use irrigation systems. For those airports using irrigation systems, data concerning the water source – municipal, well, lake/river/stream, non-potable (reclaimed)/effluent – was also be collected.

Runway Usage

The common sense assumption regarding turf airports is that runway usage impacts the quality of turf. However, the usage rates of turf airports are so low it may have no impact on turf quality.

Pest Factors on Turf Quality

Large and small pests may have an effect on turf quality. Pests include larger animals such as armadillos and moles, while smaller pests may include mound-building ants. Questions were asked to ascertain the impact of pests on turf quality.

CHAPTER III

RESEARCH METHODS

Research Design

This pilot study of turfgrass management practices of turf airports in the Southeast was performed by surveying the people who live on and are responsible for the maintenance of these airports. The survey results have been statistically analyzed and summarized leading primarily to descriptions of the observed results. As Chapter II indicates, there is little prior research in the area of turf airport management practices, so it is hoped the descriptive research of observed results will lead to further research in this area.

Research Model

The study consists of descriptive (survey) research of turf airports. This pilot study attempts to determine how turfgrass research is being applied to turf runways. The descriptive research in this study tries to outline the turf species and cultural practices used at turf airports.

Survey Population

The survey population consisted of turf airports in the Southeast United States defined as Georgia, Alabama and Florida which have FAA forms 5010 on file. There were a total of 1,629 landing facilities in the Southeast, 1,055 of which were airports, 403 of which had paved runways. The study focused on the 658 airports in the Southeast with a turf runway on file with the FAA 5010 database. It should be noted 658 plus 403 does not add up to 1,055 because some airports had both a paved runway and an additional turf runway. 611 of these turf airports were private use and 32 were public use. The survey

attempted to contact the entire population of 658 airports with a plan of achieving a 50% response rate or 329 airports to serve as the sample size (Gay, Mills, & Airasian, 2006). The data collection period started on June 21, 2007 and terminated on August 25, 2007 with 199 electronic surveys received or 30% of the population. Since consideration of only the population of respondents out of the total population cannot be considered random, the analysis of data and findings considers this factor.

Sources of Data

The survey data was collected using an author developed survey instrument. In order to contact the airports, the FAA 5010 database was used for contact information supplemented by state records of contact information. Only Florida maintained an active list of airports (Aviation, 2007). Jack Joyner of the Georgia Department of Transportation (personal communication, May 30, 2007) verified both Alabama and Georgia maintained no state databases of private airports.

The Data Collection Device

The survey instrument was developed based on a review of literature and personal conversations with Dr. J. Bryan Unruh, who manages a 20+ acre turf research facility in Jay, Florida for the University of Florida. In order to increase response rates, Dr. Unruh provided a cover letter endorsing the survey shown in Appendix B, as suggested by Gay, Mills, and Airasian (2006).

The questions were designed to get the most information about turf management practices while specifically avoiding questions about dollar values or safety. The nature of this study and lack of prior studies of this nature made such questions of dollar value

or safety unwise for the researcher to ask as they may have lowered the response rate and, if collected, be subject to misinterpretation.

During survey development, consideration was given to anonymity of respondent airports. The goal of anonymity was to increase response rates whereas knowing the identity of the responding airport allows for correlations to the FAA form 5010 database. The survey was distributed with all questions being optional for the respondent, including airport identification. Of the 199 responses, 70% of the respondents provided their airport identification and 67% provided an email address.

The questions asked can be categorized as described in the following sections.

Hypothesis Support Questions

Three questions were asked in support of the research hypothesis. Two different quality questions were asked using a Likert scale pertaining to turf quality. One question was asked regarding how many times per season a soil test was performed. These questions were asked in the context of the other questions solicited in the survey.

Demographics

The number of runways and taxiways on the airport along with their length and width was assessed. While the runway information can be obtained from FAA form 5010 data, the taxiway acreage cannot be found in FAA records. Also, the surrounding features of the airport, such as pine trees, farmland, sea water, etc. are not available from FAA records. Surrounding features will impact the turf management practices. Other optional demographics included the general latitude, airport identifier and email address of the respondent. Results of quality and maintenance practices could be skewed if a major turf

renovation event occurred at the airport or if the airport was closed. For this reason two questions asked if the airport was open or had major renovations in the last three years.

Turf Species and Environment Questions

Questions were asked to determine the species of turf used on the runways. Pictures of different turf species were provided in the survey to increase the accuracy of the respondents. Since many airports have mixed varieties of turf species, questions about percentage cover by species were also asked.

Extension Services

A question was also added to determine the frequency of usage of state cooperative extension services.

Drought and Runoff

How drought and runoff effect quality were asked. Both questions were Likert scale opinions on the impact of drought and drainage on turf quality.

Mowing

Mowing was a key area of interest to the study. Questions focused on the frequency and reasons for the mowing frequency. An additional question determined the type of mowing equipment used. Also asked was who mowed the runways, volunteers or what type of compensated party.

Irrigation

The first irrigation question asked if an irrigation system was used. If one was used, a question about the water source followed.

Activity

The impact of runway usage on quality was asked using a Likert rating scale.

Pests and Rodents

Questions about the impact of pests, such as mound-building ants and rodents, moles or armadillos were asked. The questions focused on which pests and rodents pose the most recurring challenges to turf quality.

Fertilization and Pesticide Usage (Treatments)

The frequency of fertilization and pesticide applications broadly grouped into “treatments” were asked. This question focused on the average frequency practices over the last three years.

Thatch

The turf phenomena of thatch was described along with practices for its control. The respondent was asked questions to determine what thatch management practices have been used in the recent past.

General Responses

Recognizing this pilot study may lead to future studies, the respondents were asked what challenges they face in managing their turf assets and what questions they would like to see asked in any future studies.

Instrument Pretest

The survey was pretested in the context of its web delivery method by sending it to Dr. Unruh for initial review. Following his review, the survey was sent to three local airports and was taken by a total of four different people. No significant changes were made as a result of the pretest. The length of the survey and order of questions was one focus of the pretest. The actual survey found 89% of participants completed the six page survey with the remainder abandoning the survey early.

Distribution Method

The survey was a web based survey hosted at a dedicated url <http://www.turfairportstudy.com> shown in Appendix D. To encourage responses, the website had links to an edited version of the proposal, turf links and a blog containing notes on the survey.

The survey was custom programmed in Cold Fusion by the author with results being stored in a Microsoft Access database. The survey programming was done such that incomplete surveys were retained up to the point of abandonment. All question responses were optional. There was only one branch in the survey, which was after the first question asking if the airport was still open. If the airport was closed, the questioning skipped to the end. Fourteen (7%) of the respondents said their airport was closed.

An initial postal mailing to 658 recipients was conducted on June 15, 2007 consisting of the cover letter shown in Appendix B which included instructions to take the survey. A mail house computer error resulted in this batch of 658 letters having the personalized introduction omitted. In addition, 92 (14%) of the letters were returned due to bad addresses or lack of a forwarding address. Following the postal mailing of June 15, a personalized email was sent on June 30, 2007 to 214 people having email addresses on file. Of the 92 returned letters of June 15, addresses were found for 68 of this set by reviewing county and town tax records to find the proper address and a tri-fold letter containing the cover letter and instructions were mailed out on July 8, 2007. On July 22, 2007, a personalized email was sent to 75 of the survey respondents, with links to all the airports not yet responding within 25 miles of the responding airport, asking for their help to contact the non-responding airport. A sample email is shown in Appendix F. On July

29, 2007 the postcard shown in Appendix E was sent to 473 airports still not responding. Lastly on August 16, 2007, 167 emails were sent to non-responders in a last ditch effort to increase the response rate.

Instrument Reliability

One large factor affecting the reliability of the survey was the short time period the survey was open, which was from June 15 to August 15, 2007. Were the survey to be taken during a different season or a different year, some of the results may have differed as the seasons may have effected the perceptions of the respondents. Weather also could have effected the perceptions of the respondents. During the first half of the survey period, a severe drought effected much of the area, in the latter half of the survey period there was less drought which may have effected reliability (NOAA, 2007). Fortunately, there were no major hurricanes effecting Georgia, Florida or Alabama during the survey period.

The background and experience of the respondents played a large factor in the reliability of the results. From comments received and conversations during phone surveys, it was clear respondents varied from professional airline pilots, crop dusters, farmers and retired blue collar workers. This diversity of backgrounds certainly effected the perceptions and attitudes towards the questions.

The flow of the survey questions could affect reliability. After half of the surveys were completed, the flow of questions was altered slightly so the “Still Open” question was presented first. Prior to this change, the “Still Open” question was presented on the last page. Also, the respondents were given the opportunity to answer the survey by telephone. Approximately 15 (7%) of the respondents responded to the survey by

telephone, which may have resulted in different attitudes towards the questions than the web presentation.

Instrument Validity

The validity of the survey was tested during the instrument pretest. The questions targeted at comparing runway acreage to taxiway acreage did not produce valid results. The reason for this is all questions were optional; therefore there is no way to know if the respondent did not answer the taxiway size questions because they did not have taxiways or because they skipped the questions. A question should have been added asking if a taxiway existed.

Treatment of the Data and Procedures

After the survey period was closed, the survey data had database operations performed against it to make it more usable. Any surveys which were clearly test surveys conducted by the author were eliminated. Any places where the respondent hit the “back” button in their browser resulted in duplicate answers to questions. These duplicates were eliminated and only the last result was retained. Any place a response was skipped a code was added to the database to indicate the skipped response to the answer in order to make every survey have the same number of responses easing data analysis while preserving data integrity. For those questions where free-form answers could be given, a mapping table was created to map the typed in results to a lesser category of answers.

All results are analyzed relative to a level of significance of $\alpha = 0.05$.

CHAPTER IV

RESULTS

The entire population of turf airports in Alabama, Florida and Georgia totals 658. All 658 airports were solicited for participation in the survey. When the survey period closed, 199 surveys had been received or 30% of the entire population. The sample size was thus the entire population of 658 with a rate of response of 30%. The surveys received were thus not random, but skewed in some way by the willingness of the 199 respondents to participate making it impossible to extrapolate the opinions of the 459 non-responding airports (Gay, Mills & Airasian, 2006).

Open vs. Closed Facilities

Of the 199 respondents, 14 responded their facility was no longer used for operations. Since closed airports do not have turf management practices of interest to the study, the 14 closed airports were excluded from the analysis unless otherwise noted. Therefore, in the discussions which follow only the 185 airports still in operation are the most considered.

