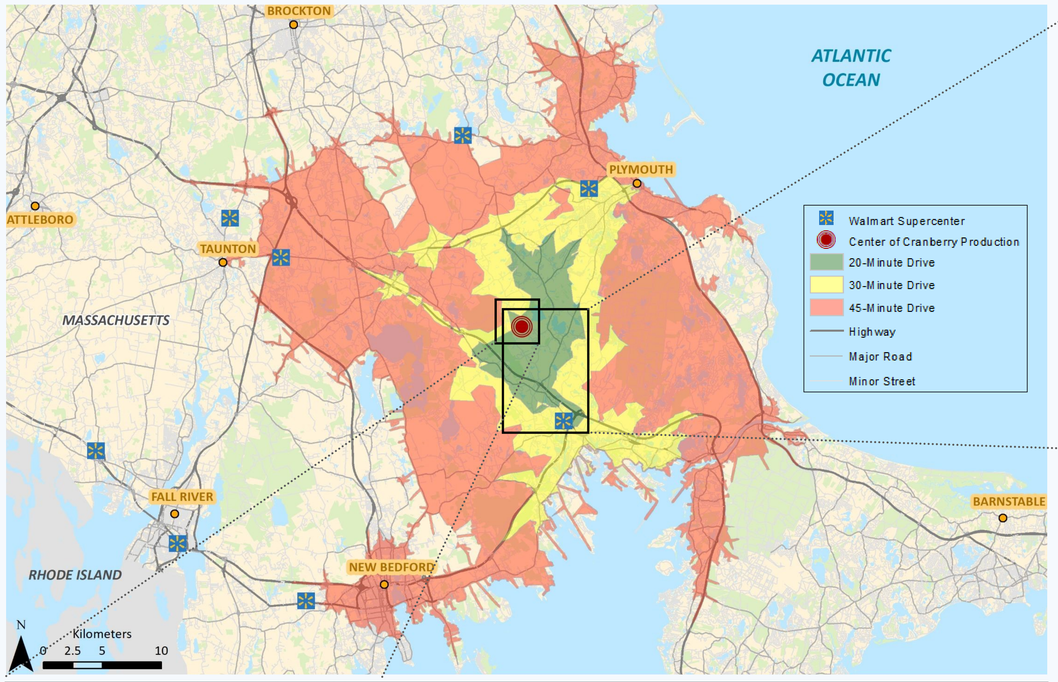
Save Money. Live Better...Buy Local?

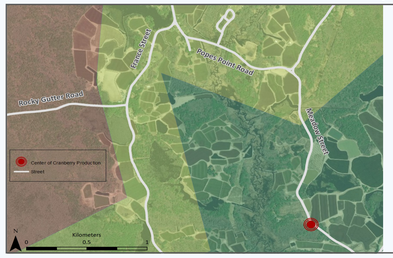
Optimizing Transportation Routes for Intrastate Food Purchasing

INTRODUCTION

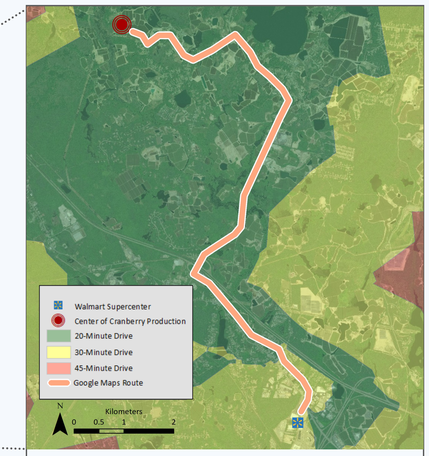
Consumers across the U.S. are eager for locally-sourced food. Farmers' markets, community-supported agriculture, local food in supermarkets—all have blossomed in recent years as customers seek alternatives to standard food purchasing options. While the impact and definition of "local" can be debated, consumer demand continues to grow. Food companies, distributors, and grocers are taking note. Walmart, the world's largest corporation in the world by revenue is also the largest grocer in the United States by market share at about 15%. Walmart has committed to doubling its current local (intra-state) purchasing by 2025. While shoppers are often willing to pay a premium for local food, food sellers like Walmart must also account for the feasibility of transporting crops that grow in certain areas to store locations all over the state, considering driving distance and time, cost of fuel and labor, and other inputs.

This project is a *hypothetical study* that uses a proximity analysis to investigate which Walmart supercenters should be prioritized for transportation of Massachusetts-grown cranberries. The use of Walmart supercenters and cranberries is meant as a proxy for any food seller and crop. Some crops need to be processed before transport to market; the estimated "Center of Cranberry Production" is a stand-in for any processing center where a supermarket such as Walmart would begin shipment. As this is a pilot study, the goal is to conclude whether these datasets and GIS operations are useful in helping grocers determine which transportation routes, produce items, and states they should prioritize in their quest to make local (intra-state) food available to customers.





This image illustrates some issues encountered when creating the network analyst model, aside from the polygons not perfectly mapping onto the roads. From the center of cranberry production, the model predicts driving time is up 20 minutes driving north along Meadow Street, 20-30 minutes to reach Popes Point Road and France Street and 30-45 minutes once the right turn is made onto Rocky Gutter Road. In most areas, the model seems to predict logical times. However, some driving times are skewed. Google Maps estimates driving time to be 6 minutes for the 4 kilometers.



