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The Location and Design of Safe and Convenient Park-and-Ride Lots

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16. Abstract

Park-and-ride lots are places where tripmakers may leave their vehicles when changing to a high-occupancy vehicle (HOV) mode. They are most often used by carpool, vanpool, public transit, or subscription bus commuters who drive to these lots because HOV access is inconvenient or not available within walking distances of their homes.

The lots themselves may be specially constructed for this purpose (usually state-owned) or portions of existing parking lots at shopping centers, churches etc. ("joint-use") where an agreement between the owner and the state to formalize the park-and-ride activity has been concluded.

The California Department of Transportation (Caltrans) operates more than 200 owned or joint-use lots. In 1982, Caltrans conducted a questionnaire survey at 37 park-and-ride lots of both types throughout the state. Results of this study and subsequent research confirm previous reports showing that park-and-ride lots constructed along major highways in commuting corridors are well patronized and make a substantial contribution to saving vehicle-miles and related travel costs.

Available data indicate that highest priority should be given to constructing lots more than 20 miles from major employment centers for ridesharing programs, and more than 10 miles from such centers for transit stops. Where possible, lots should be paved, clearly marked, landscaped, lighted, provided with passenger shelters, bike lockers, and public telephones, maintained in a clean condition, and be easily accessible and visible from roads interchanging with the major commuter highway.

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Research Report

THE LOCATION AND DESIGN OF SAFE AND CONVENIENT PARK-AND-RIDE LOTS

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The base maps of Figures 9 - 16 are from the U. S. Geological Survey. The photography is by Michael Aronson.

SUMMARY

This document reports on the location and desirable design features of park-and-ride lots provided as integral elements of urban transportation systems management programs.

Park-and-ride lots are places where tripmakers may leave their vehicles when changing to a high-occupancy (HOV) mode. They are most often used by carpool, vanpool, public transit, or subscription bus commuters who drive to these lots because HOV access is inconvenient or not available within walking distances of their homes. Such lots may be government-constructed and owned, or, by agreement with owners of private parking lots at shopping centers, churches, etc., may be "joint-use" lots.

In this study, data obtained from users of 37 existing lots were analyzed to determine how the utilization and the benefits gained might relate to locational and design characteristics; multiple regression was used. At eight locations where park-and-ride activity had developed spontaneously ("ad hoc parking") in the San Francisco Bay Area, surveys were also conducted, and the data treated in a similar fashion. In addition, personal inspection of a number of lots, their interfaces with the highway system, and their approaches was conducted.

The data from the surveys of parkers proved to show no strong relationships between use of the lot or benefits gained (vehicle-miles saved, numbers of single-car drivers converting to ridesharing) on the one hand, and the locational characteristics or certain design features on the other. However, there are strong indications that the benefits of a lot designed for use by carpoolers and vanpoolers increase with distance from the employment centers, and that priority in investment for future lots should be given to locations

at least 20 miles from employment foci for ridesharing and 10 miles from such centers for transit-related lots.

Basic lot design follows standard procedures for parking facilities anywhere, with a few special features. These include careful siting of entrances and exits in relation to freeway ramps or major highway interchanges; provision of landscaping, lighting, and public telephone to provide a feeling that the lot is being maintained and is secure; and passenger shelters and bike lockers to protect waiting commuters and bicycles, respectively, from adverse weather.

IMPLEMENTATION

This research report will be provided to, and will be included in the training of, planners and engineers involved in the identification and analysis of potential or proposed locations, and in planning, designing and evaluating operational park-and-ride facilities.

Specific conclusions and recommendations will be included in Caltrans' guidelines for the planning and design of the facilities.

1. INTRODUCTION

Park-and-ride lots are places where tripmakers may leave their vehicles when changing to a high occupancy vehicle (HOV) mode. They are most often used by commuters who drive from their homes to the lot, park their cars, and continue to their destinations by carpool, vanpool, public transit, or subscription bus. The park-and-ride lot provides convenient access to transit for those who do not have transit service within walking distance of their homes. For carpoolers and vanpoolers, the park-and-ride lot saves time by providing a common meeting place for all passengers.

Such parking lots are an important component of Transportation Systems Management (TSM) strategies, consideration of which is mandated by urban transportation planning regulations promulgated by the federal government. Promotion of the use of high-occupancy vehicles is one of the basic--and, perhaps, more successful--elements of a TSM program. Park-and-ride lots, in turn, may be important in assuring the success of HOV promotions.

The lots themselves may be unimproved areas adjacent to freeway interchanges, or specially constructed paved parking lots with lighting, landscaping, and passenger shelters. The most important requirement is that the design and location of park-and-ride lots must be oriented towards making them safe and convenient places to park cars.

