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Food mirages: Geographic and economic barriers to healthful food access in Portland, Oregon

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ABSTRACT

This paper investigated the role of grocery store prices in structuring food access for low-income households in Portland, Oregon. We conducted a detailed healthful foods market basket survey and developed an index of store cost based on the USDA Thrifty Food Plan. Using this index, we estimated the difference in street-network distance between the nearest low-cost grocery store and the nearest grocery store irrespective of cost. Spatial regression of this metric in relation to income, poverty, and gentrification at the census tract scale lead to a new theory regarding food access in the urban landscape. Food deserts are sparse in Portland, but food mirages are abundant, particularly in gentrifying areas where poverty remains high. In a food mirage, grocery stores are plentiful but prices are beyond the means of low-income households, making them functionally equivalent to food deserts in that a long journey to obtain affordable, nutritious food is required in either case. Results suggested that evaluation of food environments should, at a minimum, consider both proximity and price in assessing healthy food access for low-income households.

1. Introduction

Much of the recent discussion around equitable food access in North American cities has centered on food deserts, or areas lacking physical access to full-service grocery stores. This paper argues that the food environment in Portland, Oregon is marked not only by food deserts but also by *food mirages*. In a food mirage, full service grocery stores appear plentiful but, because food prices are high, healthful foods are economically inaccessible for low-income households. Food mirages are invisible using conventional approaches to food desert identification, but affect food access for low-income households similarly—a long journey to obtain affordable, nutritious food is required either way.

We borrow the term food mirage from Short et al. (2007), who critique the assumption that food access arises from proximity to a full-service national chain grocery store. Everett (2011) also uses the term in her account of a public health coalition that aimed to encourage healthier eating habits among low-income Hispanic households in North Portland. Everett reports:

> …although North Portland has several large grocery stores, Hispanic parents find them expensive and lacking in culturally appropriate foods, and therefore travel long distances to shop in discount supermarkets. We describe this phenomenon as a 'food mirage,' rather than a food desert, and argue that the potential impact on health is similar—managing the challenges of time, distance and cost means infrequent shopping trips and less fresh produce. (Everett, 2011, p. 14)

Taking Everett's anecdotal evidence as a point of departure, this paper identified food mirages with spatial analysis of food price data from a 2011 market basket survey of healthful food in the City of Portland. We assessed store affordability for low-income households in relation to benchmark prices informed by the U.S. Department of Agriculture (USDA) Thrifty Food Plan (TFP). Geographic information systems (GIS) and spatial regression were used to investigate relationships among store locations, affordability, and socioeconomic variables at the census tract scale. Throughout this paper, we refer to "food mirages" as census tracts where food access limitations stem from a lack of affordable, healthful options rather than an absence of grocery stores. Results confirmed previous findings that conventionally defined food deserts are rare in Portland (Sparks et al., 2010; Leete et al., 2012). Food mirages, by contrast, cover much of the city, with the most extreme cases coinciding with gentrifying areas with relatively high rates of household poverty. We argue that the barriers to healthful food access in Portland arise primarily from demand-side considerations – incomes, food budgets, and the spatial patterning of food prices – rather than solely the locations of full-service grocery stores and areas of concentrated social deprivation. The paper concludes by connecting food mirages to inner city gentrification and possible emergence of suburban food deserts.

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1.1. Food deserts

At its core, the food desert metaphor posits a linkage between poverty, access to nutritious and affordable food, and poor diet-related health outcomes (Beaulac et al., 2009; Larson et al., 2009; Charreire et al., 2010; Walker et al., 2010). Formulated generally, the concept has broad explanatory power. Socioeconomic status has been identified as a key predictor of diet across developed countries (Darmon and Drewnowski, 2008; Monsivais and Drewnowski, 2009). Fruit and vegetable consumption tends to vary inversely with distance to a grocery store (Rose and Richards, 2004; Zenk et al., 2008), although at least one study found this not to be the case (Boone-Heinonen et al., 2011). Statistically significant correlations between socioeconomic status and the local food environment have been found in numerous case studies, particularly in Midwestern and Eastern U.S. cities (Alwitt and Donley, 1997; Moore and Diez Roux, 2006; Franco et al., 2008; Gordon et al., 2011).

As the food desert concept has become relevant to politics and policy (Ver Ploeg et al., 2009), this general formulation has been operationalized for GIS analyses based on the following assumptions. First, full-service grocery stores, usually national chain stores, have been assumed to proxy for the presence of nutritious, affordable food. Second, households have been assumed to buy food from the nearest retailer. Third, food deserts are assumed to exist only in areas of concentrated poverty (Leete et al., 2012). Jiao et al. (2012) also note that the mode of transportation is assumed to be the same for all residents. We refer to these assumptions as the conventional approach to food desert identification.