Research Hypothesis: Soil Testing and Quality

The research study posited the quality of turf airports engaging in soil samples at least every other year would be greater than those not conducting such tests. There were three questions directly related to this hypothesis in the survey: (Question 9) “Soil Testing Frequency. Considering the last three years, how often have soil samples been taken at your airport?”; (Question 12) “During Summer months, over the last three years, the quality of the turf on the runways and taxiways is better than that of other turf runway airports”; and (Question 13) “During Summer months, over the last three years, the

quality of the turf on the runways and taxiways could be improved”. The soil testing frequency question is clearly more objective than the quality questions which are based in large part on perceptions.

Considering the 185 open airports, the soil testing responses are shown in Tables 2 and 3. In Table 3, the soil testing responses are grouped into broad categories of those who tested the soil, those who never tested the soil, and those who were unsure if a soil test had been done. Table 4 presents the Chi-Square analysis of the compressed results in Table 3.

Table 2

Soil Testing Frequency

Soil Test Behavior	Frequency	Percentage
Two Times per Year	1	0.5%
One Time per Year	9	4.9%
Every other Year	23	12.4%
Never Tested	108	58.4%
Unsure	16	8.6%
No Answer	28	15.1%
Total	185	100.0%

Note: From question 9: “Soil Testing Frequency. Considering the last three years, how often have soil samples been taken at your airport?”

Table 3

Soil Testing Frequency (Compressed)

Soil Test Behavior	Frequency	Percentage
At Least One Test	33	21.0%
Never Soil Tested	108	68.8%
Unsure	16	10.2%
Total	157	100.0%

Note: From question 9: “Soil Testing Frequency. Considering the last three years, how often have soil samples been taken at your airport?” “At Least One Test” includes responses of “One Time per Year”, “Two Times per Year” and “Every other Year”.

Table 4

Chi-Square Statistical Analysis of Compressed Results in Table 3

Measure	Expected	Observed
At Least One Test	52.3	33
Never Soil Tested	52.3	108
Unsure	52.3	16
Degree of Freedom	--	2
Level of Significance	--	.05
Critical Value	--	5.99
Chi-Square Value	--	91.58

The two quality questions were asked using a Likert scale. The results of the 185 open airports are shown in Tables 5, 6, 8 and 9. Table 5 and 6 show the results of the comparative quality question, while tables 8 and 9 show the results of quality gauged by the quality improvement question. Table 6 and 9 compress the Likert responses of Tables

5 and 8 respectively. Tables 7 and 10 present a Chi-Square analysis of the compressed results in Tables 6 and 9 respectively.

Table 5

Turf Quality - Comparative

Comparative Turf Quality	Frequency	Percentage
Strongly Agree	21	11.4%
Agree	47	25.4%
Undecided	54	29.2%
Disagree	26	14.1%
Strongly Disagree	5	2.7%
No Answer	32	17.3%
Total	185	100.0%

Note: From question 12: “During Summer months, over the last three years, the quality of the turf on the runways and taxiways is better than that of other turf runway airports.”

Table 6

Turf Quality – Comparative (Compressed)

Comparative Turf Quality	Frequency	Percentage
Strongly Agree/Agree	68	36.8%
Undecided	54	29.2%
Strongly Disagree/Disagree	31	16.8%
Total	153	100.0%

Note: From question 12: “During Summer months, over the last three years, the quality of the turf on the runways and taxiways is better than that of other turf runway airports.”

Table 7

Chi-Square Statistical Analysis of Compressed Results in Table 6

Measure	Expected	Observed
Strongly Agree/Disagree	51	68
Undecided	51	54
Strongly Disagree/Disagree	51	31
Degree of Freedom	--	2
Level of Significance	--	.05
Critical Value	--	5.99
Chi-Square Value	--	13.69

Table 8

Turf Quality – Room for Improvement

Could Be Improved	Frequency	Percentage
Strongly Agree	23	12.4%
Agree	83	44.9%
Undecided	28	15.1%
Disagree	18	9.7%
Strongly Disagree	1	0.5%
No Answer	32	17.3%
Total	185	100.0%

Note: From question 13: “During Summer months, over the last three years, the quality of the turf on the runways and taxiways could be improved.”

Table 9

Turf Quality – Room for Improvement (Compressed)

Quality Good/Quality Poor	Frequency	Percentage
Strongly Agree/Agree	106	69.3%
Undecided	28	18.3%
Strongly Disagree/Disagree	19	12.4%
Total	153	100.0%

Note: From question 13: “During Summer months, over the last three years, the quality of the turf on the runways and taxiways could be improved.”

Table 10

Chi-Square Statistical Analysis of Compressed Results in Table 9

Measure	Expected	Observed
Strongly Agree/Disagree	51	106
Undecided	51	28
Strongly Disagree/Disagree	51	19
Degree of Freedom	--	2
Level of Significance	--	.05
Critical Value	--	5.99
Chi-Square Value	--	89.76

Taking the broad categories of soil testing frequencies and turf quality comparisons, the response matrix is shown in Table 11. The two dimensional Chi-Square analysis of Table 11 is shown in Table 12. The two dimensional Chi-Square analysis shown in Tables 11 showed no significant difference between those airports conducting soil tests and those airports never conducting soil tests.

Table 11

Soil Testing vs. Relative Quality Measures

Soil Test/Likert	SA/A	SD/D	Undecided	Total
Ever Tested	19	6	8	33
Never Tested	41	22	40	103
Unsure	7	3	6	16
Total	67	31	54	152

Note: From question 9: “Soil Testing Frequency. Considering the last three years, how often have soil samples been taken at your airport?” vs. answers to question 12, “During Summer months, over the last three years, the quality of the turf on the runways and taxiways is better than that of other turf runway airports.” Compressed Results. “SA/A” means Strongly Agree/Agree; “SD/D” means “Strongly Disagree/Disagree”.

Table 12

Chi-Square Two Dimensional Analysis of Table 11

Soil Test/Likert	SA/A	SD/D	Undecided
Ever Tested	19/14.5	6/6.7	8/11.7
Never Tested	41/45.4	22/21.0	40/36.6
Unsure	7/7.1	3/3.3	6/5.7
Chi-Square	Value		
Degree of Freedom	4		
Level of Significance	0.05		
Critical Value	9.488		
Chi-Square Value	3.46		

Note: Ever Tested, Never Tested and Unsure rows show Observed/Expected Frequencies

Taking the broad categories of soil testing frequencies and quality improvement questions, the response matrix is shown in Table 13. The two dimensional Chi-Square analysis of Table 13 is shown in Table 14. The two dimensional Chi-Square analysis

shown in Tables 13 showed no significant difference between those airports conducting soil tests and those airports never conducting soil tests.

Table 13

Soil Testing vs. Quality Improvement

Soil Test/Likert	SA/A	SD/D	Undecided	Total
Ever Tested	21	7	5	33
Never Tested	74	11	18	103
Unsure	11	1	4	16
Total	106	19	27	152

Note: From question 9: “Soil Testing Frequency. Considering the last three years, how often have soil samples been taken at your airport?” vs. answers to question 13, “During Summer months, over the last three years, the quality of the turf on the runways and taxiways could be improved.” Compressed Results. “SA/A” means Strongly Agree/Agree; “SD/D” means “Strongly Disagree/Disagree”.

Table 14

Chi-Square Two Dimensional Analysis of Table 13

Soil Test/Likert	SA/A	SD/D	Undecided
Ever Tested	21/23.0	7/4.2	5/5.9
Never Tested	74/71.8	11/12.9	18/18.3
Unsure	11/11.2	1/2.0	4/2.8
Chi-Square	Value		
Degree of Freedom	4		
Level of Significance	0.05		
Critical Value	9.488		
Chi-Square Value	3.62		

Note: Ever Tested, Never Tested and Unsure rows show Observed/Expected Frequencies

Other Related Areas of Interest

Turf Species

As can be seen by Table 15 below, by far the most common species of Turfgrass is Bahiagrass at 61.7%.

Table 15

Turf Species

Turf Species	Frequency	Percentage
Bahiagrass	100	61.7%
Bermudagrass	27	16.7%
Centipede	10	6.2%
Fesque	5	3.1%
Mixed	5	3.1%
Other	4	2.5%
St. Augustine	3	1.9%
Unsure	8	4.9%
Total	162	100%

Note: From question 2: “What is the most predominant species of turfgrass on your turf runways and taxiways?” Out of 185 open airports, there were 23 no responses to this question.

Complementing the turf species question is the consistency of the turf species usage, or, what percentage of the runways and taxiways use the reported species. Table 16 shows the results. In at least 51.6% of the airports, one species fully covers the airport. Furthermore, for those airports reporting Bahiagrass, all answered the coverage question with 90% of Bahiagrass respondents saying Bahiagrass accounted for 75-100% of coverage.

Table 16

Turf Species Coverage

Turf Species Coverage	Frequency	Percentage
100% Coverage	83	51.6%
75% Coverage	58	36.0%
50% Coverage	12	7.5%
25% Coverage	4	2.5%
Unsure	4	2.5%
Total	161	100%

Note: From question 3: “For the species selected above, what percent covers your runways and taxiways. For example, if the species above covers 75% of the runways and taxiways, but another species covers the remaining 25%, you would answer, 75%.” Out of 185 open airports, there were 24 no responses to this question.

Irrigation

A vast minority of airports (7.8%) use an irrigation system, as shown in Table 17.

Table 17

Irrigation System

Has Irrigation	Frequency	Percentage
No Irrigation	142	92.2%
Has Irrigation	12	7.8%
Total	154	100%

Note: From question 24: “Considering the last three years, is a regular irrigation method (i.e., sprinklers) used to water the runways and/or taxiways?” Out of 185 open airports, there were 31 no responses to this question.

Of those 12 airports reporting an irrigation source, 50% used a well and 50% used a lake, river or stream as the irrigation source.

Runway Usage and Turf Quality

While a paved runway tends to accumulate rubber tire markings, decay of markings and cracks in concrete, turf runways are subject to a different kind of wear. Furthermore, turf airports may have such limited frequency of operations as the aircraft usage may have little effect on wear. Table 18 shows 52.6% of respondents either “Agree” or “Strongly Agree” frequency of aircraft operations impacts quality as opposed to 32.9% “Strongly Disagree” or “Disagree”.

