



Partnership for AiR Transportation
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Land Use Management and Airport Controls

Trends and indicators of incompatible land use

prepared by
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FINAL REPORT

LAND USE MANAGEMENT AND AIRPORT CONTROLS
Trends and indicators of incompatible land use

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the FAA, NASA or Transport Canada.

The Partnership for AiR Transportation Noise and Emissions Reduction — PARTNER — is a leading aviation cooperative research organization, and an FAA/NASA/Transport Canada-sponsored Center of Excellence. PARTNER fosters breakthrough technological, operational, policy, and workforce advances for the betterment of mobility, economy, national security, and the environment. The organization's operational headquarters is at the Massachusetts Institute of Technology.

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1. Executive Summary

The Partnership for Air Transportation Noise and Emissions Reduction (PARTNER), an FAA/NASA/Transport Canada-sponsored Center of Excellence, initiated a three-year project to study land use and noise complaint patterns for a set of selected airports. The project was undertaken in an effort to better understand the dynamics of land use management, public concerns, and annoyance related to air traffic. The main goal of the project was to act as a neutral party investigating the opinions and dynamics of all impacted by land use planning.

For the study, three airports were selected in consultation with the FAA: Denver International Airport, Fort Lauderdale-Hollywood International Airport and Orlando-Sanford International Airport. These airports represented three distinct profiles. Denver International Airport is an example of an airport that was originally considered to have good geographic separation from populated land use areas; Fort Lauderdale-Hollywood International Airport has experienced a rapid growth in airline traffic in recent years; and Orlando-Sanford International Airport represents a well-established medium-sized commercial airport with a history of moderate commercial air traffic. The study reviewed the history of noise complaints for the affected airports. Salient issues related to annoyance, trends and cycles in the number of complaints at the airport were identified. Potential patterns in the geographic location of complaints and concerns were discussed. Interviews of airport and municipal officials were also conducted in order to determine their perspective on airport noise concerns and land use strategies. A review of land use and various demographics related to populations surrounding the airports was performed to identify possible drivers influencing public perception. Finally, interviews and focus groups were conducted with noise complainants in order to gain insight into their perspectives of compatible land use, noise concerns and other related problems.

Study results show that a disproportionate number of complaints come from a few households. The results also suggest that the size of a population tends to increase near airports. The collected data indicates a pattern where construction of housing units occurs at a rate higher than for the surrounding county, particularly for the first few decades of an airport's operation. This indicates the necessity of having appropriate zoning ordinances in place early in the development of new airports to limit (or prohibit) the construction of residential units in incompatible locations. During the study, it was noted that each of the airports had noise abatement strategies, but these procedures were not always followed.

The study provides insight into issues which may affect public opinion concerning land use adjacent to airports and possible sources of noise concerns among affected populations. Results of the study suggest that additional research using psychoacoustic assessments of noise complaint populations, a critical assessment of land use decisions, a more in-depth look at noise levels and characteristics of aircraft, and the dynamics and drivers of public concerns would be beneficial to more effectively manage noise and land use issues.

2. Background

Airports have grown continually since the mid-1960s. This persistent growth has almost always been accompanied by a negative community reaction (Van Praag 2005). In addition to FAA's plan to modernize the National Airspace System¹ through 2025, many airports in the United States are seeking to increase their capacity. A major concern related to the creation and expansion of airports is incompatible land use, in and around noise-sensitive (such as hospitals and educational institutions) and residential communities. For instance, an earlier study acknowledged that residential populations tended to move towards airports, which ultimately led to complaints by community members and a negative public perception of the airport (Kelly, 1997).

Despite this negative community reaction, the aviation industry continues to develop new services to meet the demands of our dynamic economy. Airports create employment opportunities, thereby making areas around airports major industrial compounds that increase the local rate of employment. Businesses that rely upon the aviation industry are established in the vicinity of airports to reduce the cost of transporting goods and supplies. A study by McMillan (2004) suggests that better employment opportunities attract people toward airports. A large number of people want to live as close as possible to their place of employment, thus minimizing their time commuting to work. This leads to more residents near the airport and, in turn, the construction of schools, hospitals, shopping centers, churches, and other community facilities. Often there is prime land located near the airport attracting real estate developers, resulting in higher development of those areas. However, the increased population also results in increased air traffic. It becomes absolutely essential to ensure compatible land use around airports.

Airport land-use planning and noise management are challenges faced by airports around the world. For example, O'Hare International Airport (as it is known today) began as a four-runway airport in 1945. Although community opposition began as far back as the 1960s when a new runway was to be built, noise-related lawsuits did not start until the 1980s (Metropolitan Planning Council, 1996). Over the past few decades, O'Hare has expanded and grown to become one of the nation's largest and busiest airports. During the earlier years, residential and other incompatible land uses began to develop around the airfield unabated possibly due to a lack of understanding of the potential noise impact. Because of this unrestricted development, since 1982 O'Hare and the O'Hare's Noise Compatibility Commission (ONCC) have employed the largest land acquisition and home insulation programs in the country. Due to this initiative, the number of homes affected by O'Hare's noise decreased almost 50 percent between 1979 and 1993. In May of 1995, a noise abatement program consistent with the Part 150 Noise Compatibility Plan was initiated to continue noise impact reduction. Additional measures such as the purchase of a hush house, continual soundproofing, and more stringent land use controls have been employed in recent years to ensure that O'Hare manages noise impact and compatible development for mutual benefits in the future.

The Dallas and Fort Worth region in Texas was required to meet demands of a different kind. In 1961, the Civil Aeronautics Board (CAB) determined that an alternate joint airport should be built to service both Dallas and Fort Worth as it was no longer beneficial to invest any more money into either city's current airport (Dallas/Fort Worth International Airport, 2006). The new airport, built 17 miles from both Dallas and Fort Worth, opened on January 13, 1974.

¹ The new system is known as The Next Generation Air Transportation System (NextGen). Through NextGen, the FAA plans to develop a roadmap of new technologies and procedures to support greater capacity and less congestion. More details can be found at the FAA website.

Over time, extensive development ensued near the Dallas/Fort Worth International Airport (DFW). In the 1990s, a Noise Office was set up to deal with the issues and complaints similar to other airports (NPC Noise News, 1999). In 1997, DFW began to use a new noise monitoring system to act as a final arbitrator in disputes between residents and the airport regarding aircraft altitude and noise; DFW has continued to mitigate noise in impacted areas (NPC Noise News, 1998).

Like other major airports, the Hartsfield-Jackson Atlanta International Airport has a difficult task of balancing community demands for limited airport growth while still attempting to maintain high volumes of traffic and an international status. The Hartsfield-Jackson Atlanta International Airport, built in the 1920s, is termed the world's busiest airport in the United States. Today it plays an important role in the aviation industry as a model of innovation and development (City of Atlanta, 2003a). The Environmental and Technical Services Division of the City of Atlanta Department of Aviation continues to protect its growth by utilizing recommended guidelines for compatible land use planning and noise mitigation (City of Atlanta, 2003b). Noise management has been in effect for over 25 years, and the Airport Noise Abatement and Land Use Compatibility (ANALUC) study in 1978 set the stage for Atlanta's future land use planning and control (2003b). The strategy continues to evolve and now utilizes home acquisition and sound insulation measures, with a total cost of \$71.5 million. The airport also strives to protect itself for the future by utilizing aviation easements² on mitigated homes (2003b). Regardless of the initiatives, in the late 1990s, Atlanta residents were dissatisfied with plans to expand the airport. These plans were viewed as additional expenses coupled with further anticipated noise impact (NPC Noise News, 1997b), and therefore not economically beneficial (despite the promised increase in jobs). Atlanta though, has since expanded.

The City of Denver has experienced the extremes of community resistance, resulting in a court order for the city to build a new airport and close the old, Stapleton. Denver International Airport has attempted to learn from O'Hare, Atlanta, and DFW as well as many other airports' situations in order to protect the City of Denver's wishes to continue meeting air traffic demands, and to be prepared for significant growth in the distant future. These brief case studies demonstrate that regardless of an airport's importance in the aviation industry, there will always be challenges and barriers to overcome.

Historically, many locations have succumbed to pressure to reduce airport related noise by relocating large airport complexes to areas which are less populated. This has invariably led to the new airport's subsequent incompatible land use, and more noise complaints and issues. If we are to achieve the desired balance between airport accessibility and service, and peaceful coexistence with the surrounding communities, we must understand the dynamics and evolution of airport incompatible land use.

2.1 Incompatible Land Use

Basically, an airport incompatible land use is any type of land development which jeopardizes the safe operation of aircraft near an airport. These uses include developments such as residential buildings, schools and libraries, nursing homes and hospitals, wetlands and open water, landfills and sewerage treatment facilities, generators of light emissions and others. According to the FAA guidelines on land use planning, incompatible land use and noise are a

² Aviation easement is an easement over private property near an airport that limits the height of structures and trees.

growing concern in the United States. Published work related to land use can be traced back to the early 1900s, however, the Federal guidelines attempting to ensure compatible land use with respect to airports and surrounding communities were compiled and published only up until recent times (FAA, 1998). In recent years, it became increasingly apparent that, “allowing incompatible real-estate development around airport signals the first step toward closing the airport” (Esler, 2006). According to the U.S. Department of Transportation, an average of 60 public-use landing facilities were shut down between 1993 and 1998 and, in almost every case, incompatible land use was a major contributor. In the case of Stapleton Airport near Denver, the airport was overwhelmed by noise complaints and eventually forced to discontinue operations due to a lawsuit by local citizens.

Guiding compatible land use has been difficult, as most airports’ boundaries have had pre-existing development for years. The additional problem stems from the fact that controlling compatible land use does not preclude minimized noise impact on the community. In fact, much of the opposition from communities is generated outside compatible land use jurisdiction. In planning an airport’s noise mitigation program, the economic impact of an airport cannot be overlooked. Airports are an economic engine that are vitally important to a community’s ability to expand, attract industry, and improve quality of life (Arata 1970). All of this is linked, however, to the public’s perception of the airport. If individual citizens do not support their local airport, it is likely to manifest as negative economic effects for the entire region.

2.2 Mitigation Efforts

Much can be done by airports to build and improve relationships with surrounding communities. In fact, over the past few decades, the number of people exposed to airport noise has decreased, which, combined with improved airport/community dialogue, can have a very positive impact (Thomas 2004). Tedrick (1983) recommends that airports avoid using a “cookie-cutter” approach to compatible land use, but instead focus on the unique issues of their airport’s environment, while maintaining a wider view of the national airspace system. Wisconsin, Oregon, California, and Florida, among others, have established guidelines or handbooks for airports nearby communities to help ensure that new developments near airports are compatible. Below are proactive approaches that can be used by local governmental authorities to prevent, or discourage, near airport incompatible land uses before they occur:

- Overlay or, conventional zoning and control of planned unit developments with certain density of clear zone requirements attached.
- Subdivision regulations requiring open space, restrictions on development in stipulated zones, and other constraints.
- Building code restrictions or conditions to insure sound proofing.
- Agreement with land owners for avigation easements granting over-flight rights even if such an agreement carries a price tag. It will release the local government authorities from claims against any nuisance, damage or other claim arising from operation of the nearby airport.
- Real property notice requirements pursuant to state law, which alert the buyer to the location of the airport, and possible nuisances or damages which might follow.
- Airport runway and clear zone requirement over and above what any regulatory agency, such as the FAA, might otherwise mandate.
- Buy-out by the local government of real property in certain identification zones, either by agreement, or by condemnation under police powers.

However, some airports have expressed the desire that the federal government play a much stronger role in ensuring land use compatibility. The compatible land use guide entitled “*Land Use Compatibility and Airports* (1998)” was developed for airport managers, local land use planners, and public officials, with the purpose of providing information on FAA programs, and to promote an understanding of land use compatibility around airports. When local land use planners and airport planners evaluate new development around the airport, the FAA guidelines stipulate that (1) the local comprehensive land use plans are incorporated with the airport master plan; and (2) a comprehensive review is required for the types of future land uses.

According to the compatible land use guidelines, several regulations related to planning have been enacted over the years and are summarized below:

- Federal Airport Act, 1946 - Established a federal airport grants-in-aid system known as the Federal Aid to Airports Program (FAAP). It was replaced by the Airport and Airway Development Act (AADA) in 1970. This act obligated the airport owner to operate, maintain, and comply with several standards and assurances.
- Aviation Safety and Noise Abatement (ASNA) Act, 1979 - Assists airport owners in preparing and carrying out noise compatibility programs.
- Federal Aviation Regulations Part 150 Airport Noise Compatibility Planning Program, 1981 - Funds airport noise compatibility planning programs and provides financial assistance to airport owners to assess noise impacts, and identify and carry out noise-reduction measures.
- Airport Noise and Capacity Act, 1990 - Enacted in recognition of the need to establish a uniform policy at the national level to reduce aviation noise and preclude the proliferation of local noise and access restrictions. Required a phased elimination of the operation of civil, subsonic Stage 2 turbojet airplanes over 75,000 pounds to or from airports in the contiguous United States by December 31, 1999.

Many articles exist that provide a survey of federal noise legislation, and their effectiveness. Wesler 1981, Hartman 1986, and Foster 1977 all give an account of these regulations and provide a review of how they are executed in the aviation industry. The land use compatibility guide also includes a list of preventive measures against the introduction of additional noise-sensitive land areas within the existing, as well as future noise contours. These measures, also called land use controls, are as follows:

- Zoning Changes, Residential Density - planned development, large-lot, and multi-family zoning.
- Noise Overlay Zoning - special regulations for high-noise areas.
- Transfer of Development Rights - zoning framework to authorize private sale of development rights to encourage sparse development in high-noise areas.
- Environmental Zoning - environmental protection zoning to support airport land use compatibility.
- Subdivision Regulation Changes - requires dedication of noise/aviation easements, plat notes.
- Building Code Changes - requires sound insulation materials in new construction.
- Dedicated Noise/Avigation Easements - requires development permits.
- Fair Disclosure Regulations - requires seller to notify buyer of aircraft noise.

- Comprehensive Planning - policies supporting land use compatibility; can involve specific land use plans and policies to guide rezoning, variances, conditional uses, and public projects.
- Capital Improvement Programming - public investments which support airport land use compatibility.

Apart from these preventive measures, the guidelines suggest possible remedial measures for noise issues in existing incompatible land use areas. A summary of the suggested remedial measures are as follows:

- Guaranteed Purchase (Fee Simple) - outright purchase of property with the intent of removing incompatible use by demolition of structure.
- Development Rights Purchase - purchase of rights to develop property.
- Land Banking - acquisition of vacant land for long-term airport facility needs.
- Redevelopment - acquisition and redevelopment of property.
- Purchase Assurance - airport acts as buyer of last resort, sound-insulates house, sells property, and retains easement.
- Noise/Avigation Easement Purchase - purchase of easement only.
- Sales Assistance - airport sound-insulates house, guarantees that the property owner will receive the appraised value (or some increment thereof, regardless of final sales value that is negotiated with a buyer), retains easement.
- Sound Attenuation - the airport provides sound insulation for homes and other noise-sensitive institutions while retaining an easement. This is the most prominent and expensive noise-mitigation effort employed by airports. A survey of the top 50 airports in the United States determined the six highest average amounts spent annually for home insulation are as follows. O'Hare: \$25 million; Minneapolis: \$17.5 million; Seattle Tacoma: \$15 million; Los Angeles and Atlanta: \$8 million; San Francisco: \$7.5 million; and Boston: \$5 million (City of Chicago, 2000).

All of these efforts can be significantly strengthened with a more comprehensive understanding of noise annoyance and a better system of metrics with which to predict it. Because annoyance is subjective, even if aircraft create no pollution and are perfectly silent, just the sight of one may cause someone to become annoyed or complain. For many decades, the same subjective factor (Schultz, 1978) has been used to address and even predict the level of annoyance that can be expected from the public living in areas that surround airports. There is a growing consensus, however, that one metric is not sufficient to predict and address the multitude of highly subjective factors that play a role in aviation noise annoyance (Rice 1984).

3. Project Overview

This research activity endeavored to assess how airports are impacted by incompatible land use and how this phenomenon fuels noise concerns and complaints. Many airports built in sparsely populated areas soon become surrounded by densely populated developments that subsequently generate frequent noise complaints. Air commerce is an important and necessary factor in today's economy, whether it supports large city businesses, engenders vacation travel, or promotes leisure community development. As an integral part of local and regional economies, airports must peacefully coexist with their surroundings while meeting the changing needs of the community. At the same time, if airports are to be effective at providing for the

travel and commercial needs of local and regional populations, they must be accessible and provide a wide range of services.

The first step of this study was to explore the detrimental factors which lead to incompatible land use in the vicinity of airports. To this end, three airports were selected for this study. Noise concerns and complaints experienced as a result of incompatible land use were examined. This study encompassed representative airports for airline hub and non-hub operations as well as heavy use corporate aviation airports with histories of noise concerns resulting from incompatible land use. The research explored the developmental history of the selected airports, as well as the land use surrounding their various locations. Attention was given to operational patterns such as approach and departure corridors, times of peak operation, changes in the operational nature of the airport over time, and correlative changes in noise issues. Additional efforts included quantitative analysis on census data, documenting trends, and searching for indicators and factors that affect population growth around airports. Purdue researchers coordinated their findings with census data maps prepared by Florida International University (FIU) in order to determine if patterns in noise issues and complaints were correlated to flight tracks, demographic data, and operational schemes.

We aimed to study the procedural patterns, varying sizes, and geographic locations of airports that may greatly affect the nature of land use issues and noise complaints. Indeed, these three airports represent the vast majority of air carrier airports in the United States, in terms of their sizes and operational patterns, and also in terms of the challenges they face related to land use and noise impact issues. The following case studies will not only highlight these airports in more detail and explain the varying challenges they face, but also show how communication between all stakeholders serves as the common denominator for success in each situation.

Common to these airports is their historically persistent noise complaints and other issues related to incompatible land use. Changes in size, operational levels, runway orientation, and approach/departure procedures were parameters captured by this assessment. The evolution of these airports was studied in conjunction with the emergence of incompatible land use issues and complaints. Together, the varied nature of these airports provided insights into the problems being faced around the country and globe. A brief introduction of the three selected airports is given below.

Fort Lauderdale-Hollywood International Airport (FLL) was chosen for this study based on its history, its important role in the south-Florida airspace system, and the increased demand it has seen in recent years. It was chosen to represent the mid-sized origin and destination airport. FLL is an origin and destination airport that has seen rapid growth over the past decade. It is surrounded on all sides by residential, commercial, or industrial development. Yet its proximity to the ocean and other major airports has placed constraints on its prospect of growth. This airport represents the medium-sized airports around the country that are continuing to expand, but that are still constrained by the near airport development of residential housing. FLL is a classic example of a landlocked airport that is surrounded by residential development.

Orlando-Sanford International Airport (SFB) was selected to represent the regional-sized or “reliever hub” airport. It has similar trends in growth as FLL, but serves a much more specific role as a Naval Air Station (NAS). Although it was also a military base during World War II, land use developments around the airport are not as dense as those found around FLL. SFB is a reliever hub for Orlando International Airport causing over 90% of its traffic to be general aviation and training-based operations. SFB represents the nation’s small hubs that are increasing in size and utilization, as larger hubs are approaching capacity limits. Its traffic is

greatly varied depending on the time of year as it serves as a U.S. point of entry for European tourists visiting nearby attractions. This translates into noise concerns and complaints that greatly fluctuate from week to week and season to season. Studying SFB provided an excellent insight into the effects increased operations can have on a local community.

Denver International Airport (DEN) continues to stand as one of the busiest airports in the United States and around the world. Its 10-year history has demonstrated its importance as a mid-continent hub and a gateway to the western half of the United States. DEN was built to replace the ailing Stapleton airport, the former Denver airport that had become land-locked and unable to meet operational demands. As will be discussed, DEN was opened in 1995 to alleviate land use constraints and the impact of aircraft operations and noise on the surrounding community. In our study, DEN was chosen to represent the large hub airports. It was unique in that it was one of the newest airports whose planners had access to various compatibility planning tools and guidelines.

4. Methodology

As part of the PARTNER Center of Excellence (COE), the project team researched trends and indicators of incompatible land use around airports. We also explored the problems of mitigation strategies and stakeholder dynamics.

Throughout the course of this study, we worked closely with airport administrators, civic leaders, and aviation organizations to identify and collect salient data concerning incompatible land use problems at the representative airports. Qualitative research strategies were utilized to capture and evaluate data related to airport utilization, growth, and other factors impacting noise issues and concerns. Airport managers and authorities, civic leaders, and complainants were contacted and interviewed in order to collect data concerning the most prominent issues precipitated by incompatible land use at their airport. The study reviewed the history of noise complaints for the affected airports in an attempt to identify salient issues related to annoyance, trends and cycles. Personal interviews were conducted to gather the richest possible data and the results were coordinated with other data obtained through census and Geographical Information System (GIS).

For examining land use trends, demographic data from the U.S. Census Bureau was obtained for the areas surrounding the airports. Similar information was also obtained at the county-level to provide comparison values near the airport versus the county overall. The census data was analyzed at the census tract level, since that is the smallest geographic unit for which census data is available. Parameters were calculated on a per unit area basis to allow comparisons for areas near the airport versus nearby counties. A collection of the census data was relegated to Appendix B for information.

At the beginning of the project, Purdue University, FIU, the FAA, and Wyle Laboratories selected four airports. Among these were Chicago's Midway and O'Hare International Airports, yet although they were not carried into the main Project 6 study, initial land use trend analysis was conducted. Aerial images were obtained for these airports.

The Chicago airports were removed from the list of case studies due to concerns regarding the potential impact of the interviews upon public perception. Although correlation of the complaint data with the census data is not possible for these airports, the census data can still be used to augment the growth trend database. For this reason, the trend data for the Chicago airports is included in the study, although the correlation will not incorporate these airports. In lieu of the removal of the Chicago airports, Denver International Airport (DEN) was added.

Since DEN started operations at its new location in the mid-1990s, it allows the opportunity to examine population growth early in the life of an airport. Moreover, the previous location of DEN in Stapleton provides additional historical data of an area that has become encroached.

During this phase of Project 6, Purdue and FIU worked with several collaborators including Wyle Laboratories, various airport noise offices, community members, and several departments within Purdue University. These collaborations served to enhance the quality and robustness of the research, and allowed for a more thorough investigation.

One of the primary collaborators at Purdue was the school of Mechanical Engineering. In January 2005, noise samples were collected at both FLL and SFB. They were returned to Purdue where the original data was analyzed. These noise samples were used in laboratory experiments to study human perceptions of noise and to gauge annoyance. Although the experiment was not directly linked to Project 6, general findings of the study suggest that an individual's perception of noise is influenced by factors such as loudness, sharpness and roughness of sound. Certain types of aircraft were found to be more annoying than others due to their specific qualities in those areas. Finally, Wyle Laboratories provided assistance in acquiring aircraft flight track data for the research airports and, on several occasions, provided oversight and advice on methodologies.

5. Multi-Airport Trends

Several common themes emerged when noise complaint data from the study airports was compared. It was found that most complaints tend to be focused on low and loud aircraft. Higher densities of complainants are usually found under flight paths suggesting frequency of flights as a predictor. Initially, there appeared to be a significant portion of complaints related to certain aircraft types such as MD-80s, B-727s, and other older aircraft models. However, this was not consistent for all three airports due to their differing fleet mixes. There were only a few complaints concerning emissions or other environmental issues.

5.1 Chronic Complainants

Chronic complainants are defined as single households who protest excessively and make up a large percentage of an airport's annual recorded complaints. However, research findings show that no specific formula exists for defining that percentage. Several variables are involved in determining if an airport has a chronic complainant problem. These include:

- Total number of yearly complaints,
- Total number of households submitting those complaints,
- Airport size,
- Number of operations per day, and
- The population of the surrounding area.

Analysis of noise complaint patterns at SFB and DEN indicate that the majority of complaints at both of these airports originate from individual chronic complainants. For example, in 2003, DEN's top complainant submitted 1,151 of the 4,694 total noise complaints. This accounts for 24.5 percent of the total complaints for that year. Similarly, in 2004, the top complainant submitted 25 percent of the total. This trend continues for other years and these two airports are therefore considered to have chronic complainants. In recent years at SFB, the top ten chronic complainants have been responsible for well over 75 percent of the total noise complaints received by the airport.

When the total number of submitted complaints is within several percentage points of the total number of households submitting the complaints, it is likely that no chronic complaint problem exists at that airport. This is the case at FLL where, between 1997 and 2005, the household with the highest number of complaints only submitted 287 complaints. The next highest household complaint number was 98. The vast majority of complaints at FLL come from nearly the same number of households. In contrast, at SFB, the highest household for one year in 2004 submitted over 550 complaints. When you consider the total number of complaints and the populations surrounding these two airports, this data becomes even more important.

Chronic complainants cite a variety of reasons why they are annoyed by air traffic. In general, the low and loud infractions are cited. Even if these are legitimate concerns, what sets chronic complainants apart is the volume of complaints and the unique manner in which they are submitted. For example, a chronic complainant at DEN has called the noise hotline from work to complain about an aircraft that he could see flying over his residence. In this case, the individual is complaining about the amount of noise he would have been subjected to had he been at home. Chronic complainants tend to call for each and every aircraft that they see, without thinking if that particular flight is truly disruptive.

Our researchers took a close look at this by conducting interviews with several chronic complainants. The individuals could rarely explain why they were upset. More often it was found that because a flight was going over their heads, they believed it deserved their attention. One hypothesis our researchers formed during the course of these interactions is that these individuals use noise complaints as a way to feel involved in their communities. It was discovered that these individuals are not always truly annoyed by each incident they complain about; rather they might be annoyed with the airport as a whole or something that is completely unrelated. Some chronic complainants have mentioned that they feel it is their “duty” or obligation to voice their concern about aircraft noise on behalf of the community or subdivision in which they live. One SFB resident was known as her neighborhood’s aircraft noise complainant. This resident admitted that not every aircraft she complained about actually annoyed her. She stated that she complains anyway about aircraft she thinks will annoy her neighbors. When our researchers talked to others who lived in the area, they stated they did not complain about the airplanes even if they were annoyed, because they knew this neighbor would take care of it for them. This situation provides an inaccurate portrayal of the noise complaint situation to the airport noise office, and makes it harder for them to deal with the actual issues.

Each airport deals with chronic complainants in a different way. SFB has been successful by visiting residents in their homes and attempting to understand their concerns first-hand. However, this is usually only a temporary fix. A short time following the initial meeting, most residents continue to submit numerous complaints to the airport. Most chronic complainants submit relatively excessive numbers of complaints for a period of time ranging from six months to several years. At some point, the number of complaints submitted begins to decrease or even stop. When our researchers asked airport officials if they knew why this happened, they had several explanations. In their experience, they said that sometimes complainants would move away from the area or stop complaining because they became frustrated. One resident reported that he was not seeing any changes, and felt that the airport could not do anything further to help, yet the resident was still annoyed with the aircraft noise. Another former chronic complainant reported that she stopped complaining after she got a job. Previously, she had been at home during the day, and experienced more air traffic, but once she became employed, she experienced less noise from air traffic, and her complaints subsequently decreased. These and

other lifestyle factors play an important role in understanding the dynamics of chronic complainants, and how to best handle their concerns.

5.2 Methods of Complaint Collection

The method airports use to collect and organize their noise complaint data is crucial to the usefulness of that data during analysis. For this study, FLL and SFB provided researchers with raw noise complaint data. Raw data for DEN was not made available because they perform in-house complaint analysis. All three airports utilize similar methods to capture complaints when they are submitted. At FLL, complainants can place phone calls to the airport noise office or community outreach center, and they are also able to file complaints in person at the community outreach center. Recently, FLL updated their website to include a page for online complaint reporting. The online form does not capture the same data from the complainant as does the one used when a resident calls the airport. When a resident files a complaint over the phone, a standard form is filled out by the person receiving the phone call. However, depending on who records the complaint, varying levels of detail are recorded. Also, if a complainant files many complaints in one day, all of those complaints likely end up on one complaint form. This can cause the complaint data to misrepresent the public's concerns during analysis.

At SFB, residents are able to file noise complaints by calling the airport noise hotline or by submitting them online. Similar to FLL, complaints filed over the telephone are recorded by different people. Depending on how busy that person is, or their level of knowledge about the individual complainant, the depth of information recorded can greatly vary. In some cases, noise complaints are recorded on scratch paper and never transferred to the standard noise complaint form. Online forms are more consistent, but sometimes lack important details about the complaints. DEN provides residents with a noise complaint hotline and, an online reporting website. Denver receives the majority of complaints from phone hotline, but has a standardized way of recording each complaint, therefore making data analysis more consistent.

One of the primary flaws of the present methods of complaint collection is that they often fail to capture the actual reason someone is complaining. All methods mentioned above ask complainants why they are complaining by providing a list of predetermined options from which to choose. Several main trends have been identified among repeat complainants. They will either: (1) Select all options available due to their high level of annoyance or frustration, (2) always select the same options regardless of the true reason, or (3) provide no reason why they are complaining. These practices by repeat complainants only serve to confuse airport noise officials, and make it harder to help individuals with actual noise problems.

Comparing noise data between FLL and SFB provided great insight into why residents complain. However, until a standardized format and method of complaint collection and reporting is established, it will remain difficult to effectively compare data between airports.

5.3 Community Outreach and Education

The most effective method identified for improving community support is the establishment of a relationship with the complainant. According to interviews with noise managers and community members, the most positive results occurred when airport officials took additional time to sit with the concerned community member and discuss specific issues. Although this does not always result in decreased noise complaints, it does increase rapport between the community and airport. This increase in rapport is beneficial for both parties, because it adds trust and perspective to the experience.

Community outreach is an essential tool to ensure successful airport operations and development. Many airports focus on community outreach in different ways depending on state requirements and resource availability. For example, California recognizes community outreach as an integral part of the airport's daily operations and requires the airport through Title 21 to include the community in many aspects. The community is included in important decision making for development, noise and land use decisions, and many other important items. Many other states have not yet taken such a proactive approach. Some comprehensive understanding of community outreach was gathered through interviews with public outreach programs, noise managers, and other active community members who estimated the success of an outreach programs. The most successful programs are ones that are serious about reaching communities, educating, and mitigating them. These programs run similar to any other company public relations office, and some airport community outreach programs employ public relations personnel to ensure professional style and successful results. If airports take the time to establish proactive programs that are centered on education and communication with the local communities, then there will be a positive experience for all parties. Helping people on the individual level does improve individual attitudes about the airport. A detailed description of the airport programs are in Sect. 6-9, but are summarized below.

FLL has a full-time noise office and community outreach program specifically developed to respond to public concerns related to the airport's proposed expansion. This airport has a moderately proactive approach. They respond to specific noise and expansion concerns on an individual basis and, by staffing a Community Outreach Center where citizens concerned about the expansion can learn more about the project. This outreach center provides the community with valuable information that can be easily understood and may relieve some stress about the adverse impact due to the proposed expansion of the airport. The multiple projects currently underway at FLL were presented at a public forum in February 2006. Representatives from the airport and consulting firms were in attendance to present the ongoing projects, and to respond to the questions and concerns of the public and other community groups. FLL has made an excellent attempt at maintaining open communication with the public and providing them with educational opportunities. The difficulty with these types of programs is that the public will only benefit if they attend, or are willing to make an effort to meet with airport officials.

SFB has also made an effort to address noise concerns in the community in a variety of ways. The key to some of SFB's successes is that the noise officer has worked diligently to establish a relationship with individual complainants, especially those deemed chronic. By meeting with them one on one and taking the time to personally answer their questions, chronic complaints have decreased. SFB has also attempted to provide educational outreach through the Sanford Aviation Noise Abatement Committee (SANAC). The establishment of a noise abatement committee served to demonstrate to the community that the airport was open to discuss the community's concerns regarding noise-related issues, as well as the airport's plans to handle them. It also offers the community members a venue where they can meet other concerned citizens and public officials in an attempt to understand the dynamics of aircraft operations and the associated noise. Some community members have expressed during interviews that the education provided, although a good attempt, has been inadequate, and that the SANAC needs to provide a more effective communication with the community. The community has also expressed feelings that the inconsistency of SANAC meetings causes them to reconsider the airport's commitment to a reduction in airport noise. Another constraint SFB faces is that, due to its size, the airport is not equipped with sufficient resources to always

address the problems effectively. The noise officer has a variety of tasks to accomplish, and cannot always spend the time that is necessary to consistently address citizens' concerns.

DEN is an airport that has diligently attempted to anticipate noise concerns from the community. Because of the low number of noise complaints, the noise office has become primarily reactive to citizens' concerns. When there is a concern, someone in the noise office will contact the individual to understand the concern and provide pertinent information. The Noise Working Group (NWG) is another tool that DEN can use to address noise issues. Currently the NWG is utilized on an as-needed basis and therefore does not proactively discuss ways to address noise concerns. DEN is well-equipped to handle increased noise complaints if the need ever arises. The airport does not currently utilize a standard method for noise or aviation education. As such, this may be an area for the noise office to explore and establish in preparation for residents moving into the new High Point development.

All three airports would benefit from studying successful community outreach and education strategies used at other airports around the country.

Additional airports have taken proactive measures to mitigate noise and have also initiated comprehensive outreach programs to educate the impacted communities. O'Hare's Noise Compatibility Commission (ONCC) and the San Francisco Roundtable were seen as two good examples of these outreach programs.

O'Hare's Noise Compatibility Commission (ONCC) has been very successful in developing compatible land use around O'Hare and ensuring that the airport takes proactive steps to mitigate noise impacted areas. The ONCC recognizes education as a foundation of community outreach, and spends time instructing the public on a variety of noise related topics. The ONCC works with public officials for compatible land use cooperation and interfaces with the airport and Air Transport Commission (ATC) to balance flight tracks. The ONCC's most successful initiative is its home and school insulation program. With the onset of the O'Hare Modernization Program (OMP), the ONCC will have to continue proactive strategies in order to mitigate communities' concerns about the construction and the impact it and the new runway configuration will have on other previously unaffected communities.

The San Francisco Roundtable; California's Title 21 has established that airports take initiative in established, solid, proactive community outreach programs. Airport noise managers at other California airports have mentioned to the researchers that they have modeled some of their community outreach efforts after those of the Roundtable. The Roundtable has been successful in facilitating cooperative compatible land use development. It is also noteworthy to mention that the cooperation is composed of many different city councils, which is indicative of the success of the program. The Roundtable also facilitates home insulation programs, noise complaint reports, and continually updates the noise mitigation strategies to ensure continual growth and success of the program. These three activities are a part of the Roundtable's successful Fly Quiet program that is being modeled by many other California airports. Perhaps the most effective strategy for community outreach is the educational workshops for the public. The researchers interviewed a chronic complainant in San Francisco who had attended the Roundtable's informational meetings and reported these educational meetings to be extremely helpful to his and the public's understanding.

Some strategies identified through interviews of other airport officials have proved ineffective. Although proactive education is pivotal to successful community relations, there is evidence that providing the public with excessive information can cause new problems. Some offices address concerns by sending the complainant a comprehensive noise monitoring report of

the noise levels and the altitude of the offended aircraft over that individual's location. Although initially this seems proactive, when community members were asked about how helpful this was to noise education, it was reported to be of little value. The community members reported that although this additional technique was indeed time consuming and demonstrated airport initiative, it was not information that was useful. The ANOMS data and maps are too technical for the average complainant, and in some cases tend to frustrate the complainant further, because they do not understand what the data represents. Education is essential for community outreach success, but it must take a form that is understood by the average citizen. Aviation jargon and terminology should be explained in simple language. The FAA/NASA/Transport Canada-sponsored Center of Excellence, PARTNER, is currently working to develop a website called NoiseQuest which could possibly serve this purpose. NoiseQuest is a website dedicated to providing the public with educational material related to noise and aviation operations, which could be used to distribute standardized information to complainants or concerned citizens at no direct cost to airports. As such, it will be a very useful tool for the public.

It is important to understand that annoyance with aviation noise and noise complaints are two separate issues. Noise annoyance does not always lead to noise complaints. Also, many noise complaints are not in any way related to aviation noise. Other factors such as fear and environmental concerns can trigger community members to submit noise complaints. Complaints that are related to aviation noise are not always due to the loudness of aircraft over-flights. There are many other offenses that are frequently cited as the reason someone submitted a noise complaint. These include frequency of flights, perceived altitude of aircraft, and time of over-flights.

The subjective nature of complaints makes it extremely hard to understand and mitigate the issues surrounding them. In many instances, solving one complainant's problem will create other problems for residents who were previously not affected. For instance, many residents have suggested that the airport instruct aircraft to fly over a different area of their town. What they fail to realize is that this would expose other residents living under the new flight path to unwanted noise, thus resulting in a relocated problem, not a solved one. Another contributor to the difficulty of dealing with noise complaints is that noise complaint problems can be misrepresented because of the high volume of complaints submitted by chronic complainants. These high levels of single household complaints can skew noise complaint data and make it very difficult for airport officials to measure the severity of the noise problem at their airport.

The following three sections provide specific case studies of three diverse airports, addressing the common challenge of land use compatibility.

6. Fort Lauderdale-Hollywood International Airport

As with many airports across the country, Fort Lauderdale-Hollywood International Airport (FLL) is a vital component of its local economy, which includes Broward County and most of southeastern Florida. At Fort Lauderdale, the ability for the airport to expand and grow is greatly dependent on its relationship with the community and their cooperation; perhaps even more so than airports not facing a population density as high as that which surrounds FLL. Vital to its ability to continue meeting air traffic demands and fulfilling its role in the economy is a balanced approach of community and airport communication, cooperation, and compromise.

6.1 Background

Fort Lauderdale's airport began as Merle Fogg Field on May 1, 1929 at the site of an abandoned nine-hole golf course. In 1942, the United States Navy selected the airport to be improved into a naval air station (NAS) for training pilots of aircraft carrier-based torpedo attack planes. At the peak of the effort, 3,600 naval personnel were stationed at the facility. After World War II, the Navy closed NAS Fort Lauderdale and the airport remained dormant for three years (Jenny). In 1946, the airfield was acquired by Broward County and has since operated as a civil aviation facility (Broward a).