These assumptions allow food environments to be reduced to quantities and scrutinized from afar. However, evidence to support their validity is mixed. On the first point, Chung and Myers (1999) and Hubley (2011) found that chain stores offer lower prices than independently owned stores, while Cummins and Macintyre, 2002a; Cassady et al., 2007 and Short et al., 2007 obtained the inverse result; this assumption may be place-specific. The second assumption may underestimate the importance of variability among food retailers. Store type may be an important parameter of overall food access (Block and Kouba, 2006; Drewnowski et al., 2012). Empirical evidence has indicated that, in some U.S. cities, low-income households do not necessarily shop at their neighborhood grocery store or even the nearest chain store because product mixes and price points vary (Drewnowski et al., 2010; Hillier et al., 2011). Nationally, Supplemental Nutrition Assistance Program (SNAP) recipients live, on average, 1.8 miles from a full-service grocery store but travel a mean distance of 4.9 miles from home to shop for food (Ver Ploeg et al., 2009). On the third point, barriers to healthful food access may not coincide with areas with concentrated poverty. Multiple researchers have failed to find food deserts in areas of social deprivation (Apparicio et al., 2007; Sharkey and Horel, 2008; Lee, 2012). Simultaneously, areas of concentrated poverty have become more diffuse, even suburbanized, with recent demographic shifts (Richardson et al., 2012). These findings suggest that other pathways to poor diet-related health outcomes, apart from spatial proximity to any full-service grocery store. One such pathway may be food prices.

1.2. Food prices

A growing body of economics and public health research links food prices to consumption patterns and diet-related health outcomes. On the basis of price per calorie, fresh produce is considerably more costly than energy-dense processed foods (Drewnowski, 2004; Rehm et al., 2011).[1] Moreover, since 1980, the real price of fresh produce has risen while the price of energy-dense food (including soda) has fallen (Wendt and Todd, 2011). Basic principles of microeconomics suggest that consumption of some commodity will be negatively correlated with its price. An econometric meta-analysis found that a 10% increase in the price of soft drinks would reduce consumption by 8% to 10%, while a 10% reduction in the price of vegetables would increase consumption 5.8% to 7% (Andreyeva et al., 2010). Price reductions, for example through discounts, vouchers or coupons, have been shown to increase consumption of fruits and vegetables (Glanz and Yaroch, 2004). The Special Supplemental Nutrition Program for Women, Infants and Children (WIC) program's cash value vouchers, which provides monthly supplementary checks to low-income women for fruit and vegetable purchases, is another type of economic subsidy that has been shown to increase the quantity of fresh fruit and vegetable purchases (Gleason and Pooler, 2011; Herman et al., 2006).

Regionally, food prices co-vary with obesity rates (Todd et al., 2011). Lower fruit and vegetable prices are associated with lower body weight among low-income populations (Powell and Chaloupka, 2009; Powell et al., 2013) and larger food budgets are associated with higher nutrient intake (Monsivais et al., 2011; Aggarwal et al., 2012). Regions with lower prices for dark green vegetables and milk tend to have relatively low child body-mass index (BMI); low-income households exhibit the highest price sensitivity for these items (Wendt and Todd, 2011). Adolescents in the highest quintile for BMI tend to come from lower-income households who, again, exhibit the highest sensitivity to food prices (Auld and Powell, 2009). These findings suggest a prominent role for food prices in understanding any shifts in food consumption patterns and health outcomes, particularly among low-income households facing very tight budget constraints.

1.3. Study area: Portland, Oregon

Conventional approaches have not found more than a few census tracts in Portland that satisfy the criteria for food deserts (Margheim, 2007; Sparks et al., 2010). Many tracts along the suburban periphery are more than 1 mile from a grocery store, but do not constitute food deserts because they lack sufficient concentrations of households experiencing poverty or social depravation (Leete et al., 2012). Redlining and disinvestment once marked closer-in neighborhoods, particularly those in North and Northeast Portland–they may have been food deserts in the late 20th century (Gibson, 2007). However, these areas are rapidly gentrifying and are largely well served by grocery stores. Citywide, lower-income areas tend to be associated with shorter distances to the nearest grocery store (Armstrong et al., 2009).

Despite relatively equitable spatial access to grocery stores, over half of Multnomah County's adult residents are considered overweight or obese, signaling the operation of some other pathway to poor diet-related health outcomes (Multnomah County Health Department, 2008). Community food assessments have revealed that low-income households experience food insecurity while living within walking distance of a full-service grocery store (Interfaith Food and Farms Partnership, 2007). Anecdotal evidence exists for low-income households spurning their neighborhood grocery stores and travelling long distances to shop at discount food retailers on the urban periphery (Casey, 2008; Everett, 2011).

The largest municipality within a rapidly growing metropolitan region, the City of Portland is located near the confluence of the Willamette and Columbia Rivers. The city has a population of over 580,000 (Population Research Center, 2012) and a notable food culture (Asimov, 2007). The Westside (west of the Willamette River) contains the downtown district and the affluent West Hills area. The Eastside (east of the Willamette River), Interstate 205 (I-205) freeway serves as an important socioeconomic boundary, with housing density and income tending to be lower directly east of I-205. The study area outlined in Fig. 1 comprises 140 census

[1] However, other measures (price-per-portion) yield more comparable results (Carlson and Frazão, 2012).

