RESEARCH & DEVELOPMENT

What Level of Tourism Traffic Should be Planned for in NC's Major Tourism Areas?

Joseph Wilck, PhD, PE; Misun Hur, PhD; Paul Kauffmann, PhD, PE; James Kleckley, PhD; Jerry Weitz, PhD; Mr. Christopher Lawson; and Mr. John Pope

Department of Engineering
216 Slay Hall, Mail Stop 117
East Carolina University
Greenville, NC 27858-4353

NCDOT Project 2013-39

FHWA/NC/2013-39

August 2015

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.: FHWA/NC/2013-39	2. Government Accession No.:	3. Recipient's Catalog No.:
4. Title and Subtitle: What Level of Tourism Traffic Should be Planned for in NC's Major Tourism Areas		5. Report Date: August 31, 2015 6. Performing Organization Code:
7. Author(s): Joseph Wilck, Misun Hur, Paul Kauffmann, James Kleckley, Jerry Weitz, Christopher Lawson, John Pope		8. Performing Organization Report No.:
9. Performing Organization Name and Address: East Carolina University Department of Engineering, 204 Slay Building, Mail Stop 117 Greenville, NC 27858-4353		10. Work Unit No.: 11. Contract or Grant No.:
12. Sponsoring Agency Name and Address: North Carolina Department of Transportation Research and Analysis Group 1 South Wilmington Street Raleigh, North Carolina 27601		13. Type of Report and Period Covered: Final Report May 1, 2013 – August 30, 2014 14. Sponsoring Agency Code: NCDOT RP2013-39
15. Supplementary Notes:		

16. Abstract:

The purpose of this research project was to provide the North Carolina Department of Transportation (NCDOT) with an implementation strategy for interpreting traffic counts in high tourism areas to aid in the development of Comprehensive Transportation Plans (CTPs). Because of the high variability of traffic counts in these areas, it is unreasonable to apply the typical weekday traffic count as the baseline metric for developing the CTPs for these areas. A literature review and an application of best practices, forecasting methods, and implementation strategies are provided to address the research needs.

Currently, the NCDOT utilizes typical weekday traffic data, local population data, and local employment data as the baseline for developing CTPs with the aid of local municipalities within North Carolina. However, there is a growing concern that high tourism areas, such as: Boone, Lake Lure, Blowing Rock, Topsail, Atlantic Beach, etc., experience a high variability in traffic due to seasonal tourism. This issue is obviously prevalent in other areas of the United States, and there is a need to identify best practices and methods used to provide an implementation strategy to the NCDOT that is equitable to the citizens of North Carolina and the financial constraints of the project budgets.

The first and primary recommendation with respect to Average Annual Daily Traffic (AADT) calculations and planning is to incorporate peak-usage and directionality; whether it be hourly or monthly. Urban areas will have AADT values similar to the design volume. However, seasonal areas, such as tourist locations, will have significant differences between the design volume and the AADT. While other states (notably Nevada and Florida) have incorporated peak-hour usage ratios into their planning forecasts, the recommendation in this report suggests using an average of the two busiest months (as shown in the case studies) when peak-hour usage rates are unknown.

17. Key Words: Tourism, Seasonal Variability, Forecasting	18. Distribution Statement:		
19. Security Classification (of this report): Unclassified.	20. Security Classification (of this page): Unclassified.	21. Number of Pages: 95	22. Price:

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized

DISCLAIMER

The contents of this final report reflect the views of the authors and not necessarily the views of East Carolina University. The authors are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of either the North Carolina Department of Transportation or the Federal Highway Administration at the time of publication. This report does not constitute a standard, specification, or regulation.

ACKNOWLEDGEMENT

The authors acknowledge the North Carolina Department of Transportation (NCDOT) for providing financial support for this project. Sincere thanks are extended to the chair of the Project's Committee, Pam Cook, the Project's Manager, Rasay Abadilla, and the Project's Committee members for their consistent support, helpful guidance, and valuable feedback. The authors express recognition to Matthew Quesenberry, Randy Perry, Stephen Piotrowski, and Kent Taylor of NCDOT for their time and effort to share their expertise and to provide useful data sets for the successful completion of this research project.

EXECUTIVE SUMMARY

The purpose of this research project was to provide the North Carolina Department of Transportation (NCDOT) with an implementation strategy for interpreting traffic counts in high tourism areas to aid in the development of Comprehensive Transportation Plans (CTPs). Because of the high variability of traffic counts in these areas, it is unreasonable to apply the typical weekday traffic count as the baseline metric for developing the CTPs for these areas. Currently, the NCDOT utilizes typical weekday traffic data, local population data, and local employment data as the baseline for developing CTPs with the aid of local municipalities within North Carolina. However, there is a growing concern that high tourism areas, such as: Boone, Lake Lure, Blowing Rock, Topsail, Atlantic Beach, etc., experience a high variability in traffic due to seasonal tourism. This issue is obviously prevalent in other areas of the United States, and there is a need to identify best practices and methods used to provide an implementation strategy to the NCDOT that is equitable to the citizens of North Carolina.

This project incorporates multiple disciplines, including: transportation planning, tourism planning, local and urban planning, environmental sustainability, economics, geography, and engineering. The project included data, methods, and resources from all of these fields, including: forecasting, seasonal variation modeling, regression, geographic information systems (GIS), employment, economic, hotel occupancy, motor vehicle transportation, and tourism behavior. The literature review focused on identifying practices and scholarly literature related to tourist traffic including choice of destinations and travel within destinations. Specific attention was given to application of forecasting approaches, factors included as significant contributors, and choice models. These included engineering, transportation planning, geography, urban planning, business, hospitality, and tourism specific databases and also consolidated databases covering several of these areas.

There are a number of factors to consider when forecasting tourism-related traffic. The data collection power of technology (e.g., GPS and GIS location on cellular phones, vehicles) and the analytical capabilities of software and hardware solutions will soon allow for almost instantaneous knowledge with respect to the capacity and utilization of a transportation system. However, there is currently a lag between the technological advancement versus the planning and strategic-level thinking of transportation management plans with respect to seasonal variance in traffic across the United States. Due to the importance of the tourism industry on the economy of North Carolina and tourisms' need for efficient transportation systems; it is imperative that equitable plans be made to accommodate this seasonal variation.

There are a number of urban form issues and accommodations to tourism traffic in North Carolina. These areas include topography, aesthetics and character, small town and downtown activity centers, access management, land use regulation, bypasses, scenic byways, turnouts along heavily traveled corridors, highway messaging, highway signs, wayfinding signs, and parking. There are also a number of non-additional infrastructure methods; including the issues related to human behavior, and enhancing bicycle and pedestrian options.

The first and primary recommendation with respect to Average Annual Daily Traffic (AADT) calculations and planning is to incorporate peak-usage and directionality; whether it be hourly or monthly. Urban areas will have AADT values similar to the design volume. However, seasonal

areas, such as tourist locations, will have significant differences between the design volume and the AADT. While other states (notably Nevada and Florida) have incorporated peak-hour usage ratios into their planning forecasts, using monthly rates (as shown in the case studies) can be useful.

An initial recommendation with respect to the calculation of AADT includes updating the seasonality factors with up-to-date data that is collected year-round. Furthermore, it is recommended that AADT is discontinued for areas with seasonal variation in favor of the service level (which includes variation) concept that is used in supply chain management, logistics management, and queuing system design.

The primary case study findings and conclusions were:

- Case Study 1: Watauga/Avery (NC 105)
  - Of the three traffic counter locations' data evaluated, two did not exhibit seasonality and one exhibited only moderate seasonality (peaking in August). The reason for this is due to the constant (year-round) traffic generated by the college students and residents.
- Case Study 2: Outer Banks (US 158)
  - Of the two traffic counter locations' data evaluated, both exhibited high seasonality; peaking in the summer.
- Case Study 3: Wrightsville Beach Area (Wilmington)
  - Urban area with steady traffic from the residents in the Wilmington area.
  - One of the traffic counter location's data exhibited a high seasonality (peaking in the summer); and one exhibited no seasonality. The one that exhibited seasonality included beach traffic.
- Case Study 4: Bryson City
  - The single traffic counter location's data exhibited a high seasonality (peaking in the summer).
- Case Study 5: Asheville
  - Urban area with steady traffic from the residents in the Asheville area.
  - One of the traffic counter location's data exhibited a moderate seasonality (peaking in June and July); whereas the other location did not exhibit seasonality.

TABLE OF CONTENTS

LIST OF FIGURES

1. PROJECT INTRODUCTION AND OVERVIEW

This project report addresses the research objectives described in the Research Needs Statement (RNS) titled "What Level of Tourism Traffic Should be Planned for in NC's Major Tourism Areas" [1]. In that RNS the following research objectives and tasks were noted:

1. A literature review of best practices.
2. An external travel model to account for peak season tourist travel.
3. A model to account for the change in employment during peak seasons.
4. A model to account for travel to and from hotel locations in areas of high tourism.
5. A model and analysis to create scenarios to represent peak tourism traffic versus typical traffic.
6. Methods and solution approaches that have been applied in other high tourism areas that do not add additional infrastructure, including an analysis of resident experiences and perceptions towards current traffic during the peak tourism season (i.e., behavioral changes to adapt to the environmental stress) and their trade-off willingness between their benefits (economic benefit) and costs (traffic congestion).
7. A determination of land use and urban form issues that must be considered when addressing peak seasonal travel demand (i.e., preservation of the local area).
8. An equitable model for determining the daily trips to use in analysis in major tourist destinations.
9. Determine the baseline average daily traffic (ADT) to use and projection methodology.

As proposed, the research tasks are summarized below. Task 1 was completed in October 2013, and is provided in Appendix A of this report; with a summary following in Section 2. Tasks 2-9 were completed in conjunction with five case studies; which are detailed in Sections 3-7. The case studies were selected by the NCDOT, ensuring an equitable mix between eastern and western North Carolina, as well as between small population and large population areas.

Data and information was provided by the NCDOT, particularly with respect to traffic counts, traffic counter locations, and calculation of AADT for areas with high seasonality. The research team, with respect to the five case study locations, primarily used traffic count data from areas that had counters with continuous (year-round) data. Preference was given to current data (e.g., 2013) over older data (e.g., prior to 2000). Other repositories were used to analyze housing, population, occupancy, and income levels; primarily via the United States Census Bureau. Local chambers of commerce and other local tourism groups were queried and referenced for information.

The case study locations were:

- Case Study 1: Watauga/Avery (NC 105)
- Case Study 2: Outer Banks (US 158)
- Case Study 3: Wrightsville Beach Area (Wilmington)
- Case Study 4: Bryson City
- Case Study 5: Asheville

An overview of North Carolina and the case study locations is provided in Figure 1.1.

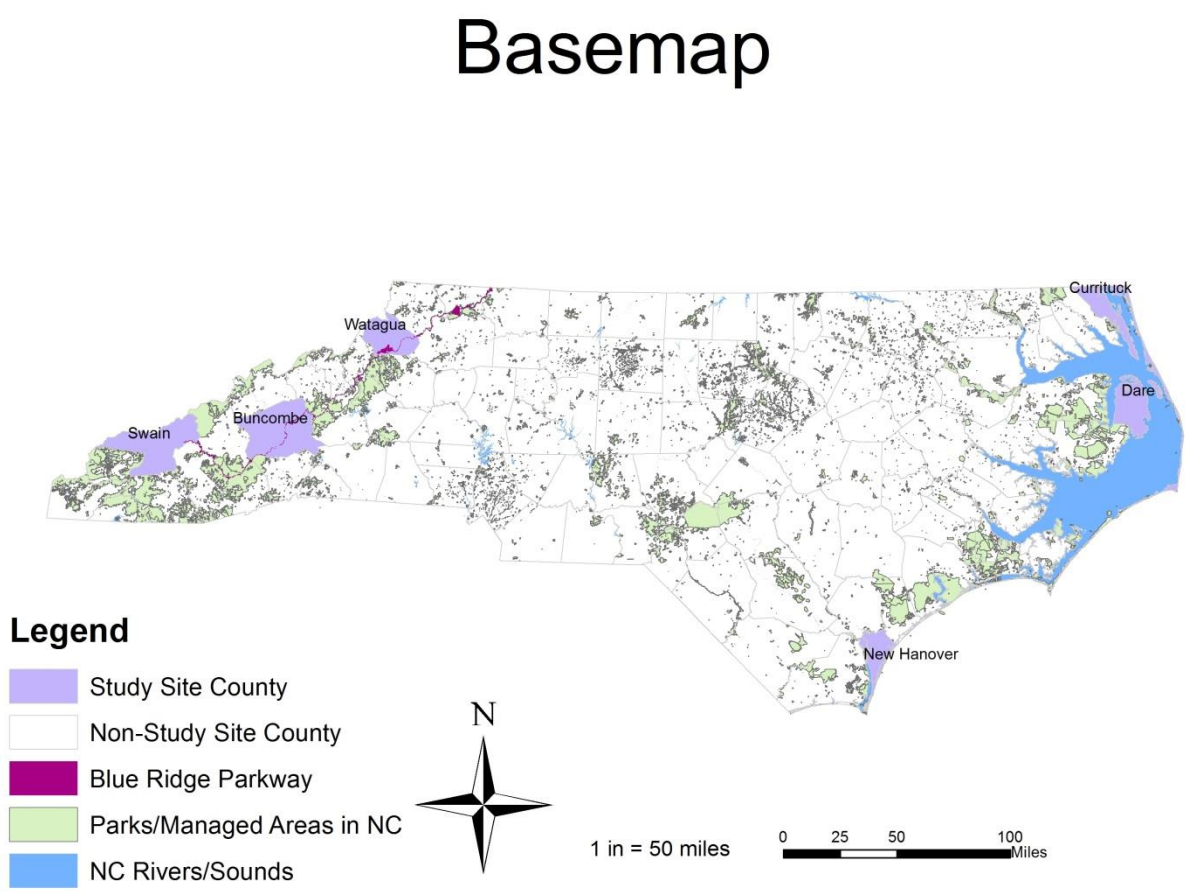

Figure 1.1. State Basemap

Task 1: Literature Review

Objective 1: Literature review.

A literature review and an application of best practices, forecasting methods, and strategic implementation models were completed to address this objective. The literature review was produced and delivered to the NCDOT as a comprehensive study that summarizes the state of the art across the United States, with particular attention to best practices, and an implementation strategy and solution model for North Carolina. The literature review was originally provided to the NCDOT in October 2013, and is provided in Appendices A, B, and C of this final report.

Task 2: External Travel Model

Objective 2: An external travel model to account for peak season tourist travel.

An external travel model to account for peak season tourist level was developed. The task required adjustments to the current AADT methodology. Currently, baseline AADT values are calculated or estimated based on data collected in April, which generally does not coincide with peak times in high tourism areas (e.g., summer months for beach tourist areas, or fall months for

mountainous tourist areas). Forecasting methods, seasonal variation, and regression were used to make the necessary adjustments to the external travel model.

Task 3: Peak Employment Model

Objective 3: A model to account for the change in employment during peak seasons.

Peak employment changes were necessary to account for peak seasonal tourism hiring. Economic data and hiring best practices were employed to develop a peak employment model. Dr. Kleckley, Director of the Bureau of Business Research at East Carolina University, led this effort. The Bureau of Business Research serves North Carolina by collecting and interpreting economic development data, economic forecast modeling and analysis, and economic forecasts to enable a better understanding of the state's economic environment. In addition, we utilized InfoUSA and Dun & Bradstreet, Inc. employment data, along with the Bureau of the Census (USA), and Office of State Budget and Management (North Carolina) for population data.

Task 4: Travel To and From Hotel Locations in High Tourism Areas

Objective 4: A model to account for travel to and from hotel locations in areas of high tourism.

Hotel occupancy data was utilized to model traffic flow in areas of high tourism during peak seasons. This is necessary since tourists from hotels utilize transportation resources, in addition to the local residents and employees counts.

Task 5: Peak Tourism Traffic versus Typical Traffic Model and Analysis

Objective 5: A model and analysis to create scenarios to represent peak tourism traffic versus typical traffic.

Using information from Tasks 1 – 4, Task 5 provided a model and analysis for various scenarios to represent typical (non-peak) traffic and peak traffic. This allowed for *What If Analysis* for various localities and parameter tuning for the model factors.

Task 6: Non-additional Infrastructure Methods

Objective 6: Methods and solution approaches that have been applied in other high tourism areas that do not add additional infrastructure, including an analysis of resident experiences and perceptions towards current traffic during the peak tourism season (i.e., behavioral changes to adapt to the environmental stress) and their trade-off willingness between their benefits (economic benefit) and costs (traffic congestion).

Using information from Tasks 1 – 4 and in conjunction with Task 5, creative strategies that did not require additional physical infrastructure were studied and approaches defined that provided value to the transportation system users. This included an investigation of benefits and costs, including public perception. For example, high traffic volume may be *good* for economic impact of a locality; however, it may lead to heavy congestion, traffic delays, and adverse environmental impact.

In Task 6 we sought to increase performance from existing road networks. We expected to find successful practices using various transportation system management (TSM) as well as traffic demand management (TDM) techniques. Then, we sought resident experiences and perceptions towards current traffic during the peak tourism seasons and identified their behavioral changes to adapt to the environmental stress. This helped us to find the place-specific solutions that we can implement for the TDM techniques.

Task 7: Land Use and Urban Form Issues for Peak Seasonal Travel Demand

Objective 7: A determination of land use and urban form issues that must be considered when addressing peak seasonal travel demand (i.e., preservation of the local area).

Solutions to peak season travel demand could have significant implications on land use patterns and community character of mountain, lakefront, and coastal tourism communities. The project team drew on extensive practical experience preparing comprehensive plans (including the establishment of character areas), land use regulations for localities, and academic research, in identifying issues associated with changes to urban form, land use, and community character that may result from various recommended transportation improvements. A suite of other derivatives are possible products for alternative plans, engineering and design, and residential input, including: maps of watersheds and imperviousness, alternative viewshed changes or impacts, tax and parcel impacts and social impacts by neighborhood (i.e., populations, density, accessibility, transportation accessibility, commute time, and local impacts).

Task 8: Equitable Model for Daily Trips in Major Tourist Localities

Objective 8: An equitable model for determining the daily trips to use in analysis in major tourist destinations.

Task 8 extended Task 2, in conjunction with Tasks 1, 3 – 7. AADT values were modeled and completed to provide equitable solution for locality CTPs. The primary methods that were used include: forecasting, regression, and seasonality. Data from various sources (i.e., economic, AADT, land use) was implemented to ensure goals and constraints are satisfied with regards to economic impact, traffic congestion, environmental impacts, and citizen perception. The model and analysis was equitable, defensible, and reproducible.

Task 9: Baseline AADT and Projection Methodology

Objective 9: Determine the baseline AADT to use and projection methodology.

Task 9 built upon Task 8 and provided baseline models for current high tourism areas throughout North Carolina, such as: Boone, Lake Lure, Blowing Rock, Topsail, Atlantic Beach, etc. These are immediately useful to the NCDOT for developing the CTPs for those localities. Task 9 was culminated by completing 3-5 case studies for specific high tourism areas. These specific areas were selected by the NCDOT personnel.

Report Organization

Section 2 provides a summary of the model. Sections 3-7 provide case study details as well as recommendations specific to those areas. Section 8 provides findings, conclusions, and recommendations with respect to the NCDOT planning for seasonality. Section 9 provides an overview for implementation and technology transfer. Appendices A, B, and C are provided with Literature Reviews.

2. MODEL

Background and Recommendations

The issue of forecasting traffic for high-tourism and/or recreational areas have been studied in the past [41-43]. It has been shown that these areas have an exceedingly high usage rate at peak times when compared to the AADT. The recommendation is to incorporate two additional parameters when applying AADT and seasonality. These two parameters include a K-factor and a D-factor. Conceptually these two parameters will be used to calculate a design hour volume (DHV) and a directional design hour volume (DDHV).

The K-factor is the ratio of the hourly, two-way traffic to the two-way AADT, unconstrained by capacity. The D-factor is the percentage of the total two-way, peak hour traffic traveling in the peak direction. The K-factor and D-factor are ratios, and are based on a given hour. For example, K_1 would depict the busiest hour of the year (study period); whereas, K_{100} would depict the 100^{th} busiest hour.

The design hour volume, DHV, is the K-factor multiplied by the AADT. For the peak direction, the directional design hour volume, DDHV, is the AADT multiplied by the K-factor multiplied by the D-factor. For the non-peak direction, the DDHV is the AADT multiplied by the K-factor multiplied by one minus the D-factor.

Formulas:

K-factor = the proportion of AADT occurring during a given hour (e.g., the Design Hour Factor)

D-factor = the proportion of the total, two-way design hour traffic, traveling in the peak direction (e.g., the Directional Distribution)

$$DHV = AADT \times K\text{-}factor$$

$$DDHV\ (Peak\ Direction) = AADT \times K\text{-}factor \times D\text{-}factor$$

$$DDHV\ (Non\text{-}peak\ Direction) = AADT \times K\text{-}factor \times (1 - D\text{-}factor)$$

Further discussion of the K-factor can be found in references [41-43].

Figure 2.1 is from a study by the Florida Department of Transportation in 2002. The K_{30} depicts the 30^{th} busiest hour (of the year, or study period) for various road types assuming two-way traffic and unconstrained by capacity. The 30^{th} hour is chosen because it has been shown to be effective for designing and planning; including, but not limited to, Florida and Nevada.

