An Economic Analysis of Environmental Horticulture with a Focus on California

Scott R. Templeton¹, Cheryl Brown², George E. Goldman³, Seung Jick Yoo⁴, and Vijay S. Pradhan⁵

Department of Agricultural and Resource Economics and Policy, 207 Giannini Hall, MC #3310,
University of California, Berkeley, CA 94720-3310

Additional index words. “green” industry, horticulture and landscaping services, expenditures, sales, jobs, landscape area, regional economics

Environmental horticulture involves the use of plants or planted landscapes to enhance indoor or outdoor human activity. Private benefits include pure aesthetic pleasure, recreation, safer playing surfaces and roadsides, stress reduction, quicker convalescence, higher workplace productivity (Beard and Green, 1994), lower cooling expenses because of shading (McPherson and Rowntree, 1993), and gains in property values (Henry, 1993). As income and population increase, the demand for activities dependent on environmental horticulture, e.g., golfing, increases (e.g., Johnson and Christensen, 1995). As the industry grows, more areas are converted into landscapes that often contain nonnative plants; are maintained through intensive use of water, mechanical, and chemical inputs; and are sources of green waste. Some land conversion, nonnative plants, intensive input use, and waste disposal can adversely affect environmental quality or human health (e.g., Balogh et al., 1992; Kross et al., 1996; Templeton et al., 1998). As a result, the industry is becoming more regulated (e.g., Environmental Protection Agency, 1996) but is not supported by governmental

and academic institutions to the degree that traditional agricultural producers are (e.g., Johnson and Christensen, 1995). Thus, up-to-date and comprehensive economic information about environmental horticulture is important for determining the industry's contributions to the economy relative to those of other industries, assessing impacts of land-use or regulatory changes, and establishing priorities of policy makers.

The primary purpose of our research was to analyze the economy of environmental horticulture in California. Although the focus is on California, our research should be of general interest because, in all likelihood, no other state accounts for more of the national economic activity associated with environmental horticulture than does California. Moreover, some of the results about California can be used with auxiliary data to estimate sales and expenditures associated with environmental horticulture for the nation as whole. Finally, our estimation methods can be used for future research about other individual states, regions, or the nation.

Previous research for California (e.g., Pittenger et al., 1991) and, with few exceptions, for other states or the whole nation (e.g., Turner and Kriesel, 1995) has focused on marketed horticultural goods and services for which secondary data have been readily

available. Many previous studies also have combined production or wholesale revenues with retail sales and, thereby, have overestimated economic impacts. The two most recent studies for California (Schuch and Klein, 1996; Templeton and Goldman, 1996) examined only segments of this economy. With few exceptions (e.g., Cox et al., 1991; Hodges et al., 1994), previous research also has not addressed spatial impacts or expenditures per unit area. No previous study has presented confidence intervals for estimators of economic size.

SCOPE, DATA, AND METHODS

In this study, we estimated total expenditures and sales (Table 1), jobs (Table 2), land area, and expenditures per unit area (Table 3) associated with management—maintenance, installation, and, in a few cases, design—of 12 landscape types in California for 1995 or a similar 12-month period. We also estimated expenditures on contractual management of green waste associated with environmental horticulture in 1995. (For brevity, we use “horticultural” for “environmental horticultural”, which includes “floricultural” and “arboricultural”.) Data covered both marketed horticultural goods and services and non-marketed, or in-house, horticultural services.

Received for publication 28 June 1999. Accepted for publication 20 Dec. 1999. Preliminary results of this research were presented on 21 Feb. 1998 at the Western Regional Science Association's 37th Annual Meeting. This research was funded by the Elvinia J. Slosson Endowment Fund, the California Association of Nurserymen, the California Landscape Contractors Association, and the Horticultural Research Institute. National Gardening Association data for California were purchased with funds from a grant from the United States Environmental Protection Agency. The California Green Industry Council, Tom Bellows, Robin Brumfield, David Burger, Steve Cieslewicz, Kim Crum, Pete Dominguez, Jim Husting, Hap Kellogg, William Latham, Deborah Nolan, Dennis Pittenger, Larry Rohlfes, Jack Wick, and three anonymous reviewers provided helpful comments. We also thank Elizabeth Bernhardt and Tedmund Swiecki for previously sharing data on urban forestry. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.
¹To whom reprint requests should be addressed. Current title and address: Assistant Professor, 259 Barre Hall, Department of Agricultural and Applied Economics, Clemson University, Clemson, SC 29634-0355.

²Assistant Professor, Dept. of Agriculture, Southeast Missouri State University.

³Economist, Cooperative Extension and member of the Giannini Foundation of Agricultural Economics.

⁴Research Fellow, Korea Energy Economics Institute, Euiwang-si, South Korea.

⁵Statistician, Cooperative Extension.

Table 1. Annual expenditures and sales related to environmental horticulture in California.