1.1 Purpose of the Report

The objective of this research was to determine at what kinds of locations along state highways parking lots for use by bus and carpool/vanpool commuters appear to be justified. Existing park-and-ride locations were evaluated, based on user surveys, on-site inspections, and interviews with persons experienced in planning and designing park-and-ride lots. The available data were analyzed, resulting in recommendations for the desirable types of locations and design features of park-and-ride lots.

At this time useful information for park-and-ride planning is becoming more important. The California Department of Transportation (Caltrans) has established more than 200 such lots in various parts of the state during the past five years. One purpose of the data analysis was to evaluate the success of the program so far; another was to provide a basis for future planning. Most of the "easy" or obvious locations for park-and-ride lots have now been developed. Future locations for lot construction must be chosen carefully, especially in view of current tight budget constraints.

The remainder of this first section of the report discusses park-and-ride lots in the context of urban transportation. Section 2 deals with the usage of existing lot locations: first the user survey conducted at 37 lots is described; then ad hoc parking activity at several selected locations is evaluated; the data which were collected from surveys and other sources are examined next to determine which characteristics are associated with successful locations; and the results of this analysis are summarized in the final part of Section 2. Section 3 lists some considerations which should be included in the design of park-and-ride lots. Section 4 summarizes the findings.

This report is intended to complement the information contained in the following reports published by the Caltrans Office of Ridesharing Facilities:

1) "Report of a Survey conducted at 37 Park-and-Ride Facilities in California - Spring 1982" (October 1982), which contains a more detailed cost-benefit analysis based on the survey data;

2) "Design Guidelines for Park-and-Ride Facilities" (March 1982), which gives specific guidelines for the geometric design of parking lots.

1.2 Types of Park-and-Ride Locations

Park-and-ride activity can basically take place at any location where it is possible to park cars for long periods of time, and where either transit service is available or carpools/vanpools pass. The primary focus of this report is on lots constructed by a public agency specifically to accommodate this activity. However, it is important to identify ad hoc parking locations as important indicators of latent demand for formal lots.

1.2.1 State-Constructed Park-and-Ride Lots

Caltrans operates more than 200 park-and-ride lots which were either constructed by it or by other governmental agencies. These lots are on state or local government-owned property. They are usually paved and striped, and have directional signs (Fig. 1). Some lots also include lighting fixtures, landscaping in and around the lot, passenger shelters, and bike lockers.

State-built lots have been limited to locations on government-owned land. Excess state highway right-of-way has often been available at freeway interchanges, which may be ideal locations for HOV interfacing. In urban areas, excess right of way at interchanges was often sold off for development, leaving few available opportunities for lot construction; this has been a problem especially in Southern California.