The history of FLL explains more than just its transition from a NAS to a civilian airfield, it explains the context within which land use planning began around the airport. During its years as a navy base, communities and naval housing were built up around the airport to support military personnel stationed there. Unfortunately, land use planning guidelines were not in existence when these developments were constructed. After its transition to a civilian airport, development around the airport continued based upon the existing infrastructure. This led to further residential housing and other incompatible land use projects. This trend has created a huge challenge for airport planners and municipal developers as they have tried to serve the interests of both the airport and the community. The landlocked nature of FLL and its importance to the airspace system in southeastern Florida make it essential to find solutions to problems related to land use. This report will describe the operational nature of the airport, its importance to the region, and several examples of how incompatible land use has affected the airport-community relationship.

Today, FLL is considered one of the nation's fastest growing airports. Its proximity to the oceanfront, the world's second largest cruise terminal, numerous golf courses, popular sporting venues, and other cultural destinations help to explain the rapid increase in its traffic numbers over the past decade, and thereby making it one of the primary air carrier airports in southeastern Florida. As shown in **Figure 6.1**, it is located approximately 18 miles to the northeast of Miami International Airport, and approximately 40 miles to the south of West Palm Beach International Airport. The airport has three runways; the two main runways are oriented east-west and the crosswind runway is oriented northwest-southeast. Due to the predominant winds, 80 percent of



Fig. 6.1 Fort Lauderdale

aircraft land and depart to the east. **Figure 6.2** shows an aerial photograph of the airport including the standard arrival/departure pattern.

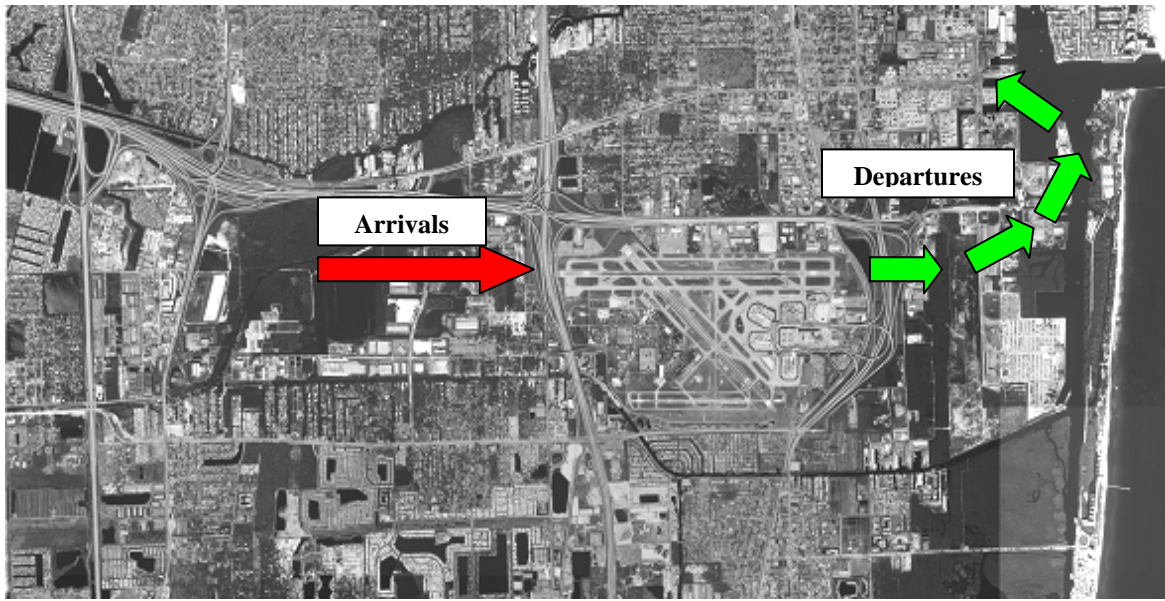


FIGURE 6.2 – FLL Aerial View including Standard Arrival/Departure Paths

6.2 Land Use

In 2005, 22.4 million passengers traveled through the airport making it the 24th busiest in the country. Compared to the passenger count from 2001, this is a 35% increase (ACI-NA 2005). To meet constantly increasing load demands, the airport continues to expand and improve its facilities. In 2004, FLL completed a \$695 million modernization program of the airport. FLL employs nearly 36,000 people and reports an annual economic impact of \$2.3 billion on the local and surrounding areas. From 1997 to 2002, the airport's direct economic impact on Broward County increased from \$559 million to \$884 million, a 58% increase (Broward b). In November 2004, Broward County Commissioner Ilene Lieberman delivered her State of the County Address in which she stated that "the economic engines of Broward County's economy are our international airport and port" (Lieberman 2004).

With landside improvements completed, FLL is now working on plans to expand its airside facilities through an extension of its southern runway 9R-27L. This will allow the airport to handle a much greater volume of air carrier traffic and increase the airport's overall flexibility. In a 2003 report conducted by Jacobs Consultancy (formerly known as Leigh Fisher Associates), the airport's ability to impact the local economy is directly correlated to its ability to expand and grow. If the proposed runway extension is approved, the total economic impact on the regional area will reach \$5.8 billion in fiscal year 2015. However, if the airfield expansion is not approved, the airport's economic impact will be reduced by \$664 million to \$5.2 billion (LFA 2003). The economic impact of the airport has a far-reaching effect on the citizens who live in the regional area. However, as will be shown, community support for this proposed development is necessary for its success.

All information presented regarding these projects was current at the time of writing. Currently, Fort Lauderdale-Hollywood International Airport is proceeding with three large-scale

studies: a new Master Plan, a Part 150 Study, and an Environmental Impact Statement (EIS). The FLL Master Plan is a multi-phase project designed to address the expansion requirements of the airport facilities from 2010-2020. Broward County has appointed Leigh Fisher Associates to develop multiple options for the final Master Plan, but selection of a final design is expected to take several years.

FLL's Master Plan is in the drafting stage. Phase One has been completed and Phase Two is expected to be published in Fall of 2006. Phase One of the Master Plan outlines analytical tasks and develops options for FLL's future expansion based on projected growth, and also includes a presentation to the Broward County Board of Commissioners (BOCC). In addition to the private presentation, Leigh Fisher has presented the Master Plan Phase One to the public on seven occasions, as well as making the presentation available on the internet.

Phase One of the Master Plan incorporates several baseline assumptions into various alternatives. These assumptions include the proposed South Runway Extension which would increase capacity at the airport. Additional terminal space and roadway enhancements are planned to meet the predicted forecasted growth. Also, the South Runway Extension has been planned subject to the acceptance of the Environmental Impact Statement (EIS). The goal of the proposed Master Plan is to ensure that none of the available alternatives are overlooked.

Phase Two of the Master Plan will ensure that the community and all airport stakeholders have been adequately informed of the options. The BOCC will be presented with the final options, and assistance in selection of the most appropriate option will be provided.

The Part 150 Study is being completed by Jacobs Consultancy and is currently in the data collection phase. The current Part 150 Study involves "analyzing existing and future noise exposure, identifying appropriate uses for land surrounding the airport, and recommending noise mitigation programs to benefit surrounding communities" (Broward c). There have been two previous Part 150 studies completed at FLL: one in 1987 and the other in 1994.

The final ongoing project at FLL is the EIS being conducted by Landrum & Brown. They were awarded the "Notice to Proceed" on July 29, 2004. Under consideration are six possible runway configurations that will be implemented in conjunction with the Master Plan in an attempt to address congestion and future growth at FLL. A key component of the EIS is public involvement. This was best showcased in a public workshop held at the Fort Lauderdale Convention Center on February 2, 2006. In attendance were representatives from Landrum & Brown, Leigh Fisher, the FAA, and the Broward County Aviation Department. The EIS was the main focus of the event, yet the Master Plan and Part 150 Study were also represented. The purpose of the event was to allow the public an opportunity to get involved, ask questions, and voice concerns about the complex process of airport development and expansion, and see how it will affect their lives.

An essential component to effective land use planning around airports is communication. Airports, local zoning offices, developers, and government officials must remain in continual contact as new projects and developments are planned and constructed. The land surrounding FLL is densely developed, as compared to the other two airports in this study. Because of this, there are currently very few controversial land use developments near the airport. However, FLL does have several land use issues that explain the importance of communication in near-airport zoning and development. In order to determine if noise complaint patterns are correlated to trends or patterns in compatible or incompatible land use, a study of these noteworthy land use issues was conducted.

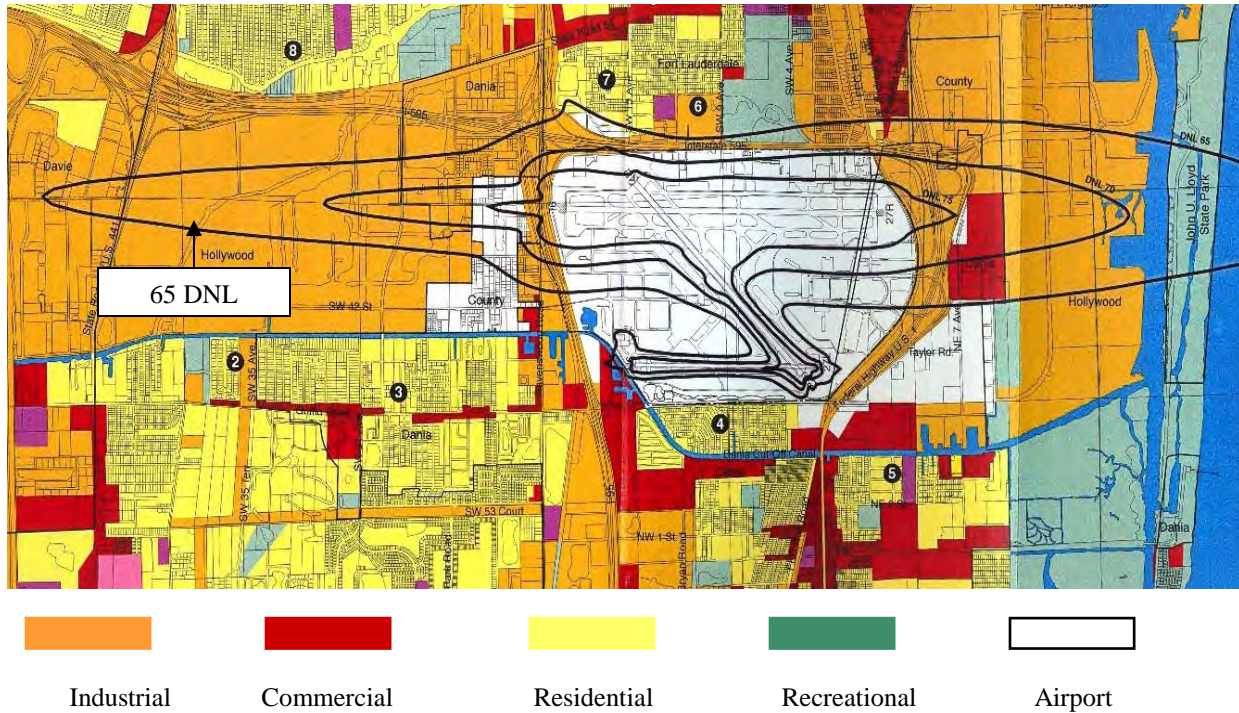
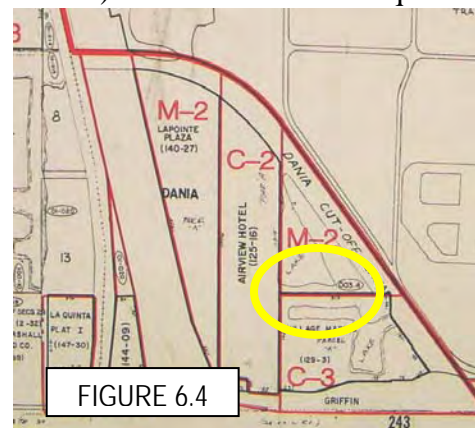


FIGURE 6.3 – DNL Contours for 2003 Flight and Runup Operations

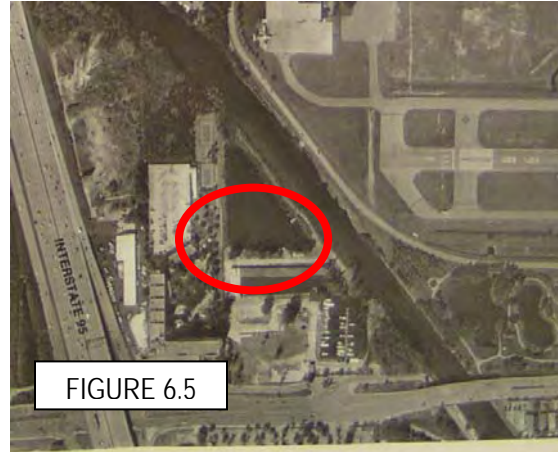
As shown in **Figure 6.3**, FLL is bordered on the north and south by pockets of residential development. Most of the residential development near FLL is further to the north, northwest, and southwest. Of the residential development surrounding the airport, only two small portions exist within the 65 DNL contour. There is no residential development within the 70 DNL. According to Florida Statute 333, disclosure regarding proximity to an airport is only required when the property is being purchased for the first time (FSL 2005). Disclosure is not required when someone is renting the property from the owner or purchasing the property from a previous owner. This potentially allows citizens to purchase or rent property and discover the impact of the airport noise only after having moved to the new location.

FLL airport officials have stated in various interviews that as new developments are planned and constructed around FLL, they try to inform and work with developers. However, the airport has no authority to enforce zoning laws or prevent near-airport construction; their only influence is to inform developers of the existing airport noise impact.

In a December 2004 interview, a FLL airport official stated that local zoning loopholes are allowing developers to rezone areas for residential development that should not be allowed for residential use. One such proposed development is located on the west end of runway 9R-27L and is referred to as the Dockominium – a condominium offering deep water access to the ocean. Currently, the land is zoned to be used for medium-industrial and conservation purposes.



As shown in **Figures 6.4 and 6.5**, the Dockominium, if allowed to be constructed, will be less than one-quarter mile from the west end of FLL's southern runway. In order to prevent the structure from entering protected airspace, it will have to be contoured specifically to fit the angle of the runway's transition area. The ownership of the development rights is currently claimed by the development company. If the airport decides it wants to stop the proposed development, the only course of action is to purchase the development rights directly from the developer. Airport administrators state that it is not in the airport's jurisdiction to halt development – the authority lies with the local municipalities. This leaves the airport powerless to have any influence to prevent incompatible land use development.



If this project is allowed to proceed, it will create several problems for the airport. The first concern related to this project is its proximity to FLL's southern runway and the effect that will have on residents who live there. At present, the primary traffic using runway 9R-27L is light general aviation traffic. Residents initially would not have large aircraft flying over their homes. However, if the proposed runway expansion is completed, the fleet mix usage of the southern runway will change drastically. Noise complaint numbers can be expected to rise significantly – and not all of these complaints will be related directly to noise. Over the past three years, both interviews with residents and noise complaint data have shown that many noise complaints are rooted in fear of aircraft over-flights or airport expansion. Also, in the event of an emergency, this structure will pose a safety threat to residents and to passengers aboard aircraft departing runway 27L. Although this structure will not protrude into the Runway Protection Zone (RPZ), it will sit directly adjacent. Furthermore, if this construction is allowed to proceed, it will stand directly in the path of any future westward runway extension. Considering these potential problems and the economic importance of the airport's ability to expand and adapt to demand, any continued progress or development of this project should be reconsidered.



FIGURE 6.6
Renaissance on the Ocean
Towers

Another example of incompatible land use planning that demonstrates the need for increased airport/local government/developer communication is a development to the southeast of the airport called Renaissance on the Ocean Towers. This pair of beachfront condominiums is directly under the typical flight path of departures using crosswind Runway 13, as shown in **Figures 6.6 and 6.7**. At the time of construction, a 2-bedroom condominium unit was selling for \$850,000. During construction the developer was made aware of the proximity of the airport as well as the potential for aircraft overflights and related noise that could be expected when the diagonal runway is in operation. Again, since the airport had no authority to halt development, construction was completed. The structures were originally designed to be 198 feet tall, however,

due to height restrictions found in Federal Aviation Regulation (FAR) Part 77, the top two floors included in the original design of the towers were not allowed to be completed. Since its completion, noise complaints from this location have been recorded. Most complainants who live in the Renaissance Towers state that their complaints are due to aircraft departures, but not usually because of the noise level. Those who complain often state they fear the departing aircraft will crash into their building.

A fundamental lack of communication is apparent in this situation and underscores the need for a closer collaboration between all stakeholders when it comes to near-airport development. The only power the airport has regarding near-airport construction is that related to height restrictions as explained in FAR Part 77. Concerning noise complaints, the Dockminium project has the potential to be a source of noise complaints especially if the southern runway expansion is completed.

Some residents of Renaissance Towers currently complain, however, following completion in early 2004 until the end of 2005, only 11 complaints were logged from this location.

As can be seen by the density of development surrounding the airport and the lack of current near-airport land use concerns, FLL's land use problems are not primarily regarding future development, but with how the airport is dealing with previously developed areas around the airport.

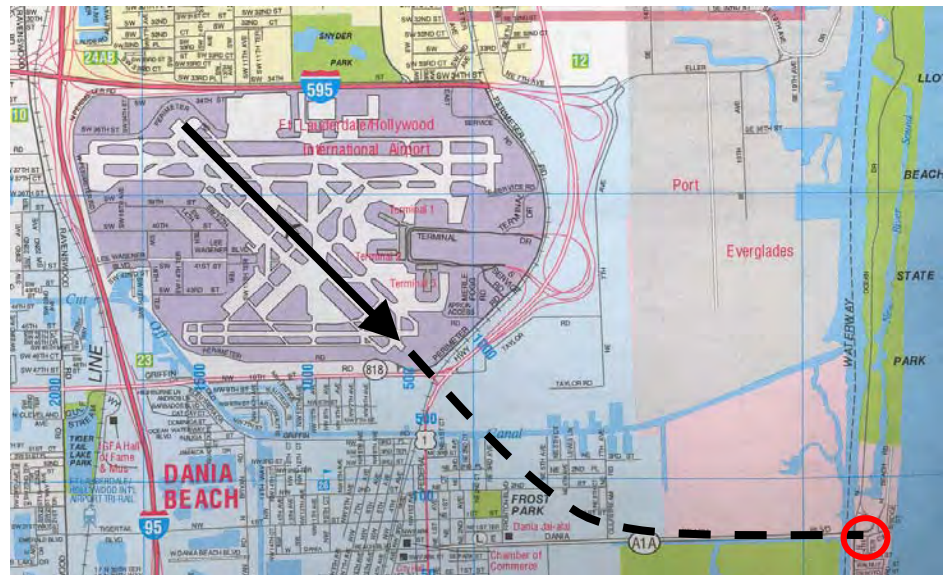


FIGURE 6.7 – Location of Renaissance Towers

Unlike Denver and Orlando-Sanford International Airports, most of FLL's surrounding land is already developed. Because of this, the biggest changes that will occur in noise complaint statistics at FLL are not related to incompatible near-airport development, but to changes in airport operations and runway usage. The following section will explore the noise complaint situation at FLL, the areas most affected by operational changes, and highlight the reasons behind resident's complaints as they relate to past land use decisions.

6.3 Noise Concerns

FLL is owned and operated by Broward County and is governed by the County Board of Commissioners. The Broward County Aviation Department (BCAD) serves as an agency of the Board and is responsible for the operation of the airport under the management of the Director of Aviation. In 1992, BCAD created the Airport Noise Abatement Committee (ANAC) "to serve as the primary mechanism for noise-related communications with and among all potentially affected and interested parties" (BCAD 2002). One of the primary functions of the ANAC is to provide a public forum for the airport and the community to interact and discuss issues related to noise.

Aircraft noise is still a serious concern for many people living near and around airports. However, due to its highly subjective nature, understanding the annoyance associated with aircraft noise is very difficult. Many variables are linked to annoyance and thus it is very hard to measure. Even though our data shows that aircraft noise level is the most common reason why citizens report noise complaints, many other elements are involved in describing annoyance. These include past experiences with aviation, local political issues, airport expansion projects, environmental concerns, and socio-economics. Unfortunately, the noise complaint data that was provided by the airport noise office is not designed to capture this kind of information. Therefore, further work in this area will be required to understand noise annoyance in a more comprehensive way.

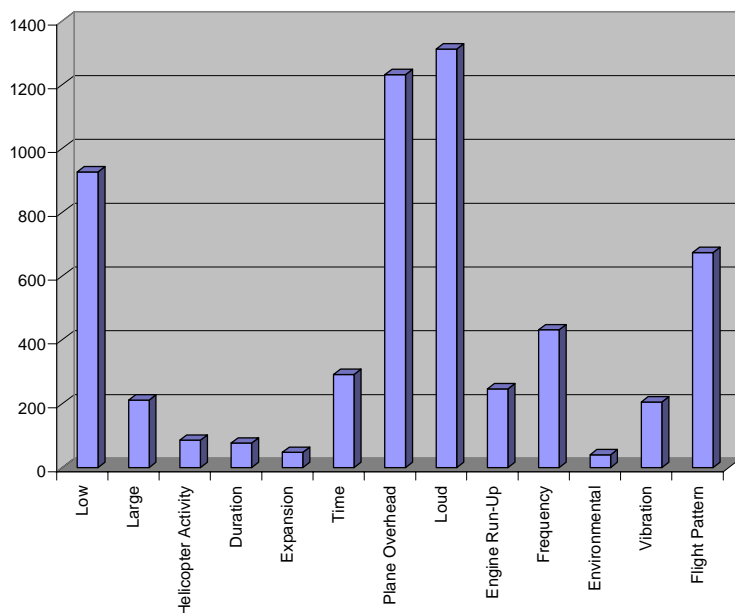


FIGURE 6.8 – Offense Statistics from 1996-2005

For analysis of noise complaints, as they relate to land use, the complainant’s proximity to the airport and the reason(s) for their complaint (as reported in the noise complaint database) were the two most important attributes studied. For the years 1996-2005, “loud aircraft,” “plane overhead,” “flight pattern,” and “low aircraft” were the most commonly reported reasons for noise complaints at FLL. **Figure 6.8** reports these offense statistics compared to all others.

Residents filing noise complaints related to aircraft noise often state that aircraft are “circling” or “buzzing” their homes and are lower in altitude than usual. The “loud” and “low” offenses are the two most often reported in tandem. Many times residents will fail to realize that the size of an aircraft flying over their home plays a large part in how high it appears. For someone not trained to identify aircraft, a Boeing 747 will appear “lower” than a Cessna 172 at the same altitude. In this case, education regarding aircraft types, flight paths, and glideslope altitudes could alleviate many of these concerns.

For the years 1996-2005, FLL had 2,754 noise complaints. **Figure 6.9** is a graph of the total noise complaint data for those years overlaid with the total number of households lodging a noise complaint. The data indicates that the complaints collected by the airport during this time were submitted by a relatively large number of households. This suggests that FLL does not have any “chronic complainants.” This stands out when compared to the other airports in this study whose data shows that very few residents were responsible for the total number of submitted complaints. From 1996 – 2005, the top ten complainants (ranked by total number of complaints filed) only made up 21% of the total number of complaints.

Several complainants’ concerns regarding aircraft over-flights were related to the environment and are worth mentioning. Even though environmental concerns were a very small percentage of the total recorded offenses shown in **Figure 6.8**, when speaking with residents who

live near the airport, it appeared that the level of their concern was not accurately captured. These residents were primarily concerned with the health side effects related to the over-flights. They stated having witnessed aircraft dumping their lavatories and fuel tanks over their homes and neighborhoods. Also, they pointed to areas on their cars and roofs where they believe “sooting” from aircraft exhaust falls onto their homes and causes property damage. In response to this concern, it was pointed out by an airport official that the nation’s second dirtiest power plant is located adjacent to the airport and may be the source of this sooting. While these concerns do not describe most citizens who complain about the aircraft, they are still valid concerns in the eyes of the residents and, therefore, should be considered. This is another area where further education regarding airport and aircraft operations could be helpful.

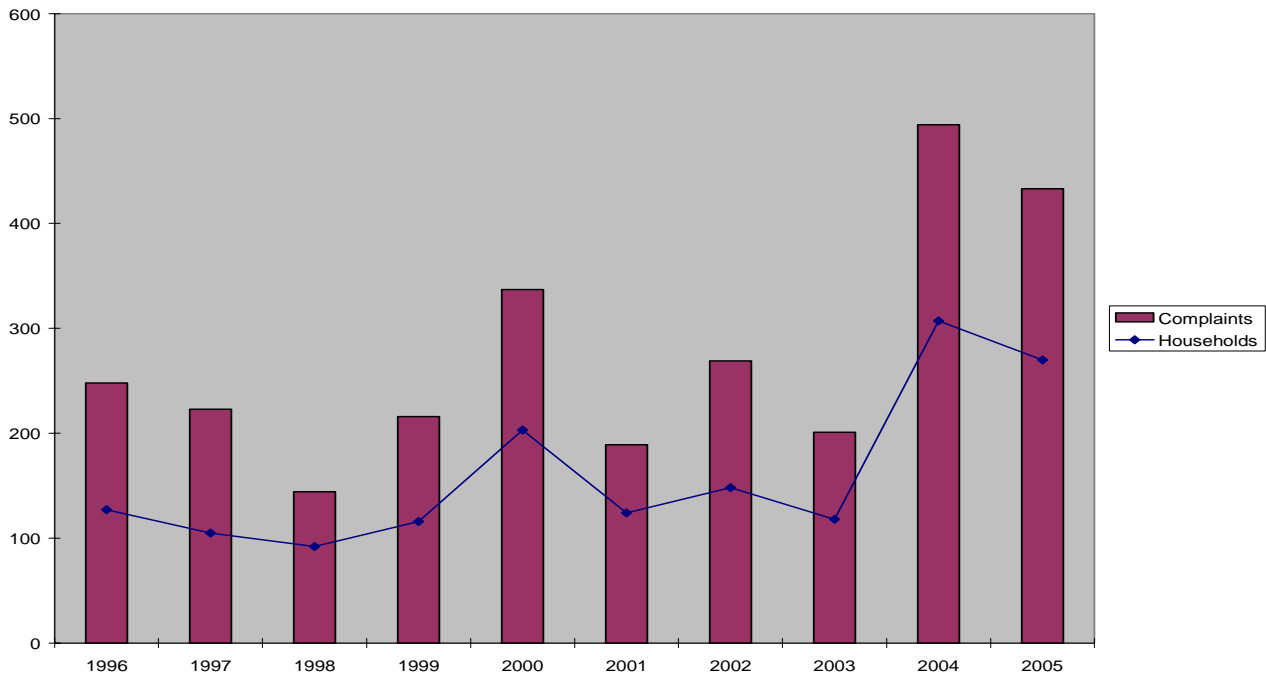


FIGURE 6.9 – Total Complaints with Number of Complaining Households from 1996-2005

6.3.1 Patterns in Noise Complaints

In order to visualize the location of the sources of noise complaints and to identify trends in the data, address information of noise complainants was extracted from the database and noise complaints were overlaid on a map of the airport and its surrounding area. Although the sources of complaints are spread across the map, specific areas were easily identified as “hot spots” for noise complaint submissions. These areas are circled in orange in **Figure 6.10**. The following cities surround the airport; each one containing an area of high noise complaint volume. (1) City of Hollywood – south and east; (2) City of Davie – directly west; (3) City of Ft. Lauderdale – directly north and east; (4) City of Dania Beach – directly south; (5) City of Plantation – northwest.

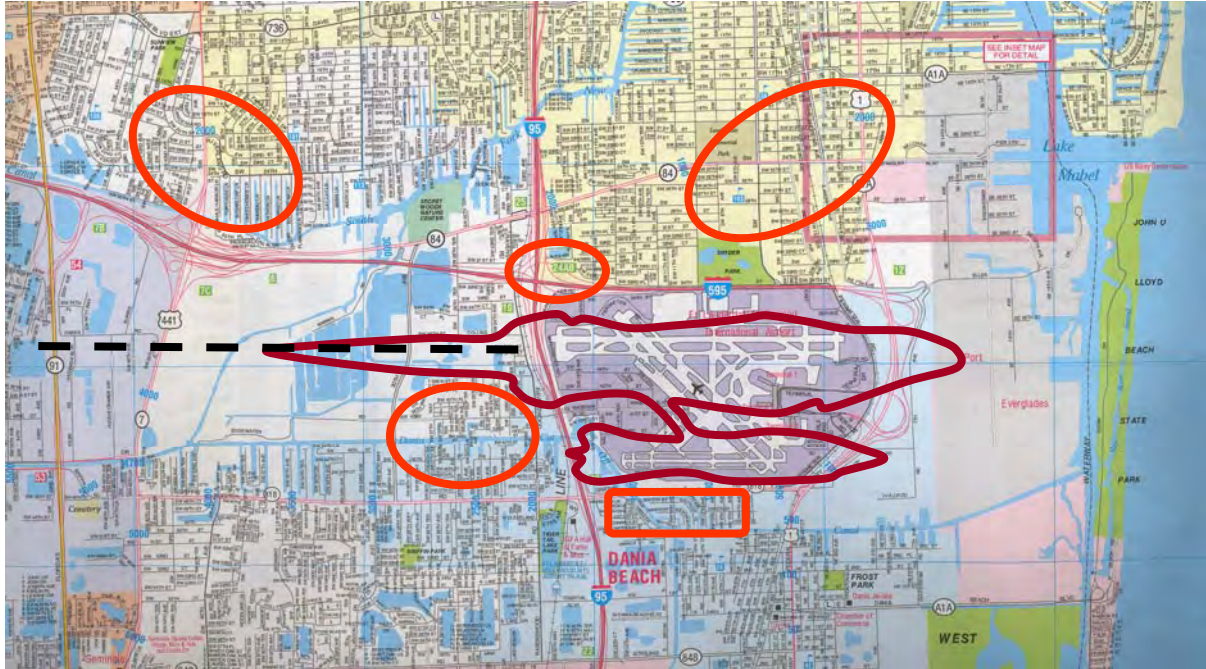


FIGURE 6.10 – Overview of area surrounding FLL with highest complaint areas highlighted

One example of this was from September 14 – October 4, 2004 when the airport performed an overlay of its primary runway, 9L-27R. During this time, the main air carrier runway became the crosswind runway, 13-31. On a standard day, arrivals approached the airport from the northwest and departed the airport to the southeast. This dramatic shift in flight patterns around the airport exposed residents usually unaffected by aircraft over-flights to increased air traffic activity and noise. Since that time, even though the main runway is now operational, the

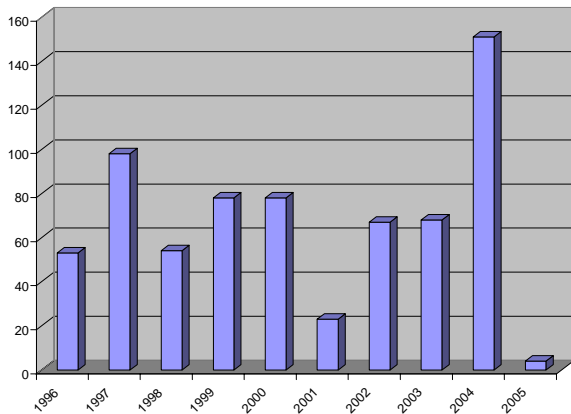


FIGURE 6.11 – “Low” Offense Statistics from 1996-2005

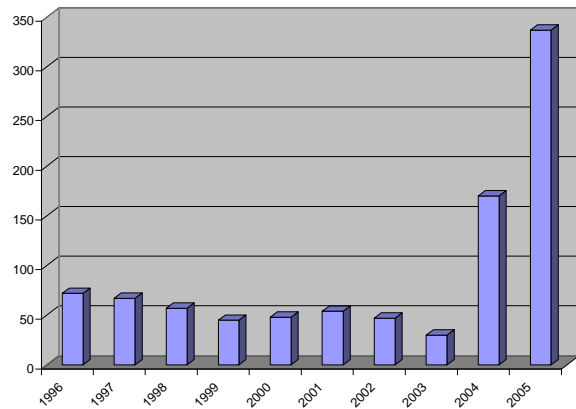


FIGURE 6.12 – “Flight Pattern” Offense Statistics from 1996-2005

crosswind runway has been used on a more regular basis. Analysis of the noise complaint data from that time period compared to previous years shows not only an 80% increase in total noise complaints, but also an increase in specific offense types that relate to this specific change in flight patterns.

As the data shows in **Figure 6.11**, “low” offense complaint statistics jumped dramatically from 2003 to 2004. This is most likely due to the new flight pattern created by the main runway closure for those few months in 2004. Similarly, as seen in **Figure 6.12**, “flight pattern” offense statistics nearly quadrupled from 2003 to 2004 and then nearly doubled again in 2005. Both of these dramatic jumps can likely be attributed to the change in flight pattern. Most citizens living around airports are accustomed to aircraft flying somewhere near their homes, but at predictable altitude and distance. However, during the overlay project, residents living to the northwest and southeast of the airport started experiencing frequent and direct flyovers on a daily basis. The airport’s Community Outreach Office reported in an interview that residents complaining about noise during this time asked questions such as, “When will this project be completed?” and “Are we going to continue to be inconvenienced after the project is done?” For those individuals who were not aware that the diagonal runway was in use, it is logical that residents chose “low” and “flight pattern” offenses to describe the reason for their complaints. As shown in **Figure 6.13** below, the flight pattern directly follows the pattern of complaints for the time the overlay project was underway. Although complaints continued from many of the same areas, new areas of complainants in Plantation (NW), Ft. Lauderdale (N), and Sunrise (NE) also emerged.

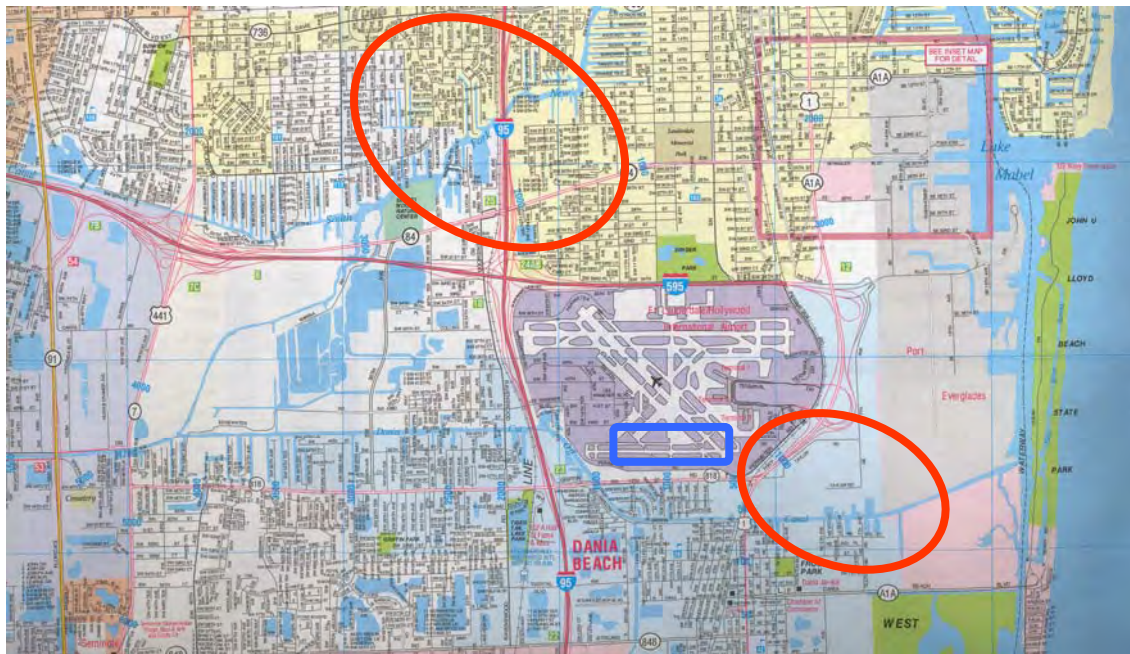


FIGURE 6.13 – Overview of area surrounding FLL with new complaint patterns identified (due to overlay project)

Another example of how airport projects greatly affect noise complaints at FLL is related to the airport’s proposed expansion of its southern runway. Melaleuca Gardens is the neighborhood located directly south of the airport and is highlighted in blue in **Figure 6.13** above. Neighborhood action groups have come together to fight against the project. Noise

complaints from this area have increased in recent years as more people have learned of the possible runway extension. Figure 3.14 shows the increase in “expansion” offense statistics over the past few years. The increases reported by this data coincide with the time frame when the airport expansion project entered the news media and more residents became aware of its existence.

During FLL’s time as a naval air station, present-day Melaleuca Gardens served as a housing district for military personnel. Since that time it has been a residential area and has developed into a very successful community. Surprisingly, this neighborhood’s location is one of its greatest assets; the area is located adjacent to a deep-water access canal that leads directly out to the ocean. Because of the area’s history as a residential community (even before near-airport land use became a hot topic), there was never an opportunity to change the zoning of this land to something more compatible with airport operations.

However, this neighborhood does provide an example of what can happen when residential and other incompatible land uses are permitted next to airports. Not only can they provide a source of noise complaints, they can pose a challenge to important airport projects, and create a negative reputation for the airport among citizens of the community.

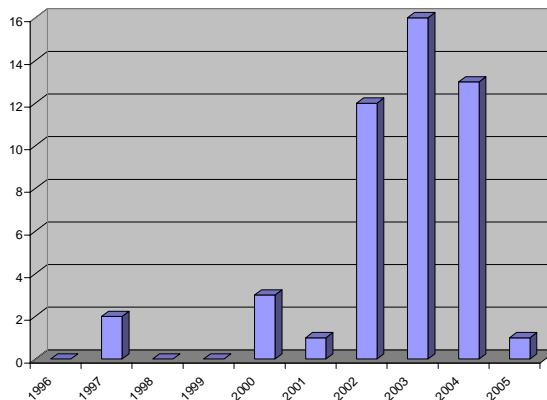


FIGURE 6.14 – “Expansion” Offense Statistics from 1996-2005

6.3.2. Noise Complaint Collection

FLL’s airport noise office collects noise complaints through several different methods. These include:

- Direct phone calls to the airport’s Noise and Environmental Officer:
 - Complaints are recorded by hand;
 - Noise officer uses Airport Noise Monitoring System (ANOMS); information to link the specific complaint to the correct airport;
 - ANOMS data is also used to provide complainant with information about the noise levels and the aircraft that flew over their home;
- Direct phone calls to the Community Outreach Center:
 - Outreach officer answers the questions of the resident and explains current airport projects;
 - Phoned-in complaints are forwarded to the airport’s noise office;
- In-person at the Community Outreach Center:
 - Outreach officer explains current operation status of the airport;
 - Records personal information for each complainant;
 - Forwards complaints to the airport’s noise office;
- Portable Document Format (PDF) online noise complaint form :
 - Filled out by resident and e-mailed to airport noise officer.