Landscape or plant type	Expenditures (\$)²	Sales (\$)²	SD (\$)³	n
Residential yards subtotal:	3,579	≤3,579	510	---
Do-it-yourself care and installation (1995)	1,864	≤1,864	329	101⁴
Professional care and installation (1995)	1,354	1,354	308	101⁴
Landscape water (1991)	361	361	46	60
Indoor environments (1995): Cut flowers	1,429	1,429	NE⁵	NA⁶
Indoor environments (1995): Houseplants	102	102	37	101
Indoor environments (1995): Christmas trees	131	75	NE	NA
Golf courses (1995)	683	683	NE	169
State (FY96–97) and other parks (FY 94–95)	600	600	NE	NA
City streets and other right-of-ways (FY 94–95)	218	218	0	470
State highways (FY 94–95)	108	108	0	1
School yards (FY 94–95) subtotal:	312	312	57	55
Public and private, K–12	286	286	57	36
Universities, CSU and UC	27	27	2	19
Electric utility vegetation (1995)	147	147	22	5
Cemeteries (1995)	141	141	25	72
Arboreta and botanical gardens (1995)	13	13	4	12
Zoos (1995)	7	7	4	5
Other landscapes in California (1994)	467	467	NE	NA
Horticultural waste (1995)	582	582	NE	NA
Out-of-state landscapes (1994)	---	1,645	NE	NA
Total	8,518	10,108	528	---

²Millions of 1995 dollars.

³The sample size is <127 because of “don't know” responses.

⁴NE = not estimable with available data.

⁵NA = not available.

Table 2. Annual employment in environmental horticulture in California.

Employer	No. of jobs	Sample	
		SD	Size
Professional horticultural services (1995)	54,015	NE ^z	NA ^y
Retail florists (1995)	10,850	NE	NA
Retail nurseries, lawn and garden stores (1995)	8,125	NE	NA
Growers of flowers and ornamental plants (1995)	9,756 ^x	NE	NA
Manufacturers of lawn and garden equipment (1995)	95 ^x	NE	NA
City, county, two federal parks (FY 94–95) and state parks (FY 96–97)	9,871	394	295 ^w
Golf courses (1995)	13,470	NE	NA
City and state roadway agencies	4,401	144	261
City street agencies (1995)	3,663	144	260 ^w
CALTRANS (FY 94–95)	738	0	1
Schools (FY 94–95) subtotal:	14,288	2,816	57
Public and private K–12	13,616	2,816	38
Public universities, CSU and UC	672	33	19
Electric utilities (1992)	272	84	5
Cemeteries (1995)	3,218	609	74
Arboreta and botanical gardens (1995)	331	54	13
Zoos (1995)	150	73	5
Total	128,842	2,914	---

^zNE = not estimable within available data.

^yNA = size of original sample is not available.

^xJobs attributable to exports.

^w260 and 33 observations on city and county urban forestry.

Table 3. Area and expenditure intensity for environmental horticulture in California.

Landscape type	Area (ha)	SD (ha)	Sample size for area	Expenditure per unit area (\$/ha)
Private residential yards (1995)	274,960	33,441	83	13,016
Golf courses (1995)	53,059	NE ^z	NA ^y	12,866
Flower and ornamental plant farms (1992)	27,165	NE	census	53,546 ^x
City, county, and two federal parks (FY 94–95)	63,815	NE	NA	9,350
City and state roadways subtotal:	29,125	158	459	10,712
City streets (1995)	19,907	158	458	10,259
State highways (FY 94–95)	9,218	0	1	11,689
School yards (FY 94–95) subtotal:	44,091	6,197	61	7,084
Public and private K–12	40,570	6,188	37	7,040
Public universities, CSU and UC	3,521	344	24	7,597
Vegetation around electric power lines (1995)	63,827	15,814	3	2,303
Cemetery grounds (1995)	7,257	1,156	76	19,420
Arboreta and botanical gardens (1995)	459	103	13	28,955
Zoo grounds (1995)	284	135	5	25,523
Total ^w	554,087	37,526	---	13,077

^zNE = not estimable with available data.

^yNA = size of original sample is not available

^xBased on 1992 revenues stated in 1995 dollars (Bureau of the Census, 1994).

^wTotal area does not include one-half of the area of roadside vegetation managed by city governments because the landscape below power lines within cities, the area of which is already included, parallels one side of a road.

Unless indicated otherwise, expenditures were also within-state sales. We also used the information about California and other data to estimate the size of the horticultural economy for the nation in 1995 and the state in 1998. To avoid double-counting, we focused on transactions at the export, retail, or final-user level. We estimated confidence intervals when data permitted.

