N.H. Sea Grant Research Project Progress Report  
For time period 2/1/14 – 1/31/15

**Today's date:** February 24, 2015

**Project number:** R/RCE-2

**Project title:** Climate adaptation for road infrastructure in coastal N.H.

**Project initiation date:** 9/1/2014

**Project completion date:** 8/31/2016

**Principal investigator:** Jo Sias Daniel

**Affiliation:** UNH

**Associate investigator(s) and affiliation(s):**
Jennifer Jacobs, UNH  
Paul Kirshen, UNH

**Technician(s) and affiliation(s):** none

**Partner(s) and affiliation(s) (List any collaborators, sponsors, industry partners, municipalities, etc., associated with this project):**

**NOTE:** For each partner, include SCALE (local, state, regional, national, international) and TYPE (gov’t, NGO, industry/business, academic institution, other)

The following partners were identified during the development of the proposal. The research team expects more partners to be added as the project progresses.

**Towns of Seabrook & Portsmouth:**
   Public Works Director  
   Deputy City Manager  
   Julia Peterson – Coastal Adaptation Workgroup  
   Dr. Charlie Goodspeed – UNH Technology Transfer Center

**Brief project overview/Abstract:**
This New Hampshire Sea Grant project will further the mission of resilient seacoast communities by the coupling of nonstationary climate change and sea level rise information with pavement design and performance methods to inform vulnerability assessments and adaptation planning. The motivation for this work is that the region’s physical infrastructure is at increasing and critical risk from climate-driven stressors due to both ambient and periodic extremes in precipitation and temperature, as well as from sea level rise resulting in increased inundation and rising groundwater tables. Anticipated changes could change the frequency, duration, and
severity of road failures as well as the time and cost of reconstructing the pavement systems. Climate change and sea level rise pose challenges that have been broadly recognized by the road engineering community. However, relatively few infrastructure researchers, let alone municipalities, incorporate climate change impacts on roads into their work due to significant knowledge and data barriers. Thus this work has implications across the Northeast as well as nationally.

This research will develop the data and tools needed to assess climate impacts on roadways and create and engage a new NH Seacoast Transportation Climate Working Group to make the results readily useable by regional stakeholders. This will be accomplished by (1) developing and engaging a NH seacoast transportation climate working group, (2) conducting pavement assessments, and (3) evaluating different adaptation strategies. The NH seacoast region’s municipal and state road agents are our primary end users and regional planners are our secondary end user community. The PIs will work with established organizations, UNH Technology Transfer Center and Coastal Adaptation Workgroup, to reach the targeted end users. Benefits to the end users include an expanded network of collaborators and climate change transportation infrastructure impacts and adaptation knowledge appropriate for municipal planning and decision making. In addition, graduate students, undergraduates, and a high school teacher will be involved in this research.

Objectives:
The three main objectives of the research are:
  1. Develop and engage a NH Transportation Climate Change Working Group
  2. Assess the impacts from predicted climate and sea level changes on pavement design and performance
  3. Develop a method of evaluating different adaptation strategies that may be used by the stakeholder community and use it to demonstrate the value of adaptation.

Research findings/progress during 2/1/14 – 1/31/15:

Accomplishments during 2/1/14 – 1/31/15 (Accomplishments are the key actions, activities or products resulting from Sea Grant research projects. They are distinct from impacts in that they reflect ongoing activities or key results that may not yet have had a significant economic, societal and/or environmental benefit but lay the foundation for such a benefit. Accomplishments may evolve into impacts in the future.):

The research team has started a review of Federal Highway Administration (FHWA) Climate Change Resilience Pilot projects (http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/index.cfm). In these projects, agencies partner with FHWA to pilot approaches to conduct climate change and extreme weather vulnerability assessments of transportation infrastructure and to analyze options for adapting and improving resiliency. The research team is reviewing the available reports on these projects with respect to how roadways were classified and how their vulnerabilities were evaluated. A summary table of the projects that have been reviewed to date is shown in Table 1 below. The research team has discovered that the information currently available for many of the projects is very general and does not contain significant details. A brief summary of the information relevant to this project is presented in the subsections below. The research team
will continue to review available information that is generated from the FHWA pilot projects to inform the work in this project.

