

*Climate, Weather and Tourism
in North Carolina: Issues and
Opportunities*

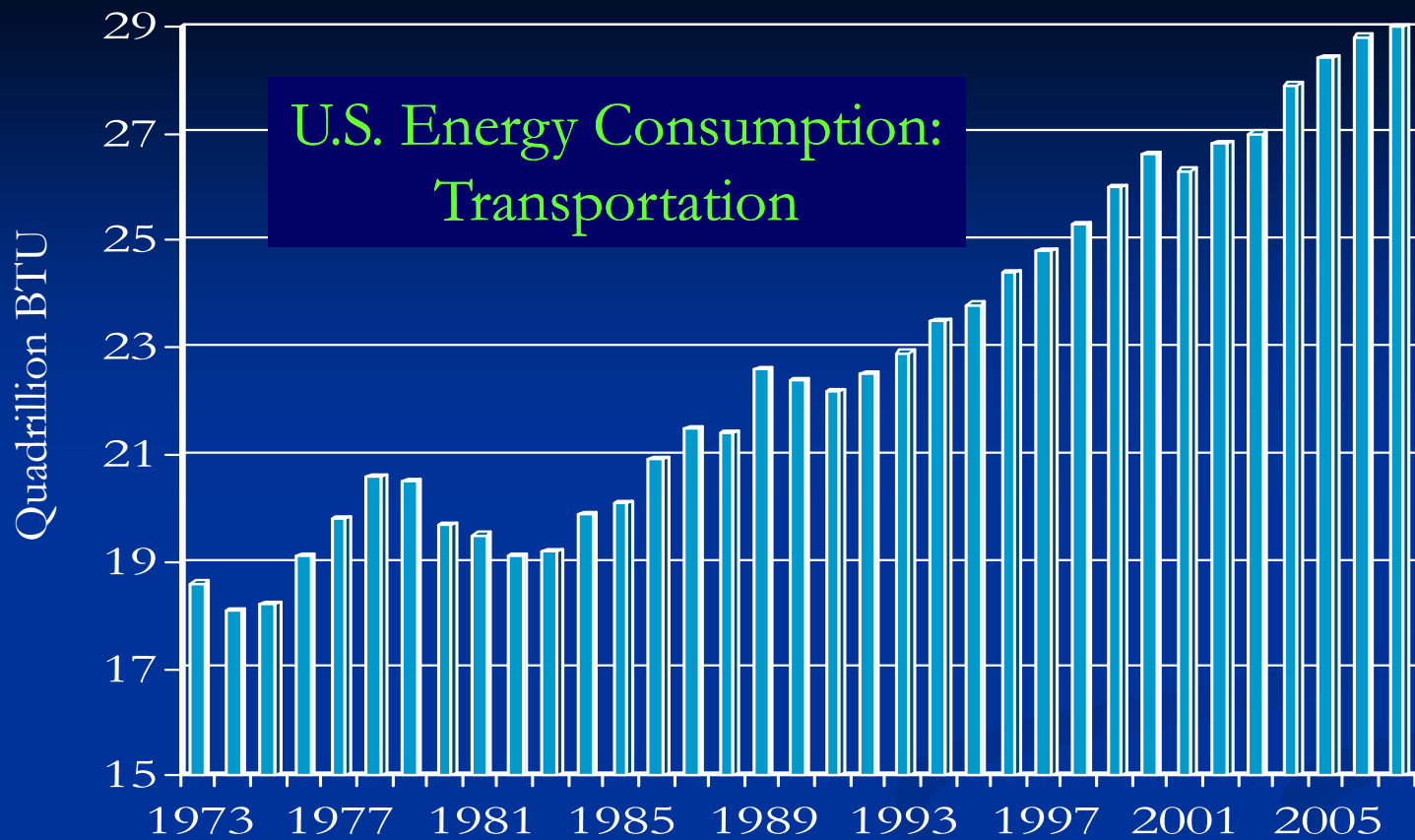
Faculty Perspectives: Transportation

"Almost all about energy"

Dr. Ron Mitchelson

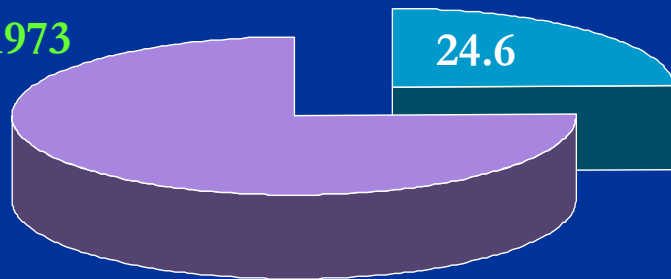
Department of Geography
East Carolina University

Saturday, November 15 2008, 1:00 PM



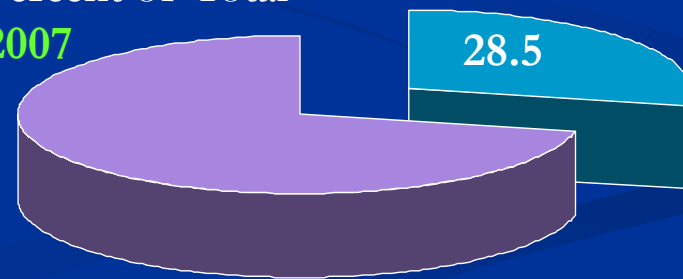
Percent of Total

1973

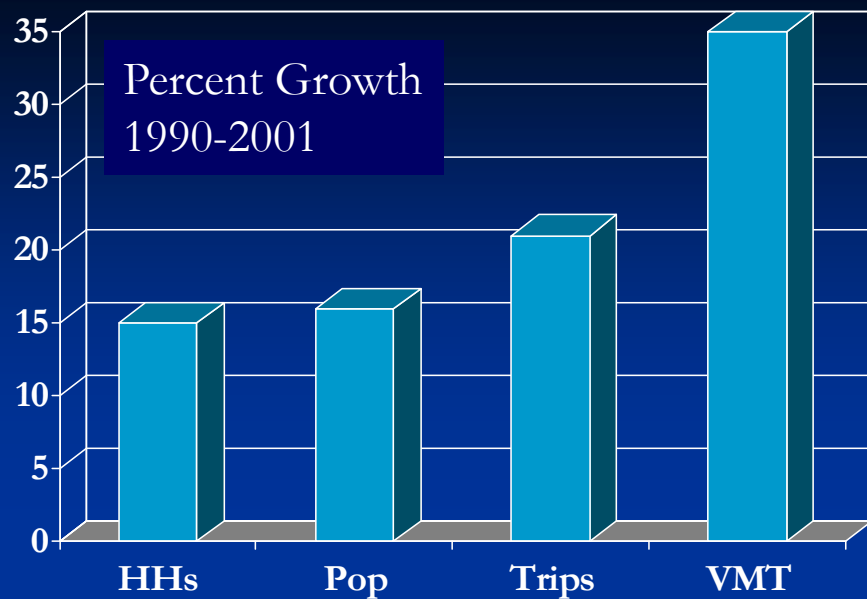


Percent of Total

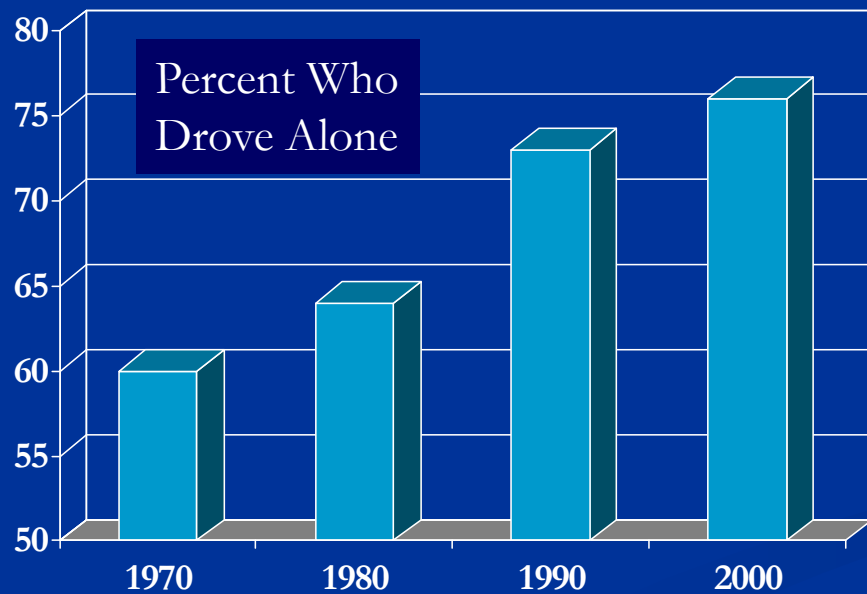
2007



Source: US DOE. March 2008. Energy Information Administration, *Monthly Energy Review*