For each airport in this study, noise complaint information was collected for all available years. A Microsoft Access noise complaint database was created to track noise complaint

information for SFB and FLL. DEN tracks and compiles its own noise complaint information and reports it online (therefore their noise complaint information was not entered into the database). Information tracked in the noise complaint database includes:

- Complainant contact information;
- Reason for complaint (i.e. low aircraft, frequency of over-flights, etc.);
- Date and time of complaint offense;
- Comments included by complainant.

A form, which includes a list of possible reasons, is completed when a resident has filed a noise complaint through telephone. During the telephone conversations, the noise complainants are asked the reason(s) for their complaints. The same form is also available online for residents to fill out and email to the airport. All stated reasons were captured and entered into a database for subsequent processing. The following is the full list of those reported reasons:

- Low aircraft;
- Helicopter activity;
- Duration of noise event;
- Airport expansion;
- Time of noise event;
- Plane overhead;
- Loud aircraft;
- Engine run-up activity;
- Frequency of noise events;
- Environmental concerns;
- Vibration;
- Flight pattern offense.

Through personal interviews with noise complainants and airport officials, the fear of aircraft crashing into citizen's homes is often found to be an underlying motivator for filing noise complaints. However, it was not included in this list because it was never formally reported on a noise complaint. From this list, it becomes clear that the term "noise complaint" is somewhat of a misnomer. In other words, many other reasons exist for filing a complaint besides the presence of a loud aircraft.

6.4 Airport and Community Relations

In an effort to improve relations with nearby communities, Broward County has created several intergovernmental agreements (IGAs) with local municipalities related to airport operations. One of these is with the City of Dania (south of the airport). The airport agreed to give the City of Dania \$ 1.6 million. In exchange, the city would no longer encourage its citizens to oppose the airport expansion program by submitting noise complaints. However, this agreement has been broken. An airport official stated in a December 2004 interview, that Broward County is not pursuing action against the city because they believe the effort would be futile and cause bad publicity for the airport. Melaleuca Gardens is one of the communities within the City of Dania.

As part of the IGA between Dania and Broward County, a "noise berm" was constructed in 1999 which acts as a barrier between the airport and the neighborhoods directly south,

including Melaleuca Gardens. The cost of the project was approximately \$1.5 million and, although it was not acoustically designed to reduce the noise levels, the effect of the project reduced sound levels by 5 dB. The original idea was for the noise berm to be used by citizens as a walkway park while providing them with an elevated view of the airport's operations.

The city of Fort Lauderdale will also be affected by the proposed airport expansion and has stated they are in favor of the project because they would benefit from the increased traffic volume at the airport. The increased noise caused by the expansion will only affect communities to the south of the airport making it understandable why Fort Lauderdale does not oppose the project. The city of Hollywood (south and east of the airport) is also opposed to the expansion. The airport is aware of the concern residents have about the proposed project and, on May 24, 2004, they opened a Community Outreach Office located directly south of the airport next to the main entrance to Melaleuca Gardens. As of December 2005, they had recorded 162 visitors. The purpose of this office is multi-fold and includes a desire to:

- Educate the community and answer their questions in person;
- Establish increased community outreach events;
- Make the airport more visible among community residents.

6.5 Summary

The history of FLL is intricately tied to its current challenges related to land use and noise mitigation. As the airport transitioned from a military field to an air carrier airport, the land use infrastructure begun by the navy set the stage for future developments. This has led to near-airport residential development and continued struggles for the airport to acquire land and expand to meet its operational demand. Among the three airports in this study, FLL represents older, former military bases whose land use planning began after the development of land use planning guidelines. In cases such as this, effective airport-community communication and interaction become even more important as actual land use planning options, to decrease airport impact, are limited.

In many ways, FLL has remained proactive in ensuring continued involvement with the community. Through the community outreach center, public airport project forums, and the use of media to inform the public on changes in operational patterns, FLL has taken important steps to gain community buy-in and educate them on the importance of the airport. Work must still be done to establish more effective communication with municipalities and developers to have more control to prevent or challenge incompatible land use developments. FLL is unique in that it is surrounded on all sides by many different local government entities. Developing land use in these areas requires coordinated communication with many different agencies and offices. This effort is crucial in providing a forum for improved and continued cooperation.

7. Orlando-Sanford International Airport

Similar to FLL, Orlando-Sanford International Airport (SFB) is one of Florida's busiest airfields. However, while FLL is landlocked and has few options for continued growth, SFB is continuing to increase operations and expand. During the course of the study, SFB transitioned from a Class D to Class C airspace and has plans for future development. The growth experienced at SFB during the study is not new, but an ongoing trend. Over the past decade, SFB experienced extensive growth and significantly contributed to the local economy, including Seminole County, the City of Sanford, and the City of Lake Mary. The airport's service to the community is currently transitioning from a small general aviation airfield to a reliever hub for Orlando and a developing air traffic base for domestic and international passengers. SFB's high volume of general aviation operations and rapid development of commercial operations causes them to experience growing pains with the community. The increase in air traffic volume has led to a misunderstanding on the trends of local noise complaint and the land use issues they reflect.

This airport provides an example of midsize, reliever-hub airports facing increased departures and arrivals and fluctuating operational schedules. Although it is the smallest airport researched in this study, its experiences provide valuable insight into what many of the nation's smaller airports will experience as the importance of secondary airports increases over the next 15-20 years.

7.1 Background

Originally opened in the early 1920s, SFB transitioned between city and military ownership several times before the city formed the Sanford Airport Authority (SAA) in 1971. Since then, the SAA has been responsible for operation and development of the airport. The Authority is comprised of nine members appointed by the Sanford City Commission, 11 elected or employed officials, and 34 other full time employees. The current airport president is a former City of Sanford Mayor, giving the airport many political connections with the City of Sanford and Seminole County.

In 1990, a terminal was built at the airport in anticipation of expanding passenger services. As seen in **Figure 7.1** below, there are currently four active runways which serve SFB. Three of the runways are east-west runways aligning with the area's prevailing winds, and are identified as 9L-27R, 9C-27C, and 9R-27L. The fourth runway, identified as the airport's crosswind runway, 18-36, is oriented north-south. Runway 9L-27R is 9,600 feet long and is primarily designated as SFB's air carrier runway. Because Runway 9L-27R has several types of instrument approaches connected to it, the runway is often used by flight training aircraft as well. Runway 9C-27C and Runway 9R-27L are each about 3,500 feet and serve the general aviation traffic at SFB. Runway 9C-27C is used by aircraft flying to SFB with intended full stop landings. Runway 9R-27L is designated as a touch and go runway used to isolate the extensive flight training activities taking place at the airport. Runway 18-36 is 6,000 feet and, although seldom used, is capable of handling both air carrier and general aviation aircraft.



FIGURE 7.1 – Aerial view of the Orlando-Sanford International Airport

SFB is located 35 miles to the north of Orlando International Airport and 44 miles to the south of Daytona Beach International Airport. Its central location allows it to act as a reliever airport for the region. In the last decade, the facilities at SFB have continued to modernize as the airport has grown and attracted more passengers. In 1996, a five-gate passenger terminal was built for international passengers, and in 2000 a seven-gate terminal expansion project was completed in anticipation of continued growth of domestic passenger service. To date, SFB has 12 gates to accommodate its domestic and international passengers. In 2005, SFB had over 9,000 passenger related aircraft operations which brought over 1.6 million domestic and international passengers to the airport. The airport has found a niche serving low cost European air carriers and smaller U.S. domestic airlines who wish to fly into the central Florida area but want to avoid the higher landing fees charged by Orlando International Airport (MCO).

Aviation activities at SFB consist of air carrier, corporate, flight training, and recreational flying operations. Occasionally, military, cargo, and air taxi operators also use the field. As a result, a wide range of aviation facilities are located at SFB. **Figure 7.2** shows that, as of June 2006, there were 6 helicopters and 361 airplanes based at SFB - a majority of these being single engine aircraft. Delta Connection Academy is the airport's largest aviation instruction school and, in recent years, their 85 aircraft (approximately 65 single engine airplanes and 20 multi-engine aircraft) have averaged over 380 operations per day or 342,000 per year. This aircraft activity accounts for 95 percent of all aircraft operations at SFB. Below, **Figure 7.3** shows SFB's annual

Table 7.2 - Aircraft Based at SFB

Single	249
Multi	50
Jet	62
Helicopter	6
<i>Source: SFB Airport Official 06/08/06</i>	

aircraft operations and the percentage of general aviation, domestic air carrier, international air carrier, and other movements at the airport.

Passenger and cargo operations began at SFB in April 1996 and have continued to grow (see figure 4.4 below). Over 84,000 tons of cargo has been brought into SFB in the past decade. For the past five years SFB has averaged over 360,000 aircraft operations annually. In that same time frame, the airport has seen an average of 8,900 yearly passenger aircraft operations with an average of 5,300 domestic flights and 3,600 international flights. These flights have brought in an average of 67,600 people each year (average of 37,900 domestic passengers and 29,700 international passengers).

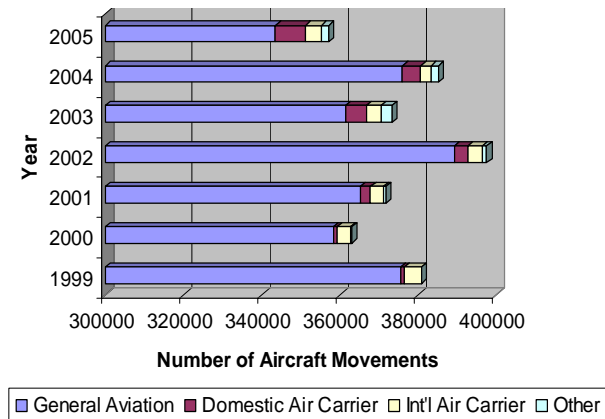


FIGURE 7.3 – SFB Annual Aircraft Operations

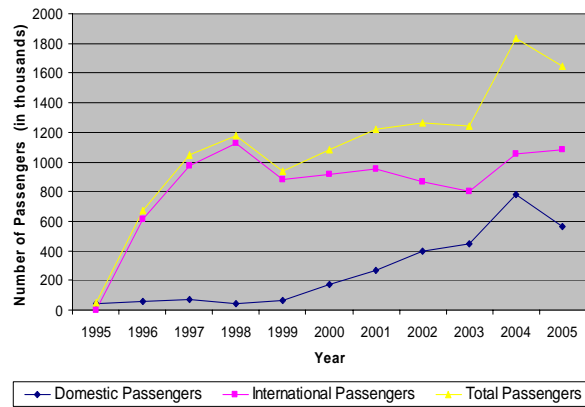


FIGURE 7.4 – SFB Annual Passenger Movements

In 2005, SFB was ranked by the Airports Council International (ACI) to be the 34th busiest airport in the United States with a total of 319,243 aircraft operations (ACI-NA 2005). Although the airport is bringing a large number of passengers into central Florida, the type of aircraft which are being used to do this account for less than five percent of the total aircraft operations at SFB. The vast majority of the aircraft operations at SFB are related to the flight training activities taking place through Delta Connection Academy and the other flight training schools on the field. The passenger aircraft flying into SFB include a continually changing variety of large jets such as B-747s, A330s, B-757s, B-737s, B-727s, and MD-80s. The majority of passenger aircraft flying into SFB are aircraft that were originally Stage 2 aircraft and have been hush-kitted or otherwise modified to achieve compliance with Stage 3 noise standards.

SFB serves as a major commercial service airport for central Florida. It provides the region with 27,000 jobs and a total economic impact of \$1.8 billion. Visitors who come to Sanford through the airport also have a major impact on the economy. Almost two-thirds of the passengers are visitors who spend, on average, \$142 each day of their visit. Delta Connection Academy (DCA) is also responsible for graduating over 300 new pilots each year. DCA attracts its students from all across the country and world to come to Sanford and train at its facilities.

7.2 Land Use

Two properties with potential land use compatibility issues researched at SFB were the ‘St. James House of Prayer’ and ‘Cameron Heights’. St. James House of Prayer was inadvertently allowed to construct their facility less than one-half mile due east of Runway 9L-27R. At the time of construction, the airport was known to have plans for future eastward

expansion of this runway. As a result of this incident, measures have been put in place to prevent occurrences of this nature from happening in the future. Affected by these new measures is a proposed residential development known as Cameron Heights. It is proposed to be built less than three miles northeast of the airport.

In early 2002, St. James House of Prayer decided to move from its previous location in downtown Sanford to a piece of undeveloped property at 2621 Cameron Avenue, Sanford, FL 32773 (see **Figure 7.5**). The property is situated directly across the street (to the east) from additional undeveloped land, some of which is owned by the Sanford Airport Authority. Before construction began, church officials applied for the property to be annexed from Seminole County into the



FIGURE 7.5 –St. James House of Prayer

City of Sanford in order to gain access to public water and sewer lines. In 2002, the City of Sanford determined that the church property was eligible for access to public utility lines because the property was within the city’s service boundary. However, since property which was situated between the SFB airport boundary and the church had not yet been incorporated, the church was not eligible for annexation into the City of Sanford at that time. Therefore, the construction of the church was solely under the supervision of Seminole County. In 2004, the adjacent property between the airport and the church was annexed into the City of Sanford. This annexation led to the annexation of the church property as well. Communication with the church officials revealed that the church paid approximately \$18,000 to purchase building permits from Seminole County, and an additional \$70,000 to the City of Sanford to establish a water line running to the building site (personal communication).

Official construction of the church began in May of 2002. Nearing completion, the church’s construction was halted due to a possible FAR Part 77 violation related to the height of the church’s planned steeple and the location of the runway protection zone (RPZ). With the addition of the steeple on top of the church, the building would penetrate the RPZ and be in violation of Part 77 height restrictions. Interviews with church officials showed that the entire congregation was surprised to hear news about not being able to build the steeple on the church. During the process of getting the building permits approved, neither the SAA, Seminole County, nor the City of Sanford stated that the property’s close proximity to the airport would limit the height of any part of the structure being built. Because the church was near completion, the congregation decided not to fight the issue and instead finished the building without the addition of the steeple.

Because of its eastern location in relation to the airport (**Figure 7.6**), the church property is primarily affected by noise and vibration produced by large aircraft departing Runway 9L. Sanford’s predominantly eastern winds require commercial aircraft to depart eastward at a low altitude before gaining clearance into Orlando’s Class B airspace. The airport’s current departure procedure, the “Sanford One Departure,” states that aircraft departing on instrument flight plans must fly a specific heading issued by air traffic control and climb to 2,000 feet until a further clearance is given by the Orlando Departure Control. Even though the church is outside of the 65 DNL contour, it still endures a substantial amount of noise and vibration from large aircraft such as MD-80s and B-747s.

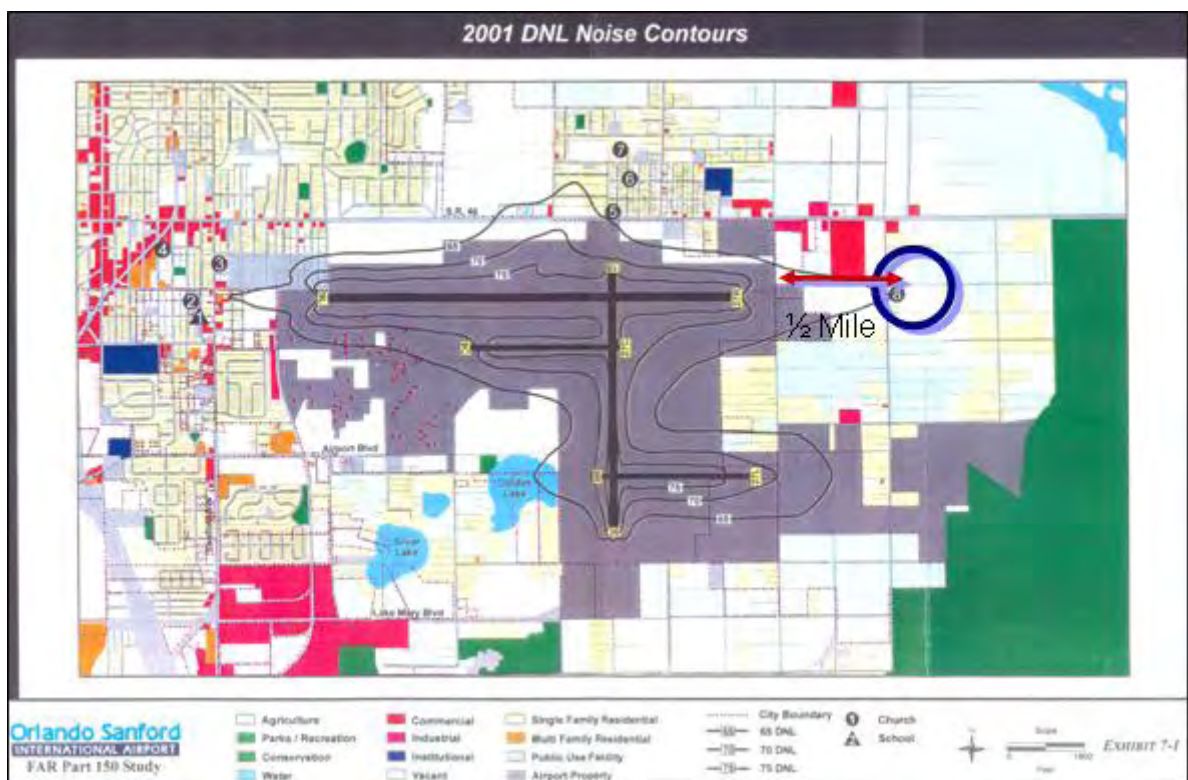


FIGURE 7.6 – St. James House of Prayer (#8) and its current proximity to SFB's runway 9L-27R

According to conversations with SFB air traffic controllers, departing commercial aircraft are typically at altitudes lower than 1,000 AGL when they are above the church property. The aircraft do not typically reach 2,000 feet until they are three or more miles away from the airport. It is at this time that communication with departing aircraft is transferred from SFB to Orlando Departure Control and a higher altitude is assigned. Exploratory noise measurements recorded at St. James House of Prayer show that the average noise level produced by commercial aircraft is between 85 and 90 dB as they are flying over the church property. While the frequency of noise events at this level are not as high as at a larger hub airport, during the busy summer months it is common to have as many as fifteen of these events per day.

While one might conclude that the amount of noise and vibration experienced by church members would cause them to complain, research over the past three years has not produced such evidence. Conversations with church members have indicated that they accept the noise and have justified it as an “expense” for their location. The church began investing in the property in 1993 before any commercial traffic operated at SFB. Church members have stated that while their location is not ideal due to loud aircraft flying overhead, they tolerate it simply because finances will not allow them to move elsewhere. Even though the current value of the church is estimated to be \$1,188,880 (SCPA), the church members have reported they would not place a value on their building and property because they could not relocate for that monetary value (personal communication).

The underlying problem with St. James House of Prayer is the future stability of the property. The current critical aircraft of the Orlando Sanford airport is the A-330 (SFB-MP 2002b). All operations at the airport are designed to be able to handle the size and needs of this

specific aircraft. As industry advancement in aircraft technology and size continues, SFB would like to increase its ability to accommodate next generation aircraft such as the A-380 as its future critical aircraft. International carriers that fly into Sanford are pursuing future purchases of the A-380 and other large aircraft. This aircraft fleet change has resulted in a short term recommendation in Sanford's Master Plan to extend and widen Runway 9L-27R to accommodate B-747/A-380 in the time period between 2007 and 2010 (SFB-MP 2002c). The plan calls for a 2,400 foot extension to Runway 9L-27R which will take place within the next five years. Additionally, initial improvements should begin within the short term (2001-2005) of the Master Plan, as a reactive measure to increased demand, and should include the extension of Runways 9R-27L and 18-36. The extension of Runway 9L-27R should take place in the medium term (2005-2010)."

Airport officials have reported that environmental studies will begin within the next three years, and once they are completed, eastward expansion of Runway 9L-27R will begin. SFB airport personnel predict this will take place the next four to five years. When the project gets underway, the church property will sit directly in the path of the runway's future expansion. It is obvious that when the airport extends this runway, they will have to purchase the land from the church and force them to relocate.

The Master Plan containing these expansion recommendations was finalized and published in July 2002, two months after the construction of the church began. The SAA was well aware of the airport's expansion intentions before authorization was given to St. James House of Prayer to begin construction of their new church. There appears to have been an overall lack of communication between the SAA, the City of Sanford, and Seminole County regarding this issue until well after the building process had begun. In fact, when attempting to discover which entity was responsible for approving construction without notice of a height restriction violation or conflict with future airport plans, conflicting reports were uncovered from the SAA, the City of Sanford, and Seminole County. When the land was annexed into the City of Sanford, the Seminole County Planning and Development Office stated they sent all related documents to the City of Sanford's Planning and Development Office. The City of Sanford's Planning and Development Office claimed they never received any documents after annexation. As of January 2005, the latest information the City of Sanford's Planning and Development Office had related to airport development were the airport's plans to build a smaller runway on the south side of the airport within the year. In reality, the construction of this runway was actually completed in November of 1998 and is currently in operation as Runway 9R-27L. Since the City of Sanford's Planning and Development Office was clearly misinformed about the current status of the airport, a request was made at the Seminole County Planning and Development Office to view any documents related to the annexation of the church. After much persistence, the staff of the Seminole County Planning and Development Office admitted that the documents were most likely being stored in a warehouse which proved extremely difficult to access.

No documents were ever able to be obtained related to the annexation of the church property. When SFB airport officials were asked how they became informed of the potential FAR Part 77 height violations the property imposed, they declined to provide that information. More recent conversations with a staff member from the City of Sanford Planning and Development Office revealed that in the case of the church, Seminole County had the responsibility of revealing future plans for the area around the church. It appears that they overlooked the importance of disclosing the airport's future expansion plans to the church builders.

Another growing land use concern for the airport is Cameron Heights, a proposed subdivision located approximately three miles northeast of the airport. The plans to construct over 200 single family homes have been recently approved by the City of Sanford but, because the subdivision is in close proximity to the east side of the airport, it will be subject to the majority of noise and other related annoyances from aircraft departing from the air carrier runway. Most of the large aircraft which depart from this runway make a climbing left turn after takeoff and proceed on course up the Florida peninsula. Since large commercial aircraft departing Sanford are staying at a relatively low altitude until instructed to climb by Orlando Departure Control, SFB is concerned future residents in Cameron Heights will complain about the noise being produced. As stated previously, the current departure procedure for the airport instructs large aircraft to initially climb to 2,000 feet and wait for a clearance to a higher altitude from Orlando Departure Control. This departure procedure limits the aircraft to staying at a low altitude for a period of up to ten minutes after taking off. While the aircraft are usually given higher altitudes as soon as they are transferred to Orlando Departure Control, they are still climbing through lower altitudes when flying over the northeast section of Sanford.

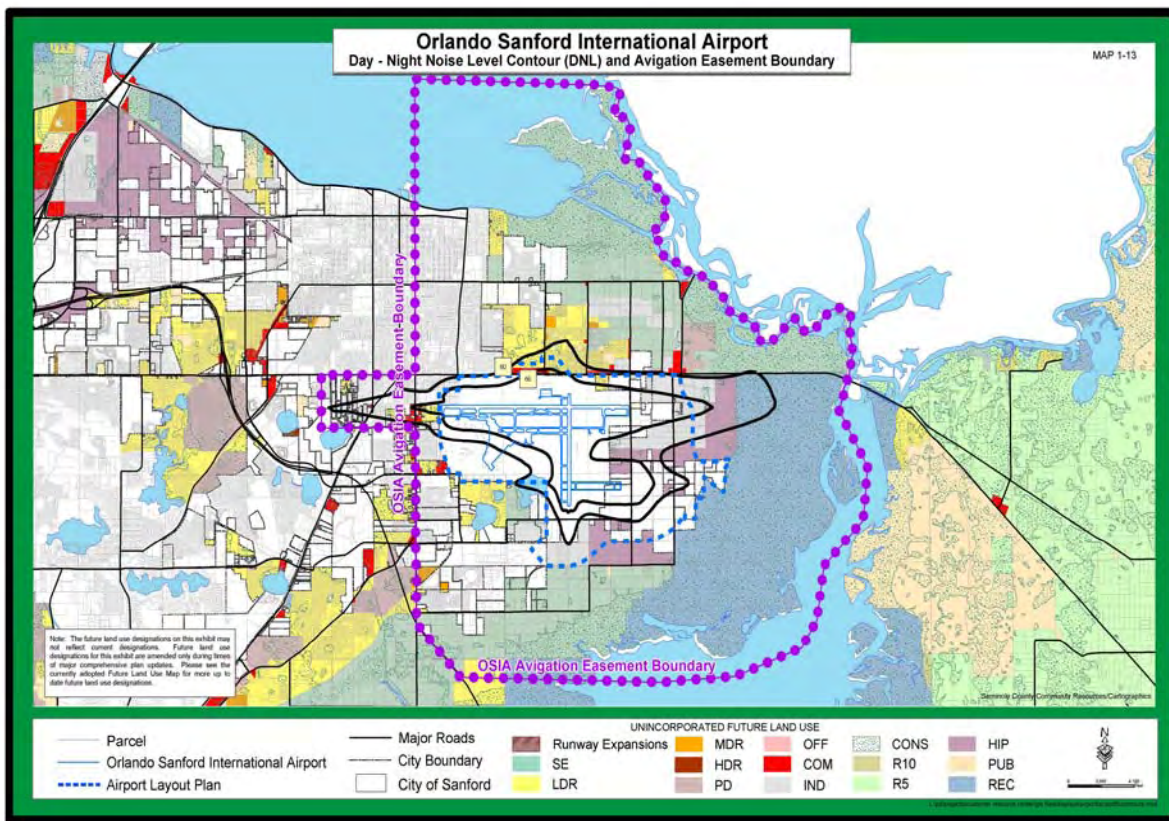


FIGURE 7.7 – SFB JPIA & Aviation Easement Boundary

In order to prevent new developments such as Cameron Heights from complaining about aircraft noise originating at Sanford, the SAA recently signed a Joint Planning Interlocal Agreement (JPIA) with the City of Sanford and Seminole County. Within this agreement the SAA has the ability to review future land use decisions in proximity to the airport and give input

to the City of Sanford and Seminole County. According to interviews with an SFB official, the agreement was signed in July 2005. Interviews with airport officials revealed that the agreement was established after the miscommunication surrounding the construction of St. James House of Prayer. The SAA has defined an area surrounding the airport within which it is to be informed of any new construction or development plans. The boundary of this area is defined to closely follow the 65 DNL contour of the airport; although it expands both north and south of the airport to encompass much of the City of Sanford (**Figure 7.7**). If the SAA suspects that a development could potentially conflict with airport operations or restrictions, it will notify the City of Sanford or Seminole County, and actions will be taken to see that the problem is solved before any annexation or approval of building plans is permitted.

In conjunction with the JPIA, the airport has also created an Avigation Easement, which all buyers of new homes built near the airport are required to sign. The Avigation Easement informs the buyer that the property which they are purchasing is in close proximity to the airport. The Avigation Easement also states there is a potential for airport noise and related annoyances to occur at properties near the airport. (see **Figure 7.7** above). Since July 2005 there has been no new construction near the airport that would require dissemination of the Avigation Easement. However, when new homes become available for purchase in the Cameron Heights development, the Avigation Easement will be included as part of the homebuyer's required paperwork.

Because of shortcomings related to the construction of the church, SFB has attempted to prevent similar issues in the future through the application of the JPIA and the Avigation Easement. By reviewing proposed plans for new development near the airport, the SAA has the ability to alert the City of Sanford and Seminole County of any potential conflicts before they occur.

7.3 Noise Concerns

In order to address noise complaints and the noise issue as a whole, SFB created the Sanford Aviation Noise Abatement Committee, known as SANAC. SANAC's purpose is to make recommendations to the Sanford Airport Authority for establishing noise abatement procedures and for monitoring their implementation at SFB. It is SANAC's responsibility to review noise complaints and recommend changes in aircraft operational procedures or land use controls in order to reduce the impact of aircraft noise on people residing in the communities around the airport. SANAC is currently comprised of seven voting members and six non-voting members. The voting members include an SAA representative, an airline representative, a general aviation representative, two Seminole County residents, one City of Sanford resident, and one resident from the City of Lake Mary. The non-voting members include the Sanford tower manager, the Orlando approach control airspace coordinator, a representative from the Orlando Aviation Noise Abatement Committee, and representatives from the City of Sanford's, the City of Lake Mary's, and Seminole County's Planning and Development Offices. At this time, SANAC holds monthly meetings to discuss current issues and areas of interest. These meetings are open for public attendance and comment. According to the SANAC website, the organization has made almost 40 recommendations to the SAA in the past ten years, the most recent being in June of 2000. The majority of these recommendations have not been implemented by the SAA.

Through interviews with community members, our research shows that while the idea of SANAC is well appreciated, it is not taken seriously by residents. Many community members

have stated that they feel intimidated when attending a SANAC meeting and that when they asked questions they felt as if they were being “talked down to.”

Another community member stated that because she was not familiar with aviation she felt that SANAC did not care enough to help her. She stated that the SANAC board members would use terminology she did not understand and would not allow time for further explanation of topics once they were addressed. She felt that the board did not want to help people, but instead just wanted to finish their meeting without any interference from her and others like her in attendance.

Our research shows that while SANAC has had a few major accomplishments in mitigating aircraft noise for communities surrounding the Sanford airport, its effectiveness and purpose is highly questioned by the community. The community members interviewed were disappointed by SANAC’s lack of motivation to help individuals understand what is going on at the airport and why aircraft are flying over their homes. They think SANAC should be more involved in communicating with the people rather than constantly defending the airport. Many of the monthly meetings have been canceled for undisclosed reasons, leading community members to assume that SANAC is one of the airport’s last priorities. SANAC’s website is not up to date, which has also sent a message to the community members that it is not a high priority (personal communication).

An additional responsibility of SANAC is to review the number of monthly noise complaints recorded by the Sanford Airport. At SFB, noise complaints are recorded in several ways. During business hours, noise complaints are recorded by an assistant working in the SAA office. Each complaint is recorded on a standard form asking for the complainant’s name, address, telephone number, nature of complaint and any details about the occurrence the complainant wishes to add. Since the airport does not have an official noise office or official, the form is forwarded to the Vice President of Operations at the airport, whose duties include reporting the monthly number of noise complaints to SANAC. If a complainant calls the airport outside of business hours, the call is forwarded to an answering service where the complainant’s name and phone number are recorded. This information is also forwarded to the Vice President of Operations at the airport. Complainants also have the choice of filing an online complaint through the SANAC website. A link on the SANAC website provides complainants with the opportunity to fill out the online form asking for their name, address, phone number, email address and nature of complaint. The form allows complainants to add any additional details or comments. When submitted, this form is emailed directly to the assistant or to the Vice President of Operations. It is the Vice President of Operation’s job to collect all the noise complaints for each month and report those numbers to the SANAC. This individual is also a voting member on the SANAC board.

Each month, SANAC reviews the number of noise complaints recorded and discusses whether or not actions should be taken to mitigate or reduce the number of complaints. Three years ago, the average number of noise complaints was anywhere from 200-300 complaints per month. In recent months the number of noise complaints has decreased to 20-30 noise complaints per month. With a population of more than 50,000 people living in the communities around the airport, SFB officials do not see noise complaints as a major issue. An airport official stated in an interview that noise was a high concern for the airport several years ago. However, since the number of noise complaints has dropped and stayed low, that concern has gone away. Most of the noise complaints the airport receives are from chronic complainers or households who complain multiple times a month.

One technique the SAA and SANAC use to mitigate noise complaints is sending the Vice President of Operations and his assistant into the community to talk to residents who have filed noise complaints. The Vice President of Operations has represented the airport at a number of home owner association meetings and in individual meetings with various residents of the community. Some of the techniques used when talking to residents include coming to their home and observing the aircraft with the residents, taking sound measurements on residents' property to assure them that the noise produced by airplanes is comparable to that of cars and other sources of noise around their home, verifying that aircraft are at proper altitudes when on approach and departure paths, and highlighting the importance and benefit the airport brings to the community.

7.4 Airport and Community Relations

When speaking to residents in the communities around SFB, it has been found that they find benefit in talking with airport personnel. Multiple residents have stated that having airport personnel come to their home has allowed them to better understand airport operations and the role the airport plays in their community. For example, one resident and his wife continuously complained to the airport that the airplanes flying over their house were too low and too loud. This couple lived in Timacuan, a retirement golf community five miles west of the airport. The entire subdivision is located under the approach path for Runway 9L. They stated that when they first bought their house, they never heard any air traffic overhead; however, the traffic dramatically increased once they moved into their new residence. At night it would scare them to look out their window and see brightly lit, large passenger jets descending directly over their house. The wife said it was a very uncomfortable feeling because she felt as if the airplanes were going to crash into her house. After airport personnel came to the house and used distance measuring lasers to verify that the airplanes were at the proper altitude of 1,000 feet above the ground, the couple admitted to having a higher sense of safety and security. In talking with the airport personnel they also realized that because aircraft like B-747s are significantly larger aircraft, they sometimes appear to be lower than they actually are. As a result, the couple has changed from filing more than 100 noise complaints a month to filing noise complaints only when they find the event to be significantly louder than normal.

As shown in **Figure 7.8**, the vast majority of noise complaints received by SFB come from highly populated communities west of the airport who complain about low and loud aircraft. These noise complaints are usually associated with large passenger aircraft on approach for Runway 9L. There are also a significant number of complaints about large aircraft departing Runway 9L from residents who live in the rural areas to the east of the airport. It is interesting to note that SFB has had relatively few noise complaints for smaller piston engine aircraft whose operations total 95 percent of the aircraft

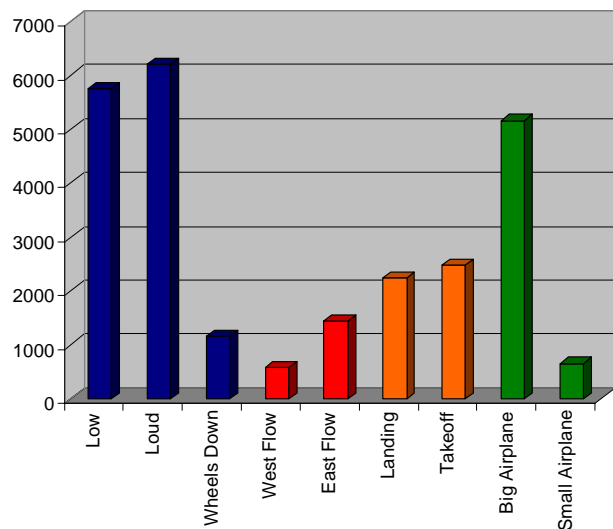


FIGURE 7.8 – Total number of noise complaint offense from 1999 – 2005 at SFB

movements at the airport. The majority of those who complain about general aviation aircraft live very close to the airport and frequently complain about small airplanes “buzzing” low over their homes.

Unlike FLL, the majority of noise complaints at SFB come from chronic complainants. In 2004, 75 percent of noise complaints came from only ten households (**Figure 7.9**). As shown in **Figure 7.10**, the total number of households complaining is considerably less than the total number of annual complaints. Complainants such as these have been known to submit several hundred grievances in one month. After interviewing a number of SFB’s chronic complainants, it was discovered that many of these individuals spend a large amount of time at home during the day and therefore are exposed to greater amounts of air traffic noise. One complainant who lived and worked west of the airport stated that the noise from commercial jets sometimes interfered with his ability to work. Because of this, every time he observed an aircraft flying over his house he would submit a complaint to SFB via their online form. Other chronic complainants have reported that they submit numerous complaints a day because they feel that the airport will not take their issue seriously unless they are receiving a large number of complaints. However, airport officials have stated that they deal with each complainant the same no matter how many complaints they have received from them.

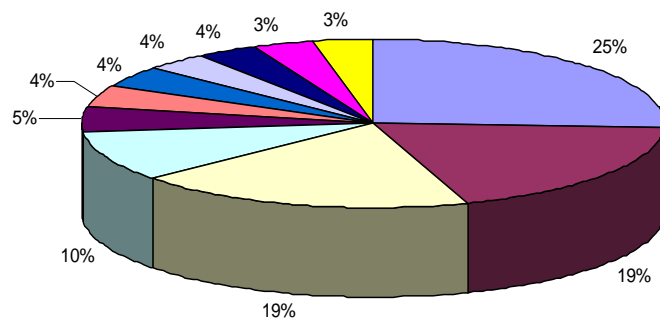


FIGURE 7.9 – 2004 Top Ten Complainants (75%) vs. all others (25%)

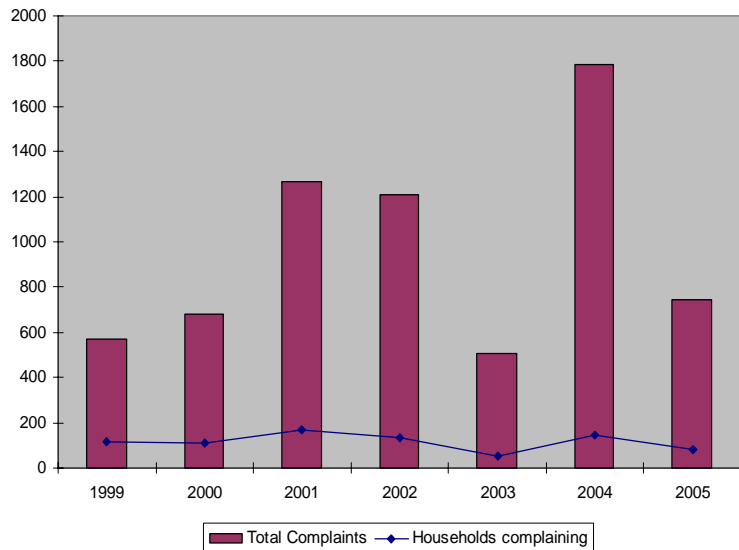


FIGURE 7.10 – Total Number of Noise Complaints vs. Total number of households complaining

At SFB, research has shown that chronic complainants usually complain in a predictable pattern. While the reasons these individuals initially complain vary from person to person, the cycle of their complaint patterns is quite similar. It was found in multiple cases that after a resident becomes upset with the amount of air traffic noise, they submit complaints to SFB on a regular basis. Because of either a lack of response or recognition from the airport, the residents become further frustrated with the issue, and the number of complaints they submit significantly increases. Our research has shown that residents will submit large numbers of complaints to the airport for a period of time varying from six months to two years. At that point, residents have

stated that they begin to lose interest in the issue and stop complaining. There are several reasons why this happens. Some residents have stated that despite filing numerous noise complaints, the issue was not resolved satisfactorily and they believe there is nothing further they can do. One resident in particular mentioned that after filing noise complaints for two consecutive years, he became “burnt out” and believed that his efforts had no effect on resolving the issue. Other residents have stated that by speaking with airport officials, it has helped them to better understand what role the airport serves in the community and why the airplanes continuously fly over their residences. Even though these individuals are still annoyed by the air traffic, they have stopped complaining and have learned to live with the aircraft noise.