Table 18

Turf Usage Impact on Quality

Freq of Ops Effects Quality	Frequency	Percentage
Strongly Agree	20	13.2%
Agree	60	39.5%
Undecided	22	14.5%
Disagree	40	26.3%
Strongly Disagree	10	6.6%
Total	152	100.0%

Note: From question 14: “The frequency of aircraft operations on the turf runways and taxiways has a noticeable impact on turf quality.” Out of 185 open airports, there were 33 no responses to this question.

Pest Factors on Turf Quality

There were two questions regarding the turf quality, one asking if pests impact quality, the other showing the most common pest. The results are shown in Table 19 and 20 respectively.

Table 19

Pest Effect on Quality

Pests Effect	Frequency	Percentage
Strongly Agree	13	8.6%
Agree	47	30.9%
Undecided	24	15.8%
Disagree	59	38.8%
Strongly Disagree	9	5.9%
Total	152	100.0%

Note: From question 17: “Considering the last three years, pests, such as mound-building ants, moles, armadillos, etc. have significantly decreased turf quality.” Out of 185 open airports, there were 33 no responses to this question.

Table 20

Pest of Most Concern to Turf Quality

Which Pest	Frequency	Percentage
Mound-Building Ants	87	59.6%
Mole-Crickets	17	11.6%
Moles	14	9.6%
Armadillos	9	6.2%
Wild Pigs	5	3.4%
None	4	2.7%
Gopher Tortoises	3	2.1%
Other	2	1.4%
Gophers	2	1.4%
Hogs & Deer	2	1.4%
Chinch Bugs	1	0.7%
Total	146	100.0%

Note: From question 18: “Which pest is of the most concern for runway and taxiway turf quality?” Out of 185 open airports, there were 39 no responses to this question.

Mowing

The four questions related to mowing are shown in Tables 21, 22, 23 and 24.

Table 21

Mowing Frequency

Mowing Frequency	Frequency	Percentage
More than 5 times/month	3	1.9%
5 times/month	19	12.3%
4 times/month	33	21.4%
3 times/month	26	16.9%
2 times/month	44	28.6%
1 time/month	18	11.7%
Less than monthly	4	2.6%
Varies	6	3.9%
Unsure	1	0.6%
Total	154	100.0%

Note: From question 20: “Considering the last three years, during June, July, August, how often are the turf runways and taxiways mowed?” Out of 185 open airports, there were 31 no responses to this question.

Table 22

Reason for Mowing Frequency

Mowing Factor	Frequency	Percentage
Grass Height	131	84.5%
Personnel Availability	11	7.1%
Amount of Rain	5	3.2%
Contract Schedule	3	1.9%
Equipment Availability	3	1.9%
Outside Air Temperature	1	0.6%
Other	1	0.6%
Total	155	100.0%

Note: From question 21: “Considering the last three years, during June, July, August, what is the largest factor which determines when the turf runways and taxiways are mowed?” Out of 185 open airports, there were 30 no responses to this question.

Table 23

Mowing Personnel

Mowing Personnel	Frequency	Percentage
Owner of Airport	55	35.5%
Compensated Individual	53	34.2%
Volunteer	36	23.2%
Professional Landscaping Company	5	3.2%
Other	4	2.6%
Barter for Hay	1	0.6%
Turf Science Interns	1	0.6%
Total	155	100.0%

Note: From question 22: “Considering the last three years, who typically mows the turf runways and taxiways?” Out of 185 open airports, there were 30 no responses to this question.

Table 24

Type Mower

Mower Type	Frequency	Percentage
Rotary	140	92.1%
Flail	7	4.6%
Hay Mower	2	1.3%
Reel	2	1.3%
Other	1	0.7%
Total	152	100.0%

Note: From question 23: “Considering the last three years, what type of mower is used to mow the turf runways and taxiways? (common types shown at right)” Out of 185 open airports, there were 33 no responses to this question.

Drought and Drainage Effects on Turf Quality

The next two questions ask about the opposite extremes of rain effects: drought and drainage. The results are shown in Tables 25 and 26 respectively.

Table 25

Drought Effect on Quality

Drought	Frequency	Percentage
Strongly Agree	33	21.7%
Agree	58	38.2%
Undecided	22	14.5%
Disagree	30	19.7%
Strongly Disagree	9	5.9%
Total	152	100.0%

Note: From question 15: “Considering the last three years, drought has significantly decreased runway and taxiway turf quality.” Out of 185 open airports, there were 33 no responses to this question.

Table 26

Runoff and Drainage Effect on Quality

Runoff	Frequency	Percentage
Strongly Agree	1	0.7%
Agree	16	10.5%
Undecided	15	9.8%
Disagree	96	62.7%
Strongly Disagree	25	16.3%
Total	153	100.0%

Note: From question 16: “Considering the last three years, excessive rain, drainage and runoff have significantly decreased runway and taxiway turf quality.” Out of 185 open airports, there were 32 no responses to this question.

Treatments

One question regarding the frequency of application of turf treatments is shown in Table 27. Table 28 shows those airports which had major renovations in the last three years.

Table 27

Frequency of Treatments

Treatment Frequency	Frequency	Percentage
4 Times/year	4	2.5%
3 Times/year	6	3.8%
2 Times/year	21	13.4%
1 Time/year	42	26.8%
Every Other Year	19	12.1%
Never	56	35.7%
Unsure	9	5.7%
Total	157	100.0%

Note: From question 11: “Considering the last three years, how many times per year have turf treatments, such as fertilization, lime or pesticide, been applied to your airport?” Out of 185 open airports, there were 28 no responses to this question.

Table 28

Renovations

Renovate	Frequency	Percentage
No	134	88.2%
Yes	18	11.8%
Total	152	100.0%

Note: From question 19: “Have your runways or taxiways undergone significant (more than 30% of the areas) renovations in the last three years?” Out of 185 open airports, there were 33 no responses to this question.

Extension Services

One question regarding the usage of Agricultural Extension services was asked with results shown in Table 29. Seventy-nine percent of respondents have never taken advantage of agricultural extension services which are offered at no cost by each of the states surveyed.

Table 29

Extension Services

Extension Service Usages	Frequency	Percentage
4 Times	2	1.3%
3 Times	2	1.3%
2 Times	1	.6%
1 Time	17	10.8%
Never	124	79.0%
Unsure	11	7.0%
Total	157	100.0%

Note: From question 10: “In the past three years how many times have Agricultural Extension services been used for advice on your airport?” Out of 185 open airports, there were 28 no responses to this question.

Runway and Airport Features

There is a possibility the orientation of the runway or the surrounding features could impact turf quality. Tables 30 and 31 ask about the runway direction and the environment surrounding the airport. Of these two questions, runway direction can also be determined using FAA records of airports.

Table 30

First Turf Runway Direction

Runway Direction	Frequency	Percentage
01/19	6	4.3%
02/20	5	3.5%
03/21	3	2.1%
04/22	3	2.1%
05/23	3	2.1%
06/24	3	2.1%
08/26	3	2.1%
09/27 (East/West)	38	27.0%
10/28	6	4.3%
11/29	2	1.4%
12/30	3	2.1%
13/31	5	3.5%
14/32	4	2.8%
15/33	5	3.5%
16/34	2	1.4%
17/35	4	2.8%
18/36 (North/South)	46	32.6%
Total	141	100.0%

Note: From question 4. Out of 185 open airports, there were 44 no responses to this question. Of the 141 airports, only three had a second runway, none reported a third runway.

Table 31

Surrounding Features

Feature	Frequency	Percentage
Pine Trees	66	41.8%
Farm Land	42	26.6%
Residential Lawns	17	10.8%
Oak Trees	14	8.9%
Pasture	5	3.2%
Citrus Trees	2	1.3%
Highway	2	1.3%
Fresh Water Lake	2	1.3%
Cotton	1	0.6%
Salt Water Way	1	0.6%
Palm Trees	1	0.6%
Other	1	0.6%
Orange Groves	2	1.3%
Gulf of Mexico	1	0.6%
Swamp	1	0.6%
Total	158	100.0%

Note: From question 8: “What is the most predominant feature surrounding the turf runways and taxiways at your airport?” Out of 185 open airports, there were 27 no responses to this question.

Demographics of Responses

Table 32 shows the breakdown by state and latitude of the responses. Latitudes of “A” through “J” are equally divided latitudes from the Northern line of Alabama to Southern Florida and are shown in Appendix C, Question 26. Table 32 also shows the total attempted contacts for each state.

Table 32

State and Latitude of Responding Airports

State	Latitude	Frequency	Mailed	Percent		Mailed Response Rate
				Of State	Of Total	
AL	A	2		9.1%	1.3%	
	B	2		9.1%	1.3%	
	C	2		9.1%	1.3%	
	D	4		18.2%	2.5%	
	E	10		45.5%	6.4%	
	F	2		9.1%	1.3%	
	Total	22	91	100.0%	14.0%	24.2%
FL	E	10		6.4%	9.8%	
	F	33		32.4%	21.0%	
	G	26		25.5%	16.6%	
	H	13		12.7%	8.3%	
	I	10		9.8%	6.4%	
	J	10		9.8%	6.4%	
	Total	102	342	100.0%	65.0%	29.8%
GA	A	2		1.3%	6.1%	
	B	8		5.1%	24.2%	
	C	13		39.4%	8.3%	
	D	9		27.3%	5.7%	
	E	1		3.0%	0.6%	
	Total	33	225	100.0%	21.0%	14.7%
Total		157	658			23.9%

Note: From question 26: “Reference the map at right, select the latitude most representative of your airport”. Question 27, “What State is your airport located in?” Out of 185 open airports, there were 28 no responses to this question. “Mailed Response Rate” is the total responses for the row of data divided by the total mailed for the row.

Comments

The last question of the survey allowed respondents to submit comments. A total of 63 comments were received. These comments were very valuable and are discussed in Chapters V and VI.

CHAPTER V

DISCUSSION

This pilot study attempted to contact all the 658 turf airports in Alabama, Florida and Georgia on file with the FAA. According the FAA, there are total of 1,055 airports in the same region, resulting in turf airports accounting for 62% of all airports in this region. In the Continental United States, turf airports account for approximately 60% of all airports (cit). The survey period was the two month period from June 15 through August 15, 2007. A total of 199 airports responded to the survey, 185 of which indicated the airports were still open. Since all questions were optional, approximately 155 responses were received per question, or 24% of the total population of turf airports.