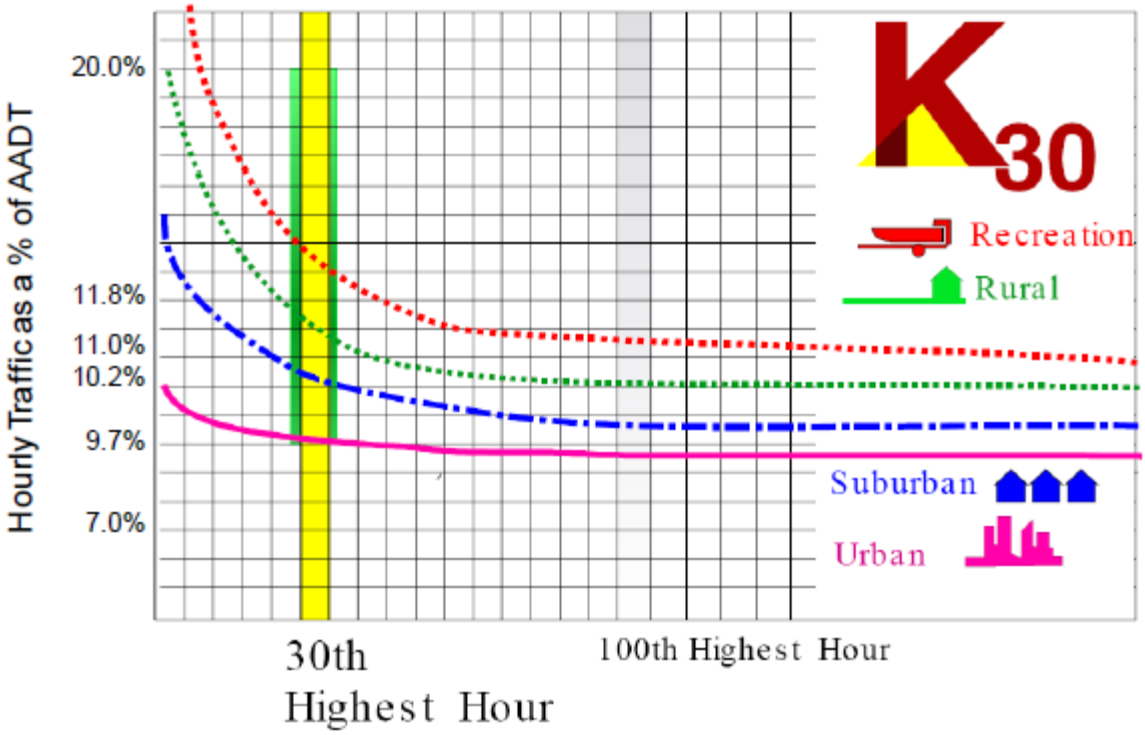

Figure 2.1. Relation between Peak-Hour and AADT ***(Figure from the Florida Department of Transportation, Project Traffic Forecasting Handbook, 2002; [41])***

The K_{30} values act as you would expect, notably:

- The K_{30} factor will decrease as the AADT on a roadway increases.
- The K_{30} factor will decrease as development density increases.
- The highest K_{30} factor (i.e., hourly traffic as a percentage of AADT) occurs on recreational roadways which exhibit high seasonality.

The D_{30} values are used to correct for traffic that is traveling primarily in one direction during the peak hour. Thus, more traffic lanes will be needed for that direction. The D-factor values should average to be 0.5 when averaging over both directions.

The values for K_{30} and D_{30} can be obtained using traffic counts, either continuous counts or short-term counts. They can be estimated based on known values for the recreational, rural, suburban, and urban areas. For example, based on Figure 2.1, the values for K_{30} will be approximately 0.14 for recreational, 0.114 for rural, 0.103 for suburban, and 0.097 for urban. The values for D_{30} would average 0.5 (i.e., equal traffic in both directions at peak hour) and adjust accordingly. Both of these parameter values would have to be adjusted for long-term planning, especially as new roadways are being constructed as road choices may change over the project's horizon.

It should be noted that while Nevada in 2012 [42] used the K_{30} and D_{30} values depending on the roadway being studied, Florida has developed a new model that uses different K values (i.e., K_{100}), D values, and percent of vehicles that are trucks based on different locations within the

state while tying-in budget considerations [43]. In other words, Florida is planning for the 100th busiest hour rather than the 30th busiest hour due to budget constraints and other restrictions.

The following standard K factors have been used by the Florida Department of Transportation since at least 2002 [41] and continued to be used as of 2014 [43]. Note that D factors would be determined using traffic counters measuring directionality of the traffic at the corresponding standard K factor representative time period.

FDOT Standard K Factors			
Area (Population) [Examples]	Facility Type	Standard K Factors* (% AADT)	Representative Time Period
Large Urbanized Areas with Core Freeways (1,000,000+) [Jacksonville, Miami]	Freeways	8.0 - 9.0 *	Typical weekday peak period or hour
	Arterials & Highways	9.0 **	Typical weekday peak hour
Other Urbanized Areas (50,000+) [Tallahassee, Ft. Myers]	Freeways	9.0 **	Typical weekday peak hour
	Arterials & Highways	9.0 **	Typical weekday peak hour
Transitioning to Urbanized Areas (Uncertain) [Fringe Development Areas]	Freeways	9.0	Typical weekday peak hour
	Arterials & Highways	9.0	Typical weekday peak hour
Urban (5,000-50,000) [Lake City, Key West]	Freeways	10.5	100th highest hour of the year
	Arterials & Highways	9.0 **	Typical weekday peak hour
Rural (< 5,000) [Chipley, Everglades]	Freeways	10.5	100th highest hour of the year
	Arterials	9.5 **	100th highest hour of the year
	Highways	9.5	100th highest hour of the year

**Value is 7.5% in approved Multimodal Transportation Districts where automobile movements are deemphasized. Essentially, this lower value represents an extensive multi-hour peak period rather than a peak hour.*

***Value is 8.0% for FDOT-designated urbanized core freeways and may be either 8.5% or 9.0% for non-core freeways. Values less than 9% essentially represent a multi-hour peak period rather than a peak hour.*

Figure 2.2. Florida Department of Transportation Standard K Factors *(Figure from the Florida Department of Transportation, Project Traffic Forecasting Handbook, 2002 and 2014; [41, 43])*

Thus, once DHV and DDHV are calculated, then a level of service (LOS) analysis can be completed and plans can be made accordingly.

The primary recommendation with respect to the model would be to use the *hourly* traffic counts (either continuous or short-term) to develop K_{30} and D_{30} values for locations and then use DHVs and DDHVs rather than AADTs for planning purposes.

Intermediate Approach used in North Carolina Case Studies

An intermediate approach was needed since hourly traffic counts were not readily available or reliable for all locations. Thus, an adaptation of the monthly traffic counts was used to approximate the K_{30} values. The recommendation is to average the top two monthly counts. This was approximated using data available from Nevada and Florida where the K_{30} ratio was 14% for high-tourism areas, 11.4% for rural areas, and so forth; and relating it to the Case Study locations. Due to the location of the Case Studies it was assumed the DHV and DDHV were

equivalent (i.e., the directions of traffic did not matter). Since the average of the top two months will be used, then that will be defined as design volume (DV).

Example of Seasonality and Explanation of Terms Used in Case Studies
Below are the figures for the Outer Banks area for the A2702 traffic counter, which will be included in Case Study 2. Figure 2.3 is a repeat of Figure 4.2 and Figure 2.4 is a repeat of Figure 4.3. As discussed further in Section 4 this area is considered high with respect to seasonal variation (month-to-month). This example provides details for how to interpret these figures.

The minimum, median, maximum, and standard deviation are based across the 12 months throughout the year; as percentages of AADT observed at the site for the entire year. Thus, for Dare County site A2702, the minimum of 5.11 (Figure 2.3) was observed in January (Figure 2.4); meaning 5.11% of the traffic passing A2702 for the entire year occurred in January. Likewise, the maximum was 12.38% occurring in July. The multiplier 2.42 (Figure 2.3) is determined by dividing the maximum (July at 12.38%) by the minimum (January at 5.11%) *[i.e., 12.38% ÷ 5.11% = 2.42]*. The AADT was the actual observed value, and the DV is the average of the top two observed months; for A2702, July and June. Note, medians are reported rather than averages for the 12 months since averages would be *100% ÷ 12 = 8.33%* for each location.

	Minimum %AADT:	Maximum %AADT:	Median %AADT:	Standard Deviation:	Multiplier:	Total ADT:	AADT:	DV:
Dare County								
U.S. 158								
A2702	5.11	12.38	8.25	2.34	2.42	21,690	1,807	2,590
A2703	5.70	12.29	7.85	2.37	2.15	117,194	9,766	14,160

Figure 2.3. Repeat of Figure 4.2, example of seasonality.

Outer Banks Area
Dare (A2702)

% of Yearly Traffic By Month	
Month	AVG %
JAN	5.11
FEB	5.52
MAR	6.65
APR	8.11
MAY	9.91
JUN	11.50
JUL	12.38
AUG	10.22
SEP	8.87
OCT	8.38
NOV	7.33
DEC	6.00

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	5.11	2.42
FEB	5.52	2.24
DEC	6.00	2.06
MAR	6.65	1.86
NOV	7.33	1.69
APR	8.11	1.53
OCT	8.38	1.48
SEP	8.87	1.40
MAY	9.91	1.25
AUG	10.22	1.21
JUN	11.50	1.08
JUL	12.38	1.00

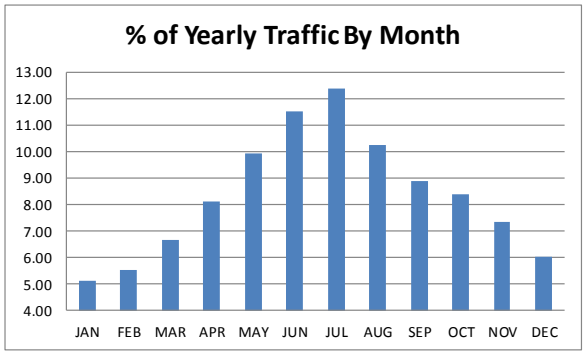

Figure 2.4. Repeat of Figure 4.3, example of seasonality.

The seasonal variation is exhibited in the histogram in Figure 2.4. In fact, June-August all exhibit twice as much traffic as January (the month with the least amount of traffic) and about 25% more than April and October, which are average months.

The seasonal variation is exhibited in the values within Figures 2.3 and 2.4. The Multiplier is the Maximum divided by the Minimum. A Multiplier of ≥ 2 (or nearly 2) is considered high variation, a $2 >$ Multiplier ≥ 1.4 is considered moderate, and below 1.4 is considered steady.

Formulas for Case Study:

$DV = (ADT_1 + ADT_2) \div 2$

Where ADT_1 is the highest average daily traffic for a single month in a calendar year, and ADT_2 is the second-highest average daily traffic for a single month in a calendar year.

3. CASE STUDY 1: WATAUGA/AVERY (NC 105)

Modeling and Data Analysis

The following locations were studied for Case Study 1. Information regarding the county, location of the traffic counter, route, and dates of data collection are provided in Figure 3.1. Also provided is the research team's evaluation of the seasonality depicted based on the data analyzed (in reference to the other Case Study traffic counter locations) in Figure 3.2. Finally, the analysis for each counter location is provided in Figures 3.3-3.5.

	Locations:	Route:	Data:	Seasonality Depicted:
Avery County				
North of Spruce Pine				
A0501	0.10 MILES SOUTH OF SR 1103 (BENT RD)	US 19E	2005-2013	No
Watauga County				
Boone				
A9401	0.10 MILES SOUTH OF SR 1672	SR 1508 (Elm Creek Rd)	1995-2006	No
A9403	0.50 MILES NORTH OF US 321 BUS	US 321	1998-2006	Moderate

Figure 3.1. Data Summary for Case Study 1

Values Explained:

The minimum, median, maximum, and standard deviation are based across the 12 months throughout the year; as percentages of AADT observed at the site for the entire year. Thus, for Avery County site A0501, the minimum of 7.01 (Figure 3.2) was observed in January (Figure 3.3); meaning 7.01% of the traffic passing A0501 for the entire year occurred in January. Likewise, the maximum was 9.26% occurring in August. The multiplier 1.32 (Figure 3.2) is determined by dividing the maximum (August at 9.26%) by the minimum (January at 7.01%) *[i.e., 9.26% ÷ 7.01% = 1.32]*. The AADT was the actual observed value, and the DV is the average of the top two observed months; in the case of A0501, August and October.

Note, medians are reported rather than averages for the 12 months since averages would be *100% ÷ 12 = 8.33%* for each location.

	Minimum %AADT:	Maximum %AADT:	Median %AADT:	Standard Deviation:	Multiplier:	Total ADT:	AADT:	DV:
Avery County								
North of Spruce Pine								
A0501	7.01	9.26	8.64	0.77	1.32	31,489	2,624	2,878
Watauga County								
Boone								
A9401	7.29	9.13	8.50	0.70	1.25	8,794	733	801
A9403	6.86	10.33	8.18	1.18	1.51	63,006	5,251	6,367

Figure 3.2. AADT and DV Summary for Case Study 1

Spruce Pine Area
Avery (A0501)

% of Yearly Traffic By Month	
Month	AVG %
JAN	7.01
FEB	7.51
MAR	7.83
APR	8.63
MAY	8.65
JUN	8.84
JUL	8.98
AUG	9.26
SEP	8.88
OCT	9.03
NOV	8.17
DEC	7.20

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	7.01	1.32
DEC	7.20	1.28
FEB	7.51	1.23
MAR	7.83	1.18
NOV	8.17	1.13
APR	8.63	1.07
MAY	8.65	1.07
JUN	8.84	1.05
SEP	8.88	1.04
JUL	8.98	1.03
OCT	9.03	1.03
AUG	9.26	1.00

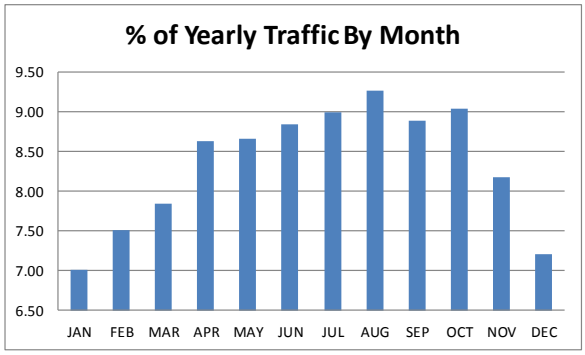

Figure 3.3. AADT Summary for Avery (Location A0501)

Boone Area
Watauga (A9401)

% of Yearly Traffic By Month	
Month	AVG %
JAN	7.30
FEB	7.29
MAR	7.85
APR	8.74
MAY	8.94
JUN	8.58
JUL	9.13
AUG	9.00
SEP	8.42
OCT	9.08
NOV	8.23
DEC	7.45

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
FEB	7.29	1.25
JAN	7.30	1.25
DEC	7.45	1.22
MAR	7.85	1.16
NOV	8.23	1.11
SEP	8.42	1.08
JUN	8.58	1.06
APR	8.74	1.04
MAY	8.94	1.02
AUG	9.00	1.01
OCT	9.08	1.01
JUL	9.13	1.00

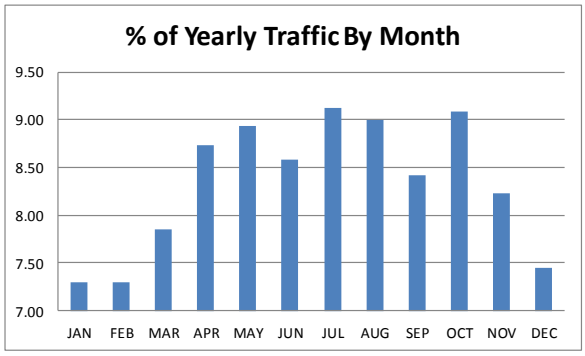

Figure 3.4. AADT Summary for Avery (Location A9401)

Boone Area
Watauga (A9403)

% of Yearly Traffic By Month	
Month	AVG %
JAN	6.86
FEB	7.12
MAR	6.99
APR	7.54
MAY	8.35
JUN	9.20
JUL	10.33
AUG	9.54
SEP	8.73
OCT	9.77
NOV	8.01
DEC	7.56

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	6.86	1.51
MAR	6.99	1.48
FEB	7.12	1.45
APR	7.54	1.37
DEC	7.56	1.37
NOV	8.01	1.29
MAY	8.35	1.24
SEP	8.73	1.18
JUN	9.20	1.12
AUG	9.54	1.08
OCT	9.77	1.06
JUL	10.33	1.00

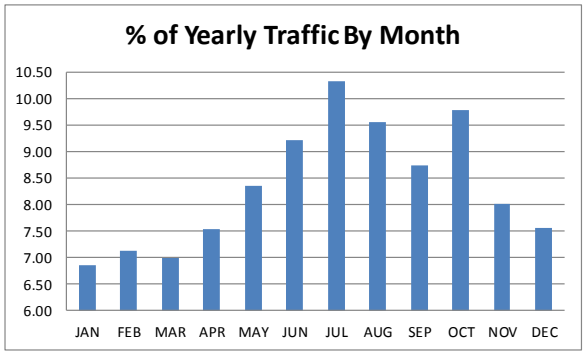

Figure 3.5. AADT Summary for Avery (Location A9403)

Case Study 1 Final Recommendations and Conclusions

The Case Study 1 location provides a number of interesting issues with respect to transportation planning, urban planning, and urban form issues. The data shows that there is moderate seasonality in one of the three locations studied for the data collected, compared to other areas studied (i.e., it does not depict as an extreme seasonality component as compared to other Case Study locations). This is likely due to the fact that the university and surrounding community provide a good deal of routine traffic in the area. The typical peaks are in July and October (with

August being third highest). The design volume (DV) for the various locations are relatively close to AADT (i.e., when compared to other case study locations) due to the minimal and/or moderate seasonality exhibited by these locations.

4. CASE STUDY 2: OUTER BANKS (US 158)

Modeling and Data Analysis

The following locations were studied for Case Study 2. Information regarding the county, location of the traffic counter, route, and dates of data collection are provided in Figure 4.1. Also provided is the research team's evaluation of the seasonality depicted based on the data analyzed (in reference to the other Case Study traffic counter locations) in Figure 4.2. Finally, the analysis for each counter location is provided in Figures 4.3-4.4.

	Locations:	Route:	Data:	Seasonality Depicted:
Dare County				
U.S. 158				
A2702	0.60 MILES WEST OF SR 1153 (OLD FERRY LANDING RD)	US 64	2005-2013	High
A2703	0.20 MILES WEST OF BARLOW LANE	US 158	1995-2013	High

Figure 4.1. Data Summary for Case Study 2

Values Explained:

The minimum, median, maximum, and standard deviation are based across the 12 months throughout the year; as percentages of AADT observed at the site for the entire year. Thus, for Dare County site A2702, the minimum of 5.11 (Figure 4.2) was observed in January (Figure 4.3); meaning 5.11% of the traffic passing A2702 for the entire year occurred in January. Likewise, the maximum was 12.38% occurring in July. The multiplier 2.42 (Figure 4.2) is determined by dividing the maximum (July at 12.38%) by the minimum (January at 5.11%) *[i.e., 12.38% ÷ 5.11% = 2.42]*. The AADT was the actual observed value, and the DV is the average of the top two observed months; for A2702, July and June.

	Minimum %AADT:	Maximum %AADT:	Median %AADT:	Standard Deviation:	Multiplier:	Total ADT:	AADT:	DV:
Dare County								
U.S. 158								
A2702	5.11	12.38	8.25	2.34	2.42	21,690	1,807	2,590
A2703	5.70	12.29	7.85	2.37	2.15	117,194	9,766	14,160

Figure 4.2. AADT and DV Summary for Case Study 2

Outer Banks Area
Dare (A2702)

% of Yearly Traffic By Month	
Month	AVG %
JAN	5.11
FEB	5.52
MAR	6.65
APR	8.11
MAY	9.91
JUN	11.50
JUL	12.38
AUG	10.22
SEP	8.87
OCT	8.38
NOV	7.33
DEC	6.00

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	5.11	2.42
FEB	5.52	2.24
DEC	6.00	2.06
MAR	6.65	1.86
NOV	7.33	1.69
APR	8.11	1.53
OCT	8.38	1.48
SEP	8.87	1.40
MAY	9.91	1.25
AUG	10.22	1.21
JUN	11.50	1.08
JUL	12.38	1.00

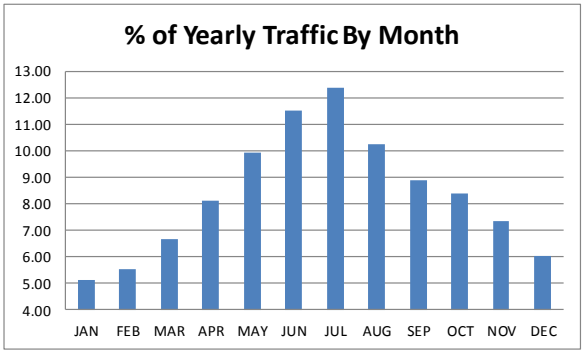

Figure 4.3. AADT Summary for Dare (Location A2702)

Outer Banks Area
Dare (A2703)

% of Yearly Traffic By Month	
Month	AVG %
JAN	5.85
FEB	5.89
MAR	6.73
APR	8.12
MAY	9.15
JUN	10.84
JUL	12.29
AUG	12.02
SEP	9.20
OCT	7.57
NOV	6.65
DEC	5.70

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
DEC	5.70	2.15
JAN	5.85	2.10
FEB	5.89	2.09
NOV	6.65	1.85
MAR	6.73	1.83
OCT	7.57	1.62
APR	8.12	1.51
MAY	9.15	1.34
SEP	9.20	1.33
JUN	10.84	1.13
AUG	12.02	1.02
JUL	12.29	1.00

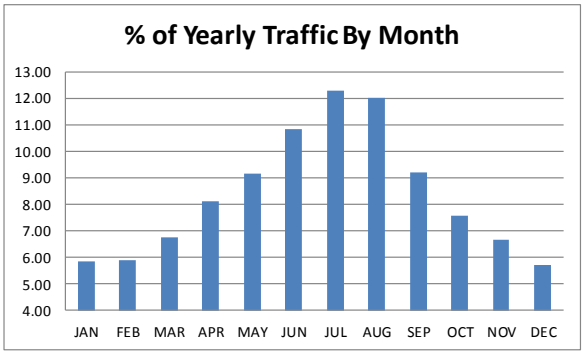

Figure 4.4. AADT Summary for Dare (Location A2703)

Case Study 2 Final Recommendations and Conclusions

The Case Study 2 location provides a number of interesting issues with respect to transportation planning, urban planning, and urban form issues with respect to seasonality in traffic. The local residents exhibited extreme behavior with respect to traffic avoidance and other plans. The opportunity for alternative transportation (i.e., walking, bicycles) could be further explored, but would require additional infrastructure and/or infrastructure improvements. The abundance of parking in some areas actually encourages more tourism traffic. The data shows that there is high seasonality in both of the two locations studied for the data collected, compared to other areas studied (i.e., it does depict an extreme seasonality component as compared to other Case Study locations). This is likely due to the fact that the permanent population is relatively small when compared to the tourism population. The obvious peaks are in the summer (June-August), and the lows in the winter (December-February). The extreme seasonality represents a significant issue with respect to traffic count variation, essentially making the AADT meaningless for this region. Due to the economy of Dare County (and the Outer Banks, in general) relying heavily on tourism, it makes the transportation network essential to the prosperity of this area and its residents [38-39].

The design volume for the various locations are significantly larger than AADT (i.e., when compared to other case study locations) due to the high seasonality and peak demand exhibited by these locations.