Primary data were collected from the following sources: the household survey of the National Gardening Association (NGA) for 1995 that was augmented with questions about yard size; the State Controller's Office (Connell, 1997a); surveys of California State University campuses (National Association of College and University Business Officers, 1996); our update of a previous survey of electric utilities; the 1992 California Commu-

nity and Urban Forestry Survey (Bernhardt and Swiecki, 1993); and our mail surveys of the California Department of Transportation, Univ. of California campuses, public school districts, private schools, cemeteries, arboreta, and zoos. Sources of secondary data include various state government agencies, professional organizations, and the 1994 IMPLAN database. (The database is usually not identified by the words for which IMPLAN stands: **IMP**act Analysis for **PLAN**ning.)

Estimators of characteristics of the horticultural economy and variances of these estimators reflect the finite number of decision-makers within that economy. For example, an unbiased, mean-based estimator of total expenditures, jobs, or land area, if any, associated with private residential yards, houseplants, school yards, cemeteries, arboreta, and zoos is

$$\hat{Y}_j = N_j \bar{y}_j \quad [\text{Eq. 1}]$$

in which N_j is the finite number of decision-makers, e.g., zoo operators, for landscape type j , e.g., zoo grounds, and $\bar{y}_j$ is the sample mean of the characteristic of interest, e.g., area, for type j , (Cochran, 1977). An unbiased estimator of the variance of this estimator is

$$v(\hat{Y}_j) = N_j^2 \frac{s_j^2}{n_j} \frac{(N_j - n_j)}{N_j} \quad [\text{Eq. 2}]$$

in which

$$s_j^2 \equiv \sum_{i=1}^{n_j} \frac{(y_{ij} - \bar{y}_j)^2}{n_j - 1} \quad [\text{Eq. 3}]$$

$$n_j = \text{sample size for } j, \text{ and } \frac{(N_j - n_j)}{N_j}$$

is the finite population correction (Cochran, 1977). A consistent, ratio-based estimator of the area of roadside vegetation in California's cities in 1995 is

$$\hat{Y}_{\hat{R}} \equiv X \hat{R} \equiv X \frac{\bar{y}}{\bar{x}} \quad [\text{Eq. 4}]$$

in which X is the total number of people in these cities in 1995, and $\bar{x}$ and $\bar{y}$ are the respective mean number of people and hectares in a 1991 sample. A frequently used estimator of the variance of this estimator (Cochran, 1977) is

[Eq. 5]

$$v(\hat{Y}_{\hat{R}}) \equiv N^2 \left(\frac{N - n}{N} \right) \frac{1}{n} \frac{\sum_{i=1}^n (y_i - \hat{R}x_i)^2}{n - 1}$$

In the ratio-based estimators of characteristics of electric utilities, X is the total number of their customers in the market in 1991, $\bar{x}$ is mean customers in 1991, and $\bar{y}$ is mean expenditures, in-house jobs, or area of landscape under electric power lines in 1995 of utilities in the sample.

Ratio-based estimators of three characteristics utilize auxiliary data. In particular, let X_{jk} and Y_{jk} be horticultural expenditures and jobs, respectively, in which k = city or county if j = parks, and k = city if j = street landscapes. Let W_k and Z_k be arboricultural expenditures and jobs, respectively, associated with k (= city or county) government's management of trees along streets and in parks. Assume

$$\frac{Y_{jk}}{X_{jk}} = \frac{Z_k}{W_k}$$

Given this assumption and formula in Cochran (1977), one can show that a consistent, ratio-based estimator of horticultural jobs associated with city parks, county parks, or city streets is

$$\hat{Y}_{\hat{R}_{jk}} \equiv X_{jk} \hat{R}_{jk} \equiv X_{jk} \frac{\bar{z}_k}{\bar{w}_k} \quad [\text{Eq. 6}]$$

and an estimator of the variance of this estimator is

[Eq. 7]

$$v\left(X_{jk} \frac{\bar{z}_k}{\bar{w}_k}\right) \equiv X_{jk}^2 \frac{(N_k - n_k)}{N_k} \frac{1}{\bar{w}_k} \frac{1}{n_k} \frac{\sum_{i=1}^{n_k} (z_{ik} - \hat{R}_k w_{ik})^2}{n_k - 1}$$

RESULTS

Private residential yards. There were 10.97 million households in all types of dwellings in the state in 1995 (Department of Finance, 1996). According to responses of California residents who were randomly selected without regard to dwelling type to participate in the NGA's annual survey ($n = 127$), 80% of all households had lawns, gardens, or other planted areas that covered a total of 274,960 ha. These households spent \$1.864 billion on do-it-yourself yard activities and \$1.185 billion for professional lawn care, landscape maintenance, and tree care in 1995. Owners of 85,293 new residences in 1995 (Real Estate Research Council of Northern California, 1999) paid an average of \$1983 per unit, according to three real-estate developers, or \$169 million for professional installation of their front yards. Also, households spent \$361 million (1995 dollars) on water for their yard plants in 1991, a drought year (Department of Water Resources, 1994). Thus, households spent an estimated total of \$3.579 billion on planted yards in 1995.

