Open-Source Food: Nutrition, Toxicology, and Availability of Wild Edible Greens in the East Bay

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Abstract

Significance. Foraged leafy greens are consumed around the globe, including in urban areas, and may play a larger role when food is scarce or expensive. It is thus important to assess the safety and nutritional value of wild greens foraged in urban environments.
Methods. Field observations, soil tests, and nutritional and toxicology tests on plant tissue were conducted for three sites, each roughly 9 square blocks, in disadvantaged neighborhoods in the East San Francisco Bay Area in 2014–2015. The sites included mixed-use areas and areas with high vehicle traffic.
Results. Edible wild greens were abundant, even during record droughts. Soil at some survey sites had elevated concentrations of lead and cadmium, but tissue tests suggest that rinsed greens are safe to eat. Daily consumption of standard servings comprise less than the EPA reference doses of lead, cadmium, and other heavy metals. Pesticides, glyphosate, and PCBs were below detection limits. The nutrient density of 6 abundant species compared favorably to that of the most nutritious domesticated leafy greens.
Conclusions. Wild edible greens harvested in industrial, mixed-use, and high-traffic urban areas in the San Francisco East Bay area are abundant and highly nutritious. Even grown in soils with elevated levels of heavy metals, tested species were safe to eat after rinsing in cold water. Wild greens could contribute to nutrition, food security, and sustainability in urban ecosystems.

Introduction

Diets that include a wide array of plant-based foods are associated with lower rates of chronic disease and better health outcomes [1–3]. Edible wild and feral plants—edible weeds—are an abundant but generally overlooked food source with the potential to contribute to dietary diversity and vegetable intake, especially in areas with limited access to fresh produce.

Edible weeds, which require neither cultivation nor intentional watering, are generally abundant in farms, gardens, parks, yards, sidewalks, and medians, on both private and public land: anywhere there has not been a concerted effort to eradicate them. Some are native to their habitat, but many are nonnative feral species that were once cultivated deliberately but have since colonized the globe [4]. Due to evolutionary selection, edible weeds thrive in places where humans disrupt the soil and they are more tolerant of environmental extremes than most commercial crops [5–7]; climate change may select for weeds and for herbicide-resistant weeds [8].

Edible weeds may be a source of interesting culinary ingredients in the global north [9] and also an important source of nutrition during food shortages [10, 11]. Studies suggest that edible weeds contribute to household food supplies in cities around the globe [12–16]. Many of these plants are also recognized as having medicinal value as teas, supplements, and poultices [17, 18]. While there is little data on foraging behavior in the United States, recent surveys suggest that a noticeable percentage of urban dwellers—representing a diverse group of ethnicities, cultures, and incomes—forage and prepare edible weeds [15, 19–21]. For instance, a 2014–2015 survey of 105 foragers in Baltimore found that they collect 170 unique taxa of plants and fungi from the city and surrounding areas, with low and high income foragers collecting a greater variety of taxa and volume of plants than middle income foragers [21]. Survey respondents cited recreation, economic and health benefits, and connection to nature as their three main motivations for foraging.

Despite the growing recognition that foraged foods are a component of urban food systems and urban ecosystems, surprisingly little is known about their safety, nutritional value, or availability. Extant studies have drawn different conclusions about the safety of food—whether cultivated or "volunteers"—growing in urban environments. For instance, researchers who sampled popular edible weeds growing near urban roads and in the surrounding countryside of Bari, Italy, found that many of the collected species had high concentrations of essential vitamins and minerals, and only two species, *Amaranthus retroflexus* and *Plantago lagopus* had levels of Cd and Pb higher than the legal limit—even when growing in putatively "clean" rural areas [22]. See also [23].

There are a number of studies of the nutritional content of wild and feral foods (e.g., [24–33]). Our study contributes to understanding the potential health and nutritional impacts of urban foraging, by measuring nutrients and unhealthful contaminants (heavy metals, pesticides, herbicides, and PCBs) in six of the most abundant edible weed species harvested in highly-trafficked urban areas in the East Bay region of Northern California.

Methods

Berkeley Open Source Food mapped wild and feral edible plants, primarily leafy greens, in three residential areas bordering busy roadways and industrial zones in Berkeley, Richmond, and Oakland, California, during 2014 and 2015. Each area comprised approximately 9 square blocks; Table 1 describes them. According to the USDA, the areas in Richmond and Oakland are more than a mile from any shop that sells fresh produce; and the area in Berkeley is more than half a mile from such a shop. All have below average income, according to the U.S. Census.

