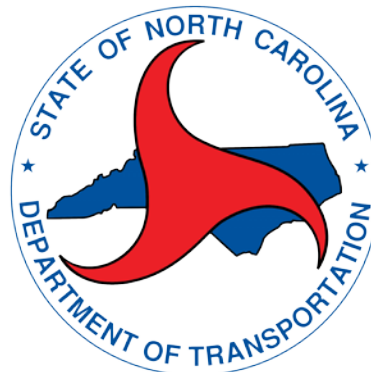# Development of network level targets and validation of construction goals in North Carolina

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Outline

- Research Objectives
- Data Collection
- Data Analysis and Results
- Conclusions and Recommendations
- Q&A

Research Objectives

- Develop a relationship between IRI values and perceived ride quality for North Carolina;

- Establish IRI limits and targets for network management and validate construction approval purposes; and

- Develop an IRI Index from 0-100 and use this index to develop IRI models.

Data Collection

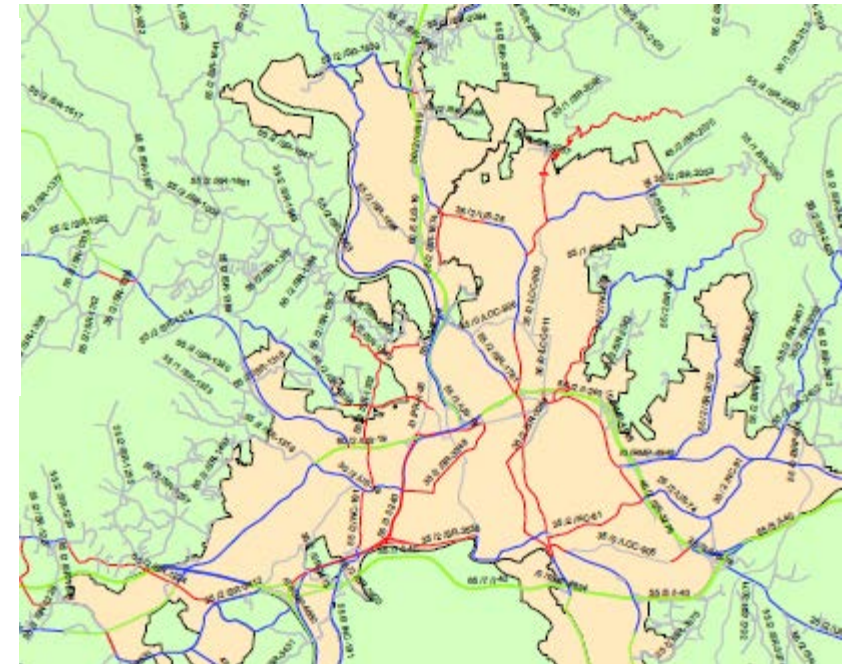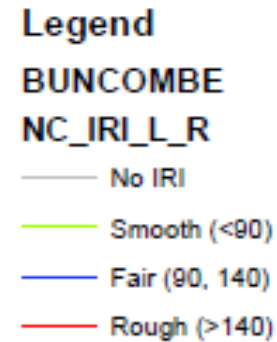# Selection of Candidate Counties
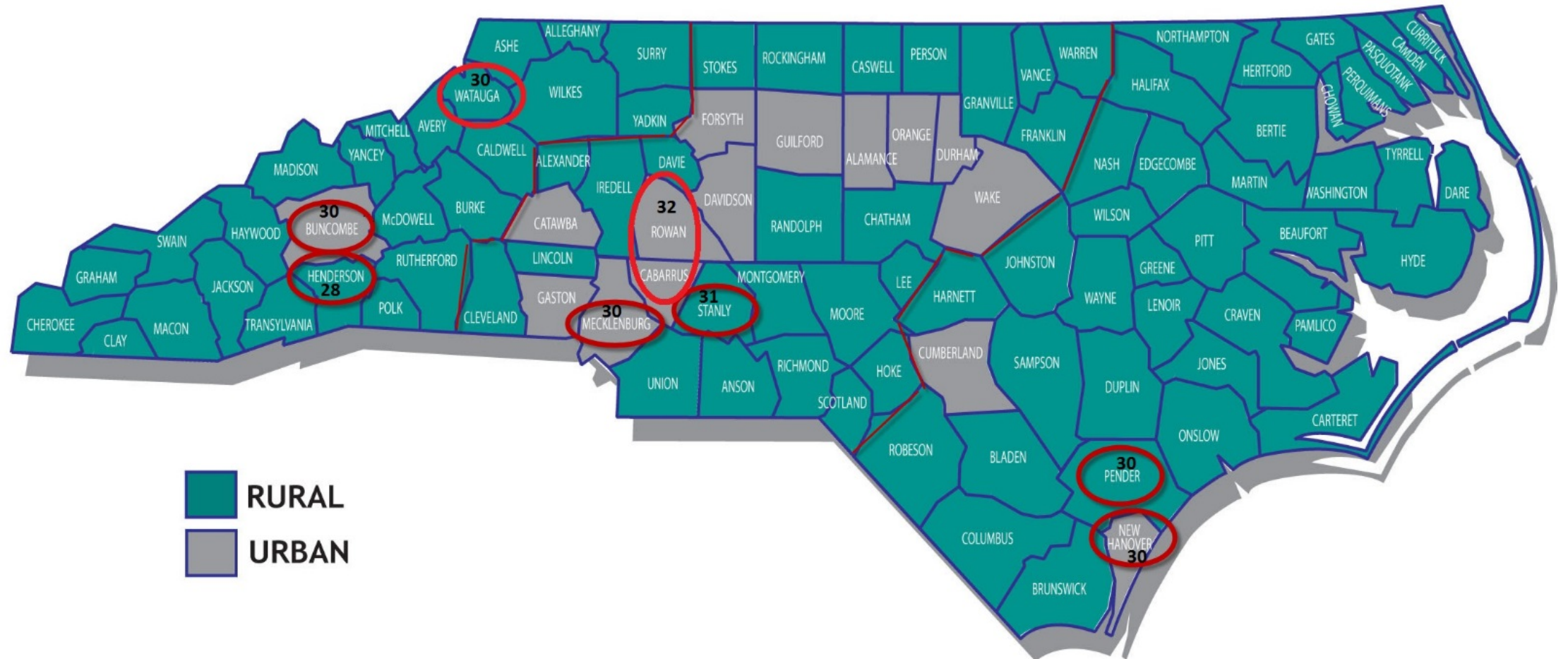
List of Selected Counties