Indoor environments. Californians spent \$1.661 billion on plants for indoor decoration, \$1.605 billion of which circulated within the state economy. Most of these expenditures were for cut flowers and greens. In particular, 4914 florists had retail sales of \$714 million in 1995 (State Board of Equalization, 1996). Home centers, discount stores, supermarkets, and other diversified retailers represent at least half of the cut flower market, according to professional judgment (H. Kellogg, personal communication) and evidence regarding related products (Templeton et al., 1998). Given an assumption that the \$714 million for florists represented only 50% of the total market, retail sales of cut flowers and greens were \$1.429 billion in 1995.

People also use potted plants and Christmas trees. According to NGA data, 21% of all households in California cared for indoor houseplants and spent \$102 million for the purchase of these plants, their care, or both in 1995. Of all households in California and other states in the "West", 48% purchased real Christmas trees and paid \$25, on average, per tree (National Christmas Tree Association, 1996). If one assumes that these figures apply to California, the state's households spent \$131 million for these trees. Since California growers sold \$19 million of cut-and-carry Christmas trees (Department of Food and Agriculture, 1996), the remaining \$112 million was spent on imported real Christmas trees, primarily from Oregon. Given the typical retail markup of 100% (M. Wade, personal communication), 50% of this remainder, or \$56 million, stayed within the state. Thus, a total of \$75 million of house-

hold spending on Christmas trees stayed within the state's economy.

Golf courses. In 1995, California had 898 golf courses, 306 private and 592 public (M. Phalen, personal communication). Private and public golf courses in the western United States spent, on average, \$771,330 and \$645,583 for landscape maintenance and \$87,945 and \$63,424 for landscape-related capital expenses, respectively, in 1995 (Golf Course Superintendents Association of America, 1996). Based on the assumption that these averages also are those of California, golf courses in the state spent \$618.2 million for maintenance and \$64.5 million for capital expenses, or \$683 million for horticulture in 1995. The median size of private, 18-hole courses in the state was 59.1 ha and the median number of employees was 15 in 1995 (M. Phalen, personal communication). Based on an assumption that these figures are mean employment and planted area for all courses in California, horticultural management of these courses entailed 13,470 jobs and course vegetation covered 53,059 ha.

Public parks. California had 23 national and 277 state parks in mid-1995 (Department of Finance, 1996). Although national and state parks covered 3.28 and 0.543 million ha, respectively (Department of Finance, 1996), only small portions were horticultural landscapes. For example, Golden Gate National Recreation Area and Muir Woods National Monument account for 29,618 and 224 ha, respectively (Department of Finance, 1996), but had only 99 and 4 ha of maintained landscapes (N. Weeks, personal communication). City, county, and district parks numbered 7738 and covered more than 63,712 ha in 1987 (Dangermond and Associates, 1989). These public parks, in total, covered at least 63,815 ha in 1995.

Agencies that manage public parks in California spent an estimated \$600 million on horticulture in FY 94–95. The federal government spent \$1.2 million for horticultural landscapes in the Golden Gate National Recreation Area and Muir Woods National Monument (N. Wood, personal communication). The state's Department of Parks and Recreation spent \$0.5 million for landscape maintenance materials in FY 96–97 (V. Bradshaw, personal communication). Under the assumption that this expense represents 15% of total expenses, which also include irrigation, labor, and administration (Dangermond and Associates, 1989), the Department spent \$3.3 million (1995 dollars) for maintenance of landscapes in state parks. Local governments reported expenditures of \$1.337 billion for city parks and recreation (Connell, 1997a) and \$175 million for county recreational facilities (Connell, 1997b). According to three parks and recreation officials, local governments spend 39% of their budgets and, by implication, spent almost \$526.6 million and \$68.9 million in FY 94–95 for horticulture at city and county parks.

Data from Bernhardt and Swiecki (1993) indicate that city and county agencies had 1.7 and 1.4 full-time equivalent (FTE), in-house jobs, respectively, per \$100,000 of expendi-

ture for arboriculture. Given these ratios, the expenditures of cities and counties for horticulture imply the equivalent of 8819 ($n = 260$, $SD = 347$) and 970 ($n = 33$, $SD = 186$) full-time jobs. Based on an assumption that the unknown ratio for state parks is the same as the ratio for county parks, the expenditure of the Department of Parks and Recreation implies 47 FTEs ($n = 33$, $SD = 9$) for landscape maintenance at state parks. The two federal parks surveyed had the equivalent of 35 full-time jobs in FY 95–96. In total then, people worked the equivalent of 9871 full-time jobs related to horticulture in city, county, state, and two federal parks.