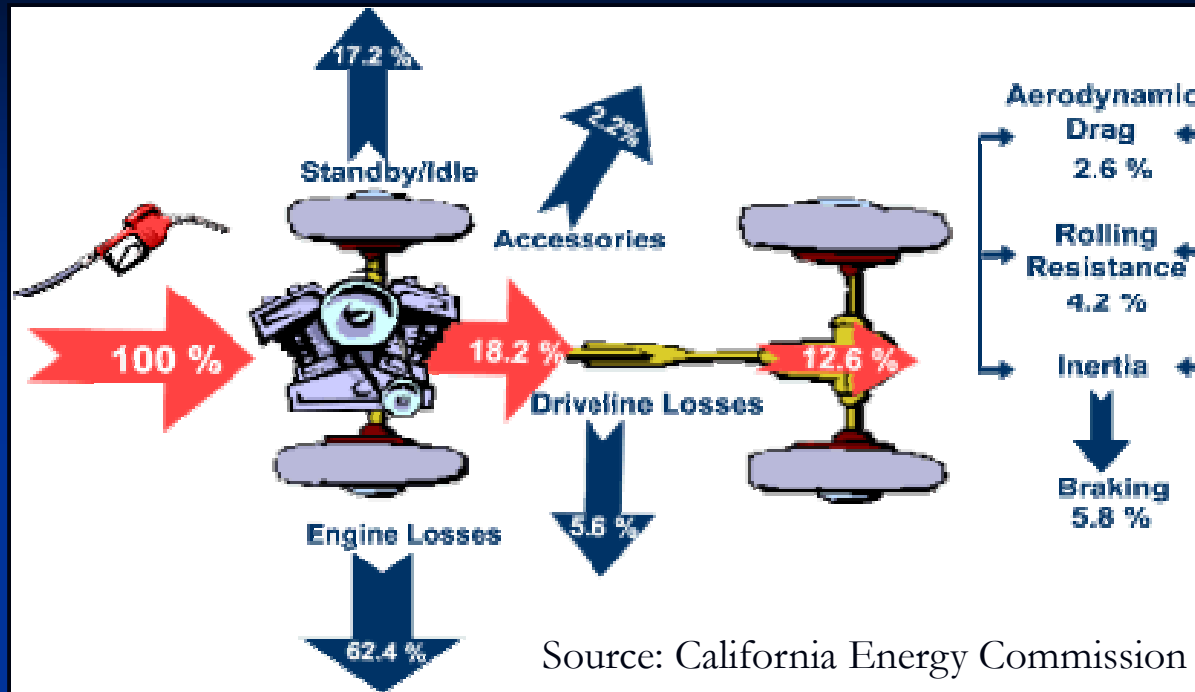


Source: USEPA. 2006.
Greenhouse Gas Emissions
from the U.S. Transportation Sector,
1990-2003



Note: a recent survey places the
drive alone percentage at 82%.

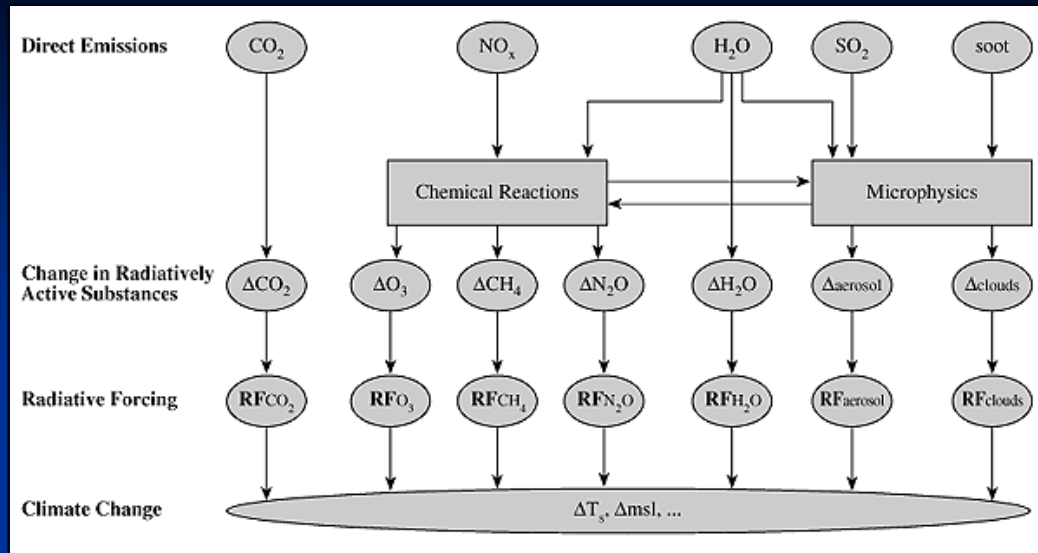
The Average Auto: Callous Inefficiency



The purpose of transportation is to provide mobility and accessibility.

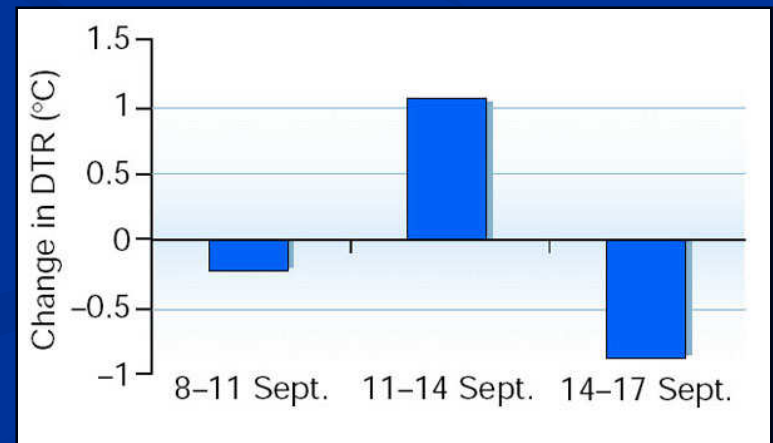
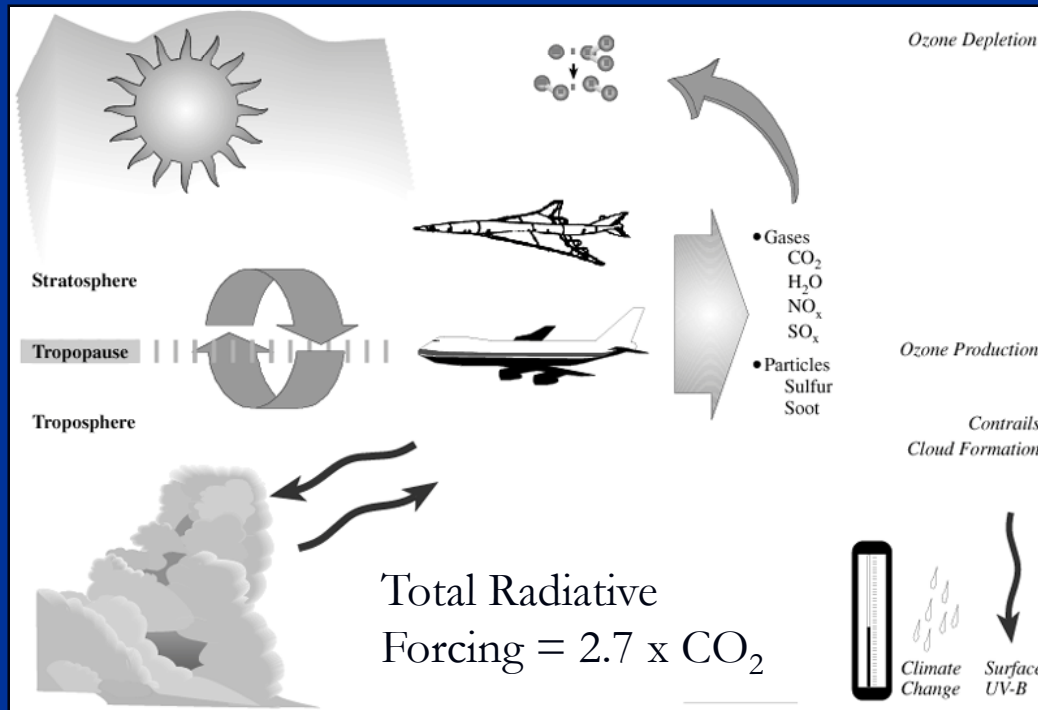
About 2% (yellow slice) of the energy contained in a gallon of gasoline is used to move the occupant.

