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Assessing the potential contribution of vacant land to urban vegetable production and consumption in Oakland, California

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Highlights

- We identify more than 335 ha of vacant public land with potential urban agricultural value.
- The contribution of vacant land to vegetable requirements depends largely on management practices.
- Committing 40 ha to vegetable production could contribute more than 5% of current needs.

1 **1. Introduction**

2 Across North America vacant land is taking center stage in the efforts of activists,
3 community members, non-profit organizations, and local governments to increase food
4 production in the city. Dozens of urban agriculture initiatives have taken root on large vacant
5 parcels and in city parks, ranging in scale and scope from small community gardens to urban
6 farms of several acres run by non-profits or commercial market gardeners. Most are launched in
7 collaboration through use or lease agreements with public agencies, private landowners, or land
8 trusts (Hodgson, Caton Campbell, & Bailkey, 2011; Nordahl, 2009). While its impact on urban
9 diets and income creation should not be overstated, urban agriculture has become an attractive
10 land use because of its potential to addresses multiple needs, supplying fresh produce in
11 neighborhoods with limited access to healthy food while offering opportunities for employment,
12 education, and recreation (Hodgson et al., 2011; Hou, Johnson, & Lawson, 2009; Redwood,
13 2011).

14 As planners, public health officials, and community groups alike articulate the linkages
15 between food systems, health, and the built environment (Corburn, 2009; Muller, Tagtow,
16 Roberts, & MacDougall, 2009; Pothukuchi, 2009), locating possible sites for urban agriculture
17 has become a priority. Over the past few years, researchers have conducted inventories of vacant
18 land with agricultural potential in Portland (Balmer et al., 2005), Vancouver (Kaethler, 2006),
19 Seattle (Horst, 2008), Cleveland (Grewal & Grewal, 2012; Taggart, Chaney, & Meaney, 2009),
20 Detroit (Colasanti & Hamm, 2010), Toronto (MacRae et al., 2010), Chicago (Taylor & Lovell,
21 2012), and New York (Ackerman, 2012). Only some of these inventories, however, estimate the
22 potential productivity of the identified land or its ability to meet consumer demands for fresh
23 fruits and vegetables.

24 To address health disparities in Oakland, California, food justice organizations interested
25 in ramping up urban agriculture have eyed the city's numerous vacant lots. Until the research
26 presented in this article was conducted, the scale of potential production was unknown, both in
27 terms of the spatial extent of vacant land and its potential contribution to the food system. In this
28 paper we detail the development, implementation, and results of a geographic information
29 system (GIS)-based inventory of Oakland's vacant and underutilized public and private land
30 conducted in collaboration with one such food justice initiative, the HOPE Collaborative
31 (hereafter, HOPE). The goals of the inventory, entitled *Cultivating the Commons* (CTC), were to:
32 1) identify potential sites for urban agriculture on vacant and underutilized public land in
33 Oakland; 2) quantify the spatial extent this land; and 3) estimate its potential contribution to
34 Oakland's food system.

35 In this article, we present a description of the study site and context before presenting the
36 methods and results of both the CTC inventory and our more recent calculations of urban
37 agriculture's potential contribution to Oakland's vegetable consumption. We conclude by
38 discussing potential limitations of the analysis and possible ways to hone the methodology.

39

40 **2. Study Site and Context**

41 ***2.1. Biophysical landscape***

42 This study was conducted in the city of Oakland, California (WGS84 37.804444, -
43 122.270833). Three primary topographic zones define the city's physical geography: flatlands,
44 foothills, and hills. The flatlands are low-lying areas largely comprised of fill (e.g., dredged
45 sediment, construction debris, quarried rocks), adjacent to the San Francisco Bay to the city's
46 west and Alameda Estuary and San Leandro Bay to the south (see Figure 1). The foothills are

47 formed on a gentle fan of alluvium spreading downwards from the Oakland hills, a series of
48 undulating, parallel ridges thrust upwards along the Hayward and Moraga faults and which run
49 along the city's eastern portion along a northwest-southeast axis (Sloan, 2006). Soils in the
50 flatlands are a mix of urban land (highly mixed, heterogeneous fill) and complexes of urban land
51 and endogenous soils derived from sedimentary, alluvial parent material, while the complexes in
52 the hills are dominated by a number of excessively drained loams weathered from uplifted
53 conglomerate and ultrabasic metamorphic rock (Welch, 1981). The climate is Mediterranean
54 with wet winters and dry summers with morning fog. Average annual precipitation is 22.9 in
55 (582.7 mm), with 89% of the total rainfall occurring between November and April. September is
56 the hottest month with an average high temperature of 80.6°F (27°C); January is the coldest
57 month, with an average high of 58.1°F (14.5°C) (NOAA, 2004). Native vegetation includes oak
58 (*Quercus* sp.) woodland, coastal shrub, and coastal terrace prairie, with large redwood (*Sequoia*
59 *sempervirens*) stands in the drainages (Beidleman & Kozloff, 2003).

60 [FIGURE 1 ABOUT HERE]

61

62 **2.2. Social landscape**

63 Oakland (pop. 391,000) is one of three core cities in the San Francisco Bay Area, a major
64 American metropolitan region populated by 7.2 million people and comprised of nine counties
65 and 101 municipalities (U.S. Census Bureau, 2010). Oakland's downtown central business
66 district is located immediately west of Lake Merritt, the physical landmark demarcating East
67 Oakland from the rest of the city. Two freeways roughly delimit the flatlands from the hills: CA-
68 24 along the north-south axis west of downtown, and I-580 along the northwest-southeast axis
69 south of the Oakland hills and foothills (see Figure 1).

70 From its founding in the early 1850s, the city grew eastwards from West Oakland and
71 downtown. The terminus of the trans-continental railroad in West Oakland led to the city's rapid
72 growth beginning in the late 19th-century, followed by major shipbuilding, automobile
73 manufacture, and food processing during the First World War. For most of the 20th century,
74 industry, commercial transportation, and warehousing were concentrated in the flatlands around
75 the Port of Oakland in West Oakland and along the Alameda Estuary. The remainder of the
76 flatlands and hills developed as residential neighborhoods (U.S. Census Bureau, 2010; Walker,
77 2001).

78 Census data reveal a disproportionate concentration of poverty in the flatlands of North,
79 West, and East Oakland, affecting a population that is majority African American, Southeast
80 Asian, and Latino. Most of Oakland's white population lives in the more affluent foothills and
81 hills neighborhoods (U.S. Census Bureau, 2010). The spatial inequities of the socioeconomic
82 landscape are largely due to the historical demarcation of areas where particular ethnic groups
83 were allowed to live as well as where investment capital flowed. During the first half of the 20th
84 century, "redlining" by insurance companies prevented investment in "high risk" low-income
85 areas, while racial covenants prevented people of color from living in white neighborhoods.
86 During the 1960s and 1970s, freeway construction bifurcated the city while deindustrialization
87 prompted the outflow of commercial capital and a declining tax base (McClintock, 2011; Self,
88 2003; Walker, 2001).

89 This bifurcation of the socioeconomic landscape into hills and flatlands has also defined
90 access to healthy and affordable food in Oakland. In Oakland, 20% of families live below the
91 federal poverty line. Approximately one-third of Alameda County's residents are food insecure
92 and 87% of Oakland school children receive free or reduced-price lunch (ACPHD, 2008; OFPC,

93 2010). Areas with limited access to healthy food—so-called “food deserts”—are located in the
94 flatlands and are closely tied to its history of disinvestment (HOPE Collaborative, 2009;
95 McClintock, 2011). Over the last decade, several food justice organizations have attempted to
96 address inequitable access to healthy food through a variety of programs and policy
97 recommendations. Urban agriculture has been central to these efforts and has begun to figure
98 prominently in food systems, public health, and land use planning discussions in Oakland
99 (McClintock, Wooten, & Brown, 2012).

100

101 ***2.3. Study Context***

102 Oakland’s vibrant food justice movement and a growing body of community-based
103 participatory research in public health (Israel, Eng, Schulz, & Parker, 2005; Minkler &
104 Wallerstein, 2003) and environmental justice (Corburn, 2005; Metzger & Lendvay, 2006;
105 Petersen, Minkler, Vasquez, & Baden, 2006) inspired this research. Developed iteratively with
106 community stakeholders, the project took shape within the following context. In 2006 the
107 Oakland City Council embraced a goal of sourcing 30% of its food locally, and passed
108 Resolution No. 79680 to support a food system assessment for the city. The resulting Oakland
109 Food System Assessment (OFSA) evaluated the existing avenues of food distribution and
110 consumption in Oakland, including food production within a 200 mi (321.9 km) radius from the
111 city (Unger & Wooten, 2006). While the vast majority of food consumed in Oakland comes
112 from outside of this area, local food systems advocates have underscored the importance of food
113 production within the city itself in order to promote education, reduce the distance between
114 production and consumption, enhance green space, and create green job opportunities (Hodgson
115 et al., 2011; OFPC, 2010). While urban agriculture in Oakland is widespread, the contribution of

116 existing gardens to the city's total consumption of vegetables is unknown and difficult to
117 quantify. There are currently more than 100 school gardens in Oakland, 10 community gardens
118 managed by the Office of Parks and Recreation (OPR), and dozens managed by non-profit
119 organizations (Farfan-Ramirez, Olivera, Pascoe, & Safinya-Davies, 2010; OFPC, 2010; Unger
120 & Wooten, 2006). No data on residential gardening exists for Oakland, but national data reveal
121 that almost 40% of Americans grow vegetables in their yards (Marks, 2008).

