ease incidence was low (1982 and 1987), the choice of fungicide had little effect on control. Even in years with low disease incidence, however, shot hole was more prevalent in untreated than in treated trees. We did not obtain sufficient data to evaluate control of leaf infections. The relative importance of fruit and leaf infections and the manner in which shot hole damages trees are not clearly understood. Shot hole is known to cause defoliation, but the extent to which fruit are damaged directly is uncertain.

A dormant application of copper fungicide improved control of shot hole by ziram when disease incidence was high. Recent evidence suggests that spores of the shot hole fungus in buds and on tree surfaces may be an important source of overwintering inoculum on almond, and the amount of this inoculum may influence disease incidence in the spring. Dormant application of copper fungicide in our studies may have reduced or impaired overwintering inoculum, improving control by ziram applications in the spring.

With regard to fungicide effects on yield, conditions in 1986 and 1987 may represent two extremes, the former producing severe and the latter no measurable loss in yield to diseases. Less obvious losses may occur in years of intermediate disease levels.

The reductions in yield reported here cannot be attributed entirely to shot hole. Several diseases were enhanced by the high rainfall during bloom in 1986. In addition to shot hole, there were symptoms of brown rot and jacket rot in the test area, but we do not have data on the incidence or severity of either. Other unrecognized disease organisms also may have been active and contributed to reduced yield. Treatments with the broad-spectrum fungicides captafol, captan, iprodione, and maneb resulted in higher yields than those with ziram, a narrow-range fungicide, suggesting that several disease organisms, not just the shot hole fungus, contributed to yield loss. Fungicides active against a variety of organisms should be included in programs for bloom disease control of almond.

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# Foraging in Central Valley agricultural drainage areas

Mark Campbell ❑ L. Clair Christensen

***For as long as there have been humans in the Central Valley grasslands, they have hunted, fished, and gathered plant or animal life for consumption. "Foraging" became a health concern with the evidence of selenium accumulation at Kesterson Reservoir. A survey suggests that a large number and variety of people forage. The amounts and frequency of consumption are probably not great enough to be a health hazard to any one person or group, but there is still some cause for concern.***

The discovery in 1983 of deaths and deformities among migratory waterfowl at the Kesterson Reservoir in the central San Joaquin Valley focused national attention on drainage and drainage-related problems in California. These problems have affected agricultural productivity and water quality but, in the context of fishing and hunting, it is their overlapping effects on fish and wildlife and public health that are of concern.

In the fall of 1986, the San Joaquin Valley Drainage Program, an interagency effort to resolve the selenium issue, requested our assistance in assessing the nature and extent of natural resource use by people in the Central Valley. Between January and May 1987, we conducted a study in the drainage area of the central San Joaquin Valley, a region stretching from Gustine to Mendota between the San Joaquin River and interstate highway I-5.

In mid-1987, the California Department of Health Services completed a report on the public health implications of elevated selenium levels in this area. No adverse effects on local residents were found, but levels of selenium in fish, aquatic birds, and waterfowl were unsafe for unrestricted human consumption. As a precaution, public warnings were issued advising people to avoid or limit consumption of fish and waterfowl taken in the Kesterson Reservoir and Grasslands.

Because selenium concentrations persist in the soil and sediment, the Department of Health Services recommended further studies to assess potential health risks. Our study was a preliminary effort to identify high-risk groups of people who collected plants and animals in the drainage area. These activities included hunting, fishing, trapping, clamming, frogging, and the collection of crayfish and edible plants. We gave legal and illegal activities equal weight under the term "foraging" to include all use of flora and fauna for consumption. Those who practiced these activities were termed "foragers."

## Study design

Assuming a journalistic stance in our research, we sought to contact individuals who were foragers themselves or who could provide detailed accounts of such activities. This information was constricted by: (1) the social system, which produced some hesitancy among informants to disclose hunting and fishing sites; and (2) the legal system, which produced a reticence to discuss any illegal practices.

The timing of our study also made direct observation of the full fishing and hunting season impossible. We relied instead on secondary sources for the bulk of our information. These included representatives from water districts (canal tenders), the California Department of Fish and Game, California Department of Parks and Recreation, Merced County Public Health Office, California State Police, U.S. Fish and Wild-

life Service, farmers, duck club managers, and ranchers. The reports of these informants were not corroborated by direct observation, but the similarities between reports provided an informal measure of their reliability.

We conducted 85 interviews (table 1) averaging 1.5 hours each and ranging from 30 minutes to 6 hours. Respondents were selected by referral. One informant was asked to identify another and so on, so that a network of informants evolved that paralleled existing social and institutional structures. The 85 interviews maintained a conversational tone, centering on the search for descriptive information on foraging: who fished (hunted, gathered, collected), where, how, how often, when, and for what.

Given the need from the outset to identify natural-resource users and patterns of use, the unstructured interview format proved most successful during this phase of the study. It was suited to the collection of preliminary data and did not determine in advance the nature or direction of the interview.