Roadside and other right-of-way vegetation. City governments and the California Department of Transportation (CALTRANS) spent \$326 million for design, installation, and maintenance of 29,125 ha of vegetation along roadsides or other right-of-ways and engaged in horticultural-related work that was the equivalent of 4401 full-time, in-house jobs. These estimates break down as follows. CALTRANS spent \$108 million in FY 94–95 to manage 9218 ha of landscapes along roads with the equivalent of 738 full-time positions for landscape design, installation, and maintenance (L. Coe and L. Shields, personal communication). City governments spent \$204.2 million for street trees and roadway-related landscaping and \$14.5 million on weed abatement in FY 94–95 (Connell, 1997a). Given 1.7 full-time equivalent, in-house jobs per \$100,000 of arboricultural expense by cities, the expenditure of \$219 million implies 3663 full-time equivalent jobs. Given the population in California's 470 cities in 1995 (Connell 1997a), a ratio of 4.13 km of road per 1000 city residents in 1991 (Bernhardt and Swiecki, 1993), and an assumption that the planted landscape strip is 0.9 m wide on each side of a road, managed vegetation along city streets covered 19,907 ha.

School yards. Planted landscapes beautify schools, enable recreation, and enhance educational environments. The University of California (UC) and California State University (CSU) had more than 500,000 students and almost 180,000 faculty and staff, all of whom are potential consumers of campus landscapes. According to survey responses and the National Association of College and University Business Officers (1996), facilities and grounds superintendents at nine UC and twenty CSU campuses spent \$26.7 million in FY 94–95 to manage 3521 ha of horticultural landscapes with the equivalent of 672 full-time, in-house jobs. According to survey responses, 993 public school districts (Connell, 1997c) and 4152 private schools (C. Calderone, personal communication) employed people to fill the equivalent of 13,616 full-time jobs and spent \$285.6 million for installation and maintenance of 40,570 ha of planted school yards in FY 94–95. In total, public universities and all K–12 schools in the state spent \$312 million to manage 44,091 ha of horticultural landscapes with the equivalent of 14,288 full-time employees, including associated supervisors and administrators.

Vegetation around electric power lines. Prior to recent deregulation, California had 37 electric utilities, but five of them accounted for 93% of all customers (Fay, 1991). These utilities or their contractors regularly inspect a 6-m diameter, aerial corridor around power lines for intrusions of tree branches, prune back branches that are too close, and remove all vegetation on the ground within 3 m of power poles in accordance with fire and safety regulations (S. Cieslewicz, personal communication). In 1995, electric utilities spent \$147 million for these and other arboricultural activities, \$114 million of which was for contractual work. These utilities had 272 full-time equivalent, in-house arboricultural jobs. Two of the five utilities had in-house tree crews. All 37 supervised or provided support services for in-house or contractual tree crews.

Based on responses from three of the largest five utilities, the estimated total lengths of distribution and transmission lines in 1995 were 316,363 and 40,821 km, respectively. Assume that the 6-m diameter aerial corridor around transmission lines translates into a vegetative strip on the ground of at least the same width, because these lines typically run through forests, pastures, deserts, and other areas with vegetation. Also assume that the aerial corridor around distribution lines translates into a 1.2-m wide vegetative strip because of roads, sidewalks, driveways and other hardscape in urban areas. Given these assumptions, the vegetative area for which utilities were responsible was 63,827 ha. (The 32 utilities that accounted for 7% of all customers in 1991 were treated as one unit for statistical purposes).

Cemeteries. Cemetery grounds beautify burial sites. The Cemetery Licensing Board and telephone, religious, and internet directories listed 198 licensed and 356 unlicensed cemetery operators in California in 1996. These operators employed people for 3218 full-time equivalent, horticultural jobs and spent \$141 million on installation and maintenance, including irrigation, of 921 cemeteries ($n = 77$, $SD = 81$) that occupied 7257 ha in 1995.

Arboreta and botanical gardens. Arboreta and botanical gardens provide recreation, education, and, in some cases, *ex situ* conservation of genetic material. California's 51 arboreta and botanical gardens had horticultural expenses of \$13 million, 459 ha of managed vegetation, and 331 full-time equivalent, horticultural jobs.

Zoos. Planted landscapes enhance recreation for people who visit zoos and habitat for some of the animals. California's 18 zoos spent \$7.25 million to have the equivalent of 150 full-time employees manage 284 planted ha in 1995.

Other horticultural landscapes in California. Airports, hotels, hospitals, business parks, and numerous other organizations paid \$467 million (1995 dollars) for contractual design, installation, and maintenance of planted landscapes around their facilities in 1994 (Table 1). This estimate is the inflation-adjusted sales of landscape-and-horticultural-service companies (IMPLAN sector 27) to all other domestic IMPLAN sectors except owner-

occupied dwellings (sector 461), funeral homes (sector 467), schools (sectors 495–497 and 522), electric utilities (sectors 443 and 511), state and local government (sectors 512 and 523), and buyers outside of California (Minnesota IMPLAN Group, 1997). This estimate also includes \$0.26 million of sales of lawn and garden equipment (sector 310) to the federal government (Minnesota IMPLAN Group, 1997).