According to Gay, Mills, and Airasian, a sample size for a population of 650 should be approximately 242 or 37% (2006). Thus, the sample size for this survey was lower than ideal. Furthermore, since an attempt was made to contact the entire population, and results are based only on those who responded, there is a sampling bias in the results which must be considered when interpreting the results.

Contacting Airports

The principal source of the mailing list used to contact the 658 airports was the FAA 5010 database. While this database is published by the FAA every 56 days, the underlying address data was out of date for at least 92 airports or 14% based on returned mail. Out of the three states, only Florida maintains a directory of airports inclusive of private airports which tended to be more accurate than the FAA's 5010 data. For 92 returned mails, county tax records were found on the internet to get valid mailing

addresses. The county records search was facilitated by using the AirNav.com website and Google Maps with the aerial/map combined view.

Open vs. Closed Facilities

Even though some airports were still charted by the FAA on sectional maps, 14 of the airports responding were closed. Due to sampling bias it is not possible to generalize or draw conclusions from this result, nor was this the intent of this study.

Demographics of the Response

In order to maintain confidentiality of the recipients, no response was required to any question, including the airport identifier. In order to have an idea if results were evenly distributed, the approximate latitude and state of the airport were asked and answered by most. As it turned out, 130 airports responded to the airport identifier question, or 70% of open airport responders. While this rate was lower than the typical 150 responses per question, it still represented a vast majority of respondents and was even higher than the 124 supplying a contact email address.

Table 32 shows the response rate of 24.2% for Alabama, 29.8% for Florida and 14.7% for Georgia. The latitudes of the airports within each state seemed to be fairly well distributed.

Of the 658 airports in the population, 42 were public use airports. Of these 42, 18 responded with a public use airport identifier, or a 42.8% response rate. No distinction was made in the analysis between public and private use airports.

Research Hypothesis: Soil Testing and Turf Quality

The research hypothesis positing the quality of turf airports engaging in soil samples at least every other year would be greater than those not conducting such tests

was not supported by the survey results. The two dimensional Chi-Square analysis shown in Tables 11 and 13 showed no significant difference between those airports conducting soil tests and those airports never conducting soil tests. While the data may suggest soil testing has no relation to turf quality the other possibility is this pilot study was inconclusive on this relationship. The principle reasons for the inconclusiveness include the sample size, the subjective quality measures and other cultural practices effecting turf quality.

The sample size showed only 10 airports or 5% who tested at least every year and only a total of 33 or 17% who tested every year or every other year. A 58% majority never tested the airport soil. This large disparity with so few soil tests contributed to the statistically insignificant results.

The two quality questions were both subjective in nature and quite open to interpretation. While the quality questions were of key importance to the study, achieving a more consistent measure of quality without expending resources not available to this pilot study would have been difficult. According to the NTEP,

Turfgrass quality is a measure of aesthetics (i.e. density, uniformity, texture, smoothness, growth habit and color), and functional use. The most common way of assessing turfgrass quality is a visual rating system that is based on the turfgrass evaluator's judgment. Subjective measures of this type are always subject to criticism and concern. However, it is a well-established fact that properly trained observers can effectively discern subtle differences between turfgrasses, using the visual rating system” (Morris, n.d., p. 2).

A trained evaluator would be necessary in future research to get a reliable measure of quality.

The other factor effecting the research hypothesis was how the airport used the results of soil testing to apply treatments. A cross check of those 10 airports doing annual soil tests revealed the majority also applied annual soil treatments. This relationship would be important to any future study.

Runway and Taxiway Acreage

Questions four through seven of the survey asked the dimensions of the runways and taxiways on the airport. The FAA 5010 database keeps track of runway dimensions at turf airports but not of taxiways dimensions. The reason for this question was to be able to estimate total acreage on airports based upon the runway acreage available from the 5010 database. 153 airports answered the runway question while only 72 airports answered the taxiway question. There was a problem with the construct of this question not found during design or beta testing: there was no place in the taxiway response for the respondent to indicate “no taxiways”. As a result of this design deficiency, the results of the question are not considered usable.

Turf Species

The turf species results showed 100 out of 162 respondents or 61.7% having Bahiagrass as the predominant species followed by 27 Bermudagrass airports or 16.7%. The Bahiagrass results are consistent with what Unruh describes as “one of our most drought-tolerant grasses. It performs well in infertile, sandy soils and does not require high inputs of fertilizers” (2003). While Bahiagrass may be resilient, its disadvantages include “tall, unsightly seedheads” and tough stems make the grass difficult to mow

(Unruh, 2003). The toughness of the grass was consistent with comments by respondents that Bahiagrass was “tough on propellers” and “tough on mower blades”. One respondent went so far as to report an FAA Airworthiness Directive related to grass seed heads, though none could be found searching FAA records. One publically owned airstrip in Northwest Florida was going so far as replacing Bahiagrass with Bermudagrass when hurricane damage required renovations and the toughness of Bahiagrass and its rapid growth rate were considered on mowing costs.

Fifty-two percent of respondents indicated one species of grass accounted for 100% of runway/taxiway coverage, with another 36% indicating at least 75% coverage. Thus, many turf airports have some mix of grass species on the runways and taxiways.

Irrigation

Only 12 airports out of 154 responding or 7.8% irrigated their runways and taxiways. Of these 12 respondents with irrigation, six used wells and six used nearby lakes or streams as a source. 11 of the 12 irrigating airports applied treatments every year while six applied treatments twice a year. These figures were at least double the amounts of treatments of the total surveyed population.

Operations and Wear

The frequency of use of turf airports has no reliable source of public information. Experience around turf airports would suggest a wide variety of usage from less than one operation a month to rates comparable to public use, general aviation airports. These usage characteristics offer the possibility that airplane operations account for less usage of the turf surfaces than the mowers. These usage characteristics were the source of the Likert question, “The frequency of aircraft operations on the turf runways and taxiways

has a noticeable impact on turf quality,” to which 53% of respondents either agreed or strongly agreed with the statement and 33% of respondents disagreed or strongly disagreed.

The survey did not ask for a numerical estimate of operations, consistent with avoiding questions which may have a regulatory or safety impact on the airport. However, knowing the number of operations would certainly help to determine a perceived threshold at which number of operations impact turf quality.

A comment received in this area by a respondent brought out an interesting practice at one airport whereby the touchdown was varied horizontally to avoid a wear pattern.

Pest Factors on Turf Quality

The survey asked the Likert question, “Considering the last three years, pests, such as mound-building ants, moles, armadillos, etc. have significantly decreased turf quality” to which 39% either agreed or strongly agreed and 44% either disagreed or strongly disagreed. Asked, “Which pest is of the most concern for runway and taxiway turf quality?”, 59.6% responded mound building ants followed next by 11.6% for mole crickets and 9.6% for moles.

Most pests are manageable for an airport through established methods. However, for the turf airport discovering a particularly destructive pest which is also considered a protected species, the impact on the airport could be severe. While none of the respondents indicated being faced by this dilemma, the possibility exists.

Mowing

Ninety-two percent of respondents said they mowed at least one time per month, of this 92%, 53% reported a mowing frequency of three times per month or more. This means most responding turf airports mow their grass during the growth seasons weekly.

The largest factor determining when turf runways and taxiways are mowed was grass height reported by 131 respondents 85%. The next highest factor was the availability of personnel reported by 11 respondents or 7.1%. The answers to the mowing factor reasons do not exclude other categories, for example, personnel availability can still be driven by grass height reasons for mowing or vice versa. Of note is only three of the respondents or 1.9% mowed based on a contract schedule.

The low contract schedule response was consistent with the response to who mows the runway. Ninety-one respondents or 59% of respondents said the airport was mowed by the owner or a volunteer with 53 respondents or 34% indicating a compensated individual performed the mowing. Only five respondents or 3.2% used a professional landscaping company. One interesting comment received about who mows, was a homeowner association owned airport where a sign-up sheet was used for mowing volunteers whereby each person mowing received \$49 in compensation. Another comment said the mowing was done by a local farmer using a hay mower and the mowed hay was bartered for the mowing service.

One-hundred-forty respondents or 92% said they used a rotary mower. It should be noted out of the 140 rotary, 123 responses directly indicated “Rotary” while the remaining 17 responses indicated particular kinds of rotary mowers, such as “Bush Hog” or “Batwing” or “Dixie Chopper”. Since these other variants were rotary mowers, they

were consolidated into rotary for the analysis. Seven respondents or 4.6% reported flail mowers while two used hay mowers and two used reel mowers.

Drought

Ninety-one respondents or 60% said they “Strongly Agreed” or “Agreed” with the statement, “Considering the last three years, drought has significantly decreased runway and taxiway turf quality”, while 39 respondents or 25% said they “Strongly Disagreed” or “Disagreed” with the statement. Figure 1 shows a consistent majority of responses by latitude having agreement with the drought statement. According to the NOAA National Climatic Data Center published July 10, 2007, there was a severe drought occurring for the survey geography and time period:

Drought in the Southeast region developed within the past several months [January through June, 2007]. The 6-month Standardized Precipitation Index reflects the lack of rainfall since the start of the year. SPI values less than -2 stretched from eastern Kentucky to parts of southern Mississippi, reflective of drought conditions that occur less than once every 50 years. For the Southeast region as a whole, only 15.8 inches of precipitation fell during the first half of the year. This was nine inches less than normal and only 0.1 inches more than the lowest January-June precipitation total since records began in 1895; the record low occurred in 1898.