5. CASE STUDY 3: WRIGHTSVILLE BEACH AREA (WILMINGTON)

Modeling and Data Analysis

The following locations were studied for Case Study 3. Information regarding the county, location of the traffic counters, routes, and dates of data collection are provided in Figure 5.1. Also provided is the research team's evaluation of the seasonality depicted based on the data analyzed (in reference to the other Case Study traffic counter locations) in Figure 5.2. Finally, the analysis for each counter location is provided in Figures 5.3-5.4.

	Locations:	Route:	Data:	Seasonality Depicted:
New Hanover County				
Wilmington/Wrightsville Beach				
A6403	0.02 MILES EAST OF SUMMER REST RD	US 74-76	2007-2013	High
A6405	0.10 MILES EAST OF US 421 NORTHBOUND RAMP	US 76/17 Business	2005-2013	No

Figure 5.1. Data Summary for Case Study 3

Values Explained:

The minimum, median, maximum, and standard deviation are based across the 12 months throughout the year; as percentages of AADT observed at the site for the entire year. Thus, for New Hanover County site A6403, the minimum of 5.78 (Figure 5.2) was observed in December (Figure 5.3); meaning 5.78% of the traffic passing A6403 for the entire year occurred in December. Likewise, the maximum was 11.44% occurring in July. The multiplier 1.98 (Figure 5.2) is determined by dividing the maximum (July at 11.44%) by the minimum (December at 5.78%) *[i.e., 11.44% ÷ 5.78% = 1.98]*. The AADT was the actual observed value, and the DV is the average of the top two observed months; in the case of A6403, July and June.

	Minimum %AADT:	Maximum %AADT:	Median %AADT:	Standard Deviation:	Multiplier:	Total ADT:	AADT:	DV:
New Hanover County								
Wilmington/Wrightsville Beach								
A6403	5.78	11.44	8.19	1.99	1.98	161,987	13,499	18,003
A6405	7.70	8.76	8.30	0.32	1.14	265,808	22,151	23,169

Figure 5.2. AADT and DV Summary for Case Study 3

Wilmington Area
New Hanover (A6403)

% of Yearly Traffic By Month	
Month	AVG %
JAN	5.97
FEB	6.34
MAR	7.50
APR	8.93
MAY	9.99
JUN	10.79
JUL	11.44
AUG	10.29
SEP	8.86
OCT	7.51
NOV	6.60
DEC	5.78

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
DEC	5.78	1.98
JAN	5.97	1.92
FEB	6.34	1.80
NOV	6.60	1.73
MAR	7.50	1.53
OCT	7.51	1.52
SEP	8.86	1.29
APR	8.93	1.28
MAY	9.99	1.15
AUG	10.29	1.11
JUN	10.79	1.06
JUL	11.44	1.00

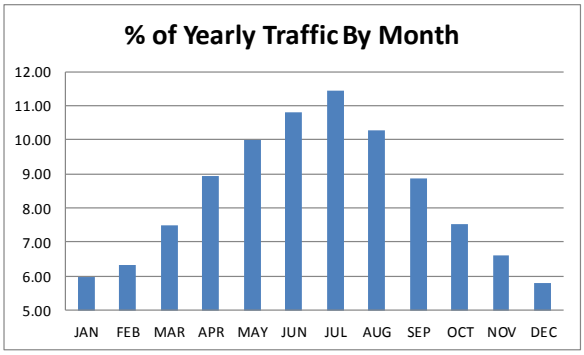

Figure 5.3. AADT Summary for Wilmington (Location A6403)

Wilmington Area
Brunswick (A6405)

% of Yearly Traffic By Month	
Month	AVG %
JAN	7.70
FEB	8.27
MAR	8.55
APR	8.62
MAY	8.27
JUN	8.68
JUL	8.76
AUG	8.58
SEP	8.26
OCT	8.32
NOV	8.06
DEC	7.94

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	7.70	1.14
DEC	7.94	1.10
NOV	8.06	1.09
SEP	8.26	1.06
FEB	8.27	1.06
MAY	8.27	1.06
OCT	8.32	1.05
MAR	8.55	1.02
AUG	8.58	1.02
APR	8.62	1.02
JUN	8.68	1.01
JUL	8.76	1.00

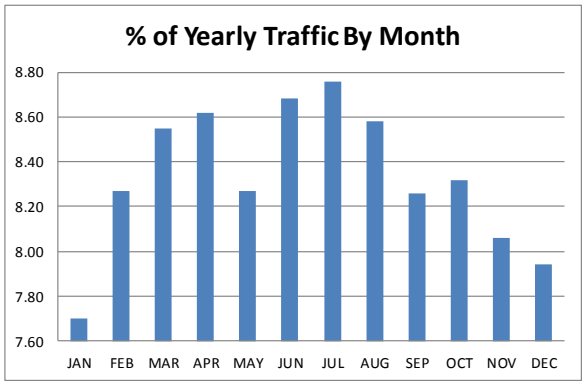

Figure 5.4. AADT Summary for Wilmington (Location A6405)

Case Study 3 Final Recommendations and Conclusions

The Case Study 3 location provides a number of interesting issues due to its population size and diversity. The figures and data indicate that the Wilmington area (within the city) and the connecting highways exhibit a relatively steady traffic flow. There are obvious bottlenecks and pinch points. One of the counter locations exhibited extreme seasonality, particularly during the summer months since this was a route that captures the summer tourism traffic; thus, the design volume for this location was significantly higher than AADT. The other counter was relatively steady, not exhibiting seasonality; thus, the design volume and AADT were practically equivalent.

6. CASE STUDY 4: BRYSON CITY

Modeling and Data Analysis

The following locations were studied for Case Study 4. Information regarding the county, location of the traffic counter, route, and dates of data collection are provided in Figure 6.1. Also provided is the research team's evaluation of the seasonality depicted based on the data analyzed (in reference to the other Case Study traffic counter locations) in Figure 6.2. Finally, the analysis for each counter location is provided in Figures 6.3.

	Locations:	Route:	Data:	Seasonality Depicted:
Swain County				
Bryson City				
A8602	0.30 MILES WEST OF NC 28	NC 28	2005-2013	High

Figure 6.1. Data Summary for Case Study 4

Values Explained:

The minimum, median, maximum, and standard deviation are based across the 12 months throughout the year; as percentages of AADT observed at the site for the entire year. Thus, for Swain County site A8602, the minimum of 5.19 (Figure 6.2) was observed in January (Figure 6.3); meaning 5.19% of the traffic passing A8602 for the entire year occurred in January. Likewise, the maximum was 12.52% occurring in July. The multiplier 2.41 (Figure 6.2) is determined by dividing the maximum (July at 12.52%) by the minimum (January at 5.19%) *[i.e., 12.52% ÷ 5.19% = 2.41]*. The AADT was the actual observed value, and the DV is the average of the top two observed months; in the case of A8602, July and August.

	Minimum %AADT:	Maximum %AADT:	Median %AADT:	Standard Deviation:	Multiplier:	Total ADT:	AADT:	DV:
Swain County								
Bryson City								
A8602	5.19	12.52	8.60	2.40	2.41	26,134	2,178	3,079

Figure 6.2. AADT and DV Summary for Case Study 4

Bryson City Area
Swain (A8602)

% of Yearly Traffic By Month	
Month	AVG %
JAN	5.19
FEB	5.58
MAR	6.47
APR	8.05
MAY	9.16
JUN	10.80
JUL	12.52
AUG	11.04
SEP	9.35
OCT	9.20
NOV	6.91
DEC	5.73

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	5.19	2.41
FEB	5.58	2.24
DEC	5.73	2.19
MAR	6.47	1.93
NOV	6.91	1.81
APR	8.05	1.56
MAY	9.16	1.37
OCT	9.20	1.36
SEP	9.35	1.34
JUN	10.80	1.16
AUG	11.04	1.13
JUL	12.52	1.00

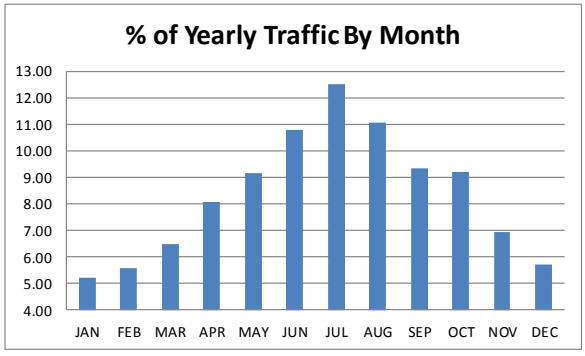

Figure 6.3. AADT Summary for Bryson City (Location A8602)

Case Study 4 Final Recommendations and Conclusions

The Case Study 4 location provides a number of interesting issues due to its proximity to the Great Smoky Mountains National Park and its seasonality in the summer months. The figures and data indicate that the Bryson City area exhibits extreme seasonality, nearly equivalent to the levels exhibited in the Dare County (Outer Banks) study (Case Study 2). Interestingly enough, the peak traffic occurs during the summer (same as Dare County), even though Bryson City is in the mountains. This is due to visitors to the Great Smoky Mountains National Park and surrounding areas. The design volume for the counter location is significantly larger than AADT (i.e., when compared to other case study locations) due to the high seasonality and peak demand exhibited by this location.

7. CASE STUDY 5: ASHEVILLE

Modeling and Data Analysis

The following locations were studied for Case Study 5. Information regarding the county, location of the traffic counters, routes, and dates of data collection are provided in Figure 7.1. Also provided is the research team's evaluation of the seasonality depicted based on the data analyzed (in reference to the other Case Study traffic counter locations) in Figure 7.2. Finally, the analysis for each counter location is provided in Figures 7.3-7.4.

	Locations:	Route:	Data:	Seasonality Depicted:
Buncombe County				
Asheville				
A1001	0.70 MILES WEST OF NC 191 (BREVARD RD)	I-26	2005-2013	No
A1003	1.45 MILES EAST OF SR 1200 (WIGGINS RD))	I-40	2006-2013	Moderate

Figure 7.1. Data Summary for Case Study 5

Values Explained:

The minimum, median, maximum, and standard deviation are based across the 12 months throughout the year; as percentages of AADT observed at the site for the entire year. Thus, for Buncombe County site A1001, the minimum of 7.48 (Figure 7.2) was observed in January (Figure 7.3); meaning 7.48% of the traffic passing A1001 for the entire year occurred in January. Likewise, the maximum was 8.71% occurring in October. The multiplier 1.17 (Figure 7.2) is determined by dividing the maximum (October at 8.71%) by the minimum (January at 7.48%) *[i.e., 8.71% ÷ 7.48% = 1.17]*. The AADT was the actual observed value, and the DV is the average of the top two observed months; in the case of A1001, June and October.

	Minimum %AADT:	Maximum %AADT:	Median %AADT:	Standard Deviation:	Multiplier:	Total ADT:	AADT:	DV:
Buncombe County								
Asheville								
A1001	7.48	8.71	8.39	0.32	1.17	320,267	26,689	27,777
A1003	6.18	9.86	8.58	1.12	1.59	283,975	23,665	27,531

Figure 7.2. AADT and DV Summary for Case Study 5

Asheville Area
Buncombe (A1001)

% of Yearly Traffic By Month	
Month	AVG %
JAN	7.48
FEB	8.08
MAR	8.37
APR	8.42
MAY	8.52
JUN	8.63
JUL	8.30
AUG	8.42
SEP	8.47
OCT	8.71
NOV	8.36
DEC	8.24

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	7.48	1.17
FEB	8.08	1.08
DEC	8.24	1.06
JUL	8.30	1.05
NOV	8.36	1.04
MAR	8.37	1.04
AUG	8.42	1.04
APR	8.42	1.03
SEP	8.47	1.03
MAY	8.52	1.02
JUN	8.63	1.01
OCT	8.71	1.00

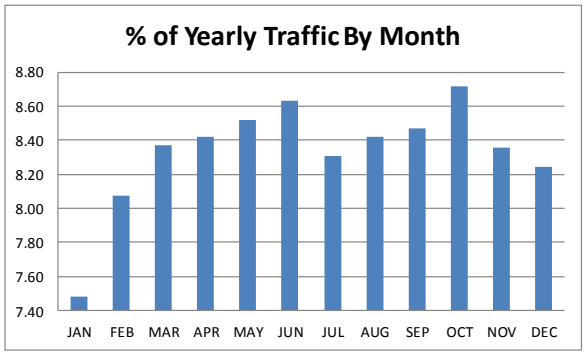

Figure 7.3. AADT Summary for Asheville (Location A1001)

Asheville Area
Buncombe (A1003)

% of Yearly Traffic By Month	
Month	AVG %
JAN	6.18
FEB	6.76
MAR	7.49
APR	7.90
MAY	8.67
JUN	9.53
JUL	9.86
AUG	9.24
SEP	8.70
OCT	9.21
NOV	8.49
DEC	7.98

Sorted by % of Yearly Traffic		
Month	AVG	Multiplier
JAN	6.18	1.59
FEB	6.76	1.46
MAR	7.49	1.32
APR	7.90	1.25
DEC	7.98	1.23
NOV	8.49	1.16
MAY	8.67	1.14
SEP	8.70	1.13
OCT	9.21	1.07
AUG	9.24	1.07
JUN	9.53	1.03
JUL	9.86	1.00

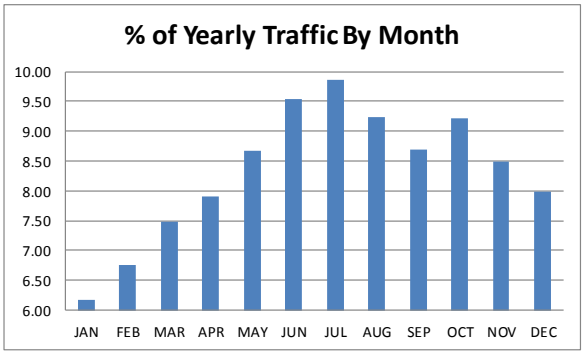

Figure 7.4. AADT Summary for Asheville (Location A1003)

Case Study 5 Final Recommendations and Conclusions

The Case Study 5 location provides a number of interesting issues due to its population size and diversity. The figures and data indicate that the Asheville area (within and nearby the city) and the connecting highways exhibit a relatively steady traffic flow with a moderate seasonality for one of the two counters studied. Essentially, the road is not used as much in January, perhaps due to extreme weather events and holidays. The road is used much more often during the summer months (when compared to January). There are obvious bottlenecks and pinch points. The design volume for one location was approximately equivalent to the AADT and for the other location moderately higher, which is due to the lack of seasonality exhibited by these locations.

8. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The primary case study findings and conclusions were:

- Case Study 1: Watauga/Avery (NC 105)
  - Of the three traffic counter locations' data evaluated, two did not exhibit seasonality and one exhibited only moderate seasonality (peaking in August). The reason for this is due to the constant (year-round) traffic generated by the college students and residents.
- Case Study 2: Outer Banks (US 158)
  - Of the two traffic counter locations' data evaluated, both exhibited high seasonality; peaking in the summer.
- Case Study 3: Wrightsville Beach Area (Wilmington)
  - Urban area with steady traffic from the residents in the Wilmington area.
  - One of the traffic counter location's data exhibited a high seasonality (peaking in the summer); and one exhibited no seasonality. The one that exhibited seasonality included beach traffic.
- Case Study 4: Bryson City
  - The single traffic counter location's data exhibited a high seasonality (peaking in the summer).
- Case Study 5: Asheville
  - Urban area with steady traffic from the residents in the Asheville area.
  - One of the traffic counter location's data exhibited a moderate seasonality (peaking in June and July); whereas the other location did not exhibit seasonality.

The first and primary recommendation with respect to AADT calculations and planning is to incorporate peak-usage and directionality; whether it be hourly or monthly. Urban areas will have AADT values similar to the design volume. However, seasonal areas, such as tourist locations, will have significant differences between the design volume and the AADT. While other states (notably Nevada and Florida) have incorporated peak-hour usage ratios into their planning forecasts, using monthly rates (as shown in the case studies) can be useful.

Specific implementation strategies and recommendations for the five case study locations were provided in those specific sections and outlined in the prior section. This section will focus on two primary areas of consideration with respect to planning for seasonal variation.

Second, the baseline models and methods of data collection for areas with anticipated seasonal variability are not current [referring to "Traffic Survey Group: Field Operations Section Seasonal Volume Count Data Collection Procedure" (Word File) and "ATR Seasonal Groups" (Excel File) – updated in April 2004]. Simply put, calculating an accurate AADT would require collecting data at both peak and non-peak times. Thus, for this research study the research team relied heavily on traffic counters that were operational year-round (or close to year-round), with a preference for counters with current data (i.e., through 2013). It is our recommendation that the NCDOT modify its procedures to allow for continuous traffic counting in some locations that experience high seasonality (note, the NCDOT is already doing this in many areas), and the NCDOT weight those counters with greater emphasis since the data is more complete than the sampling counters. In some locations, it will be difficult to find a point to collect continuous data. However, in some locations (i.e., Outer Banks) there are specific entry and exit points to the area (i.e., bridges) that would allow for a fairly accurate count and estimation.

Third, areas that exhibit large seasonal fluctuations are at an inherent disadvantage when compared against areas that do not have variation. This is true with respect to transportation planning as well as other systems. Using the metric AADT is the primary cause for this inherent disadvantage, because by its very nature (i.e., average) it does not account for variability (i.e., seasonality). Thus, as a forward-thinking (long-term) plan, perhaps the concept of a service level should be enacted. Simply put, a service level approach would suggest designing the transportation system to meet XX% of the demand for any given time period. For a system with low variability, the AADT would be equivalent to a 50% service level. However, for a system with extreme variability, the 50% service level may be above the AADT. Conceptually, the idea of service level is used in supply chain management, logistics management, and queueing systems; which are similar in network structure and in nature to transportation systems. The implementation of this recommendation could be further intensified by the use of GPS, GIS, cellular, and analytics technology. This second recommendation does warrant further discussion and investigation, perhaps with partnering organizations in other states, the Federal Highway Administration, and the Transportation Research Board.

9. IMPLEMENTATION AND TECHNOLOGY TRANSFER PLAN

The recommendations within each of the case studies can be addressed directly by the NCDOT, regional personnel, and local governing bodies. The recommendations discussed in the previous section should be addressed by the NCDOT on two levels. The first and second recommendations should be addressed tactically (i.e., 3-5 years), and phased-in as resources are available. The third recommendation should be addressed strategically (i.e., 5-10 years), and phased-in as resources are available.

Implementable Research Products (output):

The primary research product is a recommendation with respect to Average Annual Daily Traffic (AADT) calculations and planning to incorporate peak-usage and directionality; whether it be hourly or monthly. Urban areas will have AADT values similar to the design volume. However, seasonal areas, such as tourist locations, will have significant differences between the design volume and the AADT. The recommended design volume is to use the average of the two peak months for AADT for areas with high seasonal traffic. The recommendation is based on best practices and methods discussed in the literature review.

Implementation Plan:

Revise documents (e.g., specifications design guidelines, etc.):

The research product will be used during the development of Comprehensive Transportation Plans in communities that experience high seasonal traffic. Revising specifications and/or writing special provisions is needed with respect to these areas to implement the proposed recommendations.

Application to processes (e.g., design):

The research product will be used during the development of Comprehensive Transportation Plans in communities that experience high seasonal traffic. The proposed recommendations establish new design procedures with respect to calculating the design volume.

Application to projects:

The case study locations that exhibited seasonal traffic could be the initial locations for implementing the research product.

Other:

Anticipated Benefits (outcome):

The research product provides the department with best planning practices in areas with high seasonal traffic. The literature review and the proposed method are defensible to the public and reproducible.

How can Research and Development Unit participate?

Aid in the collection of AADT data for sites not analyzed as case studies that may exhibit seasonal traffic.

APPENDIX A

The literature review focused on identifying practices and scholarly literature related to tourist traffic including choice of destinations and travel within destinations. Specific attention was given to application of forecasting approaches, factors included as significant contributors, and choice models. The search was conducted using scholarly databases available through the East Carolina University library. These included engineering, transportation planning, geography, urban planning, business, hospitality, and tourism specific databases and also consolidated databases covering several of these areas. The literature review is comprised of a summary and an annotated reference list with a brief description of the publication. Additionally, several general references were identified. Examples of these include the Traffic Engineering Handbook [2], Travel Economic Impact Model [3], and the North Carolina Department of Commerce economic impact website related to tourism [4].

Introduction

This project incorporates multiple disciplines, including: transportation planning, tourism planning, local and urban planning, environmental sustainability, economics, geography, and engineering. The project included data, methods, and resources from all of these fields, including: forecasting, seasonal variation modeling, regression, geographic information systems (GIS), employment, economic, hotel occupancy, motor vehicle transportation, bicycle transportation, pedestrian transportation, and tourism behavior.

General Tourism Planning

Within tourism planning, there are a number of published resources. A commonly cited and studied book [5] by Clare Gunn explores the basics of tourism planning (i.e., growth, sustainability, ecotourism, and policy), and presents concepts and case studies from around the world, including large-scale, small-scale, and regional plans. Another book [6] by Edward Inskeep provides an overview of sustainable tourism planning (i.e., environmental, institutional, strategic, implementation, socioeconomic, and development). Seasonality is briefly mentioned in terms of carrying capacity for various attractions. The book then discusses ways to reduce seasonality (e.g., promotions in off-seasons, four-season resorts). Another book [7] by Takayuki Hara provides an overview of quantitative analysis applied to the tourism industry, including social accounting, basic regression, and basic forecasting. References [5-7] are practitioner based references and general in nature; thus, they are suitable for textbooks at the university level, but do not provide specific details for tourism traffic planning with seasonality.

General Transportation Planning

With regards to transportation planning's economic impacts, one specific resource to note is the extensive book published by the Victoria Transport Policy Institute [8]. This group has provided a holistic view of transportation planning, including: evaluation of non-motorized transportation benefits and costs, the economic value of walkability (for a locality), transportation diversity, land use, and evaluation of transportation benefits. The Victoria Policy Institute also has a number of other publications (e.g., white papers, review articles, case studies) that are appropriate for this research.

Environmental Impacts

From an environmental perspective, there exist concerns for livability to residents of tourism gateway communities, factoring in ahead of perceived economic and cultural factors [9]. Transportation affects not only the environment and perceived livability for residents, but also congestion and carrying capacity may pose negative feedbacks to the tourism and recreational quality of an area. Transportation congestion in peak flows can also inhibit emergency response and contribute to environmental impacts by increased fossil fuel consumption and emissions [10-11]. Enhanced mobility, in terms of sustainable tourism, must also factor in these environmental costs [12]; whereas, fossil fuel consumption and emissions could be reduced if individual, motorized traffic can be reduced and replaced with an emphasis on walking, cycling, and public transport. As transportation dominates the greenhouse gas emissions of tourism energy use, planning infrastructure must incorporate the modes of transport, environmental impacts, and alternative designs with greater future emphasis on increasing passenger load, decreasing travel distances, and promoting technological efficiencies. North Carolina's geography and concentration of tourism gateways provide a basis for promoting tourism hubs and green transportation infrastructure.