Horticultural waste. Californians spent \$582 million for contractual management of horticultural waste in 1995 (Table 1). In particular, the California Integrated Waste Management Board estimates that 4.44 million t of horticultural waste were disposed of as trash at landfills, 0.831 million t were composted at composting facilities, and 0.355 million t were used as alternative daily cover at landfills in 1995 (C. Schmidle, unpublished data). The average cost of collecting yard waste, if mixed with other trash that went to landfills, was \$74/t in 1995 in the United States (Allied Composting Council, 1996). The weighted-average tipping fee for horticultural waste disposed as trash or alternative daily cover at landfills in the state was \$34.20/t in 1995 (Kakutani, 1995). The average cost of collecting yard waste that was separated from other trash and, by implication, used for composting or alternative daily cover was \$60/t in 1995 in the United States (Allied Composting Council, 1996). Composting facilities in California and four other western states charged, on average, \$6.97/m³ to accept yard waste in 1995 (Markets Page™, 1996). Given $\approx 0.30 \text{ t} \cdot \text{m}^{-3}$ (T. Padia, Alameda County Waste Management Authority, personal communication), this charge is equivalent to \$23.37/t. Hence, in 1995, Californians spent \$479 million for collection of yard waste and its disposal as trash at landfills, \$69 million for its collection and disposal at composting facilities, and \$33 million for its collection and use as alternative daily cover.

Out-of-state landscapes. Nurseries, flower growers, and others sold \$1.619 billion of horticultural goods and services to customers outside of California in 1994, or \$1.645 billion in 1995 prices (Table 1). The 1994 estimate is the sum of four sub-estimates. Providers of "landscape and horticultural services" and manufacturers of yard-care equipment had exports of \$874 million and \$7.3 million, respectively, in 1994, primarily to other states (Minnesota IMPLAN Group, 1997). California growers of flowers and nursery products had sales of \$2.172 billion in 1995 (Department of Food and Agriculture, 1996). Since 17% was sales of vegetable, fruit, and nut plants (California Agricultural Statistics Service, 1996), these producers sold \$1.797 billion worth of ornamental plants. [In contrast, California farmers sold \$20.3 billion worth of agricultural crops (California Agricultural Statistics Service, 1996; Department of Food and Agriculture, 1996).] Exports of horticultural crops to buyers outside of the United States, exclusive of mushroom spawns and edible fruit or nut trees, were \$22 million in 1995 (Department of Food and Agricul-

ture, 1996). If domestic and foreign exports represent 41% of sales, the average of three such percentages in the literature (Minnesota IMPLAN Group, 1997; Schuch and Klein, 1996), then growers sold \$715 million worth of ornamental plants to buyers in other states.

Other jobs. The full-time equivalent jobs already estimated, a total of 46,001, are directly associated with in-house provision of horticultural services. Market provision of landscape and horticultural services (SIC 078) entailed an additional 54,015 jobs (Rose, 1998). Also, sales of horticultural goods directly accounted for 28,826 jobs. In particular, there were 10,850 jobs with florists (SIC 5992) and 8125 jobs at lawn and garden centers and retail nurseries (SIC 5261) in 1995 (Rose, 1998). Farmgate sales of nursery products and flowerers supported 28,753 jobs in 1995 (Rose, 1998). (In comparison, total agricultural crop production supported 351,496 jobs in the same year (Rosenberg, 1997).) Manufacture of lawn and garden equipment (SIC 3524) entailed 662 jobs in 1995 (Rose, 1998). However, only 9756 and 95 jobs, respectively, can be directly attributed to exports of horticultural products and to sales of lawn and garden equipment to the federal government and buyers outside of California. Not all of these jobs are necessarily full-time because official data include temporary, part-time, and seasonal positions.

DISCUSSION

Economic impacts. At the export, retail, or final-user level, Californians spent \$8.518 billion and had sales of \$10.108 billion for horticultural goods and services in or close to 1995 (Table 1). The 95% confidence interval is plus or minus \$1.035 billion of these estimates. In contrast, Californians spent \$64.2 billion for food in 1995 and sold \$68.5 billion (1995 dollars) of food in 1996 (Templeton et al., 1999). The difference between expenditures and sales is net exports to other states or countries. These sales directly entailed 128,842 jobs (Table 2). The 95% confidence interval is 123,130 to 134,554 jobs. These sales directly translated into \$6.971 billion in household income (Minnesota IMPLAN Group, 1997). The 95% confidence interval is plus or minus \$716 million of this estimate. These economic impacts are probably larger in California than other states because it has one of the longest growing seasons and the biggest population and economy among states in the nation (Bureau of the Census, 1996).