122 Because the *potential* contribution of urban agriculture was also unknown, the OFSA's
123 first recommendation regarding local food production was to: "Initiate an inventory of land that
124 is potentially suitable for urban agricultural production. Such an inventory would ideally include
125 both suitable public land (e.g., rights-of-way, easements, parks) and private land (e.g., rooftops,
126 vacant lots, backyard gardens)" (Unger & Wooten, 2006, p. 105). A 2008 meta-analysis of
127 existing data on production, distribution, consumption, and waste recovery in Oakland's food
128 system reiterated the need for a land inventory in order to calculate the city's agricultural
129 potential, noting that "it would be useful to have a better sense of production capacity in order to
130 understand land acquisition and programming needs/costs" (Wooten, 2008, p. 19).

131 Between October 2007 and June 2009, this paper's lead author (N. McClintock) was
132 involved with HOPE as a participant observer. During this time, HOPE members conducted an
133 assessment of the food system and built environment in six low-income "micro-zones" in the
134 flatlands. The assessment included interviews, inventories, community listening sessions, and
135 *charrettes* that involved mapping and visioning a "healthier, greener Oakland" (Herrera, Khanna,
136 & Davis, 2009; HOPE Collaborative, 2009). Participants repeatedly expressed the need to know
137 the potential for urban agriculture to expand in Oakland. Over the course of 2008, discussions
138 with HOPE members helped to define a specific research question: *To what extent could urban*

139 *agriculture on Oakland's vacant and underutilized vacant land contribute to the city's food*
140 *system? Key sub-questions included: Where is there available land? Who owns it? How much is*
141 *there? How much produce could be grown on it?*

142 In early 2009, HOPE members collectively prioritized the need to move forward with
143 such an assessment as a crucial first step toward the development of a robust food system for
144 low-income flatlands neighborhoods and funded a research assistant (J. Cooper) to help complete
145 the inventory. McClintock and Cooper completed the majority of GIS analysis and mapping
146 between January and June 2009 and released a final report (McClintock & Cooper, 2009) in
147 October 2009, with hopes that the inventory might help non-profit organizations and city
148 officials identify potential urban agriculture sites and inform food policy decisions.

149 Over the course of the project we worked collaboratively with HOPE members, city
150 officials, and urban agriculture organizations, establishing a community advisory committee
151 made up of members from these groups to brainstorm criteria for selection of potential sites and
152 provide feedback on what information would be useful in the finished report. Advisory
153 committee members also provided feedback on several drafts of the report before its release. The
154 process of defining the parameters of the research was iterative, a defining characteristic of
155 collaborative or participatory research (Israel et al., 2005; Minkler & Wallerstein, 2003).
156 Moreover, the project itself was iterative, and continued even after the report's release. Extensive
157 ground-truthing of sites was conducted throughout 2010. In Fall 2010, McClintock conducted a
158 finer-grained slope analysis and a research assistant (S. Khandeshi) analyzed a data layer of
159 privately owned vacant land. Building on methods used in assessments of vacant land in Detroit
160 (Colasanti & Hamm, 2010) and Toronto (MacRae et al., 2010), McClintock then calculated the
161 potential contribution of inventoried vacant land to Oakland's estimated current and

162 recommended vegetable consumption. The methods and results of the entire project—the CTC
163 public land inventory, the private land inventory, and productivity calculations—are reported
164 here in detail.

165

166 **3. Methods**

167 **3.1. Vacant land inventory**

168 Following the lead of early vacant land inventories conducted in Portland (Balmer et al.,
169 2005), Vancouver (Kaethler, 2006), and Seattle (Horst, 2008), our goal was to locate vacant
170 parcels that could potentially serve as sites of food production. Upon initial examination, we
171 realized that the amount of actual *vacant* public land (e.g., land with no existing use, such as a
172 park or lawn or playing field) in Oakland was limited. We therefore chose to broaden the scope
173 of our investigation to include any *underutilized* public land that could potentially be used for
174 crop production, with the understanding that actual site selection would ultimately depend on
175 additional criteria and community input.

176 [FIGURES 2a and 2b ABOUT HERE]

177 We used ArcGIS 9.3 software to identify, delineate, and catalog areas where crops could
178 potentially be grown, as well as to calculate area, slope, and aspect of the sites. The land
179 included in the inventory belongs to public agencies spanning multiple administrative levels,
180 from municipal to federal (see Table 1). We first used Alameda County Tax Assessor’s parcel
181 data obtained from the City of Oakland’s GIS database to identify the 2,551 publicly owned
182 parcels totaling 10,013 ac (4,052.1 ha) of land, or nearly a third of Oakland’s total area of 35,703
183 ac (14,448.5 ha). Zoning and General Plan land use classifications were joined to each site.

184 [TABLE 1 ABOUT HERE]

185 We then exported and overlaid the parcel layer onto National Agriculture Imagery
186 Program (NAIP) 1-m satellite imagery (USDA, 2005). Systematically following a 1-km grid
187 overlay, we used visual interpretation to select parcels containing potentially arable land,
188 including parcels that appeared vacant or that contained lawns, fields, and other open spaces
189 within a park or adjacent to a government facility (see Figures 2a and 2b). We excluded fully
190 developed parcels and spaces with an apparent use, such as playing fields and parking lots, but in
191 a few cases included parking lots that appeared to have been abandoned, as such sites could be
192 used for food production in greenhouses or raised beds.

193 We clipped out buildings and developed areas such as roads, playing fields, and parking
194 lots and classified each parcel into one of four ground cover categories: soil/grass (less than 25%
195 coverage by dense vegetation or hard surface); hard surface (>25% asphalt, concrete, or gravel,
196 and <500 ft² of contiguous open soil/grass); mixed surface (> 25% asphalt, concrete, or gravel,
197 but >500 ft² of contiguous open soil/grass), or dense vegetation (>25% dense vegetation and
198 <500 ft² of contiguous open soil/grass). Dense vegetation parcels containing <500 ft² of
199 contiguous open soil/grass were removed, while those containing >500 ft² were modified by
200 clipping out the vegetation. Finally, any parcel with <500 ft² (46.5 m²) of open space was
201 removed from the final inventory.

202 The aggregated area that remained (which included soil/grass, hard surface, and mixed
203 surface) formed the total area classified as arable. To calculate slope at each site, we transformed
204 parcel polygons to a raster and calculated average slope for each 100 m² raster square using a
205 digital elevation model (DEM). The raster was then reclassified into: slopes <10%; between 10
206 and 30%; and >30%, a practical threshold slope for cultivation (while agriculture is practiced on
207 slopes greater than 30% in many parts of the world, terracing or other stabilization techniques are

208 generally required). Using the slope raster and DEM, we also created an aspect raster, which we
209 then reclassified as “optimal” (<30% slope and W, SW, S, SE, or E aspect) or “less desirable”
210 (>30% slope and NW, N, or NE aspect). Finally, we spatially joined water meters, schools, and
211 bus stops to the inventory layer, and queried all sites within 10 ft (3.05 m) of a water meter, 0.25
212 mi (0.40 km) of a school, and/or 0.25 mi (0.40 km) of a bus stop, attributes that were presented
213 in the final database and report.

214 To account for limitations posed by visual interpretation of the NAIP imagery, we cross-
215 checked all sites with more recent Google Maps imagery and visited a geographically
216 representative sample of sites to assess vegetation density and slope. We visited 50 of 495 total
217 sites (10%) in 2009, and an additional 120 sites (24%) in 2010 under the purview of a related soil
218 sampling project (McClintock, 2012). Overall, seven densely vegetated sites (4% of total
219 ground-truthed sites) were removed from the inventory.

220 Using vacant parcels data obtained from the UC Berkeley Department of City and
221 Regional Planning in Fall 2010, we followed roughly the same GIS protocol to calculate the
222 amount of potentially arable privately owned vacant land. This time we used ArcGIS 10 and a
223 current Bing Maps base layer (rather than NAIP imagery) to visually interpret the 4,249 vacant
224 parcels. Given the extensive labor required, we modified the selection criteria, whereby parcels
225 containing >25% dense vegetation were removed from the inventory. Similarly, parcels
226 containing >25% infrastructure (such as outbuildings or pavement) or with a clear existing use
227 (such as parking or junk storage) were removed. Due to the variation in selection criteria
228 between public and private parcels, we have chosen to report the results separately.

229

230 ***3.2. Calculating consumption***

231 To calculate the vegetable needs of Oakland’s population, we used population data (sex
232 and age cohorts) from the 2010 US Census, then aggregated cohorts into larger groups based on
233 USDA recommendations for vegetable intake. Recommended consumption for all cohorts was
234 then aggregated into an overall citywide demand (see Table 2). Both the Detroit (Colasanti &
235 Hamm, 2010) and Toronto (MacRae et al., 2010) studies, however, assessed the potential for
236 vacant land to contribute to *actual* consumption rather than *recommended* consumption.
237 Following the Detroit study, we obtained consumption data from the USDA ERS Loss-Adjusted
238 Food Availability Database (USDA, 2010) which calculates average national per capita fresh
239 vegetable consumption from aggregate production, adjusting for losses between production and
240 consumption. Using the national per capita consumption for each fresh vegetable crop (see
241 Appendix A), we extrapolated current and recommended Oakland consumption based on the
242 population data presented in Table 2.

