Literature Review for Forecasting Traffic Counts for High Tourism Areas

Joseph H. Wilck, IV, John Pope, Paul J. Kauffmann
Department of Engineering
East Carolina University
Greenville, NC 27858

Abstract

This literature review paper focuses 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. An implementation strategy for interpreting traffic counts in high tourism areas is provided to aid in the development of Comprehensive Transportation Plans (CTPs). Because of the high variability of traffic counts in high tourism areas, it is unreasonable to apply the typical weekday traffic count (annual average daily traffic, AADT) as the baseline metric for developing the CTPs for these areas.

Keywords
Transportation plans, annual average daily traffic, forecasting, tourism

1. General Tourism Planning

Within tourism planning, there are a number of published resources. General references [1-3] include handbooks, travel economic models, and state-run websites. 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 general, practitioner based references; thus, they are suitable for textbooks at the university level, but do not provide specific details for tourism traffic planning with seasonality.

2. 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.

2.1 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.

2.2 Global Information Systems and Visualization
Global Information Systems (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].

2.3 Public Perception
Citizen perception is also paramount for planning projects. It is known that one should ask residents their experiences, perceptions, and expectations to determine 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.

2.4 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 and 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.
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 five 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.

### 3.1 Traditional Forecasting Models

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 [23].

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, 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 ANN yielded the best results [24].

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 [25].

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 [26].

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 [27].

This 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. An analysis is used to obtain insights into the current health of a destination area and its future strategic marketing needs with respect to tourism [28].

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 [29].

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 [30].
This research paper presents empirical results of a new combined forecasting method with a structural time series model and a time-varying parameter 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 [31].

This review paper presents key findings and methods for modeling and forecasting from 2000-2008, 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 [32].

This survey paper provides an overview of the relevant empirical research literature for forecasting tourism. The primary methods discussed include econometric, time series, autoregression, and exponential smoothing [33].

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 model, autoregressive distributed lag model, error correction model, and vector autoregressive model. The results indicate that combination methods are generally superior to single source methods [34].

### 3.2 Environmental and Emission Related Models

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 [35].

A 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 [36].

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 [37].

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 [38].

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 [39].

This article provides an overview of transportation demand management in the U.S. within a broad national transportation context. Strategies for tourist areas include shuttles, park and ride lots, transit, and bicycle and pedestrian amenities, among others [40].

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 [41].

This review article focuses on the relation between tourism and the natural environment. It emphasizes the importance of maintaining the attractiveness of the environment in travel destinations and recreational areas [42].

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 [43].

3.3 Behavior Models
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 [44].

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 [45].

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 [46].

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. Using identified travel activities, retailers can partner with lodging facilities, restaurants, and tourism boards to encourage positive shopping experiences for the tourist [47].

This research paper presents a low-cost approach to generating an origin destination matrix that is used to represent the travel pattern. The methods used to generate this matrix include a gravity model, opportunity model, and gravity-opportunity model. These models are calibrated using traffic counts [48].

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 [49].

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 [50].

This paper presents research in the use of GPS and 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 [51].

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 [52].

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 [53].

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 [54].
3.4 Statistical and Variability Models with Seasonality
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 [55].

This research paper applies quadratic programming to forecast combination by determining combination weights for the individual factors. The paper uses quality control techniques to update the combination weights. This technique is applied to forecast tourism for documented data sets and evaluating across a variety of performance measures [56].

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 [57].

This research paper analyzes the statistical precision of annual average daily traffic estimates resulting from short period traffic counts 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 than on the duration of count [58].

This research report presents the methods used by the Florida Department of Transportation to estimate seasonal factors by using data obtained from approximately 300 monitoring sites, which are used in the calculation of annual average daily traffic values. 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. This paper describes a statewide investigation to identify potentially influential variables that contribute to seasonal fluctuations in traffic volumes in urban areas in Florida. 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 [59].

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. A majority of provincial and state agencies have available to them the traffic information required to implement the classifications proposed in this article [60].

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 [61].

3.5 Urban Planning and Sustainable Tourism Models
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 [62].

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 the increasing need to conduct detailed economic impact studies and the basic approaches to measuring both the positive and negative economic impacts [63].

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 discusses the issues related to who qualifies as a tourist and what expenditures can be attributed to a specific occasion [64].
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 [65].

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 [66].

This research paper analyzes tourism counts and practices for the Maldives prior to the Indian Ocean tsunami in 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 [67].

This research paper develops a mathematical modeling framework for analyzing the traffic impacts of proposed tourism facilities. The estimation procedures quantify traffic impacts in terms of the projected increase in total network travel time or cost that would result from the development of new facilities. These results can then be used by policy makers and planners [68].

This guidebook presents economic impact analyses geared towards tourism officials. It explains the concept of economic impact analysis and illustrates applications in tourism contexts. 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 [69].

The author examines literature that evaluates the relationship between transportation and land use. 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 disregards federal and local policy [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, including detailed work on land development in mountainous regions focuses on resort area [71].

Tourism as a client-pleaser industry is in danger of destroying the 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. 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 [72].

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 primarily in North-Central Wisconsin. Tourism-related business is a special type of opportunity, whereby passenger travel benefits can lead to additional visitation to the state [73].

4. Conclusions and Future Work
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 in engineering, transportation planning, geography, urban planning, business, hospitality, and tourism specific databases and also consolidated databases covering several of these areas.
A major gap in the literature exists with respect to transportation funding models from local, regional, state, and federal authorities for local and regional areas that have seasonal traffic. Further work is needed to provide an accurate count of daily traffic and an accurate model (whether it is forecasted or counted) of that distribution over the annual cycle of seasonal traffic flow. One recommendation is the change from AADT methods to a service level method. That is, acknowledging the funding will not meet the highest level of traffic needs, but a service level percentage that is associated with both the average and variance (or deviation) of the traffic in that tourist area. New technology allows for researchers to know the number of vehicles (count) and their location (via GPS). In the future, this information could be useful when allocating transportation funding.

Acknowledgements
This work is supported by the North Carolina Department of Transportation under grant RP 2013-39. Please note that any opinions and recommendations in this paper are those of the individual contributors. They do not necessarily reflect the views of the North Carolina Department of Transportation.

References