GIS and Visualization

GIS and visualization provide powerful tools for predicting the environmental and aesthetic impacts of alternative transportation and tourism development schemes. GIS can assist environmental impact assessment, quantify land use changes on watersheds [13], support site selection and corridor suitability analysis, and visually depict aesthetic impacts in line-of-sight and viewshed analyses. GIS and geovisualization using maps, digital globes, and online cybercartography can also facilitate participatory decision-making. Assessing viewsheds can also reveal the potential for future development to obscure and diminish residential perceptions and economic values. Participatory GIS provides a new approach for incorporating community residential and planner involvement and sidestepping hurdles in communications [14] or mitigating environmental justice issues [15].

Public Perception

Citizen perception is also paramount for planning projects. It is commonly known that one should ask residents their experiences, perceptions, and expectations. Ultimately, one can see how they value tourism, how much they are willing to enter into an exchange with the tourists if they can reap some benefit without incurring unacceptable costs [16-17].

In [16], the authors investigate the dilemma of how to manage tourism related traffic at rural destinations in the United Kingdom (UK) using a "social representation perspective." They seek to increase understanding of the social realities that underpin people's attitudes towards transportation and tourism and their decisions about transportation behavior. Applying the perspective of social representations theory allows one to identify a number of widely shared assumptions about reality that might also limit and undermine transportation initiatives. The authors identify a variety of initiatives, including restrictions on car use; however, they conclude that "plans to restrict car use are often abandoned following local opposition," suggesting that such measures are politically difficult to implement. Similarly, in a rural (UK) context, public transportation proves a poor competitor to the car. In short, social representations are clear that

the car cannot be restricted, and public transportation cannot be improved enough to meet everyone's needs.

Short Term and Long Term Traffic Prediction

The papers and articles focusing on short term traffic prediction were geared towards predicting traffic flow over a course of several hours down to a few minutes. These papers tended towards researching how to predict traffic volume and traffic behavior upon an unexpected event such as a lane closure. Fries et al. [18] researched how the use of software could predict traffic conditions after an incident and found that accurate predictions required a large amount of computational capacity. Stathopoulos et al. [19] examined multivariate state space models for predicting traffic volume in congested urban areas and found that multivariate state space models are more accurate than univariate time series models. Additionally, there is a need for different model specifications throughout the day. Lowry et al. [20] applied highway traffic simulation software to determine recreational river traffic patterns.

Generally, there are fewer research references for long term traffic planning. Han, Stone, and Huntsinger [21] compiled a spreadsheet-based modeling tool to assign traffic volumes to small networks using several types of data, including census, maps, and traffic data in areas where time-consuming software has traditionally been used. Zhong and Hanson [22] estimated traffic volume in rural areas where no traffic data is available by using travel demand models and found that these models consistently overestimated traffic volume, but could be made more accurate by reducing the size of traffic analysis zones, as well as including other data such as the number of driveways per kilometer.

One paper mentioned newer, more abstract methods for modeling traffic volume. Stutz and Runkler [23] applied fuzzy neural (e.g., nerve and/or brain connections) networks to model traffic flow in both short term periods and long term studies. The authors found that fuzzy neural networks can be used to successfully predict long and short term traffic patterns.

Sharma et al. analyzes the statistical precision of annual average daily traffic (AADT) estimates resulting from short period traffic counts (SPTC) in Minnesota and Canada (Alberta and Saskatchewan). The paper considers volume adjustment factors, assignment effectiveness, and degree of correctness. The results indicate that AADT estimation errors are sensitive to the assignment effectiveness. The study results suggest that highway agencies should put more emphasis on sample site assignments to correct ATR groups than on the duration of count [24].

Aunet's report discusses Wisconsin's approach to seasonal variation and data collection; including cluster analysis, geographical mapping, coefficient of variation, and traffic factor plotting. The paper focuses solely on total volume count data [25].

Most Relevant Literature

The prior literature that was most relevant to this research project include references [21, 26, 27], [24], and [25]. They are featured in more detail below.

The key findings of the Han et al. [21] report are as follows (additional follow-up work by this group of authors can be found in references [26-27]):

- Manual transportation planning methods are used for small towns (<5000 residents) in North Carolina (oftentimes in conjunction with other methods; TransCAD)
- Paper describes a spreadsheet model for rural transportation planning
- Used census data and then manually assigned traffic to specific zones
- North Carolina Case Study (Pilot Mountain, NC)

The key findings of the Sharma et al. [24] paper are as follows:

- Annual Average Daily Traffic (AADT) estimation using Short Period Traffic Counts (SPTC) [24-72 hr.]
- Compared to results from an Automatic Traffic Recorder (ATR) using statistical analysis in Minnesota, Alberta, and Saskatchewan
- Evaluated data using descriptive statistics; and provided error coefficients and confidence levels for various SPTC

The key findings of the Aunet [25] report are as follows:

- Used a combination of approaches to predict Annual Average Daily Traffic (AADT) estimation using Short Period Traffic Counts (SPTC) [24hr. – 7 days]
- Methods used/suggested: coefficient of variation, cluster analysis, regression (monthly), and geographical mapping of continuous count sites

Overview of Transportation System Management and Transportation Demand Management

By the end of the 1980s the interstate highway system in the United States was nearly completed. In recent years, interest has turned to enhancing the performance of existing road networks [28]. Two sets of techniques are often referred to as transportation system management (TSM) and transportation demand management (traffic demand management, travel demand management, all TDM). Both TSM and TDM are ordinances that use regulatory and incentive-based strategies to reduce the impact of (often) drive-alone auto trips. The transportation system management (TSM) is a set of strategies of an operational nature used to mitigate the traffic by improving the transportation system capacity and the efficiency of the existing transportation system. TDM is any action or set of actions aimed at influencing people's travel behavior in such a way that alternative mobility options are presented and/or congestion is reduced [29]. It should be noted that TSM and TDM are overlapping concepts. The improved transportation options with biking and walking are, for example, considered as both a TSM and a TDM technique. Both systems may not be a panacea, but they can help ease some transportation problems. They are appealing because they allow for the increase of the efficiency of transportation systems inexpensively relative to infrastructure investments [30]. A successful TSM or TDM approach emphasizes modifications independent of location and land use. The list below covers the common strategies that would work in high tourism locations. The location specific strategies for the case study sites in this project will be discussed later with descriptions of each strategy.

Common TSM and TDM strategies

Adapted based on Levy [28]

- Improved vehicular flow
    - Improvements in signalized intersections
    - Removal of on-street parking
    - Reversible lanes

    - Off-street loading
    - Transit-stop relocation
    - Systematic wayfinding system
- Parking management:
    - Parking regulations
    - Park-and-ride facilities
    - Parking cash-out programs (financial incentives)
    - Priority parking for carpools, vanpools, and short-term parkers
    - Parking pricing: Various pricing scale by time and by location
    - Transportation-efficient development
- Improved transportation options:
    - Human-powered travel modes: Biking and walking
    - Transit and ridesharing
- Incentives to use (promotion of) alternative modes and reduce driving
    - Auto-restricted zones
    - Road pricing: Congestion pricing
    - Road space allocation: Bike lanes, transit-only lanes
- Reduced peak-period travel:
    - Telecommuting
    - Compressed workweek
    - Flexible schedule

Although TSM and TDM seem favorable in recent years, Meyer raised that "given the extremely high levels of automobile use in US urban areas, any serious attempt to curtail automobile use seems likely in this environment to fail" [29]. For widespread adoption of TSM/TDM actions, the actions must be linked to broader goals that the public can support. We met residents in popular tourist areas in North Carolina. Because those residents are the owners in the area who value the area the most and have to live there on a daily basis, we valued their input. We asked how residents use and perceive the existing road networks during the peak tourism seasons and their concerns towards the TSM/TDM strategies that may apply as solutions for the traffic problems. We suggested several location specific strategies that we identified as potential solutions to the current transportation problems.

Literature Review and State-of-the-art

There are a number of factors to consider when forecasting tourism-related traffic. The data collection power of technology (e.g., GPS and GIS location on cellular phones, vehicles) and the analytical capabilities of software and hardware solutions will soon allow for almost instantaneous knowledge with respect to the capacity and utilization of a transportation system. However, there is currently a lag between the technological advancement versus the planning and strategic-level thinking of transportation management plans with respect to seasonal variance in traffic across the United States. Due to the importance of the tourism industry on the economy of North Carolina and tourisms' need for efficient transportation systems; it is imperative that equitable plans be made to accommodate this seasonal variation.

Urban Form Issues and Accommodations to Tourism Traffic in North Carolina

This section lists and briefly describes issues that may need to be confronted when considering highway improvements to accommodate increased tourism traffic in North Carolina resort communities. It also makes some suggestions based on field work in five case study sites.

Topography:

Highway improvements can have a substantial impact on the resulting topography in the highway corridor of the urban area. Depending on grading and design, the design of the highway improvement can have positive or negative externalities. On one hand, highway improvements can provide positive externalities by pre-positioning access points to private properties in a manner that facilitates development. On the other hand, if the improvement leaves steep slopes along the highway right of way, guard rails may be required and access from private property to the highway would become more difficult if not precluded altogether.

Aesthetics/Character:

Rural and urban highway cross-sections can have a substantial impact on the aesthetics and character of an urban area. Functional classifications and access requirements may dictate NCDOT's choice of rural versus urban highway cross-sections. On the one hand, NCDOT's choice of highway construction specifications can positively reinforce the desired urban form if the cross section specifications are consistent with locally desired character. On the other hand, insensitivity to local aesthetics and character can detract from the desired urban form or rural character. As one example of insensitivity, a metal guardrail in a rustic, forested area in the mountains could be inconsistent with the existing character. In such as case, guard rails constructed with wood facing (with metal beam within) would be more in keeping with rural or rustic character. Such guardrails can be designed which will still meet American Association of State Highway and Transportation Officials (AASHTO) requirements. As another example, curb and gutter introduces an urban or suburban aesthetic which may not be appropriate for some localities' aesthetics and character. Where curb and gutter would take away from the character of a given area, alternative stormwater management features (i.e., rural cross sections) should be employed.

Small town and downtown activity centers:

Road widening may be inappropriate through a small town's downtown core. Where road widening may be incompatible, other solutions such as intersection improvements and signal timing coordination should be explored as possible alternatives.

Access Management:

In most instances, NCDOT's conventional access management regulations will be appropriate. However, there may be cases, such as in Bryson City along U.S. Highway 19, where the existing, mostly unrestricted access onto that route is perhaps appropriate to the character and form of slower-moving tourism traffic along a route that has many destinations.

Land Use Regulation:

Some resort areas, like part of Watauga County, are not subject to local zoning regulations. Where there is no zoning, or where the area under consideration extends beyond the extraterritorial jurisdiction of a given town or city which does exercise zoning, it may be difficult

for NCDOT access management and other good local planning standards to be implemented. NCDOT in such cases may need to encourage or even require the locality to have appropriate land use controls that include access considerations.

Bypasses:
It is common for even smaller cities and towns in NC to have bypasses constructed around them. From a traffic engineering and planning standpoint, bypasses are justified or they would not be built. Attention should be given to the impact on the town's central business district that is being bypassed and resulting urban form. When bypasses are constructed, it is best to limit the access to them so that they don't stimulate demand for the decentralization of schools, commerce, and industry from the town to the outskirts of town in a sprawl fashion. Allowing driveway access to bypasses will stimulate linear or strip commercial development that could be detrimental to the character of a resort town and the economic vitality of the small town commercial core. It should be noted that the Great Smoky Mountains Expressway in and near Bryson City might be considered by some to be a bypass, but it serves as an important alternative to using U.S. Highway 19 if one is traveling from Cherokee to Bryson City. The expressway has not, at this time, had any significant effect on suburban form in the Bryson City area.

Scenic Byways:
Scenic byways may in themselves be generators of tourist traffic. As already recognized by NCDOT, there appears to be excellent potential for the designation of a scenic loop in the Asheville region. Such a loop could include NC 209 north of Interstate 40 (a very scenic and unspoiled corridor) to Hot Springs, NC, then return southbound along U.S. Highway 25/70 then to NC 251, both of which follow portions of the scenic French Broad River. It is important that the viewsheds of scenic routes be protected by local land use regulations.

Turnouts along heavily traveled corridors:
It is desirable to allow slower moving vehicles and those tourists interested in the scenery along a given route to be able to pull off the road and let faster traffic go by them, as opposed to driving slowly. A good example of this is U.S. 19 between Cherokee and Bryson City; it has a relatively high speed limit, lots of motels along the route, plus it follows a river. There seems to be little potential to provide pullovers along U.S. 19, given the topography and the highway's close proximity to the river; however, there may be some opportunities after further study, and this may improve the carrying capacity of the highway.

Highway messaging:
U.S. 74A south of Asheville to Bat Cave, Chimney Rock, and Lake Lure is another tourism corridor in the Asheville region. This route gets very serpentine, with sharp switchbacks as it climbs in elevation going south. During winter months, the highway could be treacherous in terms of snow and ice. It may be beneficial to consider installation of an electronic message sign not far out of Asheville on U.S. 74A, which would indicate dangerous road conditions ahead, during times of inclement weather.

Highway signs:
In very mountainous terrains, highway and traffic safety signs that are customarily designed can be out of context with the rural, scenic character along the route. Consideration could be given to

preparing signs that are made of rustic materials, such as stone and wood, such as those which are used in national and state parks. In some cases, such materials may not provide the reflectivity or meet other specifications required by state specifications for signs.

NC 105 Corridor South of Boone:
The NC 105 corridor connecting Linville and Boone goes through some high elevations and portions have scenic views, but development along that highway has taken on a suburban or urban appearance. This is also an important truck route. Standard access management approaches are appropriate for this corridor, and because the corridor is urbanizing and suburbanizing, no special concerns about urban form would seem to apply if NCDOT was considering improvements to or widening of NC 105.

Wayfinding signs:
In the case of Bryson City, there are effective "wayfinding" signs throughout the town. This is an important strategy that should be promoted by NCDOT because it helps tourists who are new to the area navigate to their destinations. Wayfinding could help improve the carrying capacity of local routes and highways by getting unsure motorists more easily to where they want to go, without "drifting" or making wrong turns.

Parking:
Also in the case of Bryson City, there appears to be very little off-street or on-street parking. This may cause tourists to stay longer on the roads than necessary, searching for a parking place. NCDOT may be able to justify assistance to the town with the provision of parking on this simple basis alone – that it may increase carrying capacity and avoid congestion if more tourists can get off the road, park their cars, and the frequent their destinations.

Wrightsville Beach:
Wrightsville Beach's land use pattern is one that is predominantly residential except for the central part of town, where the bulk of the commercial development is concentrated. Congestion could probably be improved with a land use pattern that retrofits new neighborhood commercial nodes north and south of the central part of town. By providing more commercial land use within walking distance of beach houses north and south of the central area, the town could avoid vehicle trips on the main route; furthermore, neighborhood commercial land use if providing some destination alternatives to the central area, will obviate the need for vacationers to travel the main route by automobile to the central commercial area.

NC 158 in the Outer Banks:
It seems that transportation demand management may be one of the most promising solutions to traffic congestion in the Outer Banks. Word has it that all lodging facilities have the same checkout time for patrons, meaning that everyone waits until the last minute, then floods the roads shortly after checkout time. It may be that if some staggering of check out times could be arranged, congestion might be partially but significantly addressed.

As specified in the RNS, the proposed project will provide a literature review that summarizes best practices throughout the nation, implementation strategies, and solution models that account for seasonal tourism traffic that is equitable to the citizens of North Carolina. Furthermore, the

proposed project will provide implementation strategies and models that are reproducible and defensible to the public, while providing equitable solutions. These models will address CTP needs, such as: travel models for peak tourist travel, employment for peak season hiring, tourist counts, acceptable level of service during peak seasons with respect to underutilization during nonpeak seasons, land use evaluation plans, financial limitations, etc. The implementation strategies and solution models will be built using existing data to address the objectives and tasks outlined in the RNS.

Non-additional Infrastructure Methods

Prideaux [40] argues tourists may seek alternative destinations where travel is impeded by poor transportation structure. Residents in the surveys from the case studies identified the poor quality of transportation infrastructure as one of the most problematic features. This was consistent with the existing research conducted by Brothers, Morais, and Muench [39] with the Outer Banks. However, both survey locations are environmentally sensitive tourist destinations. They have had new proposals for expanding infrastructure for a new highway or a bridge, but the realization of the proposals is either impossible or seriously delayed.

We searched to identify improvements to enhance the capacity of the existing systems and to identify any action aimed at influencing people's travel behavior. Transportation strategies are location-specific. A strategy that has been an extreme success at one location can be a total failure at another location. Before suggesting a strategy, we asked local residents' perspectives first to accommodate the broader interests that the public can support. We did not, however, consider the economic applicability of our suggested strategies. It should be acknowledged that the survey results are based solely on the results of the residents' survey responses and field observations conducted by the research team.

The case study Findings and Conclusions were:

- Case Study 1: Watauga/Avery (NC 105)
    - Survey participants (local residents) identified people and mountains as the most positive aspects of the region, but the traffic was the most negative aspect.
    - Consider better organization of signage and wayfinding within Boone.
    - Consider removal of on-street parking in favor of parking lots since the angled parking slows down traffic within the town of Boone, and is used by residents (e.g., college students) rather than tourists and shoppers.
    - Of the three traffic counter locations' data evaluated, two did not exhibit seasonality and one exhibited only moderate seasonality (peaking in August). The reason for this is due to the constant (year-round) traffic generated by the college students and residents.
- Case Study 2: Outer Banks (US 158)
    - Survey participants (local residents) identified people and beach as the most positive aspects of the region, but the lack of community activities (i.e., family/children oriented activities) and traffic were the most negative aspects.
    - Tourists are encouraged to drive to destinations with ample free parking, but limited pedestrian and bicycle lanes and/or options. This includes a mix of good bicycle lanes and areas where none exist, including a lack of crosswalks for pedestrians.

    - Some local residents do not travel during peak times during the summer. They remain isolated and/or intentionally travel at odd times (e.g., go to work before 5AM for a 9AM shift).
    - Of the two traffic counter locations' data evaluated, both exhibited high seasonality; peaking in the summer.
- Case Study 3: Wrightsville Beach Area (Wilmington)
    - Urban area with steady traffic from the residents in the Wilmington area.
    - One of the traffic counter location's data exhibited a high seasonality (peaking in the summer); and one exhibited no seasonality. The one that exhibited seasonality included beach traffic.
- Case Study 4: Bryson City
    - The highway system (Great Smoky Mountains Expressway and U.S. Highway 19) work well outside of the city. The system limits congestion by having only a few entering and exiting ramps, with no commercialization along the highway.
    - In the city, additional parking and better signage and wayfinding would decrease the traffic. Tourists that are unfamiliar with the traffic pattern and/or locations of attractions would do a lot of driving back-and-forth; thus, creating more traffic.
    - The single traffic counter location's data exhibited a high seasonality (peaking in the summer).
- Case Study 5: Asheville
    - Urban area with steady traffic from the residents in the Asheville area.
    - One of the traffic counter location's data exhibited a moderate seasonality (peaking in June and July); whereas the other location did not exhibit seasonality.

References:

[1] Cook, P.R. 2012. "What Level of Tourism Traffic Should be Planned for in NC's Major Tourism Areas," *Research Needs Statement, North Carolina Department of Transportation, Fiscal Year 2014 Research*, August 1, 2012.

[2] Pline, J.L. (Editor), 1999. *Traffic Engineering Handbook*, 5th Edition, Institute of Transportation Engineers.

[3] Travel Economic Impact Model, 2004, Travel Industry Association of America.

[4] [http://www.nccommerce.com/tourism/research/economic-impact/teim], North Carolina Department of Commerce, Accessed October 2013.

[5] Gunn, C.A., with Var, T. 2002. *Tourism Planning: Basics, Concepts, and Cases*, 4th Edition, Taylor & Francis.

[6] Inskeep, E. 1991. *Tourism Planning: An integrated and sustainable development approach*, VNR Tourism and Commercial Recreation Series, Van Nostrand Reinhold.

[7] Hara, T. 2008. *Quantitative Tourism Industry Analysis*. Elsevier.

[8] Litman, T.A., with Doherty, E. 2011. Transportation Cost and Benefit Analysis: Techniques, Estimates, and Implications, Second Edition, Victoria Transport Policy Institute, http://www.vtpi.org/index.php.

[9] Frauman, E. and Banks, S. 2011. Gateway community resident perceptions of tourism development: Incorporating Importance-Performance Analysis into a Limits of Acceptable Change framework. *Tourism Management*, 32(1):128-140.

