

Interagency Transportation, Land Use, and Climate Change Cape Cod Pilot Project

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Cape Cod Commission Action Plan

On behalf of the Federal Highway Administration



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The Interagency Transportation, Land Use, and Climate Change Pilot Project utilized a scenario planning process to develop a transportation-and land use-focused development strategy for Cape Cod, MA, that will result in a reduction in future greenhouse gas (GHG) emissions and is informed by estimated climate change impacts. The Refined scenario created will support the region's long-range transportation planning vision, as well as the development of other local, regional, and state plans.

The Federal Highway Administration (FHWA) funded the U.S. Department of Transportation (USDOT) Volpe National Transportation Systems Center (Volpe Center) to develop this document for the Cape Cod Commission. It summarizes the data, methods, and assumptions used to develop the Refined scenario, as well as opportunities to integrate the Refined scenario as it currently stands into regional and local planning processes and build upon it using CommunityViz.

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Background

Interagency Transportation, Land Use, and Climate Change Pilot Project

In 2009, the Interagency Working Group on Transportation, Land Use, and Climate Change, a group of 13 federal agencies convened by FHWA, selected Cape Cod, Massachusetts, to facilitate and enhance integrated regional and intermodal gateway mobility planning at the state, regional, and local levels. The USDOT Volpe Center began the resulting Interagency Transportation, Land Use, and Climate Change Pilot Project (Pilot Project) in early 2010 in conjunction with FHWA, the National Park Service (NPS) and the U.S. Fish and Wildlife Service (FWS). These agencies viewed the Pilot Project as an opportunity to address transportation-based GHG emissions and to consider climate change effects using scenario planning as a method for doing so. The Pilot Project resulted in a multi-agency transportation and land use development scenario for Cape Cod. This scenario was developed through a process of data collection, scenario development by a consultant and by regional and local government representatives during a workshop, and scenario assessment and refinement.

Process

The following sections discuss the process through which the Pilot Project's preliminary, workshop, and Refined scenarios were developed and evaluated, including the selection of performance indicators.

Performance Indicator Selection

Prior to bringing in a consultant, the project's planning group identified desired performance indicators by which the scenarios developed as part of the pilot project must be compared. Accordingly, the request for proposals (RFP) through which the consultant was selected specified five key performance indicators:

- GHG emissions,
- Transport energy use,
- Congestion and vehicle miles traveled,
- Cost to implement the scenario, and
- Preservation of natural/existing ecosystems.

As part of its response to the RFP, the consultant provided the Pilot Project's planning group with a list of over 60 possible indicators for use in the project's scenario planning model, including indicators that matched those in the RFP.

To identify a shorter list of key indicators, the consultant scored the indicators on a scale of 1 to 5 according to its evaluation of each indicator's importance to the project and provided notes on data dependencies (see Appendix A: Full List of Performance Indicators, Data Dependencies, and Importance Ratings). This list was distributed to the planning group and technical committee to provide an opportunity for their review and comment on the priority scores. Nine project team members offered responses. The Volpe Center team reviewed and then averaged

the responses received and compared those averages with PlaceMatters' scores to identify any significant differences.

The project team and PlaceMatters ultimately selected the following indicators based on their relevance to the Pilot Project, the data available, and their sensitivity to changes in development patterns. These indicators were used for comparing the trend scenario, four preliminary scenarios, the four scenarios created by small groups at the workshop, and the final refined scenario, which are discussed below.

- GHG emissions
 - Percent change in GHG emissions
- Transport energy use
 - Fuel usage (cars/light trucks)
- Vehicle miles traveled (VMT)
 - Regional percent change in peak VMT
- Preservation of natural/existing ecosystems
 - Percent of new population in priority habitats
 - Percent land area developed (from previously undeveloped or rural)
 - Percent of new population in undeveloped or rural lands
 - Percent of new population in other high priority conservation areas
- Impact on other areas
 - Percent of new population in historic preservation areas
 - Percent of new population in water resource/wellhead protection areas and percent of new population in such areas with less than 3 dwelling units per acre
- Percent of new population in vulnerable areas, which include all areas within the Federal Emergency Management Administration (FEMA) Flood Insurance Rate Map risk areas as well as areas identified by an expert elicitation conducted for this study
- Accessibility indicators
 - New population served by transit (percent new population)
 - New employees served by transit (percent of new employment)

Cost to implement the scenario was not selected as an indicator due to several factors, including the nature of the project, lack of sufficient data, and the inability to model specific GHG emission strategies. Because the Pilot Project focused on the process by which development and transportation investment decisions are made at the regional level, the project was not at a scale where the cost for specific capital or operation projects could be estimated.

Preliminary Scenarios

In preparation for a stakeholder workshop, a consultant team from PlaceMatters, Placeways, and the University of Colorado Denver Center for Sustainable Infrastructure Systems and Transportation Research Center, developed five preliminary scenarios to illustrate the impact of development patterns (trend, targeted, and dispersed) and investments in transit (standard and enhanced) using the CommunityViz Build-Out Wizard tool. The tool compared existing development captured from 2005 land use and land cover data with development capacities identified using zoning layers, residential densities and non-residential floor area ratios. Using the resulting total development capacity and rules for minimum building setbacks and

separation, the Build-Out Wizard identified $\frac{1}{4}$ square mile grid cell areas that could potentially accommodate at least 100 new employees or dwelling units. Zoning areas that could accommodate fewer than 100 of either or were designated as open space were assumed to be built-out.

Based on the potential development locations identified using the Build-Out Wizard, the consultant team developed the Trend, Targeted, and Dispersed scenarios by randomly assigning the projected housing and employment growth according to established rules. For the Trend scenario, growth patterns were not restricted but allocation of new population and employment units among the potential development locations was based on the historic distribution of development by municipality. In order to produce the Dispersed scenario, the consultant team allocated the projected new housing and employment units based on a random number algorithm. This indiscriminate placement of growth was meant to illustrate the effects of an unconstrained sprawl pattern of development.