Four southeastern states were much drier than normal for the year-to-date period and two (Mississippi and Alabama) had their driest such period on record. Only 16.3 inches of precipitation fell in Mississippi while 15.4 inches fell in

Alabama, both totals only slightly more than half the 20th century average for each state. (§ 4)

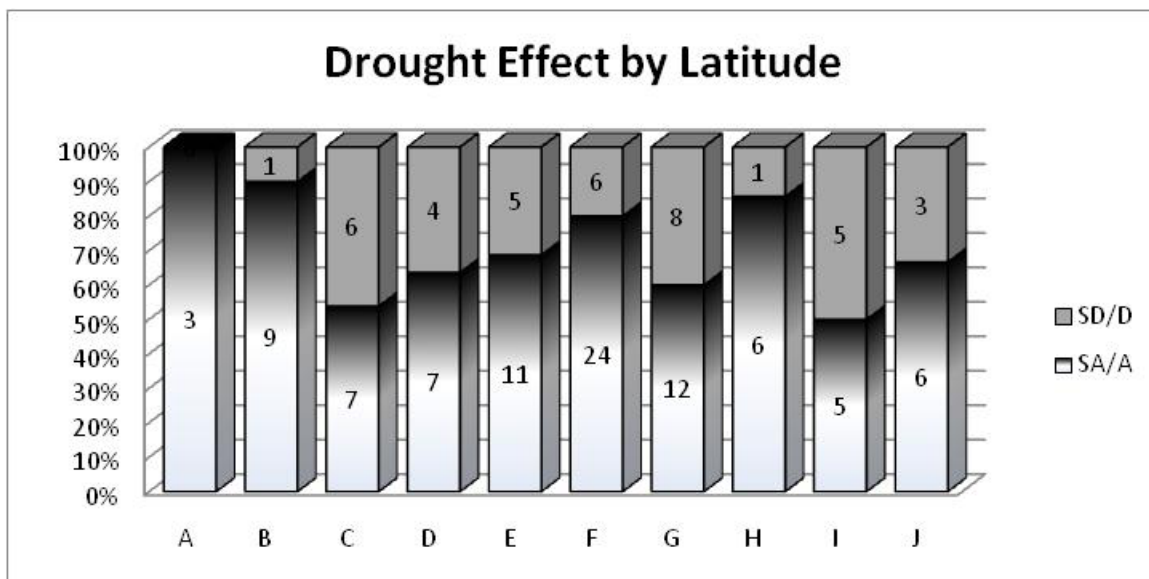


Figure 1. Drought and Airport Latitude. Note: From responses to question 15: “Considering the last three years, drought has significantly decreased runway and taxiway turf quality,” and question 26: “Airport Latitude”. 129 respondents answered the drought question as Strongly Agree, Agree, Disagree, or Strongly Disagree and also answered the latitude question. Strongly Agree/Agree are shown on the bottom of the chart, Strongly Disagree/Disagree are shown on top. Number of responses are superimposed on the bars. Latitude A was 100% Strongly Agree/Agree.

Drainage

Seventeen respondents or 11% said they “Strongly Agreed” or “Agreed” with the statement, “Considering the last three years, excessive rain, drainage and runoff have significantly decreased runway and taxiway turf quality”, while 121 respondents or 79% said they “Strongly Disagreed” or “Disagreed” with the statement. Figure 2 shows a consistent majority of responses by latitude having disagreement with the drainage statement.

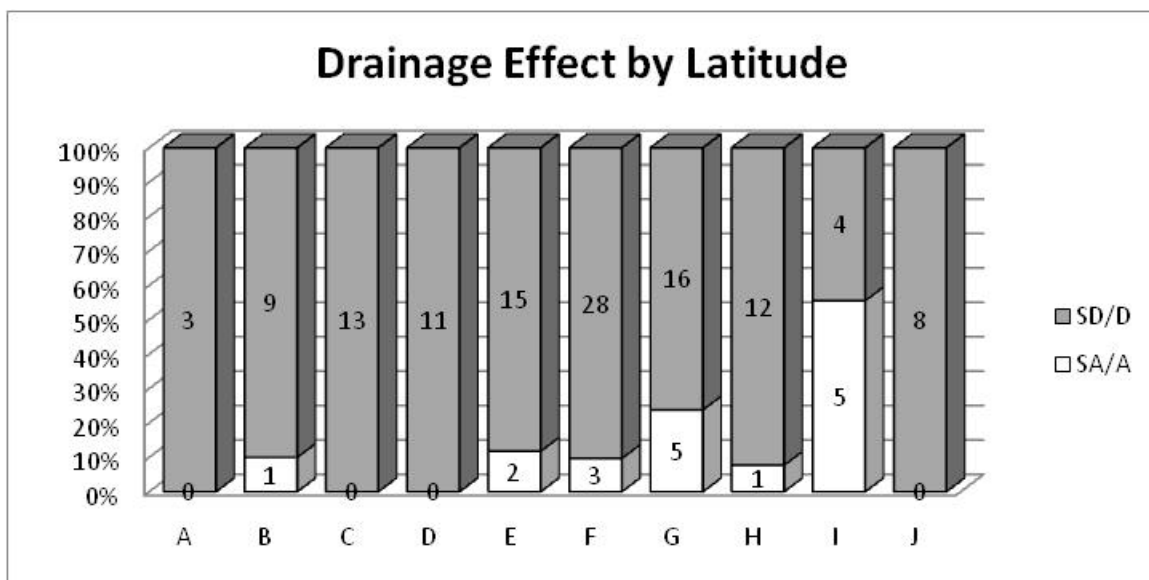


Figure 2. Drainage and Latitude. Note. From responses to question 16: “Considering the last three years, excessive rain, drainage and runoff have significantly decreased runway and taxiway turf quality,” and question 26: “Airport Latitude”. 136 respondents answered the drainage question as Strongly Agree, Agree, Disagree, or Strongly Disagree and also answered the latitude question. Strongly Agree/Agree are shown on the bottom of the chart, Strongly Disagree/Disagree are shown on top. Number of responses are superimposed on the bars. Latitude A and J was 100% Strongly Disagree/Disagree.

Treatments

Out of 148 respondents who were sure of runway treatment frequency, 92 respondents or 62% applied treatments at least every other year. Of these 92, 73 or 49% applied treatments at least annually. Fifty-six or 38% never applied treatments to the turf surfaces.

Eighteen out of 152 responding airports or 12% indicated they had performed some major renovation to the turf runways or taxiways in the last three years. The survey did not delve into the causes or types of renovations. Comments from some respondents indicated the source of renovations as a new airport (two), while one other was replanting Bermuda in place of Bahiagrass as part of repairs after Hurricane Ivan caused trucks to

drive on part of the runway and cause significant damage. In one other case, the airport is used twice a year for intense, 50 operations per day, heavily loaded crop-dusting planes which damage the runway. Fertilization is then applied with left over contents of the planes.

Extension Services

Out of those respondents who answered definitively if they had ever used state extension services for advice on maintaining turf, 22 or 15% of 146 responded they had used extension services in the past three years. Of the 146 extension service respondents, 142 also indicated what state their airport was in. For these 142, Figure 3 shows a break down by state.

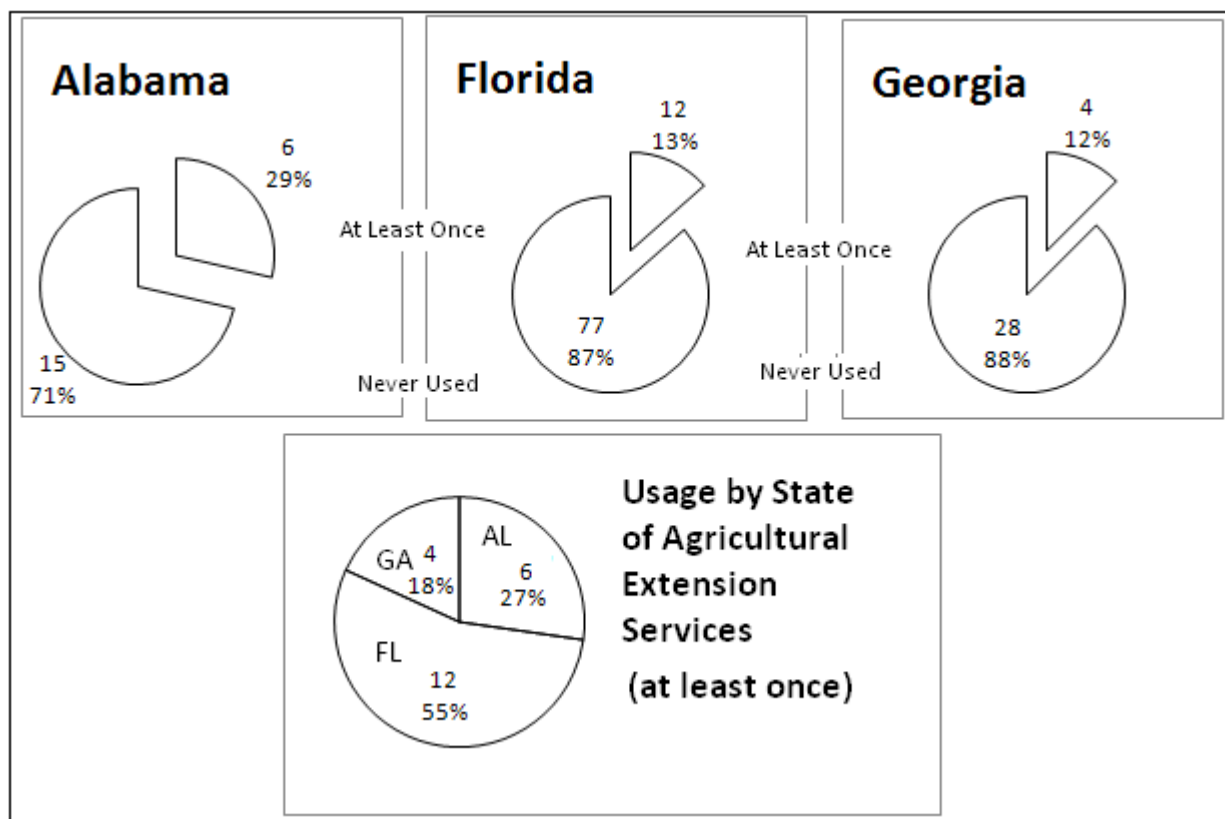


Figure 3. Usage of Agricultural Extension Services by State. Note. Based on 142 respondents answering the Question 10 either Never or 1-4 Times and also indicating what State their airport was located in.

Runway and Airport Features

Of the 141 airports responding, only three had a second runway and none reported a third runway. Of these 141 airports, 38 or 27% had East/West runways (runways 9/27) and 46 or 33% had North/South runways (runways 18/36) for a combined total of 84 or 60%. All the other directions of the compass accounted for the remaining 40% nearly equally. Nationwide, querying the FAA 5010 database, all paved and turf runways in the Continental United States, East/West and North/South runways account for 23% of all runways.

Turf airports were asked about the environment surrounding the airport. Sixty-six of 158 responding airports or 42% said pine trees, with 42 or 27% farm land, 17 or 11% residential lawns and 14 or 9% oak trees with the remainder being different environments.