243 [TABLE 2 ABOUT HERE]

244 When calculating potential productivity of vacant land, it is important to factor in both
245 the geographic adaptability of a particular crop to the local agroecosystem and its seasonality.
246 Following the Detroit study, we calculated the potential *local/seasonal* share of current and
247 recommended consumption, divided the number of months that a particular crop can be
248 harvested in Oakland by 12 months, then multiplied the coefficient by estimated current and
249 recommended consumption levels for each crop (see Appendix A). Three of the USDA database
250 crops—lima beans, okra, sweet corn, and sweet potatoes—do not grow well in Oakland,
251 requiring warmer and sunnier conditions (sweet corn, for example, rarely produces large ears
252 during the Bay Area foggy summers). They were therefore excluded from the local/seasonal
253 productivity calculations.

254

255 *3.3. Calculating productivity*

256 No yield data was available from actual urban gardens in Oakland. The Detroit study
257 used three different production scenarios to estimate the amount necessary to meet consumer
258 demands: high-productivity biointensive, low-productivity biointensive, and commercial.
259 Following this logic, we averaged California statewide yield data from 1998 to 2008 for each of
260 the vegetable crops listed in the USDA database as well as low and medium yields using
261 biointensive methods calculated in Northern California (Jeavons, 2002). Vegetable yields under
262 conventional management average 13.2 tons per acre (29.6 Mg/ha). Low biointensive yields,
263 which assume a beginning gardener, are slightly higher at 15.4 tons per acre (34.5 Mg/ha) while
264 medium biointensive yield averages are twice as high (30.8 tons per acre or 69.0 Mg/ha) (see
265 Appendix 2). Unlike the Detroit researchers, we used medium biointensive yields for each crop
266 rather than high yields (which many gardeners argue are unrealistic). Finally, we interviewed
267 three organic farmers operating intensive commercial and/or educational operations in other
268 urban or peri-urban areas with Mediterranean growing climatic conditions. Farms were located
269 in Davis and Santa Cruz, California (both approximately 110 km from Oakland, east and south,
270 respectively) and Eugene, Oregon (830 km north of Oakland). They verified that our selected
271 range of yields was realistic, depending on crop choice and management.

272 While the Toronto study calculated productivity based on Statistics Canada yield data
273 unadjusted for losses, we followed the Detroit study's method of using state and federal data to
274 calculate yields and farm to consumer losses at different stages in the commodity chain. The
275 USDA database reports average estimated post-harvest losses at various stages between farm and
276 table: farm to retail, retail to consumer, and inedible share (i.e., the portion of the raw vegetable,

277 such as stems, that are not actually consumed). These farm-to-table losses are needed to calculate
278 the overall production required to meet both estimated current consumption and recommended
279 consumption levels. Appendix 2 lists these losses for each crop of interest. On average, there is a
280 63% loss in weight from farm to table, but these vary considerably by crop.

281

282 ***3.4. Calculating potential contribution of vacant land***

283 To estimate the contribution of vegetable production on Oakland’s vacant land to the
284 city’s estimated current and recommended vegetable consumption, we calculated production
285 under four different land use scenarios. The first two scenarios use total areas calculated during
286 the GIS inventory. A highly unlikely Scenario 1 assumes that all available land with a slope
287 <30% would be used for vegetable production, while Scenario 2 uses only “optimal” acres (i.e.,
288 the Scenario 1 total excluding all NW, N, and NE-facing land). Scenarios 3 and 4 represent two
289 more realistic scenarios, where specific (but arbitrary) amounts of land would be dedicated to
290 urban agriculture, for example, by an act of City Council or OPR. Scenario 3 is based on a
291 “High” land use of 500 ac (202.3 ha), while Scenario 4 is perhaps the most realistic, a “Low”
292 land use of 100 ac (40.5 ha). In all Scenarios, we assumed that 75% of a site’s arable total land
293 area would be used for crop production, with the remaining 25% taken up by infrastructure and
294 non-productive space (between-row aisles, turning lanes at the end of the rows, etc). We then
295 calculated the potential contribution under three agricultural management practices:
296 conventional, biointensive (low), and biointensive (medium). For the sake of developing a “back
297 of the envelope” metric for other studies, we rounded down to a slightly more conservative
298 average yield for each of these management practices, using 10, 15, and 25 tons/ac (22.4, 33.6,

299 and 56.0 Mg/ha), for conventional, bio-intensive (low), and bio-intensive (medium),
300 respectively.

301

302 **4. Results**

303 ***4.1. Consumption***

304 Based on Oakland's 2010 population of 390,724, the recommended annual vegetable
305 consumption by city's population totals 90,766 tons (82,341.5 Mg) (Table 4). According to the
306 USDA Americans annually consume 97.9 lbs (44.4 kg) of fresh vegetables per capita. Assuming
307 that Oakland follows the same pattern, Oaklanders currently consume 19,126 tons (17,350.8 Mg)
308 of fresh vegetables, or only 21% of the recommended total.

309 We estimate that 28,884 tons (26,203.1 Mg) are needed to meet estimated current
310 consumption levels, and 137,016 tons (124,298.8 Mg) needed to meet recommended levels.
311 Considering the geographic adaptability and seasonality of crops, the overall possible local
312 contribution to production needs is slightly lower (see Table 3).

313 [TABLE 3 ABOUT HERE]

314

315 ***4.2. Public land***

316 Overall, we identified roughly 1,200 ac (486.0 ha) of arable land on 495 aggregated sites
317 consisting of 756 individual tax parcels (see Figure 3). Slightly more than half (629 ac, or 254.5
318 ha) of land identified in the inventory is currently owned or managed by OPR. The sites are
319 distributed relatively evenly across the city, but the vast majority of arable public land is located
320 in East Oakland, with another large number of sites located in the West Oakland flatlands. While

321 a significant amount of open space is located on public land in the Oakland hills, much of this
322 land is fragmented, located on slopes >30%, and inaccessible by road.

323 [FIGURE 3 ABOUT HERE]

324 More than one-third of the sites are small parcels >0.25 ac (0.1 ha), which, based on size
325 alone, would be best suited for community gardens. Another one-third of the sites are between
326 0.25 and 1 ac (0.1 to 0.4 ha) and might be best used as community gardens or small market
327 gardens run by urban agriculture organizations. A final one-third of the sites are between 1 and 5
328 ac (0.4 to 2.0 ha) and could be developed as large market gardens or “mini-farms” run by urban
329 agriculture organizations or leased to individual commercial urban farmers. Finally, 45 sites are
330 >5 ac (2.0 ha) and could be used as urban farms managed by urban agriculture organizations or
331 leased to commercial farmers for large-scale urban production.

332 Most of the identified land (1,078 ac, or 436.3 ha) has soil or grass as ground cover,
333 while 26 parcels totaling 30 ac (12.1 ha) are covered with an impermeable ground cover such as
334 gravel, concrete, or asphalt. Such sites would be suitable for greenhouses or raised beds (or used
335 for compost processing, distribution centers, and/or storage). The land is almost evenly divided
336 between level (<10% slope), sloping (10 to 30%), and steep land (>30%). More than a third of
337 the land (nearly 410 ac or 165.9 ha) is level (see Figure 3). Parcels with the most level terrain
338 would be optimal for community gardens. Aspect, or directional exposure to the sun, is another
339 key consideration when considering crop production, particularly on moderate to steep slopes.
340 Overall, roughly 12% of the total area faced NW, N, or NE. Our “optimal site” calculation
341 yielded a total of 730 ac (295.4 ha), or 62% of the total area (see Table 4).

342 [TABLE 4 ABOUT HERE]

343 Table 5 summarizes the potential contribution of urban agriculture on public land to
344 vegetable consumption in Oakland under three different production systems. Under ideal
345 growing practices, even the Low land use scenario, which commits 100 ac (40.5 ha) to vegetable
346 production, could yield more than 5% of the city’s estimated vegetable consumption, while the
347 High use scenario which commits 500 ac (202.3 ha), could produce roughly a third of the
348 estimated current consumption needs. More modest yields under conventional management
349 would result in 2.9 and 14.5% under the Low and High land use scenarios, respectively. Because
350 *recommended* consumption is so much higher than *current* consumption, the vacant land’s
351 potential to meet these recommendations is lower. The Low land use scenario would contribute
352 as little as 0.6 to 1.5% to the city’s food recommended consumption needs, while the High land
353 use scenario could deliver as much as 7.7%, depending on management practices.

354 [TABLE 5 ABOUT HERE]

355

356 **4.3. Private land**

357 Overall, we identified 3,008 privately owned vacant parcels, totaling 864 ac (349.6 ha)
358 (see Figure 3). The vast majority of this land (2,484 parcels totaling 289 ac, or 117.0 ha) consists
359 of lots <0.25 ac (0.1 ha). Fifteen large parcels >5 ac (2.0 ha) account for roughly a third of the
360 land (see Table 6). A slope analysis reveals that only 40%, or 337 ac (136.4 ha) of the overall
361 area is located on slopes <30%. Many of the largest parcels are located on steep slopes in the
362 Oakland hills, likely the reason that they have not been developed.