In 2005, the number of noise complaints at SFB dropped significantly. Interviews with airport officials revealed it was during that year when multiple chronic complainants stopped or greatly decreased the amount of complaints they were submitting. Because of this, the number of complaints at SFB dropped from 413 in October of 2004 to 26 in October of 2005. Currently, far fewer chronic complainants are contacting SFB to submit noise complaints. Recently, several of these individuals were contacted and asked why they stopped complaining. They stated that they were still annoyed but have lost interest in complaining because they believe nothing was ever done to help solve their issue. Other complainants believe that their neighbors were complaining and therefore it was “being taken care of.”

7.5 Summary

It is evident that SFB has experienced an increase in noise complaints due to the recent influx of commercial aircraft using the airport. The majority of passenger aircraft flying into SFB are older Stage 3-compliant aircraft. It has been reported that the commercial aircraft flying into SFB produce a much more distinct and annoying noise than newer aircraft which have improved noise reduction technologies. It is known that the communities around SFB are a combination of retirement, upper class and rural homes, all of which have expectation of being serene and quiet. Most residents are not accustomed to the increasing occurrence of larger, louder aircraft flying over their communities. Even though the airport has a noise abatement committee, it is limited as to what help it can provide to the communities. SANAC works to inform residents about airport operations and what benefits SFB brings to the community; however, there is still a gap between airport officials responsible for noise mitigation and community members hoping to reduce the noise they experience from day to day.

8. Denver International Airport

Airports around the world have faced challenges in controlling land use development around airports. Prior to 1998, airports had attempted to meet these challenges by using anecdotal methods attempted at other airports. Denver International utilized such anecdotal guidelines or learned behaviors from other airports' experiences, and attempted to learn from mistakes made in the past, such as failing to guide local government to making long term decisions that would be beneficial to the airport in the future. Other guidelines such as Part 150, ASNA, and the Federal Airport Act of 1946 were available at the creation of the new airport at Denver in order to assist with adequate planning and prevention of incompatible land uses. Compatible land use planning has been a focus for most airports, but it has become apparent that noise issues are not entirely associated with incompatible land use, but these noise problems are generated from areas outside the 65 DNL/CNEL and therefore compatible land use guidance has become irrelevant for many airports. It has become evident that regardless of these additional initiatives to ensure compatible land use within the 60 DNL, Denver will soon be facing the same challenges presented in FLL and SFB. These challenges are predominantly associated with land outside the 60 DNL, but will add complexity to noise management strategies at Denver International. With the benefit on the latest development of the FAA guidelines, Denver International Airport has been successful in avoiding noise issues associated with incompatible land uses. However, it still faces similar obstacles to other airports that are unavoidable even with the best methodologies employed.

8.1 Background

In the mid-1980s, Stapleton International Airport (STP) was overwhelmed by resistance due to rising noise complaints. In 1987 there were nearly 15,000 residents living within the 65 DNL noise contour. The airport capacity was saturated, and the airport was unable to grow due to its land-locked situation. City officials began looking at alternative options. The noise litigation brought on in 1984 by a heavily noise impacted community to the west of the airport, Park Hill, was a determining factor for relocating the airport. As part of an out of court settlement, the city of Denver was required to build a new airport by the year 2000 and also close Stapleton permanently to all aeronautical activities. City officials recognized the impact noise issues could have on airport growth and sustenance, and wanted to minimize their impact on the new airport. Airport authorities planned to build a large airport that had a huge land buffer surrounding it. They intended to keep all residential developments outside the more stringent 60 DNL noise contour and still have enough room for expansion and growth. It was stated on April 3, 2005, by airport officials that the inability to find land within city limits prompted city officials to begin negotiating annexation of property.

With the intention of building the new airport in a remote, undeveloped location, Denver city officials annexed 53 square miles from neighboring Adams County on April 21, 1988 (IGA 1988). The Intergovernmental Agreement (IGA) between the City of Denver and Adams County was established to annex property to provide a "safe, efficient, and adequately sized new airport," and to "improve the national air transportation system, avoid unacceptable noise levels, and serve as a catalyst for economic development in Adams County, Denver, and the surrounding areas" (IGA 1988). The IGA set stringent regulations between the airport and surrounding community regarding expected noise levels according to IGA noise mitigation

standards. Both parties agreed to these guidelines established in conjunction with the Master Plan in order to prevent residential incompatible land use on airport property that would result in noise complaints and possible litigation. This plan hoped to establish compatible land use agreements, as well as prevent another Stapleton. Airport officials stated on April 3, 2005, that by having an understanding of the full build-out of the airport, all surrounding communities would be aware of future airport size and the resulting impact.

Denver International Airport (DEN) opened on February 28, 1995. Today it is the nation's sixth-busiest airport with a traffic level of nearly 43 million passengers in 2005

making it the 11th-busiest airport in the world (ACI-NA 2005). It is located 23 miles northeast of downtown Denver providing the local community with airline services from 17 different national airlines and 12 regional/commuter airlines (CCDDOA 2005). The airport contributes economically to the surrounding communities by providing nearly 200,000 jobs, \$7 billion in wages, with a total of \$17 billion in economic activity (CDOT 2006). There are six runways at DEN today, with plans to double that number in the future. Five runways are 12,000 feet and the sixth is 16,000 feet, allowing DEN to withstand larger airline and cargo fleets (CCDDOA 2005).

DEN was built to handle an estimated 640,000 annual operations, with the ultimate goal of 1.5 million aircraft operations per year. Once the construction on Runway 16R-34L was completed, the estimated annual operations rose to 800,000. The north-south runways are divided essentially into arrivals on one side, and departures on the other. The east-west runways were built for crosswind conditions and additional arrivals and departures when necessary. **Table 8.1** shows a breakdown in total operations and type.

Under Instrument Meteorological Conditions (IMC), the airport tends to rely on its north-south runways, allowing 200 hourly operations. Three simultaneous independent approaches into the airport assist with arrival capacity. The east-west runways are utilized for departures in this situation, unless low visibility or strong wind conditions exist. Marginal weather days at DEN are characterized by winds from the north or northeast, which tend to produce low ceilings, reduced visibility, and precipitation. On these days, the east-west runways are not utilized, and the hourly operations drop to 165 (CCDDOA 2001)

	Number of Operations	Percent of Total Operations
Air Carrier Operations	384,384	67.71%
Air Taxi Operations	172,475	30.39%
Itinerant GA Operations	9779	1.72%
Itinerant Military Operations	878	0.15%
Total Operations	567,632	

Runway	Arrivals and Departures	Arrivals Only
	Usage (percent of total, 200%)	Usage (percent of total)
16R	11.8%	11.4%
34L	9.5%	0.1%
16L	25.1%	25.0%
34R	21.7%	3.6%
17R	16.9%	3.2%
35L	28.5%	26.0%
17L	7.9%	0.5%
35L	16.8%	16.4%
07	5.2%	5.2%
25	23.0%	0.4%
08	25.4%	0.0%
26	8.2%	8.2%

For about 90 percent of the time, the airport is in Visual Meteorological Conditions (VMC). Under these conditions, DEN can handle 240 hourly operations. The aircraft arrive on two of the north-south runways under VMC, and occasionally, the east-west runways will be used to supplement traffic flow. The east-west runways assist in the improvement of the traffic flow as well as increase capacity of the airport for arrivals and departures (CCDDOA 2001). **Table 8.2** provides a more detailed runway usage breakdown.

8.2 Land Use

The planning office at DEN has worked closely with city and county planners to ensure that the compatible land use guidelines established by the IGA are met. The IGA stipulates that all residential development be excluded from within the contour of 65 dB day-night average sound level (DNL). The IGA's 65 DNL contour was created before the new airport was constructed. The airspace traffic from Stapleton was used to estimate the DNL levels for a full 12 runway configuration at the new airport. The model also took into consideration future airspace increases. This model allowed all planners to know where residential buildings could not be constructed. In addition to residential restrictions, the IGA also stipulated compatible development guidelines surrounding the 65 DNL to ensure that if runway usage changed, residential communities would still lie well outside the 60 DNL. **Figure 8.3** shows the airport layout and noise contours.

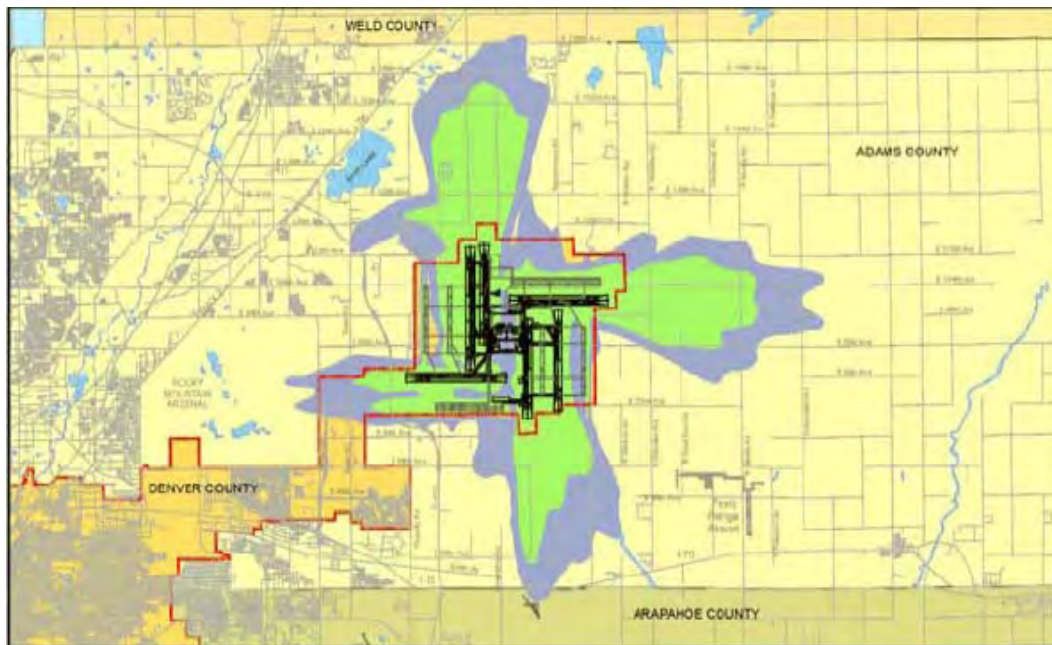


FIGURE 8.3: Airport Layout and Noise Contours

All of these initiatives have proved to be successful thus far. In fact, the City of Aurora, directly south of the airport, has worked diligently to ensure that it's zoning close to the airport remains compatible with aviation activities. The city has kept residential development near the airport to a minimum. DEN is required to perform a Part 150 Light study every two years during which the 65 DNL is recalculated using actual runway usage and noise level statistics in accordance with section 4.5.3 of the IGA. Through this process, the 65 DNL has decreased in size around the north and south runways and increased at the ends of the east-west runways. This

is due to an unforeseen increase in east-west runway usage. City and County planners have zoned the western portion outside airport property to the perimeter of the 65 DNL known as the IGA contour. This abides with IGA limitations as the IGA contour to the east and west is much smaller than the 65 DNL contour established by the Part 150 study. If residents are allowed to live up to the 65 DNL IGA perimeters, then any development west of the airport will be exposed to actual noise levels greater than 65 DNL. **Figure 8.4** below is a map of the Denver/Adams County IGA Noise Exposure Performance Standards (NEPS) locations in relation to the airport and noise contours.

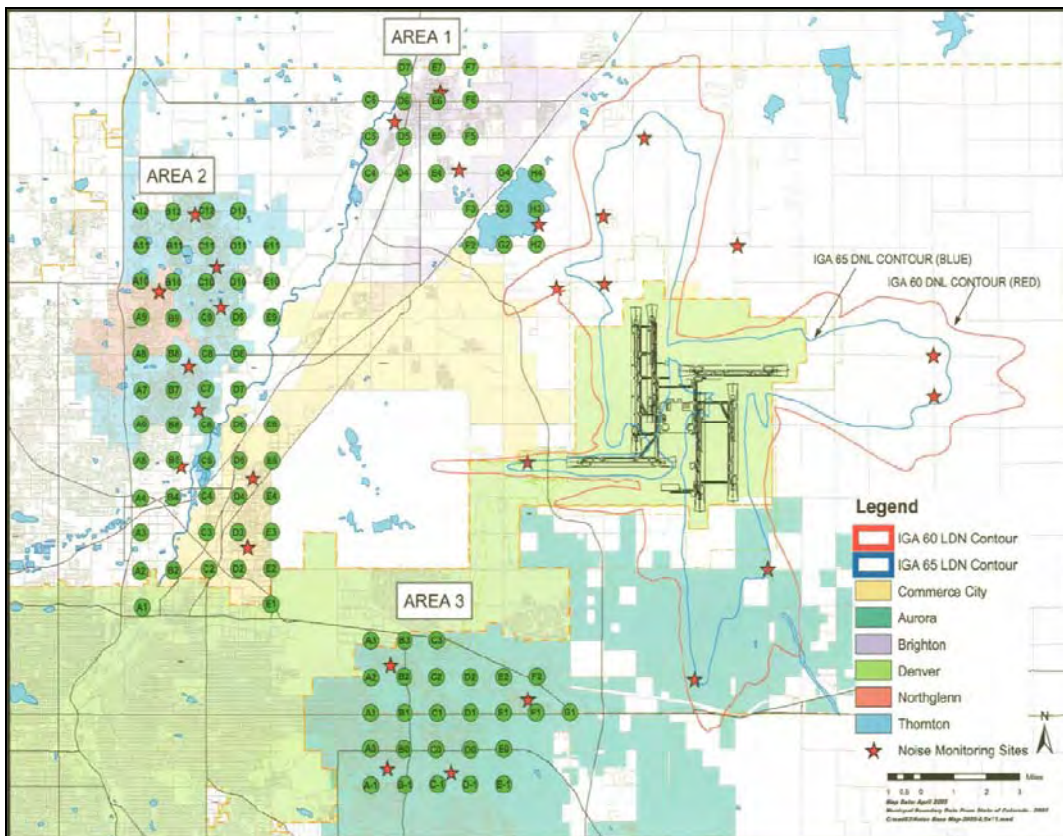


FIGURE 8.4 – Denver and Aurora IGA NEPS Locations

Developers who own land in these areas have refused to limit residential development. It has been reported to the researchers that the developers claim that residential communities must exist first in order to drive the development of commercial and other airport compatible development. During a series of interviews with the Noise Officer at DEN, it was reported that the result of this claim is a \$1.5 billion residential development planned to be built southwest of DEN called High Point. The dwellings are estimated to be valued in the range of \$150,000 to \$750,000 each. There are also plans for an 18-hole championship golf course with club house, 1,000 hotel rooms, a 500-room conference center, 10 million square feet of business park development, and one million square feet of retail and commercial development. It was reported that the only stipulation from the city council was to proceed with caution in hopes of monitoring the development of this project, ultimately attempting to prevent another Park Hill (Noise Officer, personal communication, September 18, 2005). High Point will lie directly outside the

IGA 65 DNL (but within the actual 65 DNL) 2½ miles from the end of an east-west runway that the airport has deemed necessary for future expansion. Landmark Properties Group, the developer of High Point, understands the airport’s concern that this development may be subjected to high, unwanted levels of aircraft noise and has stated that they would utilize the most stringent noise standards while constructing the 1,600 single family dwellings and 1,400 multi family dwellings. **Figure 8.5** below depicts the High Point development and its position relative to the existing runway, noise contour boundary, and potential future runway development.

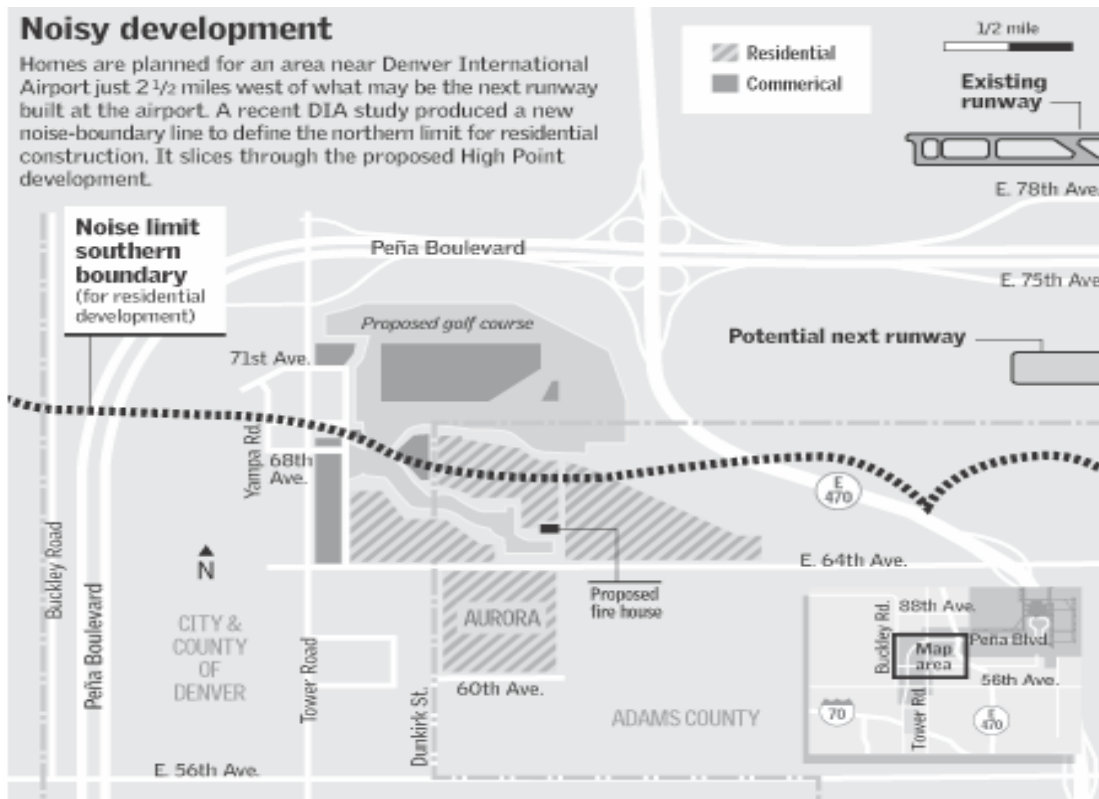


FIGURE 8.5 – High Point development in relation to DEN

One of the main concerns for DEN is that allowing the residential development at High Point will create a precedent and encourage more residential development regardless of the IGA initiative which only permits compatible development surrounding airport property. The DEN administration has anticipated that High Point will be a considerable source of noise complaints because of the addition of 3,000 houses and thousands of residents in such close proximity to the airport. As previously stated, the master plan of DEN will include 12 runways. One of the proposed runways, which is designated as 7R-25L, is oriented in the east-west direction. It will be located south of Pena Boulevard and High Point will be located just 2½ miles to the west end of Runway 7R. It has been estimated that departing aircrafts will be about 1,000 feet above the ground over the High Point development and their heights are reduced to only about 400-600 feet for arrivals. During two to three percent of the year the greater Denver area has primarily westerly winds requiring DEN to rely heavily on the use of the proposed east-west runway in order to operate efficiently. DEN can accommodate its current air traffic with its present

configuration of runways. Future operations, however, are expected to double at DEN that put more pressure on utilizing the proposed east-west runways to accommodate the increase in forecasted air traffic. It is noteworthy that the construction of the most recent runway was delayed for eight years because residents of Aurora lobbied their Congressman in order to withhold the funds necessary for the project. Along with the eight year delay, the construction cost of the runway increased by \$60 million. There is a chance that residents in High Point may try to delay or even prohibit the construction of Runway 7R. If DEN is not able to build 7R, one of the most efficient and flexible airports in the United States could be bottlenecked.

As a result of increased residential development on land near DEN, airport officials expressed a need to require developers to notify future residents of the area's proximity to the airport and the potential for aircraft noise and related annoyances. Currently, developers in the immediate area outside the 65 DNL contour are required to inform future residents that the property they are purchasing is located near the Denver airport. Even though these properties are not located within the 65 DNL, DEN airport officials are concerned that these future residential developments will become a source of frequent noise complaints. A typical disclosure statement includes notification of the property's proximity to the airport; the risk that the property may be subject to overflights by commercial, general aviation, and military aircraft and the risk that the property may be subject to noise, vibration, exhaust, air and vehicular traffic, and other conditions associated with the operation of an international airport (Morrison 2004). Most disclosures also state that DEN has published plans for future airport expansion and that the developer has not made any agreements with DEN relating to the potential adverse effects of aircraft overflights (Richmond 2002). These disclosures are included in the documents presented at the closing of a property sale and must be signed by the new home buyer.

Figures 8.6 and 8.7 represent the 2002 NEM on existing land use and 2007 NEM on future land use. It is clear that developers, airport officials, and government officials must work closely together to ensure the land use around DEN is as compatible as possible for the benefit of the communities, the airport, and the entire region.

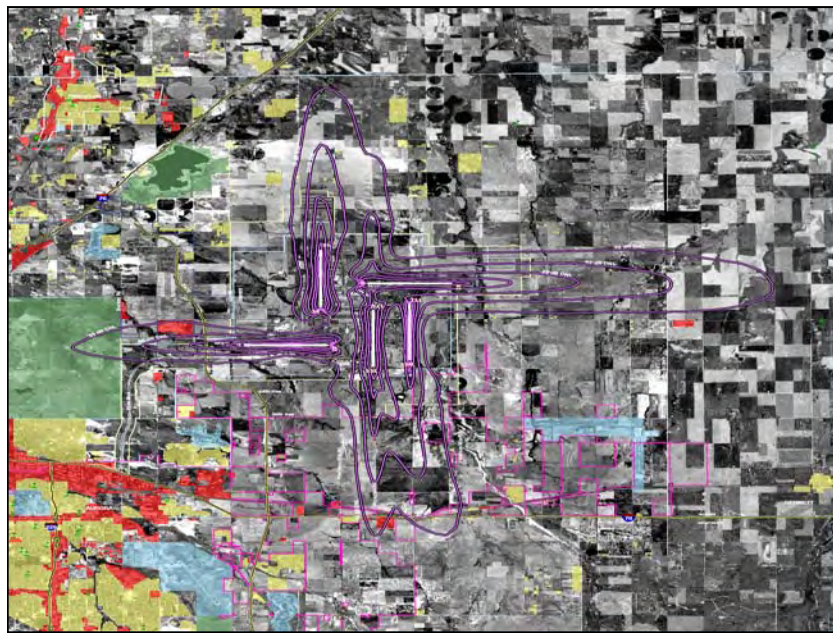


FIGURE 8.6 – 2002 NEM on Existing Land Use

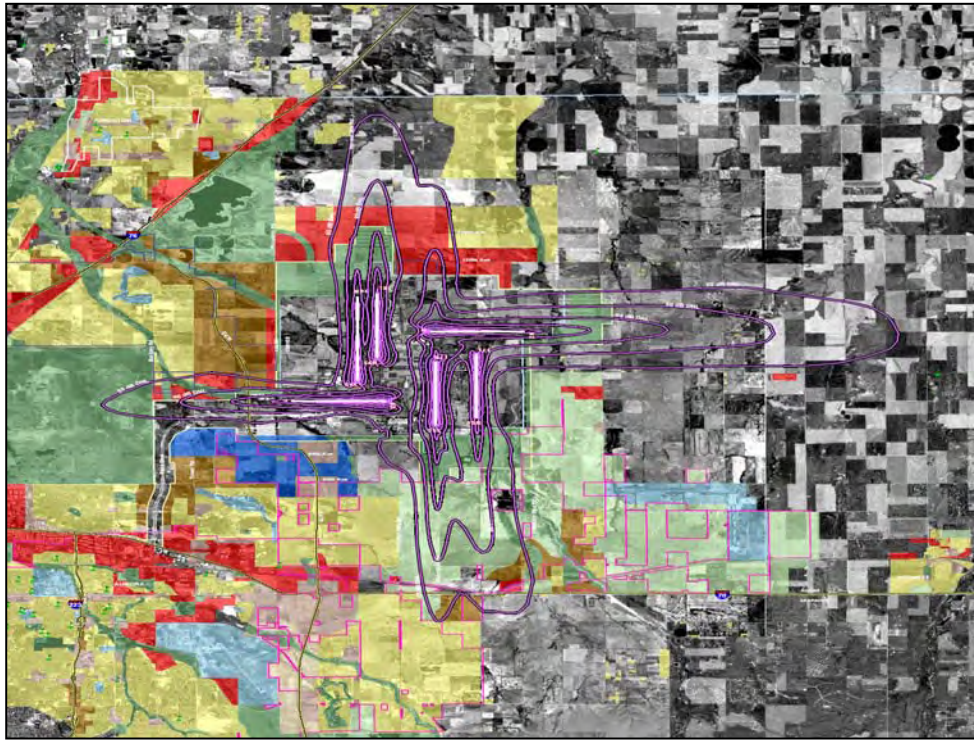
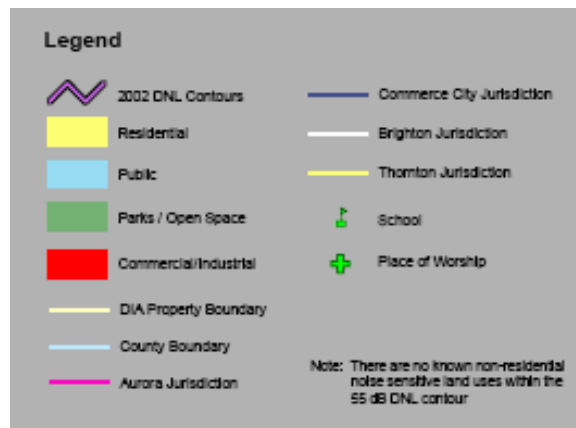


FIGURE 8.7 – 2007 NEM on Future Land Use



LEGEND for FIGURE 8.7

8.3 Noise Concerns

Denver International Airport has initiated various steps in order to mitigate noise. The IGA has provisions where mitigation payments were made in order to reduce noise levels in surrounding communities. The airport set up a noise office that would monitor noise complaints, correlate Airport Noise and Operations Monitoring Systems (ANOMS) data, monitor incoming data and trend noise levels and complaints on a quarterly basis. One month after operations commenced, the Noise Task Force (NTF) was established to address the large quantity of noise complaints. Later the NTF was renamed as the Noise Working Group (NWG). The NTF and NWG are technical committees whose members include representatives from DEN, the Federal Aviation Administration (FAA) and the airlines serving DEN. The NWG meets when necessary, to address noise issues related to DEN aircraft operations as well as develop methods to minimize the associated impact.

The IGA developed Noise Mitigation payments in order to ensure that the airport would not exceed expected noise levels. It requires the City of Denver to pay Adams County or any other incorporated city, a fee if noise levels exceed the set standard. The agreement, or Noise Exposure Performance Standards (NEPS), established a set of criteria such as the 65 DNL contours, equivalent continuous noise level at 24 monitor locations [referred to as Leq (24)], data collection and publication, annual calculation, and deviation standards (Class I-II and enforcement procedures).

The Leq (24) are the prescribed noise levels at the 24 selected grid points. At each grid point, the Leq value is determined by choosing the minimum noise levels from the following three conditions. It is either:

- 1 dB below 1987 Stapleton noise level at that location;
- the highest predicted Leq (24) for Phase 1 of the new airport at the year 1995; or
- the Leq(24) established from long range development of the airport at the year 2020.

The Leq(24) values in the NEPS are chosen to protect residential areas that existed at the inception of IGA. The noise values for Phase 1 and 2020 are calculated for a 24 hour average from Automated Radar Terminal System (ARTS) and noise levels gathered from data such as aircraft types, engine types, power usage, and altitude over the locations, etc. The Leq (24) grid point locations cannot be more than ½ mile from a monitoring station to ensure accurate noise readings.

A provision for violation payments was made to ensure that the airport maintained operational status that would have minimal noise impact on surrounding communities. The payments from DEN to the city/town associated with the violation are to be used by that city/town for noise mitigation purposes. Therefore, when the city/town is awarded money, it must provide the airport with a plan for how the money will be used for noise mitigation and reduce noise impact. Since most cities and towns have not been able to provide the airport with reasonable plans for noise mitigation, the airport has not been required to pay the full amount allotted from all of the violations over the past 10 years. In 2004-2005 alone, DEN would have been required to pay \$28.5 million, but since there were reductions in the violations the following year, the money was not awarded to any municipality. Interviews with airport officials revealed that as of April 2005, DEN had paid over \$41 million to local communities for violations. The payments will be allocated by the type of NEPS violations, Class I or II. The violations at DEN have decreased significantly since 1995.

Although the idea behind the Leq (24) grid points was to ensure that noise impacts would be kept to a minimum, a major discrepancy has been reported. The noise levels established at

many of the grid points are lower than a normal conversation. The trigger level for grid point E, -1 has been pointed out by airport officials as one that needs to be renegotiated. E, -1 is located west of Buckley Air Force Base and, since the Leq levels were calculated from DEN's noise impact, the noise created by the Air Force Base is not normally a factor. The problem is that the negotiated trigger level for E, -1 is 31.4 dB and, therefore, it is almost always in violation.

DEN was designed in accordance with the IGA in order to ensure that noise complaints and concerns were minimal. It came as a surprise to the noise office in late 1995, after almost a year of operation, that the airport had approximately 84,000 noise complaints and 15 grid point violations that year. The concern was not of an actual noise impact on the communities, as they were significantly lower than what communities were exposed to at Stapleton. It was suggested to the researchers that perhaps the citizens of Denver complained 84,000 times the first year because of the authorities' overstatement about the new airport having zero to minimum noise impact on residents.

By working with Air Traffic Control to adjust flight paths, DEN has managed to significantly reduce noise complaints since 1995. In January of 2000, noise complaints decreased significantly due to the phase out of Stage 2 aircraft and restrictions on runway use for Stage 3 compliant-by-thrust aircraft. Since then, DEN's noise office has dealt with a variety of complainants. Most complainants are merely upset about low and loud aircraft, but a significant number of people claim that the noise is damaging to the environment. Because of the environmentally conscious culture in Denver, most complaints tend to be fixated on the harm noise imposes upon the environment. Therefore, it is difficult to separate "legitimate" from "non-legitimate" complaints. Some complaints, while genuine, make the assumption that aircraft noise causes physical harm. DEN's noise office reported that there have been a few cases where complainants threatened airport officials in their messages on the hotline. The airport has dealt with these threats in a reasonable manner and has a "no tolerance" policy on the hotline. If an individual uses profanity or threats, the noise complaint will not be filed. Most complainants, however, are more reasonable and try to make complaints only when they are truly annoyed.

The majority of noise complaints at DEN are generally not triggered by the noise levels of overflights. Many complaints have originated from households well outside the 65 DNL contour. Most single event noise levels were found to be well below 50 dB. When residents were asked to characterize the most annoying environmental noise, they stated that they considered any aircraft noise, regardless of how loud it was, to be annoying. It was because the residents were given the impression from the City of Denver that they would not be impacted by aircraft noise from the airport after it was relocated far away from the town.

The researchers interviewed a community member in order to understand noise annoyance and related issues at the DEN airport. Due to widespread noise complaints, it was difficult to coordinate more interviews with community members. One informal interview was conducted that reinforced information provided by the Noise Office and transcripts of the discussions were not recorded due to Purdue Human Subjects protocol and non-disclosure agreements. Additional complainant information was located in articles published by the Denver Post. One individual is from Elizabethtown and another is located in Adams County, east of the airport. These articles provided the researchers with specific details about these complainant's issues which were representative of most of the complainants at DEN. The Noise Office provided us with audio recordings of typical noise complaints in order to gauge the type and variance in complaints. The audio recordings also provided information about the views of

chronic noise complainants as the majority of the complaints were generated from the same individuals.

In January 2006, a frequent noise complainant living to the northwest of the airport was interviewed. This resident currently files noise complaints to the airport regarding departing aircraft which create a “frightful roar” and “low rumbling” sound as they fly over his property. The resident stated that when aircraft fly over his house, he is unable to receive satellite reception for his television. As the airplanes pass, the rumbling sound increases, and he perceives the aircraft with two engines to be the loudest. He also stated that poor weather seems to increase the amount of noise created by the aircraft.

This resident has lived on his property since 1986 and claims that it is quiet the majority of the time. However, since DEN was built he claims that his quality of life has decreased because the birds and animals are no longer the loudest things in his environment. The resident stated that he would not complain about aircraft if they were silent and in fact enjoys taking photographs of the different paint schemes. He tries to only complain when he is truly irritated but admits that his main reason for complaining is because the city and airport told him that they should always contact the airport when they were annoyed with the overflights. One of the resident’s biggest grievances was that he felt the airport was not supplying enough information to the public about its operational procedures, flight tracks, and flight schedules. He stated that DEN was never forthcoming with information concerning why aircraft follow the specific flight paths over his house. He also stated that he was annoyed by train, motorcycle, and other vehicular traffic but, because there is no one to complain to, he has learned to live with it. He said that if the airport had never given him the instructions to complain about aircraft noise that he probably would not have found out how to do so on his own.

This resident’s experience is a common representation of complainants at various airports and was the reason that the Noise Office selected him for participation in this study. Clearly other factors than noise impact are present regarding annoyance. One example of an atypical complainant was an individual located 67 miles west of DEN. This individual had MS, threatened the airport officials, and was arrested for his threats. This is an example of how emotional this issue is and how careful the airport needs to be in working with these individuals.

8.4 Airport and Community Relations

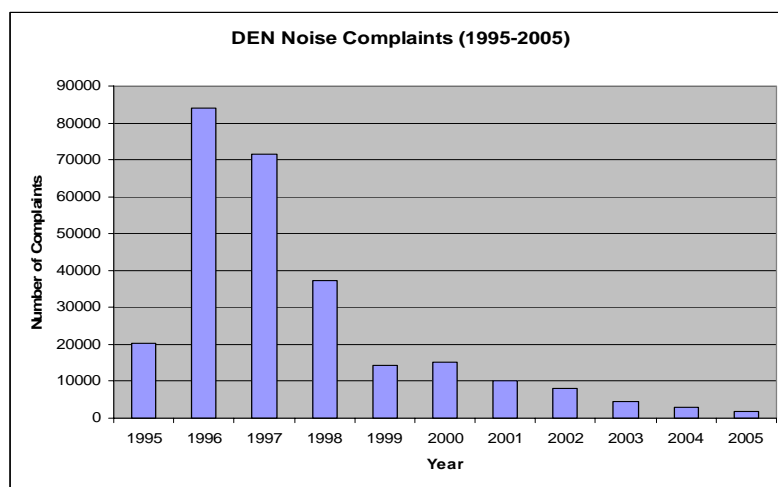


FIGURE 8.8 – DEN Noise Complaints from 1995-2005

Figure 8.8 is a graphical representation of noise complaint statistics (note that 1995 was not a full year of operations). In general, the majority of complaints occur during daylight hours. When compared to ANOMS flight tracks, the complaints seem random and are not always related to a specific aircraft type. The complaints are registered through the phone hotline with only one complaint per week from the internet. The noise office reports that noise complaints currently are minimal, a decrease of 26 percent from 2004 to 2005, and are therefore pleased with the level. Overall, noise complaints continued to decrease from 84,000 in 1995-1996 to an estimated 2,600 in 2005.

Noise complaints in Denver tend to be quite sporadic. Since 1996, complaint numbers have slowly decreased, but the pattern remains the same. As was seen at SFB, complaint reports at DEN indicate that the majority of the complaints are from only ten households.

Top Ten Complainants vs. All Others

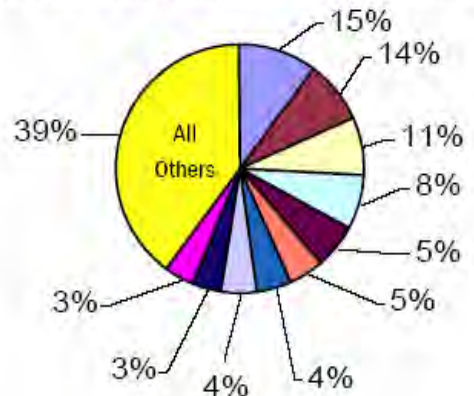


FIGURE 8.9 – Complainant Statistics for 2005

Figure 8.9 is a graphical representation of noise complaints generated from all complainants.