Aviation: Disproportionate Impacts

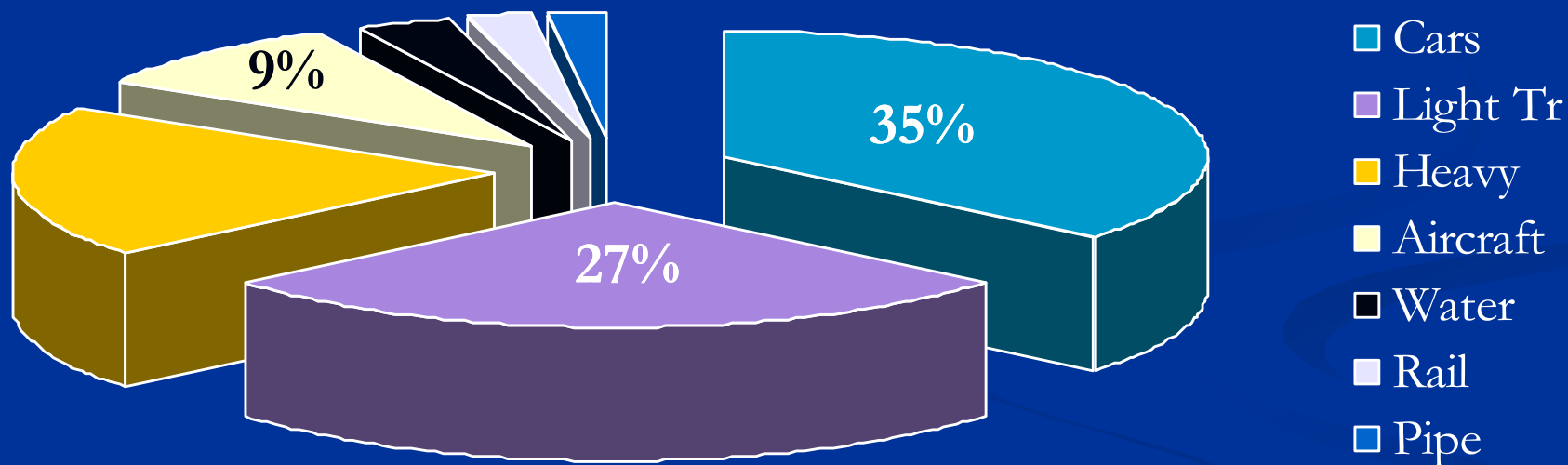


Sources: David J. Travis et al. 2002
"Contrails Reduce Temperature Range,"
Nature, Vol. 418, 601.

Penner, J. et al. 1999. *Aviation and the
Global Atmosphere*. Cambridge: Cambridge
University press.

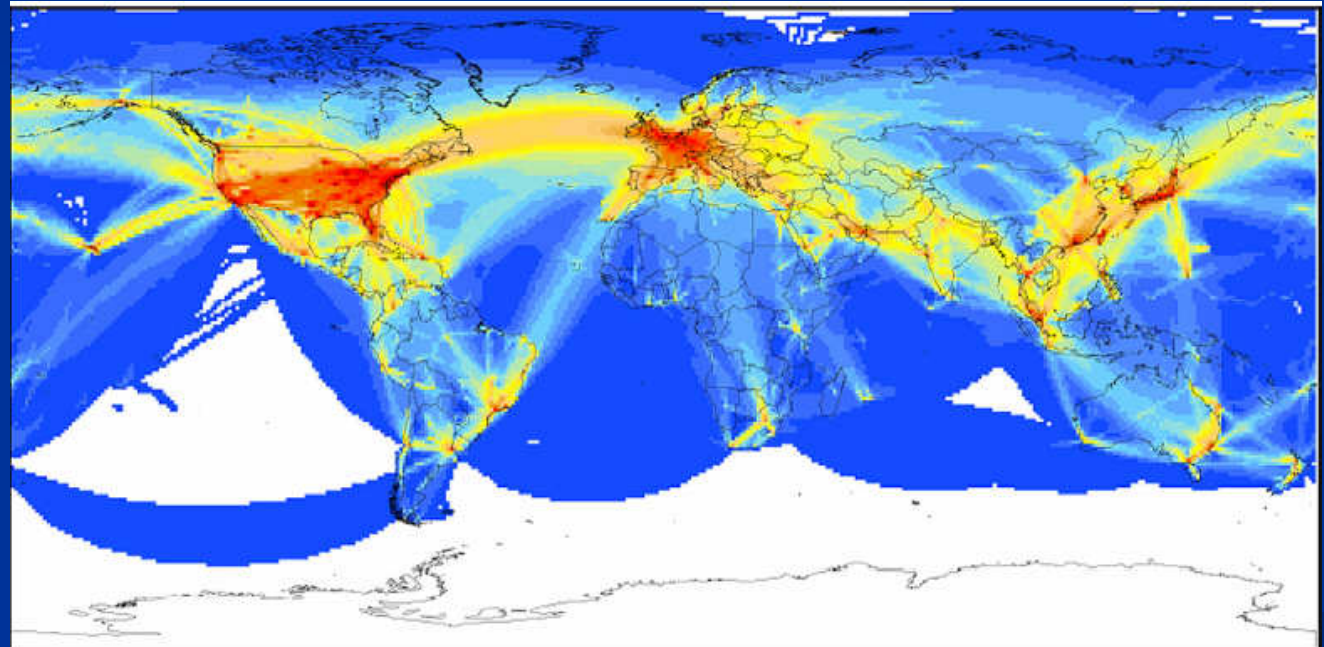
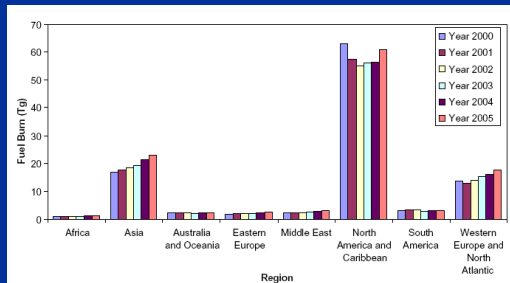
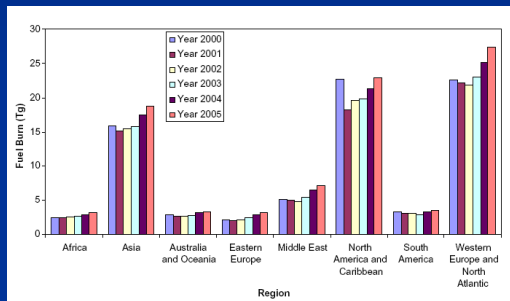
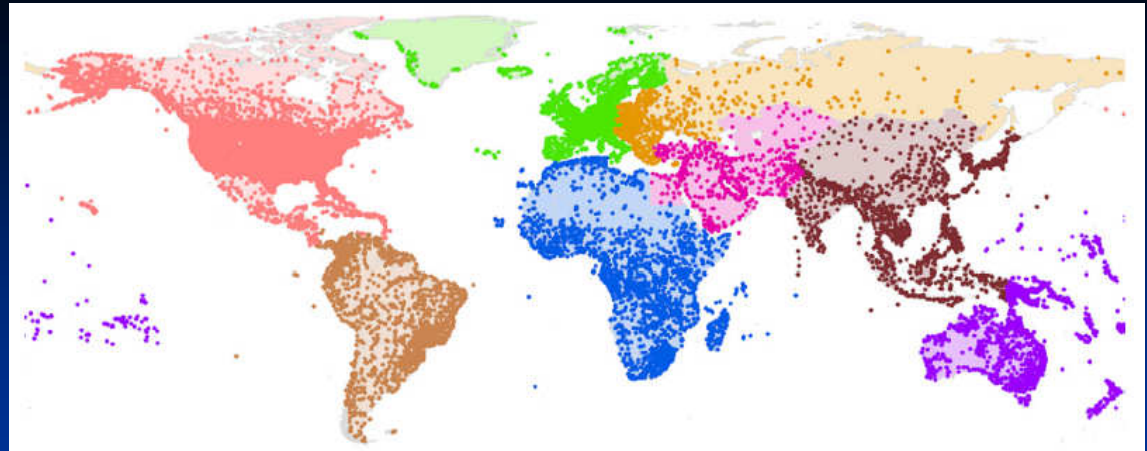