The consultant team did not create the Targeted scenario using the potential development locations identified using the Build-Out Wizard. Instead, the Targeted scenario relied on the Land Use Vision Maps (LUVMs) that were available for eight of Cape Cod's fifteen towns, restricting growth to areas identified as economic centers and industrial and service trade areas. For the seven towns that had not finalized LUVMs, the consultant team restricted growth to existing high density residential areas and intense commercial and industrial zones, as identified in town zoning maps. The Trend, Dispersed, and Targeted scenarios are depicted in Figure 1 below.

The consultant team created two versions of both the Targeted and Dispersed scenarios to document the difference between the standard transit system and an enhanced transit system in terms of their impact on the region's GHG emissions. The standard transit system for both scenarios included all existing transit stops and those associated with a planned Bourne-Sandwich bus route and commuter rail service serving Harwich from Boston, both of which were assumed to be completed by 2030 (Appendix B of the *Technical Scenario Report* lists all transit stops included in the standard system). The enhanced transit system built upon the standard system to include service of densely populated areas under each scenario. The enhanced transit system included eight additional stops under the Dispersed scenario and six new stops under the Targeted scenario. The Standard and the additional stops associated with both Enhanced transit systems are depicted in Figure 2 below.

Figure 1: Trend, Dispersed, and Targeted Scenarios - Change in Density from Baseline Household Density. Source: PlaceMatters and Placeways

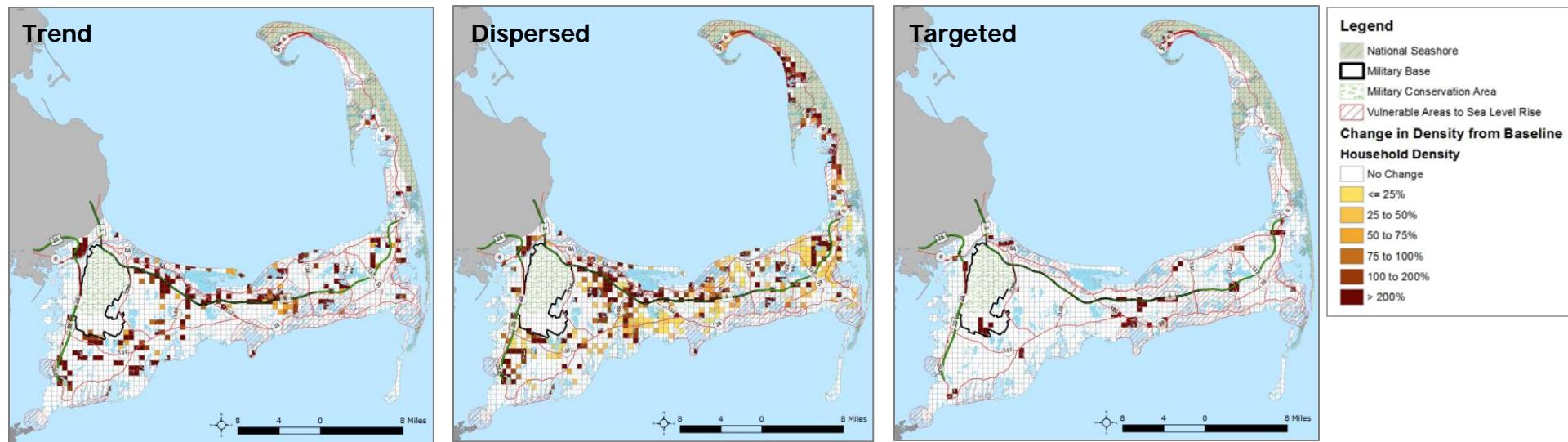
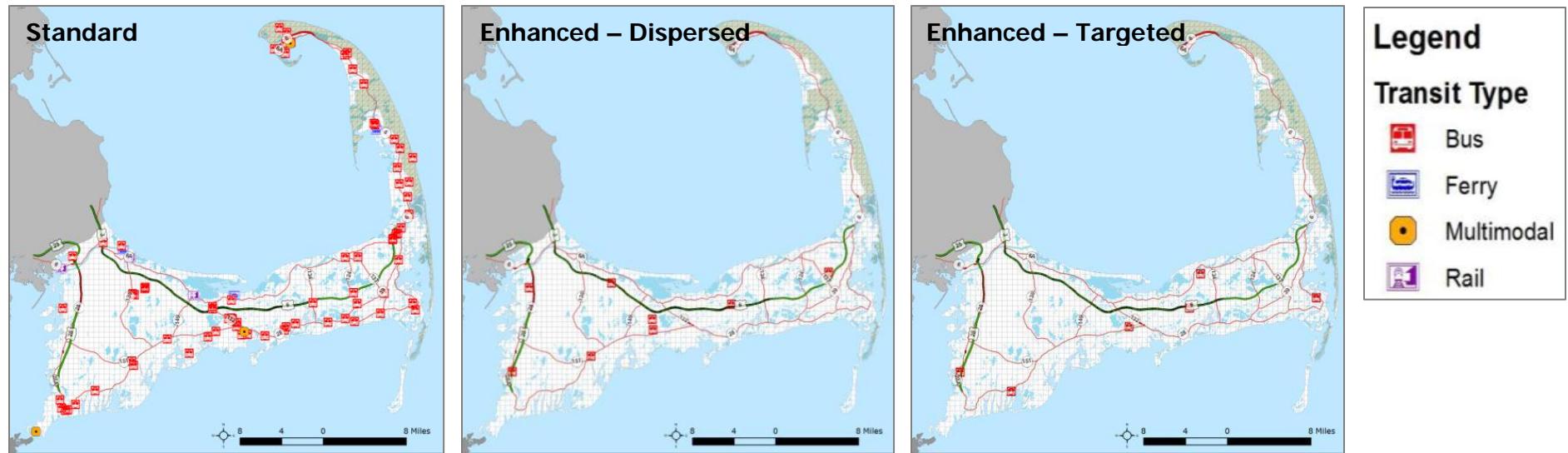