363 [TABLE 6 ABOUT HERE]

364 Using the methods described above to calculate potential contribution of vacant land to
365 Oakland’s vegetable consumption, private vacant could contribute an additional 3,370 tons

366 (3,057.2 Mg) of vegetables under conventional farming practices, equaling 2.1 of Oakland's
367 current consumption or 9.8% of recommended consumption. Low-yield biointensive could
368 produce 5,055 tons (4,585.8 Mg), 14.7% of current consumption or 3.1% of recommended
369 consumption. Medium-yield biointensive could produce 8,425 tons (7,463 Mg), 24.5% of the
370 city's current consumption needs or 5.2% of recommended needs.

371

372 **5. Discussion**

373 *5.1. Strengths of the study*

374 This study identifies potential sites of production in Oakland and provides a preliminary
375 assessment of the capacity of this vacant land to contribute to the city's vegetable consumption.
376 Moreover, the analysis also reveals that a majority of arable sites are located in the flatlands,
377 where urban agriculture advocates are most active and the need for healthy produce the greatest.

378 Clearly, urban agriculture should not supplant all other uses of urban green space; public
379 open spaces must serve multiple purposes. The spectrum of land use scenarios therefore ranges
380 from the improbable Scenario 1 (where all land would be used) to the potentially possible
381 Scenario 4 where only 100 ac (14% of the total optimal vacant land) would be devoted to urban
382 food production. Even under this scenario and the most conservative yield estimate, as much as
383 3% of the city's current consumption needs could be met. This contribution may seem
384 insignificant when weighing costs and benefits on production alone, but when considering urban
385 agriculture as only one (albeit spatially disparate) node in a network of local and regional
386 production, 3% is considerable, especially in a built environment as dense as the Bay Area.
387 Similar to our findings, vacant land in New York City could contribute to 2% of the city's
388 vegetable consumption under conventional methods (Ackerman, 2012), whereas in Detroit,

389 where vacant public land alone totals 4,848 ac (1,961.9 ha) and the population shrinking, found
390 that one-third of current consumption levels could be met by farming vacant lots (Colasanti &
391 Hamm, 2010), while Cleveland’s 3,413 ac (1,381.1 ha) of vacant lots could contribute 22 to 48%
392 to the city’s produce (Grewal & Grewal, 2012).

393 Beyond providing Oakland urban agriculture practitioners and policy makers with data,
394 this study helped to foster collaboration between researchers and the public. The project was
395 initially inspired by a broad range of stakeholders, many of whom also contributed to the land
396 inventory in an advisory capacity. Such integration of community participation is common in
397 environmental justice research and policy advocacy (Costa et al., 2002; Metzger & Lendvay,
398 2006; Petersen et al., 2006), reflecting the broader collaborative turn in planning (Innes &
399 Booher, 2010). It also gives primacy to the co-production of science for healthy city planning,
400 what Corburn (2009, p. 11) describes as a “polycentric, interactive, and multipartite sharing of
401 information” bringing together researchers, government agencies, and lay publics. On a more
402 immediate level, as Mendes et al. (2008) concluded in their comparative study of the Portland
403 and Vancouver land inventories, the success of moving from land inventory to successful
404 implementation of urban agriculture projects relies on the successful integration of stakeholders
405 into the inventory and planning process. Indeed, the preliminary GIS inventory of public land
406 that emerged from this project has played a role in ongoing efforts by city officials in Oakland to
407 update urban agriculture zoning (McClintock et al., 2012).

408 Furthermore, this study has both informed and built on other efforts to assess urban
409 agriculture’s potential on vacant and underutilized land in North American cities. The original
410 CTC report provided methodological insights for several inventories that were conducted in
411 other cities (Ackerman, 2012; Colasanti & Hamm, 2010; MacRae et al., 2010; Taggart et al.,

412 2009; Taylor & Lovell, 2012). Two of these studies, in turn, helped us refine our own
413 consumption and productivity calculations.

414

415 ***5.2. Limitations to the methodology***

416 This project solely sought to provide a rough, “back of the envelope” estimate of urban
417 agriculture’s potential contribution to the food system. While the inventory was comprehensive,
418 there are several limitations worth noting:

419

420 *5.2.1. Data availability*

421 A primary limitation was the availability and currency of geospatial data. Even though
422 the tax assessor data file was updated quarterly, there was a lag time before shape files were
423 updated to reflect the tax assessor data. Because of the dynamic nature of development plans and
424 real estate transfers, each site would ideally be crosschecked with managing agencies and the
425 online tax assessor database; time and labor constraints prevented us from doing so. As outside
426 researchers without access to the tax assessor database, it was only possible to provide this
427 “snapshot” of vacant land at the time that the inventory was completed. A searchable Web GIS
428 version of the inventory, ideally linked to the existing tax assessor database and updated
429 immediately as sites are sold or transferred, could make current information available to the
430 public in a more user-friendly fashion.

431 The currency of aerial imagery was also an obstacle. When the CTC inventory was
432 completed, only 2005 NAIP imagery was available, thus the visual record of land use was
433 already four years old. To account for this, we crosschecked all sites using Google Maps to see if
434 they had been developed in the interim. While we were able to then delete newly developed sites

435 from the inventory, we were unable to account for slight changes in vegetation. New NAIP
436 imagery, flown in Summer 2009, was released after we had completed the majority of the GIS
437 analysis of the public land. The release of ArcGIS 10, which includes up to date Bing basemap
438 imagery, greatly expedited our analysis of private land. For analysts using Quantum GIS,
439 GRASS, or other open source software, NAIP imagery is a free alternative, but may have slightly
440 lower resolution than Bing or Google imagery.

441

442 *5.2.2. Visual interpretation*

443 The study also revealed the limitations of visual interpretation. Even with 1-m resolution,
444 what appears to be arable in an aerial or satellite-photo may not hold up to ground-truthing. The
445 annual grasses of the Bay Area turn a golden brown color during the dry season, making it
446 difficult to distinguish them from bare dirt or concrete at some sites. While ground-truthing of
447 34% of the publicly owned sites confirmed that our estimates were 96% accurate, further
448 comprehensive assessment of sites should be conducted to determine if all of them are actually
449 viable for food production. Indeed, ground-truthing ultimately prompted us to hone the slope
450 analysis in 2010 to better identify slopes that might be too steep to farm.

451 Another major drawback of our approach was its labor intensiveness. Visual assessment
452 of each parcel was incredibly time consuming, and clipping out vegetation and buildings and
453 other reshaping of polygons added a significant level of precision to the project. The HOPE
454 mini-grant funded 140 hours of GIS work, but we easily spent twice this amount of time
455 inventorying the publicly owned land. The private land inventory was completed much more
456 quickly because the Bing base map allowed us to eliminate the extra step of cross checking each
457 site against Google Maps. The use of remote sensing software to process aerial imagery could

458 certainly speed up the process, but would be complicated by shading from buildings and
459 differentiating dry vegetation from other surfaces. Using higher resolution imagery for the entire
460 city would also require significant data processing capabilities. Indeed, recent land inventories
461 using remote sensing have extrapolated their results from small sub-sections of the city (Nipen,
462 2009; Welty, 2010).

463

464 *5.2.3. Estimating production and consumption*

465 There are limitations to calculating vegetable consumption (and by extension, necessary
466 production) at the city- or neighborhood-scale. Interpolating consumption based on national
467 averages is clearly problematic, especially when the demographics of poverty, race, and
468 ethnicity—all of which factor into food consumption patterns—differ between the municipal and
469 national scale. Vegetable consumption is closely correlated to education and income, with
470 significant differences in consumption between races and/or ethnic groups (Casagrande, Wang,
471 Anderson, & Gary, 2007). Given the socioeconomic disparity between the flatlands and hills,
472 consumption patterns are surely even different *within* Oakland (hence the activism that has
473 emerged to address these inequities). Considering that 22% of Oakland’s population lives in
474 poverty relative to 15% nationally (U.S. Census Bureau, 2010), the quantity of vegetables
475 actually consumed is likely lower than aggregate USDA data suggests.

476 Furthermore, the USDA averages likely do not reflect Oakland’s ethnic—and culinary—
477 diversity; the culinary traditions and diets of the city’s large Asian and Latino populations (17%
478 and 25% of the city’s population, respectively, versus 5% and 16% of the US population) are
479 rich in many vegetables that are not represented in the USDA dataset. A more accurate estimate
480 would require finer grain, in-depth consumption surveys stratified along socioeconomic lines.

481 This would also help to reveal the full spectrum of crop varieties that people actually consume in
482 Oakland.

483 In terms of production, estimates of the local/seasonal share of crop production should be
484 fine-tuned using crop yield data specific to East Bay urban agroecosystems. No such data
485 currently exists in any comprehensive form. Moreover, not all vegetables would grow equally
486 well at every site, given site-specific soil quality and micro-climatic conditions. Such variability
487 would need to be considered once actual sites were selected. Because existing soil maps are too
488 coarse to capture such variability at the site scale, we did not include a soil assessment in our
489 GIS analysis.