U.S. Greenhouse Gas Emissions, By Transport Source (2003)

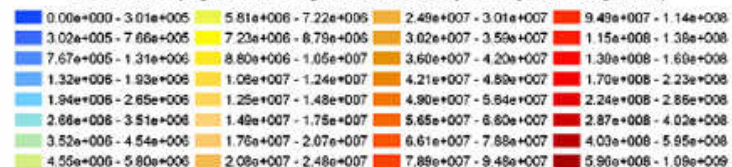


SAGE: System for Assessing Aviation's Global Emissions

(U.S. FAA)



Fuel Burn (Kg/Year/1 Degree Latitude by 1 Degree Longitude)

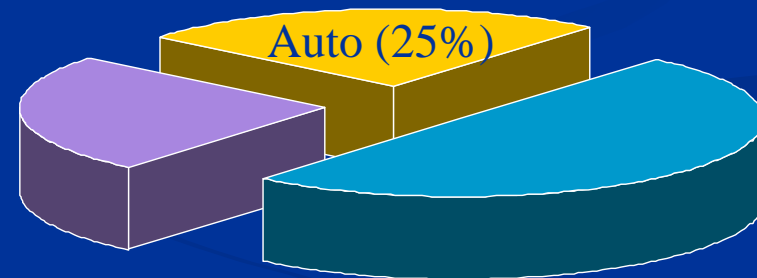
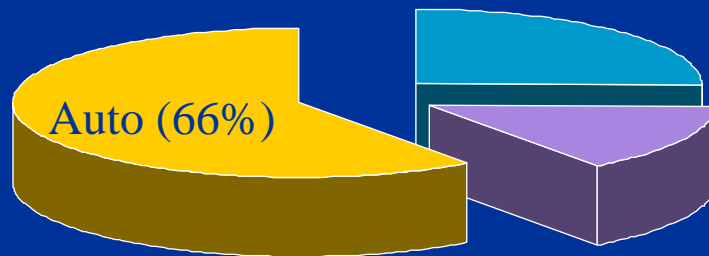


Source: Brian Kim et al.
2007. System for Assessing
Aviations Global Emissions.
Transportation Research D,
Vol. 12, 325-346.

Rocky Mountain National Park

(967 Surveys, 70% response, Summer 2001,
extrapolate to 3 million visitors)

<u>Total Emissions</u>	<u>(CO₂-eq) (kg)</u>
Transport	950,111,267
Accommodation	108,354,551
Activities	76,179,000
<i>total</i>	<i>1,134,644,818</i>



<u>Transport Emissions</u>	<u>Volume (km)</u>	<u>CO₂-eq (kg)</u>
Air (<2000)	1,258,347,175	475,655,232
Air (>2000)	735,110,208	238,175,707
Auto	3,000,385,110	236,280,327
<i>total</i>		<i>950,111,267</i>

Source: Stefan Gossling et al., 2005.
"The Eco-Efficiency
of Tourism."
Ecological Economics,
Vol. 54, 417-434.

Ecological Footprint (EF)

EF is an aggregate measure of demands made upon biophysical productivity and waste assimilation imposed by human activity in terms of an equivalent land/sea area (gha = global hectares).

In 2000, the EF ranged from 0.50 gha (Bangladesh) to 9.57 gha (United States). The 'fair earthshare' (mean) is estimated to be 2 gha/year.

The gross EF of a two week holiday from UK to Cyprus is 0.93 gha. Fifty percent of gha is air travel.

Net EF = Gross EF - generation at home
e.g.) $0.93 - 0.21 = 0.72$ (UK to Cyprus)

US Tourist (3 weeks) from Miami to Costa Rica:

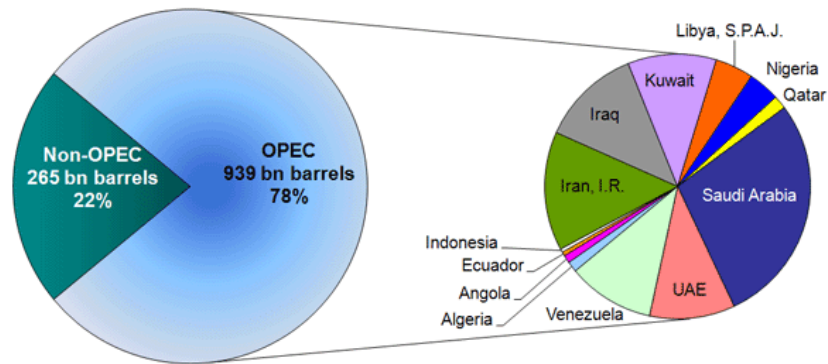
Transit = 0.37 gha

Destination = 0.12 gha

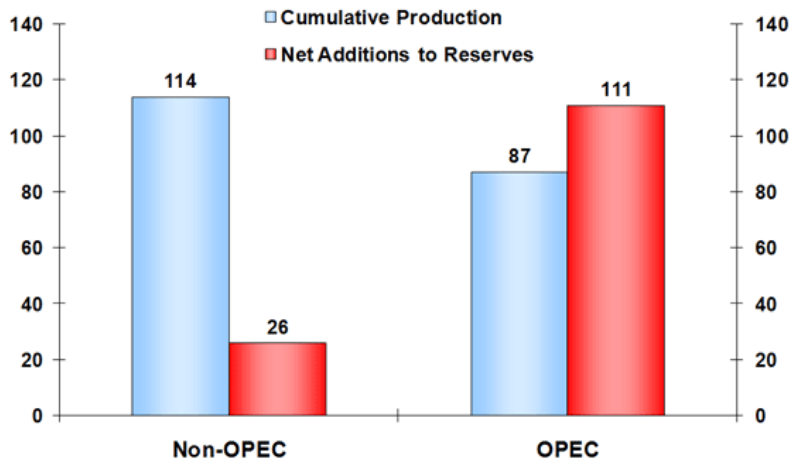
Net = $0.49 - 0.54 = -0.06$ gha

Source: Colin Hunter and Jon Shaw. 2007. "The Ecological Footprint as a Key Indicator of Sustainable Tourism," Tourism Management, Vol. 28, 46-57.

OPEC Share of World Crude Oil Reserves (2007)

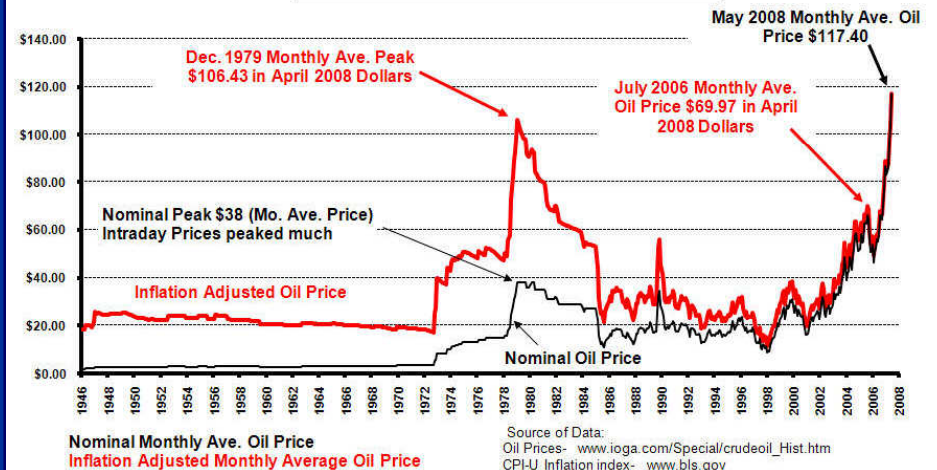


World crude oil reserves: Cumulative production versus net additions (2000-2007) (billion barrels)



Tourism = Travel
 Travel = Oil
 Tourism = Oil

Inflation Adjusted Monthly CRUDE OIL PRICES
 (1946-Present) in April 2008 Dollars
 © www.InflationData.com
 Updated 6/12/2008



"Oil Price Rallies as Saudi Arabia Announces Production Cuts"

Boston Globe (11/5/2008)

Oil Depletion:

What Could it Mean for Scottish Tourism ?