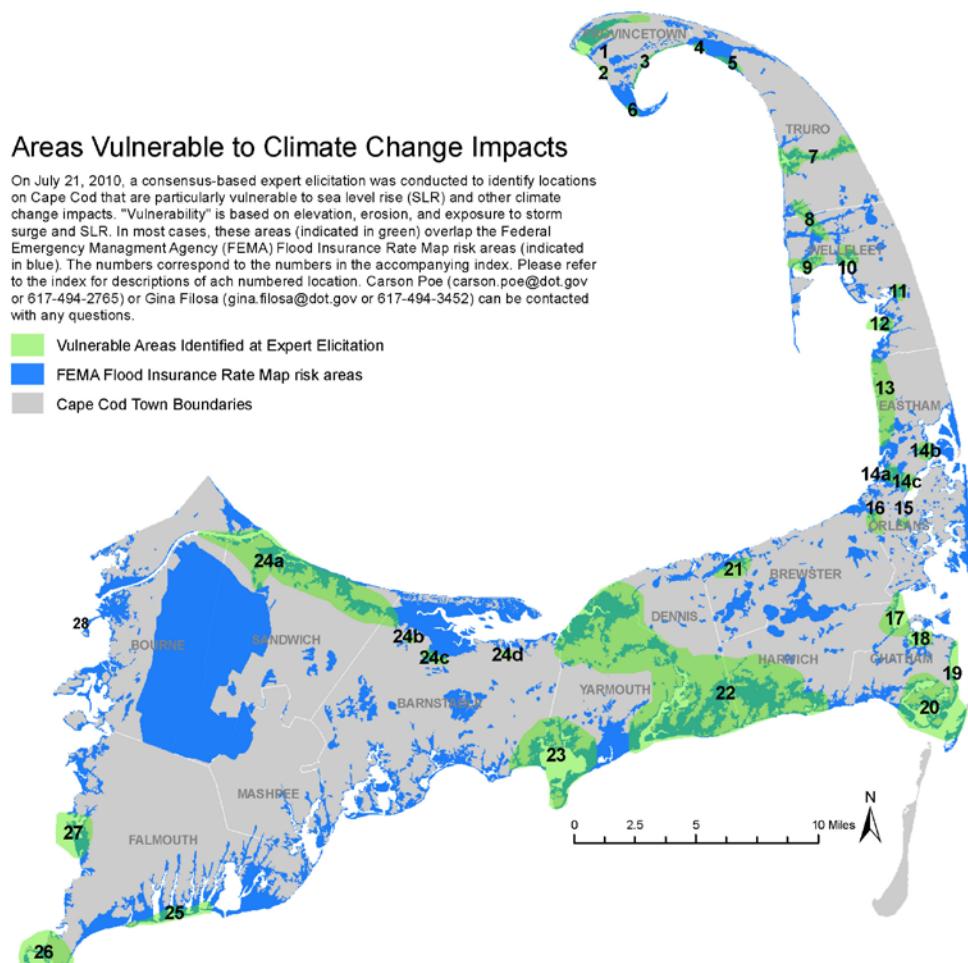
Figure 2: Standard and Enhanced Transit Scenarios. Source: PlaceMatters and Placeways.



Map of Vulnerable Areas

In order to address climate change adaptation in the development of scenarios, the Volpe Center initially intended to develop high, low, and medium sea-level rise (SLR) estimates for three time horizons. The Volpe Center convened a group of local and regional coastal experts in July 2010 to develop these estimates through an expert elicitation process, however the group determined that the desired level of detail would not be possible given the dynamic influencing SLR at the local level, a lack of robust data sources, and the feasibility of the requisite analysis and modeling within the scope and scale of the Pilot Project. Instead, the experts used GIS layers of orthophotography, landform and geologic maps, elevation data, and FEMA flood maps, as well as local knowledge to identify vulnerable areas, or areas of concern, for SLR and other climate-related impacts. The experts considered elevation, exposure to storm surge, erosion, and SLR impacts in identifying these vulnerable areas. The resulting map of vulnerable areas (see Figure 3) was available as a layer during the scenario development process and provided a basis for evaluating the scenarios based on percentage of new population in vulnerable areas. A key with descriptions of each numbered vulnerable area is available in **Appendix E** of the Volpe Center's Final Report.

Figure 3: Participants in expert elicitation held in July 2010 identified the areas highlighted in green above as being potentially vulnerable to SLR and other climate change effects.



Workshop Scenarios

The Volpe Center convened a workshop of local, regional, state, and federal stakeholders in Falmouth, Massachusetts, on November 15 and 16, 2010. In attendance were representatives from the Towns of Barnstable, Brewster, Chatham, Falmouth, Harwich, Mashpee, Sandwich, and Truro, the Martha's Vineyard Commissions, Nantucket Planning Office, Cape Cod Commission, Cape Cod Regional Transit Authority, and Massachusetts National Guard. During the workshop, these participants divided into breakout groups to allocate 16,500 new jobs and 28,000 new housing units, based on projections developed by the consultant team. Workshop participants allocated these new development units in CommunityViz, through which they were able to view layers representing the following constraints:

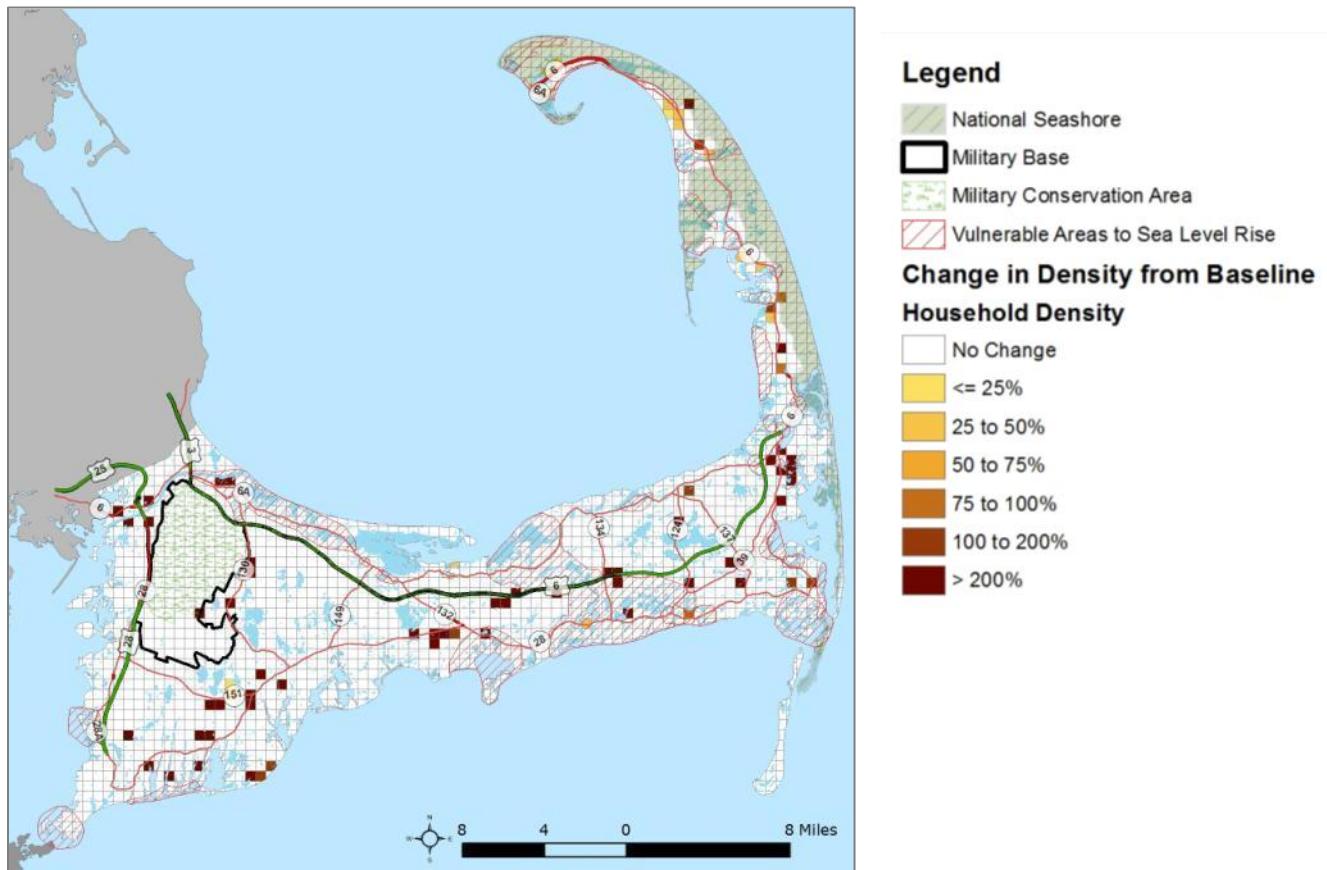
- Wellhead protection areas;
- Future water sources;
- Critical species habitat areas;
- Cape Cod National Seashore boundaries;
- Historic preservation areas; and
- Areas vulnerable to SLR and other climate change effects.

Participants were allowed to place new housing or employment units in any of these areas (with the exception of within Cape Cod National Seashore boundaries), as avoiding all of them would have been nearly impossible. Following their allocation of new housing and employment units, workshop participants adjusted Cape Cod's existing transit system to accommodate the new development, assigning new transit stops and adjusting the frequency of existing stops. After each of these exercises, where time permitted, the CommunityViz model was refreshed so that participants could evaluate the indicator performance of the decisions they had made. The resulting maps from each of the breakout groups can be found in the *Technical Scenario Report*.

Following the development of the breakout group scenarios, one facilitator met with representatives from each of the breakout groups to consolidate the four scenarios into one Refined scenario. This Refined scenario was adjusted during subsequent meetings with staff from the Cape Cod Commission, Cape Cod National Seashore, Cape Cod Regional Transit Authority, and several towns in December 2010 and February 2011. Following the February 2011 meeting, the Volpe Center solicited feedback on the Refined scenario from representatives of towns that had not been able to participate in any of the in-person meetings. The Refined scenario is depicted in Figure 4 below.

In recognition that the conditions on, and data for, Cape Cod are evolving, participants involved in developing the Refined scenario agreed that it will be used as the foundation to inform further conversations and changes in the future, and should not be considered an unalterable scenario. The following sections detail opportunities that the Cape Cod Commission plans to pursue for implementing, improving, and building upon the Refined scenario.

Figure 4: Refined Scenario, Change in Density from Baseline Household Density. Source: PlaceMatters and Placeways.



Implementing the Refined Scenario

The following sections provide information about opportunities to implement the Refined scenario based on conversations with CCC staff and other stakeholders involved in the Pilot Project.

Five-Year Plan for Public Transportation on Cape Cod

The Cape Cod Regional Transportation Authority, in cooperation with the Cape Cod Commission, plans to implement the Refined scenario in the next iteration of the *Five-Year Plan for Public Transportation on Cape Cod*. This plan presents existing conditions and trends for development, land use planning, and Cape Cod's public transportation system and a vision for the system within the plan's five year horizon and over a longer period of time. As the plan is meant to present opportunities to respond to changes in Cape Cod's future transit needs, it represents an opportunity to apply the Refined scenario as the region's desired distribution of future development. This allocation of growth, as agreed upon by regional and town planning staff and aligned with existing LUVMS, will help to strategically guide investments in transit. The future vision component of the *Five-Year Plan for Public Transportation on Cape Cod* will be developed by the Cape Cod Commission beginning in Summer 2011. The final plan is expected to be completed in 2012. Draft proposed transit investments can be added to the CommunityViz model to evaluate their impact on the performance indicators and final transit investments can be added to inform future use of the model.