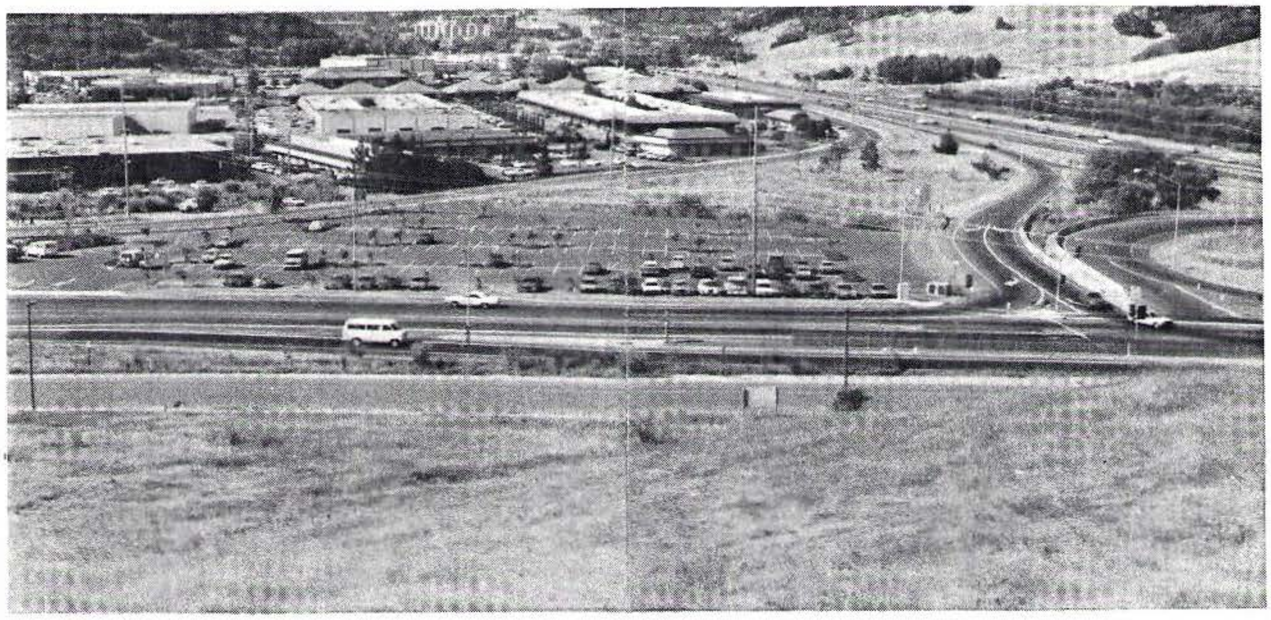


Fig. 1 - Marinwood Park-and-Ride Lot at US 101 and Lucas Valley Road. View south towards San Rafael and San Francisco. Illumination is provided by lights along Lucas Valley Road and the frontage road. Some landscaped islands have been built. Transit service is available at freeway bus pads; the one for northbound buses is behind the trees at the far right.

Fig. 2 - Park-and-Ride Lot Built by Santa Clara County Transit District for Express Bus Lines to San Jose

Transit agencies also build park-and-ride lots. These are similar to state-constructed lots, but are oriented with reference to transit stops or stations (Fig. 2). They tend to be more expensive since they often require the purchase of private land. Major examples are lots adjacent to rail transit stations.

1.2.2 Joint-Use Park-and-Ride Lots

Joint-use lots are existing privately owned parking lots which are designated as park-and-ride lots by a written or verbal agreement between the owners and a government agency. Joint-use lots are usually created at shopping centers (Fig. 3), churches, or schools near freeway interchanges or express bus stops. They can be very successful and require virtually no investment of public funds. The Los Angeles regional park-and-ride program makes extensive use of such lots, and almost all the park-and-ride lots in the San Bernardino Riverside area are privately owned.

Fig. 3 - Joint-Use Park-and-Ride Lot at a Small Shopping Center

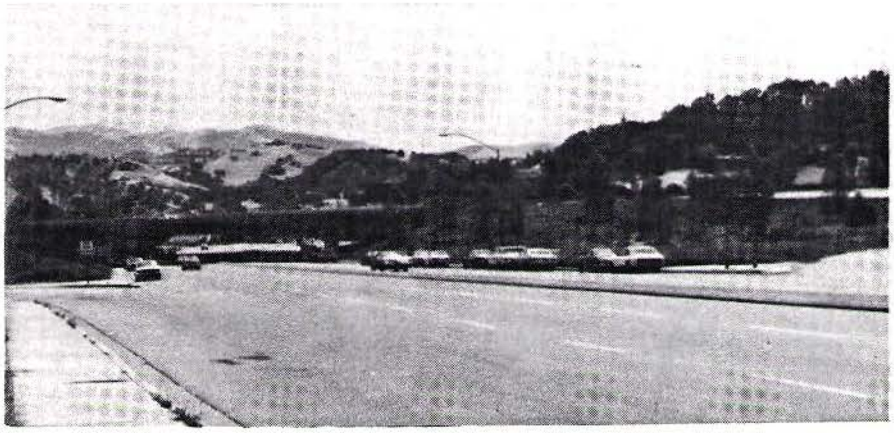
The major problems with joint-use lots are poor locations and questions of permanence. Privately owned lots may be in out-of-the-way places and will not be able to attract users. Parking lots which are not clearly visible from the road, or in areas with crime problems, may be subject to vandalism. So, even if an existing lot is available and near an important interchange, it must be evaluated to ensure that it is a secure and convenient component of a park-and-ride system.

Agreements with private owners, especially oral agreements, are subject to change. A joint-use lot may build up a high level of usage, and a change of ownership or management policy could then close the lot to these users. Business owners often worry about commuters taking up good customer parking places. Actually, park-and-ride seems to help business at some locations because commuters use the nearby stores.

Joint-use lots can be very beneficial, especially where no excess right of way is available on state lands. However, careful evaluation and secure agreements are required if the joint use lots are to be successful.

1.2.3 Ad Hoc Park-and-Ride Locations

Park-and-ride activity occurs in many places within the vicinity of major highways where no official lots exist. Commuters park in shopping center lots, on undeveloped land, or on paved or unpaved shoulders. This activity is especially likely to occur at outer suburban transit stops or adjacent to freeways in residential areas (Fig. 4). It is important to identify these ad hoc locations, as they are an obvious indicator of latent park-and-ride demand.