490 Moreover, our three yield scenarios are realistic only if gardens were to be managed with
491 a level of professional attention to spacing, planting, weeding, irrigation, pest control, and
492 harvest. Community and school gardens that are not tended with the same level of care are
493 unlikely to attain such yields. Scenario 4 (100 ac devoted to urban agriculture) is arguably the
494 most realistic in that it represents a scale that City of Oakland officials might consider given
495 conflicting stakeholder needs (an issue we address in the Conclusion) and/or the difficulty they
496 might face in securing potential commercial or non-profit farm managers to farm a larger area.

497 Finally, our production estimates incorporate USDA loss estimates that are likely higher
498 than what might occur in a localized food system. Indeed, they reflect the average losses for
499 vegetables that travel more than 1,000 miles on average from farm to plate (Weber & Matthews,
500 2008). Under a localized production system where more produce is sold at farm stands and
501 farmers' markets and less weight loss to processing, we might assume lower rates of loss
502 between retail and consumer. For this reason, our overall production estimates are likely
503 conservative.

504

505 ***5.3. Future directions***

506 This study represents only a preliminary step in an ongoing effort to expand urban
507 agriculture in Oakland. The next step would be to prioritize site suitability. The sites identified in
508 this inventory were categorized based on size, slope, and aspect. While information on ground
509 cover, presence of a water meter, accessibility to public transportation, and proximity to schools
510 were included with each site listed in the Land Locator, these factors (selected by the advisory
511 committee) were not used to rank site suitability; rather, they were simply presented as relevant
512 data to help guide such decisions. A prioritization or ranking of sites for suitability should
513 include some or all of these factors, as well as others such as soil quality, tenure, access, and
514 waste disposal (Unger and Wooten 2006).

515 Soil quality, in particular, is an issue in urban areas. Many urban soils have high levels of
516 lead (Pb) and other contaminants. This project led to the assessment of Pb at more than a
517 hundred sites identified in this inventory. Results indicated that Pb levels are lower than expected
518 across the city, but that levels are highly variable at each site and are dependent on a number of
519 variables including soil type, density of pre-1940s housing, distance to major roads, and levels of
520 soil carbon and soil phosphorus (McClintock, 2012). This data, along with EPA Brownfields and
521 California Department of Toxic Substances Control data, should figure centrally in future site
522 suitability assessment. Other indicators of soil quality, such as soil organic matter, cation
523 exchange capacity, clay content, and nutrient availability would also be useful. In many cases,
524 however, construction of raised beds and/or the importation of soil and compost may mitigate
525 many soil quality issues.

526 Since the completion of the CTC inventory in 2009, several other land inventories have
527 been released. Each of these inventories includes additional variables that could be incorporated
528 into a finer grain analysis and that could help to narrow the overall suitability of a particular site.
529 Some of these analyses are more dependent on high-resolution geospatial data than others. The
530 Halifax inventory, for example, uses LiDAR data to model potential sun exposure at different
531 times of day in potential backyard gardens in several sample neighborhoods, and reports an
532 additional 22% loss of available space due to shading (Nipen, 2009). A Somerville
533 (Massachusetts) inventory includes soil type and population density in the analysis (Bickerdike,
534 DiLisio, Haskin, McCullagh, & Pierce-Quinonez, 2010). One Cleveland inventory, conducted by
535 the Cleveland-Cuyahoga County Food Policy Coalition, includes presence of hydrological
536 features and soil, as well as proximity to community gardens greenhouses and other consumer
537 markets (Taggart et al., 2009). Furthermore, it excludes industrial and brownfields sites, as does
538 the New York assessment (Ackerman, 2012).

539 With the exception of a recent Cleveland study (Grewal & Grewal, 2012), vacant land
540 inventories to date have not included economic variables. A suite of economic indicators such as
541 parcel values, crop values, job creation, and infrastructure costs would be necessary to conduct
542 cost-benefit analyses to compare urban agriculture to other land uses. At the same time, such an
543 econometric analysis would likely fail to capture the multiple—but difficult or impossible to
544 quantify—attributes that make parks and other green space valuable in urban landscapes, notably
545 the aesthetic, recreational, educational, and health benefits offered by such spaces.

546

547 **6. Conclusion**

548 Despite the methodological limitations outlined above, mapping vacant land is an
549 important step in an ongoing process to bring urban agriculture’s potential to fruition in Oakland
550 and other cities. It will surely take a long time for cultivation to reach the 100 or 500 ac as
551 envisioned in the Low and High land use scenarios presented above. Ultimately, the delineation
552 of polygons is only a preliminary step in the long process of mapping the agricultural potential of
553 a city such as Oakland. Indeed, the politics of negotiating competing uses of vacant land is far
554 more complex than identifying potential sites of production. The real work in planning for urban
555 agriculture lies in identifying and negotiating the varied interests of multiple stakeholders.

556 As in any case of multiple land uses, such conflicting interests may hinder urban
557 agriculture at a particular site. For example, people who use the site for walking dogs, playing
558 Frisbee, flying kites, or picnicking would likely object to its conversion to agricultural use.
559 Similarly, “not-in-my-backyard” (NIMBY) sentiments from neighbors concerned over noise,
560 human or vehicle traffic, odors from compost or manure, or impact on property values may
561 prove a challenge to cultivation at particular sites. These conflicting interests and concerns must
562 figure centrally into public discussions over how much and which land to devote to urban
563 agriculture. In Oakland, all projects proposed on OPR land, for example, are required to go
564 through a lengthy approval process that includes several public comment periods where such
565 conflicts are heard.

566 The cultivation of private land ultimately depends on the will of the landowner.
567 Municipalities have little control over how a vacant parcel is to be used other than easing zoning
568 and permitting restrictions on urban agriculture (McClintock et al., 2012) or incentivizing
569 landowners to convert their property to agricultural use. A municipal government could waive
570 blight fines or provide property tax credits, for example, for vacant property owners allowing

571 cultivation on their property, a policy exemplified by Maryland House Bill 1062 (Property Tax
572 Credit: Urban Agricultural Property) signed into law in May 2010.

573 While negotiating stakeholder interests ultimately determines how much vacant land is
574 used for urban agriculture, a vacant land inventory can help not only to identify possible
575 locations and posit their potential contribution to the food system, but can also help to embed the
576 socioecological landscape with alternative possibilities, a first step in realizing a vision of what
577 an alternative food system might look like. Geographer Kevin St. Martin (2009, p. 494) describes
578 such an approach as “a cartography of the commons that can effectively recast space as a site of
579 multiple economic possibilities and resources as the basis of community livelihoods.” How this
580 vision is ultimately interpreted and mobilized—and by whom—will also necessarily become part
581 of this process. Additional analyses, as described above, may help stakeholders prioritize sites,
582 but the prioritization process itself will depend on how well differing views of land use are
583 negotiated and integrated and on how such spaces are valued.

References

1. Ackerman, K. (2012). *The Potential for Urban Agriculture in New York City: Growing Capacity, Food Security, and Green Infrastructure*. New York, NY: Columbia University Urban Design Lab. Retrieved from <http://www.urbandesignlab.columbia.edu/?pid=nyc-urban-agriculture>
2. Balmer, K., Gill, J., Kaplinger, H., Miller, J., Paterson, M., Rhoads, A., ... Wall, T. (2005). *The Diggable City: Making Urban Agriculture a Planning Priority*. Portland, OR: Portland State University School of Urban Studies & Planning. Retrieved from <http://www.portlandoregon.gov/bps/42793>
3. Beidleman, L., & Kozloff, E. (2003). *Plants of the San Francisco Bay Region: Mendocino to Monterey*. Berkeley: University of California Press.
4. ACPHD. (2008). *Life and Death from Unnatural Causes: Health and Social Inequity in Alameda County*. Oakland, CA: Alameda County Public Health Department. Retrieved from <http://www.acphd.org/media/53628/unnatcs2008.pdf>
5. Bickerdike, C., DiLisio, C., Haskin, J., McCullagh, M., & Pierce-Quinonez, M. (2010). *From Factories to Fresh Food: Planning for Urban Agriculture in Somerville*. Boston: Tufts University Agriculture, Food & Environment Program. Retrieved from <https://wikis.uit.tufts.edu/confluence/download/attachments/30411091/GWS+2010+Final+Report.pdf>
6. Casagrande, S. S., Wang, Y., Anderson, C., & Gary, T. L. (2007). Have Americans increased their fruit and vegetable intake? The trends between 1988 and 2002. *American Journal of Preventative Medicine*, 32(4), 257–263.