Table 1. FHWA Pilot Projects

<table>
<thead>
<tr>
<th>Year</th>
<th>Status</th>
<th>Location</th>
<th>Agency</th>
<th>Contact Name</th>
<th>URL</th>
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<tr>
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<td>DOT</td>
<td>Judy Gates</td>
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<td>DOT</td>
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<td>James H. Lambert</td>
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<td>TPA</td>
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<td>MPA</td>
<td>Brian Gibson</td>
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<td>MTC</td>
<td>Brenda Dix</td>
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<td>DOT</td>
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California Study
Road networks were classified into six categories: interstates/freeways and state routes; arterial, collector, and local streets, connectors to isolated neighborhoods, tunnels and tubes, toll, interstate, and state bridges, and local bridges. It defined freeway as a divided highway that features at least two lanes in each direction operating without signals, stop signs, or at-grade intersections. Generally, “arterials” have interchanges with the freeway system, while “collectors” do not; “arterials” connect between cities or form major corridors within cities, while “collectors” connect between these major corridors. Connectors to isolated neighborhoods provide the only means of vehicular access to a particular neighborhood or area. The roads were further classified by physical characteristics, functionality, jurisdiction, and socio-economic considerations. Key road segments were identified as highway and state routes; data in the form of TeleAtlas Road Network was collected from Caltrans and MTC.

Gulf Study
The primary roadway network, which was examined for this study, is fairly expansive, made up of over 644 miles (1,847 lane-miles) and approximately 630 bridges, with the network being defined by Interstates and U.S. Highways connecting the Mobile area to northern Alabama, the Florida panhandle to the east, and Mississippi and Louisiana to the west. Arterials radiate west from the downtown area to create connections to and among population and employment centers in the study area. Secondary and collector roads provide for localized travel providing access to specific subdivisions or retail/employment centers. The assessment categories for importance of the roadways were the following: locally identified priority corridors, functions as community connection, system redundancy, serves area economic centers, functional classification, usage, intermodal connectivity, identified evacuation route, component of the disaster relief and recovery plan, component of the national defense system, providers of access to health facilities. For this study, a series of segments (identified in the scoring matrix) were identified which grouped together consecutive links that were of the same functional class into a single segment. Scoring was applied to the segments, not for individual links. The methodology applied for the highway mode involved the collection and analysis of field data, GIS data, and other information provided from the SARPC and Mobile County for the purpose of generating a score for each particular column in the matrix. A summary of the methodology applied to develop results for each criterion is included on page 21-23 of the report. The analysis included
a test to determine the availability of redundant capacity of the roadway network - using the SARPC MATS model for the year 2035. This analysis was performed on a series of selected links to represent various travel patterns within the study area. While neither the scope nor the budget permitted redundancy testing of every link in the system, the project team was able to assess redundancy of certain types of links (for example, links that connect housing and commercial areas) and then extrapolate the redundancy to the other links of the same type. For information about this methodology can be found in Appendix B of the report.

**Hawaii Study**
Roadways were chosen based on geographic location or for providing access to other critical assets most susceptible to climate change as determined by a workshop summarized at the beginning of the report. Roadways were scored based on the following criteria: Societal Value of Asset, Level of Use, Degree of Redundancy, Cost to Replace, Economic Loss, Environmental Impacts, Cultural Value, Loss of Life, Recovery Time Needed.

**Maryland Study**
This study used the FHWA functional classifications to group roadways.

**Minnesota Study**
The state’s trunk highway system was the roadway network selected for analysis in each district. The trunk highway system comprises the entirety of the state owned and maintained road infrastructure and includes all interstates, US routes, and signed state roads.

**New Jersey Study**
Roads were selected in both the coastal area and central corridor of New Jersey as those regions were deemed most susceptible to sea level rise due to natural features. The criticality of roadways was determined using a GIS-based methodology, where attribute data collected during the asset inventory was used to quantitatively allocate all Congestion Management System (CMS) network roads into tiers of criticality. Although this application of the GIS tool uses only the jobs and population attributes common to each MPO’s Traffic Analysis Zone (TAZ) files. More detailed information for criticality assessment methodology can be found in Appendix A of the report on pages 123-124.

**Virginia Study**
The report looked at roadways that were on hurricane evacuation routes, carried more than 10,000 vehicles per day (AADT), were on a maintenance priority route, and were at low lying elevations.