In addition to these direct economic impacts, environmental horticulture also generates "indirect" and "induced" impacts when, at prevailing prices, exports of horticultural goods and services from California increase or imports decrease with corresponding increases in purchases of goods and services produced within the state. In particular, a \$100 million increase in net exports of nursery products, horticultural services, or lawn and garden equipment generates respective additional impacts of \$122, \$208, or \$74.6 million in sales and total impacts of \$134, \$183, or \$67.4 million in total income

(Minnesota IMPLAN Group, 1997). These additional impacts occur because businesses that supply inputs, e.g., fertilizers, to those who sell horticultural goods and services at the export or final-user level also purchase products from other businesses, and people spend most of the income that they earn from these input suppliers and other businesses.

These estimates understate the size of the horticultural economy in the state, however. For example, expenditures and jobs associated with in-house provision of horticultural services for "other landscapes in California" and jobs associated with contractual management of green waste were not estimable for lack of data. Market expenditures for "other landscapes in California" and "out-of-state landscapes" were estimated with IMPLAN data, which understate purchases of landscape and horticultural services (e.g., Templeton and Goldman, 1996). Also, the available data did not permit a breakdown of expenditures between marketed and nonmarketed horticultural services for landscapes other than private residential yards and vegetation around electric power lines. By filling these information gaps with more detailed, primary data, researchers can better estimate the overall size, internal makeup, and changes of the horticultural economy.

Horticultural landscape area. There were 554,087 ha of horticultural landscapes (Table 3). The 95% confidence interval is 480,537 to 627,637 ha. This area is primarily for "consumption" activities. In 1992, production of floricultural crops, bulbs, nonvegetable and nonfruit nursery crops, sod, and flower seeds covered 27,165 ha: 25,909 ha outdoors and 1256 ha under glass or other protection (Bureau of the Census, 1994; California Agricultural Statistics Service, 1996). In contrast, harvested cropland covered 3.114 million ha in 1992 (Bureau of Census, 1994). The estimate of 554,087 ha does not, however, include the area of "other landscapes in California". Future estimation should include areas of maintained grounds in all federal and state parks, roadside vegetation managed by counties, turf at sports facilities and airports, and landscapes around corporate offices, retail shopping centers, hospitals, hotels, and amusement parks. Estimation of the proportion of horticultural landscapes that are irrigated or receive chemical treatments should also be the subject of future research.

Expenditure intensity. Expenditure intensities for horticultural landscapes have an interesting economic pattern (Table 3). Let R_j and R_k be expenditures per hectare for landscapes $j \neq k$. Under the null hypothesis that these ratios are equal and the two samples come from one underlying population, the t statistic with $n_j + n_k - 2$ df is

$$\frac{\hat{R}_j - \hat{R}_k}{s \sqrt{\frac{1}{n_j} + \frac{1}{n_k}}}$$

in which

$$s = \sqrt{\frac{(n_j - 1)s_j^2 + (n_k - 1)s_k^2}{n_j + n_k - 2}}$$

and

$$s_j^2 \equiv v(\hat{R}_j) \equiv v\left(\frac{\bar{y}_j}{\bar{x}_j}\right) \equiv \frac{(N_j - n_j)}{N_j} \frac{1}{\bar{x}_j^2} \frac{1}{n_j} \frac{\sum_{i=1}^{n_j} (y_{ij} - \hat{R}_j x_{ij})^2}{n_j - 1}$$

(Cochran, 1977). To calculate s_j^2 or s_k^2 , any sample unit in landscape j or k had to report both expenditures and area. After elimination of incomplete responses, the estimated expenditures per hectare are \$2280 for vegetation around electric power lines ($n = 3$, $SD = \$367$), \$7549 for all school yards ($n = 54$, $SD = \$796$), \$11,020 for roadside vegetation ($n = 459$, $SD = \$109$), \$13,694 for private residential yards ($n = 63$, $SD = \$2412$), \$19,145 for cemetery grounds ($n = 72$, $SD = \$1940$), \$25,523 for zoo landscapes ($n = 5$, $SD = \$3960$), and \$30,294 for arboreta ($n = 12$, $SD = \$6298$). (Because of this data restriction, these expenses per hectare can differ slightly from those in Table 3 and the usable sample sizes are less than or equal to those for separate estimation of expenditures or area.) Pair-wise differences between expenses per hectare of these landscapes are highly significant ($P \leq 0.0001$) except the difference between zoos and arboreta ($P = 0.14$).

Expenditure intensity increases as the contribution of plant quality and variety to the associated consumption activity increases. Thus, expenditures per hectare of utility landscapes are low relative to those for other landscapes because utilities prune or trim only those branches of trees and large shrubs that would interfere with power lines, not all branches, and remove, not grow, vegetation around the base of some power poles. Similarly, expenses per hectare are lower for school yards and roadsides than for private residential yards, golf courses, and cemeteries because planted landscapes of high variety or quality do not contribute as much to formal education and transportation as they do to backyard recreation, enjoyment of golfing, or the solace of visiting graves of loved ones. Arboreta and botanical gardens have the highest expenditure intensity of the nonproduction horticultural landscapes considered because managed plants are the main reason why people visit these facilities. The greater the variety and quality of plants, the better the recreational and educational experience.