7. Colasanti, K., & Hamm, M. (2010). Assessing the local food supply capacity of Detroit, Michigan. *Journal of Agriculture, Food Systems, and Community Development*, 1(2), 41–58.
8. Corburn, J. (2009). *Toward the Healthy City: People, Places, and the Politics of Urban Planning*. Cambridge, MA: MIT Press.
9. Costa, S., Palaniappan, M., Wong, A. K., Hays, J., Landeiro, C., & Rongerude, J. (2002). *Neighborhood Knowledge for Change: The West Oakland Environmental Indicators Project*. Oakland: Pacific Institute for Studies in Development, Environment, and Security. Retrieved from http://www.pacinst.org/reports/environmental_indicators/
10. Farfan-Ramirez, L., Olivera, M., Pascoe, K., & Safinya-Davies, P. (2010). *School Gardens Assessment: Alameda County Public Schools*. Oakland: UC Cooperative Extension-Alameda County.
11. Grewal, S. S., & Grewal, P. S. (2012). Can cities become self-reliant in food? *Cities*, 29(1), 1–11.
12. Herrera, H., Khanna, N., & Davis, L. (2009). Food systems and public health: The community perspective. *Journal of Hunger and Environmental Nutrition*, 4, 430–445.
13. Hodgson, K., Caton Campbell, M., & Bailkey, M. (2011). *Urban Agriculture: Growing Healthy, Sustainable Places*. Washington: American Planning Association.
14. HOPE Collaborative. (2009). *A Place with No Sidewalks: An Assessment of Food Access, the Built Environment and Local, Sustainable Economic Development in Ecological Micro-Zones in the City of Oakland, California in 2008*. Oakland: HOPE Collaborative. Retrieved from http://www.hopecollaborative.net/images/stories/docs/hp_aplacewithn%20sidewalks.pdf

15. Horst, M. (2008). *Growing Green: An Inventory of Public Lands Suitable for Gardening in Seattle, Washington*. Seattle: University of Washington College of Architecture and Urban Planning. Retrieved from http://www.seattle.gov/Neighborhoods/ppatch/pubs/MHORST_GROWINGGREEN.pdf
16. Hou, J., Johnson, J. M., & Lawson, L. J. (2009). *Greening Cities, Growing Communities: Learning from Seattle's Urban Community Gardens*. Seattle: University of Washington Press.
17. Innes, J. E., & Booher, D. E. (2010). *Planning with Complexity: An introduction to collaborative rationality for public policy*. New York: Routledge.
18. Israel, B., Eng, E., Schulz, A., & Parker, E. (2005). *Methods in Community-Based Participatory Research for Health*. New York: John Wiley & Sons.
19. Jeavons, J. (2002). *How to Grow More Vegetables (than you ever thought possible on less land than you can imagine)*. Berkeley: Ten Speed Press.
20. Kaethler, T. M. (2006). *Growing Space: The Potential of Urban Agriculture in the City of Vancouver*. Vancouver: University of British Columbia School of Community and Regional Planning. Retrieved from <http://www.urbanfarmers.ca/publications/growing-space-potential-urban-agriculture-city-vancouver>
21. MacRae, R., Gallant, E., Patel, S., Michalak, M., Bunch, M., & Schaffner, S. (2010). Could Toronto provide 10% of its fresh vegetable requirements from within its own boundaries? Matching consumption requirements with growing spaces. *Journal of Agriculture, Food Systems, and Community Development*, 1(2), 105-127.

22. Marks, A. (2008, May 16). As food prices shoot up, so do backyard gardens. *Christian Science Monitor*. Retrieved from <http://www.csmonitor.com/USA/Society/2008/0516/p01s01-ussc.html>
23. McClintock, N. (2011). From Industrial Garden to Food Desert: Demarcated Devaluation in the Flatlands of Oakland, California. In A. H. Alkon & J. Agyeman (Eds.), *Cultivating Food Justice: Race, Class, and Sustainability* (pp. 89–120). Cambridge, MA: MIT Press.
24. McClintock, N. (2012). Assessing soil lead contamination at multiple scales in Oakland, California: Implications for urban agriculture and environmental justice. *Applied Geography*, 35(1–2), 460–473.
25. McClintock, N., & Cooper, J. (2009). *Cultivating the Commons: An Assessment of the Potential for Urban Agriculture on Oakland's Public Land*. Oakland: Institute for Food & Development Policy/City Slicker Farms/HOPE Collaborative. Retrieved from http://www.hopecollaborative.net/images/stories/docs/hp_cultivatingthecommons.pdf
26. McClintock, N., Wooten, H., & Brown, A. (2012). Toward a food policy “first step” in Oakland, California: A food policy council’s efforts to *promote urban agriculture zoning*. *Journal of Agriculture, Food Systems, and Community Development*, 2(4), 15–42.
27. Mendes, W., Balmer, K., Kaethler, T., & Rhoads, A. (2008). Using Land Inventories to Plan for Urban Agriculture: Experiences from Portland and Vancouver. *Journal of the American Planning Association*, 74(4), 435–449.
28. Metzger, E. S., & Lendvay, J. M. (2006). Seeking Environmental Justice through Public Participation: A Community-Based Water Quality Assessment in Bayview Hunters Point. *Environmental Practice*, 8, 104–114.

29. Minkler, M., & Wallerstein, N. (2003). *Community-Based Participatory Research for Health*. San Francisco: Jossey-Bass.
30. Muller, M., Tagtow, A., Roberts, S. L., & MacDougall, E. (2009). Aligning Food Systems Policies to Advance Public Health. *Journal of Hunger & Environmental Nutrition*, 4(3&4), 225–240.
31. Nipen, A. (2009). Assessing the Available Land Area for Urban Agriculture on the Halifax Peninsula. Halifax: Dalhousie University Environmental Science Program. Retrieved from http://environmental.science.dal.ca/Files/Environmental%20Programs/ENVS_4900_thesis_p/ro/a_nipen.pdf
32. NOAA. (2004). Climatography of the United States No. 20, 1971-2000, Oakland Museum, CA Station. Asheville, NC: National Oceanic and Atmospheric Administration. Retrieved from <http://www.ggweather.com/climate/oakland.pdf>
33. Nordahl, D. (2009). *Public Produce: The New Urban Agriculture*. Washington: Island Press.
34. OFPC. (2010). *Transforming Oakland Food System: A Plan for Action*. Oakland: Oakland Food Policy Council / Food First. Retrieved from http://www.oaklandfood.org/home/policy_recommendations
35. Petersen, D., Minkler, M., Vasquez, V. B., & Baden, A. C. (2006). Community-Based Participatory Research as a Tool for Policy Change: A Case Study of the Southern California Environmental Justice Collaborative. *Review of Policy Research*, 23(2), 339–353.
36. Pothukuchi, K. (2009). Community and Regional Food Planning: Building Institutional Support in the United States. *International Planning Studies*, 14(4), 349–367.
37. Redwood, M. (Ed.). (2011). *Agriculture in Urban Planning: Generating Livelihoods and Food Security*. London: Earthscan.

38. Self, R. O. (2003). *American Babylon: Race and the Struggle for Postwar Oakland*. Princeton: Princeton University Press.
39. Sloan, D. (2006). *Geology of the San Francisco Bay Region*. Berkeley: University of California Press.
40. St. Martin, K. (2009). Toward a cartography of the commons: Constituting the political and economic possibilities of place. *The Professional Geographer*, 61(4), 493–507.
41. Taggart, M., Chaney, M., & Meaney, D. (2009). *Vacant Land Inventory for Urban Agriculture*. Cleveland, OH: Cleveland-Cuyahoga Food Policy Coalition. Retrieved from <http://cccfoodpolicy.org/document/vacant-land-inventory-urban-agriculture-report-urban-land-ecology-conference>
42. Taylor, J. R., & Lovell, S. T. (2012). Mapping public and private spaces of urban agriculture in Chicago through the analysis of high-resolution aerial images in Google Earth. *Landscape and Urban Planning*, 108(1), 57–70.
43. U.S. Census Bureau. (2010). *United States Decennial Census*. Retrieved from <http://factfinder2.census.gov/>
44. Unger, S., & Wooten, H. (2006). *A Food Systems Assessment for Oakland, CA: Towards a Sustainable Food Plan*. Oakland Mayor's Office of Sustainability. Retrieved from <http://oaklandfoodsystem.pbworks.com>
45. USDA (2005). National Agriculture Imagery Program. United States Department of Agriculture. Retrieved from <http://datagateway.nrcs.usda.gov/>
46. USDA. (2010). Loss-Adjusted Food Availability Data Sets. United States Department of Agriculture Economic Research Service. Retrieved from <http://www.ers.usda.gov/Data/FoodConsumption/FoodGuideIndex.htm>

47. Walker, R. (2001). Industry builds the city: the suburbanization of manufacturing in the San Francisco Bay Area, 1850-1940. *Journal of Historical Geography*, 27(1), 36–57.
48. Weber, C. L., & Matthews, H. S. (2008). Food-Miles and the Relative Climate Change Impacts of Food Choices in the United States. *Environmental Science & Technology*, 42(10), 3508–3513.
49. Welch, L. E. (1981). *Soil Survey of Alameda County, Western Part*. United States Department of Agriculture Soil Conservation Service. Retrieved from http://soils.usda.gov/survey/online_surveys/california/
50. Welty, E. (2010). *Mapping the Agricultural Potential of Urban Arable Land in Boulder, CO*. Boulder, CO: Colorado University Department of Environmental Studies.
51. Wooten, H. (2008). *Food System Meta-Analysis for Oakland, California*. Oakland: Public Health Law & Policy / Food First. Retrieved from <http://www.foodfirst.org/en/node/2397>

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Table 5 Potential contribution of urban agriculture on public land to Oakland's estimated and recommended vegetable needs under three management types and four land use scenarios

Table 6. Size distribution of privately owned vacant land in Oakland

Table 1: Potentially arable vacant or underutilized public land in Oakland, California