Long Range Transportation Plan

The *Five-Year Plan for Public Transportation on Cape Cod* forms the basis for the public transportation component of Cape Cod's *Regional Transportation Plan* (RTP). The RTP is revised every four years and is due to be completed in 2011. Therefore, it will not be able to incorporate aspects of the Refined scenario. However, since the Cape Cod Commission is planning on using the Refined scenario to guide the future vision for public transportation for the long range transportation plan, the vision for Cape Cod's overall transportation system should maintain consistency. Therefore, the Cape Cod Commission is interested in using the Refined scenario to supplement existing TransCAD modeling and inform the next revision to the RTP.

The Cape Cod Commission can also use the Refined scenario as the basis for where development and employment will occur in its next iteration of the RTP. All long-range transportation plans include a "future-year" vision for where development will occur over the life of the plan (i.e., 20 years, 25 years, etc.). In the past, the Cape Cod Commission used a generic build-out analysis for its future-year vision for development. Now, the Cape Cod Commission can use the Refined scenario since it more accurately reflects where decision-makers on the Cape think development will – and should – occur over the next 20 years.

In the more immediate future, the Cape Cod Commission will be able to use the CommunityViz model to estimate the air quality impacts associated with certain recommendations in the 2011 RTP in order to prioritize them in the MPO's recommended program.

Regional Policy Plan

Cape Cod's *Regional Policy Plan* (RPP) presents a coherent set of goals, policies, and standards to guide planning and development in the region. If the Refined scenario is to be implemented as the region's future vision for growth and development, its incorporation into the RPP is vital to its uniform application across multiple disciplines. The RPP identifies strategies to encourage development in particular areas, specifically the use of Growth Incentive Zones, which facilitate compact, mixed-use growth while reducing development potential elsewhere. Towns may ultimately implement the Refined scenario by establishing Growth Incentive Zones in the scenario's most growth-intensive areas. Towns may also choose to incorporate the Refined scenario into Local Comprehensive Plans, which guide municipalities toward needed zoning and bylaw revisions. Both Local Comprehensive Plans and Growth Incentive Zones must be consistent with the goals and strategies of the RPP. Therefore, in order to implement the Refined scenario at the municipal level, it must be captured in the RPP.

Future Applications of the Refined Scenario and CommunityViz

Additional Transportation Considerations

A variety of transportation issues could not be addressed within the scope and timeline of the Pilot Project. The following represent opportunities to build upon the Refined scenario, enhance the scenario analysis, and tailor performance indicator calculations for Cape Cod.

Transportation GHG Emission Reduction Strategies

Climate change mitigation could only be captured in scenario development through the placement of new housing and employment units and resulting VMT and GHG reductions. Although the Refined scenario resulted in a 5.3 percent reduction in GHG emissions and VMT compared to the Trend scenario, the incorporation of GHG emission reduction measures directly into the scenario would have likely resulted in a more substantial reduction. The Volpe Center originally intended to use or modify GHG emission reduction factors documented in the report *Moving Cooler*.¹ However, most figures presented in *Moving Cooler* were only applicable at the national level and any available regional figures were not suited to Cape Cod. The Volpe Center convened a subgroup of the Technical Committee to adapt the GHG emission reduction values associated with certain strategies to the regional characteristics of Cape Cod. However, the subgroup determined that sufficient data did not exist for the current size, fuel consumption, and vehicle types of public and private fleets, and that this lack of available baseline data would severely limit their ability to develop reasonable figures. Instead, they elected to narrow the list of GHG emission reduction measures in *Moving Cooler* based on the feasibility of their application on Cape Cod. During the workshop, stakeholders discussed this narrowed list of measures and participated in a polling exercise to determine which were most viable. If the data become available, the Cape Cod Commission could integrate these measures into the scenario planning tool, which would more accurately and comprehensively capture the Cape's aspirations for GHG emission reduction from the transportation sector.

Freight

Scenario development and analysis did not capture the impact of the changes in freight movement that would be expected to accompany an influx of population and jobs. As discussed in the Data Sources and Assumptions section below, calculations of the GHG emissions associated with varying levels of VMT accounted for the fuel efficiency of heavy trucks and the carbon content of diesel fuel, however the split among vehicle and fuel types was not specific to Cape Cod and could not be adjusted to reflect future shifts in vehicle and fuel types. In further developing the Refined scenario, the Cape Cod Commission has an opportunity to explore the potential impact of shifts in freight movement on GHG emissions, including a possible shift to rail freight.

Environmental Justice

¹ Cambridge Systematics, Inc. (2009) *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*.

The Cape Cod Commission could use CommunityViz and the existing scenario model to evaluate the impact of future transportation projects on different socioeconomic groups by projecting Census data for the distribution of existing socioeconomic groups on Cape Cod to the Refined scenario horizon year. The Common Impacts Wizard tool that is part of CommunityViz may provide a useful framework for this analysis.

Other Considerations

Climate Change Vulnerability and Hazard Mitigation Planning

In order to address the climate change adaptation focus of the Pilot Projects, the Volpe Center facilitated an expert elicitation to identify areas of Cape Cod that are potentially vulnerable to SLR and other climate change effects. Although the Volpe Center originally intended to develop specific estimates for SLR, the experts determined that this was not possible given the time, data, and resources available. Nonetheless, the resulting map of vulnerable areas and its supplementary index with area descriptions was a valuable resource and input into the scenario planning process. Workshop participants were able to view these vulnerable areas as they placed development and the map sparked conversation surrounding the meaning and intent of the experts' designations of "vulnerable" areas.

These designations were not meant to suggest that all of the areas will be permanently flooded. Instead, they are vulnerable to a range of climate change effects, including more frequent flooding events and more intense storm surge. As a result, the experts suggested that the vulnerability of these areas should be studied in greater detail, particularly before any changes in infrastructure are implemented.