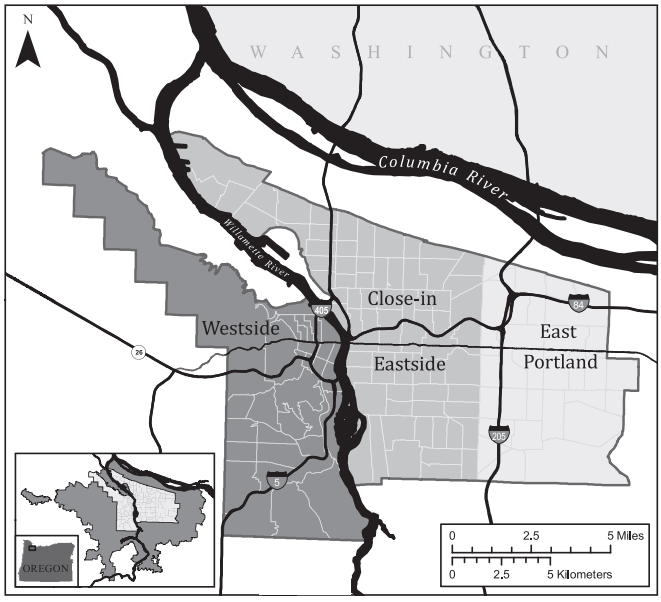

Fig. 1. Study area, defined by census tracts with centroids inside the City of Portland. Census tracts with limited residential land use were removed. Inset maps indicate that Portland comprises the large central area in the Portland Metropolitan region (defined by an urban growth boundary) and show the location of Portland metropolitan region in the State of Oregon.

tracts (of 397 tracts in the Portland metropolitan region) with centroids in the City of Portland boundary, excluding three census tracts dominated by industrial land use (less than 10% residential). Three socioeconomically distinct regions were defined within the study area: the Westside (west of the Willamette River), close-in Eastside (east of Willamette River, west of the I-205 corridor), and East Portland (east of the I-205 corridor).

2. Methods

2.1. Data collection

2.1.1. Identifying grocery stores

We built a spatial dataset of grocery stores by cross-referencing geocoded store addresses identified through two sources: U.S. Census North American Industry Classification System (NAICS) and SNAP retailers. The addresses of all 'Supermarkets and other grocery (except convenience) stores' (code=445110) from the NAICS were obtained from SimplyMap and geocoded in ArcGIS 10.0. This particular NAICS code tends to incompletely capture full-service grocery stores (Forsyth et al., 2010). For example, Fred Meyer, a Kroger subsidiary that functions as a grocery store throughout the Portland metropolitan area, is coded as a department store in NAICS. To ensure completeness, we cross-referenced the resulting dataset with SNAP retailers, then manually edited based on local knowledge, Google StreetView, internet research, and site visits.

Since this paper concerns access to healthful foods, particularly fresh produce, we defined a grocery store as any food retailer with a minimum of 10 fresh produce items available. This definition included small and independent grocers, who can serve as key food access points in areas not served by chain stores (Bodor et al., 2008; Short et al., 2007) but excluded discount retailers that may sell non-perishable food items but not dairy or produce. Following refinement by these criteria, the final dataset contained a total of 79 grocery stores lying inside of the study area boundary or within one kilometer of it. All of these stores were surveyed. To avoid edge effects, another 51 chain stores outside the study area were surveyed and price level was imputed to other stores in the same chain found within the urban growth boundary ($n=74$).

2.1.2. Market basket design

The healthy foods market basket survey was designed in relation to the food budget embedded in the Thrifty Food Plan (TFP), which is used to determine eligibility for SNAP. The TFP reflects the prices and quantities that constitute a food budget representing ⅓ of the net income for a family at or below 130% of the poverty level (Carlson et al., 2007). Survey design excluded most highly processed foods listed in the TFP, focusing instead on produce, legumes, and whole grains. For example, whole or minimally processed vegetables and fruit items made up 55% of the healthy market basket survey, reflecting the USDA nutrition guidelines. The survey contained a total of 43 items in eight food categories: fresh produce, frozen and canned vegetables, grains, legumes, oils, meat, and dairy (Grocery CART PDX, 2012).

2.1.3. Survey methodology

In designing the survey, we attempted to model the purchasing behavior of a health-conscious and price-sensitive food shopper. Rather than comparing prices of healthful versus unhealthful foods, we assumed a preference for healthful foods and measured how far one must travel to obtain them, depending on budget constraints. This methodology aimed to identify the lowest-cost, reasonably healthful food available at each store. For any survey item, a store typically offered a range of options. Prices were gathered based on items with the lowest price per unit. Some variation in quantity and quality were allowed.[2] All prices were converted to comparable units. No data was collected regarding food brand, food quality, or other non-price attributes that may factor into consumer decisions (local, organic, etc.). Thus, our methodology differed from other market basket surveys with rigid guidelines for brand or quantity (Chung and Myers, 1999). Prices were collected in 2011 by students at Portland Community College and Portland State University as well as by community volunteers.