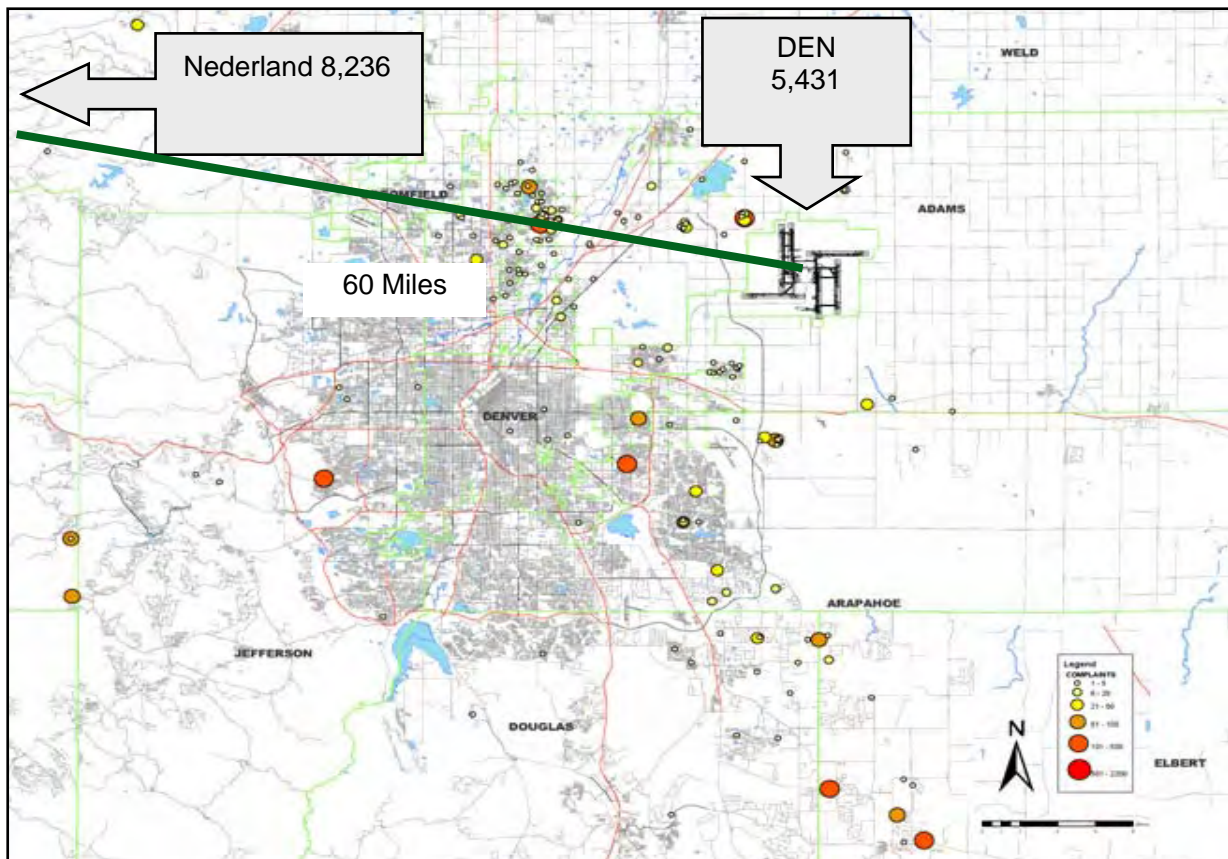


FIGURE 8.10 – High complaint areas surrounding DEN

As there are currently minimal residential areas in the vicinity of the airport, most of the complaints are from 30-60 miles away. **Figure 8.10** is a representation of the Nederland area 60 miles northwest of DEN. This town produces a large percentage of DEN's total noise complaints.

The question arises as to the cause of the 84,000 noise complaints filed during the first year of DEN's existence. Initially it was thought that the problem stemmed from a high number of Stage 2 aircraft departing west over residential communities. However, after the Stage 2 phase-out occurred, the complaints continued. The NTF realized that the residents to the west had never been subjected to aircraft noise from Stapleton and therefore DEN had created a new noise problem. According to a personal interview, the city of Denver had promised current residents of Adams County that the airport would not be noisy. Other literature was distributed describing the value of an airport in the largely undeveloped Adams County hoping to gain community support. When the airport commenced operations in February 1995, it is possible that the communities were surprised to hear any aircraft noise at all. The other explanation is tied to political tension surrounding the new airport. When the city and county politicians were asked to vote on the inception of the IGA, only half of the constituents supported the annexation. The County held a vote to annex the land to the city of Denver and the annexation passed with 55 percent pro and 45 percent con. This could be intricately linked to the annoyance and opposition that resulted after the first year of operation

8.5 Summary

DEN was designed to cure the land use/noise impact problems surrounding the previous location of Stapleton International Airport. The location of DEN was chosen to provide a land buffer between the airport and community to protect them both from the negative effects produced when the two are in close proximity. DEN was supposed to be the model airport for operational flexibility and land use management; however, DEN has begun to suffer many of the same land use management-related issues felt by airports built 50 years ago. As older airports around the country find themselves constrained and no longer able to grow, the need to build newer, more flexible airports in less-populated areas may become more prevalent around the country. Conversely, the success found at DEN could be greatly dampened as developments around the airport have the potential to return it to the same problems experienced by Stapleton nearly 10 years ago. After the new airport was moved to the Denver extension in Adams County, the city of Denver began to follow. Residential and commercial developments have begun to spring up all around the airport and the effects are beginning to appear. Because airports in the U.S. and the FAA have no power to control their surrounding land use, DEN and other airports can only work with surrounding governments to explain the importance of compatible land use.

Airports in fact often have very little authority when it comes to land that is outside of the jurisdiction of the airport development plan. A great deal of the responsibility to manage the land around airports falls on the shoulders of local governments. Increased tax revenues and other incentives often drive incompatible land uses closer to airports causing greater financial constraints in the future. Airports act as economic engines, and are vital to the health and growth of their regional areas. Greater care must be taken to protect the land use surrounding airports, provide avenues for expansion, and communicate with citizens and local governments to follow established procedures in their plans for expansion as airports grow and change to meet operational demands.

9. Conclusion

The airports chosen for this study provide a representation for the three main categories of airports in the United States. FLL is a medium-sized, long-established airfield situated in a densely populated area facing issues related to airport expansion and changes in airport operations. SFB is a reliever hub airport that was once known only for its general aviation operations, but is now faced with increased commercial operations and growing noise complaints. DEN is a large hub airport which originated as a long term solution for airport noise control and land use issues. It is now dealing with the same near-airport residential development concerns faced by many airports around the world. All of these issues have the potential to create problems between airport officials, community members, local governments, and land developers. There is no universal solution to noise complaint or incompatible land use issues.

During the course of this study, land use patterns and demographic data were studied using census data from the areas surrounding the three main airports, as well as ORD, MDW, and Stapleton. Time-phased assessments of changes in certain demographic parameters were developed for the period 1970 to 2000. The data was visualized using map contours and GIS software, and based on our analysis, trends show a tendency for increased population near airports, with average family incomes less than those of the surrounding counties. Some of the attributes studied had similar graphs when compared as ratios relative to the county. These suggest that the parameters are not independent, and thus do not offer any extra information. The data also shows a pattern where construction of housing units occurs at a rate higher than for the surrounding county, particularly for the first few decades of an airport's operation. This indicates the necessity of having appropriate zoning ordinances in place early in the development of new airports to control the construction of residential units in incompatible locations. The statistical significance of the trend analysis, or the number of airports required for analysis, was found to be dependent on the confidence level sought, the population size, and the trend percentage. The further away the trend percentage is from 50%, the fewer the airports needed to obtain a desired confidence interval.

Correlations between census data and noise complaints were difficult to establish. Both higher and lower attributes were found in areas around each of the three selected airports where noise complainants were located. On a local level, some relationships could be observed. On a global level, no conclusions could be made.

Although each airport is unique, a lack of communication between all stakeholders involved was found to be the root of almost every issue the airports faced. These gaps in communication led to noise annoyance grievances between airport officials and the residents of surrounding communities. It also led to multiple problems involving local land use planning and incompatible land use development. Because of the complex situations they face, the airports studied had no real plans to solve either of the issues (noise complaints or incompatible land use) in the long term. Each airport found it difficult to enact noise mitigation strategies that would alleviate the concerns of the community as a whole without creating other issues of the same impact. In addition, local airports do not have the authority to control near-airport land use or development. This allows local municipalities to zone the land surrounding airports for incompatible purposes; while conversely, airports often make attempts to work with municipalities and developers to prevent incompatible developments. However, these are not always successful. The need for greater cooperation and coordination between airports, governments, and developers is essential if any positive changes are going to be made.

9.1 Recommendations

The work done over the past three years has confirmed many previously held ideas about near-airport land use, noise complaints, and airport/community interactions. It has also shed new light on airport noise and its negative impact on peoples' lives. At times, the findings of this research created more questions than answers indicating that there is a great deal of work left to be done. Diligent efforts by airport officials, federal, state, and local governments, as well as developers and community members must be put forth to ensure that as much as possible is being done to not only address current problems, but to prevent similar problems in the future.

Certain recommendations are suggested in order to prevent incompatible airport land use and to minimize impact on citizens' lives:

- First and foremost, a proactive and effective communication link should be established and maintained between city, county, airport, community, and real estate representatives. Airports should be able to voice their concerns about near-airport incompatible land use, and have a substantial influence in the decision making process.
- Community members should be informed of future projects and how they may impact their lives.
- Airports should also make efforts to educate surrounding communities and provide forums where aviation education can take place, and concerns and questions can be addressed.
- A nationally standardized method of complaint collection and reporting should be designed and implemented in order to increase the value of noise complaint data, and the ability to draw conclusions from its comparison and analysis.

Due to the importance of local airports, a cooperative and successful relationship between the airports, the local governments and the impacted neighborhood communities will only serve to benefit everyone involved. Two airports that have been very successful at establishing this type of relationship with their surrounding communities are O'Hare International Airport (ORD) and San Francisco International Airport (SFO). The steps taken by both of these airports have been met with great success and are recommended to airports of similar size. Another asset will be the website, NoiseQuest, that is currently being developed by the FAA/NASA/Transport Canada-sponsored Center of Excellence, PARTNER. As described earlier, NoiseQuest is a website dedicated to providing the public with educational material related to noise and aviation operations. NoiseQuest could be used to distribute standardized information to complainants or concerned citizens at no direct cost to airports.

9.2 Suggestions for Future Work

The work to understand the dynamics of land use management and aviation noise annoyance is far from complete. This project has confirmed many previously held ideas and has uncovered new information on the effects of incompatible land use on peoples' lives, yet it has also revealed areas where future work could greatly enhance our current understanding.

One limiting factor of this research was the number of airports that were studied. A larger sample of airports would provide a broader spectrum of demographics and an increased ability to generalize common land use trends. A supplemental study at emerging secondary airports similar in size to SFB is being completed to compare how they are handling their prominent land use and noise issues.

Although this study could not report any conclusive findings regarding the relationship between demographic factors and noise annoyance and complaints, further work in this area would aid airport noise officers and zoning officials as they work together to plan compatible land use developments around airports. Airport officials would also be able to predict the location of and prepare for increased noise complaints during airport operational changes. Further study into citizens identified as chronic complainants would benefit airports as they plan their mitigation strategies and determine if a noise problem even exists at their airport. Psycho-acoustical tests could provide answers to questions about chronic complainants' sensitivity to noise and other physiological or lifestyle factors that could affect their perception.

Future land use studies using census data blocks would provide a finer and more detailed view of demographic factors when overlaid with noise complaint data. These smaller sections of data would help to pinpoint more precisely where the demographic data is located within a specific area. Also, the addition of education level as a demographic factor could help to answer whether a correlation exists between education level and an individual's propensity to complain.

Finally, a feasibility study into the development of a land use metric should be undertaken. This metric could provide local governments with a baseline for making land use and zoning decisions based on the characteristics of various types of possible developments. A more standardized and enforced method of land use and zoning regulation could reduce the number of incompatible land use developments, and drive airports and municipalities toward a higher level of coordination related to land use planning.

REFERENCES

- Acevedo 1999 Acevedo, W., "Analyzing Land Use Change in Urban Environment," United States Geological Survey, 1999.
- Albee 2003 Albee, W., "A case for buffer zones," Wyle Laboratories, 2003.
- ACI-NA 2005 Airports Council International-NA, "Stats and surveys: traffic statistics," URL: <http://www.aci-na.org/asp/traffic.asp?art=215>, [accessed July 2006].
- Arata 1970 Arata, W.H., "Planning airports to serve air transportation in underdeveloped and emerging nations," AIAA 7th Annual Meeting and Technical Display, Houston, Texas, October 19-22, 1970.
- BCAD 2002 Broward County Aviation Department, "Airport noise abatement committee draft charter," revised December, 2002.
- Bishop 1965 Bishop, D.E. & Pearsons, K.S., "Recent studies in evaluating aircraft noise and its subjective effects," AIAA Aircraft Design and Technology Meeting, Los Angeles, California, November 15-18, 1965.
- Broward a Broward County, About the Airport, "FLL's high flyers," URL: http://www.broward.org/airport/about_history.htm, [accessed July 2006].
- Broward b Broward County, About the Airport, "FLL takes wing," URL: http://www.broward.org/airport/about_history.htm, [accessed June 2006].
- Broward c Broward County, Noise Information, URL: http://www.broward.org/airport/community_noise.htm, [accessed July 2006].
- Burleson 2003 Burleson, C. & Maurice, L., "Aviation and the environment: Challenges and Opportunities," AIAA-2003 International Air and Space Symposium and Exposition, Dayton, Ohio, July 14-17, 2003.
- CCDDOA 2001 City & County of Denver Department of Aviation, Airport layout narrative report, pages 1-4, 2001.
- CCDDOA 2004 City & County of Denver Department of Aviation, Airport layout narrative report, 2004.

- CCDDOA 2005 City & County of Denver Department of Aviation, Denver International Airport, URL: <http://www.flydenver.com/guide/index.asp>, [accessed July 2006].
- Chapkis 1980 Chapkis, R.L., Blankenship, G.L., & Marsh, A.H., "Comparison of Aircraft Noise-Contour Prediction Programs," AIAA 6th Aeroacoustics Conference, Hartford, Connecticut, June 4-6, 1980.
- Cheek 2000 William V. Cheek and Associates, " Airport land use compatibility and air Safety study," Phoenix, Arizona
- CODOT 2006 Colorado Department of Transportation, "Economic impact study: Colorado's commercial service airports, URL: <http://www.colorado-aeronautics.org/images/EconImpact2003/CommercialAirports>, [accessed July 2006].
- Creative 2005 Creative Research Systems, <http://www.surveysystem.com>, [accessed June 2005].
- DEN Denver International Airport, "Noise Management," URL: <http://www.flydenver.com/diabiz/community/noise/index.asp>, [accessed July 2006].
- Esler 2006 Esler, J., "Why you community needs its airport," Aviation Week, July 25, 2006. URL: http://www.aviationnow.com/avnow/news/channel_bca_story.jsp?id=news/airport0806.xml, [accessed December 2006]
- FAA 1998 Federal Aviation Administration, "Land use compatibility and airports," May 1998, 141 pages.
- Fidel & Silvati 2004 Fidel, S. and Silvati, L. "Parasimonious alternatives to regression analysis for characterizing prevalence rates of aircraft noise annoyance," Noise Control Eng. J. 52(2), 56-68.
- Foster 1977 Foster, C.R., "Noise regulations of the federal government," AIAA 13th Propulsion Conference, Orlando, Florida, July 11-13, 1977.
- FSL 2005 Florida State Legislature, 2005 Florida Statutes, URL: http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&URL=Ch0333/titl0333.htm, [accessed July 2006].
- Gallagher 1975 Gallagher, D., "Land use analysis of US urban areas using high resolution imagery from skylab," Purdue University, 1975.

- Goddard 1991 Goddard, K., "Re-Engining – the sound case for aircraft noise reduction," AIAA 27th Joint Propulsion Conference, Sacramento, California, June, 1991.
- Hartman 1986 Hartman, B.D., "A history of noise control programs and review of the regulatory process," AIAA, September 1986.
- HTBN 2002 HTBN, Corp., Denver International Airport: 14 CFR Part 150 Study, 2002.
- Hull 1978 Hull, B. and Linsley, C., "Noisy Airplanes," Transportation USA, Vol. 4, No. 2, DOT, Washington, D.C., 1978.
- IGA 1988 City and County of Denver & Adams County of the State of Colorado, Intergovernmental agreement on new airport, pgs. 1-17, 1988.
- Jenny Jenny, R., "Naval air station Fort Lauderdale history," URL: <http://www.bobjenny-artist.com/nas/history.htm>, [accessed July 2006].
- Kelly 1997 Kelly, T., "Amendment to Part IV (Aircraft Noise) of Transport Canada's Guidelines 'Land Use in the Vicinity of Airport'," Canadian Acoustics, 25(1), pgs. 19-22, 1997.
- LFA 2003 Leigh Fisher Associates. "Economic Impact Assessment for FY 2002 and future years with and without proposed runway 9R-27L expansion: Fort Lauderdale-Hollywood International Airport," WA 0215, A and WA 0322, 2003.
- Lieberman 2004 Lieberman, Ilene, "State of the county," November 16, 2004.
- McMillan 2004 McMillan, D.P., "Airport Expansions and Property Values: Chicago O'Hare Airport," Journal of Urban Economics, pp. 627-680, 2004.
- Morrison 2004 Morrison Homes, Resident Disclosure Agreement, 2004.
- Olislangers 1995 Olislangers, R.P., "Comprehensive Land Use Planning: McClellan-Palomar Airport," Transportation Congress, Proceedings of 1995 Conference, 1995.
- PSRC 2006 Puget Sound Regional Council, "Compatible land use planning resources," URL: <http://www.psrc.org/projects/air/landuse/airbib.htm>, [accessed December 2006]
- Rice 1984 Rice, C.G., "Assessment and prediction of Aircraft Community Noise Annoyance," AIAA 9th Aeroacoustics Conference, Williamsburg, Virginia, October 15-17, 1984.

- Richmond 2002 Richmond American Homes, Resident Disclosure Agreement, 2004.
- SANAC a Sanford Noise Abatement Committee, "SANAC mission statement,"
URL: <http://www.orlandosanfordairport.com/sanac/smission.htm>,
[accessed June 2006].
- SANAC b Sanford Noise Abatement Committee, "Noise Reduction Proposal
list," URL: <http://www.orlandosanfordairport.com/sanac/snri.htm>,
[accessed June 2006].
- SCPA Seminole County Property Appraiser, "Get information by parcel number,"
URL: http://www.scpafl.org/pls/web/re_web.seminole_county_title?parcel=03203130000800000&cpad=cameron&cpad_num=&cctr=&ctotal=&cfparcel=27193150100000980&cmap=Y&cmap=Y&cdor=&crank=15,
[accessed June 2006].
- Schomer 2002 Schomer, P.D., "On normalizing DNL to provide better correlation with
with response," Sound and Vibration/ December 2002, 14-25.
- Schultz 1978 Schultz, T. J., "Synthesis of social surveys on noise annoyance,"
Journal of the Acoustical Society of America, 64(2), 377-405.
- SFB a Orlando Sanford International Airport, "History and General Information,"
URL: <http://www.orlandosanford.com/history.htm>, [accessed June 2006].
- SFB b Orlando Sanford International Airport, "Airport Cargo,"
URL: <http://www.orlandosanford.com/cargo.asp>, [accessed June 2006].
- SFB c Orlando Sanford International Airport, "Passenger Counts,"
URL: <http://www.orlandosanford.com/pass.asp>, [accessed June 2006].
- SFB-MP 2002a Orlando Sanford International Airport Master Plan Update, "Economic Impact
Assessment," 11-1, 2002.
- SFB-MP 2002b Orlando Sanford International Airport Master Plan Update, "Critical Aircraft,"
pgs. 2-7, 2002.
- SFB-MP 2002c Orlando Sanford International Airport Master Plan Update,
"Runway requirements," 6-3-1, 2002.

- Shea Shea Homes, Resident Disclosure Agreement.
- Shutes 1971 Shutes, O., "Incompatible Land Use Around Hollywood-Burbank Airport," Masters Thesis, 1971.
- Tedrick 1983 Tedrick, R.N., and Hixson, R.B., "Aircraft noise and the airport community," AIAA International Air Transportation Conference, Montreal, Canada, June 1-3, 1983.
- Thomas 2004 Thomas, C.S., Hume, K.I., and Hooper, P.D., "Aircraft noise, aircraft growth and regional development," AIAA 10th Aeroacoustics Conference, Manchester, United Kingdom, May 10-12, 2004.
- Tucker 1985 Tucker, J.W., "Community Encroachment: Community Expansion vs. Airport Survival," Masters Thesis, 1985.
- Van Praag 2005 Van Praag, B. and Baarsma, B.E., "Using happiness surveys to value intangibles: The case of airport noise," Royal Economic Economic Society, 2005.
- Wang 2002 Wang, Y.Q., "Remote Sensing and Modeling in Regional Land Cover Change Study," Symposium on Geospatial Theory, Processing and Applications, Ottawa, 2002
- WBA 2000 Wilbur Smith Associates, Inc., "Florida Airports Economic Impact Study," Columbia, South Carolina, 2000.
- Wesler 1981 Wesler, J.E., "Federal Policies Affecting Airport Noise Compatibility Programs," International Air Transportation Conference, Atlantic City, New Jersey, May 26-28, 1981.

APPENDIX A – A lists of symbols

AAAE	American Association of Airport Executives
AADA	Airport and Airway Development Act
ANAC	Airport Noise Abatement Committee
ANOMS	Airport Noise and Operations Monitoring System
ANALUC	Airport Noise Abatement and Land Use Compatibility
ARTS	Automated Radar Terminal System
ASNA	Aviation Safety and Noise Abatement
BOCC	Broward County Board of Commissioners
CAB	Civil Aeronautics Board
CEQ	Council on Environmental Quality
COE	Center of Excellence
dB	Decibel
DEN	Denver International Airport
DMSP	Defense Meteorological Satellite Program
DNL	24-hour Average Day-Night Sound Level
DOT	Department of Transportation
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ETM+	Enhanced Thematic Mapper Plus
FAA	Federal Aviation Administration
FAAP	Federal Aid to Airports Program
FAR	Federal Aviation Regulation
FLL	Fort Lauderdale-Hollywood International Airport
GIS	Geographical Information Systems
IGA	Intergovernmental Agreement
IMC	Instrument Meteorological Conditions
INM	Integrated Noise Model
JCA	Joint Cooperative Agreement
Ldn	Also referred to as DNL: 24-hour Average Day-Night Sound Level
Leq	Equivalent Conditions Sound Level
MDW	Chicago Midway International Airport
MP	Master Plan
MSS	Multispectral Scanner
NAS	Naval Air Station
NCP	Noise Compatibility Plan
NDVI	Normalized Difference Vegetation Index
NEM	Noise Exposure Map
NEPS	Noise Exposure Performance Standards

NTF	Noise Task Force
NWG	Noise Working Group
OLS	Operational Linescan System
ONCC	O'Hare Noise Compatibility Commission
ORD	Chicago O'Hare International Airport
PARTNER	Partnership for AiR Transportation Noise and Emissions Reduction
PDF	Portable Document Format
RPZ	Runway Protection Zone
SAA	Sanford Aviation Authority
SANAC	Sanford Aviation Noise Abatement Committee
SEL	Sound Exposure Level
SFB	Orlando-Sanford International Airport
STP	Stapleton International Airport
TM	Thematic Mapper
USGS	United States Geological Survey
VMC	Visual Meteorological Conditions

APPENDIX B: Geo-Coded Noise Complaints Graphed with Census Data

In an attempt to better understand noise complaint patterns, complaints at the three study airports were overlaid on GIS maps generated from census data. Noise complaints at FLL and SFB were geo-coded and graphed simultaneously with the census data, whereas noise complaints from DEN were provided in digital map form. These maps were geo-referenced and graphed with the census data. Three census attributes of interest were selected for the study: total population density, average family income, and property values.

In 2003, Wyle Laboratories examined population growth around some U.S. and Canadian airports using geo-referenced raster images derived from satellite imagery for the years 1990 and 2000. Initially, to improve the understanding of the incompatible land use phenomena, FIU used historical aerial imagery and historical/census data. The census data allowed for analysis of decade-to-decade comparisons that show time-sequenced patterns of population movement near airports. Additionally, Wyle Labs provided flight tracks that were overlaid on the attribute/complaint maps.

The aerial images and the building count programs were thought to be potentially effective tools to supplement housing census data, particularly for earlier decades. Although building count results were obtained, it was difficult to validate the accuracy of the programs. The difficulty was primarily due to the photographic quality of the aerials and the ability to generate a reliable basis that could be used to validate the programs.

In addition to graphing the census data with the noise complaints, baseline flight tracks were included in the graphs.³ However, flight tracks for SFB were not available. It should be noted that the complaints from the Denver area were from years 2002, 2003, and 2004. Complaints from the Sanford area were from 2001 and 2002, and complaints from the Fort Lauderdale area were from 2003, 2004, and 2005. Aggregate maps were also generated for FLL and SFB that combined all the noise complaint data for the years analyzed. This was done for each of the three attributes being examined.

Census data is only available for year 2000, so direct correlations between the census data and the complaints needed to be considered appropriately. In addition, the baseline flight tracks for DEN were from 2002, and the baseline flight tracks from FLL were from 2004.

During the first year, demographic data was analyzed for an area covering a 2-mile radius from the airports in the study. This area has been extended to cover a 5-mile radius for all airports studied. The census data that could identify possible indicators or drivers for population growth were analyzed. The literature review identified several factors that may affect population growth:

- Better employment opportunities (Avecedo 1999, McMillan 2004),
- Better transportation accessibility (Tucker 1985),
- Land prices (prime location of land) (Olislangers 1995), and
- Population expansion.

To examine these factors, the following demographic parameters were selected in the first year of the study:

- Population Change: Derived from the “Working Population” (people between the ages of 18 and 64) and “Retired Population” (over 64) census attributes.

³ Base line flight track data were provided by Wyle Laboratories.

- Economic Status of population: Derived from the “Household Income” census attribute.
- Local Industry/Business: Derived from the “Labor Force Status” census attribute, which included employment in the manufacturing, wholesale and retail, and professional fields.
- Housing Characteristics: Derived from the “Year-Round Occupied,” “Vacant or Seasonal Occupied,” “Owner Occupied,” and “Renter Occupied” census attributes.
- Property Value: Derived from the “Median Value” census attribute.
- Travel Accessibility: Derived from the “Mean Travel Time to Work” census attribute.
- Year Structure Built: Derived from the census attribute of the same name.

In the second year of the research, the work was extended as follows:

- Two additional airport areas were included (STP and DEN),
- Two additional decades were analyzed for Phase 1 airports (1970 and 1980),
- Data from Phase One was converted for use with GIS software,
- Data from Phase Two was produced in a format suitable for use in GIS software,
- GIS shape files were obtained for all of the areas of the study,
- Multi-decade comparison charts were generated.

For Phase Two work, a normalized neighborhood database was acquired that contained U.S. census data from 1970-2000 in electronic format, with all parameters normalized in respect to Year 2000 census tracts. The database included information from the national level down to the census tract level, and the output was GIS software useable. Thus, the main tools used for the remainder of the project were the normalized electronic database of census data and GIS software. During the second year of the study, some of the attributes were modified as follows:

- Economic Status was modified to examine average income per family. This was necessary because median income was not available in the normalized database, however, average income per family could be calculated by dividing the total number of families, into the total income for a given census tract.
- Local Industry/Business was augmented to include farming.
- Housing was modified to include only the sum of the housing units in a census tract.
- Travel Accessibility was removed due to difficulties in correlating changes in travel time histograms throughout the decades to the proximity of work locations.

B.1 Individual Airport Results

Since data was analyzed for 1970, 1980, 1990, and 2000, it is possible to generate time-phased graphs of changes in the demographic parameters of interest. In this section we will present portions of the data in different ways, each giving a varied perspective on the data. First, we will show two attributes for one of the airports by using the entire county map at the census tract level. Then, we will show graphs of some of the attributes for each decade. Finally, we will show summary graphs that normalize the data relative to the respective counties, and plot single attributes for all of the study areas in one graph.

To obtain a detailed overall view of changes in a census attribute, it is best to display the features in a GIS-generated map. Figures **B.1-B.7** show examples of two attributes: average family income and total population. These maps were made for the Fort Lauderdale area.

Figures B.1-B.3 show the average family income for each census tract in Broward County and the Fort Lauderdale area for the years 1970, 1980, 1990, and 2000, respectively. The

areas corresponding to a 5-mile radius from the airport are marked by a circle. Examination of the maps in **Figures B.1-B.3** show that certain census tracts further from the airport have larger increases in average income over time. Overall, however, income levels near the airport were very close to those of the county for the time period between 1970 and 2000. This is due in part because the airport is in close proximity to the Intracoastal Waterway and the ocean, where property values and average incomes are higher. Census tracts to the east of the airport, encompassing the Intracoastal Waterway, show significantly higher values throughout the time of interest, when compared with census tracts to the west of the airport. The general trend of similar income between the airport census tracts and the county census tracts is specific to Fort Lauderdale only. In general, the other airports demonstrated the opposite trend.

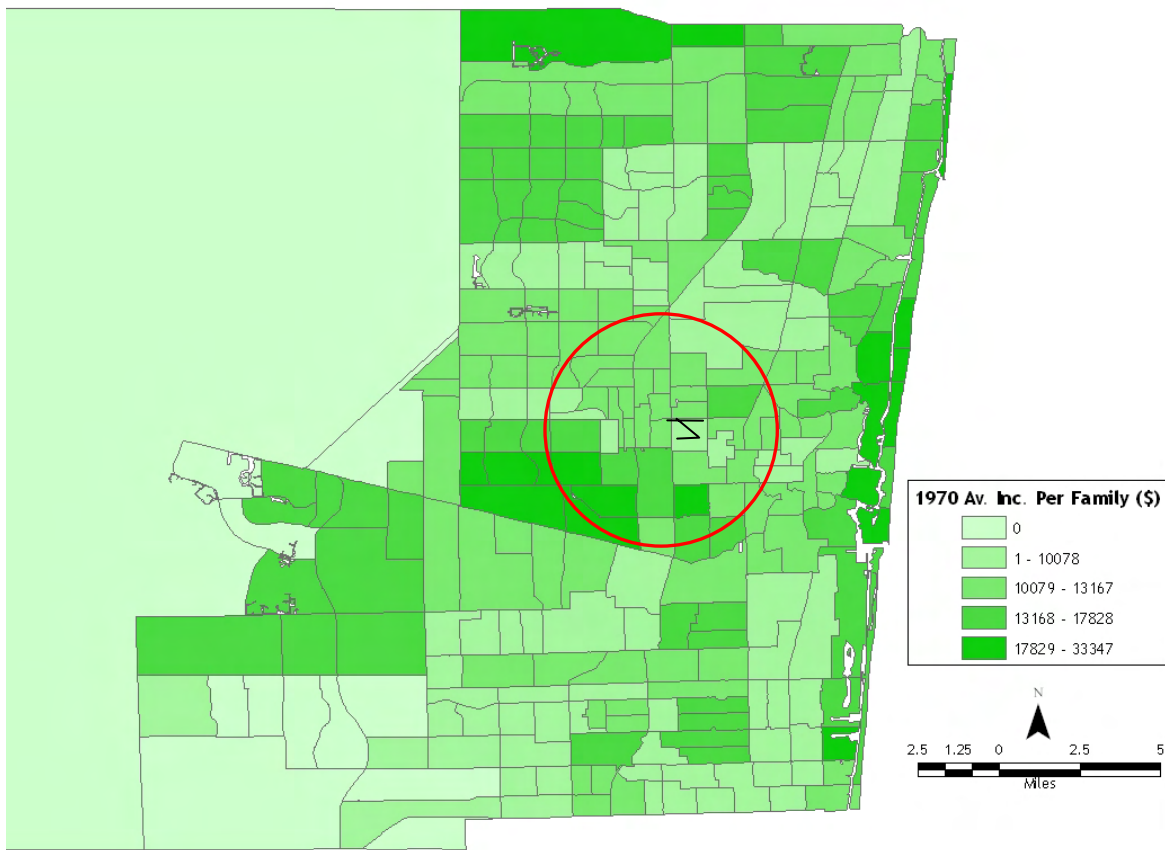


FIGURE B.1 - Average family income for census tracts in the Fort Lauderdale area (1970)

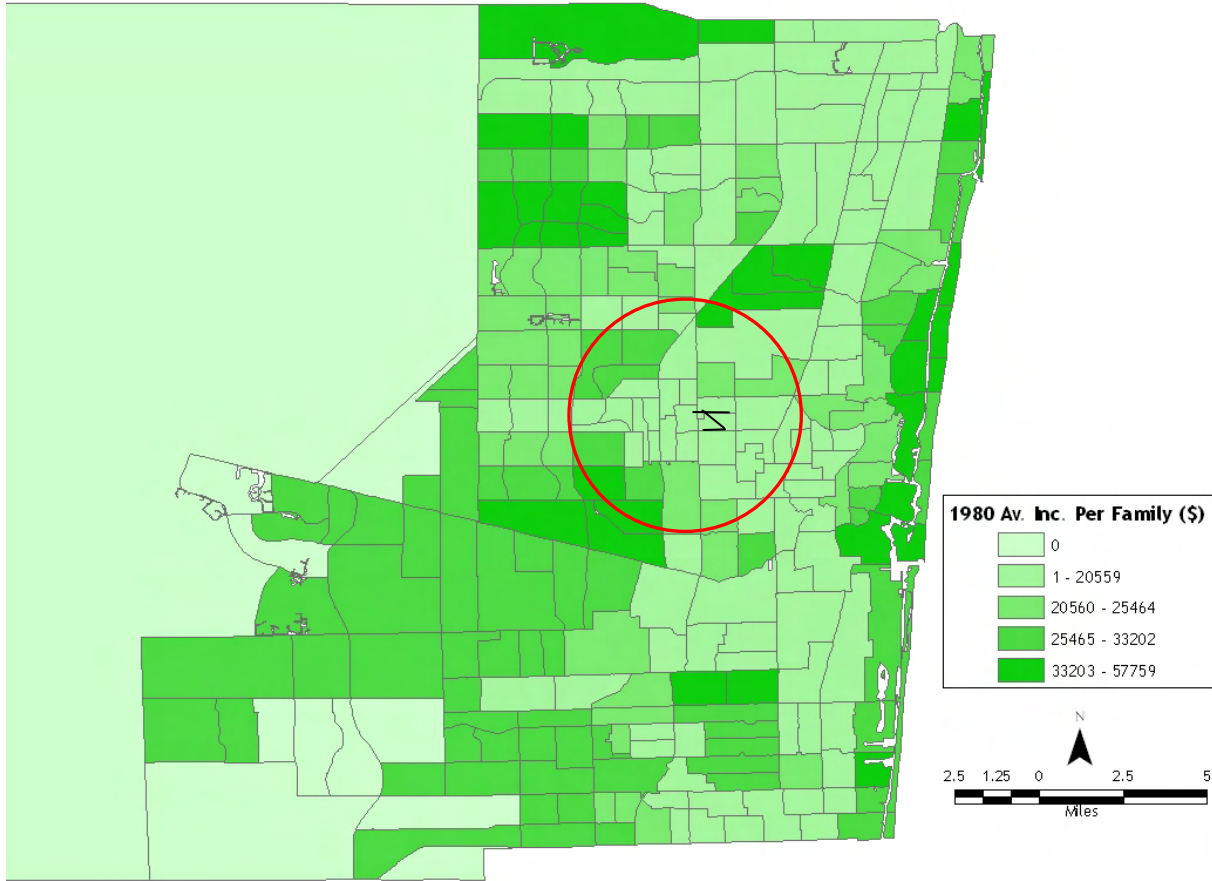


FIGURE B.2 - Average family income for census tracts in the Fort Lauderdale area (1980)

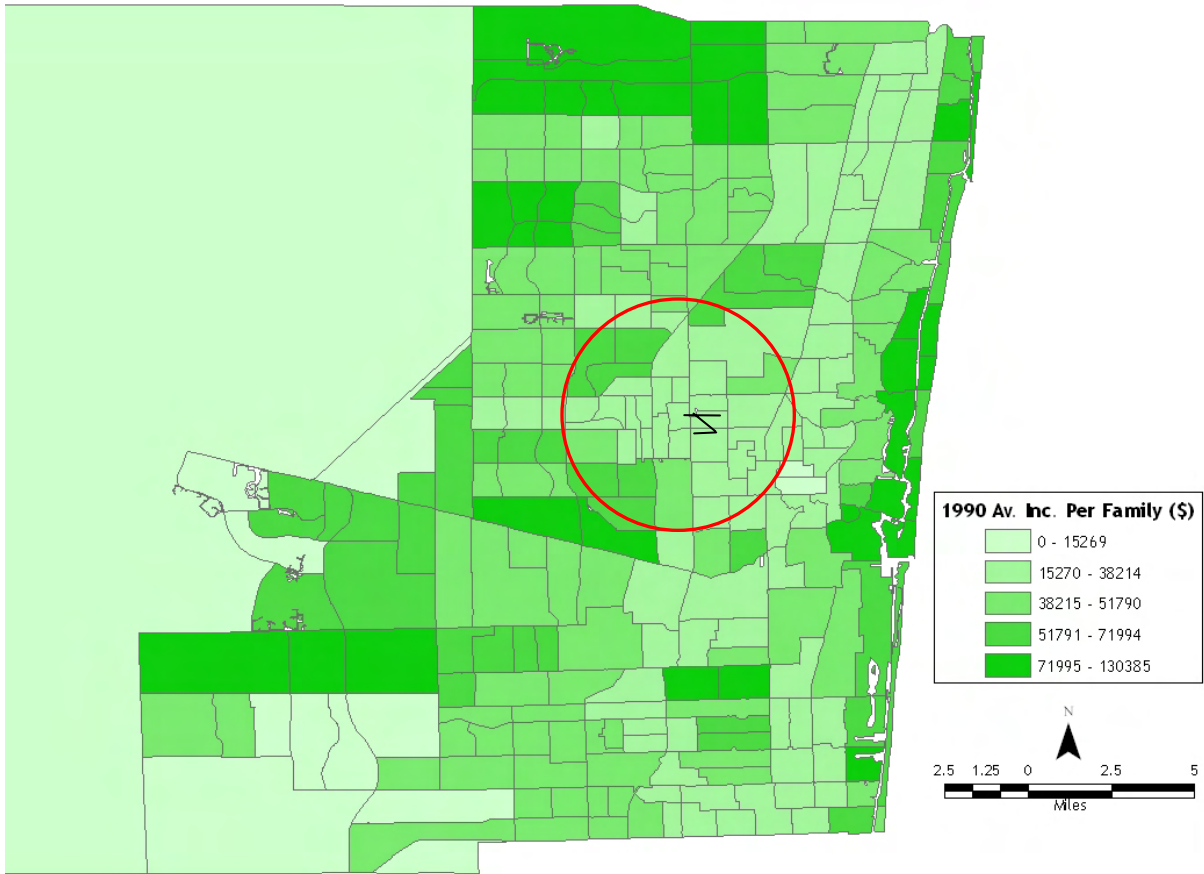


FIGURE B.3 - Average family income for census tracts in the Fort Lauderdale area (1990)

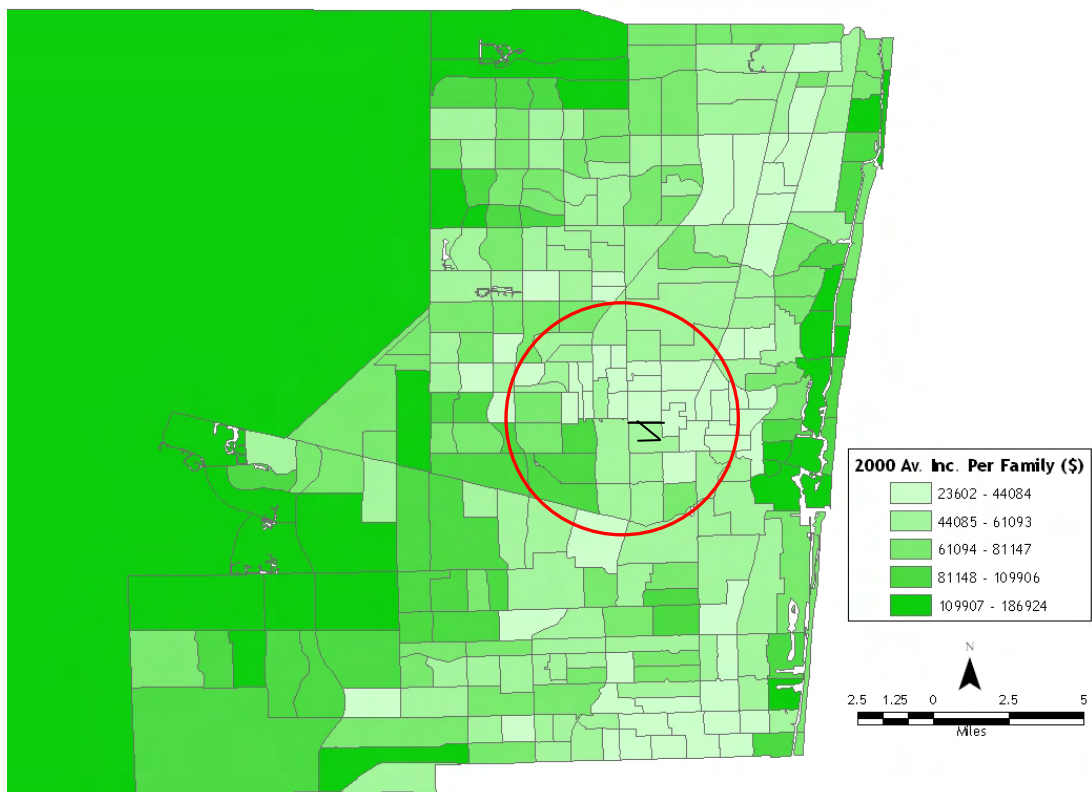


FIGURE B.4 - Average family income for census tracts in the Fort Lauderdale area (2000)

Figures B.5-B.8 show GIS maps of total population per census tract for the Fort Lauderdale area. The maps show that the population increased throughout the county. The tracts near the airports had higher populations than the county tracts, however, over time, the county tracts showed a higher rate of change than the airport tracts. While these maps show the global change picture, it is also necessary to obtain a specific value to compare how the areas near an airport are doing relative to the entire county. To answer these questions, charts were prepared that compare attributes for the area around the airport and for the home county.