Teams of observers used the iNaturalist smartphone app with customized database fields to record estimates of the number of 1/2c servings of a variety of edible weeds at

city	bounding streets
Berkeley	Martin Luther King Jr. Way, California St., Dwight Way, Carleton St.
Oakland	14th St., 17th St., Peralta St., Wood St.
Richmond	Carlson Blvd., Potrero Ave., S. 47th St., S. 43rd St.

Table 1. Boundaries of the study sites in Berkeley, Oakland, and Richmond, CA.

each address. The website for iNaturalist is `https://inaturalist.org`. The iNaturalist project page for the study reported here is `https://www.inaturalist.org/projects/berkeley-open-source-food` (last visited 19 May 2018). As of 19 May 2018, Berkeley Open Source Food has accumulated 631 observations of 52 species, made by 13 people.

Observations were geo-tagged and accompanied by representative photographs to support each observation—species identification and abundance. Some representative "voucher" samples were submitted to the University and Jepson Herbaria at the University of California, Berkeley; see table 4.

The number of 1/2c servings was estimated on an approximately logarithmic scale intended to facilitate accurate, repeatable categorization: <1, 1–5, 6–10, 11–20, 21–50, 51–100, 101–500, 501–1000, and >1000. Observations were generally made by pairs of observers conferring about each address. Observers (faculty and students at the University of California, Berkeley) estimated the number of "visible" and the number of "available" servings. "Visible" servings are those available to a person with legal access to the property. "Available" servings are those within an arm's reach of a public right-of-way, such as a sidewalk or road. While we do not know the intrinsic accuracy of the estimated number of servings, the measurements were reproducible: estimates made by different observers were calibrated against each other on sets of ten addresses. After new observers received approximately an hour of training, inter-rater concordance of the estimates across pairs of observers was essentially perfect.

Soil samples were taken at 28 sites in Richmond and Oakland and sent to the Soil and Plant Tissue Testing Lab at the University of Massachusetts, Amherst, for metal assays. The concentrations of Zinc (Zn), Copper (Cu), Arsenic (As), Selenium (Se), Lead (Pb), Nickel (Ni), Chromium (Cr), Cadmium (Cd), and Molybdenum (Mb) were measured. Soil samples were taken "per address," homogenizing sub-samples taken at 3–4 locations near the street at each address tested.

Tissue samples, collected 12 May 2015, targeted locations where soil testing had shown the concentration of metals to be highest (sample sites 28 and 29, Willow St. near 16th and 17th Streets, Oakland, CA), and included samples of plants growing through asphalt. Plant tissue samples were rinsed in tap water as if to make salad, then dried at the University and Jepson Herbaria at the University of California, Berkeley and sent to Brookside Laboratories (New Bremen, Ohio) to be assayed for metals (As, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Zn). Voucher specimens for each tested species were submitted (references Thomas Carlson 5001, 5002a/b, and 5003–5009).

Fresh plant tissue samples collected on 21 March 2016 were rinsed in tap water, then assayed by SCC Global Services (Emeryville, CA) for vitamins, minerals, polyphenols, and some organic chemical contaminants, including PCBs, glyphosate, and multi-residue pesticides (via QuEChERS). Oxalis (*Oxalis pes-caprae*) and dock (*Rumex crispus*), two species high in oxalic acid, were assayed for oxalic acid.

Results

Soil samples were collected in Richmond, CA, on 18 June 2014, and in West Oakland, CA, on 28 August 2014. Soil sample locations are in Table 2. Soil metals test results are in Table 3. Locations and species for dried tissue tests are in Table 4. Metals tests on dried tissue are in Table 5. Wet tissue sample species and locations, along with toxicology test results, are in Table 6. Results of nutritional tests on wet tissue are reported per serving in Table 7 and per 100g in Table 8. The tables include values for kale, generally regarded as one of the most nutritious cultivated leafy greens. (Values for kale are from the USDA Food Composition Database, `httpa://ndb.nal.usda.gov` retrieved 15 July 2018.) Per serving and per 100g, the wild greens are generally more nutritious. Kale does stand out in its value of Vitamin C per 100g.