[10] Wilck, J., and Cavalier, T. 2012. A Construction Heuristic for the Split Delivery Vehicle Routing Problem. *American Journal of Operations Research*, 2(2), 153-162.
[11] Wilck, J., Cavalier, T. 2012. A Genetic Algorithm for the Split Delivery Vehicle Routing Problem. *American Journal of Operations Research*, 2(2), 207-216.
[12] Høyer, K.G. 2000. Sustainable tourism or sustainable mobility? The Norwegian case. *Journal of Sustainable Tourism*, 8(2):147-160.
[13] Rodriguez-Rodriguez, D. 2012. Integrated networks. A territorial planning proposal for biodiversity conservation in urban, densely populated regions: The case of the Autonomous Region of Madrid, Spain. *J. of Environmental Planning and Management*, 55(5):667-83.
[14] Sieber, R. 2006. Public Participation and Geographic Information Systems: A Literature Review and Framework. *Annals of the American Association of Geographers*, 96(3):491-507.
[15] Beever, L.B. 2002. Addressing Environmental Justice (EJ) through Community Impact Assessment (CIA). *In: Proceedings, 8th TRB Conference on the Application of Transportation Planning Methods*, Corpus Christi, TX, 22–26 April 2001, ed. R. Donnelly and G. Bennett, 388–98. Washington, DC: Transportation Research Board.
[16] Dickinson, J. E. and Dickinson, J. A. 2006. Local Transport and Social Representations: Challenging the Assumptions for Sustainable Tourism, *Journal of Sustainable Tourism*, 14(2): 192-208.
[17] Jurowski, C., Uysal, M., and Williams, D. R. 1997. A theoretical Analysis of Host Community Resident Reactions to Tourism. *Journal of Travel Research*, 36(3): 3-11.
[18] Fries, R., Inamdar, I., Chowdhury, M., Taaffe, K., and Ozbay, K. 2007. Feasibility of Traffic Simulation for Decision Support in Real-Time Regional Traffic Management. Transportation Research Record, *Journal of the Transportation Research Board*, 2035: 169-176.
[19] Stathopoulos, A., and Karlaftis, M.G. 2003. A multivariate state space approach for urban traffic flow modeling and prediction. *Transportation Research Part C: Emerging Technologies*, 11(2): 121-135.
[20] Lowry, M.B., Laninga, T., Zimmerman, M., and Kingsbury, K.T. 2011. Using Traffic Simulation Software to Manage Recreational River Boats on Public Lands. Transportation Research Record: *Journal of the Transportation Research Board*, 2244: 107-115.
[21] Han, Y., Stone, J.R., and Huntsinger, L.F. 2007. Manual Traffic Allocation for Small-Town Networks. Transportation Research Record: *Journal of the Transportation Research Board*, 1997: 24-34.
[22] Zhong, Ming., and Hanson, B.L. 2008. Travel Demand Modeling for Traffic Estimation on Low-Class Local Roads. *Traffic and Transportation Studies,* 588-598. [http://dx.doi.org/10.1061/40995(322)54]
[23] Stutz, C., and Runkler, T.A. 2002. Classification and Prediction of Road Traffic Using Application-Specific Fuzzy Clustering. *IEEE Transactions on Fuzzy Systems*, 10(3): 297-308.
[24] Sharma, S., Gulati, B., and Rizak, S. 1996. Statewide Traffic Volume Studies and Precision of AADT Estimates. *Journal of Transportation Engineering*, 122(6): 430-439.

[25] Aunet, B. 2000. Wisconsin's Approach to Variation in Traffic Data, Wisconsin Department of Transportation, [http://ntl.bts.gov/lib/10000/10900/10982/051ppr.pdf].
[26] Han, Y., and Stone, J.R. 2008. Synthesized Through-Trip Models for Small and Medium Urban Areas. Transportation Research Record: Journal of the Transportation Research Board, No. 2077, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 148–155. [DOI: 10.3141/2077-19]
[27] Han, Y. 2007. Synthesized Through-Trip Models for Small and Medium Urban Areas. Ph.D. Dissertation, North Carolina State University.
[28] Levy, J.M. 2012. Contemporary Urban Planning (10th Ed.), Pearson.
[29] Meyer, M.D. 1999. Demand Management as an Element of Transportation Policy: Using Carrots and Sticks to Influence Travel Behavior. *Transportation Research Part A*, 33: 575-599.
[30] Ferguson, E. 1990. Transportation demand management planning, development, and implementation. *Journal of the American Planning Association*, 56(4), 442-456.
[31] Agrawal, A., and Gibson, C. C. 1999. Enchantment and disenchantment: The role of community in natural resource conservation. *World Development*, 27(4), 629-649.
[32] Theodori, G. L., and Kyle, G.T. 2013. Community, Place, and conservation. In W. P. Stewart, D.R. Williams, & L. E. Kruger (Eds.), Place-based conservation: Perspectives from the social sciences (pp. 49-70). Dordrecht, Netherlands: Springer Science Business Media.
[33] Lidwell, W., Holden, K., and Butler, J. 2010. Universal Principles of Design. Beverly, MA: Rockport Publishers.
[34] Gresham Smith and Partners. 2009. Complete Streets Design Guidelines. Tennessee Department of Transportation. (http://www.tdot.state.tn.us/bikeped/CompleteStreets.pdf)
[35] Wood, J. 2013. Nearly 5,000 parking tickets valued at $60K validated in Boone in 2012, topic to eliminate validation stamps discussed at Town Budget Retreat Friday. High Country Press. (http://www.hcpress.com/business/5k-parking-tickets-valued-at-60k-validated-in-boone-in-2012-topic-to-eliminate-validation-stamps-discussed-at-budget-retreat-friday.html)
[36] Seattle Department of Transportation. 2008. Seattle Best Practices in Transportation Demand Management, in Seattle Department of Transportation (Ed.), Urban Mobility Plan. (http://www.seattle.gov/transportation/docs/ump/07%20seattle%20best%20practices%20in%20transportation%20demand%20management.pdf)
[37] Lawrie, J., Guenther, J., Cook, T., Meletiou, M. P., and O'Brien, S. W. 2004. Pathways to prosperity. The economic impact of investments in bicycle facilities: A case study of the North Carolina Northern Outer Banks. Institute for Transportation Research and Education (ITRE), North Carolina State University.
[38] Kleckley, J. and Long, P., Technical Presentation, Center for Sustainable Tourism and Bureau of Business Research, East Carolina University, The Impact of Tourism on Community Life in Dare County, (www.sustainabletourism.org).
[39] Brothers, G., Morais, D., and Muench, F. 2012. Outer Banks, North Carolina Visitor Appraisal: A Critical Incidents and Loyalty Assessment, North Carolina State University in cooperation with Outer Banks Convention and Visitor's Bureau and Accommodation Managers on the Outer Banks, June 26, 2012.

[40] Prideaux, B. 2000. The role of the transport system in destination development. *Tourism Management*, 21, 53-63.
[41] Florida Department of Transportation, Project Traffic Forecasting Handbook, 2002.
[42] Nevada Department of Transportation, Traffic Forecasting Guidelines, 2012.
[43] Florida Department of Transportation, Project Traffic Forecasting Handbook, 2014.

APPENDIX B

Literature Review: What Level of Tourism Traffic Should be Planned for in NC's Major Tourism Areas? (From October 31, 2013)

Summary
This literature review focused on identifying practices and scholarly literature related to tourist traffic including choice of destinations and travel within destinations. Specific attention was given to application of forecasting approaches, factors included as significant contributors, and choice models. The search was conducted using scholarly databases available through the East Carolina University library. These included engineering, transportation planning, geography, urban planning, business, hospitality, and tourism specific databases and also consolidated databases covering several of these areas. The literature review is comprised of a summary and an annotated reference list with a brief description of the publication. Additionally, several general references were identified. Examples of these include the Traffic Engineering Handbook [1], Travel Economic Impact Model [2], and the North Carolina Department of Commerce economic impact website related to tourism [3].

Introduction:
This project incorporates multiple disciplines, including: transportation planning, tourism planning, local and urban planning, environmental sustainability, economics, geography, and engineering. The project will include data, methods, and resources from all of these fields, including: forecasting, seasonal variation modeling, regression, geographic information systems (GIS), employment, economic, hotel occupancy, motor vehicle transportation, bicycle transportation, pedestrian transportation, and tourism behavior.

General Tourism Planning:
Within tourism planning, there are a number of published resources. A commonly cited and studied book [4] by Clare Gunn explores the basics of tourism planning (i.e., growth, sustainability, ecotourism, and policy), and presents concepts and case studies from around the world, including large-scale, small-scale, and regional plans. Another book [5] by Edward Inskeep provides an overview of sustainable tourism planning (i.e., environmental, institutional, strategic, implementation, socioeconomic, and development). Seasonality is briefly mentioned in terms of carrying capacity for various attractions. The book then discusses ways to reduce seasonality (e.g., promotions in off-seasons, four-season resorts). Another book [6] by Takayuki Hara provides an overview of quantitative analysis applied to the tourism industry, including social accounting, basic regression, and basic forecasting. References [4-6] are practitioner based references and general in nature; thus, they are suitable for textbooks at the university level, but do not provide specific details for tourism traffic planning with seasonality.

General Transportation Planning:
With regards to transportation planning's economic impacts, one specific resource to note is the extensive book published by the Victoria Transport Policy Institute [7]. This group has provided a holistic view of transportation planning, including: evaluation of non-motorized transportation benefits and costs, the economic value of walkability (for a locality), transportation diversity, land use, and evaluation of transportation benefits. The Victoria Policy Institute also has a

number of other publications (e.g., white papers, review articles, case studies) that are appropriate for this research.

Environmental Impacts:
From an environmental perspective, there exist concerns for livability to residents of tourism gateway communities, factoring in ahead of perceived economic and cultural factors [8]. Transportation affects not only the environment and perceived livability for residents, but also congestion and carrying capacity may pose negative feedbacks to the tourism and recreational quality of an area. Transportation congestion in peak flows can also inhibit emergency response and contribute to environmental impacts by increased fossil fuel consumption and emissions [9-10]. Enhanced mobility, in terms of sustainable tourism, must also factor in these environmental costs [11]; whereas, fossil fuel consumption and emissions could be reduced if individual, motorized traffic can be reduced and replaced with an emphasis on walking, cycling, and public transport. As transportation dominates the greenhouse gas emissions of tourism energy use, planning infrastructure must incorporate the modes of transport, environmental impacts, and alternative designs with greater future emphasis on increasing passenger load, decreasing travel distances, and promoting technological efficiencies. North Carolina's geography and concentration of tourism gateways provide a basis for promoting tourism hubs and green transportation infrastructure.

GIS and Visualization:
GIS and visualization provide powerful tools for predicting the environmental and aesthetic impacts of alternative transportation and tourism development schemes. GIS can assist environmental impact assessment, quantify land use changes on watersheds [12], support site selection and corridor suitability analysis, and visually depict aesthetic impacts in line-of-sight and viewshed analyses. GIS and geovisualization using maps, digital globes, and online cybercartography can also facilitate participatory decision-making. Assessing viewsheds can also reveal the potential for future development to obscure and diminish residential perceptions and economic values. Participatory GIS provides a new approach for incorporating community residential and planner involvement and sidestepping hurdles in communications [13] or mitigating environmental justice issues [14].

Public Perception:
Citizen perception is also paramount for planning projects. It is commonly known that one should ask residents their experiences, perceptions, and expectations. Ultimately, one can see how they value tourism, how much they are willing to enter into an exchange with the tourists if they can reap some benefit without incurring unacceptable costs [15-16].

In [15], the authors investigate the dilemma of how to manage tourism related traffic at rural destinations in the United Kingdom (UK) using a "social representation perspective." They seek to increase understanding of the social realities that underpin people's attitudes towards transportation and tourism and their decisions about transportation behavior. Applying the perspective of social representations theory allows one to identify a number of widely shared assumptions about reality that might also limit and undermine transportation initiatives. The authors identify a variety of initiatives, including restrictions on car use; however, they conclude that "plans to restrict car use are often abandoned following local opposition," suggesting that

such measures are politically difficult to implement. Similarly, in a rural (UK) context, public transportation proves a poor competitor to the car. In short, social representations are clear that the car cannot be restricted, and public transportation cannot be improved enough to meet everyone's needs.

Short Term and Long Term Traffic Prediction:
The papers and articles focusing on short term traffic prediction were geared towards predicting traffic flow over a course of several hours down to a few minutes. These papers tended towards researching how to predict traffic volume and traffic behavior upon an unexpected event such as a lane closure. Fries et al. [17] researched how the use of software could predict traffic conditions after an incident and found that accurate predictions required a large amount of computational capacity. Stathopoulos et al. [18] examined multivariate state space models for predicting traffic volume in congested urban areas and found that multivariate state space models are more accurate than univariate time series models. Additionally, there is a need for different model specifications throughout the day. Lowry et al. [19] applied highway traffic simulation software to determine recreational river traffic patterns.

Generally, there are fewer research references for long term traffic planning. Han, Stone, and Huntsinger [20] compiled a spreadsheet-based modeling tool to assign traffic volumes to small networks using several types of data, including census, maps, and traffic data in areas where time-consuming software has traditionally been used. Zhong and Hanson [21] estimated traffic volume in rural areas where no traffic data is available by using travel demand models and found that these models consistently overestimated traffic volume, but could be made more accurate by reducing the size of traffic analysis zones, as well as including other data such as the number of driveways per kilometer.

One paper mentioned newer, more abstract methods for modeling traffic volume. Stutz and Runkler [22] applied fuzzy neural networks to model traffic flow in both short term periods and long term studies. The authors found that fuzzy neural networks can be used to successfully predict long and short term traffic patterns.

Annotated Reference List
Overall, there is an abundance of broadly-scoped literature relevant to this research project. However, there is limited information available in the literature that provides quantitative modeling and evaluation for transportation planning in high tourism areas given equitable and financial constraints.

The annotated reference list that follows contains a brief description of the publication's potential implications with respect to this project. Generally, the publications can be categorized into these groups:

- Traditional forecasting models: these publications are more economic in nature and examine issues such as short and long term tourism demand.
- Environmental and emission related: these models examine methods to forecast the emissions and environmental impacts of tourism and tourism trends such as concentration in geographical areas.

- Behavior models: these examine how tourists make decisions on where to vacation and side trips once in the desired location.
- Statistical and variability models: these models examine the statistical tools to examine traffic flow and the sources for and the analytical methods applied to model variation and error in traffic forecasts.
- Urban planning and sustainable tourism models: these models examine urban planning and sustainable tourism practices with respect to tourism, behavior, or policy.

Andrawis et al. [23]:
This research paper focuses on the aggregate combination of short term and long term forecasts to improve the accuracy of the forecasted system. The research shows that using a diverse set of factors improves the forecast, including time aggregations. This method is then applied to the inbound tourism at the national-level of Egypt as well as other countries.

Ariztegui et al. [24]:
This research paper presents a model for estimated traffic emissions inventories for cities. It provides a mileage calculation method with respect to zones (within the city) and various speeds. It contrasts two factors with various influences, time resolution and total mileage estimation. The city of Madrid, Spain was used as an example for the methodology.

Asakura and Iryo [25]:
This research paper discusses tracking methods used for travel data collection using mobile communication devices. The results indicate that the data is accurate and detailed. The data can be used to evaluate behavior with respect to transportation policy and traffic demand management. The paper specifically applies its methodology to a tourism location to analyze tourism behavior with respect to traffic.

Aunet [26]:
This report discusses Wisconsin's approach to seasonal variation and data collection; including cluster analysis, geographical mapping, coefficient of variation, and traffic factor plotting. The paper focuses solely on total volume count data.

Chan et al. [27]:
This research paper applies quadratic programming to forecast combination by determining combination weights for the individual factors. The paper uses quality control techniques (e.g., CUSUM) to update the combination weights. This technique is applied to forecast tourism for documented data sets and evaluating across a variety of performance measures.

Cho [28]:
This research paper uses extrapolative approaches to forecast tourism demand using historical data. Three time-series forecasting techniques are used in the evaluation, including: exponential smoothing, univariate ARIMA, and Elman's Model of Artificial Neural Networks (ANN). The methods are used to predict the number of arrivals from different countries of origin to Hong Kong. The Elman's Model of Artificial Neural Networks (ANN) yielded the best results.

Crompton et al. [29]:
This paper presents a generalized economic impact model for local tourism planning. The model is based on four principles: exclusion of local residents, exclusion of "time-switchers" and "casuals," use of income rather than sales output measures of economic impact, and correct interpretation of employment multipliers. The economic impact of a specific festival in Ocean City, Maryland is presented as a case study using the model.

Edwards and Griffin [30]:
This research paper studies the spatial behavior of tourists using global positioning systems (GPS) tracking devices in Sydney, Australia and Melbourne, Australia. Tourists were tracked as pedestrians, public transportation patrons, and/or drivers. Visual maps were then created to provide city managers with a diagnostic tool; which has included changes in the visitor information and guides available for tourists.

Fleming and Toepper [31]:
This article provides a policy review prepared by the U. S. Department of Commerce Task Force on Accountability Research to examine the issues of accountability and evaluation in travel research. It specifically focuses the estimation of total economic impact of the programs conducted by state and local tourism offices as well as by the private sector. This article details, generally, the increasing need to conduct detailed economic impact studies and the basic approaches to measuring both the positive and negative economic impacts.

Frechtling [32]:
This article discusses the estimation of expenditures by tourists and provides an overview of eleven methods and models from the literature. These models provide context for occasion, venue, and time frame. The paper also discusses the issues related to who qualifies as a tourist and what expenditures can be attributed to a specific occasion.

Granato [33]:
This research paper discusses the vulnerabilities of using traffic count data that was observed for a short period of time to project the annual average daily traffic count for the same location. The paper discusses sampling error, estimation error, confidence, and discrepancies with respect to an urban location (Cedar Rapids, Iowa). The paper discusses the benefits gained by instituting longer data collection periods (days versus hours, weeks versus days, etc.) and how the models can be improved with a larger set of data.

Hadavandi et al. [34]:
This paper presents a hybrid artificial intelligence model using genetic fuzzy systems analysis to predict tourist arrivals. The genetic fuzzy systems analysis is applied as a learning rule and forecasts the arrival pattern of tourists. The method is used for a case study of tourist arrivals in Taiwan.

Kask et al. [35]:
The paper presents the Scientific, Academic, Volunteer, and Educational (SAVE) tourist market concept. SAVE markets are considered low-maintenance due to their educational and volunteer nature; thus, they are good seed markets for developing countries and rural areas of developed

nations wishing to increase tourism. However, since these are developing countries there does not exist a good structure to evaluate community development and tourism planning.

Kim et al. [36]:
This research paper evaluates the performances of prediction intervals generated from alternative time series models, in the context of tourism forecasting. The models include an autoregressive model, using bias-corrected bootstrap, seasonal ARIMA models, innovations state space models for exponential smoothing, and Harvey's structural time series models. The models are then applied to thirteen monthly time series for tourist arrivals into Hong Kong and Australia. The mean coverage rates and widths of the alternative prediction intervals are evaluated in an empirical setting. It is found that all models produce satisfactory prediction intervals, except for the autoregressive model. In particular, those based on the bias corrected bootstrap perform best in general, providing tight intervals with accurate coverage rates, especially when the forecast horizon is long.

Kutz [37]:
The handbook offers a comprehensive coverage work with respect to transportation systems, including: freight, passenger, air, rail, road, marine, and pipeline. The applied examples include experience in engineering, planning, and design tools and techniques. Additional focus is provided on applications in automobile and non-automobile transportation, safety, and environmental issues.

Lim and McAleer [38]:
This paper presents forecasting techniques, including exponential smoothing, seasonal methods, and combination methods to predict quarterly tourist arrivals for Australia from Hong Kong, Malaysia, and Singapore from 1975-1999.

McKercher [39]:
This research paper presents a qualitative strategic market portfolio analysis model for the tourism industry that depicts the complex inter-relationship between a destination and markets it serves. A NEST analysis is used to obtain insights into the current health of a destination area and its future strategic marketing needs with respect to tourism.

Nannia et al. [40]:
This research paper reports the results of an integrated assessment of traffic impact on a tourist-popular high altitude region which includes mountain passes and road tunnels. A modeling system for air quality assessment and management has been established and revised. The system has been used to evaluate the impact of traffic due to the re-opening of the Mont Blanc tunnel.

Saveriades [41]:
This concept paper presents research regarding social character of a tourist destination. This is relevant due to the socio-cultural deterioration or a decline in the quality of the experience gained by visitors. The carrying capacity of a destination is determined by its ability to absorb tourist development before negative impacts are felt by the host community, and by the level of tourist development beyond which tourist flows will decline because the destination area ceases to satisfy and attract them.

Scuttari et al. [42]:
This paper discusses tourism mobility analysis and how it can be used as a tool for planners and policy-makers to develop integrated and sustainable transportation and tourism strategies. This methodology was implemented in Italy's South Tyrol region, an alpine province at the forefront of sustainable tourism and mobility innovation. The case study indicated that sustainable behavior can be influenced by the management techniques.

Shareefa and McAlee [43]:
This research paper analyzes tourism counts and practices for the Maldives prior to the Indian Ocean tsunami on December 26, 2004. Prior to 2004, the Maldives were highly dependent on tourism for its economic impact. However, due to the devastation of the tsunami, the tourism has not recovered. The study includes univariate and multivariate time series models, conditional correlations, diversification, and segmentation. The results indicate that for the Maldives to recover the government and the major tour operators should refocus their marketing efforts independently of each tourist source country.

Sharma et al. [44]:
This research paper analyzes the statistical precision of annual average daily traffic (AADT) estimates resulting from short period traffic counts (SPTC) in Minnesota and Canada (Alberta and Saskatchewan). The paper considers volume adjustment factors, assignment effectiveness, and degree of correctness. The results indicate that AADT estimation errors are sensitive to the assignment effectiveness. The study results suggest that highway agencies should put more emphasis on sample site assignments to correct ATR groups than on the duration of count.

Shen et al. [45]:
This research study investigated the performance of combination forecasts in the context of international tourism demand. Various econometric models, time series models, and combination methods were used to study outbound tourism traffic from the United Kingdom to seven destination countries. The results suggest that combination forecasts, in general, outperform the best individual forecasts.

Song et al. [46]:
This research study evaluated six alternative econometric forecasting models for international tourism in Denmark from six origin countries from 1969-1997. The forecasting methods were then evaluated over different time horizons based on mean absolute percentage error and root mean square percentage error.

Song et al. [47]:
This research paper presents empirical results a new combined forecasting method with a structural time series model (STSM) and a time-varying parameter (TVP) regression approach. The models were then compared using quarterly tourist arrivals to Hong Kong from four key source markets: China, South Korea, United Kingdom, and the USA. The results indicate that the new approach is superior to alternative methods.

Song and Li [48]:
This review paper presents key findings and methods for modeling and forecasting from 2000 to 2008, including time-series, econometric, and combination techniques. This survey identifies some new research directions, which include improving the forecasting accuracy through integrating both qualitative and quantitative forecasting approaches, tourism cycles, seasonality analysis, impact assessment, and risk forecasting.

Swanson and Horridge [49]:
This research paper presents a structural equation model to test the causal relationships between tourist travel motivations and souvenir consumption. A survey was used and data was collected from 398 tourists who had traveled to Arizona, Colorado, New Mexico, and Utah. Factor analysis was used to determine dimensions, scales, attributes and activities. Results indicate that the travel activities of tourists had positive correlations with souvenir consumption, while tourist demographics had no correlation. Thus, retailers who can identify the travel activities of their tourist customer should do so to provide a better souvenir product mix with appealing attributes sold in an appealing environment. By using identified travel activities, retailers can partner with lodging facilities, restaurants, and tourism boards to encourage positive shopping experiences for the tourist.

Tamin and Willumson [50]:
This research paper presents a low-cost approach to generating an origin destination (O-D) matrix that is used to represent the travel pattern. Generally, O-D matrices obtained through a large scale survey such as home or roadside interviews. A low-cost approach would be beneficial, particularly in developing countries. The methods used to generate this matrix include a gravity model, opportunity model, and gravity-opportunity model. These models are calibrated using traffic counts.