2.2. Defining and mapping food mirages

2.2.1. Benchmark prices

We defined a set of benchmark prices to compare price levels across stores. Benchmark prices are taken as the average price for each survey item at Fred Meyer, a subsidiary of the Kroger national chain, and Winco, a Western U.S. regional discounter. These stores were selected because they had all survey items available and the average of store prices was comparable to TFP assumptions for produce. Shopping the TFP at this price level would result in a food budget comprising roughly 30% of income for households at 130% of the poverty line (Voss-Andreae, 2011). Both retailers tended to have lower market basket costs than all other chain retailers surveyed, including other national discounters such as Wal-Mart and Target.

Benchmark prices served as the basis for the affordability index (AI), a calculated value that reflected store affordability for low-income households (at or below 130% of the poverty line). Specifically, AI functions as a multiplier indicating the increased cost of a basket of goods relative to benchmark prices. It is defined in (1) as the ratio of observed market basket cost to benchmark basket cost:

$$AI_i = \frac{\sum_{j=1}^{n} X_{ij}}{\sum_{j=1}^{n} B_i} \quad (1)$$

[2] For example, the survey calls for a 16 oz. bottle of vegetable oil, but if a 32 oz. bottle was less expensive per-unit, the price of a 32 oz. bottle was collected and the price halved.

where X_{ij} is the sum of costs for item j at store i and B_j is the benchmark cost for item j. Any store with $AI=1$ has prices comparable to benchmark. $AI=2$ indicates that the same basket of goods would cost twice as much as the same basket at benchmark prices. We assumed that only stores with $AI \leq 1$ are affordable for low-income households, in the sense that SNAP recipients on a TFP budget would be able to keep costs of a healthful diet within 30% of income. Stores with $AI \leq 1$ were considered low-cost stores. Similar to Jiao et al. (2012), we determined that grocery stores with $AI > 1.4$ are high-cost stores.

2.2.2. Deriving 'potential' food mirages

Apparicio et al. (2007) have argued that food access cannot be described in a single measure because distance, density, and variety all factor into a comprehensive view of the food environment. However, Sparks et al. (2010) and Leete et al. (2012) found reasonable agreement between these food access measures in the case of Portland, so we looked at access only in terms of distance. We measured the street-network (rather than Euclidean) walking distance from census block centroids ($n=7376$) to the nearest store in ArcGIS 10.0. We repeated the process for only those stores with $AI \leq 1$. We took the difference between these store distances as the food mirage value for each block. Blocks were chosen because they are the finest scale available from the U.S. Census, with an average of 52 blocks nested within each census tract. Eq. (2) was then used to obtain D_i, a census tract-level estimate of potential food mirage distance from the population-weighted mean block-level distances:

$$D_i = \frac{\sum_{b \in i} p_b(\min |d_{sb})}{\sum_{b \in i} p_b} \quad (2)$$

where p_b is the block-level population and d_{sb} is the distance to nearest store for block b in tract i. We considered D_i to be 'potential' food mirages because the presence of an actual economic barrier arises only where large food mirage distances coincide with low incomes.

2.2.3. Identifying actual food mirages

To identify actual food mirages, we eliminated census tracts with a low-cost store within 1 mile (1.6 km), since no economic barrier was present. We also removed tracts with annual incomes above the 75th percentile ($60,170), as these residents can presumably afford to drive to any grocery store. 95% of households in poverty reside in the remaining 85 census tracts, from 140 total tracts. Within this subset, we distinguished between three types of food access situations that differ based on the distance to the nearest store: <0.5 mile (extreme food mirage), between 0.5 and 1 mile (moderate food mirage), and >1 mile (akin to a low-density food desert or, more specifically, a food 'hinterland' as described by Leete et al. (2012)).

2.3. Spatial regression

2.3.1. Model development

We developed a series of regression models to explore correlations between the food environment and socioeconomic context at the census tract scale. Using stepwise linear regression, we selected the following socioeconomic predictor variables: median family income, poverty rate, and % change in white population from 2000 to 2010. Note that the poverty rate in Portland does not always co-vary with median income (correlation $=0.37$) due to affordable housing requirements. These data were derived from the 2006–2010 American Community Survey. We take % change in white population between 2000 and 2010 U.S. Census as a proxy for gentrification, which has marked Portland's cultural landscape, particularly in areas of the close-in Eastside (Gibson, 2007).