S. 45th St., Richmond, CA	
1	807 S. 45th St.
2	819 S. 45th St.
3	825 S. 45th St.
4	831 S. 45th St.
5	845 S. 45th St.
6	800 S. 45th St.
7	814 S. 45th St.
8	822 S. 45th St.
9	826 S. 45th St.
10	832 S. 45th St.
Carlson Blvd, Richmond, CA	
11	946 Carlson Blvd
12	942 Carlson Blvd
13	934 Carlson Blvd
14	928 Carlson Blvd
15	922 Carlson Blvd
16	916 Carlson Blvd
17	908 Carlson Blvd
18	900 Carlson Blvd
August 28th, 2014 Oakland, CA	
20	1724 14th St.
21	1738 14th St.
22	1740 14th St.
23	15th St. & Wood
24	1726 15th St.
25	1725 15th St.
26	1719 15th St.
27	1715 15th St.
28	17th St. & Wood
29	16th St. & Willow

Table 2. Sites where soil samples were taken. 3–4 samples were taken along the front of each address and homogenized.

Metals

Plant uptake of toxic metals varies by species and is influenced by pH, salinity, and other soil properties; there is typically a "plateau" effect that limits the ability of plants to accumulate metals as the concentration of metals in soil increases [34]. With the exception of Cd, the measured amount of each metal was far below the US EPA maximum acceptable daily dose (RfD) for children and adults (see table 5). The US EPA RfD for dietary Cd is 0.001mg/kg/d (the units are milligrams of cadmium per kilogram of body mass per day; see `https://www.epa.gov/sites/production/files`

Element	USEPA limit (mg/kg)	1–10	11–18	20–22	23–26	27	28	29
Zn	23600	187.2	243.3	261.8	212.2	349.1	2887.2	453.1
Cu	N/A	41.4	38.6	40.8	25.6	37.8	66.8	63.8
As	25	N/A	N/A	3.4	1.7	2.8	5.1	4.1
Se	20	N/A	N/A	2.4	2.1	2.7	3.4	3.7
Pb	400	199.8	359.7	196.5	120.1	150.0	354.6	700.9
Ni	1600	32.4	30.5	32.7	23.3	32.3	73.7	40.9
Cr	230	43.7	35.5	51.3	39.1	54.9	56.7	83.6
Cd	70	1.2	0.7	25.7	21.3	30.9	58.8	41.9
Mo	N/A	N/A	N/A	0.8	0.4	1.0	0.9	0.7

Table 3. Soil metal test results. See table 2 for the locations sampled. Soil tests were performed by the Soil and Plant Nutrient Testing Laboratory at the University of Massachusetts, Amherst, Center for Agriculture, Food, and the Environment

sample	species	location	soil sample	notes
5001	*Malva sylvestris* mallow	Willow & 16th	28	
5002a	*Helminthotheca echioides* bristly ox tongue	Willow & 16th	28	
5002b	*Helminthotheca echioides* bristly ox tongue (different population)	Willow & 16th		in asphalt
5003	*Hypochaeris radicata* cat's ear	Willow between 16th & 17th	28	
5004	*Plantago lanceolata* English plantain	Willow & 17th	29	
5005	*Lactuca ludoviciana* wild lettuce	Willow & 17th	29	
5006	*Trophaleum majus* nasturtium	Willow & 15th		in asphalt
5007	*Taraxacum officinale* dandelion	Willow & 15th		in asphalt
5009	*Foeniculum vulgare* sweet fennel	Wood & 15th		in asphalt

Table 4. Species on which dried tissue tests were performed, and sites where samples were taken. All samples were collected on 12 May 2015 in Oakland, CA. Tissue samples were rinsed with tap water, then dried in botanical voucher sample driers at the University and Jepson Herbaria, University of California, Berkeley, before being sent for testing at Brookside Laboratories. Sample numbers refer to voucher specimens in the University and Jepson Herbaria, submitted by Prof. T. Carlson; the full reference for the first sample is, e.g., "Thomas Carlson 5001."