The runway direction and environment questions were asked to account for factors which could effect turf growth and thus turf quality. The subjectivity of the quality questions discussed earlier does not allow for further investigation of this relationship in this pilot study.

Questions Not Asked

The pilot study did not ask all the questions which could be asked in a study of turf airports. The questions were not asked either to keep the length of the survey reasonable or to avoid sensitive areas which may cause respondents to not participate.

Soil Testing and Quality Measures

Receiving accurate, consistently collected soil sample test results would provide a numerical guide to the results. Combining soil test results with professional evaluations of turf with the proper horticultural expertise would create a more objective result.

Aeration and Thatch

How turf airports deal with thatch and soil aeration would be useful to know. This would help paint the full picture of turf cultural practices.

Overseeding

Overseeding is the practice of seeding an area with a different species of grass which will grow in months when the primary species is dormant. This question was dropped since it was unlikely airports would engage in this practice.

Soil Type

One respondent commented a question on soil types would be helpful. Soil types would allow for better cross sections of lime and fertilization as well as quality questions. While this question could be asked, the United States Department of Agriculture maintains an extensive database of soil types. The soil types in this database are specific enough to cover just the area of an airport (J. Unruh, personal communication, September 28, 2007). Soil types can be found at <http://soils.usda.gov>.

Frequency and Type of Operations

Asking how frequently the airport is used and by what type, weight, horsepower and gear type (tail wheel or nose wheel) of aircraft would help relate many of the other questions. While this question would be helpful, it was not asked to avoid entering topics which may be perceived by the respondent as related to economic, safety or regulatory areas.

Renovation Details

It would have been helpful to specifically ask when renovations were done, what types of renovations were done and what prompted the renovations.

Mowing

The age and brands of the mowers used along with the average, minimum, maximum and target grass heights would be helpful to know.

Surface Integrity

Questions ascertaining what measures are taken to keep the landing surfaces smooth would be helpful. For example, one respondent asked if vibratory rollers were

used on runways to keep the surfaces smooth. Another respondent commented he pulled the runway regularly with a landscape rake.

Economic

Many questions with economic ramifications would have been helpful. The questions include:

- How much is spent annually on runway maintenance, broken down by categories of mowing, treatments, and any other cultural practices.
- How many residences are on the airport, how many hangars and how many combined residences/hangars.
- Valuations of the airport and/or the properties/structures on the airport.

CHAPTER VI

CONCLUSIONS

This pilot study sought to identify how turf airports in Alabama, Florida and Georgia are maintained. There are 658 turf airports in these three states accounting for 62% of all airports in this region. A total of 199 airports or 24% of the population responded to the survey between June 15 and August 15, 2007.

Contact Records for Airports

Public records for contact information of private airports are often out of date. Of the 658 postal mailings, 92 or 14% were returned by the postal service. Email addresses could be found for 230 or 35%. Any future research needs to factor in the time and expense it will take to create an accurate mailing list. While county tax records are generally easily accessible for Florida and Georgia, they were less so available for Alabama. In any case, the county records search was often against owner names which have changed hands since the FAA 5010 data was last updated.

Scale of Turf Usage

Turf management and quality measures need to consider the turf usage. Figure 4 shows a scale of turf usage in order of increasing cost. The study concludes the cultural practices of turf airports lie somewhere less than residential lawns yet more than the grassy areas between highways. One example of a difference in management practices would be the occurrence of mushrooms in turf. While this may be a concern for some golf courses or certainly putting greens, a turf airport would likely ignore this occurrence unless it was associated with some underlying, turf killing disease.

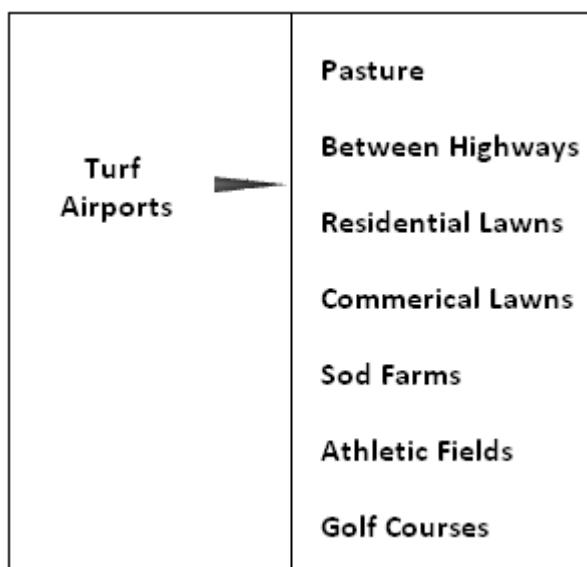


Figure 4. Comparison of Turf Management Practices. Note. From Unruh, J., B., personal communication, September 28, 2007.

Research Hypothesis: Soil Testing and Turf Quality

The analysis of the questions related to soil testing frequency and turf quality found no statistical relationship between the two variables. This result supports the null hypothesis of no relationship between soil testing and turf quality. The low numbers of airports conducting soil tests (33 out of 157, or 21%) combined with the subjectivity of the turf quality questions bring up the strong alternative possibility the results were inconclusive. In Chapter VII, it is suggested how a future study could improve the quality questions and move the study approach from descriptive survey study to an experimental study.

Turf Species

The turf species showed the top three species of grass to be Bahiagrass, Bermudagrass and Centipede. These varieties accounted for 84% of all responses, with Bahiagrass alone accounting for 62%.

Some respondent comments asked about the best cultural practices for managing their turf. Knowing the top three species means if guidelines were to be published for the Southeastern states, these three varieties could receive emphasis.

Irrigation

A vast minority of turf airports invest in irrigation, only 8%.

Turf Wear and Turf Quality

It is significant that 33% of responding airports said aircraft operations have no impact on turf quality. While not the majority, it does mean that it should not be assumed aircraft operations are a large contributor to turf quality. While the reasons 33% feel aircraft operations do not impact quality cannot be determined from the data collected, it can be hypothesized the reasons are a combination of infrequent operations and the small size and weight of aircraft using certain turf airports.

Pests

Respondents were nearly equally split when asked if pests significantly decrease turf quality, with 40% agreeing, 44% disagreeing and 16% undecided. The top four pests impacting turf quality are 60% mound-building ants, 12% mole-cricket, 10% moles and 6% armadillos. Any guidelines on pest control focusing on these four pests would be most helpful to turf airports.

Mowing

Fourteen percent of airports mow their runways five times per month or more while 79% mowed between one and three times per month with 7% either being unsure, varying or less than monthly. Eighty-five percent of airports mow because of grass height rather than a regular contract schedule. Mowing is done by the owner or volunteers in

58% of cases with a paid individual in 34% of cases; professional landscaping companies are used in only 3% of the cases. The most common mower type is a rotary mower, reported by 92% of respondents.

Drought and Drainage

The survey was conducted during a period the NOAA reported as one of the driest since records were kept in 1895 (2007, ¶ 4). Considering this significant factor and only 8% of surveyed airports irrigate, 60% of respondents agreed drought had a significant effect on turf quality. Conversely, 79% of respondents disagreed excessive rain, drainage or runoff decreased turf quality. Taken in light of the drought, these results could differ in a period of above normal rainfall.

Treatments

Thirty-eight percent of turf airports never apply treatments to their airports. This large percentage can support an argument that no money should be spent on turf treatments and the runway should be treated like a pasture.

Extension Services

Only 15% of respondents had used free Agricultural Extension services. Combining the 69% of airports not soil testing and those 85% not taking advantage of extension services, these turf airports could discover the optimum treatment needs of their airport by using a cyclical combination of extension services followed by soil testing and treatments to the turf.

Runway and Airport Features

Sixty percent of all turf airports have a North/South or East/West runway compared to 23% of all airports in the United States having this orientation. While the

intent of this question was to discover a relationship to turf quality, its only use in this study is an interesting fact.

Forty-two percent of surveyed airports were surrounded by trees, 27% by farm land and 11% by residential lawns.

Environmental Impact of Turf Airports

The combination of low treatment rates and low occurrence of installed irrigation systems of responding airports means, in the aggregate, the responding turf airports have a low impact on the environment relative to leaching of fertilizer into the water supply or due to water usage.

CHAPTER VII

RECOMMENDATIONS

Extension Services Outreach

Only 15% of responding airports have ever used Agricultural Extension services. Turf airports should be made aware of Agricultural Extension services through public service announcements in aviation trade journals or shows.

Turf Airports Benefiting Turf Research

Turf runways and taxiways represent very level surfaces of grass. At least 72 of the 185 responding airports indicated the existence of taxiways. These runway and taxiway surfaces offer an excellent proving ground for new mower technology, treatment testing, or turf species variants. While irrigation is not available over the whole surface of the airport, it is quite likely irrigation does exist in subsections of these airports to facilitate research.

Future Research

Experimental Comparison of Turf Maintenance Practices

This pilot study offered a set of metrics which can serve a more thorough, funded study of turf airports. The data in this study could be used to create a representative sample of airports to conduct experimental research comparing controlled factors across airports in a specific geography.

One experimental study suggested by this pilot study is having independent variables of treatments and aeration against a dependent variable of quality measures and expense. The study could collect additional metrics consisting of soil samples to have a history of changes in soil nutrients during the time span of the study.

The variety of current turf management practices would allow an experimental study to control independent variables of care by carefully selecting candidate airports rather than trying to alter behavior to control independent variables.

Dr. J. Bryan Unruh confirmed the guidelines of the NTEP on turf quality ratings discussed in Chapter VI and added comments about the challenges faced in quality ratings. Even a trained turf evaluator needs to maintain proficiency to work ratings in a timely and consistent fashion and avoid visual illusions or distractions. There are certain objective measures of quality, such as comparison of surface areas of clearly bad or diseased growth to the total surface area. Dr. Unruh also said digital imaging and processing is starting to enter the discipline to increase the objectivity of measurements (personal communication, September 28, 2007). These various techniques would need to be considered to come up with the most consistent turf quality measure in a future study.

Broader Geography

While this pilot study limited its research to the Southeastern United States, a future study could consider a larger part of the country.

Operations and Wear

Finding the threshold number of operations per month at which turf quality is effected would be helpful to turf management and as a possible basis for fee assessments at turf airports. The research would need to consider the type, weight and gear type (conventional or nose gear) of the operating aircraft.