Scenario 1: Energy Inflation (2005-2015)

low priced oil ends and no intervention
(500% oil, 300% gas, 200% electricity)

Scenario 2: Pay for Climate Change (2005-2015)

carbon taxes (VAT), train subsidy, renewable technologies initiated
(200% oil, 100% gas, 100% electricity)

	<u>2015 Baseline</u>	<u>Scene1</u>	<u>Scene2</u>
GDP	84,548	+1	-4
Employment (fte)	2,163,269	-2	-3
Govt Rev	27,018	-10	0
Daytrip Expend	3,468	-1	-1
Domestic Tour Expend	2,095	+1	+1
UK Expend	3,514	-19	-16
International Expend	1,842	-37	-27
Overnight Expend	7,452	-18	-14
Tourism+Day Expend	10,920	-13	-10

In addition, tourism markets are segmented and the income elasticity (in the origin area) for short-haul tourist trips is much smaller than the income elasticity for long-haul tourist trips.

Years

1980-2003

Origin Destination

Japan New Zealand

Japan Taiwan

Income
Elasticity

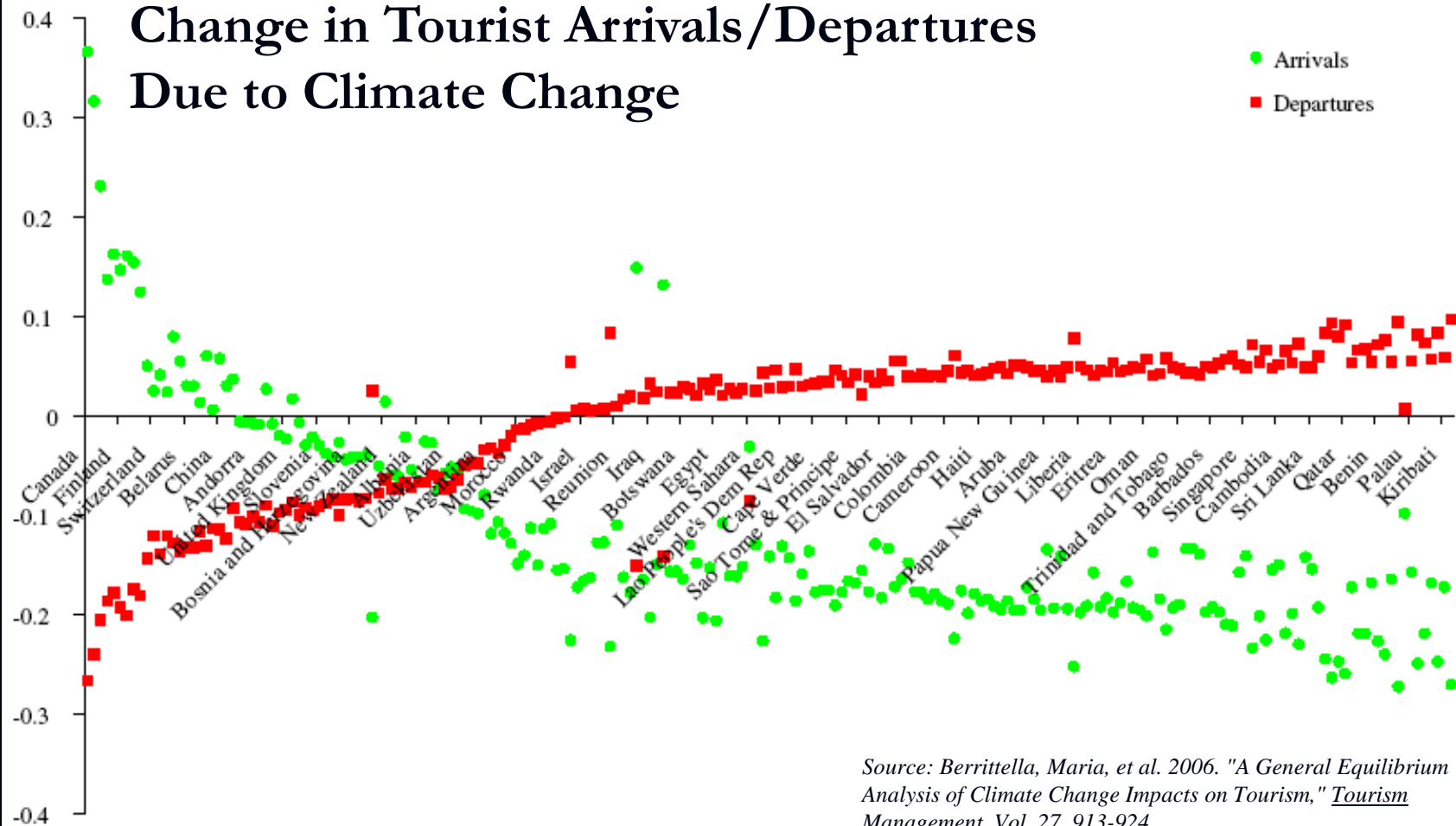
2.60

1.20



Source: Lim, Christine, et al. 2008. "Modeling Income Effects on Long and Short Haul International Travel from Japan," Tourism Management. Vol. 29, 1099-1109.

Change in Tourist Arrivals/Departures Due to Climate Change



Source: Berritella, Maria, et al. 2006. "A General Equilibrium Analysis of Climate Change Impacts on Tourism," *Tourism Management*, Vol. 27, 913-924.

The Change in arrivals and departures due to climate change as a percentage of arrivals and departures without climate change. Countries shown in rank order of mean annual temperature, 1961 - 1990.

Canadian Rockies

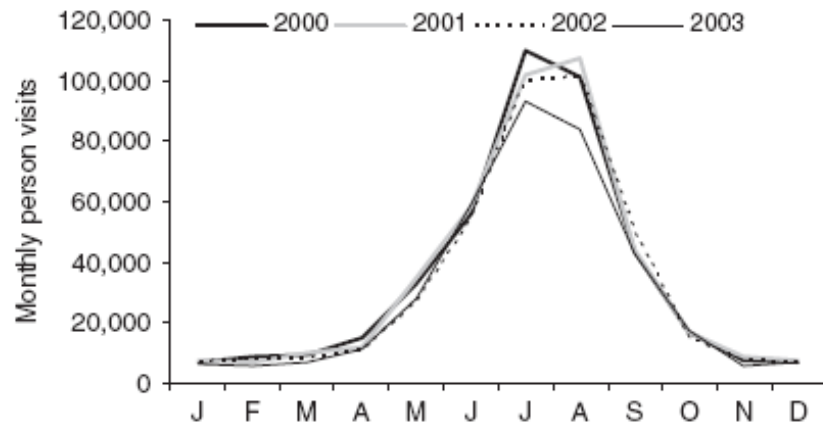
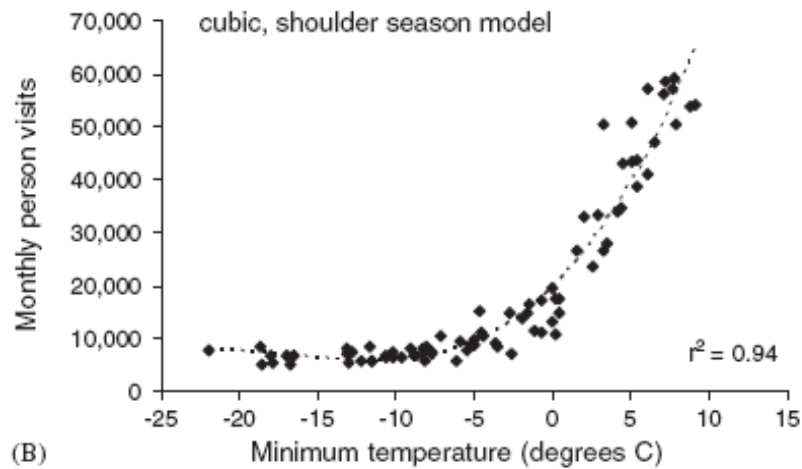


Fig. 2. WLNP visitation, 2000–2003.