Element	5001	5002a	5002b	5003	5004-1	5004-2	5005	5006	5007	5009-1	5009-2
As	1.709	1.687116	1.664110	1.679687	1.518404	1.607692	1.65625	1.623277	1.690590	1.590909	1.573482
Cd	0.709	0.858895	<0.3834	<0.3906	0.506134	0.499999	5.382812	<0.3828	<0.3987	<0.3918	<0.3993
Cr	<0.787	<0.7668	<0.7668	<0.7812	<0.7668	<0.7692	<0.7812	<0.7656	<0.7974	<0.7836	<0.7987
Cu	13.929	13.55828	7.967791	7.867187	8.872699	9.038461	17.47656	4.785604	8.508771	5.266457	5.071884
Pb	<3.9370	<3.8343	<3.8343	<3.9062	<3.8343	<3.8461	<3.9062	<3.8284	<3.9872	<3.9184	<3.9936
Hg	<0.0393	<0.0383	<0.0383	<0.0390	<0.0383	<0.0384	<0.0390	<0.0382	<0.0398	<0.0391	<0.0399
Mo	<3.9370	<3.8343	<3.8343	<3.9062	<3.8343	<3.8461	<3.9062	<3.8284	<3.9872	<3.9184	<3.9936
Ni	<0.7874	<0.7668	<0.7668	<0.7812	<0.7668	<0.7692	<0.7812	<0.7656	<0.7974	<0.7836	<0.7987
Se	<2.3622	<2.3006	<2.3006	<2.3437	<2.3006	<2.3076	<2.3437	<2.2970	<2.3923	<2.3510	<2.3961
Zn	161.0236	69.64723	71.78680	110.625	183.0521	183.5384	398.2031	115.1607	70.86921	30.70532	30.54313
DWT%	24.3	13.9	12.8	12.6	19.6	19.6	12.6	15.1	12.7	19.3	19.3

Table 5. Metals tests of dry plant tissue. Results are in mg/kg (i.e., parts per million by mass). Tests were performed by Brookside Laboratories, Inc., New Bremen, OH. The concentration of lead (Pb) was below quantification limits in all samples. The repeated measurements differ by far more than the reported precision of the measurements, but with the exception of Cu, the measurements seem to be repeatable to two or three digits. Samples 5004-1 and 5004-2 are repeated tests on sample 5004; 5009-01 and 5009-02 were repeated tests on sample 5009. The bottom row, DWT%, gives the dry weight percentage for each sample. For instance, sample 5005 (a wild lettuce) weighed 36g before drying and 4.537g dry; the dry weight percentage is $100 \times 4.537/36 = 12.6\%$. The original concentration of Cd in the wet tissue of 5005 is thus estimated to be $5.383 \times 0.126 = 0.678$ppm. See table 4 for more information about the samples.

species	sample location	QuEChERS Multi-residue	glyphosate	PCBs
chickweed *Stellaria media*	Willow & 14th St. Campbell & 14th–15th St.	ND	ND	ND
dandelion *Taraxacum officinale*	Willow & 14th St.	ND	ND	ND
dock *Rumex crispus*	Willow & 14th St.	ND	ND	ND
mallow *Malva sylvestris*	Willow & Wood, 14th–17th St.	ND	ND	ND
nasturtium *Tropaeolum majus*	Campbell & 14th–15th St.	ND	ND	ND
oxalis, sourgrass *Oxalis pes caprae*	Willow & 15th–17th St.	ND	ND	ND

Table 6. Multi-pesticide residue, PCB, and glyphosate tests of wet plant tissue collected in West Oakland, CA, on 21 March 2016. Tests were performed by SCS Global Services in Emeryville, CA. ND means the substance was not detected. The multi-residue test covers approximately 330 pesticides and herbicides.

	chickweed *Stellaria media*	dandelion *Taraxacum officinale*	dock *Rumex crispus*	mallow *Malva sylvestris*	nasturtium *Tropaeolum majus*	oxalis *Oxalis pes-caprae*	kale *Brassica oleracea*
serving (g)	101	70	98	68	72	84	21
cal (Kcal)	29.51	24.40	32.85	35.36	33.78	23.21	7.0
fat cal (Kcal)	2.43	2.43	2.43	2.43	4.60	2.13	2.79
fat (g)	0.27	0.27	0.27	0.27	0.51	0.24	0.31
saturated fat (g)	0.01	0.01	0.02	0.01	0.03	0.01	0.04
TFA (g)	0	0	0	0	0	0	0
cholesterol (mg)	0	0	0	0	0	0	0
carbohydrates (g)	5.27	3.88	4.72	5.30	4.97	4.45	0.93*
dietary fiber (g)	3.69	3.68	3.34	4.88	2.23	2.52	0.90
total sugars (g)	0	0	0	0	0.27	0	0.21
protein (g)	1.45	1.59	2.59	2.78	2.33	0.83	0.61
Vitamin A (IU)	2315.32	4603.9	5311.82	3168.76	5891.04	1998.25	1011.0
Vitamin C (mg)	10.82	3.14	35.63	5.87	1.07	7.93	19.6
Na (mg)	45.83	36.64	99.46	29.07	28.78	24.33	11.0
Ca (mg)	66.92	67.13	67.40	185.39	106.89	41.07	53.0
Fe (mg)	1.56	1.91	1.29	2.27	0.85	1.58	0.34
K (mg)	446.24	308.06	305.40	242.14	214.54	108.21	73.0