Open Status of Airports

The free and easy availability of aerial photography allows for an inexpensive study to determine which turf airports are still open versus closed. Out of 199 airports

responding, 14 indicated they were closed, or 7%. An aerial survey of airports in the FAA 5010 database, done using imagery readily available on the Internet would give a true number of private airports still open.

Propellers and Mower Blades

During ground operations, propeller and mower blades likely face similar wear challenges. Mower blade manufacturers and propeller manufacturers may benefit from sharing information.

Social, Economic and Zoning Challenges

The comments received during the study suggest an interest in social, economic and zoning challenges faced by private airports. Like this turf survey, there is little prior survey research in this area. Topic areas for such a survey may include:

- Property valuations;
- Square footage of hangar storage space, both per hangar and total per airport;
- The nature of the airport ownership, be it an individual, Limited Liability Corporation, Homeowner Association, etc.;
- How are the runways and taxiways owned;
- How is the airport insured for liability and if there have been liability lawsuits;
- How is the private use status of the airport enforced;
- Accident history and the airport and surrounding community response;
- What zoning issues has the airport faced;
- What threats exist to the continued operation of the airport;
- Aviation easements for over flights of surrounding properties.

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APPENDIX A
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APPENDIX B
SURVEY COVER LETTER



IFAS

West Florida Research and Education Center

5988 Highway 90, Bldg. 4900
Milton, FL 32583
(850) 983-5216
Fax: (850) 983-5774
Miltongators.com

|

June 14, 2007

TURF AIRPORT RESEARCH STUDY

Dear <recipient>,

I am inviting you to participate in the Turf Airport Research study being conducted by Bill Tuccio of Embry-Riddle University. Turf research focuses on many different usages of turf, including golf courses, athletic fields and residential lawns. Some research has been conducted on aviation uses of turf, but this has focused mostly on the areas between runways and taxiways. The research study you are being asked to participate in is the first recorded research I can find on turf usages for runways and taxiways.

The study is carefully constructed to focus on turf management practices and is careful to avoid any questions related to FAA regulations, safety issues, environmental or economic issues. While avoiding these controversial topics, the study asks the questions any turf manager often asks, "What do other similar managers do?" You represent one of 658 airports in Alabama, Georgia and Florida being asked to participate in this survey.

I have used my extensive experience in maintaining, managing and researching turf to review the questions you are receiving in this brief study. In my opinion, the questions being asked by Bill in this study are appropriate for the first study of its kind on turf airports.

As you may know, out of 12,609 airports in the continental United States, over 8,000 – 60% – only have turf runways. By and large, these turf runways are private airports and often airport communities. The research author, Bill Tuccio, is very familiar with general aviation. He has been a flight instructor in New York, Florida and Alaska, a Beechcraft Baron charter pilot in Vermont, an ATR and Shorts pilot for American Eagle and today lives on the private Yellow River Airport (FD93) in Florida. He and his pilot wife own a Maule. Bill is also teaching his 15 year old son to fly.

You will be able to share in the results of the survey, which are expected to be published in the Fall, 2007 to the same site where you will begin the survey:

<http://www.turfairportstudy.com>

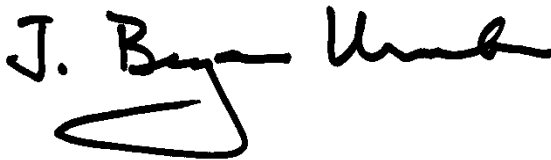
The survey is completely confidential and you needn't answer any question you do not want to. You are given the option of entering your airport identifier and email address. If supplied, the airport identifier will allow analysis against airport registry information and the email address will allow Bill to follow-up with you to let you know when the results are available or to ask further questions.

I hope you take advantage of this opportunity to discover the turf management practices of turf airports in the Southeast. The survey only takes about 5 minutes to complete. To take the survey, simply go to:

<http://www.turfairportstudy.com>

If you do not have access to the Internet but would still like to participate, call (850) 537-8592 and Bill or his wife, Barbara, can administer the survey to you over the telephone. Bill can be reached for questions at the number above or by email at bill@turfairportstudy.com.

Sincerely,

A handwritten signature in black ink that reads "J. Bryan Unruh". The signature is fluid and cursive, with a large, stylized loop at the end of the last name.

Dr. J. Bryan Unruh

Cc:
Bill Tuccio
Yellow River Airport
34 Sky Lane
Holt, FL 32564

APPENDIX C
DATA COLLECTION DEVICE

PAGE 1**Welcome to the Turf Airport Study****DIRECTIONS**

The survey should only take you about 5 minutes to complete.

Please feel free to skip any questions you like. At the bottom of each page you will find a **Next >** button. At the end of the survey, you can enter any comments or questions about the survey.

1. Is your airport still maintained for aircraft operations?

☐ Yes

☐ No




Turf Species.



2. What is the most predominant species of turfgrass on your turf runways and taxiways?

The pictures below/right should help you decide. If you have mixed varieties, please select the most predominant.

☐ Bahiagrass

(Click for larger image in new
browser)

<p> <input type="checkbox"/> Bermudagrass <input type="checkbox"/> Centipede <input type="checkbox"/> Seashore Paspalum <input type="checkbox"/> St. Augustine <input type="checkbox"/> Zoysiagrass <input type="checkbox"/> Unsure <input type="checkbox"/> Other >> <input type="text"/> </p> <p>3. For the species selected above, what percent covers your runways and taxiways. For example, if the species above covers 75% of the runways and taxiways, but another species covers the remaining 25%, you would answer, 75%.</p> <p> <input type="checkbox"/> 25 % <input type="checkbox"/> 50 % <input type="checkbox"/> 75 % <input type="checkbox"/> 100 % <input type="checkbox"/> Unsure </p>	<div data-bbox="1027 268 1429 571">  </div> <div data-bbox="1027 571 1429 709"> <p>Bahia</p> </div> <div data-bbox="1027 751 1429 1050">  </div> <div data-bbox="1027 1050 1429 1188"> <p>Bermuda</p> </div> <div data-bbox="1027 1230 1429 1533">  </div> <div data-bbox="1027 1533 1429 1671"> <p>Centipede</p> </div>
---	--

<div data-bbox="292 199 381 262">Next ></div>	
	St. Augustine
	
	Zoysia
	<p>(Courtesy: L.B. McCarty (1991), UFL, Sod Production in Florida)</p>

PAGE 2

General Demographics

Turf and Taxiway Acreage. These questions are a means to determine how many acres of turf are used for airport operations and environmental conditions the turf is subjected to.

First Turf Runway:

4. Direction	Select	Length		ft	Width		ft
--------------	--------	--------	--	----	-------	--	----

Second Turf Runway (if applicable):

5. Direction	N/A	Length		ft	Width		ft
--------------	-----	--------	--	----	-------	--	----

Third Turf Runway (if applicable):

6. Direction	N/A	Length		ft	Width		ft
--------------	-----	--------	--	----	-------	--	----

Turf Taxiway Acreage: In the blocks below, enter the dimensions of all *turf* taxiways on the airport. Only fill in as many blocks as needed for your airport.

7. Length	Width

<input type="text"/>	ft	<input type="text"/>	ft
<input type="text"/>	ft	<input type="text"/>	ft
<input type="text"/>	ft	<input type="text"/>	ft
<input type="text"/>	ft	<input type="text"/>	ft
<input type="text"/>	ft	<input type="text"/>	ft
<input type="text"/>	ft	<input type="text"/>	ft
<input type="text"/>	ft	<input type="text"/>	ft

Surrounding Features.

8. What is the most predominant feature surrounding the turf runways and taxiways at your airport?

- ☐ Pine Trees
- ☐ Oak Trees
- ☐ Farm Land
- ☐ Sod Farm
- ☐ Residential Lawns
- ☐ Industrial

- ☐ Golf Course
- ☐ Fresh Water Lake
- ☐ Fresh Water River
- ☐ Salt Water Way
- ☐ Gulf of Mexico
- ☐ Atlantic Ocean
- ☐ Swamp
- ☐ Other >>

PAGE 3**Turf Treatments****Soil Testing Frequency.**

9. Considering the last three years, how often have soil samples been taken at your airport?

- ☐ 4 Times per Year
- ☐ 3 Times per Year
- ☐ 2 Times per Year
- ☐ 1 Time per Year
- ☐ Every Other Year
- ☐ Never

☐ Unsure

Extension Services.

10. In the past three years how many times have Agricultural Extension services been used for advice on your airport?

☐ 4 Times

☐ 3 Times

☐ 2 Times

☐ 1 Time

☐ Never

☐ Unsure

Treatments.

11. Considering the last three years, how many times per year have turf treatments, such as fertilization, lime or pesticide, been applied to your airport?

☐ 4 Times per Year

☐ 3 Times per Year

☐ 2 Times per Year

☐ 1 Time per Year

☐ Every Other Year

☐ Never

☐ Unsure

PAGE 4

Turf Quality

State the degree to which you agree or disagree with the following statements:

12. *During Summer months*, over the last three years, the quality of the turf on the runways and taxiways is better than that of other turf runway airports:

☐ Strongly Agree

☐ Agree

☐ Undecided

☐ Disagree

☐ Strongly Disagree

13. *During Summer months*, over the last three years, the quality of the turf on the runways and taxiways could be improved.

☐ Strongly Agree

☐ Agree

☐ Undecided

☐ Disagree

☐ Strongly Disagree

14. The frequency of aircraft operations on the turf runways and taxiways has a noticeable impact on turf quality.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Undecided
- ☐ Disagree
- ☐ Strongly Disagree

15. *Considering the last three years*, drought has significantly decreased runway and taxiway turf quality.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Undecided
- ☐ Disagree
- ☐ Strongly Disagree

16. *Considering the last three years*, excessive rain, drainage and runoff have significantly decreased runway and taxiway turf quality.

- ☐ Strongly Agree
- ☐ Agree

- ☐ Undecided
- ☐ Disagree
- ☐ Strongly Disagree

17. *Considering the last three years*, pests, such as mound-building ants, moles, armadillos, etc. have significantly decreased turf quality.

- ☐ Strongly Agree
 - ☐ Agree
 - ☐ Undecided
 - ☐ Disagree
 - ☐ Strongly Disagree
-

18. Which pest is of the most concern for runway and taxiway turf quality?

- ☐ Mound-Building Ants
- ☐ Moles
- ☐ Armadillos
- ☐ Mole-Crickets
- ☐ Other >>

19. Have your runways or taxiways undergone significant (more than 30% of the areas)

renovations in the last three years?