Workshop participants expressed concern over the tradeoffs associated with targeting new development in existing population and employment centers, many of which are located in areas identified as vulnerable. Ultimately, the Refined scenario placed about 20 percent of new population in vulnerable areas, which was lower than most of the other scenarios but still a cause for concern. Therefore, a potential next step is to assess the vulnerability of these areas to flooding, storm surge, and other climate change effects, particularly with respect to existing infrastructure and expected development. Staff from FEMA Region 1 have expressed great interest in the potential hazard mitigation applications of the Pilot Project, and could serve as valuable partners in pursuing opportunities to expand the Refined scenario and the Cape Cod Commission's use of CommunityViz.

Land Use

The Refined scenario was developed with a strong consideration of existing LUVMS, which had been completed for eight out of Cape Cod's fifteen towns at the time of the workshop. Although representatives from all fifteen towns had an opportunity to contribute to, and comment on, the Refined scenario, the Cape Cod Commission may wish to integrate it into, or validate it against, the region-wide LUVMS, once it is completed.

The Cape Cod Commission is also currently conducting a build-out analysis for the Town of Yarmouth and, as it was used in developing the preliminary scenarios, could use the CommunityViz Build-Out Wizard as a tool enhance this process. The Cape Cod Commission may also choose to use this tool to conduct a build-out analysis for the entire region.

Water Resources

During a polling exercise at the Pilot Project's November 2010 workshop in which local regional participants were asked to identify the two highest priority issues on Cape Cod, water quality and supply received 40 percent of the votes (the full results are presented in Figure 5 and Table 1 below). The next highest-priority issue, avoiding development in critical habitat and conservation areas, received fewer than half as many votes while reducing GHG emissions and avoiding development in vulnerable areas received 19 percent of the votes combined. If the Refined scenario is to be implemented as the future vision for growth distribution, the Cape Cod Commission may consider using CommunityViz to assess the impact of the Refined scenario on freshwater resources and wastewater collection and processing and adjust it according to regional priorities.

Figure 5: Results of a polling exercise to identify the issues of highest priority on Cape Cod; poll administered during November 2010 Scenario Planning Workshop; participants were asked to identify their top two issues. Source: PlaceMatters and Placeways

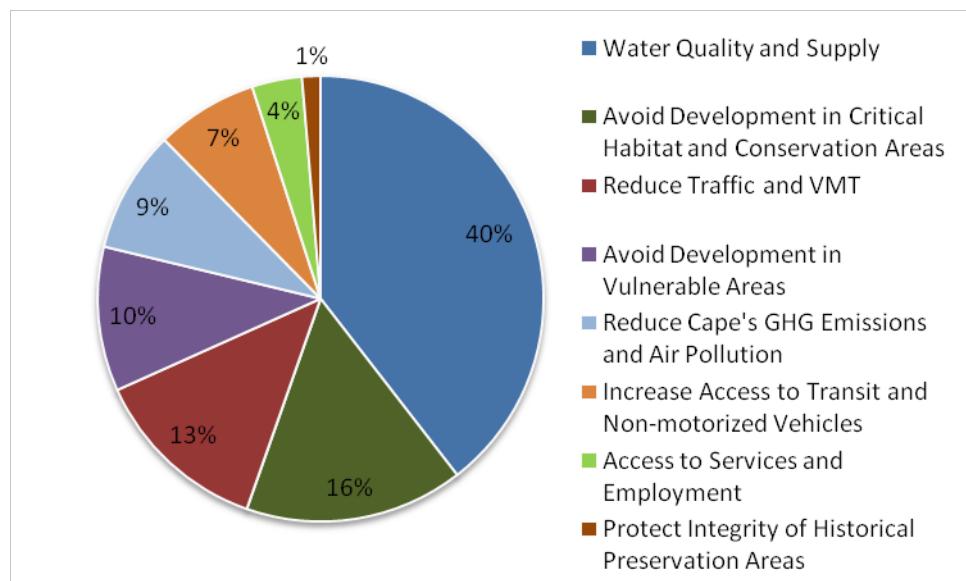


Table 1: Results of polling exercise. Source: PlaceMatters and Placeways

Priority	Percent of participants
Water Quality and Supply	40%
Avoid Development in Critical Habitat and Conservation Areas	16%
Reduce Traffic and VMT	13%
Avoid Development in Vulnerable Areas	10%
Reduce Cape's GHG Emissions and Air Pollution	9%
Increase Access to Transit and Non-motorized Vehicles	7%
Access to Services and Employment	4%
Protect Integrity of Historical Preservation Areas	1%

Further Refinements to the Scenario Development Process

The following section documents the data, assumptions, and processes used to develop the preliminary, workshop, and Refined scenarios.

Scenario Planning Consultant and Software Tool

Scenario Planning Consultant Team

Based on a review of responses to an RFP, the Volpe Center selected a consultant team composed of representatives from PlaceMatters, Inc., Placeways, LLC, and the University of Colorado Denver Center for Sustainable Infrastructure Systems and Transportation Research Center.

Scenario Planning Software Tool

Through its selection of the consultant team, the Pilot Project elected to use the software tool CommunityViz for scenario development. CommunityViz is a decision-support extension for ArcGIS, a group of geographic information system (GIS) software products that builds upon the information, organization, and presentation capabilities of GIS. CommunityViz enables users of a GIS to establish alternative futures, analyze their effects, and communicate results to stakeholders. The consultant team used CommunityViz in developing the preliminary scenarios, conducting the workshop, developing the Refined scenario, and conducting an evaluation of the scenarios using performance indicators that linked transportation, land use, and population density data with VMT, associated GHG emissions, and other stakeholder-defined issues.