Region	Initial Selected County	Final Selected County	Urban Loop	Rural Loop	JCP Loop
Mountains	Buncombe	Buncombe	Yes	Yes	Yes
	Henderson	Henderson	Yes	Yes	
		Watauga	Yes		
Piedmont	Mecklenburg	Cabarrus		Yes	
	Stanly	Mecklenburg	Yes		Yes
		Rowan		Yes	
		Stanly	Yes	Yes	
Coastal	New Hanover	New Hanover	Yes	Yes	
	Pender	Pender	Yes	Yes	

Selection of Candidate Roadways

Pavement Type	Pavement Smoothness	Urban Loop			Rural Loop		
		Speed Limit ≤ 35 MPH	35 ~ 55 MPH	≥ 55 MPH	≤ 35 MPH	35 ~ 55 MPH	≥ 55 MPH
Flexible (ASP)	Smooth (IRI < 90 in/mile)	✔	✔	✔	✔	✔	✔
	Rough (IRI > 140 in/mile)	✔	✔	✔	✔	✔	✔
JCP	Smooth (IRI < 90 in/mile)			✔			✔
	Rough (IRI > 140 in/mile)			✔			✔

A total of 3,539 observations (ASP: 3,073 (87%), JCP: 466 (13%)) were collected in this study.

Selection of Candidate Roadways

BUNCOMBE COUNTY

Legend
BUNCOMBE
NC_IRI_L_R
— No IRI
— Smooth (<90)
— Fair (90, 140)
— Rough (>140)

NCDOT collected "fresh IRI data" right before surveys using line lasers.
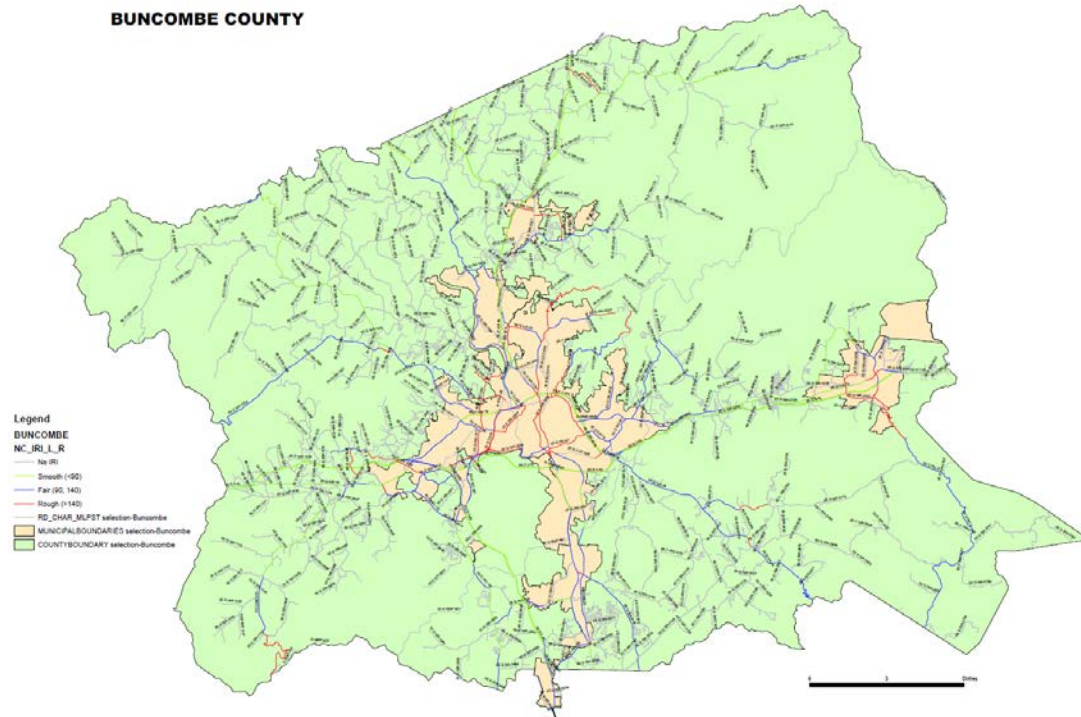
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Recruitment of Research Participants