- ☐ Yes ☐ No

PAGE 5

Mowing and Irrigation

20. *Considering the last three years*, during June, July, August, how often are the turf runways and taxiways mowed?

- ☐ More than Five times per month
- ☐ Five times per month
- ☐ Four times per month
- ☐ Three times per month
- ☐ Two times per month
- ☐ One time per month
- ☐ Less than once per month
- ☐ Varies too much to say
- ☐ Unsure

21. *Considering the last three years*, during June, July, August, what is the largest factor which determines when the turf runways and taxiways are mowed?

- ☐ Mowing Personnel Availability
- ☐ Mowing Equipment Availability

☐ Grass Height

☐ Other >>

22. *Considering the last three years*, who typically mows the turf runways and taxiways?

☐ A volunteer

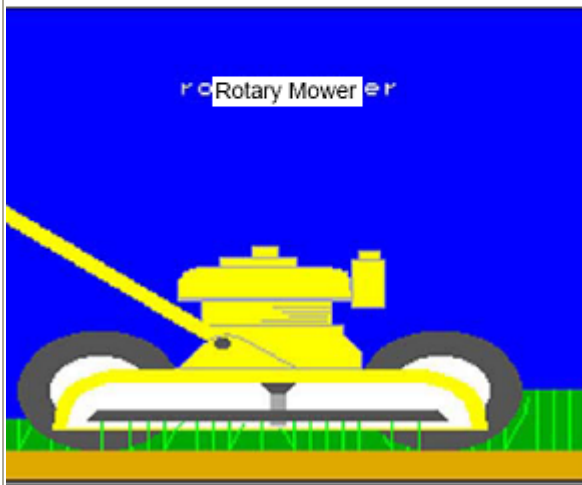
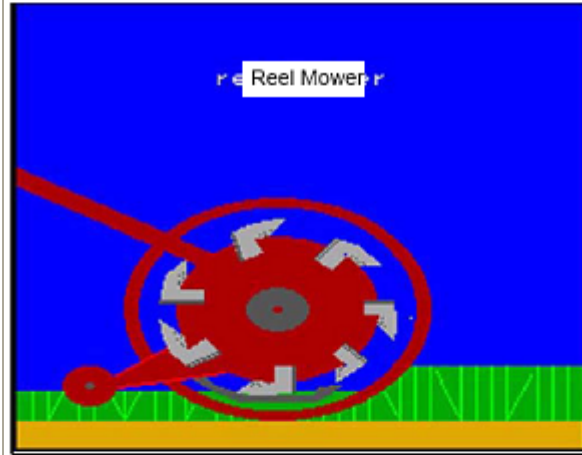
☐ A professional landscaping company

☐ An individual compensated for services

☐ Other >>

23. Considering the last three years, what type of mower is used to mow the turf runways and taxiways? (common types shown at right)

- ☐ Reel
- ☐ Rotary
- ☐ Flail
- ☐ Other >>



reference: UFL, "Mowing your Florida Lawn"

24. Considering the last three years, is a regular irrigation method (i.e., sprinklers) used to water the runways and/or taxiways?

- ☐ Yes
- ☐ No

25. If an irrigation system is used, what is the source of the water?

- ☐ Municipal water supply

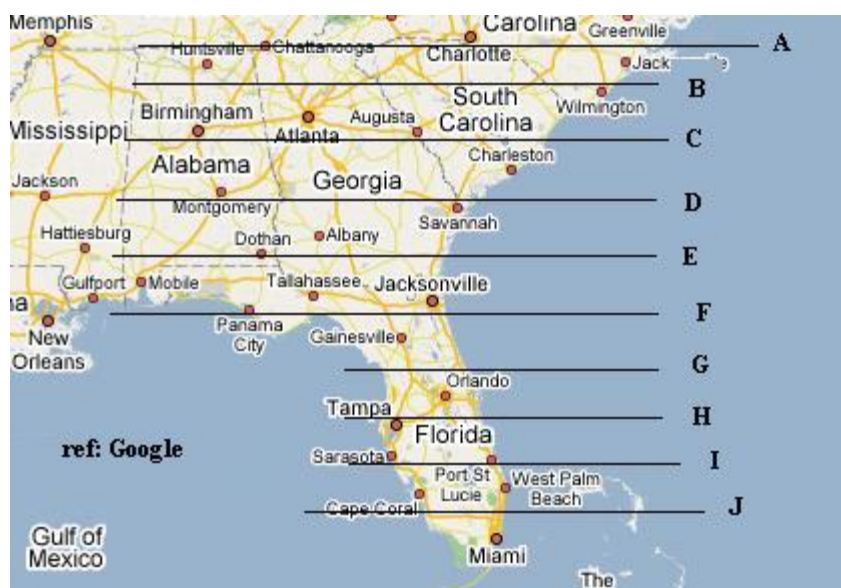
<input type="checkbox"/> Well <input type="checkbox"/> Lake/River/Stream <input type="checkbox"/> Reclaimed (runoff) <input type="checkbox"/> Effluent (discharge from waste treatment or other facility) <input type="checkbox"/> Other >> <hr/>	
--	--

PAGE 6

Geography and Closing

26. Reference the map at right, select the latitude most representative of your airport.

- ☐ A
☐ B
☐ C
☐ D
☐ E
☐ F
☐ G
☐ H
☐ I
☐ J



☐ H

☐ I

☐ J

27. What State is your airport located in?

☐ Alabama

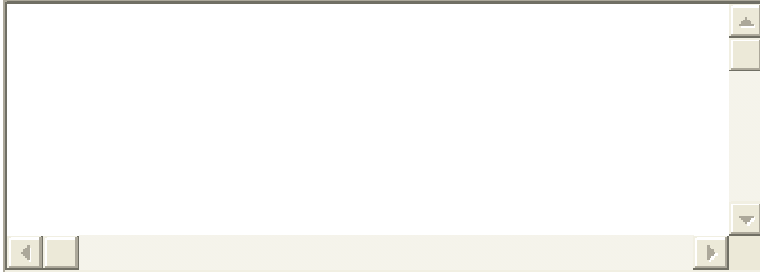
☐ Florida

☐ Georgia

28. If you would like to provide the 3 or 4 letter identifier for your airport, please do so:

29. If you would like to provide an email address, we will email you the results of the survey in a few months:

30. Your time contributing to this survey is very much appreciated. Please feel free to provide any general comments below, or suggest questions for future research:



CONCLUDE

Thanks for participating in the Turf Airport Study!

We hope to report results in the Fall of 2007. If you provided your email address, we will email you the results. You can also check back at this website for updates.

[Click Here](#) to go to the Turf Airport Study home page.

APPENDIX D

HOME PAGE OF SURVEY WEBSITE

http://turfairportstudy.com/turf/welcome.html

UNIVERSITY of FLORIDA

TURF AIRPORT STUDY 2007

[Click here to start survey](#)

EMBRY-RIDDLE
AERONAUTICAL UNIVERSITY

BACKGROUND ON STUDY
[Blog Notes on Study](#)
[UFL Cover Letter](#)
[Univ. of Florida/IFAS - More Information](#)
[Turf Airport Study Research Paper](#)

Contact
Bill Tuccio
Yellow River Airport (FD93)
34 Sky Lane
Holt, FL 32564
(850)-537-8592
[For email, click here](#)

(July, 2007) Come on', is this Study Real? I have received phone calls and/or emails from folks wanting to verify the legitimacy of this study. Feel free to call or email me so I can address your concerns! Or, look at the Blog posts which I copy from the surveys, after eliminating any name or airport references. **Your response is very important to me! Please, call or email if you have any questions.**

APPENDIX E

POSTCARD MAILING JULY 29, 2007

Your Airport: Yellow River Airport

In June, 650 turf airports (like yours) in the Southeast were mailed out asking for a brief, online survey about how you manage the grass at your turf airport. So far nearly 125 airports have responded!

If you have not yet taken the Turf Airport Survey, would you or someone at your airport consider taking this 5 minute survey? Just go to:

>>> <http://www.TurfAirportStudy.com> <<<

You can also call 850-537-8592 to take the survey by phone. Questions? Email bill@turfairportstudy.com. Your participation will help answer the question, "How do other turf airports manage their runway?" On the site you can find comments from other turf airports and more information. If your airport is no longer used for airport operations, please drop me an email, or just answer the first question in the survey. Thanks!! Bill Tucco

UF UNIVERSITY of
FLORIDA

Embry-Riddle University

APPENDIX F
EMAIL SOLICITATION

Dear Turf Airport Study Respondent (xxxx),

You recently took the time to complete a survey on the turf management practices of your airport. So far, I have received responses from over 100 airports out of nearly 650 targeted in Georgia, Alabama and Florida. In order to have a useful set of data, I am trying to get responses from more airports. As you may know, the FAA records of ownership and management is often out of date.

The purpose of this email is to impose upon you one more time. Below are airports I am trying to include in the study who have not yet responded who are near your airport. I'm asking for you help in contacting these airports.

If you know the contact email for a person who could answer the survey, could you forward this on with some encouragement to take the survey? If you know the airport is closed, could you let me know with a reply? And if you know anything about who I could contact, would you mind responding with the contact information?

The web address to take the survey is:
<http://www.turfairportstudy.com>

I hope you appreciate this email as an effort to know more about how we all maintain our grass strips. The list of airports near you are below my email signature.

Best,
 Bill Tuccio
 Yellow River Airport (FD93)
 34 Sky Lane
 Holt, FL 32564
 850-537-8592
bill@turfairportstudy.com

LIST OF TURF AIRPORTS NEAR YOU:

3M5: MOONTOWN in HUNTSVILLE, AL
<http://www.airnav.com/airport/3M5>
 3AL8: FLINT RIVER RANCH in OWENS CROSSROADS, AL
<http://www.airnav.com/airport/3AL8>
 AL72: PALMER FIELD in MADISON, AL
<http://www.airnav.com/airport/AL72>
 4AL8: MILTON in HUNTSVILLE, AL
<http://www.airnav.com/airport/4AL8>
 AL93: BIG SKY in HUNTSVILLE, AL
<http://www.airnav.com/airport/AL93>
 1M3: ARDMORE in ARDMORE, AL
<http://www.airnav.com/airport/1M3>