2.3.2. Spatial autocorrelation

Spatial regression techniques were used to identify relationships with socioeconomic variables while accounting for spatial autocorrelation to avoid spurious correlations that arise from spatial dependencies among adjacent geographic units (Rogerson, 2010). Robust Lagrange Multiplier diagnostics from ordinary least squares regressions, conducted in OpenGeoDa v.1.0.1 (Anselin et al., 2006), indicated that a spatial lag model was appropriate. Spatial lag regression takes the form of:

$$Y_i = \beta_0 + \beta_1 X_i + \rho W Y_j + \varepsilon_i \quad (3)$$

where Y_i the food environment variable for tract i, X_i is the socioeconomic predictor for tract i, β_i is the regression coefficient, ρ is a spatial autoregressive coefficient, WY_j is the spatially lagged food environment variable averaged over five nearest neighbors, and ε_i is a random error term. Spatial regressions were conducted for two dependent variables: distance to the nearest grocery store and potential food mirage distance. To determine whether the influence of predictor variables differed across the study area, we conducted stratified analysis in three regions: Westside, close-in Eastside, and East Portland (see Fig. 1 and Section 1.3) East Portland.

3. Results

3.1. Store distance and food affordability

Grocery stores were fairly evenly distributed throughout the study area (Fig. 2a). The average street-network distance to the nearest grocery store was 0.7 mile (1.1 km). Without considering prices, food access would appear best near the city center, where store distances are less than 0.25 mile (0.4 km), and worst along the peripheries of the study area, where store distances exceed 2 mile (3.2 km). When grocery stores are classified by price level, however, a different spatial distribution is evident. Most low-cost stores were clustered in the vicinity of I-205. As a result, the average street-network distance to the nearest low-cost grocery store is 2.5 mile (4 km). Based on tract-level population and poverty rates, we estimated that 81% of all people in poverty in Portland reside in census tracts that are more than 1 mile from a low-cost store, representing 13% of the total population. In contrast, 20% of the low-income population resides in census tracts that are more than 1 mile from any type of grocery store, representing 3% of the population. A negative correlation between AI and proximity to the nearest affordable store was found, such that store distance increases nonlinearly as AI falls to 1 (Fig. 2b).

3.2. A typology of food mirages

The techniques in Section 2.2.2 were used to derive the population-weighted distance to nearest grocery, nearest low-cost store, and food mirage distance by census tract (Fig. 3a–c). Although few areas of the city were more than 1 mile from a grocery store, much of the City of Portland is not served by a low-cost store. As a result, much of the city is a potential food mirage for households facing tight budget constraints.

Fig. 4 used the techniques described in Section 2.2.3 to identify and map actual food mirages. Extreme food mirages, symbolized by the smallest circles, tended to appear in the close-in Eastside. Food hinterlands, symbolized by the largest circles, occured mainly in census tracts east of I-205. Summary statistics in Table 1 indicated that extreme food mirages tend to have the lowest incomes and highest rates of poverty, as well as the largest increases in white population (mean increase 5.08%). By contrast, food hinterlands were associated with higher mean incomes and diversifying populations (mean decrease in white population 3.3%), although poverty rates were comparable to extreme food mirages. Of the 81% of people in