Phone Interview

VS.

Face-to-face Interview

A total of 241 individuals participated

Region	Final Selected County	Number of Participants
Mountains	Buncombe	30
	Henderson	28
	Watauga	30
Piedmont	Cabarrus	32*
	Mecklenburg	30
	Rowan	32*
	Stanly	31
Coastal	New Hanover	30
	Pender	30

* A total of 32 individuals were recruited from Cabarrus and Rowan county

Survey Data Collection

- Planning and preparation
- The Surveys (10:00 A.M., 12:00 P.M., and 2:00 P.M on Saturdays)

Survey Data Collection

- Roadway information

- Seating positions

- Numerical ratings (0~5)

- Categorical ratings (Acceptable, Unacceptable)

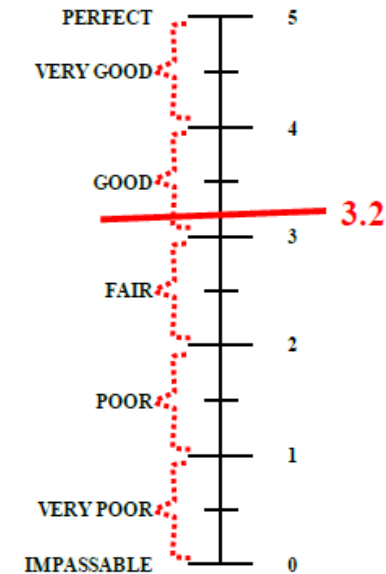# Data Analysis and Results

Quality of Survey Data

Loop	Time Slot	Van	Kendall's W	Chi-SQ	DF	P-value
Buncombe County_ Asphalt Urban Loop	10:00 A.M.	PL 7631	0.4043	6.0700	3	0.1085
		PL 7780	0.3209	4.8135	3	0.1859
	12:00 P.M.	PL 7631	0.6893*	10.2245	3	0.0168**
		PL 7780	0.6653*	9.9795	3	0.0187**
	2:00 P.M.	PL 7631	0.6553*	9.8297	3	0.0201**
		PL 7780	0.6408*	9.6122	3	0.0222**

- 65 out of 88 Kendall's W coefficients are larger than 0.5 and also have a p-value that is less than 0.025

- 74% of participants agreed with each other when assessing the same roadway sections

- The quality of the survey (categorical) data was satisfactory.

Factors potentially affecting perceived ride quality

All factors included in the analysis

- IRI: IRI values measured by the NCDOT;

- Van: Two UNC Charlotte vans used for surveys (plate numbers are PL 7631 and PL 7780);

- Region: three regions in North Carolina – Mountains, Piedmont, and Coastal;

- UrbanRuralJCP: type of roadway loops – ASP urban, ASP rural, and JCP;

- SeatingPosition: participants' seating positions in the van – 1 through 6;

- SpeedLimit: speed limits of selected roadway sections: 30, 35, 45, 55, 60, 65, or 70 MPH.

Influential factors

- IRI
- Seating Position
- Speed Limit

Factors affecting perceived ride quality (Acceptable/Unacceptable) – conclusions

- Roadways that had greater measured IRI values and higher speed limits were more likely to be rated as "Unacceptable".

- Participants seating in positions 1, 3, and 5 (window positions) were more likely to rate roadways favorably.

- Participants' ratings were not affected by the two vehicles used by this research project.

- The regions in North Carolina did not significantly affect participants' ratings.