Wie and Choy [51]:
This research paper develops a mathematical modeling framework for analyzing the traffic impacts of proposed tourism facilities. The estimation procedures make it possible to quantify traffic impacts in terms of the projected increase in total network travel time/cost that would result from the development of new facilities. These results can then be used by policy makers and planners.

Witt and Witt [52]:
This survey paper provides an overview of the relevant empirical research literature for forecasting tourism. The primary methods discussed include econometric, time series (including autoregression), and exponential smoothing.

Wong et al. [53]:
This research paper uses combination forecasting methods to predict tourist arrivals in Hong Kong from ten external locations. The forecasts are derived from four different forecasting models: autoregressive integrated moving average (ARIMA) model, autoregressive distributed lag model (ADLM), error correction model (ECM), and vector autoregressive (VAR) model. The results indicate that combination methods are generally superior to single source methods.

Yang et al. [54]:
This research report presents the methods used by the Florida Department of Transportation (FDOT) to estimate seasonal factors (SFs) by using data obtained from approximately 300 telemetry traffic monitoring sites, which are used in the calculation of annual average daily traffic (AADT) at portable traffic monitoring sites (PTMSs). Both the estimation and the application of seasonal factors are based on the consideration of similarities in the traffic characteristics of roads and on engineering judgment. FDOT desires a more objective and data-driven method to improve the accuracy of SF estimation for PTMSs. A previous study investigated traffic and land use data in Southeast and North Florida and demonstrated the possibility of identifying the link between land use variables and seasonal factors. This paper describes a statewide investigation to identify potentially influential variables that contribute to seasonal fluctuations in traffic volumes in urban areas in Florida. A method is also developed for assigning seasonal factors to PTMSs. The test results show that the errors of the estimated seasonal factors are on average 5%. This method is promising for application in both urban and rural areas to improve accuracy in AADT estimation.

Zheng et al. [55]:
This research paper focuses on the use of online photo-sharing services to track people's travel patterns with respect to tourist destinations. The movement is modeled using a Markov Chain model and topological characteristics of travel routes are analyzed by performing sequence clustering techniques on the travel routes. The method is demonstrated on four cities.

Ashworth and Page [56]:
This concept paper presents arguments for the future of urban tourism planning with a focus on social sciences dynamics. Essentially the authors argue that tourism planning at the local urban level should be fused with social science methodology.

McKercher et al. [57]:
This paper presents research in the use of global positioning systems (GPS) and geographical information systems (GIS) to compare and contrast behavior patterns of tourists in Hong Kong with respect to first-time versus repeat visitors. The results indicate that first-time visitors travel more widely throughout the area; whereas, repeating visitors confine their movements. Furthermore, first-time visitors and repeat visitors visit attractions at different times and for different amounts of times. Essentially, repeat visitors take short trips to-and-from destinations and back to the hotel; whereas, first-time visitors spend the entire day visiting many attractions without returning to the hotel.

Modsching et al. [58]:
The paper presents an argument for using real-time tracking devices to determine the behavior of tourists. The methodology is then applied to the city of Görlitz, Germany and results are then shared with policy makers and planners.

O'Connor et al. [59]:
The research paper presents a model for agent-based simulation to determine the behavior and patterns of patrons in parks. This model was specifically applied to a pedestrian area in Twelve

Apostles National Park in Victoria, Australia. Data was collected from 900 tourists and analyzed to predict recreational behavior.

Shoval and Isaacson [60]:
This research paper presents an overview of using real-time tracking devices for tourists. Specifically it compares and contrasts the variety of systems, including land-based tracking, satellite tracking, and hybrid systems.

Sharma [61]:
Traffic volumes vary from hour to hour, day to day, and month to month, but it is primarily the AADT and certain other traffic peaking characteristics, such as peak-hour factor, that are used in planning and designing roadway facilities. The author suggests an improved method of road classification for use by provincial or state highway agencies, one that is based on temporal volume variations and road use characteristics, such as trip purpose, and trip length distribution. The highway system in Alberta, Canada, is investigated. Variations of traffic volume are cyclical in nature and reflect the hourly, daily, and seasonal trip-making patterns of road users. Examples of different road classifications based on temporal volume variations and road use characteristics include "urban and/or commuter," "rural long distance," "non-recreational low flow," "partially recreational," and "highly recreational." A majority of provincial and state agencies have available to them the traffic information required to implement the classifications proposed in this article.

Litman [62]:
Roadway improvements that alleviate congestion reduce the generalized cost of driving (i.e., the price), which encourages more vehicle use. Traffic congestion tends to maintain equilibrium. Congestion reaches a point at which it constrains further growth in peak-period trips. If road capacity increases, the number of peak-period trips also increases until congestion again limits further traffic growth. Research indicates that generated traffic often fills a significant portion of capacity added to congested urban roads. This paper defines types of generated traffic, discusses generated traffic impacts, recommends ways to incorporate generated traffic into evaluation, and describes alternatives to roadway capacity expansion. The author reviews a number of models, including The FHWA *Spreadsheet Model for Induced Travel Estimation* (SMITE). The report also highlights land use impacts, noting that: "an important issue related to generated and induced travel is the degree to which roadway improvements affect land use patterns, and in particular, whether highway capacity expansion stimulates lower-density, urban fringe development (i.e., urban sprawl). In reviewing alternatives to adding road capacity, the author notes that "a 'No Build' option may become more attractive since peak-period traffic volumes will simply level off without additional capacity." Other alternatives include congestion pricing, commute trip reduction programs, land use management, pedestrian and bicycle improvements, and public transit.

Cullinane and Cullinane [63]:
This article investigates traffic demand management in rural areas and as it relates to national parks in Great Britain; specifically it investigates attitudes of private car users toward public transportation. The authors recognize the "absurdity" of more and more transportation improvements in response to more and more traffic. The authors investigate reasons for failure to

implement traffic management measures in national parks in Great Britain. Survey respondents (1997 data) viewed traffic congestion as a major problem. The authors are not optimistic that visitors to national parks can be persuaded to choose public transportation over private automobile use because visitors do not view public transportation as viable. The authors are unsure whether visitors will even think about public transportation use in national parks.

Meyer [64]:
This article provides an overview of transportation demand management in the U.S. within a broad national transportation context. TDM is defined broadly as "any action or set of actions aimed at influencing people's travel behavior in such a way that alternative mobility options are presented and/or congestion is reduced." TDM strategies focus on influencing individual behavior. TDM strategies for tourist areas include shuttles, park and ride lots, transit, and bicycle and pedestrian amenities, among others. After examining the effectiveness of TDM strategies in the U.S. during the last two decades, the author concludes (based in part on a review of Maryland's congestion management system applied to a the U.S. Highway 301 corridor) that the most effective TDM strategies are those that increase the price of travel for single occupant vehicle use (e.g., road pricing or another strategy which directly adds costs to a traveler's automobile trip). Some level of incentive or disincentive must be present to encourage automobile users to change their travel behavior. The author also recognizes the importance of transportation and land use connections, or in other words: "exercising control over the trip generating characteristics of the land use (e.g., development density) can be used to make the resulting demand consistent with the existing transportation infrastructure and the level of service desired."

Spellerberg [65]:
Few reports have been produced on the ecological effects (or ecological risks) of roads and traffic, yet there is much literature on the mitigation of such effects. The author presents a summary of construction-related, short-term, and long-term ecological effects of roads. The literature review extends to New Zealand and Great Britain. Considerable attention is paid to wildlife impacts, reflecting principles and considerations of landscape ecology.

Farrell and Runyan [66]:
This article reviews literature on the relation between tourism and the natural environment. It emphasizes the importance of maintaining the attractiveness of the natural environment in travel destinations and recreational areas. Negative change to natural features via physical alteration can be critically damaging. Landscape should not be taken for granted as a supply amenity. The concept of "carrying capacity" is conceptually inviting but difficult to put into practice. The authors cite the U.S. Forest Service's "Recreation Opportunity Spectrum" as a land management program that accommodates a diversity of resource objectives ranging from primitive to modern (extensively developed).

Stynes [67]:
This publication is a guidebook for tourism officials who wish to complete economic impact analyses. It explains the concept of economic impact analysis and illustrates applications in tourism contexts. Economic impact analysis may be used to "argue for favorable treatment in allocation of resources or local tax, zoning or other policy decisions." Tourism economic impact

studies reviewed in the handbook include the National Park Service's Money Generation Model and the Bureau of Economic Analysis's RIMS II Multipliers, and input-output models, among others.

Goodwin [68]:
Disparate evidence indicates that the provision of extra road capacity results in a greater volume of traffic. Traffic growth rates have been slowest where congestion is worse and fastest where existing capacity is still spare, or new capacity is provided. However, this does not necessarily prove that the provision of capacity caused the growth. An average road improvement has induced an additional 10% of base traffic in the short term and 20% in the long term; individual schemes with induced traffic at double this level may not be very unusual, especially for peak periods. Studies generally show unexpected short-term growth on traffic flows a year after improvement or widening and greater longer-term overall growth in traffic than forecasted. The review also finds that limited relief is provided to alternative routes with road widening; traffic counted on improved roads has, in general, not been offset by equivalent reductions in traffic on the unimproved alternative routes either in the short or long run.

Kelly [69]:
The type and location of major transportation facilities greatly influences urban form. The author examines literature spanning six decades. The relationship between transportation and land use is not one-way, however. It is cyclical, in that transportation facilities influence land use patterns which in turn influence transportation demand. The author cites a 1976 study, called "The Growth Shapers," that suggested that infrastructure investments (especially highways and sewers) shape the growth that occurs in metropolitan areas, and also that changing the design of infrastructure can be an additional [land use] control method. A new road makes private land with access to it relatively more accessible and therefore more attractive to particular types of development. Highways make longer commutes less time-consuming and reduce the costs of commuting. For instance, construction of a new highway leading out of a central city increases the supply of land that falls within a 20-minute commuting distance, thus making that land attractive to consumers and presumably more valuable. Kelly also underscores the importance of locating transportation improvements in relation to local environmental protection objectives. Building roads in the direction of mountain vistas, steep slopes, farmlands, and/or wetlands can be counter to land preservation efforts. Similarly, placing a road along a river attracts land development to the river's flood plain, which contravenes federal and local policy.

Riebsame et al. [70]:
The authors describe land use change in the Rocky Mountains in Colorado which may be comparable in certain land use respects to western North Carolina and communities of interest in this study. The wave of development in mountainous Colorado differs from prior development based on commodity production. Instead, the development wave in Colorado is driven by services, recreation, and information businesses and is characterized by widespread land-use conversion, especially from agricultural to residential. Neither urban nor agricultural (rural) land use models are adequate to understand the amenity-driven land use changes in mountain areas. A mixture of economic and quality-of-life considerations attract people to amenity-rich areas. The area has become an "exurban" zone of countryside dwellers, some of whom maintain their city-center or suburban jobs.

Most detailed work on land development in mountainous regions focuses on resort area. But most resort studies focus on concentrated development (e.g., hotels and other facilities), which is clearly an important element of landscape change in the Rocky Mountains, but which offers little insight on changes outside of resort towns. The region increasingly attracts permanent and part-time residents willing and able to travel long distances by various means (from private jets to four-wheel-drive family automobiles) for occupational and recreational pursuits. Telecommuting and personal, technical, and information service activities (e.g., consulting, advising, and writing via electronic mail) allow more people to live where they please, not where their jobs dictate. Newer mountain residents want to live on large lots in rural and wildland settings, and even value a sense of isolation. Mountain resort studies also neglect to determine how resorts and their wildland settings attract non-recreational economic activities such as software development firms, financial services, mail order companies, retirees, and self-employed workers of all types, from writers to lawyers. The footloose services economy, enabled by almost ubiquitous mobility of both people and information, and attracted by a rural charisma, results in sprawl of suburban-like development into even the most deeply rural parts of the Rockies. A lack of affordable housing in resort areas (due to spiraling land prices) pushes "locals" and workers out to other small towns or to more deeply rural settings; workers in the recreation and tourism industry often commute quite long distances to resort towns, creating sprawling bedroom communities and isolated rural subdivisions. Preference for ridge top and other "view" sites has become painfully obvious in many Colorado mountain valleys. The remainder of the paper focuses on affluent, dispersed residential development in rural areas.

Sorupia [71]:
Tourism as a client-pleaser industry is in danger of destroying the very environment it promotes. Tourism cannot thrive without travel; hence, transportation is an integral part of the tourism industry. It is largely due to the improvement of transportation that tourism has expanded. The transportation system of a tourist destination has an impact on the tourism experience which explains how people travel and why they choose different forms of holiday, destination, and transportation. Too much access brings in a larger number of people that can increase the level of degradation, decrease the experience, and impact the natural state of the resources. Transportation sometimes does not stimulate the desired tourism development and therefore it is important to understand the central position of transport in destination development if the destination's growth process is to be understood.

Forman and Alexander [72]:
The authors examine the importance of road ecology. Roads have an important barrier effect that subdivides populations of species, with demographic and probably genetic consequences. Road networks interrupt horizontal ecological flows, alter landscape spatial pattern, and therefore inhibit important interior species. A few states in the U.S. have built wildlife underpasses and overpasses to address local roadkill or wildlife movement concerns.

Weisbrod and Beckwith [73]:
This article examines issues involved in measuring and evaluating economic development impacts of major highway investment, and application of those findings for investment decision-making. It focuses on a proposed highway construction project to create a 200 mile four-lane

highway across North-Central Wisconsin. This article summarizes literature investigating the relationship of highway locations to nearby business growth patterns. There is mixed evidence concerning whether or not there is any statistical or causal relationship between regional economic growth and highway improvements. However, direct user benefits to individual auto and truck travelers whenever a section of highway is improved include reduced travel time, lower transportation costs and accident reduction. Tourism-related business is a special type of opportunity, whereby passenger travel benefits can lead to additional visitation to the state.

References (Appendix B)

[1] Pline, J.L. (Editor), 1999. *Traffic Engineering Handbook*, 5th Edition, Institute of Transportation Engineers.

[2] Travel Economic Impact Model, 2004, Travel Industry Association of America.

[3] [http://www.nccommerce.com/tourism/research/economic-impact/teim], North Carolina Department of Commerce, Accessed October 2013.

[4] Gunn, C.A., with Var, T. 2002. *Tourism Planning: Basics, Concepts, and Cases*, 4th Edition, Taylor & Francis.

[5] Inskeep, E. 1991. *Tourism Planning: An integrated and sustainable development approach*, VNR Tourism and Commercial Recreation Series, Van Nostrand Reinhold.

[6] Hara, T. 2008. *Quantitative Tourism Industry Analysis*. Elsevier.

[7] Litman, T.A., with Doherty, E. 2011. Transportation Cost and Benefit Analysis: Techniques, Estimates, and Implications, Second Edition, Victoria Transport Policy Institute, http://www.vtpi.org/index.php.

[8] Frauman, E. and Banks, S. 2011. Gateway community resident perceptions of tourism development: Incorporating Importance-Performance Analysis into a Limits of Acceptable Change framework. *Tourism Management*, 32(1):128-140.

[9] Wilck, J., and Cavalier, T. 2012. A Construction Heuristic for the Split Delivery Vehicle Routing Problem. *American Journal of Operations Research*, 2(2), 153-162.

[10] Wilck, J., Cavalier, T. 2012. A Genetic Algorithm for the Split Delivery Vehicle Routing Problem. *American Journal of Operations Research*, 2(2), 207-216.

[11] Høyer, K.G. 2000. Sustainable tourism or sustainable mobility? The Norwegian case. *Journal of Sustainable Tourism*, 8(2):147-160.

[12] Rodriguez-Rodriguez, D. 2012. Integrated networks. A territorial planning proposal for biodiversity conservation in urban, densely populated regions: The case of the Autonomous Region of Madrid, Spain. *J. of Environmental Planning and Management*, 55(5):667-83.

[13] Sieber, R. 2006. Public Participation and Geographic Information Systems: A Literature Review and Framework. *Annals of the American Association of Geographers*, 96(3):491-507.

[14] Beever, L.B. 2002. Addressing Environmental Justice (EJ) through Community Impact Assessment (CIA). *In: Proceedings, 8th TRB Conference on the Application of Transportation Planning Methods*, Corpus Christi, TX, 22–26 April 2001, ed. R. Donnelly and G. Bennett, 388–98. Washington, DC: Transportation Research Board.

[15] Dickinson, J. E. and Dickinson, J. A. 2006. Local Transport and Social Representations: Challenging the Assumptions for Sustainable Tourism, *Journal of Sustainable Tourism*, 14(2): 192-208.

[16] Jurowski, C., Uysal, M., and Williams, D. R. 1997. A theoretical Analysis of Host Community Resident Reactions to Tourism. *Journal of Travel Research*, 36(3): 3-11.
[17] Fries, R., Inamdar, I., Chowdhury, M., Taaffe, K., and Ozbay, K. 2007. Feasibility of Traffic Simulation for Decision Support in Real-Time Regional Traffic Management. Transportation Research Record, *Journal of the Transportation Research Board*, 2035: 169-176.
[18] Stathopoulos, A., and Karlaftis, M.G. 2003. A multivariate state space approach for urban traffic flow modeling and prediction. *Transportation Research Part C: Emerging Technologies*, 11(2): 121-135.
[19] Lowry, M.B., Laninga, T., Zimmerman, M., and Kingsbury, K.T. 2011. Using Traffic Simulation Software to Manage Recreational River Boats on Public Lands. Transportation Research Record: *Journal of the Transportation Research Board*, 2244: 107-115.
[20] Han, Y., Stone, J.R., and Huntsinger, L.F. 2007. Manual Traffic Allocation for Small-Town Networks. Transportation Research Record: *Journal of the Transportation Research Board*, 1997: 24-34.
[21] Zhong, Ming., and Hanson, B.L. 2008. Travel Demand Modeling for Traffic Estimation on Low-Class Local Roads. *Traffic and Transportation Studies*, 588-598. [http://dx.doi.org/10.1061/40995(322)54]
[22] Stutz, C., and Runkler, T.A. 2002. Classification and Prediction of Road Traffic Using Application-Specific Fuzzy Clustering. *IEEE Transactions on Fuzzy Systems*, 10(3): 297-308.
[23] Andrawis, R.R., Atiya, A.F., and El-Shishin, H. 2011. Combination of long term and short term forecasts, with application to tourism demand forecasting. *International Journal of Forecasting*, 27: 870-886.
[24] Ariztegui, J., Casanova, J., and Valdes, M. 2004. A structured methodology to calculate traffic emissions inventories for city centres. *Science of the Total Environment*, 334– 335: 101-109.
[25] Asakura, Y., and Iryo, T. 2007. Analysis of tourist behaviour based on the tracking data collected using a mobile communication instrument. *Transportation Research Part A*, 41: 684-690.
[26] Aunet, B. 2000. Wisconsin's Approach to Variation in Traffic Data, Wisconsin Department of Transportation, [http://ntl.bts.gov/lib/10000/10900/10982/051ppr.pdf].
[27] Chan, C.K., Witt, S.F., Lee, Y.C.E., and Song, H. 2010. Tourism forecast combination using the CUSUM technique. *Tourism Management*, 31: 891-897.
[28] Cho, V. 2003. A comparison of three different approaches to tourist arrival forecasting. *Tourism Management*, 24: 323-330.
[29] Crompton, J.L., Lee, S., and Shuster, T.J. 2001. A Guide for Undertaking Economic Impact Studies: The Springfest Example. *Journal of Travel Research*, 40: 79-87.
[30] Edwards, D. and Griffin, T. 2013. Understanding tourists' spatial behaviour: GPS tracking as an aid to sustainable destination management. *Journal of Sustainable Tourism*, 21(4): 580-595.
[31] Fleming, W.R. and Toepper, L. 1990. Economic Impact Studies: Relating The Positive And Negative Impacts To Tourism Development. *Journal of Travel Research*, 29(1): 35-42.

[32] Frechtling, D.C., 2006. An Assessment of Visitor Expenditure Methods and Models. *Journal of Travel Research*, 45(1): 26-35.
[33] Granato, S. 1998. The Impact of Factoring Traffic Counts for Daily and Monthly Variation in Reducing Sample Counting Error, *Transportation Conference Proceedings*, Transportation Research Board.
[34] Hadavandi, E., Ghanbari, A., Shahanaghi, K. and Abbasian-Naghneh, S. 2011. Tourist arrival forecasting by evolutionary fuzzy systems. *Tourism Management*, 32(5): 1196-1203.
[35] Kask, S, Kline, C., and Lamoureux, K. 2011. Modeling Tourist and Community Decision Making: The SAVE Market. *Annals of Tourism Research*, 38(4): 1387-1409.
[36] Kim, J.H., Wong, K., Athanasopoulos, G., and Liu, S. 2011. Beyond point forecasting: Evaluation of alternative prediction intervals for tourist arrivals. *International Journal of Forecasting*, 27: 887-901.
[37] Kutz, M. 2011. Handbook of Transportation Engineering, 2nd edition. McGraw-Hill.
[38] Lim, C. and McAleer, M. 2001. Forecasting Tourist Arrivals. *Annals of Tourism Research*, 28(4): 965-977.
[39] McKercher, B. 1995. The Destination-Market Matrix: A Tourism Market Portfolio Analysis Model. *Journal of Travel and Tourism Marketing*, 4(2): 23-40.
[40] Nannia, A., Brusasca, G., Calori, G., Finardi, S., Tinarelli, G., Zublena, M., Agnesod, G., and Pession, G. 2004. Integrated assessment of traffic impact in an Alpine region. *Science of the Total Environment*, 334-335: 465-471.
[41] Saveriades, A. 2000. Establishing the social tourism carrying capacity for the tourist resorts of the east coast of the Republic of Cyprus. *Tourism Management*, 21(2): 147-156.
[42] Scuttari, A., Lucia, M.D., and Martini, U. 2013. Integrated planning for sustainable tourism and mobility: a tourism traffic analysis in Italy's South Tyrol region. *Journal of Sustainable Tourism*, 21(4): 614-637.
[43] Shareefa, R., and McAlee, M. 2007. Modelling the uncertainty in monthly international tourist arrivals to the Maldives. *Tourism Management*, 28: 23-45.
[44] Sharma, S., Gulati, B., and Rizak, S. 1996. Statewide Traffic Volume Studies and Precision of AADT Estimates. *Journal of Transportation Engineering*, 122(6): 430-439.
[45] Shen, S., Li, G., and Song, H. 2011. Combination Forecasts of International Tourism Demand. *Annals of Tourism Research*, 38(1): 72-89.
[46] Song, H., Witt, S.F., and Jensen, T.C. 2003. Tourism forecasting: accuracy of alternative econometric models. *International Journal of Forecasting*, 19: 123-141.
[47] Song, H., Li, G., Witt, S.F., and Athanasopoulos, G. 2001. Forecasting tourist arrivals using time-varying parameter structural time series models. *International Journal of Forecasting*, 27: 855-869.
[48] Song, H. and Li, G. 2008. Tourism demand modelling and forecasting—A review of recent research. *Tourism Management*, 29: 203-220.
[49] Swanson, K.K. and Horridge, P.E. 2004. A Structural Model for Souvenir Consumption, Travel Activities, and Tourist Demographics. *Journal of Travel Research*, 42(4): 372-380.