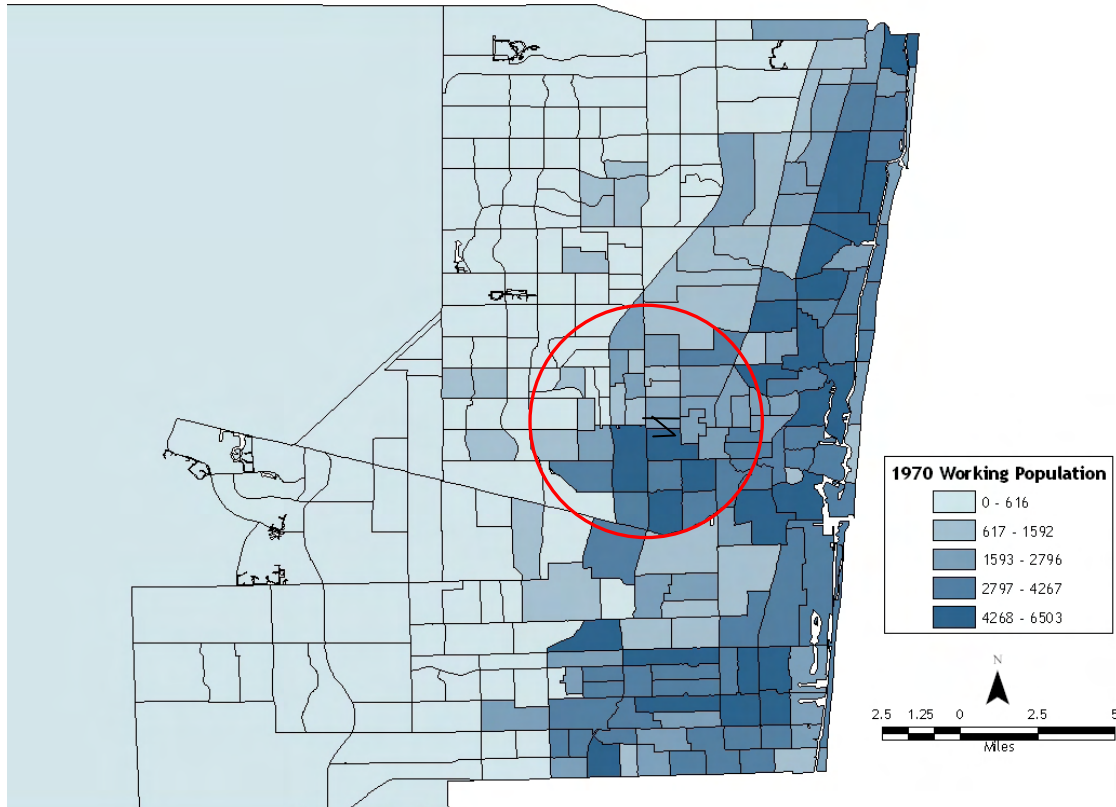


FIGURE B.5 - Working population in the Fort Lauderdale area (1970)

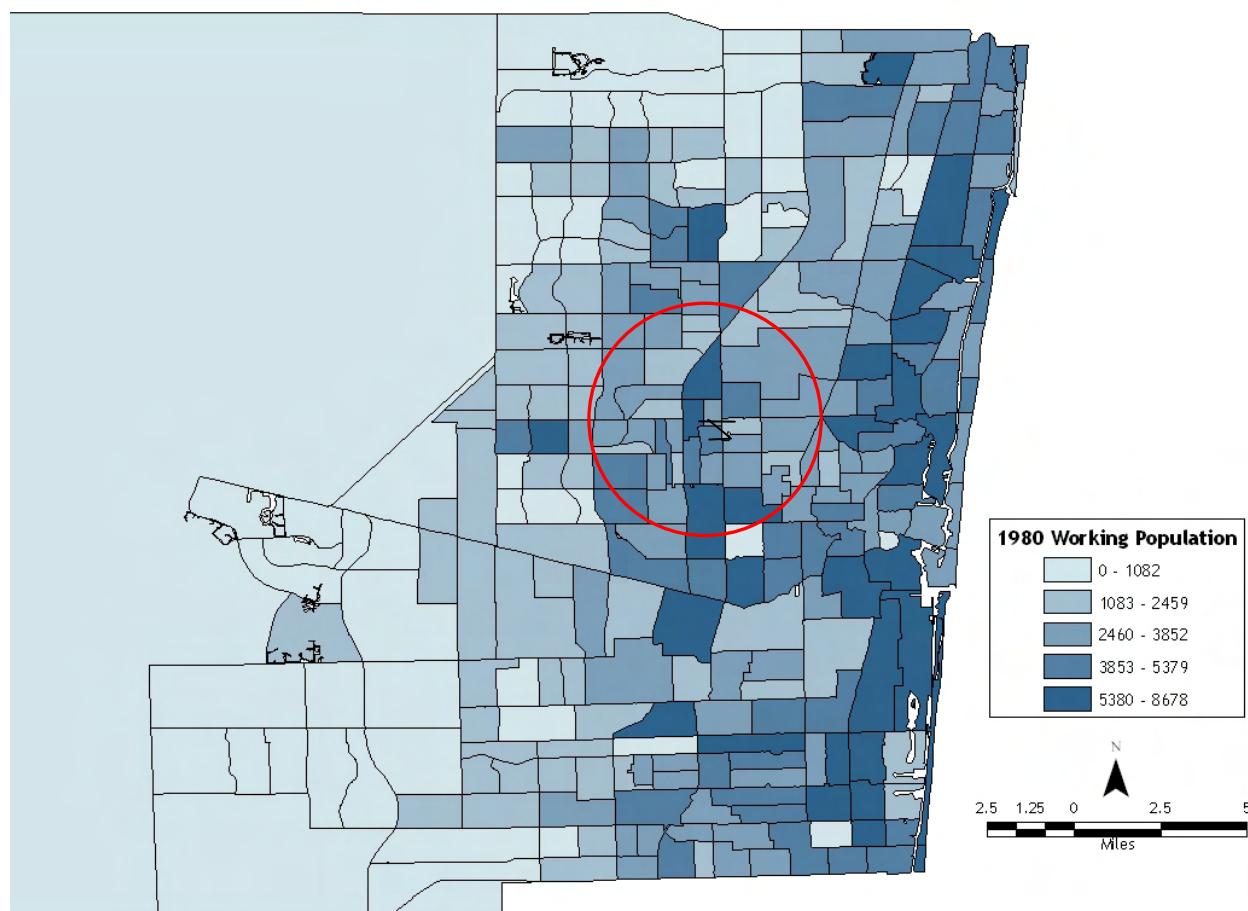


FIGURE B.6 - Working population in the Fort Lauderdale area (1980)

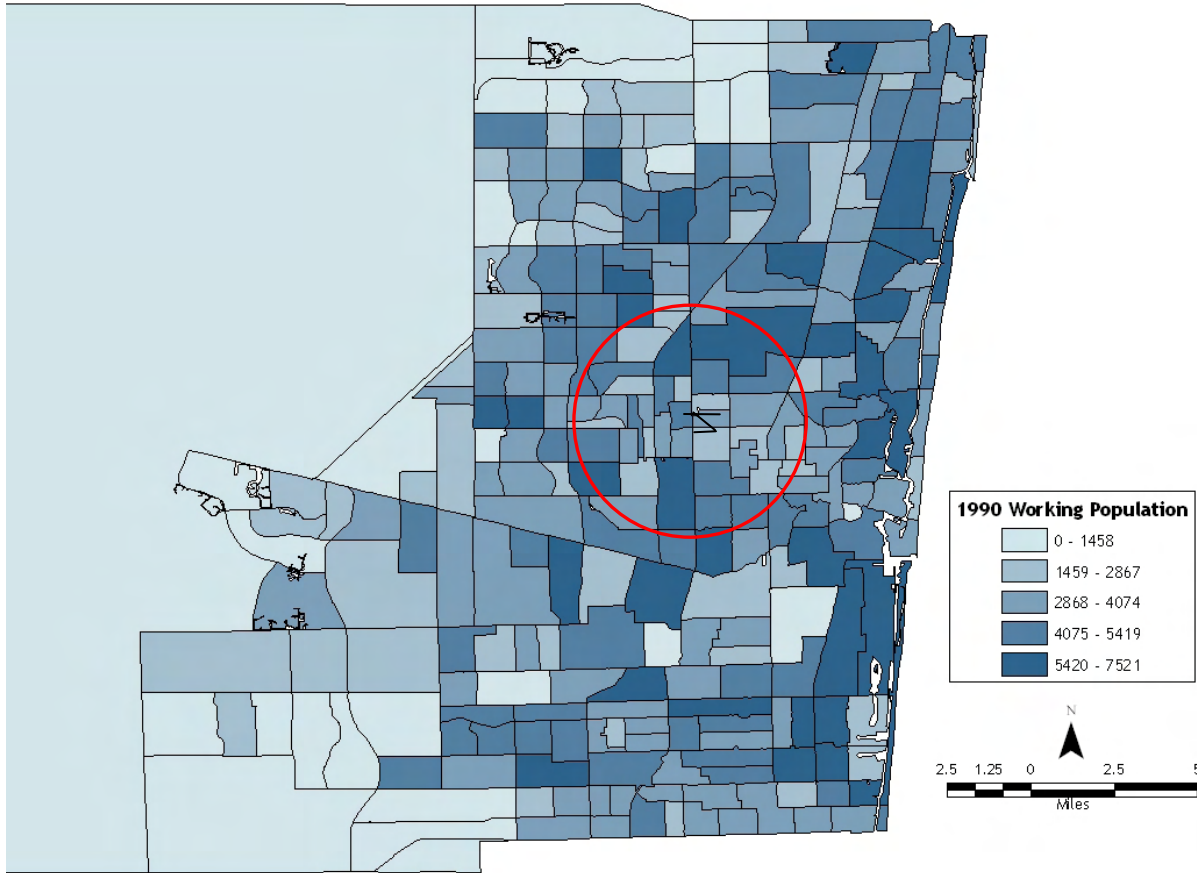


FIGURE B.7- Working population in the Fort Lauderdale area (1990)

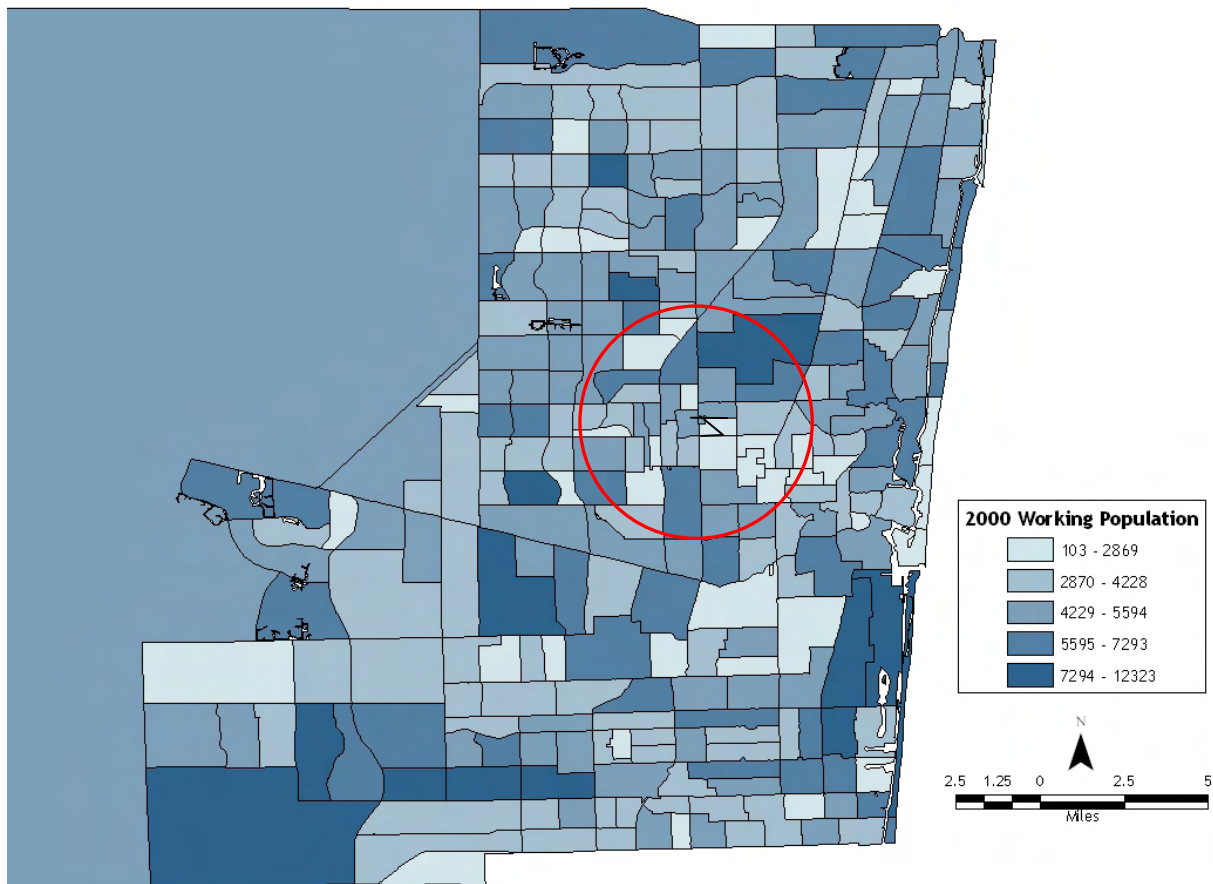


FIGURE B.8 - Working population in the Fort Lauderdale area (2000)

Figures B.9-B.20 are subsets of the data plotted as a single attribute function of a decade for an airport and its home county. In particular, **Figures B.9-B.14** show a comparison of working population for each decade of the study. The data is shown as population density to compare areas near the airport with data for the entire county. The graphs show that the population density is almost always greater near the airport, except for DEN and ORD. This result was expected for DEN, since it had been relocated to a new site, with low population, however, ORD was the only developed airport with a lower population density than the surrounding county. The old DEN and FLL both had significantly greater population densities near the airport than the counties. Finally, SFB had a population density that was only slightly greater than the county.

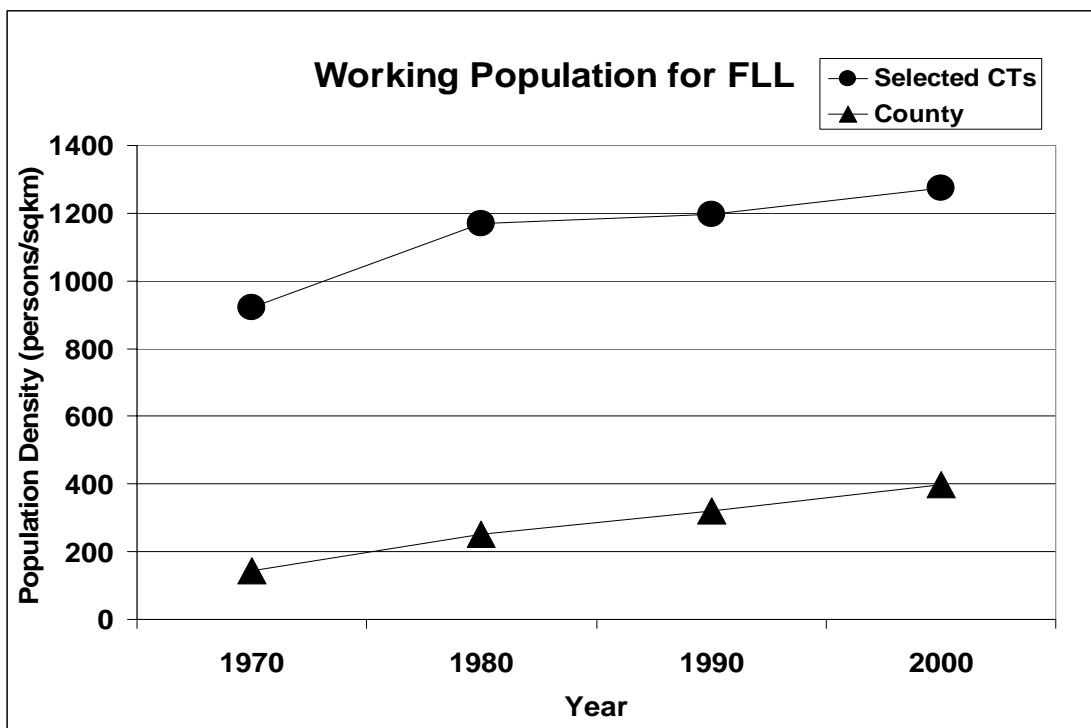


FIGURE B.9 - Working population for FLL and Broward County

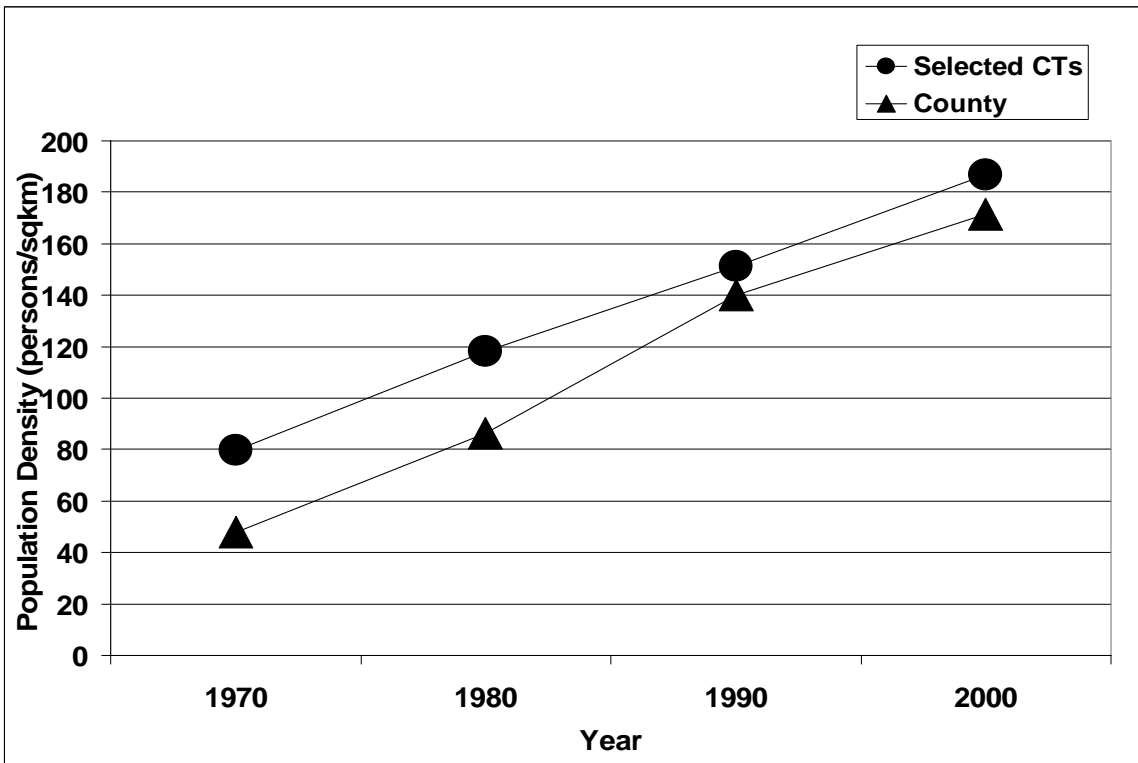


FIGURE B.10 - Working population for SFB and Volusia County

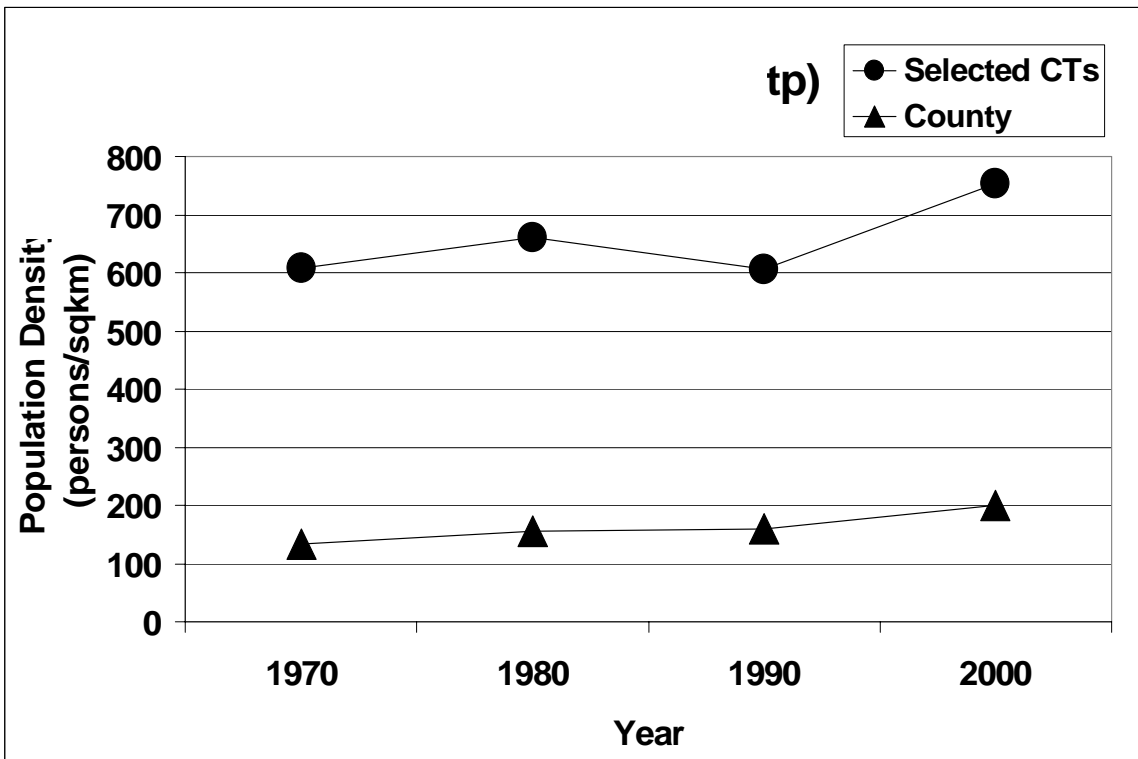


FIGURE B.11 – Working population for Stapleton (STP) and Adams/Denver counties

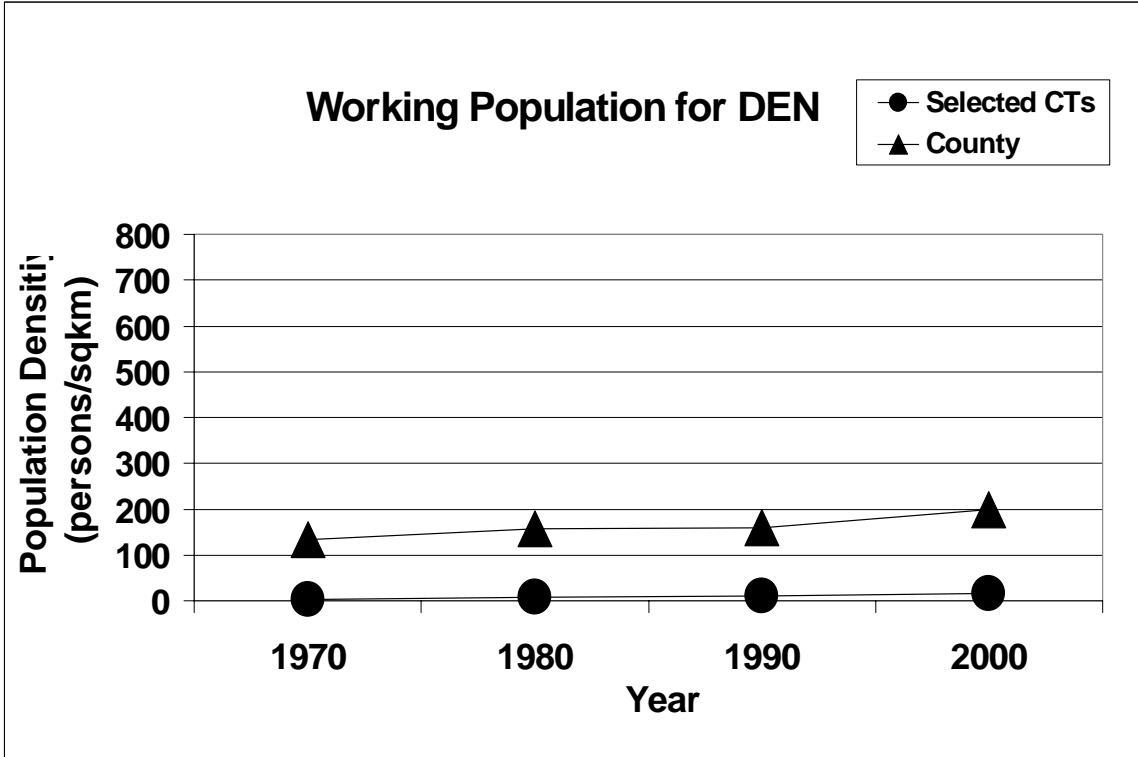


FIGURE B.12 - Working population for DEN and Adams/Denver counties

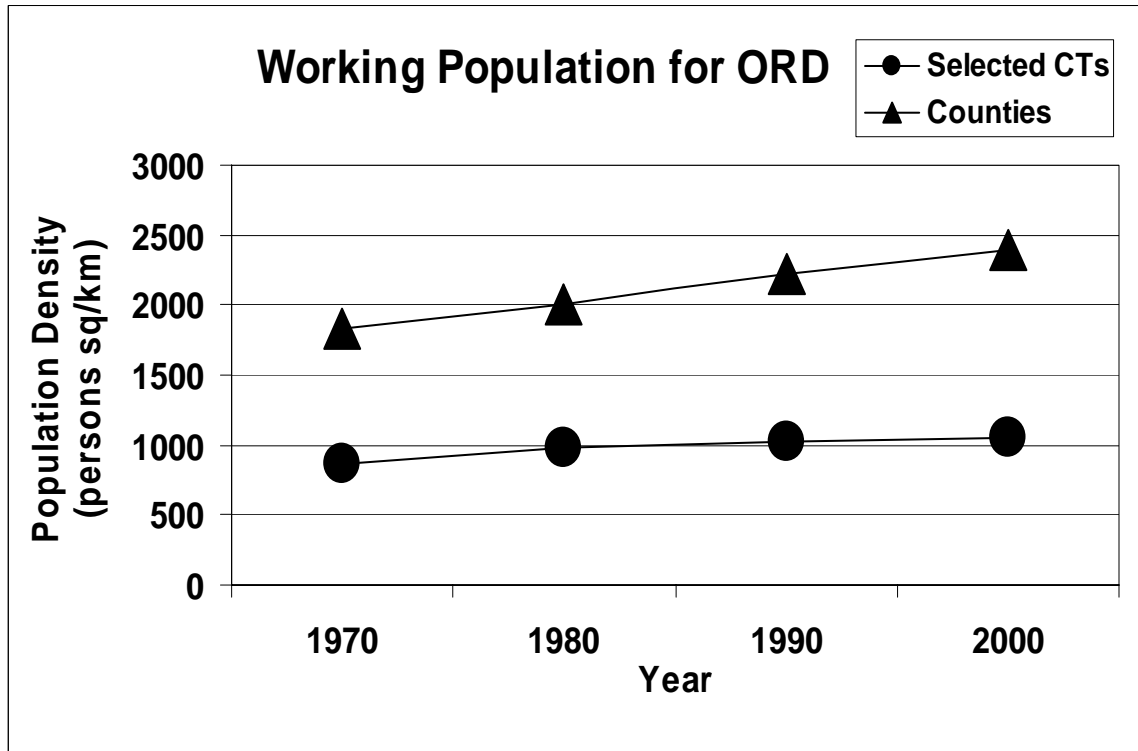


FIGURE B.13 - Working population for ORD and Cook County

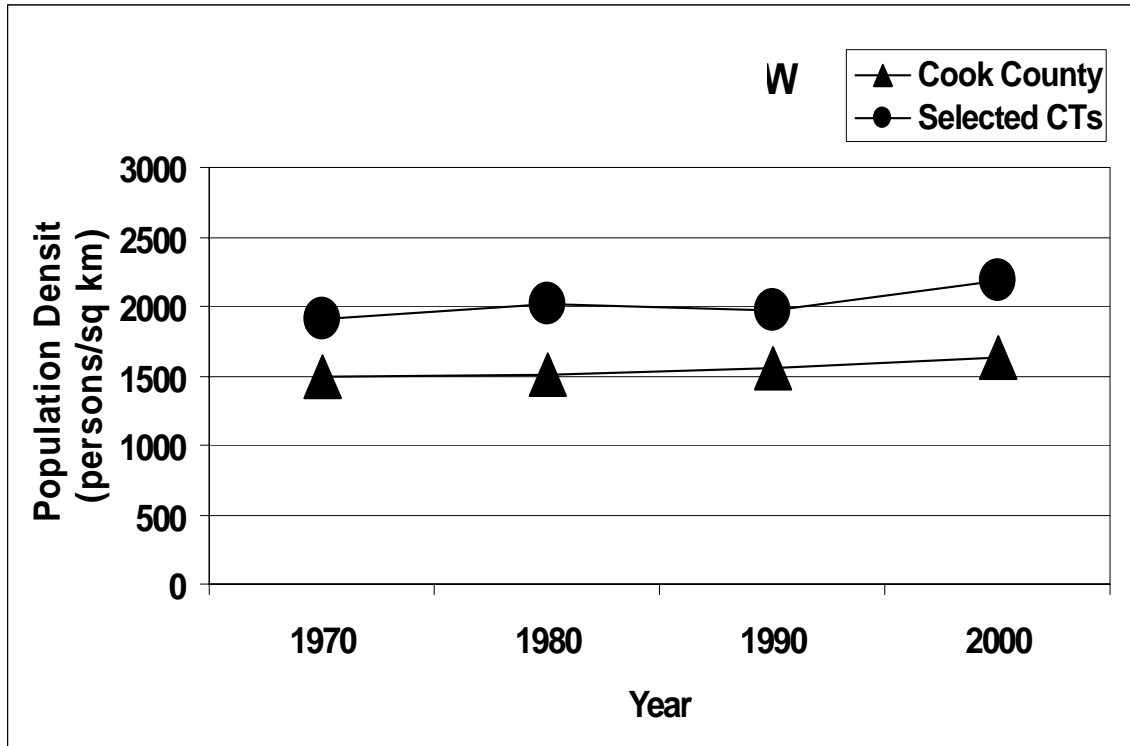


FIGURE B.14 - Working population for MDW and Cook/DuPage counties

Figures B.15-B.20 show the number of housing structures built as a density value for each decade. The figures show that there is greater housing construction near the airport during the earlier decades that then conversely starts to decline. In the case of SFB, this does not apply, since the rate of housing construction closely tracks the rate for the county. For the case of DEN, we see that construction is starting to increase. Once again, ORD is an interesting case, since the density of housing units has been consistently lower than the density for the county.