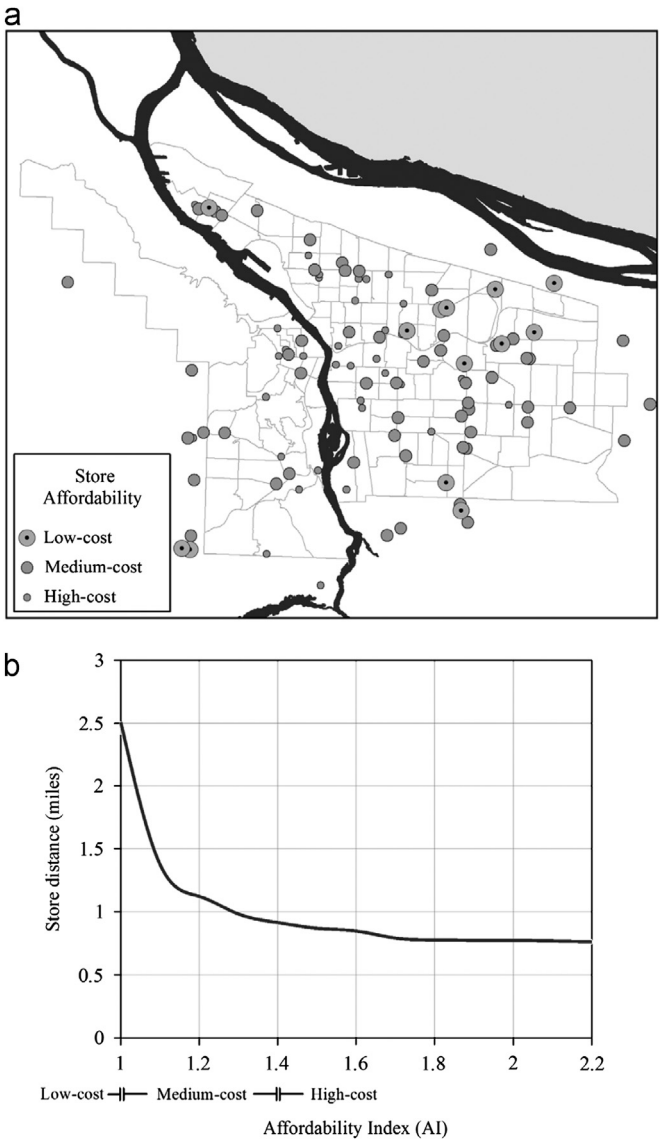

Fig. 2. (a) Spatial distribution of grocery stores by cost. The majority of low-cost stores, defined by affordability index ($AI \leq 1$), are spatially clustered in or near East Portland. (b) Relationship between *AI* value and block-level distance to the nearest grocery store. Although Portland residents live an average of 0.7 mile (1.1 km) from the nearest grocery store, they must travel an average of 1.9 mile (3.1 km) farther to reach the nearest low-cost grocery store.

poverty residing more than 1 mile from a low-cost store, the majority (65%) live in either moderate or extreme food mirages and must travel, on average, 1.8 miles (2.9 km) past the nearest grocery store to arrive at the nearest low-cost store. For the remainder, the nearest grocery store is low-cost.

3.3. Results of regression analysis

Spatial regression results for store distance indicated that, after accounting for the effect of spatial autocorrelation, higher income tracts were associated with longer store distances, although the same was true for higher-poverty census tracts (Table 2). This result arose from the fact that some downtown census tracts were characterized by both relatively high poverty rates and high median family incomes. Gentrifying census tracts were associated with shorter store distances. Note that coefficients are higher for East Portland, since grocery stores are generally more dispersed in this region (Table 1). These relationships were inverted with respect to potential food mirage distance

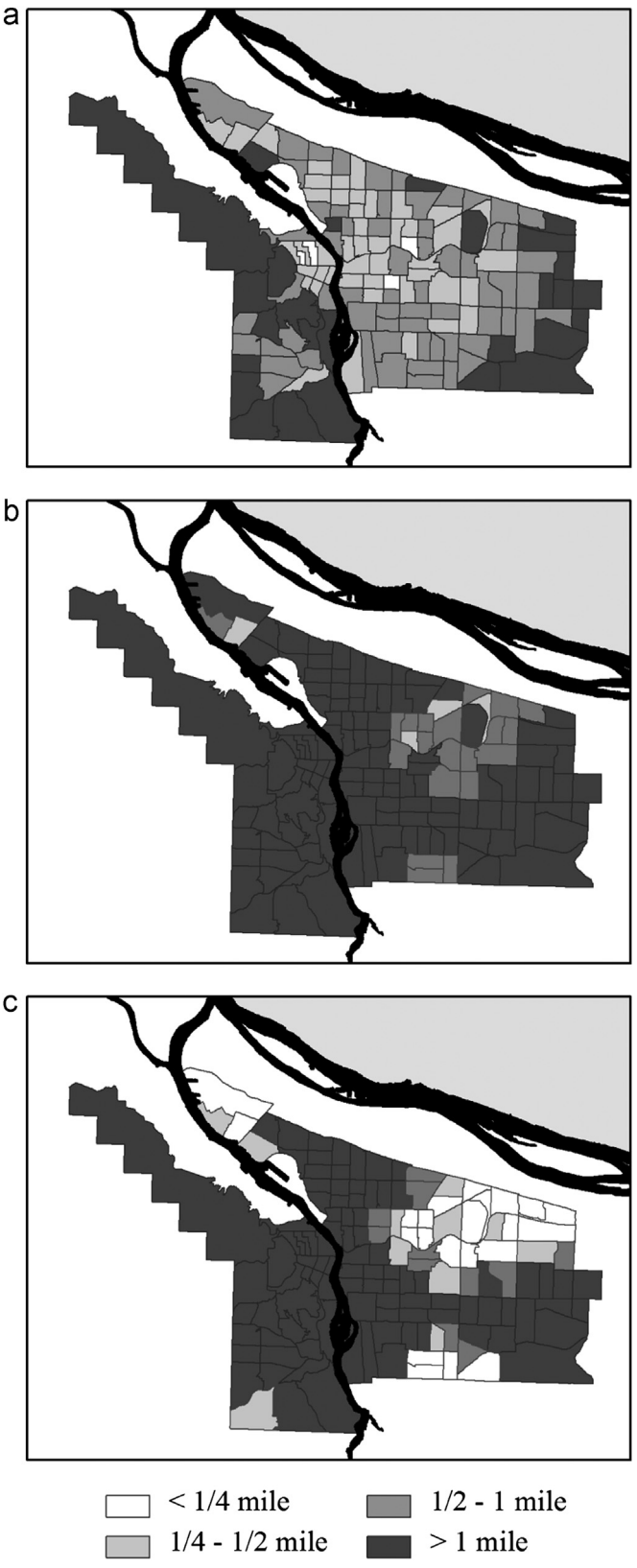

Fig. 3. Population-weighted street-network distance by census tract ($n=140$). (a) Distance to nearest grocery store. 27 tracts were found to be located more than 1 mile from any grocery store. These census tracts are either conventionally-defined food deserts (areas of concentrated poverty) or food hinterlands (see Leete et al., 2012). (b) Distance to nearest low-cost store. 116 census tracts are more than 1 mile away from a low-cost store. (c) Food mirage distance, calculated by subtracting (b) from (a). 96 census tracts are associated with a food mirage distance of more than 1 mile.