Caution should be used, however, in analyzing these expenditure intensities. For example, the estimated area of responsibility for electric utilities overestimates the area of active management and, thus, underestimates expenses per managed hectare, because some types of vegetation do not interfere with safe provision of electricity. People's preferences might not be adequately reflected in the budgets for park and other public landscapes. The estimate of \$13,016/ha of private residential planted yard does not reflect \$168 million that households in the state spent on vegetable gardening, fruit trees, and growing berries. Also, garden space is included in the area of planted yards but some of the area might be used for growing vegetables or fruits. The estimate of 59.1 ha for the average area of golf courses in the state might be high (Balogh et al., 1992). If the average vegetative area were

54 ha, then expenses per hectare would be \$14,078 instead of \$12,866. Either figure underestimates management intensity on greens, tees, and fairways because roughs account for two-thirds to three-fourths of the vegetative area but receive the least care (Balogh et al., 1992).

Estimated national economy and recent state growth. Households nationwide spent \$34.787 billion in 1995 for yard-related horticulture, except water, and indoor houseplants. This figure consists of \$20.587 billion for do-it-yourself activities (National Gardening Association, 1996) and \$14.2 billion for professional services (National Gardening Association, unpublished data). Californians spent \$3.320 billion for yards, except water, and indoor plants (Table 1), or 9.5% of the national figure. If this percentage is, on average, California's share of national expenditures for other horticultural landscapes and cut flowers, total statewide expenditure of \$8.518 billion implies that people in the United States spent \$89.252 billion for environmental horticulture in 1995. Since net imports of flowers and nursery products were \$616 million (Economic Research Service, 1996), the industry of environmental horticulture contributed an estimated \$88.636 billion in 1995 to the gross domestic product of the United States.

California's horticultural economy has probably grown since 1995. If the state's 258,517 new households (Department of Finance, 1999) were the same, on average, as sample households, then the data in Tables 1 and 3 imply that Californians in 1998 spent an additional \$39 million (1995 dollars) for indoor plants and \$84 million (1995 dollars) for new residential yards that occupied 6482 ha. Real income per capita increased 7.9% during 1995–1998 (Bureau of Economic Analysis, 1999; B. Annis, personal communication). For each 1% increase in real household income, households spend 0.75% to 1.5% more for horticultural goods (Gineo and Omamo, 1990). If people spend 1% more, the data in Table 1 imply a separate increase of \$423 million in expenditures (1995 dollars) for yard-related horticulture and plants for indoor environments. In response to growth of population and real per capita income, then, sales of products and services for yards and indoor plants increased an estimated \$540 million. The data in this paper also imply that California's 57 new golf courses (M. Phalen, personal communication), if identical on average to previously existing courses, spent at least \$43 million (1995 dollars) for horticulture and covered 3368 ha in 1998. Electric utilities spent an estimated \$121 million (1995 dollars) more for arboriculture in 1998 because a new regulation requires more clearance around power lines, and tree growth substantially increased 2 to 3 years after the drought ended (S. Cieslewicz, personal communication). In real terms (1995 dollars), then, estimated horticultural expenditures and sales of Californians increased \$0.71 billion between 1995 and 1998. In nominal terms, expenditures and sales were \$9.81 billion and \$11.5 billion in 1998.

CONCLUSIONS

The methods and results of this study are important. The methods can be used to estimate economic impacts of environmental horticulture in other states or the nation as a whole. The sales and job information can be and have already been used to assess potential magnitudes of growth of marketed horticultural goods or services and to develop business plans. The estimates of areas of different horticultural landscapes can improve planning for water conservation (Department of Water Resources, 1998) and regulation of environmental risks of pesticide or fertilizer use (Balogh et al., 1992). Water or chemical "requirements" for different landscapes can be multiplied by their corresponding statewide areas and reasonable percentages of areas that are irrigated or treated to obtain estimates for water or chemical use in total or by landscape type.

Expansion of residential yards, golf courses, and other horticultural landscapes occurs through contraction of habitat and, in some cases, economic activity associated with agricultural farms (Medvitz, 1998), wetlands (Balogh et al., 1992), forests, or other landscapes. Habitat alteration, green waste disposal, and use of pesticides and fertilizers, leaf blowers, lawn mowers, nonnative plants, and water on horticultural landscapes have become contentious policy issues. Policy makers can use our results to broadly assess net economic impacts of changes in land use or policies that affect management of horticultural landscapes in California and judge them in light of any associated impacts on the environment and human health. Moreover, private and public policy makers could use our results to justify allocating more resources for research, product development, education, extension, and regulation that could resolve these contentious issues and enable the horticultural industry to continue its economic growth.

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