[50] Tamin, O.Z. and Willumson, L.G. 1989/1990. Transport Demand Model Estimation from Traffic Counts. Transportation. 16(1): 3-26.
[51] Wie, B.-W. and Choy, D. 1993. Traffic Impact Analysis of Tourism Development, *Annals of Tourism Research,* 20: 505-518.
[52] Witt, S.F. and Witt, C.A. 1995. Forecasting tourism demand: A review of empirical research. *International Journal of Forecasting,* 11(3): 447-475.
[53] Wong, K.K.F., Song, H., Witt, S.F., and Wu, D.C. 2007. Tourism forecasting: To combine or not to combine? *Tourism Management,* 28: 1068-1078.
[54] Yang, S., Lu, C., Zhao, F., Reel, R., and O'Hara, J.D. 2009. Estimation for Seasonal Factors of Similarity-Based Traffic for Urban Roads in Florida. *Transportation Research Record: Journal of the Transportation Research Board,* 2121(1): 74-80.
[55] Zheng, Y.-T., Zha, Z.-J., and Chua, T.-S. 2012. Mining Travel Patterns from Geotagged Photos. *ACM Transactions on Intelligent Systems and Technology,* 3(3), Article 56.
[56] Ashworth, G., and Page, S. 2011. Urban tourism research: Recent progress and current paradoxes. *Tourism Management,* 32(1): 1-15.
[57] McKercher, B., Shoval, N., Ng, E., and Birenboim, A. 2012. First and repeat visitor behaviour: GPS tracking and GIS analysis in Hong Kong. *Tourism Geographies: An International Journal of Tourism Space, Place and Environment,* 14(1): 147-161.
[58] Modsching, M., Kramer, R., Gretzel, U., and ten Hagen, K. 2006. Capturing the beaten paths: A novel method for analysing tourists' spatial behaviour at an urban destination. In M. Hitz, M. Sigala, and J. Murphy (Editors.), *Information and communication technologies in tourism* Vienna: Springer: 75-86.
[59] O'Connor, A., Zerger, A., and Itami, B. 2005. Geo-temporal tracking and analysis of tourist movement. *Mathematics and Computers in Simulation,* 69(1–2): 135-150.
[60] Shoval, N., and Isaacson, M. 2007. Tracking tourist in the digital age. *Annals of Tourism Research,* 34(1): 141-159.
[61] Sharma, S.C. 1983. Improved Classification of Canadian Primary Highways According to Type of Road. *Canadian Journal of Civil Engineering,* 10: 497-509.
[62] Litman, T. 2010. *Generated Traffic and Induced Travel: Implications for Transport Planning.* Victoria Transport Policy Institute.
[63] Cullinane, S. and Cullinane, K. 1999. Attitudes Towards Traffic Problems and Public Transport in the Dartmoor and Lake District National Parks. *Journal of Transport Geography,* 7: 79-87.
[64] Meyer, M.D. 1999. Demand Management as an Element of Transportation Policy: Using Carrots and Sticks to Influence Travel Behavior. *Transportation Research Part A,* 33: 575-599.
[65] Spellerberg, I.F. 1998. Ecological Effects of Roads and Traffic: A Literature Review. *Global Ecology and Biogeography Letters* 7: 317-333.
[66] Farrell, B.H. and Runyan, D. 1991. Ecology and Tourism. *Annals of Tourism Research* 18: 26-40.
[67] Stynes, D.J. 1997. *Economic Impacts of Tourism: A Handbook for Tourism Professionals.* Illinois Bureau of Tourism and Illinois Department of Commerce and Community Affairs.
[68] Goodwin, P.P. 1996. Empirical Evidence on Induced Traffic: A Review and Synthesis. *Transportation,* 23: 35-54.

[69] Kelly, E.D. 1994. The Transportation Land-Use Link. *Journal of Planning Literature*, 9(2): 128-145.
[70] Riebsame, W.E., Gosnell, H., and Theobald, D.M. 1996. Land Use and Landscape Change in the Colorado Mountains I: Theory, Scale, and Pattern. *Mountain Research and Development*, 16(4): 395-405.
[71] Sorupia, E. 2005. Rethinking the Role of Transportation in Tourism. *Proceedings of the Eastern Asia Society for Transportation Studies*, 5: 1767-1777.
[72] Forman, R.T.T. and Alexander, L.E. 1998. Roads and Their Major Ecological Effects. *Annual Review of Ecology and Systematics*, 29: 207-23.
[73] Weisbrod, G.E. and Beckwith, J. 1992. Measuring Economic Development Benefits for Highway Decision-Making: The Wisconsin Case. *Transportation Quarterly*, 46 (1).

APPENDIX C

Additional references investigated.

Title:
Integrated Planning of Tourism Investment and Transportation Network Design

Source Data:
Transportation Research Board Annual Meeting 2014 Paper #14-0274

Abstract:
Development of a viable and sustainable tourism industry requires wise strategic planning of investments on tourism sites and the supporting transportation infrastructure. In view of the interactive relationship between transportation and tourism industry, this paper proposes an integrated modeling framework to simultaneously address tourism planning and transportation network design. A bi-level optimization model is proposed to decide the optimal locations for tourism investment and highway capacity expansion. The upper-level problem minimizes the total system cost while the lower level model determines user equilibrium flow of both tourist and non-tourist road users under traffic congestion. A customized solution approach is developed based on relaxation, reformulation and approximation. The authors apply the proposed methodology to an empirical case study for Heilongjiang Province, China to show implications of the optimal strategies for tourism planning.

Authors:
Bai, Yun
Kou, Xiaofeng
An, Shi
Ouyang, Yanfeng
Wang, Jian
Zhu, Xiaoying

Title:
Agent-Based Tour Chaining Model for Advanced Tourist Information and Scheduling Systems
Accession Number: 01047525

Source Data:
Transportation Research Board Annual Meeting 2007 Paper #07-2672

Abstract:
Recent technologies make it possible to implement real-time tourist information and scheduling systems under ubiquitous information and computing environments. This study develops an agent-based simulation model to evaluate such plausible systems. The agent-based simulation model incorporates activity chaining behavior into tour activity scheduling systems. Individual tourist's activity chaining behavior is formulated as a utility maximization problem. The underlying assumption of the model is that tourists increase their activities within their time and budget constraints to maximize their utilities. The model seeks individual's optimal tour schedules by solving Prize-Collecting Multiple-Day Traveling Salesman Problem (PC-MD-TSP). The simulation model also includes real-time and end-of-day rescheduling capabilities by taking tourists' unpredicted delays into consideration. Through experiments in an isolated tour island, this paper presents possible effects of tour information and scheduling systems.

Authors:
Kim, Hyunmyung
Oh, Jun-Seok
Jayakrishnan, R

Title:
A Simulation Study on the Impacts of High Aviation Carbon Taxes on Tourism - An Application of a Portfolio Vacation Choice Model

Source Data:
Transportation Research Board Annual Meeting 2014 Paper #14-1624

Abstract:
Aviation carbon taxes have occasionally been debated as a measure to curb aviation CO_2 emissions. This paper presents a simulation study on impacts of high aviation carbon taxes on tourism, and its related CO_2 emissions. The authors investigate the scenario in which – as a result of high aviation carbon taxes – air fares increase by 50%. To assess these impacts they simulate choice probabilities of vacation alternatives – which are conceptualized as portfolios consisting of a destination, mode of transport, accommodation type, and a length of stay – using a portfolio vacation choice model. They derive lower and upper bounds of the impacts. Simulation results suggest that a substantial reduction of the contribution of tourism travel to anthropogenic climate change can be achieved. Tourism travel related CO_2-equivalent emissions are estimated to drop in between 9% and 32%. Furthermore, the authors find that the choice probability of nearby destinations (< 200 km) increases considerably: between 4% and 18%. Related to that they find that the choice probability of short vacations (< 1 week) increases considerably too: between 3% and 11%.

Authors:
van Cranenburgh, Sander
Chorus, Caspar G
van Wee, Bert

Title:
Economic Impact Analysis of Ferry Operations in Wisconsin

Source Data:
Transportation Research Board Annual Meeting 2007 Paper #07-0171

Abstract:
Many travelers view ferry transportation as an adventure and an experience that cannot be obtained from other modes of transportation. In Wisconsin, the ferries strengthen the state's economy by generating tourism and support for local business. Ferry operations in Wisconsin hold historic, economic, and environmental value to their surrounding areas and are important to not only the state and local economies, but also the neighboring states' economies. The ferries provide critical transportation mobility to communities, and a convenient travel bypass to avoid congested Chicago highways. Most ferry operations in Wisconsin are privately owned and independently operated. They are located in separate parts of the state and operate small fleets of one or more vessels. This paper presents economic analyses of selected ferry operations in Wisconsin. The intent is to quantify the significance of the ferry operations to the economies and transportation of their respective communities in Wisconsin. A cost and time analysis compares travel by ferry versus highway from the traveler's perspective. An economic impact analysis quantifies the baseline estimates of direct, indirect, and induced output and total jobs supplied that can be attributed to the ferry operations.

Authors:
Adams, Teresa M
Gardner, Raine
Gollnik, Bob
Ray, Mark
Ruetsche, Judith
Sokolowski, David
Leong, Dennis
Lichtman AICP, Liat
Russell, Robert
Scheler, David

Title:
Impact of Congestion Charge on Retail: London Experience

Source Data:
Transportation Research Board Annual Meeting 2006 Paper #06-0691

Abstract:
The effect of London's congestion charge on the retail sector has aroused considerable interest since the introduction of the scheme in February 2003. Many unusual events that may have had an impact on retail sales in central London happened in close succession in 2003 (e.g. the closure of the Central Line and the Iraq War). This makes it difficult to isolate the effect of the congestion charge which was introduced at about the same time. We investigate the impact of the congestion charge using a variety of econometric models applied to a total retail sales index for central London (monthly) and weekly retail sales data for six John Lewis stores (the Oxford Street store inside the charging zone and five other stores in the London area but outside the charging zone). The results from the analysis broadly suggest that the charge had a significant impact on sales at the John Lewis store in Oxford Street (inside the charging zone) over the period studied. However, the analysis also suggests the charge did not affect overall retail sales in central London, an area larger than but encompassing the congestion charging zone. While estimating the impact of the congestion charge, the study controls for other factors which may also influence retail sales such as London GVA (Gross Value Added), London tourism, Consumer Price Index (CPI), the closure of the Central Line and various annual events of importance to retail.

Authors:
Quddus, Mohammed A
Carmel, Alon
Bell, Michael G H

Title:
TOURISM BUSINESS AND INTELLIGENT TRANSPORTATION SYSTEMS: ACADIA NATIONAL PARK, MAINE

Record URL:
http://dx.doi.org/10.3141/1895-23

Abstract:
A suite of intelligent transportation system (ITS) technologies was deployed as part of the Acadia National Park (Maine) field operational test (FOT). This study evaluated the FOT that took place in 2002 and focused on the experience of the managers of businesses in the gateway communities near the park. The ITS FOT was intended to test the effectiveness of ITS for addressing the transportation problems that had the potential to negatively affect visitor experience at the park and in turn the tourism industry upon which the region depends. A survey of 257 business managers presents their views on transportation problems in the area, attitudes toward the Island Explorer bus service, and reactions to ITS. The results indicate that managers perceive many benefits of ITS to visitors. They also see general economic benefits from ITS but are more neutral about direct effects to their own businesses. Finally, a surprisingly negative reaction from the business community to Acadia traveler information on the new Maine 511 telephone service illustrates the challenge of marrying the interests of the business community with those of travelers.

Authors:
Zimmerman, C A
Daigle, J
Pol, J

Title:
LINKING ECONOMIC DEVELOPMENT TO HIGHWAY IMPROVEMENTS: PINE RIDGE RESERVATION, SOUTH DAKOTA

Record URL:
http://dx.doi.org/10.3141/1848-15

Abstract:
Much of the literature on the economic benefits associated with investments in transportation infrastructure focuses on locations with at least some measure of private-sector economic activity. The focus here is on the Pine Ridge Indian Reservation in South Dakota, an area with extremely limited private economic activity and a transportation network with limited connectivity and accessibility. The study was one of a series sponsored by the Federal Highway Administration to examine linkages between transportation improvements and economic development in rural areas. The Pine Ridge study established a framework for analyzing these linkages and focused the analysis on tourism, a key sector that both offers great potential for economic development and is dependent on improvements in transportation infrastructure. The analysis estimated the potential benefits of the tourism sector and identified the transportation improvements that would be needed to support this sector. It was found that, assuming implementation of a suite of supportive initiatives, a mature tourism sector at Pine Ridge could attract more than 1 million visitors each year, which would have an estimated total economic impact of $153 million during a 15-year period. By the end of the analysis period, these tourists would generate more than 1 million automobile trips per year, with a peak average daily traffic of 5,200 vehicles. The local enhancements in transportation infrastructure that would be needed to provide adequate levels of service include both upgrading the functional class of key roads and performing adequate maintenance throughout the life cycle of the improved roads. The costs of these transportation investments are estimated at $73.3 million.

Authors:
Khan, S
Levy, D

Title:
TRANSPORTATION NEEDS OF NATIONAL PARKS AND PUBLIC LANDS

Record URL:
http://onlinepubs.trb.org/onlinepubs/millennium/00128.pdf

Abstract:
Transportation plays a key role in the way that people access and enjoy federal lands. The transportation systems serving federal lands provide opportunities for recreational travel and tourism, protect and enhance resources, and provide sustained economic development in rural and urban areas. However, in many areas, access and user demands are exceeding the system's carrying capacity. The Transportation Research Board's Task Force on Transportation Needs for National Parks and Public Lands (A5T55) provides a forum for identification of research needs and requirements regarding recreational travel and tourism on public lands. Significant issues include the following: transportation planning; visitor information systems; customer needs, scenic preservation; transportation management tools; safety and maintenance of transportation infrastructure; development of better data on recreational travel; advanced mobility technologies including transit, paratransit, guideway, personal, and nonmotorized; environmental management; and increased funding.

Authors:
Eck, R W
Wilson, E M

Title:
TOURISM TRAVEL AND TRANSPORTATION SYSTEM DEVELOPMENT

Record URL:
http://ntl.bts.gov/lib/16000/16200/16209/PB2000103006.pdf

Abstract:
This report contains findings and recommendations for coordinating and integrating state transportation and tourism program decision making. The report includes evaluation of approaches for accommodating tourism travel, principles for integrating transportation and tourism objectives, guidelines for achieving interagency coordination in transportation planning, measures of tourism travel output and linkages with economic development, and approaches for improving traveler information. The report should be useful to practitioners in state departments of transportation and state offices of tourism who are interested in the effective coordination and integration of transportation system development and operational activities with statewide efforts to support and accommodate increased tourism.

Authors:
Frechtling, D C
Meyer, M D
Pisarski, A E

Title:
INTERIM REPORT ON COLORADO SCENIC AND HISTORIC BYWAYS ECONOMIC-IMPACT STUDY

Record URL:
http://dx.doi.org/10.3141/1599-11

Abstract:
Despite the extensive use of highway designations to promote tourism, there has been little research on the economic effects of these efforts. An interim economic-impact study was conducted as an attempt to estimate the economic effects of Colorado Scenic and Historic Byway designation on tourism-related businesses in communities along the byway routes. The study's research strategies included a review of the literature and research on the economic impacts of travel and tourism, a byways traffic analysis, and a survey of community tourism businesses. The results indicated the economic significance of the travel and tourism industry, and more specifically of byway designation. The findings suggested that byway designation may have an effect on increased visitor traffic, visitor expenditures, and total retail sales in communities along the byway routes.

Authors:
Sem, J
Goff, P
Pearce, S

Title:
MEASURING ECONOMIC DEVELOPMENT BENEFITS FOR HIGHWAY DECISION MAKING IN WISCONSIN

Abstract:
The Wisconsin Highway 29/45/10 study was a pioneering effort to conduct a comprehensive evaluation of potential economic development benefits associated with a proposed major regional highway project and apply those findings for cost-benefit analysis. A series of five alternative design levels, for each of two alternative highway routes, was evaluated. A set of interacting transportation and economic analysis models and techniques were used to evaluate the alternatives in terms of the potential for greater business expansion, new business attraction and tourism, and auto passenger-user benefits. A rigorous cost-benefit evaluation framework, designed to avoid double counting, was used to rank the alternatives for public policy decision making.

Supplemental Notes:
This paper appears in Transportation Research Record No. 1262, Planning, Management and Economic Analysis 1990.

Authors:
Weisbrod, Glen E
Beckwith, James

Title:
Zion National Park: Enhancing Visitor Experience Through Improved Transportation

Record URL:
http://www.westernite.org/annualmeetin...ntations/Session%208A%20-%20Upchurch.pdf

Abstract:
In the year 2000 Zion National Park introduced the Zion Canyon Shuttle to transport visitors into Zion Canyon while alleviating traffic congestion and improving visitor experience. Now in its 14th season of operation, the Shuttle is successfully accomplishing those goals and receives kudos from Park visitors. Continued and increasing popularity of Zion National Park – now with 2.8 million visitors annually - has created new transportation challenges at the gateway to the Park. At the gateway area visitors arrive to the Park, usually via private automobile, and change mode to ride shuttle transportation into Zion Canyon. The challenges include waiting times of 10 to 22 minutes at the park's primary entrance station on many summer days, parking lots at the Park visitor center that are routinely filled to capacity between 11:30 a.m. and 2:30 p.m. on most summer days (forcing visitors to park their vehicles on the streets of Springdale - the Park's gateway community), insufficient parking for recreational vehicles, inadequate wayfinding for motorists and pedestrians, visitor crowding, and a variety of related issues. This paper offers analyses of the primary transportation issues and describes alternatives for improving transportation and, in turn, visitor experience. The needed entrance station capacity to avoid queuing and waiting times is presented, along with alternatives for providing that level of capacity. An evaluation of parking demand and parking alternatives that are being considered by the Park are described.

Authors:
Upchurch, Jonathan

Title:
Principles of Sustainable Transportation in the National Parks

Record URL:
http://docs.trb.org/prp/14-0566.pdf

Abstract:
The historic and contemporary relationships between transportation and the national parks have given rise to a growing body of scientific and professional literature on this topic. Based on this literature, the authors develop and present a set of principles for managing sustainable transportation in the national parks. These principles address sustainability by reducing the environmental impact of transportation, enhancing the quality of the transportation-related visitor experience, and using transportation as a tool to achieve park management objectives.

Authors:
Manning, Robert
Lawson, Steven
Newman, Peter
Hallo, Jeffrey
Monz, Christopher

Title:
Understanding Mobility Behavior in Areas with Seasonal Variations of Transport Demand

Source Data:
Transportation Research Board Annual Meeting 2013 Paper #13-2093

Abstract:
The presented research addresses the topic of mobility management and in particular customer satisfaction in touristic destinations that suffer from the seasonal variations of transport demand. The paper demonstrates that the research conducted so far addressing the factors that affect the transit choices of tourists, residents and other target groups in touristic areas is very limited. In this respect, the research aims to contribute to the existing knowledge by investigating the underlying unobserved factors that influence transit ridership as well as the levels of satisfaction when using transit services of both tourists and residents in touristic areas in the peak summer period and in winter. The popular tourism destination of the Island of Kos in Greece was used as the case study for this research, while two appropriate statistical methods were employed, Factor Analysis and Ordered Probit models. According to the analysis, the most significant factor for the tourists when deciding to use public transport is service production, reflecting route frequencies and reliability of service. On the contrary, residents place more focus on qualitative aspects such as comfort, safety and information. Furthermore, a common factor that holds a high position in the preferences of both tourists and residents is transfer quality, comprising attributes related to transfer coordination. The paper presents in detail the results derived from the two analyses and discusses the use of these results by local authorities in order to adjust their policy plans accordingly and to define actions that can better tackle the residents and tourists' needs and expectations.

Authors:
Antoniou, Constantinos
Tyrinopoulos, Yannis

Title:
Dynamic Analysis of Japanese Tourists' Three Stage Choices: Tourism Participation, Destination Choice, and Travel Mode Choice

Record URL:
http://dx.doi.org/10.3141/2322-10

Abstract:
Finding ways to encourage people to participate in domestic tourism has been a central political issue in Japan for many years. One issue is the unbalanced regional trend in domestic tourist destinations. Various transport policies have been proposed. Under such policy considerations, jointly representing tourism participation, destination choice, and travel mode choice becomes important. However, tourism demand shows monthly variations. To date, the above three aspects have not been satisfactorily analyzed in a dynamic fashion. This study seeks to gain a better understanding of interrelated tourist behavior and provide a scientific tool to support tourism policy decisions by jointly analyzing these choice aspects to build a dynamic nested logit model while taking the influence of state dependence into account. Empirical analysis confirmed the effectiveness of the model with the use of retrospective panel survey data collected from 1,253 respondents in Japan in 2010. To the authors' best knowledge, this was the first panel survey in Japan to investigate tourists' behavior over the course of 1 year on a monthly basis. Model estimation results confirmed significantly negative effects of state dependence with respect to tourism participation behavior (implying a decreasing tendency of continuous tourism participation at the monthly level), but positive effects with respect to destination and travel mode choice behaviors. The positive value of state dependence for the travel mode choice behavior suggests that people prefer to use the same type of travel modes when they travel. The influence of travel mode choice on destination choice shows largely regional variations. Results also clarified effects of tourism motivation, individual characteristics, destination-specific attributes, and travel mode–specific attributes on the three choice aspects. Implications of model estimations for policy decisions are discussed.