(B)

So, the effect of warmer temperatures would yield an increase in visitorship of 10 - 36%.

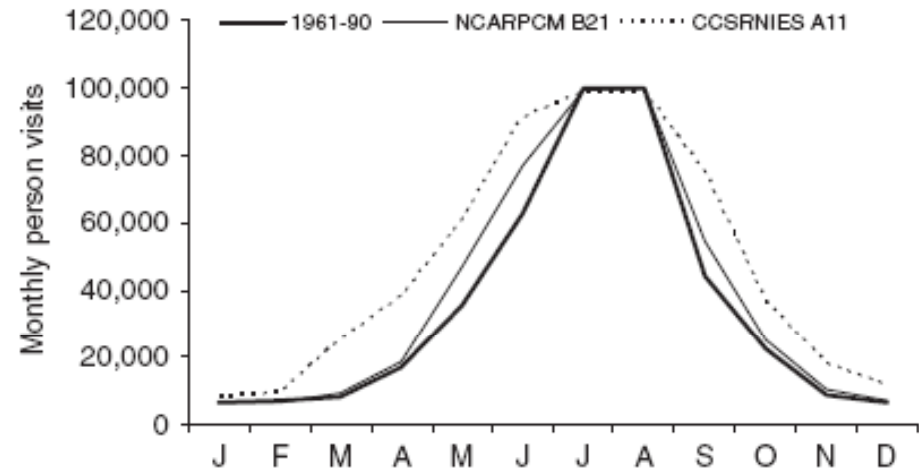


Fig. 4. Projected changes in seasonality in WLNP under climate change (2050s).

Source: Daniel Scott et al. 2007. "Implications of Climate Change for Nature-Based Tourism in the Canadian Rocky Mountains," *Tourism Management*, Vol. 28, 570-579.

Climate Impacts on Transportation Operations and Infrastructure

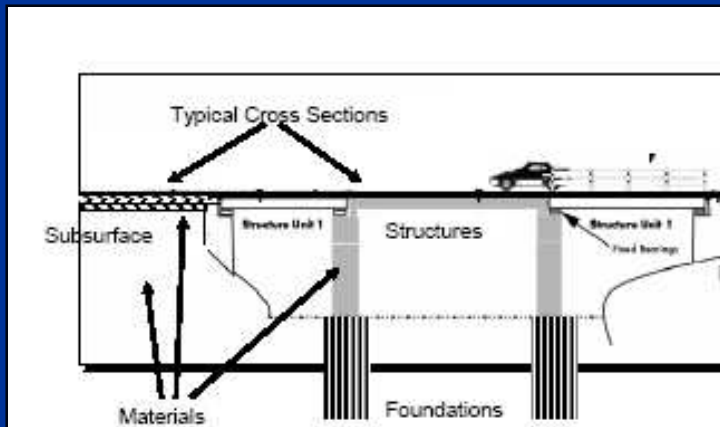
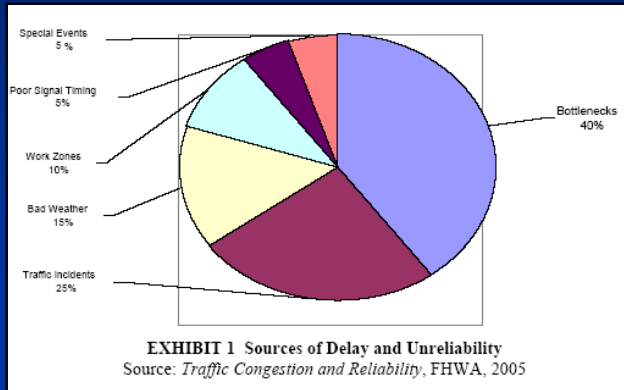


FIGURE 1 Critical components of infrastructure design.

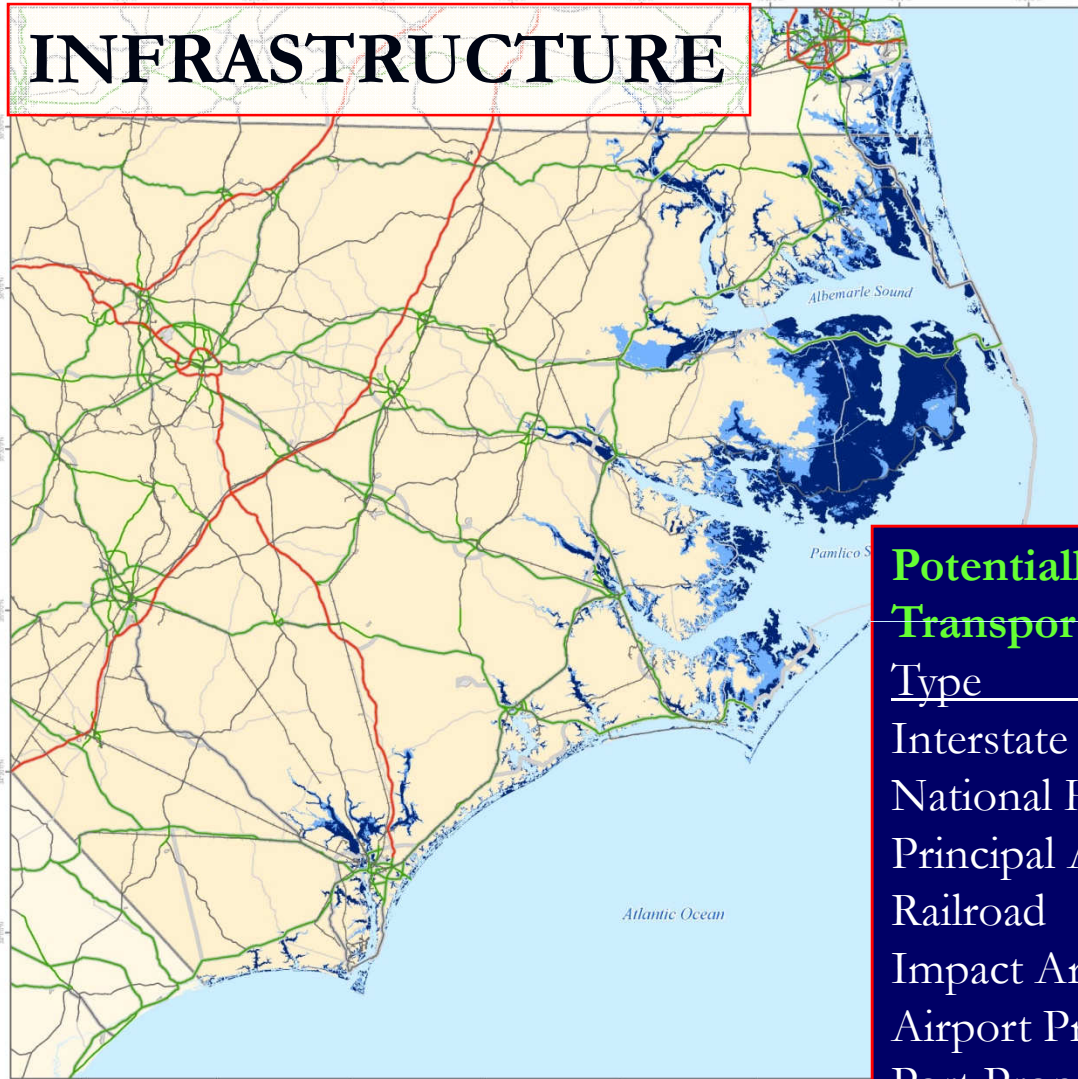
Exhibit A: Principal Climate Impacts on Operations		
Climate-Related Road Weather Variables	Roadway Impacts	Operational Impacts
Air temperature and humidity	<ul style="list-style-type: none"> • Contribution to snow and icing • Freeze/thaw cycle impacts on pavement smoothness 	<ul style="list-style-type: none"> • Traffic speed
Wind speed	<ul style="list-style-type: none"> • Visibility • Lane obstruction • Major storm disruption • Appurtenance damage • Structural damage 	<ul style="list-style-type: none"> • Travel speed and delay • Accident risk • Road closure
Rainfall	<ul style="list-style-type: none"> • Visibility distance • Pavement friction • Lane obstruction and submersion • Landslides and scour • Structural damage 	<ul style="list-style-type: none"> • Roadway capacity • Travel speed and delay • Accident risk • Road closure
Sleet/Snow	<ul style="list-style-type: none"> • Visibility distance • Pavement friction • Lane obstruction • Avalanche risk • Appurtenance damage 	
Fog	<ul style="list-style-type: none"> • Visibility distance 	<ul style="list-style-type: none"> • Speed variance • Travel time delay • Accident risk
Sea level	<ul style="list-style-type: none"> • Lane submersion • Structural damage 	<ul style="list-style-type: none"> • Traffic speed • Travel time delay • Accident risk • Road closure