<i>Land type by level of government:</i> Landowner or managing agency	Total public land			Public land w/ urban agriculture potential			% of total area
	No. parcels	ac	ha	No. parcels	ac	ha	
<i>Municipal:</i>							
City of Oakland	1,167	6,659.4	2,695.0	206	232.7	94.2	19.4
Oakland Parks & Recreation (OPR)	**	**		266	629.1	254.6	52.5
Redevelopment Agency	104	32.9	13.3	8	2.1	0.8	0.2
Housing Authority	343	127.9	51.8	13	2.3	0.9	0.2
Oakland Unified School District	165	493.2	199.6	10	5.8	2.3	0.5
<i>County:</i>							
Alameda Co. Flood Control	114	50.9	20.6	25	8.9	3.6	0.7
Alameda Co. Superintendent of Schools	1	1.8	0.7	1	0.6	0.2	0.1
Peralta Community College District	23	188.9	76.4	24	36.5	14.8	3.0
AC Transit District	8	23.8	9.6	1	0.6	0.2	0.1
County of Alameda	29	159.8	64.7	1	8.9	3.6	0.7
<i>Regional:</i>							
Bay Area Rapid Transit (BART)	100	59.4	24.0	8	1.9	0.8	0.2
East Bay Municipal Utilities District	115	405.0	163.9	48	28.0	11.3	2.3
East Bay Regional Parks District	100	835.8	338.2	65	109.0	44.1	9.1
<i>State:</i>							
University of California Regents	19	748.8	303.0	41	92.6	37.5	7.7
State of California	248	195.0	78.9	39	42.7	17.3	3.6
<i>Federal:</i>							
Amtrak	8	19.1	7.7	0	0	0	0
US Postal Service	6	9.2	3.7	0	0	0	0
Other federal land	21	496.7	201.0	0	0	0	0
Total **	2,551	10,013.0	4,052.1	756	1,201.7	486.3	100

** Oakland Parks and Recreation (OPR) land is included in City of Oakland total listed in the row above.

++ The sum of individual rows may slightly exceed the total due to rounding

Table 2: Oakland's recommended vegetable needs

Oakland population (2010) ^a	----- Individual -----				----- Citywide -----	
	cups / day ^b	(g / day)	lbs / year	(kg / year)	tons / year	(Mg / year)
Males						
< 5 yrs	13,396	1	(229)	183	(83.6)	1,222 (1,108.6)
5 to 9	11,708	1.5	(343)	274	(125.2)	1,603 (1,454.2)
10 to 14	10,500	2.5	(571)	456	(208.4)	2,395 (2,172.7)
15 to 19	11,293	3	(680)	548	(248.2)	3,091 (2,804.1)
20 to 34	46,201	3.5	(800)	639	(292.0)	14,755 (13,385.5)
35 to 79	91,836	3	(680)	548	(248.2)	25,140 (22,806.6)
> 79 yrs	4,585	2.5	(571)	456	(414.1)	1,046 (948.9)
Females						
< 5 yrs	12,703	1	(229)	183	(83.6)	1,159 (1,051.4)
5 to 9	11,286	1.5	(343)	274	(125.2)	1,545 (1,401.6)
10 to 14	10,325	2	(457)	365	(166.8)	1,884 (1,709.1)
15 to 19	11,163	2.5	(571)	456	(208.4)	2,547 (2,310.6)
20 to 44	79,322	2.5	(571)	456	(208.4)	18,095 (16,415.5)
45 to 64	51,250	2.5	(571)	456	(208.4)	11,691 (10,605.9)
>64 yrs	25,156	2	(457)	365	(166.8)	4,591 (4,164.9)
Total	390,724					90,766 (82,341.5)

^a Data source: (U.S. Census Bureau, 2010)

^b Data source: (USDA, 2010)

Table 3: Total and locally possible vegetable production (including losses) necessary to meet estimated existing and recommended consumption needs in Oakland

	Production needed to meet:	
	Estimated current consumption	Recommended consumption
	----- tons (Mg) -----	
Total production needed (including losses)	28,884 (26,203.1)	137,016 (124,298.8)
Possible local/seasonal share of total production (including losses)	23,954 (21,730.7)	113,630 (103,083.4)

Table 4: Land area disaggregated by slope and aspect

	Area **		% total	Description
	ac	(ha)		
<i>Slope</i>				
Under 10%	409.6	(165.8)	34.1	Flat terrain to gradual slope (< 5.7 degrees)
10 to 20%	211.0	(85.3)	17.6	Gradual to moderate (5.7 to 11.3 degrees)
20 to 30%	207.2	(83.9)	17.2	Moderate to steep (11.3 to 16.7 degrees)
Over 30%	374.1	(151.4)	31.1	Very steep (> 16.7 degrees)
Total	1,201.9	(486.4)	100.0	
<i>Aspect</i>				
NW-N-NE	140.0	(56.7)	11.6	Often shaded
W-SW-S-SE-E	1,061.9	(429.7)	88.3	Receives more direct sunlight
Total	1,201.9	(486.4)	100.0	
<i>Aspect + Slope</i>				
Optimal	730.1	(295.5)	60.1	Western, southern, or eastern exposure, slope under 30%
Less Desirable	471.8	(190.9)	39.9	Northern exposure, slope greater than 30%
Total	1,201.9	(486.4)	100.0	

** Total difference in area (0.2 ac) is due to conversion from vector to raster data. Total% may exceed 100 due to rounding.

Table 5. Potential contribution of urban agriculture on public land to Oakland’s estimated and recommended vegetable needs under three management types and four land use scenarios

Consumption level	Agricultural management practice	Avg. yield tons/ac (Mg/ha)	Area needed Ac (ha)	----- Land use scenario ^a -----			
				1 All 828 ac (335.1 ha)	2 Optimal 730 ac (295.4 ha)	3 High 500 ac (202.3 ha)	4 Low 100 ac (40.5 ha)
				----- % contribution to vegetable needs ^b -----			
Current (estimated)	Conventional	10 (22.4)	2,582 (1,044.9)	24.1	21.2	14.5	2.9
	Biointensive – Low	15 (33.6)	1,722 (696.9)	36.1	31.8	21.8	4.4
	Biointensive – Med	25 (56.0)	1,033 (418.0)	60.1	53.0	36.3	7.3
Recommended	Conventional	10 (22.4)	12,250 (4,957.4)	5.1	4.5	3.1	0.6
	Biointensive – Low	15 (33.6)	8,167 (3,305.1)	7.6	6.7	4.6	0.9
	Biointensive – Med	25 (56.0)	4,900 (1,983.0)	12.7	11.2	7.7	1.5

^a Scenario 1 includes all identified publicly owned vacant or underutilized public land with a slope < 30%. Scenario 2 removes NW, N, and NE-facing slopes from the Scenario 1 total area. Scenarios 3 and 4 are based on arbitrary values (high and low, respectively) of land area that might be converted to crop production via a municipal policy or initiative.

^b assumes that 75% of land in each scenario will be used for crop production

Table 6. Size distribution of privately owned vacant land in Oakland

Parcel Size		Potential use	No. parcels	Total area	
ac	(ha)			ac	(ha)
100 ft ² to 0.25 ac	(9.3 m ² to 0.1 ha)	Community garden	2,484	289	(117.0)
0.25 to 0.5 ac	(0.1 to 0.2)	Community garden / market garden	338	113	(45.7)
0.5 to 1 ac	(0.2 to 0.4)	Market garden	115	81	(32.8)
1 to 5 ac	(0.4 to 2.0)	Urban farm	56	119	(48.2)
> 5 ac	(> 2.0)	Urban farm	15	262	(106.0)
Total			3,008	864	(349.6)
Total (< 30% slope)				337	(136.4)

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Figure 1: The hills and flatlands of Oakland, California. Note that the industrial areas (blue) are located in the flatlands along the waterfront. Freeways are labeled in red and downtown (central business district) labeled as “CBD”.

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Appendix B: Average conventional and biointensive yields and farm-to-table losses

Appendix A: Estimated and recommended vegetable consumption in Oakland and possible local/seasonal share

Crop	US per capita consumption (USDA 2010) (lbs/year)	----- Oakland -----		Annual months of production	Possible local/seasonal availability (%)	Possible local/seasonal share of:	
		Estimated current consumption (tons/year)	Recommended consumption (tons/year)			Estimated current consumption (tons/year)	Recommended consumption (tons/year)
Artichokes	0.2	42	197	10	83	35	164
Asparagus	0.3	57	269	5	42	24	112
Bell peppers	4.6	908	4,308	7	58	530	2,513
Broccoli	1.8	360	1,710	12	100	360	1,710
Brussels sprouts	0.1	27	129	12	100	27	129
Cabbage	3.9	761	3,611	12	100	761	3,611
Carrots	5.5	1,067	5,062	12	100	1,067	5,062
Cauliflower	0.2	47	225	10	83	39	187
Celery	3.8	737	3,498	9	75	553	2,624
Collard greens	0.1	28	132	11	92	26	121
Sweet corn	0.3	64	304	0	0	0	0
Cucumbers	2.9	570	2,703	6	50	285	1,352
Eggplant	0.3	60	284	4	33	20	95
Escarole /endive	0.1	18	83	12	100	18	83
Garlic	1.3	253	1,198	12	100	253	1,198
Head lettuce	11.4	2,226	10,559	12	100	2,226	10,559
Kale	0.1	15	70	12	100	15	70
Leaf lettuce	4.9	961	4,556	12	100	961	4,556
Lima beans	0.0	2	8	0	0	0	0
Mushrooms	1.6	316	1,501	12	100	316	1,501
Mustard greens	0.2	29	140	6	50	15	70
Okra	0.2	31	149	0	0	0	0
Onions	9.3	1,821	8,637	12	100	1,821	8,637
Potatoes	27.0	5,271	25,001	11	92	4,831	22,918
Pumpkins	1.9	362	1,716	4	33	121	572
Radishes	0.3	51	241	12	100	51	241
Snap beans	1.0	201	953	12	100	201	953
Spinach	0.6	126	599	12	100	126	599
Squash	2.2	423	2,009	5	42	176	837
Sweet potatoes	1.4	281	1,332	0	0	0	0
Tomatoes	10.2	1,997	9,473	6	50	999	4,737
Turnip greens	0.1	22	106	7	58	13	62
Fresh vegetables	97.9	19,134	90,766		83	15,869	75,274