Authors:
Wu, Lingling
Zhang, Junyi
Fujiwara, Akimasa

Title:
Moving the Guests at a 400th Anniversary: Jamestown 2007

Abstract:
The year 2007 marked the 400th anniversary of the establishment of the first permanent English colony in North America at what is now known as Jamestown, Virginia. In preparation for this most recent in a series of anniversary events celebrated every 50 years since the early 1800s, a group of federal, state, and local agencies undertook the development of a multimodal transportation plan to accommodate the expected increases in visitation to the Jamestown–Williamsburg–Yorktown area, commonly referred to as "America's Historic Triangle." Under the general direction and leadership of the Virginia Department of Rail & Public Transportation, a group of public and private organizations formulated and implemented a visitor transportation plan for the region which fulfilled all defined transportation objectives. In addition to the Department of Rail & Public Transportation, the participants in this process included the Virginia Department of Transportation, the National Park Service, the Colonial Williamsburg Foundation, the Jamestown-Yorktown Foundation, the City of Williamsburg, James City County, York County, the College of William and May, Williamsburg Area Transit Authority, Hampton Roads Transit, and a team of consulting planning and engineering firms. The resulting visitor transportation plan built upon existing visitor parking, shuttle bus services, and traveler information system elements to create a system to both link visitors to individual sites as well as to link major visitor attractions to each other. Many of the plan elements developed for the 400th Anniversary commemoration activities in 2007 have been retained and incorporated into the local public transportation system serving "America's Historic Triangle." This paper describes how the plan was developed, its implementation for the 400th Anniversary events, and its continuing evolution since 2007.

Authors:
Grimm, Lewis G
Rickards, Mark D
Geyer, Dorothy M
McDaniel, Danny

Monograph Title:
Tools of the Trade: 12th National Conference on Transportation Planning for Small and Medium-Sized Communities

Title:
Traveler Behavior and Values Analysis in the Context of Vacation Destination and Travel Mode Choices: European Union Case Study

Record URL:
http://dx.doi.org/10.3141/2156-16

Abstract:
The tourism industry has a dramatic impact on the world's economy and development. For this reason, it is important to study vacation traveler behavior, including where individuals travel on vacation and what travel mode they use to get there. This study uses the unique Eurobarometer vacation travel survey to model jointly travelers' choice of holiday destination and travel mode while also considering an extensive array of stated motivation-based preference and value factors. The study further builds on the existing literature by applying the model to a large-scale travel market characterized by multiple origins and destinations within the European Union. The empirical results indicate the important effects of nationality, traveler demographics, travel companionship arrangement, traveler preferences and values, and trip and destination characteristics on holiday destination and travel mode choice. These results have important policy implications not only for each country within the European Union but also for countries and regions around the world.

Authors:
LaMondia, Jeffrey
Snell, Tara
Bhat, Chandra R

Title:
Gateway to Zion: Nimby and a National Park Community

Abstract:
The town of Springdale, Utah, lies at the entrance to Zion National Park in the southwestern corner of the state. This spectacular national park is immensely popular, receiving 2.6 million visitors in 2006, and shows no signs of slowing down. Springdale, in contrast, has 500 residents and one main road through town. Springdale's economy relies on the tourists for survival, but the main road is clogged during the peak season with cars, buses, pedestrians, and cyclists. In 2006, Springdale and Utah Department of Transportation (UDOT) began working together to pursue a non-motorized trail to provide an alternative to the primary route into and out of both the town and national park. The town used innovative evaluation strategies to screen trail alignment alternatives and harnessed local resources to build support for the trail. This paper provides an overview of the trail planning process, and discusses the challenges posed by a small but vocal faction of property owners. It will also outline the process of establishing consensus among a wide range of interagency interests. Techniques of interest to small and medium-sized communities include budget-conscious methods of evaluating and selecting trail alignments, and approaches to dealing with project opponents.

Authors:
Vyas, Maria

Monograph Title:
Tools of the Trade: 11th National Conference on Transportation Planning for Small and Medium-Sized Communities

Title:
Tahoe Basin Region Visitor Model: Activity-Based Approach

Source Data:
Transportation Research Board Annual Meeting 2008 Paper #08-2719

Abstract:
This paper describes a travel-demand model for seasonal-residents and visitors developed for and applied to the Lake Tahoe basin region. The model includes development of synthetic seasonal-resident, day-visitor, thru-visitor, and overnight-visitor populations, as well as activity-based travel-demand components estimated and calibrated using a variety of travel surveys conducted in the region. Model development issues involving travel survey deficiencies, the importance of external-internal traffic flows, how to determine population size, and seasonal differences are discussed.

Authors:
Frazier, Christopher Rawls
Picado, Rosella
Willison, Christi

Title:
An Annual Time Use Model for Domestic Vacation Travel

Source Data:
Transportation Research Board Annual Meeting 2008 Paper #08-2220

Abstract:
Vacation travel in the USA constitutes about 25 percent of all long-distance travel, and about 80 percent of this vacation travel is undertaken using the automobile. Further, vacation travel by the automobile has been increasing consistently over the past two decades. At the same time that the overall amount of vacation travel by the private automobile has been increasing, the geographic footprint of vacation travel around households' residences is also becoming more compact. The net result is that vacation travel warrants careful attention in the context of regional and statewide transportation air quality planning and policy analysis, as well as for boosting tourism by developing appropriate marketing strategies and service provision strategies in an environmentally sustainable manner. This paper contributes to the vacation travel literature by examining how households decide what vacation travel activities to participate in on an annual basis, and to what extent, given the total annual vacation travel time that is available at their disposal. To our knowledge, this is the first comprehensive modeling exercise in the literature to undertake such a vacation travel time-use analysis to examine purpose-specific time investments. The consideration of different purposes of vacation travel is particularly important today because of the increasing variety of vacation travel activities households participate in. A mixed multiple discrete-continuous extreme value (MDCEV) model structure that is consistent with the notion of "optimal arousal" in vacation type time-use decisions is used in the analysis. The data used is drawn from the 1995 American Travel Survey (ATS). The empirical results show that most households participate in different types of domestic vacation travel over the course of a year, and they spend significantly different amounts of time on each type of vacation travel. The research identifies differences in vacation travel preferences based on household demographics, economic characteristics, and residence characteristics. Thus, the model developed here can be used to predict the changes in vacation travel time-use patterns due to the changes in demographic, economic, and residence characteristics over time. Such predictions, in turn, can be used to examine the changing vacation travel needs of households, so that appropriate service and transportation facilities may be planned. The paper also proposes a structural framework to integrate the model in this paper within a larger microsimulation-based system for predicting complete vacation activity-travel patterns for transportation air quality analysis.

Authors:
LaMondia, Jeffrey James
Bhat, Chandra R
Hensher, David A

Title:
Advanced Traveler Information System for Alpine Leisure Trips

Source Data:
Transportation Research Board Annual Meeting 2008 Paper #08-1600

Abstract:
The paper deals with empirical data to learn about the use and compliance of Traveler Information Systems for leisure trips in winter tourism. Within the vicinity of skiing resorts in the Alps traffic problems arise because of very high seasonal peaks on low road capacity. Since extending road capacity is not a feasible option, a research project is undergoing to improve the usage of the given transport infrastructure by means of traveler information. In order to quantify the potential and provide data for a most effective Traveler Information System a computer aided personal interview (CAPI) with 1188 valid interviews and a computer aided self interview (CASI) has been conducted within the skiing resorts of the Saalachtal (Austria). The surveys indicate a high open-mindedness of skiing tourists towards new Traveler Information Systems. The internet is widely being used for pre-trip information while onboard devices (e.g. Personal Navigation Devices (PND)) dominate on-trip information. Routine behavior is the most important item for not making use of such travel information. A CHAID-analysis has been applied to identify key factors influencing the use of such devices. The use of pre-trip information depends on trip purpose and the mental map while on-trip information relates also to personal characteristics like age and employment. Routing information combined with data on snow conditions are most important for all respondents. 30% of all PND-users actually strictly follow the navigation advice, which is quite relevant for the anticipated traffic control strategies.

Authors:
Berger, Martin
Fellendorf, Martin

Title:
Shifting Modes of Travel to National Parks: Pilot Study at Muir Woods National Monument, California (With Discussion and Closure)

Record URL:
http://dx.doi.org/10.3141/2077-21

Abstract:
The Muir Woods Shuttle is a three-summer (2005–2007) pilot public transit route designed to transport visitors to Muir Woods National Monument in Marin County, California. The shuttle was developed by the County of Marin and the National Park Service and is funded through an FHWA earmark. More than 700,000 people visit Muir Woods every year, primarily in private automobiles; automobile congestion significantly affects park resources and visitor experience. Goals for the shuttle include reducing vehicular parking impact and demand at the park, reducing vehicular traffic in the park, and reducing congestion on nearby roads. Nelson\Nygaard has conducted evaluations of shuttle performance for all three pilot years to make service enhancement, marketing, and funding recommendations for future service. Evaluation is based on extensive original data collection including ride checks, onboard passenger surveys, and nonpassenger visitor surveys for four weekends per summer. Improvements added in 2007 such as increased frequency and an expanded service area were a direct result of the 2005–2006 studies. Results from evaluations of 2005–2006 service indicate strong demand for public transit to Muir Woods. Almost 14,600 trips (one-way) were made on the shuttle between Memorial Day and Labor Day 2006, representing a 140% increase in ridership over 2005, despite the round-trip charge of $2 added in 2006. In 2006, unlike 2005, ridership was high from the beginning of the season. Evaluation continued through the summer of 2007 with additional focus on identifying sources of funding to continue this very successful service.

Authors:
Nelson, Bonnie
Taylor, Valerie
Nabti, Jumana

Discussers: Upchurch, Jonathan

Title:
GUIDING TOURISTS TO AND THROUGH THE PARKS: STUDY ASSESSES TRAVELER INFORMATION NEEDS

Record URL:
http://onlinepubs.trb.org/onlinepubs/trnews/trnews233.pdf

Abstract:
This article briefly introduces a recent crosscutting study by the Federal Highway Administration that examined the impacts of traveler information systems in four locations: Acadia National Park on the coast of Maine; Branson, Missouri; Salt Lake City, Utah; and the I-81 Corridor-Shenandoah Valley in Virginia. The study involved an analysis of available data on system use and customer satisfaction, as well as interviews with representatives of the traveler information and tourism communities.

Authors:
Burt, M
Zimmerman, C A

Title:
INTEGRATING TOURISM AND RECREATION TRAVEL WITH TRANSPORTATION PLANNING AND PROJECT DELIVERY

Record URL:
http://trb.org/publications/nchrp/nchrp_syn_329.pdf

Abstract:
This synthesis report will be of interest to local, regional, state, and federal officials, as well as to other transportation professionals that work with them in dealing with tourism and recreation travel. This report provides an overview of current practice at transportation agencies, metropolitan planning organizations, state tourism and parks departments, federal land management agencies, and regional planning agencies. Overall, findings reveal that many state departments of transportation (DOTs) are now actively involved in tourism-related planning issues--either proactively or in building solutions to infrastructure, access, or environmental issues that impinge on the success of tourism in the region. This synthesis report combines information culled from survey responses from multiple sources with a literature review drawn primarily from Transportation Research Board publications, conference proceedings, academic publications, and state DOT reports. Case study information showing New Jersey and Wisconsin support for tourism offers additional insight.

Authors:
Petraglia, L
Weisbrod, G

Title:
TRANSPORTS TO NATURE: TRANSPORTATION STRATEGIES ENHANCING VISITOR EXPERIENCE OF NATIONAL PARKS

Record URL:
http://onlinepubs.trb.org/onlinepubs/trnews/trnews224.pdf

Abstract:
The National Park Service received 300 million visitors at its 380 sites in 2000. As the numbers of visitors at national parks continue to increase, the concerns about traffic congestion, vehicle-generated noise and air pollution, deteriorating roadways, and wildlife degradation are challenges which must be faced. The National Park Service, working with the Department of Transportation, is deploying several innovative strategies to ensure that the ever-increasing numbers of park visitors can opt for modes that are convenient and environment-friendly. This article looks at some of the successful initiatives incorporating alternative transportation modes, innovative strategies, and advanced technologies.

Authors:
Turnbull, K F

Title:
ENHANCING TRANSIT CIRCULATION IN RESORT AREAS: OPERATIONAL AND DESIGN STRATEGIES

Record URL:
http://dx.doi.org/10.3141/1735-10

Abstract:
Many resort areas and other major activity centers are facing transportation challenges as rising traffic congestion erodes the quality of a visitor's experience. Many resort areas have turned to public transportation as an alternative strategy for visitor circulation, but these services often become enmeshed in the same traffic jam that they were intended to circumvent. The city of Virginia Beach, Virginia, undertook an aggressive, long-term effort to establish and enhance an effective transit circulation in its beachfront resort area through a combination of physical design improvements and operational management. The development and implementation of the combination strategy are described, and lessons learned that are relevant to other resort-area transit-circulator services are outlined.

Authors:
Thrasher, S A
Hickey, T R
Hudome, R J

Title:
CURRENT STATE PRACTICES IN THE TRANSPORTATION-TOURISM INTERFACE

Abstract:
This digest presents the findings of Phase I of NCHRP Project 2-17(6), "Tourism Travel Contributions to Economic Development". This two-phase project is designed to examine and refine the institutional practices of the agencies that are counterparts in the transportation-tourism interface: state transportation agencies (DOTs) and state tourism offices (STOs). Phase I involved a series of data collection and analysis tasks structured to produce an overview of the current state of knowledge and practice in the transportation-tourism interface. The Phase I findings, along with brief discussions, are grouped according to the following three topics: (1) overall policy and institutional coordination; (2) consideration of tourism in statewide planning and programming; and (3) traveler information services. The issues identified in the research so far touch all aspects of the DOT planning process: policies, processes, procedures, and programs. Each state has its unique DOT and STO organizational structure and objectives for tourism to enhance local resources; however, as in any interagency coordination effort, common factors must be addressed.

Corporate Authors:
Transportation Research Board

Order URL:
http://www.trb.org/publications/pages/262.aspx

Title:
DEVELOPMENT OF CRITERIA FOR SCENIC ROADS

Abstract:
This paper discusses the development of criteria used to determine highway improvement programs for three corridors through the Upper Great Lakes region of Michigan, Minnesota, and Wisconsin. These improvements would provide safe, efficient travel and foster new economic growth. One objective of the study was that the findings be applicable to future planning and development of comparable highway corridors in the region. Inasmuch as the tourism and recreation industry and scenic quality of the area held the greatest potentials for such growth, it was necessary to develop a procedure for comparative evaluation of scenic values. The aspects of the study included definition of operating speed as related to functional and scenic criteria; development of new design-hour and traffic service level criteria for planning highway improvements in rural recreation regions; and development of a method for comparing scenic values in the planning and design of scenic routes. The scenic evaluation feature uses a point system to assist in selecting an alignment that takes advantage of the best scenic potential. A table relating to traffic service function and to scenic viewing is presented. The route selection procedure is outlined in a flow chart indicating the elements of scenic inventory and evaluation plus the other considerations normally used in highway planning.

Authors:
Mulder Jr, William J

Monograph Title:
Social, economic, behavioral and urban growth considerations in planning

Title:
Economic Impact of Investments in Bicycle Facilities: Case Study of North Carolina's Northern Outer Banks

Record URL:
http://dx.doi.org/10.3141/1939-02

Abstract:
The northern Outer Banks coastal area in North Carolina is well suited to drawing bicycle tourism because of its geography, climate, and attractions. In 2003, the North Carolina Department of Transportation commissioned a study to examine the value of public investment in bicycle facilities that have been constructed in this area over the past 10 years at a cost of approximately $6.7 million. A particular challenge in conducting this study was that tourists visited the Outer Banks for a variety of reasons, not just for cycling. Thus, the collection of information on the amount and nature of bicycling activity and on the spending patterns of bicyclists in the area was critical for the development of an economic impact analysis. Researchers surveyed cyclists using the bicycle facilities (shared-use paths and wide paved shoulders) and obtained data from self-administered surveys of tourists at visitor centers during the primary tourist season. The data collected were then used to determine the economic impact of bicycling visitors to the area. Seventeen percent of tourists to the area reported that they bicycled while there; this translates to 680,000 people annually. The economic impact of bicycling visitors is significant: a conservative annual estimate is $60 million, with 1,407 jobs created or supported per year. This is almost nine times greater than the one-time expenditure required to construct the facilities. Continued investment in bicycle facilities is expected to increase this favorable economic impact and is therefore recommended.

Authors:
Meletiou, Mary Paul
Lawrie, Judson J
Cook, Thomas J
O'Brien, Sarah W
Guenther, John

Title:
TRANSPORTATION AND TOURISM IN HAWAII: COMPUTABLE GENERAL EQUILIBRIUM MODEL

Record URL:
http://dx.doi.org/10.3141/1839-16

Abstract:
Using data from the state of Hawaii input-output (I-O) table, the economic impact of the transportation sector in Hawaii was described, modeled, and forecast under a number of alternative scenarios. Transportation is compared with the key economic sectors in the state in output, exports, household consumption, visitor spending, number of employees, and compensation of employees. Next, the overall transportation sector was disaggregated into key activities and functions to present a more complete picture of the important role of transportation in Hawaii. A computable general equilibrium (CGE) model of the economy with a special focus on transportation is developed. Because tourism is the state's leading sector, the effects of both an increase and a decrease in visitor expenditures were modeled. Both measuring the economic importance of transportation in Hawaii and estimating probable consequences of potential economic changes are of interest. The visitor industry dominates Hawaii's economy, with small increases in visitor expenditures contributing significantly to the gross state product. Transportation industries, along with restaurant and accommodation services, account for a disproportionately large share of this growth. Key residential transportation sectors (transit and motor vehicles) contract in response to cost increases generated by a growth in visitor demand. The use of the I-O table and CGE modeling provides a useful analytical and planning tool for evaluating economic scenarios within a region such as Hawaii. The increased availability of both data sets and new modeling techniques offers opportunities to planners, engineers, and transportation policy makers.

Authors:
Konan, D E
Kim, Karl

Title:
TOURISM TRAVEL CONTRIBUTIONS TO ECONOMIC DEVELOPMENT. VOLUME II: SUPPORTING MATERIALS AND REFERENCES

Record URL:
http://www.nap.edu/catalog/6359.html

Abstract:
The materials in this second volume report on "Tourism Travel Contributions to Economic Development" were assembled as references that provide state departments of transportation (DOTs) and state tourism offices (STOs) with background for the study team's recommendations proposed in volume 1. The contents of this second volume are: (1.0) The survey instrument distributed to 53 AASHTO-member transportation departments and 53 STOs to identify current practices in institutional coordination, planning analytics, and traveler information services. (2.0) A statistical summary of the national survey results for only those answers that could be quantified, including breakdowns of state DOT and STO responses. This information is valuable for state DOTs and STOs to compare their practices in addressing the transportation needs of tourism to a national profile of such practices. (3.0) Excerpts of state policy documents selected for their apparent effectiveness in addressing interagency coordination issues and transportation investment considerations. These excerpts can guide state agencies interested in instituting such policies, or can encourage those agencies with established policies to re-evaluate them for their effectiveness. (4.0) A tourism expenditure worksheet developed by the Oregon Tourism Division to examine the impact of projects funded under their Regional Strategies Program. This worksheet represents a simplified approach to linking transportation investment with tourism impacts. Although this approach is not recommended by the study team, it is a useful reference in terms of introducing state DOTs and STOs to modeling efforts currently being used in a very few instances.

Authors:
Frechtling, D C
Meyer, M D
Pisarski, A E

Title:
COMPREHENSIVE FRAMEWORK FOR HIGHWAY ECONOMIC IMPACT ASSESSMENT: METHODS AND RESULTS

Abstract:
A framework for assessing economic impacts of highway improvements that is comprehensive in scope, diverse in methodology, and useful both for ranking needed improvements and in making investment decisions is presented. Current user benefit assessment techniques are expanded by adding an assessment of regional economic benefits. These benefits are measured in terms of changes in business costs, both in absolute terms, and in relation to costs experienced by areas or regions not affected by the proposed improvement. Changes in business costs increase the productivity of affected businesses, allowing them to expand markets and market share, increase profits, or otherwise enhance their competitive position. Regional economic benefits include opportunities for business expansion, business attraction, and tourism development. Business expansion benefits include the indirect and induced effects of user benefits (travel time savings, operating cost changes, and safety benefits). Business attraction benefits include the effects of the highway investment on the types and quantity of new economic activity that may occur in the affected region as a result of the highway. This assessment typically includes the development of several scenarios, on the basis of varying levels of effort and initiative by local economic developers. Tourism benefits include changes in expenditures resulting from new tourist travel patterns. Three case studies are presented, illustrating the application of the framework to inter- and intraurban highway projects in Wisconsin, Massachusetts, and Indiana. The case studies suggest that the framework captures regional benefits the value of which is equal to 50 to 150% of user benefits alone. Regional benefits are sensitive to the level of improvement of the affected links, and to the implementation of related public policies.

Supplemental Notes:
This paper appears in Transportation Research Record No. 1274, Transportation and Economic Development 1990: Proceedings of a Conference, Williamsburg, Virginia, November 5-8, 1989.

Authors:
Seskin, Samuel N

Title:
BENEFITS AND COSTS OF TOURISM: A REGIONAL POINT OF VIEW

Abstract:
This paper explores the impact of tourism on a regional economy. It is both conceptual and empirical insofar as quantitative measures are available for the Oregon economy. Its intent is to illuminate public policy decisions and give direction to research appropriate to their implementation. inasmuch as the objective of regional policy is to promote the welfare of the residents of the region, careful consideration is given to distinquishing between resident and nonresident effects--a distinction not generally made in tourist impact studies. Also, contrary to most studies, the costs associated with tourism are given explicit consideration. And, in addition to the gross effects, attention is directed to redistribution effects among residents of a region. The fiscal effect appears to be adverse in Oregon; this is, the costs incurred by the state to provide facilities and services (parks, highways) used directly by tourists are greater than the taxes collected directly from them (user fees, state gasoline tax). Financial capital is sufficiently mobile that it is affected little by growth or nongrowth of the tourist industry. Labor, on the other hand, is not so mobile, and there appears to be a small labor benefit. Despite the fact that the jobs pay little, are seasonal, and offer limited opportunities for upward mobility, they do match the needs of a part of the labor force. Owners of natural resources have the most to gain from tourism, but their gains are partially offset by losses to resident consumers who pay higher prices for products of fixed-quantity natural resources. The local fiscal effect is unknown. The low capital-labor ratio in tourist industry activities and the low wages of the industry tend to result in low property tax revenue generated per worker in the industry. Whether this results in an adverse fiscal effect on local government depends on the characteristics of its labor force. Because of the difficulties in assigning weights to the various effects and in handling redistribution effects, it is difficult to arrive at a consensus. /Author/

Supplemental Notes:
Sponsored by Committee on Application of Economic Analysis to Transportation Problems.

Authors:
Farness, Donald H

Discussers:
Wallerstein, L B

Monograph Title:
Cost-benefit and other economic analyses of transportation