- Asphalt (urban and rural) sections were more likely to be rated as "Acceptable" than JCP sections.

- JCP sample sizes were small and not representative.

Determination of Smoothness Targets Using "Acceptable" Categorical Ratings
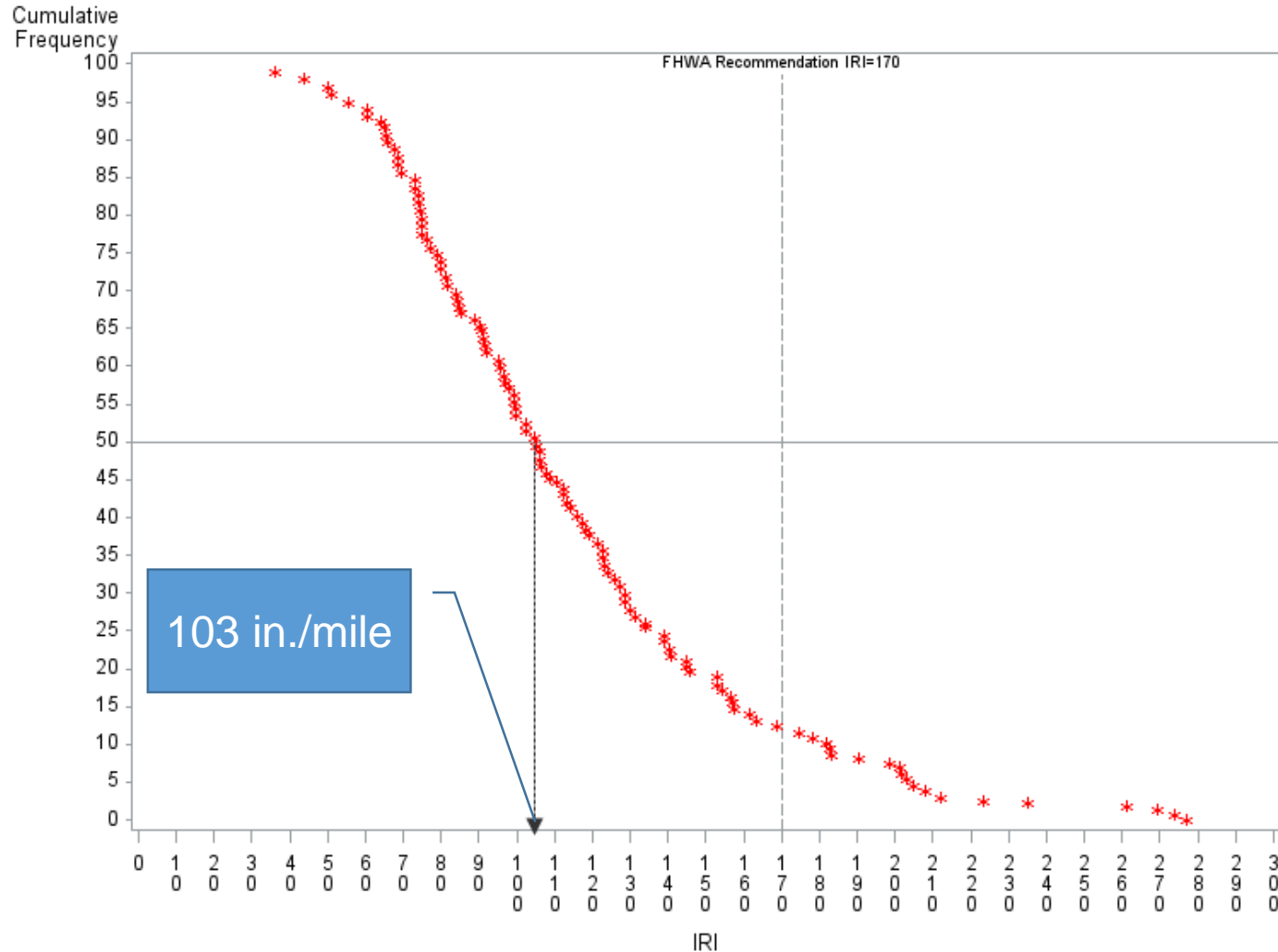
Cumulative Percentage of "Acceptable"	IRI Threshold (inch/mile)	Cumulative Percentage of "Acceptable"	IRI Threshold (inch/mile)
100%	35	45%	110
95%	55	40%	117
90%	65	35%	123
85%	70	30%	129
80%	75	25%	137
75%	78	20%	146
70%	83	15%	158
65%	91	10%	182
60%	95	5%	203
55%	100	0%	278
50%	103		