Data Sources and Assumptions

Baseline and Future Growth Assumptions

The consultant team reviewed three data sets for potential use in establishing baseline (2008) and horizon year (2030) population, housing, and employment figures:

- Massachusetts Department of Transportation (MassDOT) Travel Demand Model
- Cape Cod Commission Transportation Travel Demand Model
- Consultant-prepared estimates (based on U.S. Census 2000)

The consultant team's review of both the MassDOT and Cape Cod Commission models revealed inconsistencies. While the Cape Cod Commission model contained relatively complete network link data for transportation analysis and its projected population and employment figures for 2030 aligned with those derived from the Census, its employment figures did not correspond well with mapped employment areas. The consultant team found a similar issue with the MassDOT model and also noted that its population projections were significantly lower than those in the Cape Cod Commission model and Census-based projections. Ultimately, they decided to use growth values derived from the U.S. Census 2000.

2030 Horizon Estimates

The consultant team applied 2030 growth projections derived from the U.S Census 2000 to its base year data to derive the growth figures that formed the basis of the Pilot Project's scenario

planning exercise. During scenario development, local and regional stakeholders were asked to allocate 16,500 new jobs and 28,000 new households (based on an estimated 60,000 new population).

Residential Housing, Population, and Employment Base Year Spatial Placement

In order to determine the spatial placement of population for the base year (2008), the consultant team used the Land Use (2005) data layer from MassGIS and adjusted municipal-level total population figures based on 2008 estimates from the U.S. Census 2000. The consultant team also used the MassGIS Land Use (2005) layer in conjunction with the Parcel-based Existing Land Use layer obtained from Cape Cod Commission to determine the spatial placement of base year employment. Similar to its approach to the population data, the consultant team used U.S. Census 2000 estimates for 2008 to adjust municipal-level total employment figures.

Development Capacity

In developing its preliminary scenarios (Trend, Dispersed Development, and Targeted Development), the consultant team relied on the August 2007 Zoning data layer maintained by MassGIS to conduct a regional build-out analysis for potential development capacity. The consultant team validated the MassGIS layer against local zoning maps and, in some cases, adjusted it to account for discrepancies.

VMT and GHG Estimates

In order to incorporate estimates of GHG reductions into scenario development, the consultant team used estimates of VMT from CCC's TransCAD transportation model. The consultant team also evaluated a statewide TransCAD model maintained by MassDOT but decided to use the CCC model based on assumptions that it was more sensitive to regional factors. The CCC's model also more closely matched the Pilot Project's base and horizon year, having been completed in 2007 and extending to 2035. Using the CCC transportation model as a baseline, the consultant team applied the 5D method developed by Ewing and Cervero² to estimate the impact of land use changes on VMT. The consultant team calculated the following metrics to account for each variable in the 5D analysis:

- Design: Road miles per square mile
- Density: Household units per acre
- Diversity: Normalized ratio of population to jobs
- Destination Accessibility: Proximity of neighborhoods to regional destinations
- Distance to Transit: Number of people served by traditional transit service areas

Specific formulas used to calculate each variable are available on page 9 of the *Technical Scenario Report*.

To determine changes in VMT, the consultant team calculated the percent change between these variables in the Trend scenario and the alternative scenarios and then applied elasticity values to weight the impact of changes in each variable on changes in VMT. The consultant team used the following elasticity values developed by Ewing and Cervero:

- Design: -0.12

² Ewing, Reid, and Robert Cervero. 2010. Travel and the Built Environment. *Journal of the American Planning Association* 76(3): 265-294.

- Density: -0.04
- Diversity: -0.02
- Destination Accessibility: -0.20
- Distance to Transit: -0.05

With trend and alternative scenario VMT derived from the Cape Cod Commission transportation model and 5D analysis, the consultant team allocated the resulting change in VMT among the four vehicle types based on the Cape Cod Commission transportation model: (1) passenger vehicles, (2), light duty vehicles, (3), medium trucks, and (4) heavy trucks. The consultant team then calculated the total change in consumption of each fuel type (gasoline and diesel) based on the fuel split and average fuel efficiency. Finally, the consultant team multiplied the carbon equivalent content per gallon for each fuel by the change in consumption to arrive at the change in GHG emissions. Because assumptions for mode mix and technology adoption were kept constant across all scenarios, relative GHG reductions were not different from relative VMT reductions. Scenario analysis used the following baseline assumptions for vehicles and fuels:

- Fuel Consumption:
 - Car: 35 miles per gallon
 - Light, Medium, and Heavy Trucks: 20 miles per gallon
- Mode Split:
 - Heavy Trucks: 0.3%
 - Medium Trucks: 2.1%
 - Light Trucks: 8.7%
 - Cars: 88.8%
- Carbon Content

Opportunities to Enhance Baseline Data

Throughout the scenario development and evaluation processes, the Volpe Center and the consultant team have documented opportunities to enhance the baseline data and analysis used in the Pilot Project. These opportunities are presented below:

- Baseline data and projections
 - Both the MassDOT and Cape Cod Commission TransCAD models exhibited inconsistencies compared to other land use and population data. Employment quantities did not correspond well to mapped employment areas in both models and the MassDOT model's population change projections were low compared to other estimates. To address the former issue, the consultant team suggests applying a single trend growth pattern to both the transportation model and the scenarios.
 - U.S. Census 2010 projections were not available at the time of preliminary scenario development and, therefore, could not be incorporated into the Pilot Project. As these newer estimates might suggest flat or even declining growth for the 2030 horizon year, the consultant team suggests that the Cape Cod Commission may want to consider them in any future scenario development.
 - The consultant team assigned bounds to the changes in VMT that could result from its 5D analysis to avoid overestimation. These bounds are documented on page 10 of their *Technical Scenario Report* but may need to be adjusted based on an updated regional transportation model.