Table 7. Nutritional tests of wet plant tissue (performed by SCS Global Services in Emeryville, CA) collected by Berkeley Open Source Food in West Oakland, CA, and USDA National Nutrient Database values for raw kale. Serving sizes for chickweed, dandelion, dock, and kale were 1c; serving sizes for mallow, nasturtium, and oxalis were 1/2c. Masses are listed. "cal" stands for calories and "TFA" stands for trans fatty acids. See table 6 for sample sites. (*This number is suspiciously low—and values listed on other websites are generally 4–6g—but it is the value the USDA lists.)

	chickweed *Stellaria media*	dandelion *Taraxacum officinale*	dock *Rumex crispus*	mallow *Malva sylvestris*	nasturtium *Tropaeolum majus*	oxalis *Oxalis pes-caprae*	kale *Brassica oleracea*
cal (Kcal)	29.09	34.86	33.37	52.14	46.91	27.52	35.0
fat cal (Kcal)	2.40	3.47	2.47	3.58	6.39	2.52	13.41
fat (g)	0.27	0.39	0.27	0.40	0.71	0.28	1.49
saturated fat (g)	0.01	0.01	0.02	0.01	0.04	0.01	0.18
TFA (g)	0	0	0	0	0	0	0
cholesterol (mg)	0	0	0	0	0	0	0
carbohydrates (g)	5.19	5.55	4.79	7.81	6.90	5.27	4.42
dietary fiber (g)	3.64	5.26	3.39	7.20	3.10	2.99	4.10
total sugars (g)	0	0	0	0	0.37	0	0.99
protein (g)	1.43	2.27	2.63	4.10	3.23	0.98	2.92
Vitamin A (IU)	2282	6577	5396	4637	8182	2369	4812
Vitamin C (mg)	10.66	4.49	36.19	8.65	1.49	9.40	93.40
Na (mg)	45.17	52.34	101.04	42.87	39.97	28.85	53.0
Ca (mg)	65.96	95.90	68.47	273.39	148.46	48.69	254.0
Fe (mg)	1.54	2.73	1.31	3.35	1.18	1.87	1.60
K (mg)	439.82	440.08	310.24	357.09	297.97	128.29	348.0
total phenolics (mg/g)	0.77	0.49	2.77	1.29	2.82	1.68	NA
oxalic acid–soluble (mg/g)			0.18		10.94		
oxalic acid–total (mg/g)			0.39		15.42		

Table 8. Nutritional tests of wet plant tissue (performed by SCS Global Services in Emeryville, CA) collected by Berkeley Open Source Food in West Oakland, CA, and USDA National Nutrient Database values for raw kale. Results are per 100g of wet tissue except total phenolics and oxalic acid, which are concentrations (mg/g) See table 6 for sample locations.

`/2016-09/documents/cadmium-compounds.pdf`, last accessed 3 June 2018). Thus, a 55kg (121lbs) adult would be expected to tolerate 0.055mg/d of Cd in food "likely [...] without appreciable risk of deleterious noncancer effects during a lifetime." The species with the highest concentration of Cd was *Lactuca serriola*, a wild lettuce, which had 0.678ppm Cd in wet tissue (see Table 5). While it is hard to imagine someone eating 100g/d of *L. serriola* (because it is intensely bitter), that would translate to 0.0678mg/d, over the daily limit for a 55kg person, and equal to the limit for a 68kg (150lbs) person.

Conclusions

A healthy and sustainable food system requires a year-round, adequately abundant supply of nutrient-dense, safe, affordable food produced without draining or contaminating vital natural resources: water, air and soil. While weeds are generally unwanted and unwelcome, our research suggests that they could be a helpful component of sustainable food systems since all the plants we collected had a higher concentration of most nutrients than domesticated leafy greens—after rinsing in water—none had detectable levels of pesticides, PCBs, or heavy metals, even though they were harvested from high-traffic areas.