The closest Walmart supercenter to the center of cranberry production is in Wareham, MA. According to the network analyst model, it falls just outside the 20-minute driving range and within the 30-minute driving range. The route in the figure above depicts the preferred route using Google Maps, which calculates the driving time as approximately 15 minutes. Driving directions can be produced from the network analyst tool as well.

This image also demonstrates how the various driving ranges buffer the major highways. As the Wareham Walmart is located beyond the 20-minute buffers, it falls into the 30-minute service area.

NEXT STEPS

A few improvements could render this model more useful for real-life application. Speed limit or traffic data, if available, could be joined to the roads data. Once the service areas accurately reflect true driving times, the model can be used to compare multiple crops' service areas. Exact starting points from a processing or production center should be used, in place of an approximated one, as was done in this pilot. More "breaks" can be set: multiple 5-minute intervals would enable more precise findings.

Overall, with a few data additions and a few adjustments to the GIS operations, this model has the potential to serve as a good first step in a decision-making scenario. Users seeking to compare the relative reach of "local" crops can prioritize those that can be transported to the maximum number of facilities in a cost-effective way.

The model may also be coupled with census data to reflect local populations' food purchasing preferences. These data may include education, income, and other demographic data. This step can further differentiate facilities to be prioritized.

METHODOLOGY

1. Prepare Cranberry Data: Massachusetts cranberry bog rasters from USDA's CropScape were isolated and converted to polygons (light pink areas in Fig. 1).

2. Merge Cranberry Polygons: The polygons were merged and dissolved into one noncontiguous polygon.

3. Create Center of Cranberry Production: An estimated "Center of Cranberry Production" was created based on the center-point of the new polygon (dark red target in Fig. 1). It represents an approximation of where cranberries are grown in Massachusetts.

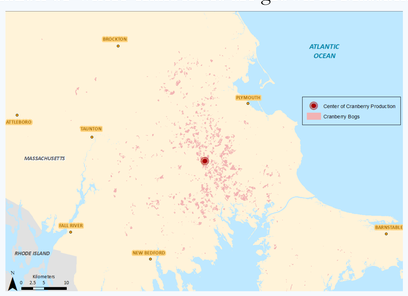


Figure 1. *Cranberry bogs in MA (from CropScape data) and estimated center of cranberry growing region.*

4. Prepare Roads Data: Speed limits were assigned to each road segment. The limits were estimated based on the following MassDOT road classification:

Class	Description	Assigned Speed Limit
1	Limited Access Highway	45 mph
2	Multi-lane Highway, not limited access	35 mph
3	Other numbered route	30 mph
4	Major road - arterials and collectors	25 mph
5	Minor street or road (with street name)	15 mph
6	Minor street or road (no street name)	15 mph

Conservative speed limits were chosen to reflect impacts of traffic. Time required to drive was calculated from the given length of each segment.

5. Build Service Area: The network analyst tool was used to create three concentric service areas based on driving times of 20 minutes, 30 minutes, and 45 minutes from the approximated Center of Cranberry Production.

6. Compare with Walmart Supercenter Facilities: Walmart supercenters were mapped using ReferenceUSA data. Supercenters falling within or just outside the service areas were inspected.

DISCUSSION

According to the model, two Walmart supercenters are located within the 30-minute service area and one is inside the 45-minute service area. Another three are just beyond the 45-minute limit. The roads data appear robust enough for the network analyst tool to create multiple functional service areas. This map is much more conclusive and useful than a simple Euclidean Distance "as the crow flies" model. For instance, the Walmart supercenter in New Bedford is about 30 kilometers away and just on the edge of the 45 -minute service area. The supercenter in Halifax is 17 kilometers away and also on the edge of the 45-minute service area. Without the network analyst, the Walmart in New Bedford may not have been considered for local shipment. The utility of this map is that it allows comparison of multiple routes and multiple crops simultaneously

Despite its advantages, this model has multiple limitations. Crops data collection time varies. While cranberry bogs may not be affected, some cropland cover will be influenced by the season the images were collected. Images of fruits taken during summer or winter will achieve significantly different results. Other issues include possible omissions in the roads data if traffic patterns change before the data are updated, for example. The service areas may overestimate traffic. Assigned speed limits can be raised.

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Cartographer: Jeremy Edelman
Course: Fundamentals of GIS
Tufts / NUTR 231 / Fall 2018
Map Date: December 20, 2018
Projection: NAD 1983 StatePlane Massachusetts Mainland FIPS 2001

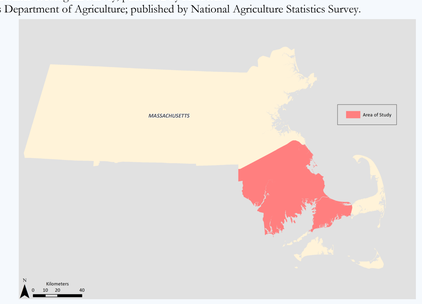

Figure 2. *Area of study in southeastern Massachusetts where cranberry production is concentrated.*