- Region-specific analysis
 - The scenario development and analysis were not able to capture the intricacies of Cape Cod's seasonal population variations. PlaceMatters was able to develop general summer population multipliers for each town based on existing summer population figures and vacant housing unit data from the U.S. Census 2000, but these multipliers were not incorporated into their analysis. In its *Technical Scenario Report*, the consultant team proposes a methodology to further explore the winter/summer population dynamics for the 2030 horizon year.
 - The consultant team did not apply region-specific elasticity values to its 5D analysis. Therefore, the Cape Cod Commission can adjust the elasticity values applied to the 5D variables in order to account for regional factors that may influence their impact on changes in VMT.
 - Reliable region-specific estimates in mode and fuel type split were not available for the consultant team's analysis. If these were developed for the Baseline and Trend scenarios, the mode and fuel split could be manipulated as a variable in developing alternative scenarios. That is, stakeholders could establish a desired split between gasoline, diesel, and alternative fuels and between passenger car and type of truck in the Refined scenario. The Cape Cod Commission could also add specific transit and non-motorized mode assumptions.
- Transit:
 - Access to transit, used as a 5D variable and performance indicator in developing the Refined scenario, was calculated using a simple circular buffer for each transit stop that did not consider the street network. Introducing the street network into the calculation of transit accessibility would have more accurately captured how riders can walk, bicycle, or drive to the station but would have significantly increased the time needed to calculate scenario performance in a workshop setting. However, the consultant team suggests that future development of the Refined scenario could balance accuracy and efficiency by using the circular buffer approach during workshops and meetings and then supplementing it with a post analysis using the street network.
 - The access to transit stop buffer did not consider the Cape Cod Regional Transit Authority flag zone, in which riders can flag the bus to stop along the corridor, thus increasing the effective service area. This could be addressed by creating a linear corridor buffer for the flag zone area.
 - The current CommunityViz model cannot account for the impact of service frequency, fare levels, or other amenities and marketing techniques on ridership, and therefore mode split, as transit was addressed in scenario development and evaluation through proxy measures of population and employees with access to transit. The model also does not capture incoming potential ridership traffic from other modes – namely ferry and airplane. In its *Technical Scenario Report*, the consultant team suggests several options for introducing ridership changes into scenario analysis, including developing ridership estimates from other measures, including ferry and plane ridership, and conducting a transit stop suitability analysis based on the allocation of new population and employment in the Refined scenario. Alternatively, a ratio of the existing "access to transit" measure to existing total system ridership could be extrapolated to develop an estimated ridership figure for the 2030 horizon year.

- Some existing and proposed transit services – such as the B-bus service and potential Cape Cod National Seashore beach parking shuttles³ – were not included in the model but could be added.

³ See *Cape Cod National Seashore: Integrated Parking and Transit Plan* (<http://www.volpe.dot.gov/interagencypilotproject.html>).

Appendix A: Full List of Performance Indicators, Data Dependencies, and Importance Ratings

Indicator	Importance Rating (1-5)		Notes
	Planning Group/Technical Committee Average	PlaceMatters	
Vehicle Miles Traveled			
VMT for total study area	5.0	5	
VMT by town	4.9	5	
VMT per capita	4.0	5	TransCAD dependent
Vehicle trips by mode	5.0	5	TransCAD dependent
Implementation Costs of Mitigation Programs: Capital, Operational			
Total study area	4.1	4	
Per program:	3.7	3	
alternative fuels	3.8	3	
alternative modes	4.0	4	
roadway hardware	3.3	3	
renewal generation in highway rights-of-way	3.5	3	
operational improvements	3.6	3	
pricing strategies	3.4	3	
Per capita	2.8	3	
New roadway centerline distance	4.9	5	TransCAD dependent
New bike lane centerline distance	4.9	5	
Preservation of Natural/Existing Ecosystems: Total Study Area Indicators			
Area consumed by sea-level rise	4.5	4	
Open space consumed by development	3.8	3	
High-value conservation lands/wetlands consumed by development	4.1	3	
New development on or near critical or endangered habitat: dwelling units, roadways, rail	3.9	3	
New dwelling units within 1/2 mile of the projected 20-year shoreline	4.1	4	
New impervious surfaces	3.6	3	
Land Use, Social, and Economic Indicators for New Dwelling Units			
Population: full-time and part-time	4.8	5	
Dwelling units: by study area, by town, and by density	4.0	4	
Employment: in season and off-season	3.8	4	
Population density outside of open space	3.0	3	

Indicator	Importance Rating (1-5)		Notes
	Planning Group/Technical Committee Average	PlaceMatters	
Land use mix	3.8	4	
Building energy consumption	2.9	2	Use current averages w slider bar for level of improvement
Accessibility Indicators for New Dwelling Units			
Average distance to centers	3.9	4	
Average distance to shoreline	3.5	3	
Average distance to gateways	2.8	3	
Population in transit service areas	4.1	4	
Medium and high density dwelling units near centers	3.5	4	
Medium and high density dwelling units near transit	4.3	4	
Transit service area coverage	4.3	4	
Bicycle network coverage	3.6	3	
Transportation Energy Use			
Total study area	4.8	5	TransCAD dependent
By town	4.7	5	TransCAD dependent
Per capita	4.1	5	TransCAD dependent
On-road fuel consumption per capita	3.9	5	TransCAD dependent
By transportation source or program:	4.0	4	TransCAD dependent
conventional internal combustion passenger vehicles	4.0	4	
gas-electric hybrids	4.0	4	
flexible fuel vehicles	4.0	4	
passenger rail	3.9	4	
bus or BRT fleet	3.9	4	
alternative fuel mix	3.0	4	
electric utility energy used for plug-in hybrids or all-electric vehicles	3.4	3	
Greenhouse Gas, Ozone and Particulate Matter Indicators: CO2, CO, CH4, SF6, HFC, NOx, ROG, PM10, PM2.5			
Total study area	4.4	4	TransCAD dependent
By town	4.4	4	TransCAD dependent
Per capita	3.6	4	TransCAD dependent
By transportation source or program:			TransCAD dependent
conventional internal combustion passenger vehicles	3.9	3	
gas-electric hybrids	3.9	3	
flexible fuel vehicles	3.9	3	
passenger rail	3.8	3	
bus or BRT fleet	3.8	3	
alternative fuel mix	3.6	3	

Indicator	Importance Rating (1-5)			Notes
	Planning Group/Technical Committee	Average	PlaceMatters	
electric utility energy used for plug-in hybrids or all-electric vehicles	4.1	4		