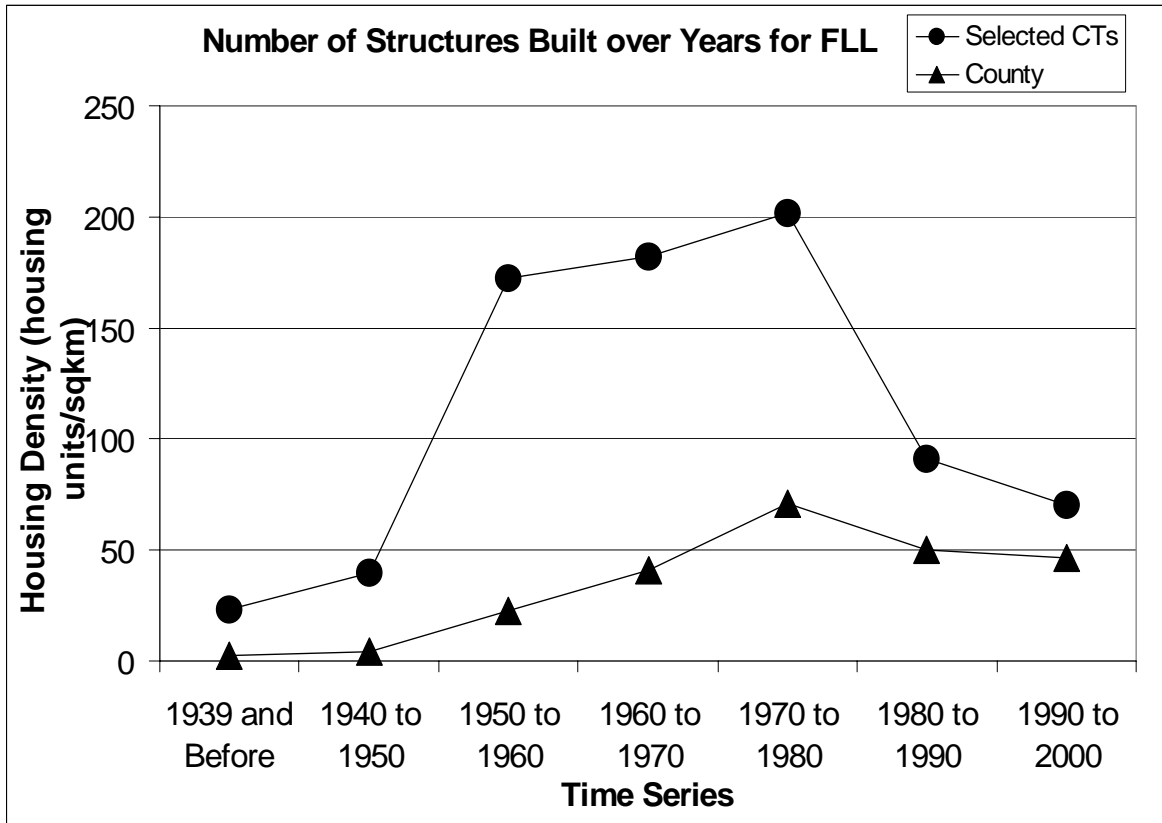


FIGURE B.15 - Housing structures built per decade (FLL and Broward County)

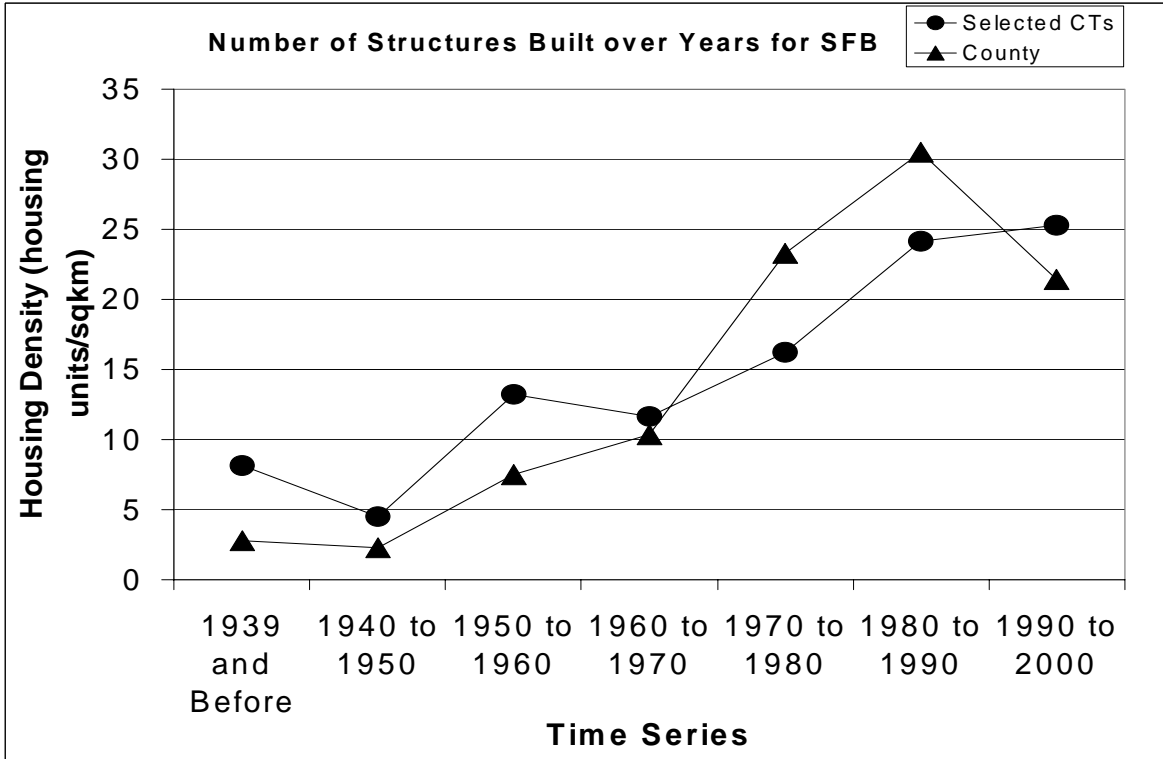


FIGURE B.16 - Housing structures built per decade (SFB and Volusia County)

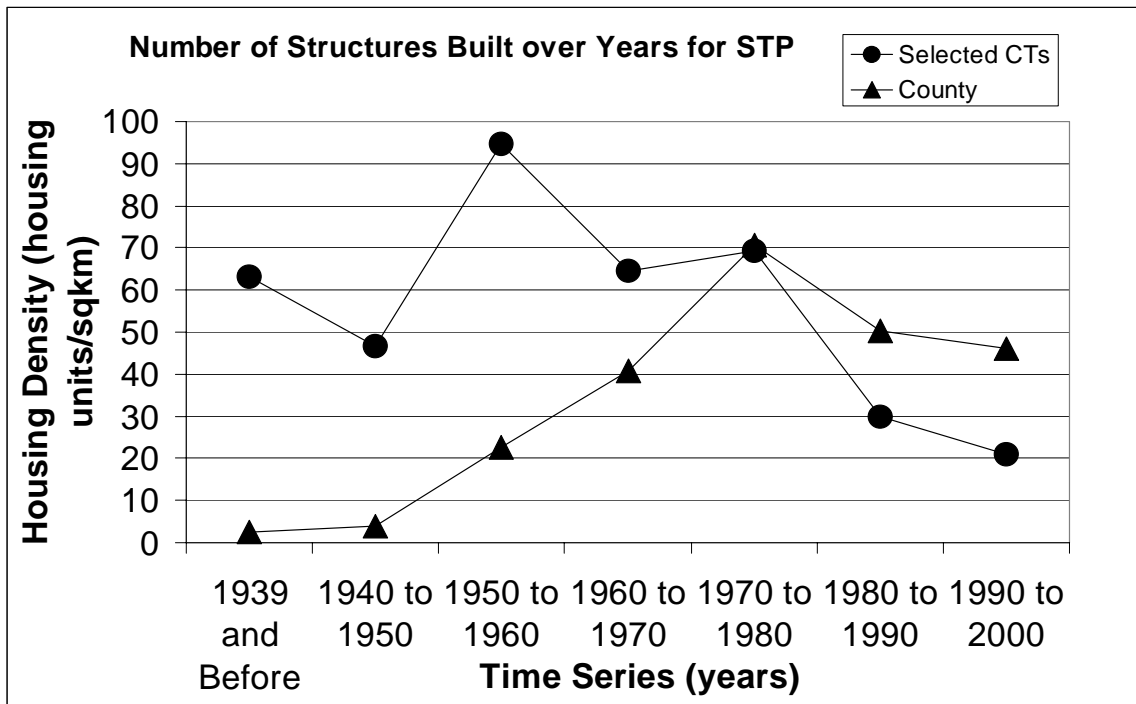


FIGURE B.17 - Housing structures built per decade (STP and Adams/Denver counties)

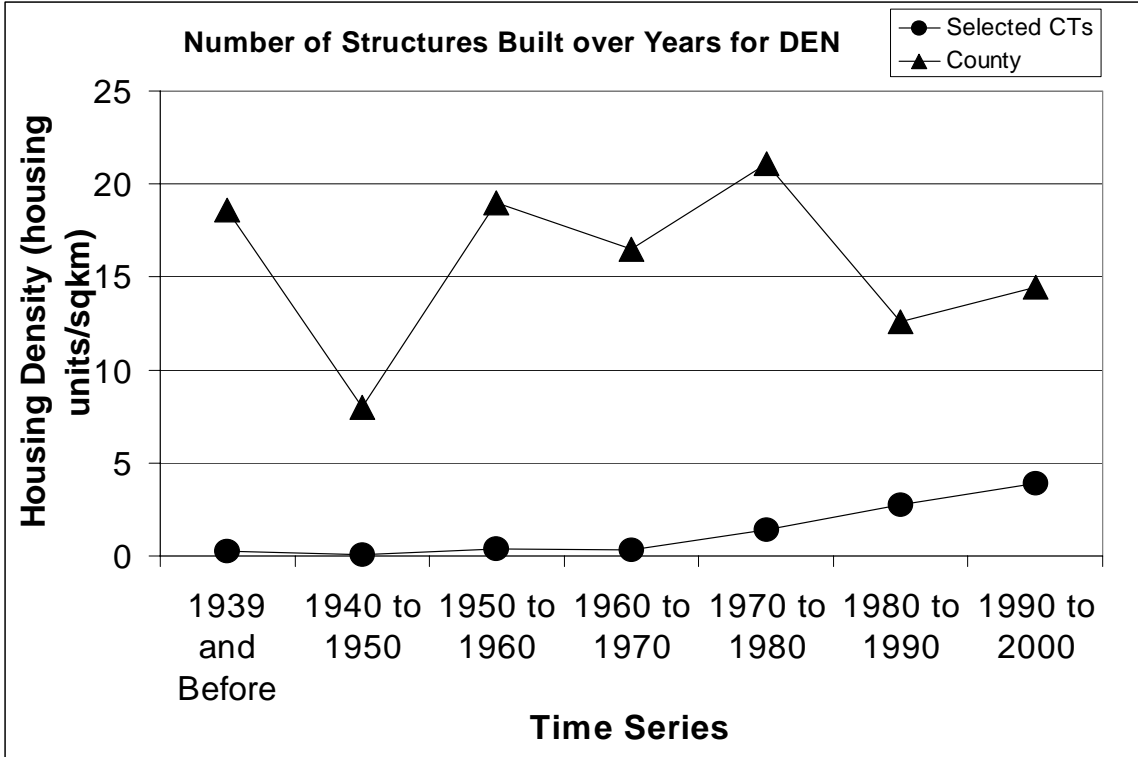


FIGURE B.18 - Housing structures built per decade (DEN and Adams/Denver counties)

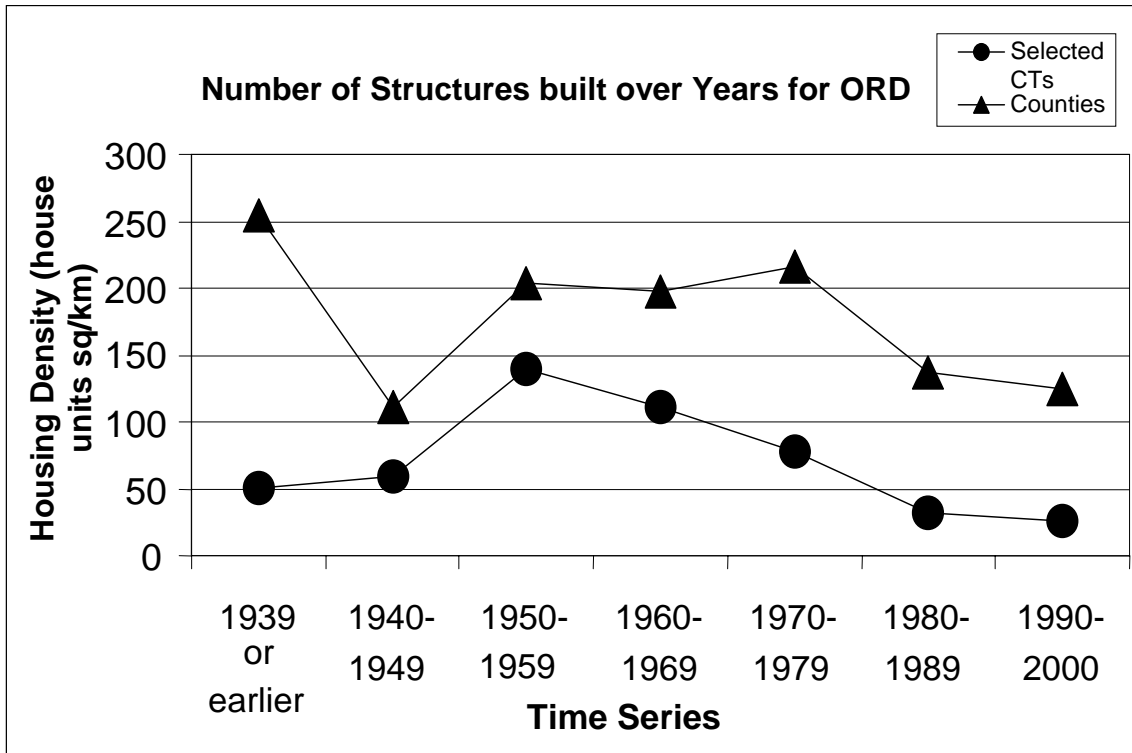


FIGURE B.19 - Housing structures built per decade (ORD and Cook County)

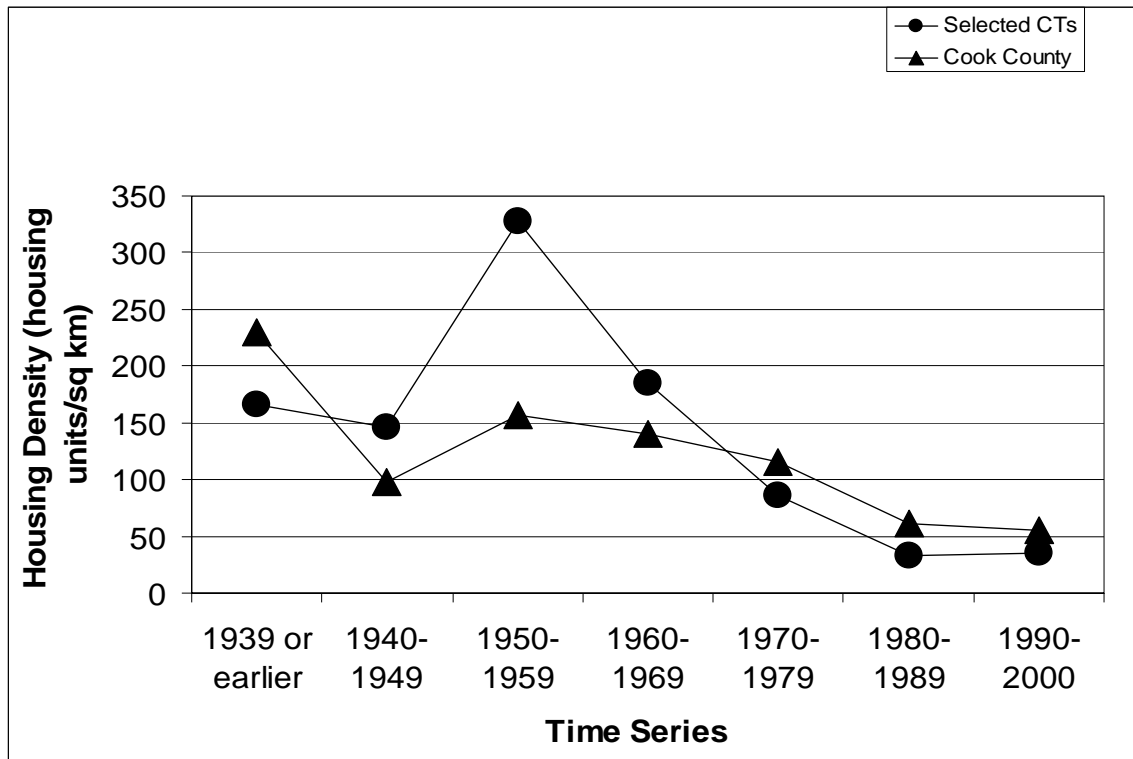


FIGURE B.20 - Housing structures built per decade (MDW and Cook/DuPage counties)

The following maps provide descriptions of the selected geographic areas.

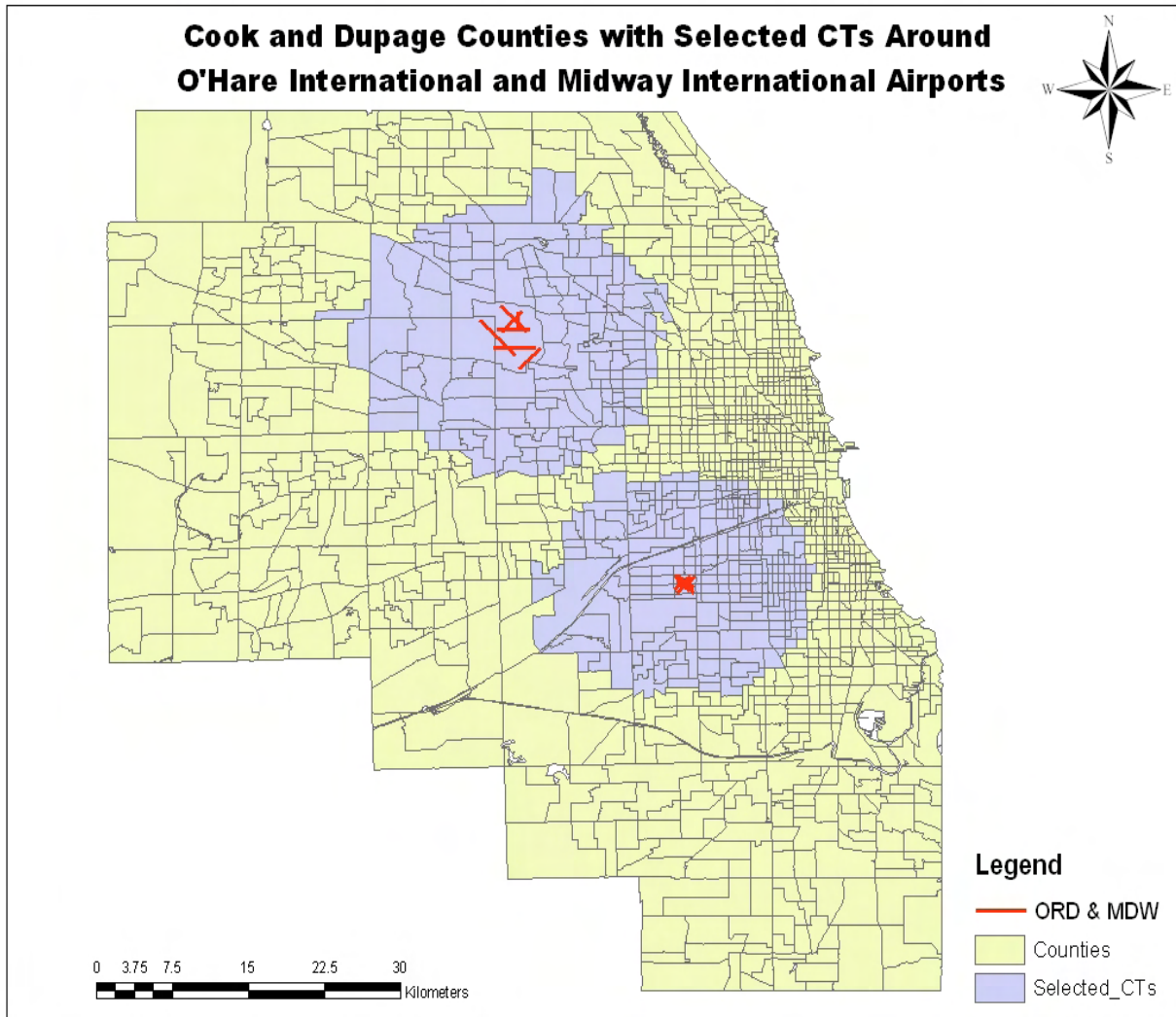


Figure B.21 shows Chicago's O'Hare Airport (ORD) in the upper left and Midway (MDW) in the lower right. The areas in a darker shade represent census tracts within an approximate 5-mile radius from the airport. The remaining census tracts are for the adjacent counties of Cook and DuPage.

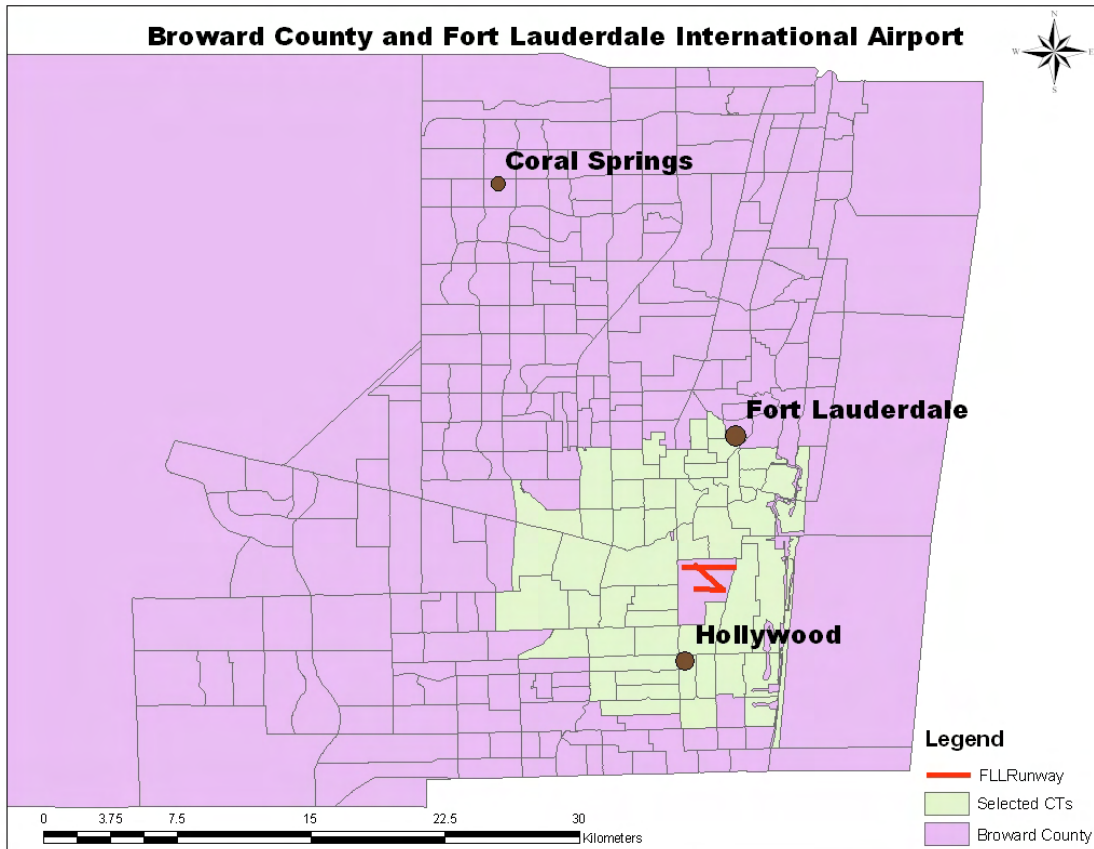


Figure B.22 shows Fort Lauderdale International Airport (FLL), along with census tracts for Broward County. In this figure the lighter area around the airport represents census tracts at an approximate 5-mile radius from the airport. Note that there are census tracts allocated to the County that include part of the Atlantic Ocean to the east (right of the figure). This does not affect the results, since attributes calculated as density (per unit area) use land area rather than just census tract area.

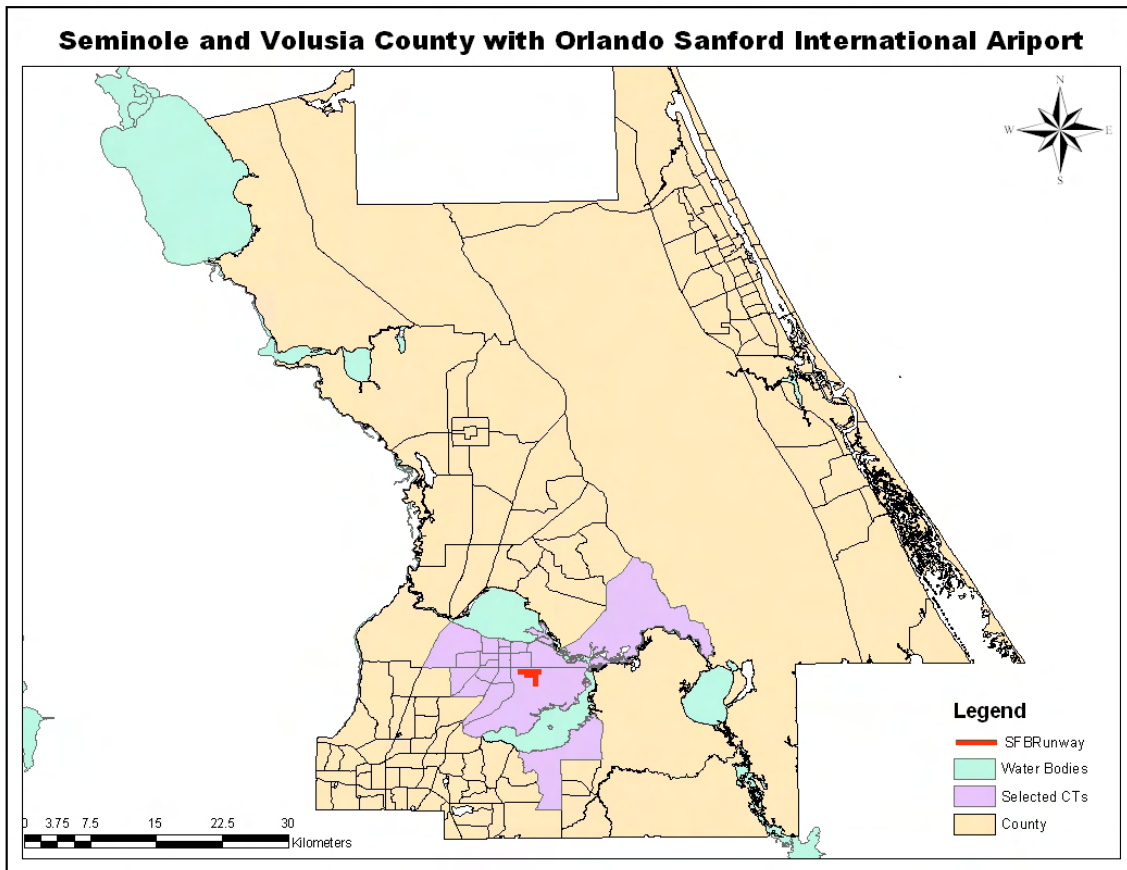


Figure B.23 shows census tracts for Orlando's Sanford International Airport (SFB). Once again, areas near the airport, but in a different shade, correspond to an approximate 5-mile radius from the airport. In this case, there are bodies of water near the airport to the north and south. A census tract to the northeast has limits beyond the 5-mile radius. For sparsely populated areas, census tracts are larger and the geographic size of the study area may be larger than the 5-mile radius, due to the size of such census tracts. In highly populated areas (as seen in Chicago and Fort Lauderdale) census tracts are much smaller, and it becomes easier to approximate a 5-mile radius near the airport. The problem of larger tract sizes will be seen in the case of Denver.

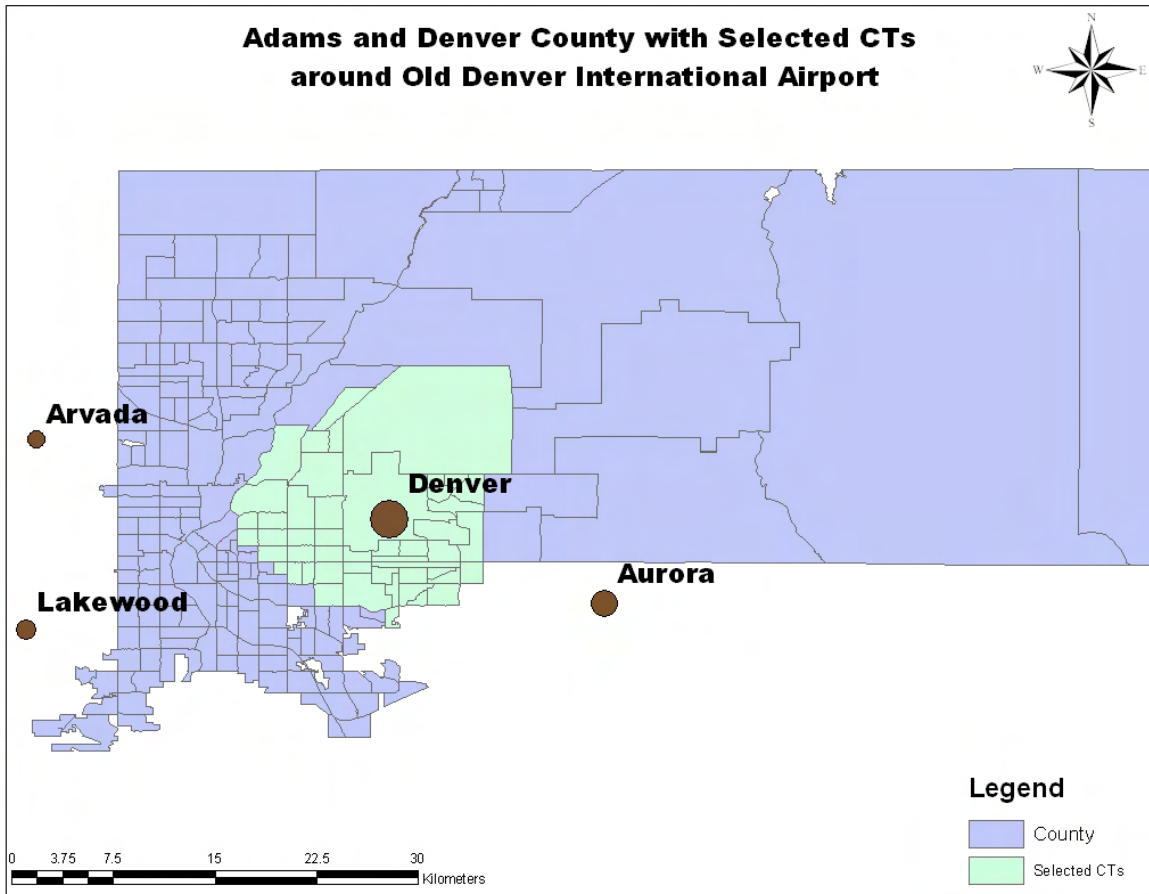


Figure B.24 shows the areas of Adams and Denver counties, along with the old location of Denver’s international airport at Stapleton. Note that while areas to the south and to the east are more heavily populated with smaller census tracts, the areas towards the northwest are more sparsely populated with relatively large census tracts. Showing the same counties,

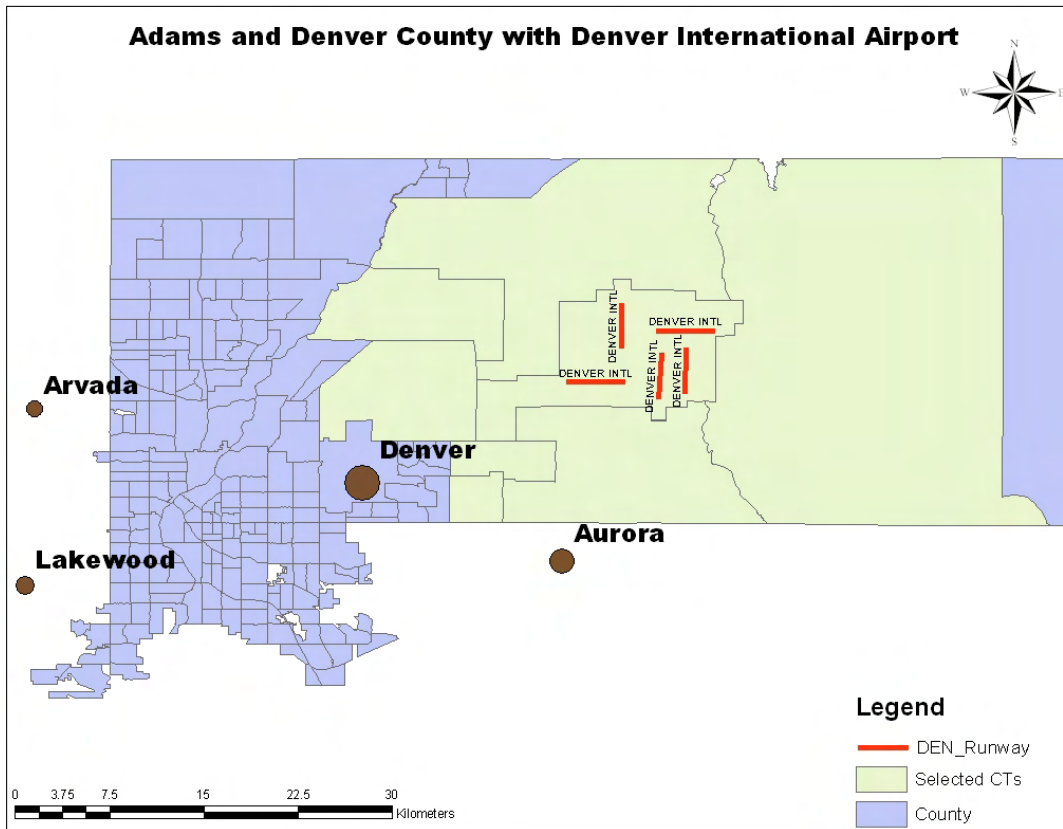


FIGURE B.25 – Census tract map for DEN and Denver/Adams counties, Denver, CO

Note: this figure highlights the new location of DEN. The sparse population near the airport is seen by the very large census tracts surrounding the area. Due to the size of the census tracts in this area, attributes analyzed for areas around DEN will cover an area larger than the 5-mile radius used for the other airports.

B.2 Research Results and Observations

To compare all of the airports for a single attribute in a graph, we plotted ratios of the attributes for a given airport and its county as a function of decade. These summary graphs are shown in Figures B.26-B.33 on the following pages. All values greater than one indicate that there was a greater value for that attribute in the area surrounding the airport than in the county. All values less than one indicate that the attribute was greater in the county than in the area around the airport. Note that this information could also be graphed on a log scale to better show the relationship of the ratios when comparing ratios whose value is less than one with those that are greater than one.

Figure B.26 shows working population as a ratio of population density in the area near the airport to the population density for the entire county. The graphs show that all but ORD and DEN have greater population densities near the airport. It also shows that the ratios for MDW and SFB are relatively flat with time, while the ratios for FLL and STP were decreasing (the ratio leveled out at STP for 1990/2000, since new construction would occur with the relocation of the airport). **Figures B.27, B.28, and B.29** show very similar behavior to the population graph;

however, **Figure B.30**, which focuses upon people working in farming, shows an increase in farming employment near MDW. **Figure B.31** shows that the average family income is less in the areas near the airport. There has been a significant increase in this parameter at DEN in the 1980/1990 data (period where the new airport became operational). **Figure B.32** shows the ratios of total housing units per decade for the different airports, and it is also very similar to the population graph of **Figure B.26**. Finally, **Figure B.33** shows that the number of structures built exhibits a pattern of high construction near the airports early in their histories. These taper off with time, approaching or even going below the county level.