Determination of Smoothness Targets Using "Unacceptable" Categorical Ratings
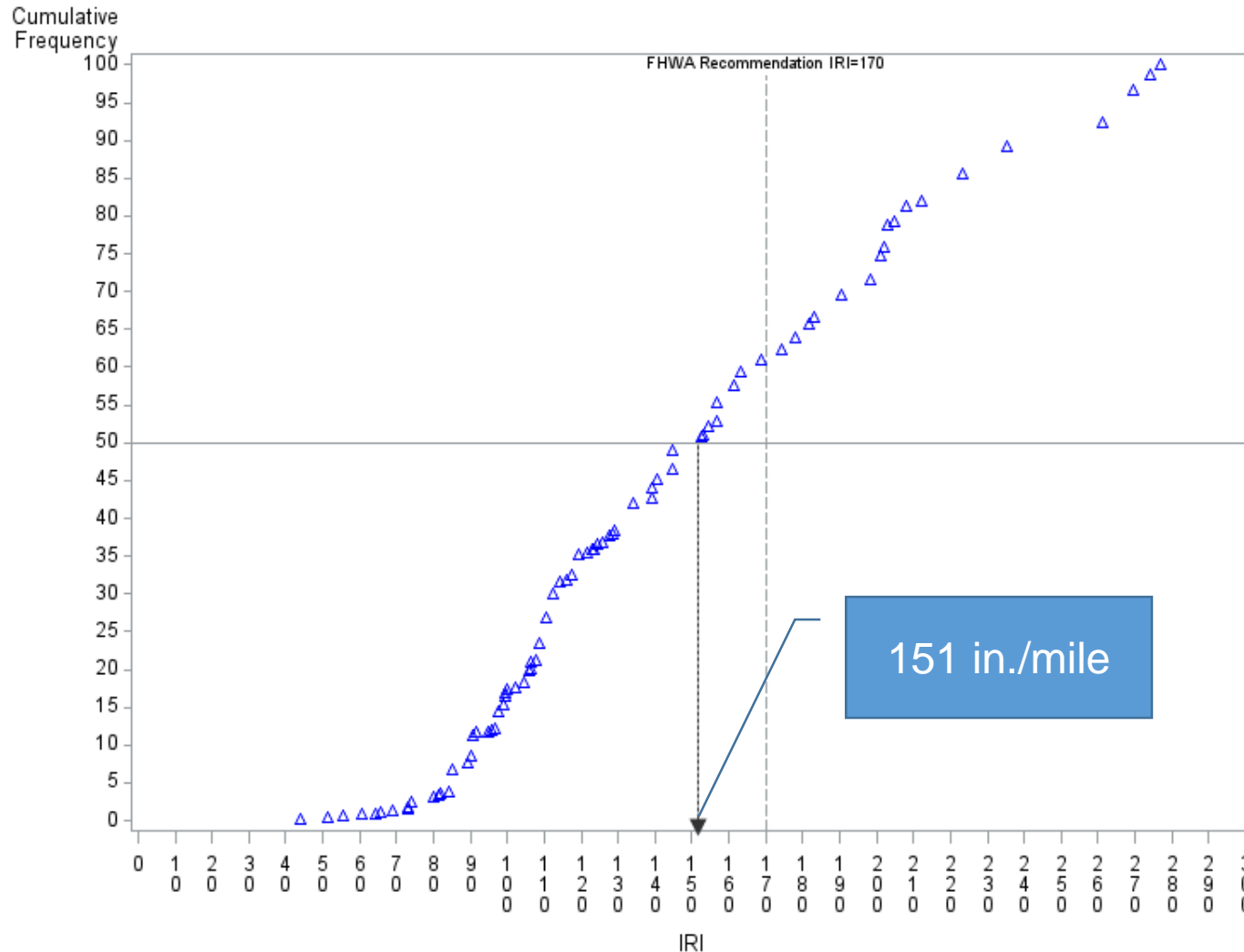
Acceptable Ride Threshold by Region, Pavement Type and Location (Categorical Ratings)

Region	Pavement Type	IRI Threshold for "Acceptable" (inch/mile)
Mountains	ASP	< 113
	JCP*	< 50
Piedmont	ASP	< 106
	JCP*	< 86
Coastal	ASP	< 113
	JCP*	N/A

Pavement Type	Location	IRI Threshold for "Acceptable" (inch/mile)
ASP	Urban	< 110
	Rural	< 106
JCP	Urban & Rural*	< 77

* JCP sample sizes were too small to draw informative conclusions.

Development of the IRI Index

- Use the conditions obtained from analyses of categorical ratings
  - When IRI = 55 inches/mile, IRI Index value = 100 (perfect condition); and
  - When IRI = 203 inches/mile, IRI Index value = 0 (impassible/very unacceptable condition).