Source: U.S. DOT. Center for Climate Change and Environmental Forecasting, 2008.

Eustatic Sea
Level Rise: 59 cm

State of North Carolina
Regularly Inundated Areas, At-Risk Areas and Affected Transportation Infrastructure

INFRASTRUCTURE



- Regularly Inundated Area
- At-Risk Area
- Airport Property
- Ports Property Area
- Interstate Highway
- Non-Interstate Principal Arterial
- Minor Arterial
- NHS (indicated by background)
- Railroad

Potentially Impacted Transportation Network Type	Inundated At-Risk	
	Length (km)	
Interstate Highways	0.3	0.5
Non-Interstate Principal Arterials	59.5	70.7
Minor Arterials	95.7	115.3
National Highway System Routes	134.7	170.7
Other Transportation Types (km)		
Railroads	28.9	76.6
Potentially Impacted Land Area (acres)		
Total Impacted Area	1,144,709	691,357
Airport Property Area	257	816
Airport Runway Area	2	65
Port Property Area	54	163

Notes:
 The methodologies and source data used to generate these maps are discussed in The National Academy of Sciences' report on Transportation Infrastructure, Study Group, Methodology, and Recommendations. This report also sets summary standards for the transportation infrastructure affected according to this analysis. These maps are presented as an overview of areas that, without protection, may regularly be inundated or may be at-risk of periodic inundation due to storm surges, using the methodologies used in this study. These maps are not intended for navigational or engineering purposes, and are meant to provide a rough idea of the areas and transportation facilities that might be affected under the scenarios and methodologies used in this study.
Warnings: Sea level rise data is the change in sea level caused by any combination of the various worldwides, primarily due to thermal expansion and ice melt.
Source: Interstates, Non-Interstate Principal Arterials, Minor Arterials, and NHS - National Highway Planning Network; Ports - Federal Railroad Administration; Runways - Engineers from Digital Orthophoto Quads clipped to the main high water line; Airport Property and Runways - The Atlas; Coordinates System: UTM 18 N - North American Datum 1983
 Scale: 1:910,000
 0 10 20 30 40 50 Kilometers
 0 10 20 30 40 50 60 Miles

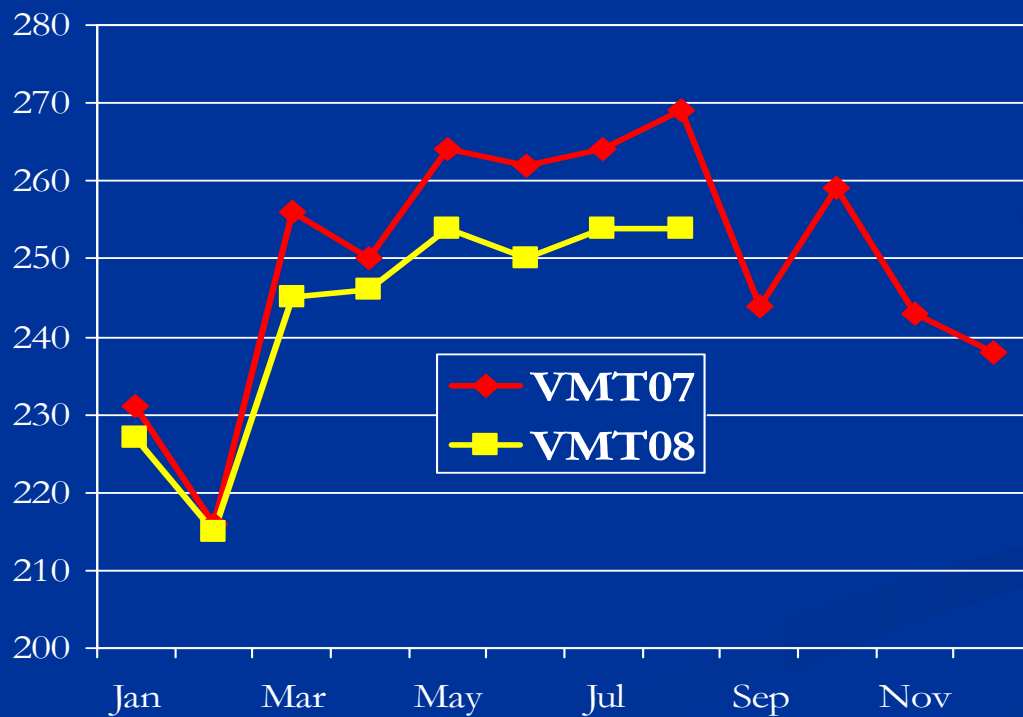
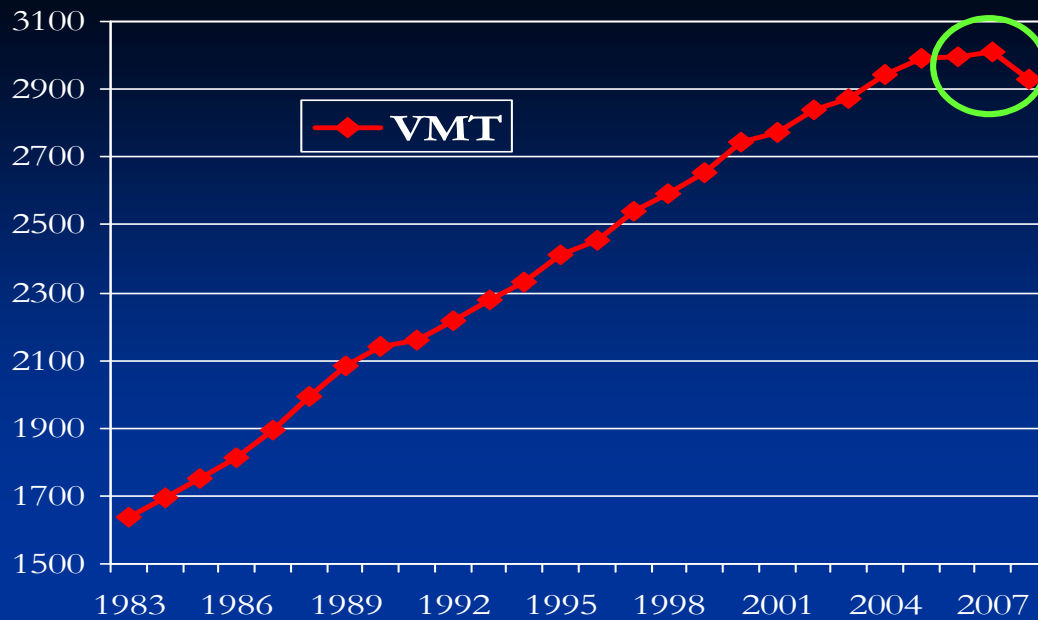


Source: U.S. DOT. Center for Climate Change and Environmental Forecasting. 2008. "The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure."