Assuming that the San Joaquin Valley drainage program might require more accurate measures of natural resource use, we concentrated additional energies on the foraging activities of Southeast Asian refugees. County health department officials assumed high rates of contact between these individuals and items taken from the drainage area. Our study included a survey of 44 families among the approximately 8,000 Southeast Asians living in the Merced area. Of the 44 families, 36 were Hmong, 4 Laotian, and 4 Mien, with a total of 105 adults and 134 children. Interviews followed a case study format and relied on key informants. We made no attempt to randomize the sample set.

The nature of the study setting concentrated our attention on fishing rather than hunting. Water is distributed through the supply systems of scores of independently operated water districts. These same waterways draw off surface and subsurface drainage. The fact that fish and other aquatic wildlife are restricted to this network of canals, rivers, and drains produces a real concern with regard to contaminants, such as selenium, in agricultural water.

**TABLE 1. Description of respondents**

| Type | Number |
|---|---|
| Water district personnel | 23 |
| County agencies (Public Health, Cooperative Extension, Catholic charities, Lao Family) | 14 |
| State agencies (California Fish & Game) | 14 |
| Federal agencies (Office of Refugee Services, USFWS, Bureau of Reclamation) | 6 |
| Local residents (hunters and fishers) | 19 |
| Caretakers, farmers, private land managers | 9 |

## Foraging in the Central Valley

California's Central Valley once contained abundant tule elk, deer, beaver, grizzly bear, and waterfowl, and hunting and fishing in the San Joaquin Valley were common. Since the opening of the Main and the San Joaquin and Kings River canals in 1872, however, agriculture has become dominant. The wetlands, which once spread between Gustine and Firebaugh, are now contained within the Grassland Water District and a handful of state and federal refuges.

Between the irrigated fields and alkali flats of this region, four distinct groups of people reportedly fish, hunt, and collect wildlife. Informants identified white, black, Asian, and Hispanic groups. Each group reportedly has a somewhat different choice of game as well as methods and location of activities.

Our attention to water has emphasized the collection of aquatic wildlife, but small game and furbearers composed a sizable portion of foraged items. Foragers hunted and collected rabbit, squirrel, skunk, raccoon, otter, beaver, muskrat, coyote, opossum, weasel, and badger in the study area.

There are seven types of water in the study area: refuges (standing water supplies), rivers, private impounded waters, natural sloughs, farm sumps, regular canals, and irrigated fields. We have combined some of these categories—farm sumps and private impounded waters—while further differentiating the regular canals.

The canals in the study area form a highly stratified system of water flows and qualities. The major supply canals carry enormous quantities of water capable of diluting "substances of concern"—a term used to refer to selenium and other toxic or potentially toxic substances such as arsenic, boron, chromium, iron, manganese, molybdenum, zinc, and total dissolved solids. The levels of trace elements and heavy metals are lowest in the major supply canals.

As a supply canal enters a farm, it branches into secondary systems referred to here as ditches, then into branch ditches and drains. In ditches and branch ditches, water flows are lower than in major canals, and intakes of contaminants from agricultural drainage and farm waste are higher. Further, since ditches and branch ditches are often dirt-lined, they are more susceptible to seepage from subsurface flows than cement or gravel-lined primary canals. Although drains are a separate category of canal, we combined them with branch ditches, because the foraging activities are similar in both and the quality of water in branch ditches is comparable to that in many drains.

Foraging methods vary widely according to the items taken and location, and they include the use of trot lines, gill nets, seines, and throw lines. Trot lines are prepared with monofilament line with several bait hooks strung 24 to 36 inches apart. These lines, some reaching 2 miles in length, are left for 2 or 3 days in reservoirs, sloughs, farm sumps, and duck ponds. They are set by boat, by hand, and sometimes through the elaborate contrivance of kites. Gill nets and seines are hand-woven from twine or monofilament line or are made from tennis nets or cotton gin netting. Throw lines are constructed of aluminum beverage cans; monofilament line is spooled around the can and weighted with hooks and sinkers to allow casting.

## Natural resource users

Foragers in the study area can be divided into four categories: those hunting or fishing for sport, the generalists, commercial foragers, and "true foragers." We derived these four types from the texts of interviews, and they represent patterns in foraging practices. Informants discriminated between types of natural-resource users based on their choice of equipment, technique, and location, as well as on what they foraged and what they did with the items they collected.

The first category includes those who are drawn to the mechanics of sporting activities. Costs of the activity, including equipment and travel, are never recovered from the outcome, particularly for those who practice "catch and release." People in this category comply with fish and game laws and thereby exhibit a conservative approach to natural resource use.

Generalists choose methods and equipment according to their outcome and efficiency rather than to be in style. They are prone to combine activities such as dove, rabbit, and squirrel hunting or catfish, carp, striper, and perch fishing in their zeal to succeed.