**Tampa Study**
The roadway facilities were grouped into three categories based on roadway functional classifications identified in Tampa Bay Regional Planning Model: Interstates, arterials, and all others. The data were assembled and organized in a transportation asset geodatabase, which serves as the primary data repository, inventory management, and mapping tool. The Tampa Bay Regional Planning Model (TBRPM) roadway network data was used as the principal roadway layer, and the associated Traffic Analysis Zones provided basic socio-economic data. Selected activity centers and trip generating and/or attracting facilities (some of which are classified as special generators in the model) were also assembled. A criticality screening process was performed to focus analytical resources on transportation assets based on their relative regional
significance. This analysis involved the identification of critical areas and activity centers (destinations) as well as the transportation facilities providing access to those destinations. The project team performed a criticality screening process of the regional roadway network, leveraging the MPO’s travel demand model. Traffic analysis zones were considered as geographical units for a zone/area-based criticality determination. A relative importance of criticality of a zone or area depended on the magnitude of population, employment, and the geographical area of the zone. A combined measure of population and jobs density was used as the area-based criticality measure for analysis.

**Washington Study**
This study only looked at state highways. Classifications and criticality of roadways were determined in workshops and were not specifically explained in the report.

**Impacts during 2/1/14 – 1/31/15** (Impacts are significant economic, societal and/or environmental benefits of research.):

**NOTE:** Include quantitative data to validate the impact, if possible.

None to date

**Economic benefits realized during 2/1/14 – 1/31/15** (businesses retained or created, jobs retained or created, market and non-market economic benefits):

**NOTE:** Please quantify and provide supporting data if possible.

None to date

**Tools, technologies or information services resulting from this project that were developed or used during 2/1/14 – 1/31/15 to improve ecosystem-based management** (i.e., products that address the management of land, water and living resources in coastal areas, for example that reduce contaminants that harm coastal ecosystems and seafood consumers; that track changes in ecosystem processes, biological responses and conditions, etc.):

None to date

**Patents:** none to date

**Technology transfer** (Has a private company utilized this research successfully?): none to date

**Related grants and contracts** (Other grants and contracts that funded this research or that were obtained as a result of this research.):

None to date
**Leveraged funding** (leveraged funding comes from outside sources and is used to accomplish the goals and objectives of your project. Match associated with your project is not leveraged funding). Provide amount, source, purpose, and start and end date.

**Infrastructure and Climate Network (ICNet)**
Funded by NSF RCN SEES: Engineering Research Collaboratory for Sustainable Infrastructure in a Changing Climate, 10/1/12-9/30/16, $750,000
The research team is leveraging the lessons learned in the development of the network and climate data/products/tools that are being developed for use in this project.

**Flooded Pavement Assessment**
Funded by FHWA, 10/1/13-1/31/17, $425,000
The research team is leveraging the work being done on evaluating pavement performance during flood conditions and as the pavement system recovers after flood waters recede.

**UNH Center for Infrastructure Resilience to Climate**
Funded by UNH VPR’s office, 1/1/15-12/31/16, $200,000
The research team will be leveraging internal funds for developing a new center to engage stakeholders in this project.

**Problems encountered:** The September start date has been problematic in terms of recruiting/identifying a graduate student to begin work on this project. The preliminary work to date has been accomplished with an undergraduate student. A PhD student has been identified for this project and the PIs anticipate that this student will begin working on the project in late spring/early summer.

**Publications to date**
NOTE: Please cite and attach PDF or send a hardcopy, or provide possible title, authors, etc. and status if not yet published.

**Peer reviewed publications:**
None to date

**Theses/Dissertations:** none to date

**Other communications products (non peer-reviewed pubs, manuals, tech reports, videos, etc.):**
None to date

**Presentations during 2/1/14 – 1/31/15, with published abstract citation if applicable:**
NOTE: For presentations to civic groups, etc. (i.e., to the public rather than a scientific conference), please include number of attendees.

NH SeaGrant Symposium January 30, 2015

**Awards:** none to date
## Students Supported  *All fields are required*

<table>
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<tr>
<th>Student Name</th>
<th>Institution</th>
<th>Cont’d or New for 2014?</th>
<th>Where is he/she now?</th>
<th>Dates of support</th>
<th>Type of degree: Undergrad Master’s PhD</th>
<th>Year degree awarded</th>
<th>Title of thesis (if supported by N.H. Sea Grant)</th>
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