Potentially Impacted Transportation Network

Type	Inundated	At Risk
Interstate Highway (km)	0.3	0.5
National Hwy System	134.7	170.7
Principal Arterials	59.5	70.7
Railroad	28.9	76.6
Impact Area (acres)	1,144,709	691,357
Airport Property	257	816
Port Property	54	163

Note:
Assuming Eustatic Sea Level Rise of 59 cm.

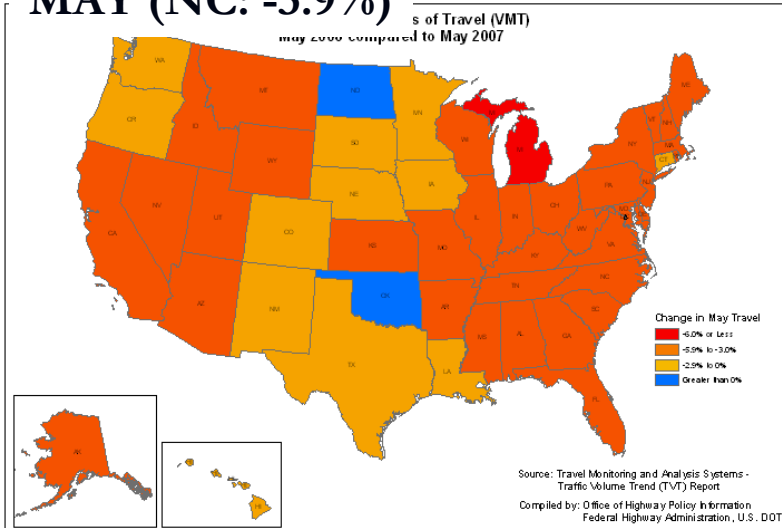


Cumulative Travel

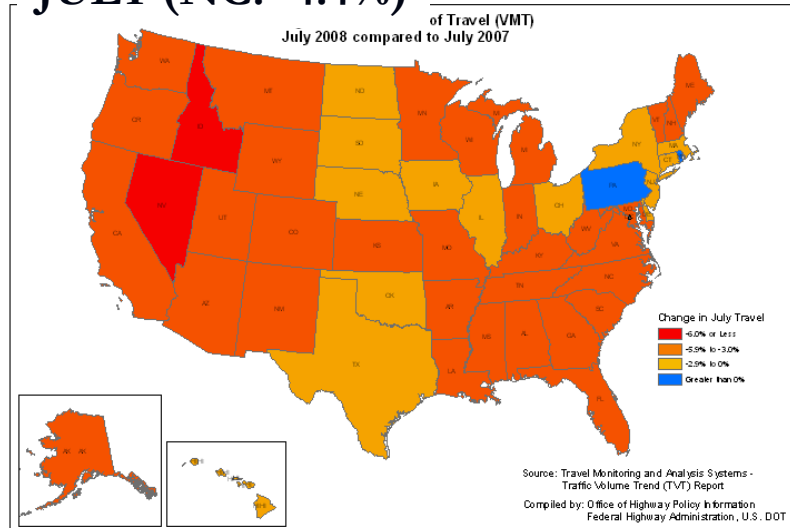
Is down
67.2 billion
miles (-3.3%)
over 2007 in
the U.S.

Source: U.S. Department of
Transportation, Federal Highway
Administration. *Traffic Volume Trends*
August 2008.

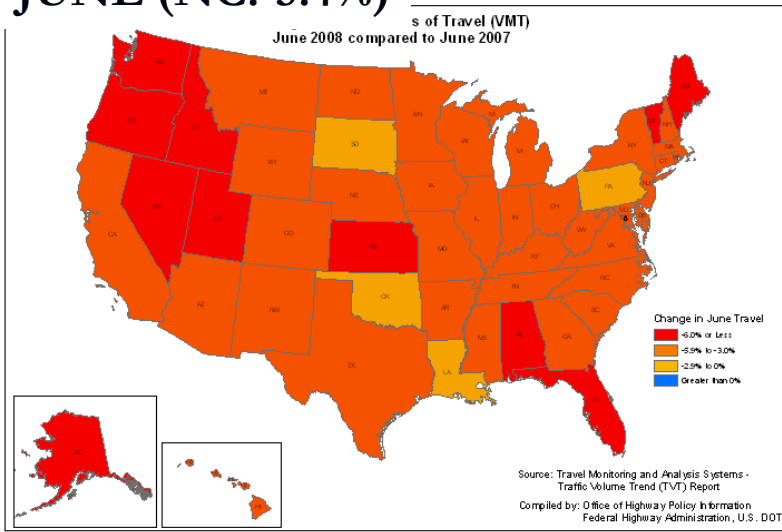
MAY (NC: -3.9%)



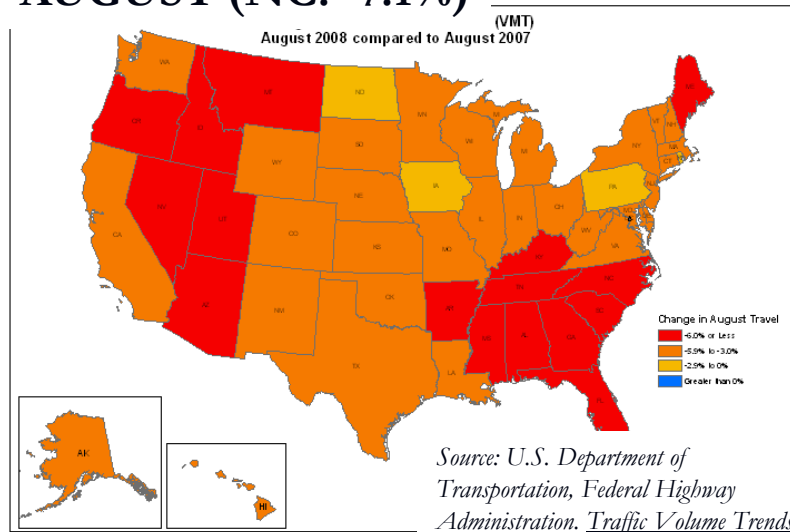
JULY (NC: -4.4%)



JUNE (NC: -5.4%)



AUGUST (NC: -7.1%)



Don't Forget to Evacuate !!

Clearance time is the interval required to clear the roadway of all vehicles evacuating in response to a hurricane. The interval begins when the first evacuating vehicle enters the road network and ends when the last vehicle reaches assumed point of safety. (Does not include time needed for officials to assemble and declare.)

$$\text{Clearance (hrs)} = \text{Mobilization Time} + \text{Travel Time} + \text{Queuing Time}$$

<u>North Coast</u>	<u>Low Occ</u>		<u>High Occ</u>	
	<u>#</u>	<u>Clear</u>	<u>#</u>	<u>Clear</u>
Dare	80,327		166,727	
Currituck	27,340		42,640	
	107,667	17.00	209,367	32.00
<u>Pamlico South</u>				
Pamlico	13,032		16,585	
Craven	54,212		57,144	
Carteret	75,576		108,224	
Jones	4,515		4,570	
	147,335	12.25	186,523	17.50

Note: FEMA identifies no fewer than 25 critical roadway segments and intersections in NC. (e.g., 64W-east of Plymouth, 264 W- west of Washington, 70- through Havelock, I-40N at I-95)

(Scenario assumed: Category 4-5 storm and "medium" response)

Some Recent Evacuation Lessons Learned

Texas (Katrina, Rita):

Evacuation of people with special needs: RUCS, statewide data base, community colleges

Fuel availability and distribution: TX DOT and Texas Oil and Gas Assoc

Traffic control: TX Dept of Safety and Border Patrol

Public awareness: Utilities and monthly billing statements

Alabama (Contraflow Plan on I-65 based on Ivan, 2004 and Dennis, 2005)

Public perception = 2.5 hours (commute time), actual = 7.5 hours

Pre-position dedicated equipment at 30 traffic control points

State troopers (at least vehicles) needed to actually clear existing traffic

Northern terminus (Montgomery) required substantial modification

Lane reversal (during Dennis) specified for 7/9 from 8:00 am to 5:00 pm

Annual exercise program

Source: US DOT, FHA. Appendix E: Best Practices, "Catastrophic Hurricane Evacuation Plan Evaluation: A Report to Congress."

Accessed (11/2008) at www.fhwa.dot.gov/reports/hurricaneevacuation/appendixe.htm