Discussion

Laboratory tests for substances toxic to humans focused on metals and chemicals expected in the study zone; there is a possibility that other contaminants were missed by the testing, such as pathogenic microbes. (Other studies, e.g., [35], suggest that appropriate washing suffices to mitigate the risk of pathogenic microbes such as *E. coli* O157:H7.) We did not measure the concentration of certain naturally occurring minerals and chemicals in plants, such as phytates, which in high concentration might have negative health consequences for some humans. (We did measure oxalic acid in two species known to have high concentrations.)

While kale has higher concentration of Vitamin C than the species we tested, we did not test any wild greens in the same family as kale (*Brassicacaea*), such as wild mustard (*Hirschfeldia incana, Brassica nigra, Sinapis arvensis*, et al.) or wild radish (*Raphanus raphanistrum*), which are also abundant in the study areas. We suspect they would have Vitamin C levels closer to that of kale.

Measuring the year-round availability and abundance of these plants was beyond the scope of this study. However, some of the neighborhood mappings occurred in summer (August) of 2014, considered the worst drought year in California in 1200 years (see `https://en.wikipedia.org/wiki/2011%E2%80%9317_California_drought#2014` Last visited 20 May 2018), a time expected to have little food, absent deliberate irrigation. Even during this low-production period, almost every address in all three study areas had several servings of several different species, suggesting that wild edible greens are a reliable source of nutrition year-round.

According to the most recent data from the USDA Economic Research Service (2105), waste-adjusted availability of vegetables in the U.S. is approximately 1.72 cups per capita per day [36], somewhat less than the recommended intake of 2-3 cups daily [37]. Waste-adjusted availability is is the sum of domestically produced vegetables and imports, less the waste that occurs throughout the food chain. Our observations suggest that wild and feral food can potentially contribute to nutrient security by filling in the gap between recommended and available daily servings of vegetables.

Many of these species volunteer on farms and in gardens, where such “accidental crops” may provide additional nutrition and income. A 2014 survey of 21 farms and gardens in the East Bay [38] found that of the 15 most most frequently reported “pest” plants, 11 are edible, and 9 are “culinary quality,” namely, Plantago, oxalis, mallow, bristly ox tongue, dandelion, blackberry, calendula, purslane, and hairy bittercress. Wild foods might also contribute to a healthy ecosystem by building soil organic matter, retaining water and nutrients in the soil, and reducing erosion. Wild plants may enhance biodiversity by serving as a habitat for insects and animals and other plants.

Recognizing urban foraging as a legitimate source of nutrition to promote a varied diet raises ethical, legal, and policy issues beyond the scope of this paper. [39] make a case for permitting foraging in municipal parks and public schools. Foraging is currently prohibited on most public lands in the US. For instance, the City of Berkeley Municipal Code section 12.44.020 states:

> Cutting, trimming or removal–Permit and inspection required. It is unlawful for any person to cut, trim, remove, mutilate, injure or in any way impair the growth of any tree, shrub or plant being or growing in or on any street, parking strip, public square, park or playground in the City, or to cause or permit the same to be done. . . . (Ord. 3380-NS §2, 1954)

The East Bay Regional Park District also prohibits taking any plant material whatsoever. Despite the fact that the parks use grazing, prescribed burning, and mechanical, chemical, and biological means to control some invasive species, including a number of edible species. (See, e.g., `https://www.ebparks.org/civicax/filebank/blobdload.aspx?BlobID=23687`, last accessed 16 July 2018. Listed edible species include sweet fennel, artichoke thistle, and Himalayan blackberry, among others.) park users are expressly forbidden from collecting any plants, including those the District seeks to eradicate. EBRPD Ordinance 38 [40] states:

> SECTION 804. PLANTS. No person shall damage, injure, collect or remove any plant or tree or portion thereof, whether living or dead, including but not limited to flowers, mushrooms, bushes, vines, grass, turf, cones and dead wood located on District parklands. In addition, any person who willfully or negligently cuts, destroys or mutilates vegetation shall be arrested or issued a citation pursuant to Penal Code Section 384a.

If foraging were permitted, what rules and norms would be needed to prevent over-foraging and harming existing ecosystems? To what extent can the "culture" of foragers ensure appropriate ecological stewardship? Because most of these edible plants are invasive, it is plausible that harvesting them will improve the overall ecology; however, such issues need to be addressed. Other countries where foraging is an established practice, including Scandinavian countries, have national rules and cultural norms governing foraging. (See, for instance, `https://en.wikipedia.org/wiki/Freedom_to_roam`, last accessed 16 July 2018.)

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