Appendix B: Average conventional and biointensive yields and farm-to-table losses

Crop	Average yields			Average losses			
	Conventional ^a	Biointensive (low) ^b	Biointensive (medium) ^b	Farm to retail ^c	Retail to consumer ^c	Inedible share ^c	Total farm to table loss ^c
	(tons/acre)			(%)			
Artichokes	6.1	nd	nd	7	19	60	49
Asparagus	1.5	2.1	4.1	9	9	47	57
Bell peppers	15.0	7.8	15.7	8	8	18	73
Broccoli	7.5	5.7	11.3	8	12	39	59
Brussels sprouts	9.0	15.5	30.9	8	19	10	71
Cabbage	20.0	20.9	41.8	7	14	20	68
Carrots	15.0	21.8	43.6	3	5	11	83
Cauliflower	9.0	9.6	19.2	8	14	61	50
Celery	36.5	52.3	104.5	7	5	11	80
Collard greens	8.5	20.9	41.8	12	38	43	45
Cucumbers	12.0	34.4	68.8	8	6	27	69
Eggplant	10.0	11.8	23.5	10	21	19	63
Escarole /endive	7.8	nd	nd	10	47	14	54
Garlic	8.5	13.1	26.1	19	7	14	69
Head lettuce	18.0	16.3	32.7	7	9	16	74
Kale	10.0	16.6	33.1	12	39	39	46
Leaf lettuce	11.5	29.4	58.8	7	14	21	68
Mushrooms	35.9	nd	nd	6	13	3	81
Mustard greens	7.5	39.2	78.4	12	63	27	43
Onions	22.5	21.8	43.6	6	10	10	78
Potatoes	18.5	21.8	43.6	4	7	0	90
Pumpkins	12.0	10.5	20.9	10	11	30	63
Radishes	11.5	21.8	43.6	3	21	10	73
Snap beans	5.0	6.5	13.1	6	18	12	71
Spinach	8.0	10.9	21.8	12	14	28	61
Squash	10.0	10.9	21.8	10	13	17	69
Tomatoes	15.0	21.8	43.6	15	13	9	70
Turnip greens	nd	5.4	10.9	12	41	30	49
Fresh vegetables	13.2	15.4	30.8	9	18	24	63

Data sources: ^aUSDA 2010; ^bJeavons 2002; ^cUSDA 201

Figure 1
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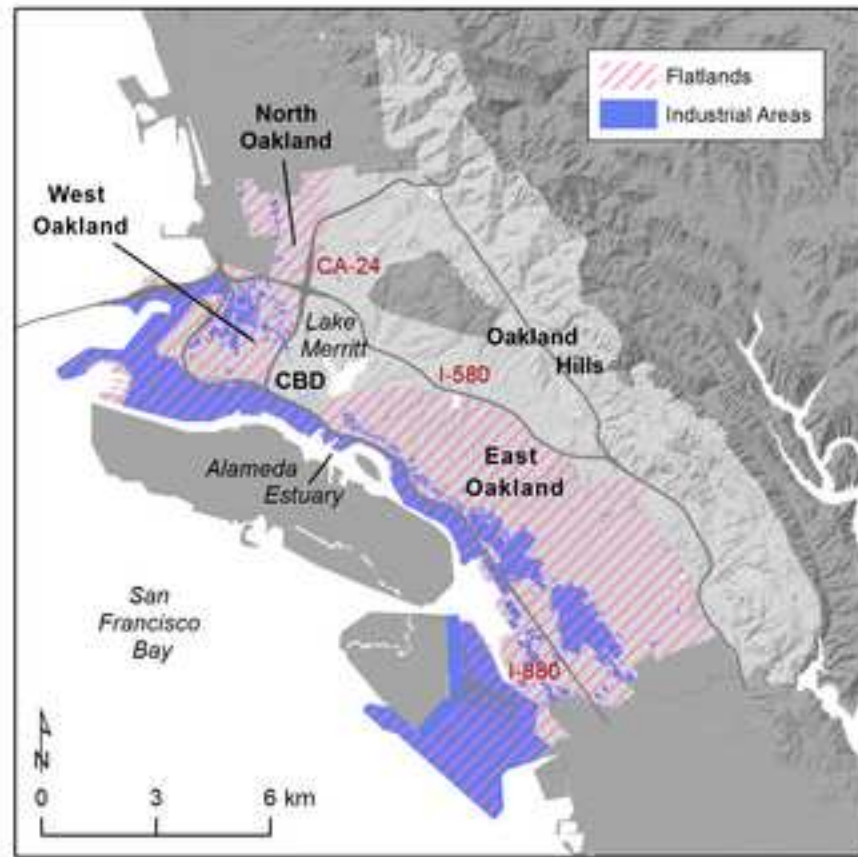


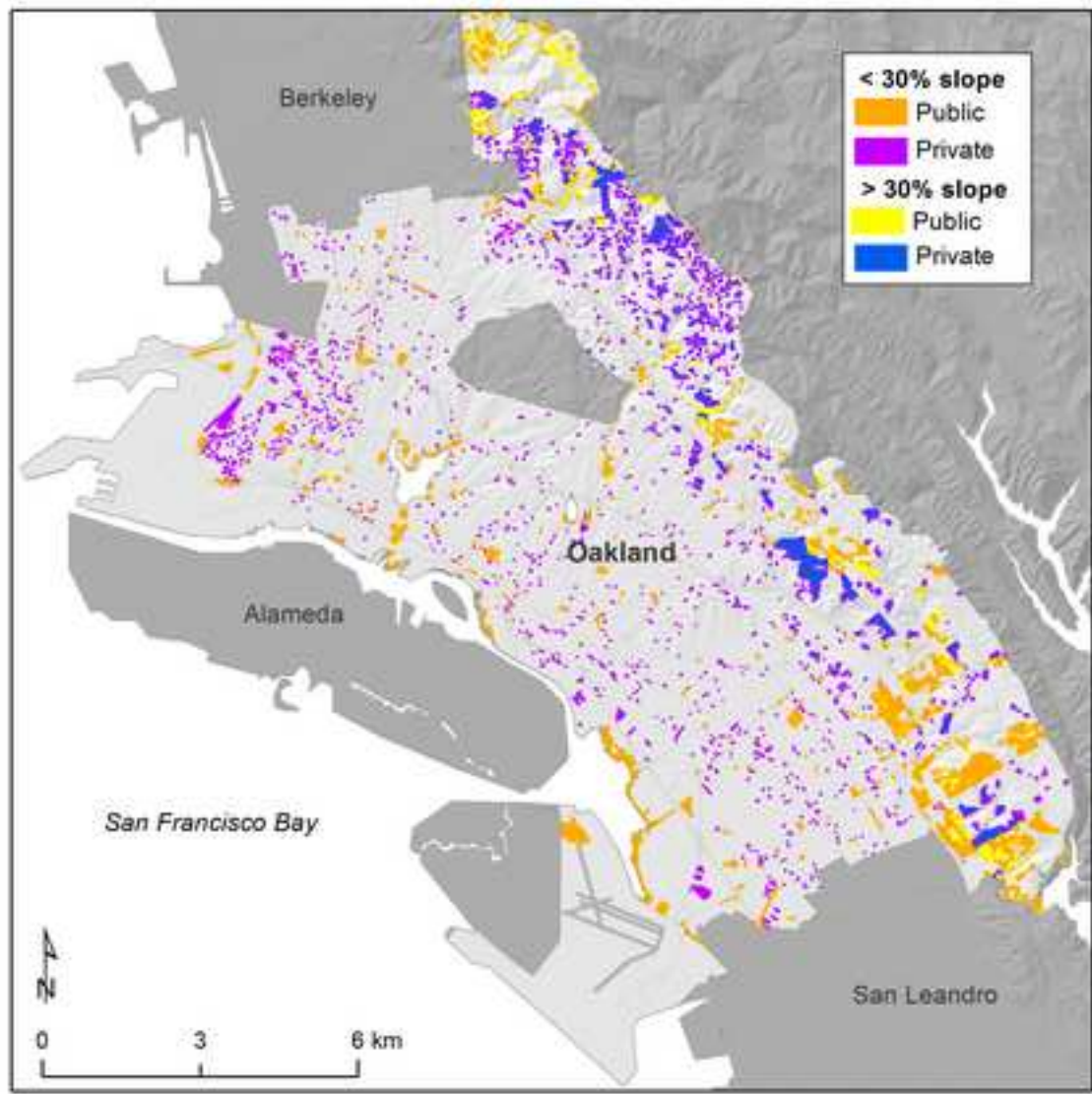
Figure 2a
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Figure 2b
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Figure 3
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