- The equation to calculate the IRI index is:

$$IRI\_IDX = 137.162162 - 0.675676 * IRI$$

- This equation is used to calculate IRI index values for the historic PMS data.
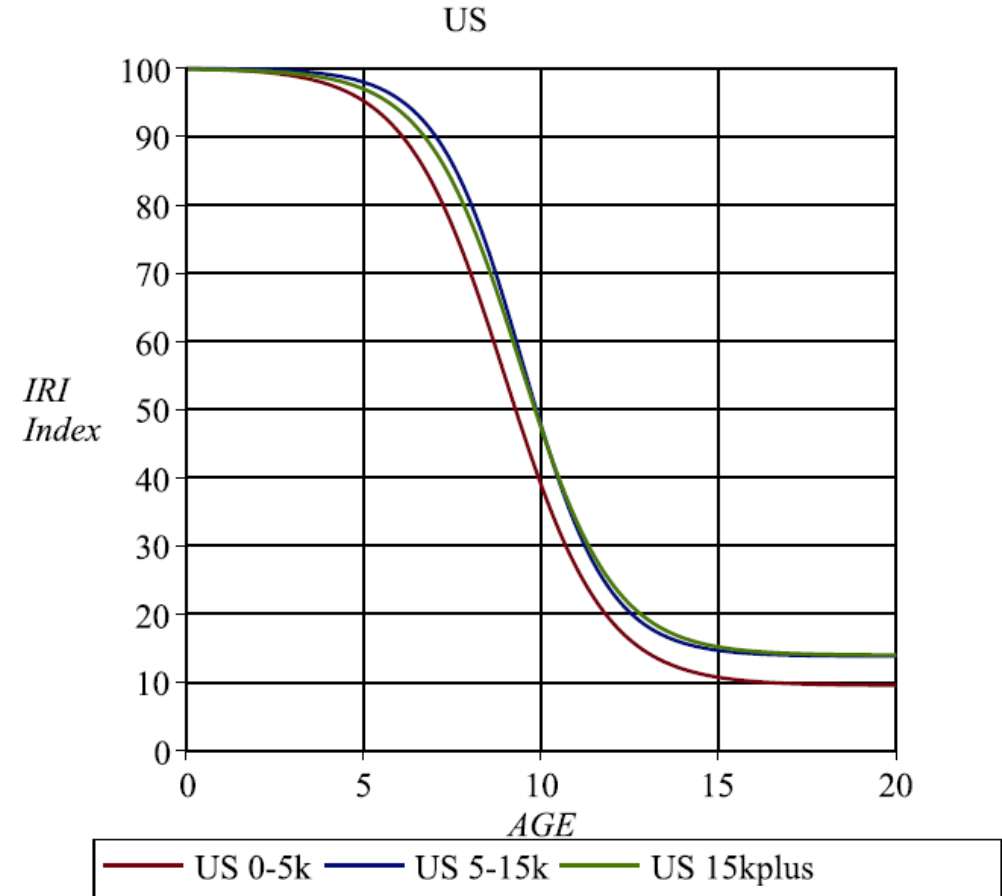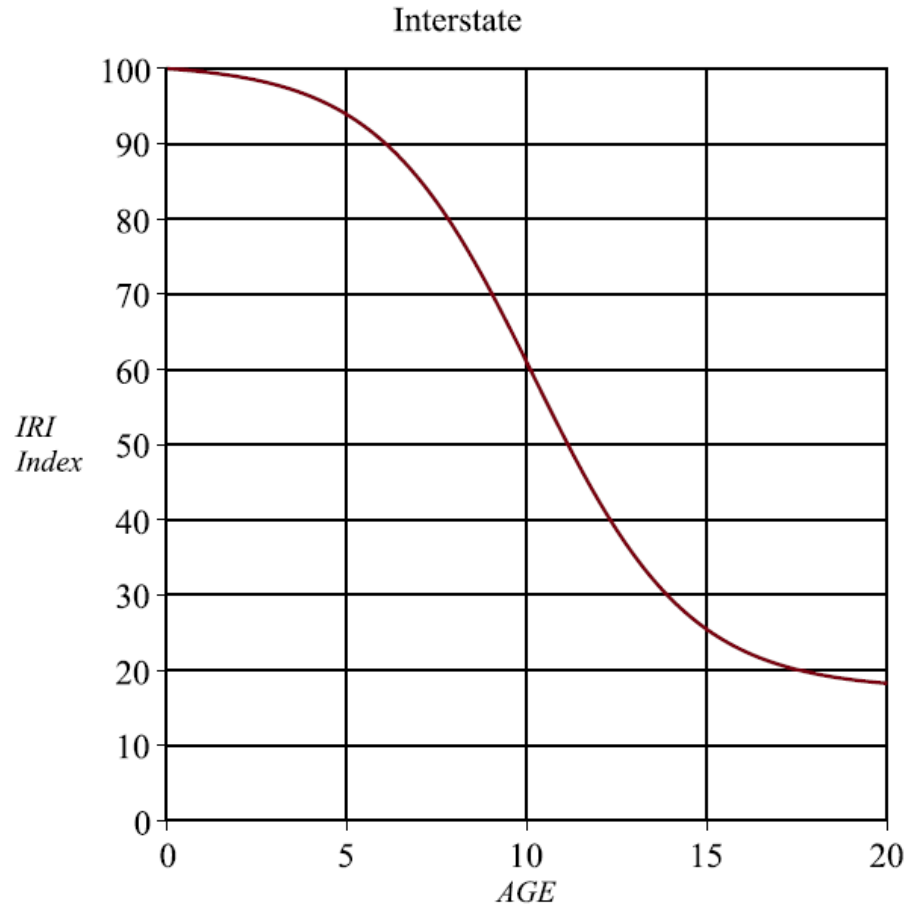
Development of IRI PMS Index Models