Fig. 4. Map of 'actual' food mirages, with household poverty overlay. Tracts where no access barrier is present, either because low-cost stores are within 1 mile or because tract-level median family income was in the top quartile, were removed. In the urban core, grocery stores tend to be plentiful (small circles) but prices are high. Along the periphery, stores are in general more dispersed (larger circles) but low-cost stores are available. Households in poverty reside in both the urban core and suburban periphery.

Table 1
Mean values for tract-level variables for study area partitioned into food access situations: extreme food mirage (nearest store < 0.5 mile), moderate food mirage (0.5 mile < nearest store < 1 mile), food hinterland (nearest store > 1 mile), no food mirage (low cost store < 1 mile), and high incomes (median income > 75th percentile for study area). Extreme food mirages are associated with the lowest incomes, highest rates of gentrification, and highest poverty rates.

	Income	Households in poverty (%)	Gentrification (% change white)	Nearest store (miles)	Food mirage distance (miles)
Extreme food mirage	$38,690	22.40	5.08%	0.37	2.55
Moderate food mirage	$44,821	17.91	1.18%	0.70	2.01
Food hinterland	$46,363	20.17	−3.30	1.30	1.53
No food mirage	$54,178	13.17	−2.18%	0.53	0.17
High incomes	$86,029	7.67	−0.63%	0.91	2.41
Study area	$54,067	16.36	0.62%	0.72	1.92

(Table 3). Potential food mirage distance was negatively associated with median family income and the household poverty rate, while positively associated with gentrification. Stratified regression revealed that coefficients were statistically significant in the close-in Eastside area of the city, indicating that the link between socioeconomic context and food mirages was strongest in this region.

4. Discussion

4.1. Gentrification in food mirages

The conventional food desert approach presumes that grocery store prices are reasonably equivalent, such that any full-service grocery store proxies for access to affordable food. Our survey demonstrated that grocery stores in the same city offered drastically different price points, such that many stores are not affordable for low-income households. Food access depends on store affordability, which must be understood as a function of income. As income increases, so do the number of affordable stores and thus spatial proximity to affordable food. By foregrounding interactions among income, price, and proximity, a food mirage approach captures otherwise-invisible barriers to healthful diets.

Table 2
Spatial regression results for store distance by census tract ($n=140$). Coefficients are smaller than one would obtain using ordinary least square regression because variation in the response variable has been partitioned between the socio-economic variables and the spatial lag. Units for coefficients are feet per unit of the predictor variable.

Spatial extent	Median family income (US$1000)	Household poverty rate	Gentrification	Spatial Lag
Study area	44.48849***	60.57993**	−54.33194**	0.5246***
Close-in eastside	25.49712*	54.8377**	−13.1580	0.3658**
Far-out eastside	174.4405***	181.5422**	80.9157	0.4540**
Westside	49.99646**	43.2656	−231.5638**	0.2868

* $p=0.05$.
** $p=0.01, 0.001$.
*** $p<0.0001$.

Table 3
Spatial regression results for mirage distance by census tract ($n=140$). Signs of all relationships are the inverse of results for store distance. Units for coefficients are feet per unit of the predictor variable.

Spatial extent	Median family income (US$1000)	Household poverty rate	Gentrification	Lag
Study area	−16.2482	−9.9357	32.3834	0.9529***
Close-in eastside	−39.9766**	−50.6037*	48.74478*	0.9630***
Far-out eastside	−66.2258	−29.5479	−99.8234	0.9230***
Westside	−12.6220	−42.3495	142.7623	0.7620***

* $p=0.05$.
** $p=0.01, 0.001$.
*** $p<0.0001$.

These barriers are particularly relevant for low-income households in gentrifying areas of Portland, where stores are plentiful but prices are uniformly high.

It is no coincidence that food mirages are at their most extreme in gentrifying census tracts of North and Northeast Portland. In these areas, a wide variety of urban amenities, including higher-cost grocery stores, have recently clustered to service increasingly affluent (and mostly white) populations—similar shifts are underway in numerous American cities (Quastel, 2009; Hyra, 2012). In the case of Portland, this shift is associated with increasing costs of living, in terms of both housing and food, which has lead to displacement of low-income households into suburban areas of the East Portland, where the cost of living is lower (Gibson, 2007). In effect, low-income households are migrating out of extreme food mirages and into food hinterlands. To the extent that this process is concentrating poverty in certain East Portland census tracts, the same processes that have produced food mirages could be producing the beginnings of suburban food deserts.