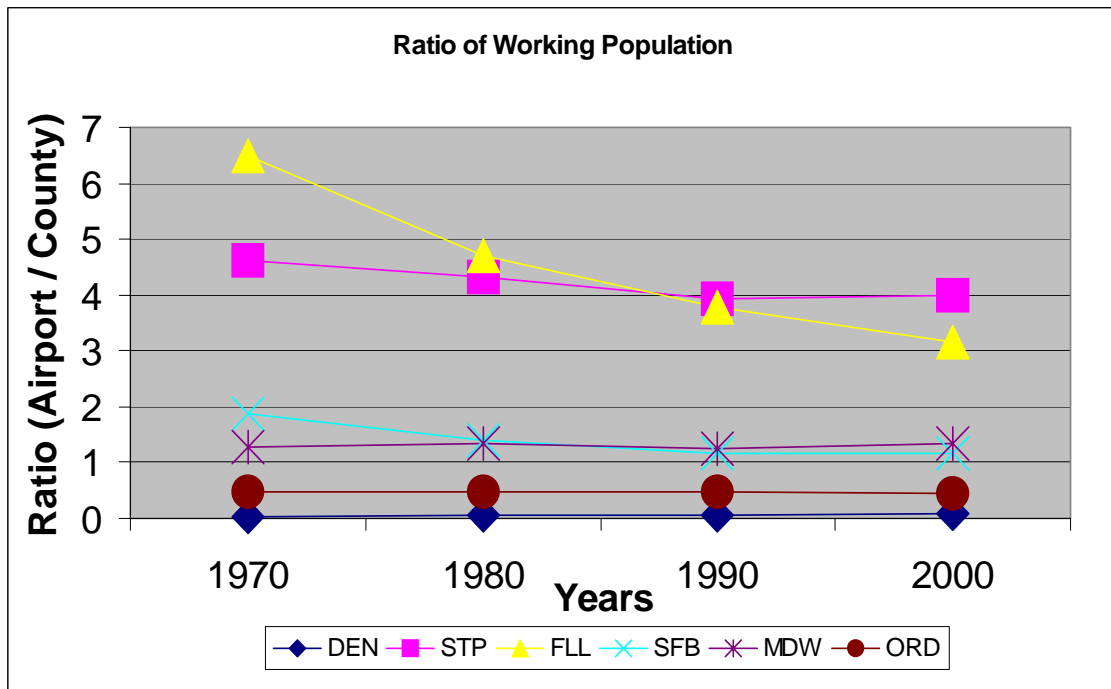


FIGURE B.26 - Ratio of working population vs. decade (all airports)

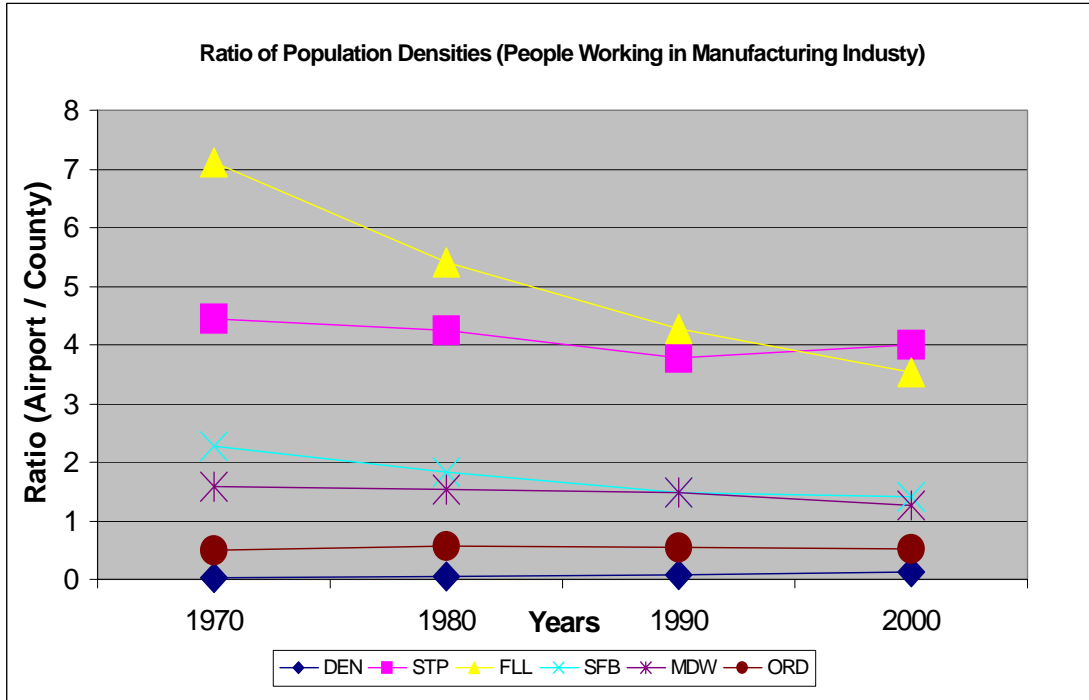


FIGURE B.27 - Ratio of manufacturing vs. decade (all airports)

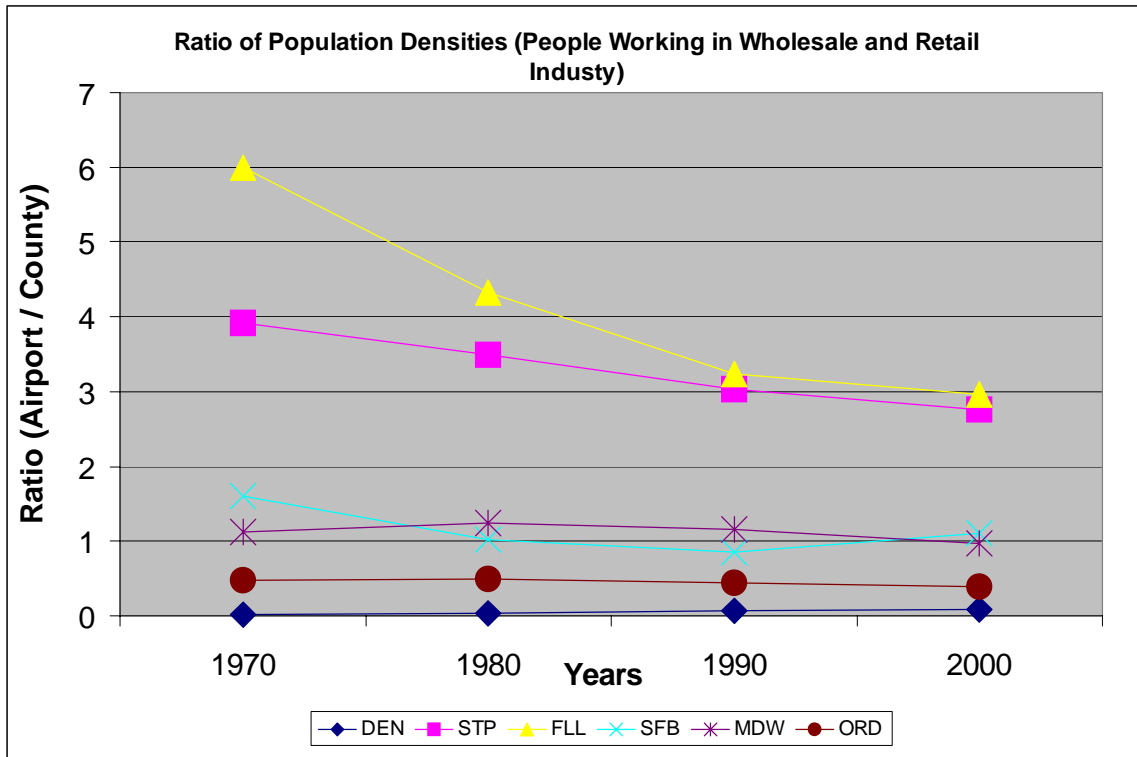


FIGURE B.28 - Ratio of professional work vs. decade (all airports)

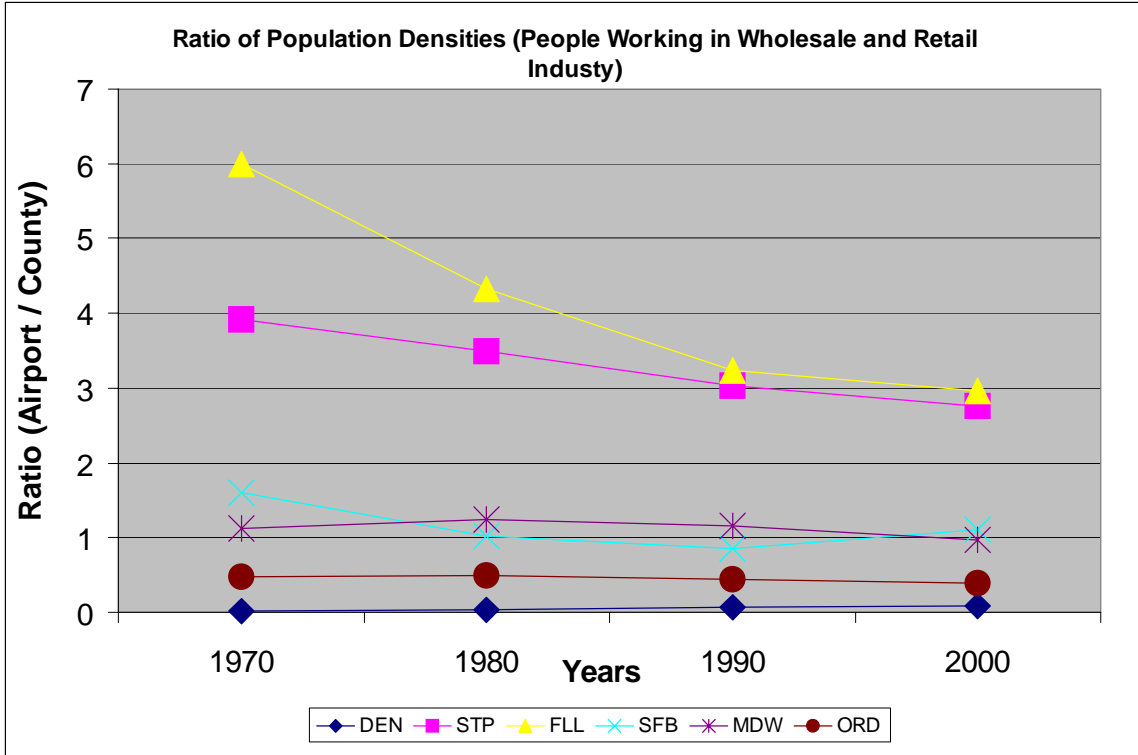


FIGURE B.29 - Ratio of wholesale/retail vs. decade (all airports)

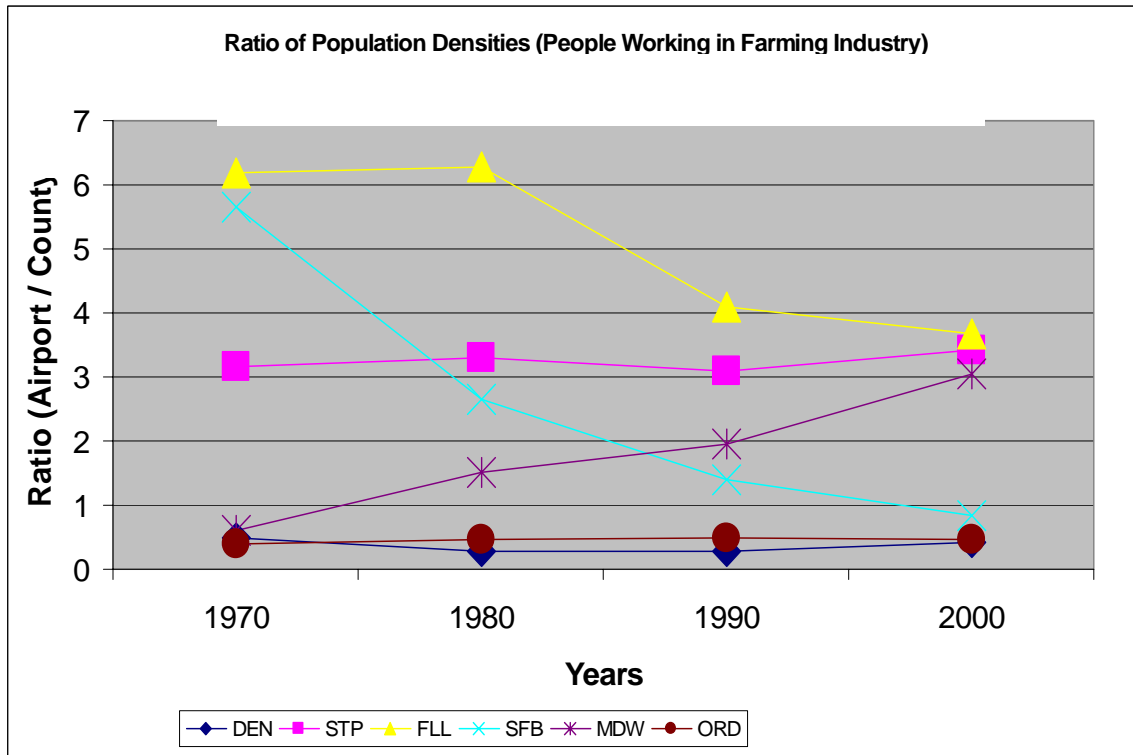


FIGURE B.30 - Ratio of farming vs. decade (all airports)

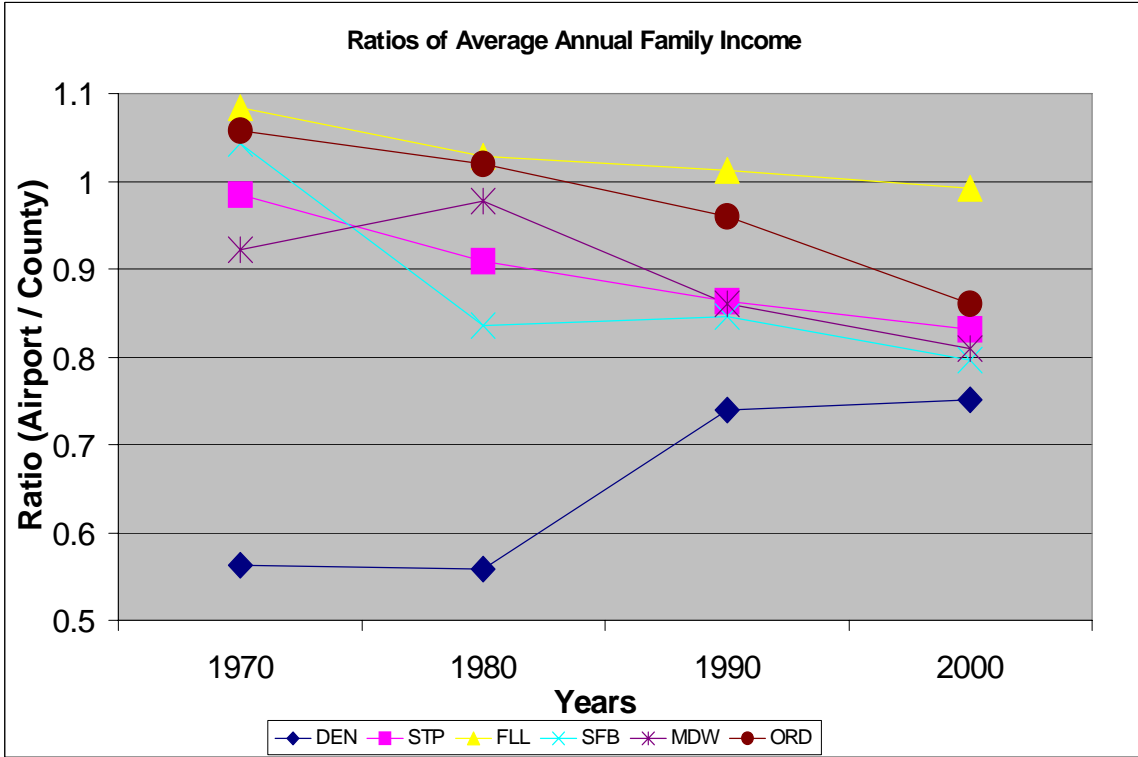


FIGURE B.31 - Ratio of average annual family income vs. decade (all airports)

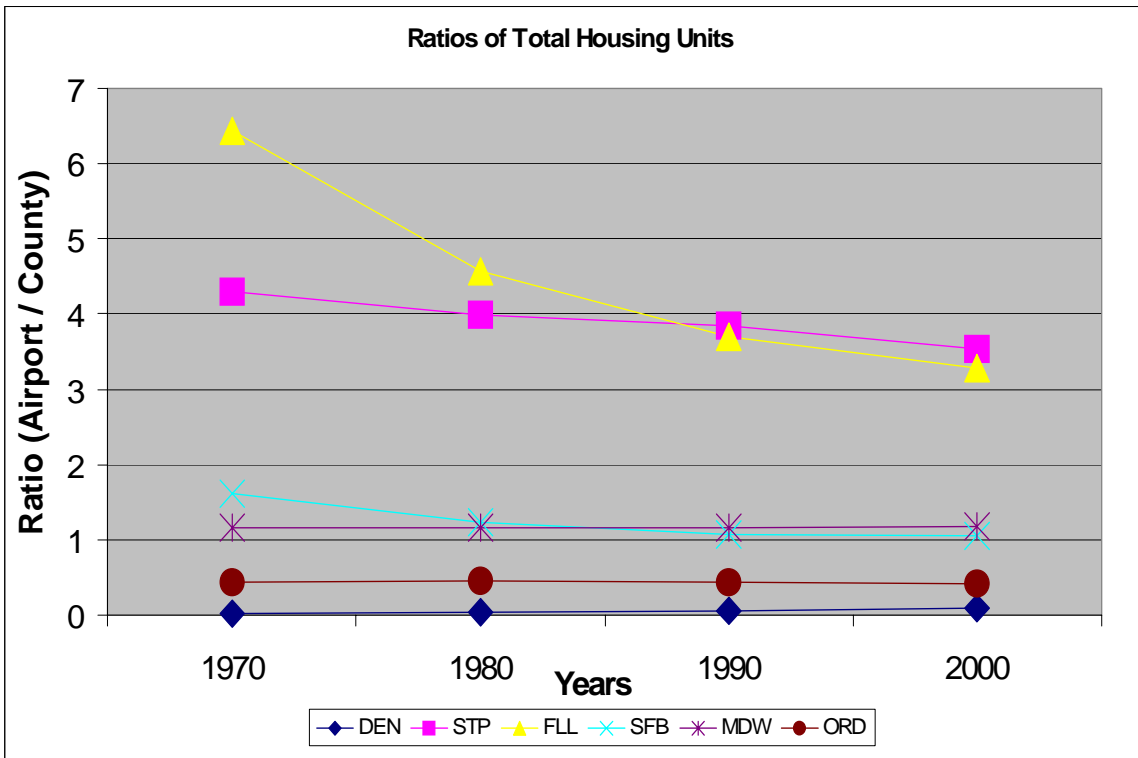


FIGURE B.32 - Ratio of total housing units vs. decade (all airports)

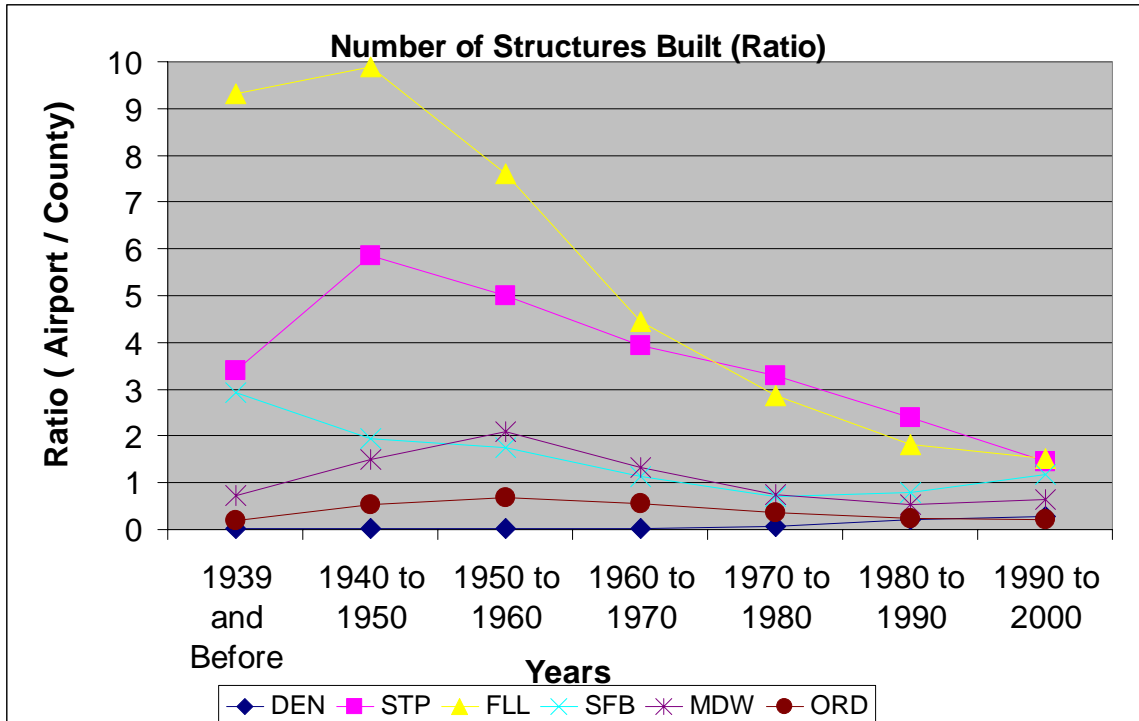


FIGURE B.33 - Ratio of structures built vs. decade (all airports)

Based on the information obtained from all of the data collected to date, the following observations are made:

- Population density is increasing in all of the counties and airports studied,
- Population density is greater near all airports, except in DEN and ORD,
- Population density is greater in MDW than in ORD,
- Manufacturing, Professional, Wholesale/retail, and Farming are greater near all the airports except DEN and ORD,
- Trends in all categories are generally similar between the counties and the airports (e.g., both up or both down),
- Average family incomes are nearly the same between the airports and counties in the 1970s, but county incomes increase at a faster rate than near the airports (FLL income remains essentially the same as the county),
- Density of total housing units increase in all counties and around all airports,
- There is a higher housing density near MDW than ORD,
- ORD has been able to maintain growth in the demographic parameters at a lower rate than Cook County.

From the graphs showing the ratios of an attribute at the airport and county levels, we observe the following:

- There is a pattern in the ratio of housing structures built, where the ratio peaks and decreases towards one or below one,
- DEN shows increases in all ratios (beginning of population growth),
- MDW has been relatively stable near one in all ratios (except farming),

- ORD has been able to maintain steady values at ratios less than one,
- Based on the similarities, it appears that these parameters are not independent, thus only one of them would need to be analyzed.

B.3 Population Density

One hypothesis explored during this phase of research was that population density is a valid predictor of noise complaints around an airport. A GIS map was generated for each airport overlaid with population density census data and overlaid with noise complaint data for the corresponding year. After analyzing these maps, no conclusive patterns between population density and number of noise complaints were uncovered. Further statistical analysis is suggested in order to identify other predictors of noise complaints and annoyance

Figures B.34-B.36 show the population density attribute with the noise complaint maps for each airport. Note that in **Figures B.34-B.36**, for the Fort Lauderdale and Sanford areas, the red dots indicate complainant locations. The colored dots in **Figure B.36**, for the Denver area, represent the number of noise complaints from each complainant. The Sanford area, shown in **Figure B.34**, shows the complainants from 2001 and 2002. A number of the complainants, shown in the circled area, come from areas of lower population density. These complainants also appear to be in the direct flight path of runway 9L-27R. Just to the west of the airport, there are a number of noise complainants living in more dense areas.

For FLL, however, there is a lack of correlation between population density and complaints. **Figure B.35** shows a number of complainants to the north and south of the airport that are from fairly densely populated areas. However to the west of the airport, a number of the complainants live in less dense areas. **Figure B.36** shows the Denver area with the year 2004 complaints. Again, no discernable correlation is found with the population density and the noise complaints. Note that DEN is shown without runway 34L-16R as it was opened in September of 2003.

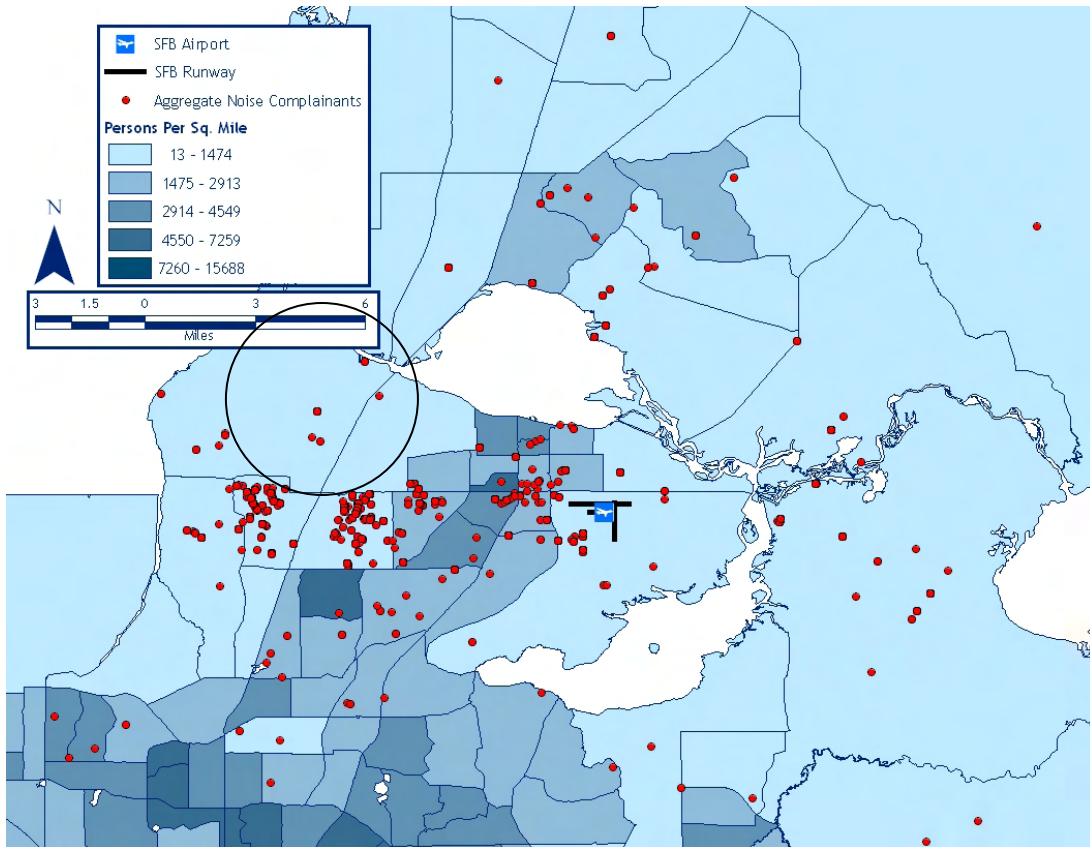


FIGURE B.34 – Sanford area population density with complainants from 2001 and 2002

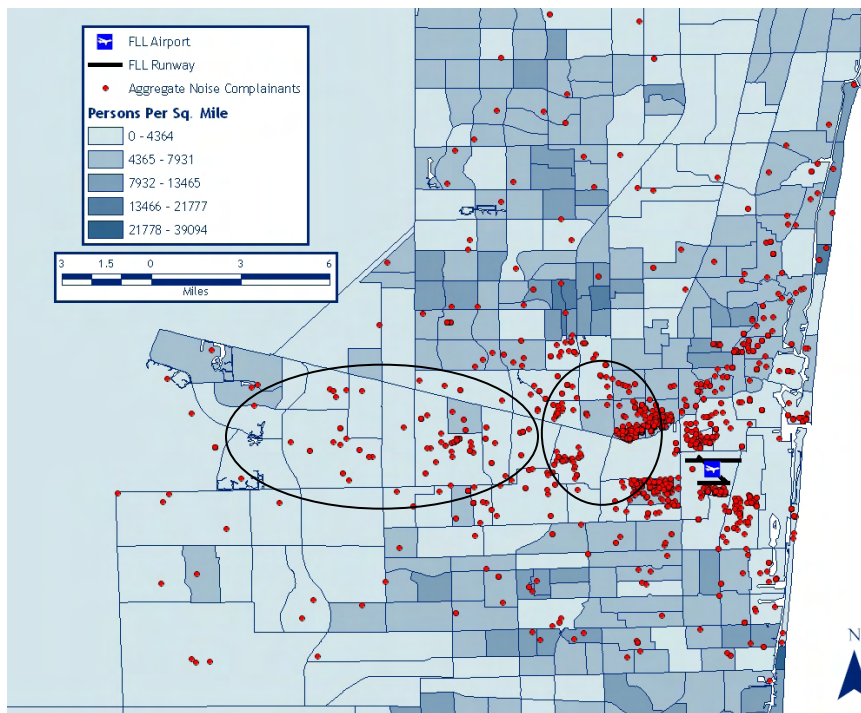


FIGURE B.35 – Ft. Lauderdale area population density with complainants from 2003 through 2005

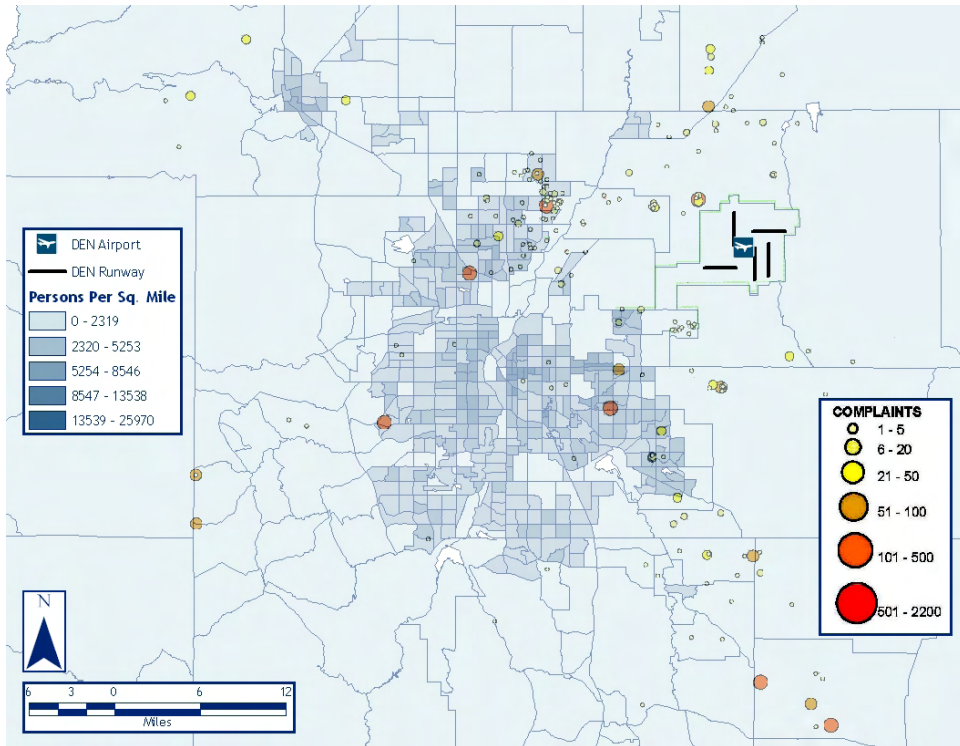


FIGURE B.36 – Denver area population density with complaints from 2004

B.4 Affluence

Initially, researchers believed that by understanding patterns of income, property value, and other demographic attributes it might be possible to determine if affluence is a predictor of noise complaints. Preliminary interviews indicated areas with households of higher affluence complained more often. However, as more interviews were conducted, researchers could not conclusively determine if affluence is a valid predictor of noise annoyance and complaints. The researchers then decided to create and analyze GIS maps overlaid with complaint patterns and demographic census data to justify this conclusion. **Figures B.37-B.40** show a sample of the GIS maps created with the noise complaints and average income attributes. **Figure B.37** shows that a number of the complainants to the west of the airport in the Sanford area live in areas with higher average incomes. Fort Lauderdale, **Figure B.38**, has some complainants in higher income areas, but that generalization is less likely than with Sanford. **Figure B.39** shows the same information in **Figure B.40** with the baseline flight tracks. This graph demonstrates that being in larger volume flight paths is more significant to complaint patterns than the average income attribute. **Figure B.40** shows the Denver area with the 2004 complaints and 2002 flight tracks. Denver, like Sanford, demonstrated little correlation between noise complaints and average income.

For this study, a number of maps were generated for the property value and average income attributes, however, only a few are provided in this report. After analyzing maps with these attributes, the results were once again inconclusive. There did not appear to be any patterns that were recognizable, and further statistical analysis is suggested.

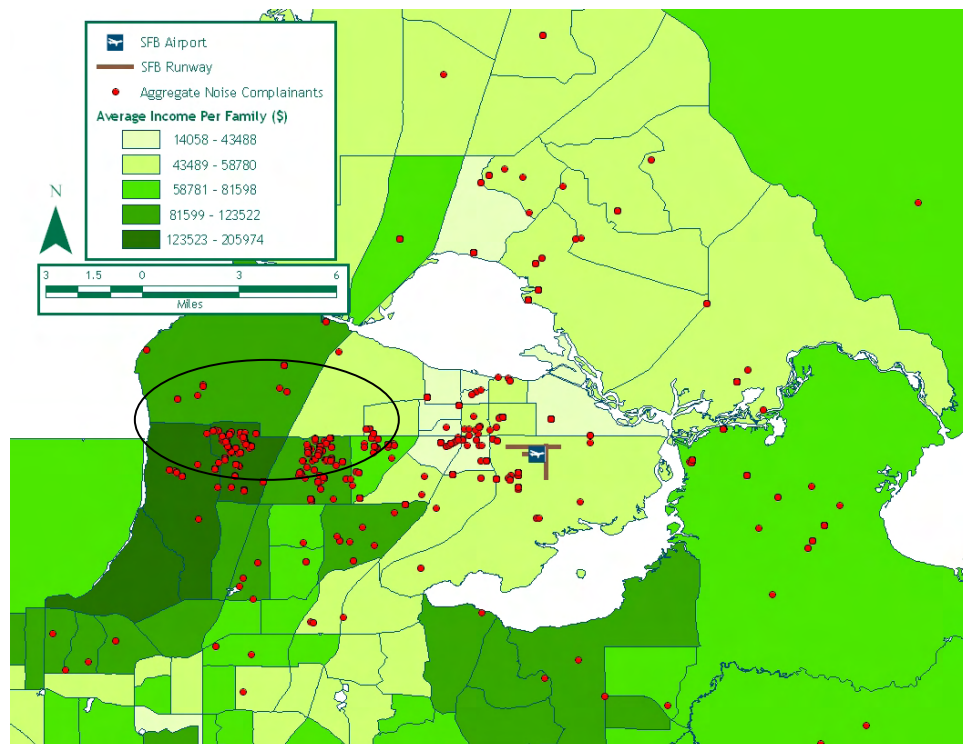


FIGURE B.37 – Sanford area average income with complainants from 2001 and 2002

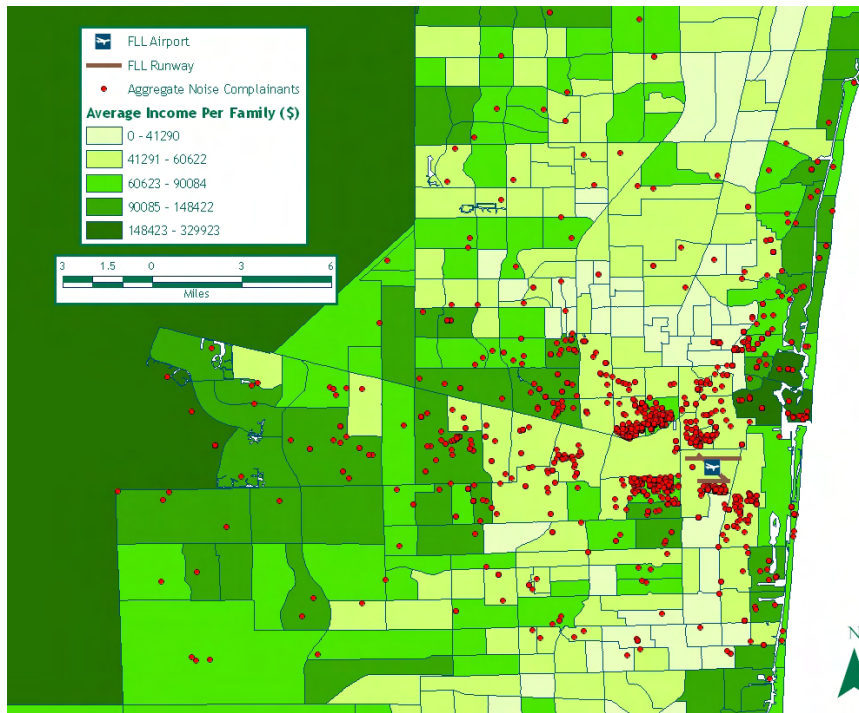


FIGURE B.38 – Fort Lauderdale area average income with complainants from 2003 through 2005

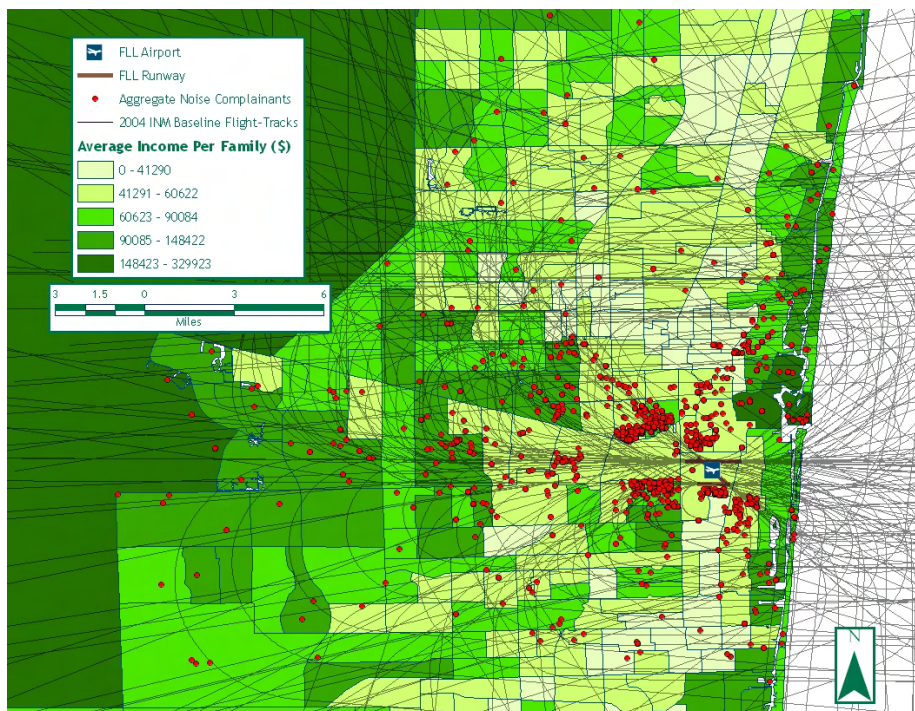


FIGURE B.39 – Fort Lauderdale area average income with complainants from 2003 through 2005 and 2004 baseline flight tracks

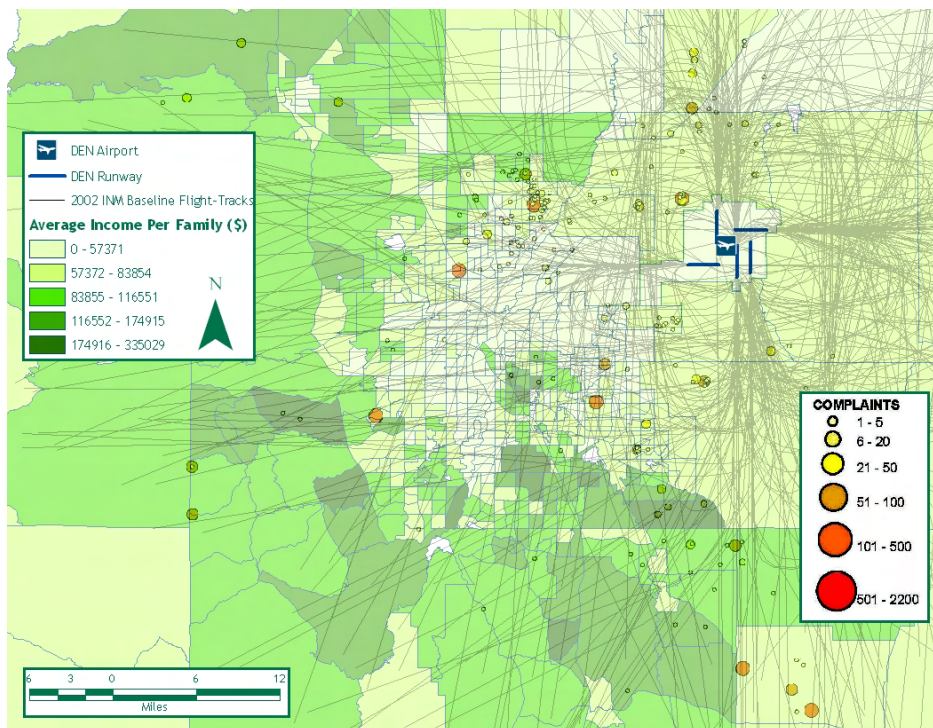


FIGURE B.40 – Denver area average income with complaints from 2004 and baseline flight tracks from 2002

B.5 Suggested Future Work

In this project, population growth trends were examined at six airports and their surrounding counties. In 2004, there were approximately 382 primary airports in the United States. A point of interest is to determine how many airports need to be analyzed before the trend analysis becomes statistically significant. That is, how many airports need to be included in the study to say with a level of confidence that the trend is representative of all airports? There are a number of different approaches to answer this question. In this study, a sample size calculator provided by Creative Research Systems (2005) was used. The following defines terms related to the sample size calculator:

- **Trend Percentage:** the percentage of the sample size that demonstrate a specific trend (i.e. number of airports in the study that show increasing population density near the airport over time).

p = trend percentage, expressed as decimal

- **Confidence Interval:** the plus or minus value which represents the range of error and depends on sample size considered, population size and trend percentage. - The further away the trend percentage is from 50%, the confidence interval decreases. For higher and lower trend percentages, the error (confidence interval) decreases.

c = confidence interval, expressed as decimal

- **Confidence Level:** represents how often the true percentage of the population that demonstrates the subject trend lies within the confidence interval.

- ss = sample size
- Z = Z value (e.g. 1.96 for 95% confidence level)

Formulas used in this sample size calculator include:

$$ss = \frac{Z^2 p(1-p)}{c^2}$$

A finite population correction is made using

$$SS = \frac{ss}{1 + \frac{ss-1}{pop}}$$

where pop = population
 SS = corrected sample size

Based upon these calculations, it can be seen that with a trend percentage of 50% and a confidence level of 95%, 80 airports would have to be considered in the study, to obtain a confidence interval of approximately 10%. That is, the percentage of airports in the entire population (382) that would exhibit the subject trend is between 40% and 60 % (+/- 10%). If only 20 airports were studied, the confidence interval more than doubles to 21% and the percentage of airports in the population that would exhibit the trend would be between 29% and 71%.