- The nonlinear sigmoidal model form was used:

$$IRI\_IDX = a + \frac{b}{1+e^{-\frac{(AGE-c)}{d}}}$$

Family	a	b	c	d
Interstate	17.4005	83.2975	10.2039	-2.1468
US 0-5k	9.5364	90.6060	8.9859	-1.3923
US 5-15k	13.8097	86.2227	9.4789	-1.2021
US 15kplus	13.9738	85.9696	9.4014	-1.3182
NC 0-1k	12.2099	93.1391	8.9980	-3.2134
NC 1-5k	10.8656	89.7020	10.6332	-2.1029
NC 5kplus	3.6272	97.1205	8.8690	-1.8804
SR	0.9845	99.3379	7.7592	-1.3565

Development of IRI PMS Index Models

Development of IRI PMS Index Models
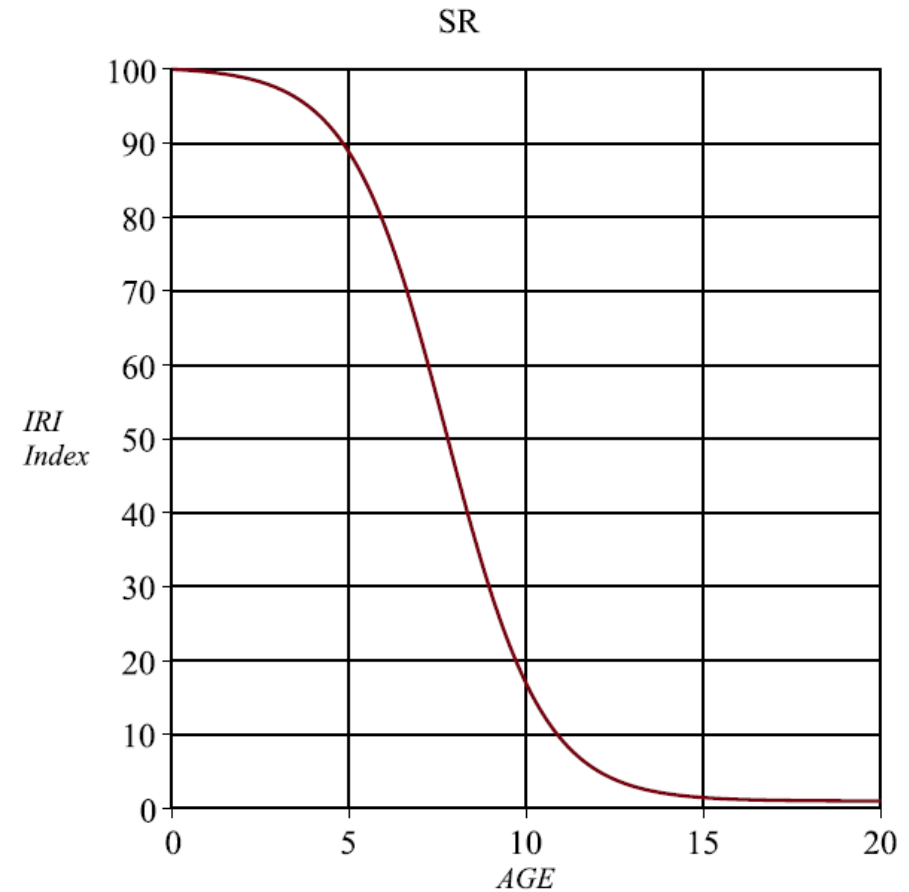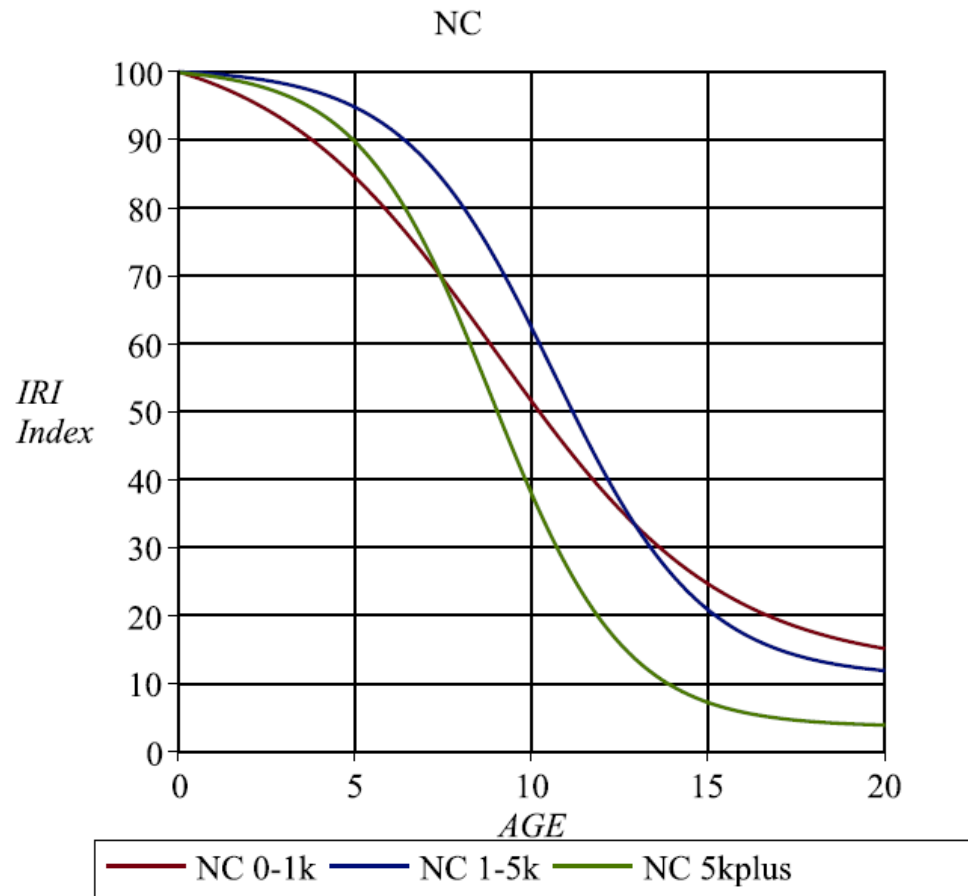
Conclusions and Recommendations