Commercial foragers include trash fishermen, trappers, and bounty hunters. Economic considerations govern their use of natural resources.

"True foragers" maximize their efforts by collecting large quantities of wildlife. Their efficiency is increased by the collection of nonpreferred species (often in violation of fish and game laws). They may gather a mixture of mammals, fish, shellfish, crayfish, edible plants, birds, and bird eggs in a single trip.

These four types of foragers are further distinguished by their methods. The first, who fishes for game-fish such as black bass, may use a light-weight graphite rod set with light test line to enhance the experience of

Pole-fishing for catfish and bass to feed his family, a fisherman keeps the catch fresh in nets at the water's edge. Fish in such waterways in the central San Joaquin Valley agricultural drainage area have been found to contain high selenium levels, prompting this study of human foraging activities.

fishing. The practice of "catch and release" is geared to the perpetuation of this experience. Generalists select equipment and practices according to their success. If black bass are not biting, they might switch to a pole and fish for catfish. Commercialists' methods, dictated by state fish and game laws, are oriented toward the gross accumulation of a specific item and require capital expenditures for boats, nets, licenses, and the like. True foragers are identified by their selection of nonpreferred game and a mechanistic approach to fishing and hunting. Unlike those of commercialists, these methods are indiscriminate, with less need for capital inputs.

Another characteristic separating the four types of natural resource users is the choice of fishing sites. Those fishing for sport choose only the highest quality water found in the major canals. Generalists fish in standing water in the refuge areas, as well as in rivers and sloughs. They also collect crayfish in irrigated fields. Commercialists collect fish and shellfish in the major canals and reservoirs of the study areas. True foragers collect from nearly every type of water including private impounded water and farm sumps.

## Southeast Asian foraging

Interviews with Southeast Asians revealed their use of several items taken from the drainage area. Respondents reported taking eight types of fish, as well as crayfish, snails, frogs, clams and birds (table 2).

Concerned with quantity of consumption, we attempted in the survey to assess patterns of use. Of the respondents, 64% said they were only interested in getting enough for their families, while the other 36% said they usually gathered enough to sell or trade to others. Almost all of the respondents expressed a knowledge of fish and game laws.

Of the 44 families, 26 indicated that they foraged for recreation; 7 foraged for items that were unavailable through commercial sources; 4 stated that foraging was cheaper than buying food; and 3 said foraging was necessary to provide enough food for their families. None of the respondents reported the use of foraged items for medicinal purposes.

At the time of the survey, there were approximately 8,000 Southeast Asians in Merced County, of which 80% were Hmong and the remaining 20% Mien, Laotian, Vietnamese, and Cambodian. The study revealed that approximately 61% of those interviewed have foraged or currently forage. The total number of foragers from the Southeast Asian community in Merced could be as high as 5,000 individuals.

**TABLE 2. Items reported foraged or eaten by Southeast Asian respondents**

| Item | Number reporting item |
|---|---|
| **Fish:** | |
| Striped bass | 35 |
| Catfish | 20 |
| Carp | 14 |
| Trout | 13 |
| Black bass | 6 |
| Crappie | 4 |
| Blackfish | 2 |
| Sunfish | 1 |
| **Other aquatics:** | |
| Crayfish | 19 |
| Snails | 16 |
| Frogs | 14 |
| Clams | 4 |
| **Birds:** | |
| Pheasants | 13 |
| Ducks (coots) | 9 |
| Quail | 9 |
| Doves | 6 |
| Geese | 2 |
| Bird eggs | 1 |

## Conclusions

One of the major reasons for the survey was to determine the extent to which Southeast Asians as a group forage. They are relatively new to the area and have a history of foraging in their native countries for part of their food. The general feeling was that they might be at more risk than others, because they foraged more and used a wider variety of items.

It was found that the frequency of foraging by all categories of foragers is related to the seasonal availability of food items.

Our survey indicated that only a small portion of the total family diet of Southeast Asians is composed of foraged items. This is most likely the case for all ethnic groups using the drainage area for foraging.

The consensus among the families studied was that foraging is an expensive practice. Part of the reason for continuing was recreation.

Commercial foraging distributes items taken from the drainage area beyond the forager's table. Commercial activities, such as the sale of trash fish, waterfowl, frogs, and shellfish, were practiced by three of the four classes of foragers (generalists, commercialists, and true foragers). Commercial markets for foraged items extend as far as Los Angeles and Seattle.

The need remains to document the quantities and frequencies of contact between foragers and selenium-containing food items. The use of more specific measures such as fish and game citations or hunter/fisher counts maintained by state and federal agencies needs to be explored. Nonetheless, the information obtained in this study has contributed to a more accurate picture of the effect of agricultural drainage on human populations. Our description of natural resource use included an inventory of items frequently taken as well as the context within which foraging activities took place. It also revealed the fact that the variety of user groups far exceeds original estimates. This has established a point of reference for biologists, health officials, and medical toxicologists considering the effect of agricultural drainage on public health.

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