4.2. Food justice

Although food mirages can be measured quantitatively and mapped in a GIS, identifying potential remedies requires a more critical, discursive approach. Issues of class and food justice are sensitive to their framing (Cummins and Macintyre, 2002b). If poor diet-related health outcomes are framed as problems of proximity to a grocery store – *any* grocery store – then simply by adding grocery stores to under-served areas would seem to resolve the problem. Guthman (2011) contends that the discourse around food justice has placed too much emphasis on supply-side, geographic measures of access at the expense of demand-side, economic barriers related to household income and budget constraints. In doing so, the discourse

neatly sidesteps complex issues of affordability, need, and class. Supporting this assertion, Short et al. (2007) argue that efforts to increase food availability in low-income neighborhoods "should not distract from ensuring that residents can pay for it" (Short et al., 2007, p. 362). These critiques are particularly relevant in Portland, where food access depends on not only grocery store locations but also food prices and the patterning of affluence and poverty.

By the same token, framing food access as merely a problem of price neglects its systemic context. For example, a proliferation of Wal-marts throughout low-income neighborhoods has been proposed as a solution to inequitable food access (The White House, Office of the First Lady, 2011). However, our price survey found that Walmart prices were slightly above our benchmark for affordability, mainly because of above-benchmark prices for fresh produce, which comprised a large share of our market basket. Apart from price, the nutritional value of Wal-mart produce has been called into question (Clifford, 2013). Furthermore, in considering an intervention in the food environment, one must balance any improvements in food access against possible negative externalities imposed on households, communities, and to the food system at large (Goetz and Swaminathan, 2006; Neumark et al., 2007; Dube et al., 2007; Courtemanche and Carden, 2011; Davis et al., 2012; Hauter, 2012). Another possible remedy to food mirages would be intervention in agricultural sector to slow the growth in fresh produce prices, but this would require consideration of broader food production priorities. At the minimum, food access depends on both price and proximity; however, any intervention must be evaluated in its broader context.

4.3. Study limitations

We have focused solely on food price variation over urban space in relation to socioeconomic context at the census tract scale. We believe this focus is justified, given that economic barriers to accessing affordable, nutritious food within cities largely remain unexamined. Our assessment of the food environment was, however, limited in that it ignored other attributes that may influence food consumption decisions, including quality, convenience, cultural appropriateness, and brand loyalty. Our assessment implicitly assumed households do all their shopping at one store, which may not be the case. Further, we only considered street-network walking distance, so our results do not pertain to other modes of transportation, which can significantly impact effective access for households (Jiao et al., 2012). See Armstrong et al. (2009) for a careful analysis of the dimensions of cultural appropriateness and modes of transportation in the case of Portland's food environment.

4.4. Conclusion

This study has investigated how store locations and prices interact with socioeconomic variation to structure the food environment in Portland, Oregon. It has provided evidence that conventionally defined food deserts do not sufficiently describe the barriers to healthful food access faced by Portland's low-income households. Price-based barriers were shown to exist in areas that would not appear problematic from a conventional food desert standpoint. On average, the nearest grocery store is 0.7 mile (about a 30-min round-trip walk for the average person), but the nearest low-cost grocery store is 1.9 miles farther away (nearly a 2-h round-trip walk).

This study has posited a typology of food mirages. The most extreme food mirages occur where grocery stores are abundant but costly, as is the case in denser, often gentrifying, neighborhoods. By contrast, food hinterlands occur in lower-density neighborhoods, where grocery stores tend to be more affordable for low-income households but distance to nearest store exceeds 1 mile. We suggested that the processes of gentrification have lead to the displacement of low-income households from extreme food mirages to food hinterlands. The logical outcome of this process is the production of areas with both lower population density and lower income—in short, suburban food deserts. Although food mirages may arise from different processes than food deserts, they result in the same problem for low-income households—limited access to healthful foods and long travel times to get to an affordable grocery store or supermarket.

Food affordability is undoubtedly a difficult concept. No single price level captures the term's meaning for all demographics since affordability must be tied to incomes, budget constraints, and, to some extent, preferences. Characterizing food price variation requires careful measurement and considerable effort. Our measure of food mirages hinges on a set of assumptions, embedded in the affordability index (*AI*), that are specific to low-households: incomes at or below 130% of the poverty line, where 30% of income is spent on food. Although capturing food price variation and defining food affordability are empirically challenging, these issues must be at least considered in any complete evaluation of food access, particularly access for low-income households.

Food access is primarily an issue of income and class. As such, food prices matter. They cannot be overlooked in a food environment assessment because members of low-income households are likely price-sensitive shoppers. Spatial patterning of store prices is a critical, yet under-articulated, dimension of the food environment. By drawing attention to food mirages in Portland, this analysis invoked broader questions related to gentrification, income distribution, and food production priorities. The survey results presented here suggest that research efforts aiming to describe and interpret the food environment should consider implementing healthy market basket surveys to complement data obtained remotely. Results also suggest that policy-makers seeking to improve health outcomes by intervening in the food environment on behalf of low-income households within a rubric of food justice should consider the possible effects of their actions on price variation over urban space.

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