Conclusions

- The quality of collected public perceived ride quality ratings was satisfactory.

- Roadways that had greater measured IRI values and higher speed limits were more likely to be rated as "Unacceptable".

- Participants seating in positions 1, 3, and 5 (window positions) were more likely to rate roadways favorably.

Conclusions

- Participants' ratings were not affected by the two vehicles used by this research project.

- Statistical analysis indicated that the regions in North Carolina did not significantly affect participants' ratings. It appeared that participants in different regions tended to rate familiar roadways in a very similar manner.

- It was unexpected that pavement types (ASP urban, ASP rural, and JCP) were not a significant factor. Most likely this was caused by the rather small numbers of ratings collected from JCP sections.

Conclusions

- In North Carolina, if the measured IRI value of a roadway section is less than 103 inches/mile, most likely this section would be rated as "Acceptable" by the general driving public.

- Most likely a roadway would be rated as "Unacceptable" if its measured IRI value is greater than 151 inches/mile.

Conclusions

- The target initial IRI value for a new construction project was determined to be between 60 and 70 inches/mile.

- For a "perfect" roadway section, its IRI value was determined to be between 50 and 60 inches/mile.

- If the IRI value is greater than 200 inches/mile, the roadway section is considered as "Very Unacceptable".

Conclusions

- It should be noted that the results from the JCP sections are not sufficient to draw explicit conclusions because of the limited number of JCP sections that were surveyed in this study.

Recommendations

- It is recommended that the developed IRI models to be included in the NCDOT treatment decision-making process for increased PMS performance. A separate branch can be developed using these models and added to the decision tree. IRI trigger values should be determined to suggest appropriate treatments.

- It is recommended that further JCP sections be studied to validate smoothness targets.

Recommendations

- The following data collection methods have proven to be effective in this research project, and are recommended for future studies in this research area:
    - The face-to-face recruiting method is more effective than phone calls.

    - Need to over-recruit participants to avoid "no-shows" to ensure that the appropriate sample sizes and statistical significance are met.

    - One survey loop took approximately 2 hours to complete. Thus, locations of survey loops should be close to one another to prevent logistical challenges.

Thanks!