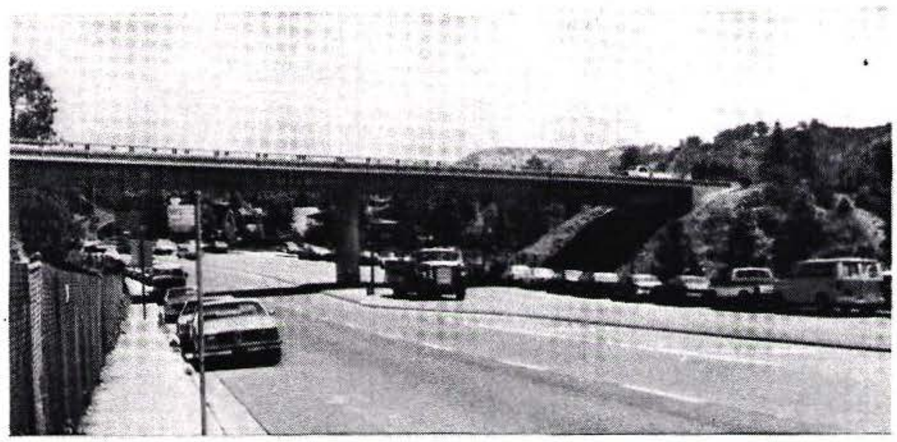


Fig. 4 - Commuter Parking at Interchange of Route 24 and Pleasant Hill Road in Lafayette, 22 Miles East of San Francisco. Vehicles park at curb along Pleasant Hill Road (upper photo) and along frontage road (lower photo).

There are several reasons why it may be desirable to construct off-street parking at such sites. First, ad hoc parking may involve a safety hazard; cars parked at the side of a busy road or next to an interchange could be an obstruction to smooth traffic flow. Commuter parking may also be considered a nuisance even at safe locations; for example, where shopping center lots are used without formal agreements, business owners often complain about such vehicles parking all day and taking up customer spaces.

Prohibiting cars from parking in ad hoc locations, and possibly issuing citations, may serve to discourage ridesharing or transit use. It may be necessary to provide a lot merely to maintain the existing level of park-and-ride activity.

1.3 Benefits of Park-and-Ride Lots

Benefits are realized when commuters leave their cars in park-and-ride lots and continue their trips in HOVs, such as carpools, vanpools, or transit. There are benefits to users and to society as a whole.

User benefits are derived from lower travel costs. Transit users save on vehicle operating costs (mainly fuel and maintenance costs), tolls, and parking fees. Carpoolers and vanpoolers still pay for vehicle operating costs, but the costs are shared among the pool members; toll and parking charges are often reduced or completely eliminated; another benefit is time saved where HOVs are allocated special lanes bypassing bottlenecks at freeway on-ramps or toll plazas.

There are also benefits to society. Fewer vehicle-miles traveled (VMT) mean less fuel consumption and less production of air pollutants. But these impacts of park-and-ride are actually relatively small. Cold engines consume more fuel per mile and pollute more than do warm engines, and there is additional hydrocarbon emission after the engine has been turned off ("hot soak"). Therefore, the number of automobile <u>trips</u> (starts and stops) matters more than the number of vehicle-miles. Park-and-ride decreases the latter, but not the former, because trips are still made to access the HOVs.

High occupancy vehicles make more efficient use of the existing transportation facilities. Relatively small shifts to HOV use can help reduce congestion on highways; the benefits of this may be very high in typical peak period situations in major metropolitan areas, but they are difficult to quantify.

Usually, overall benefits of park-and-ride usage are calculated using vehicle-miles saved by cars left in lots. Average operating-cost-per-mile and fuel-consumption-per-mile factors can be used in such computations. However, vehicle-mile reduction should not be the only criterion for judging the benefits of park-and-ride lots. The less quantifiable benefits can be important and should be included in the total evaluation. For example, the Manzanita lot near Mill Valley on US 101 in Marin County is only 12 miles from San Francisco and, hence, cannot be credited with a large savings in VMT. Yet, the lot keeps 300 cars off a very congested freeway, off the Golden Gate Bridge, and out of downtown San Francisco.

2. USAGE OF FACILITIES

Planning of future park-and-ride facilities should be based on an understanding of how existing facilities are used. This section of the report summarizes and evaluates data collected by Caltrans personnel in the Spring of 1982, and presents conclusions and observations about the characteristics of successful park-and-ride locations.

2.1 Caltrans Survey of Park-and-Ride Facilities

From February to April, 1982, Caltrans surveyed commuters at 37 park-and-ride lots throughout the state, including both state-owned and joint-use lots. Nineteen of the lots are in the San Francisco Bay Area, one is in Bakersfield, nine are in the Los Angeles area, and eight in the San Bernardino area (Figs. 5-7 and Tables 1-3).

The survey involved a questionnaire form handed to persons in each parking lot during morning commute hours. A sample of the form is included in Appendix A. Each respondent was asked to fill out the questionnaire and return it either that morning or in the afternoon when returning to the lot. A tally was kept of vehicles and persons entering and leaving the lot while the form was being distributed.

The survey was designed to answer questions about travel modes and the effectiveness of the park-and-ride program. Respondents were asked to identify the modes they used to travel to the lot and from the lot to their destination, and their usual mode of travel before they began to use the lot. Respondents were also asked whether their driving mileage had increased or decreased since using the lot and, if so, by approximately how many miles per

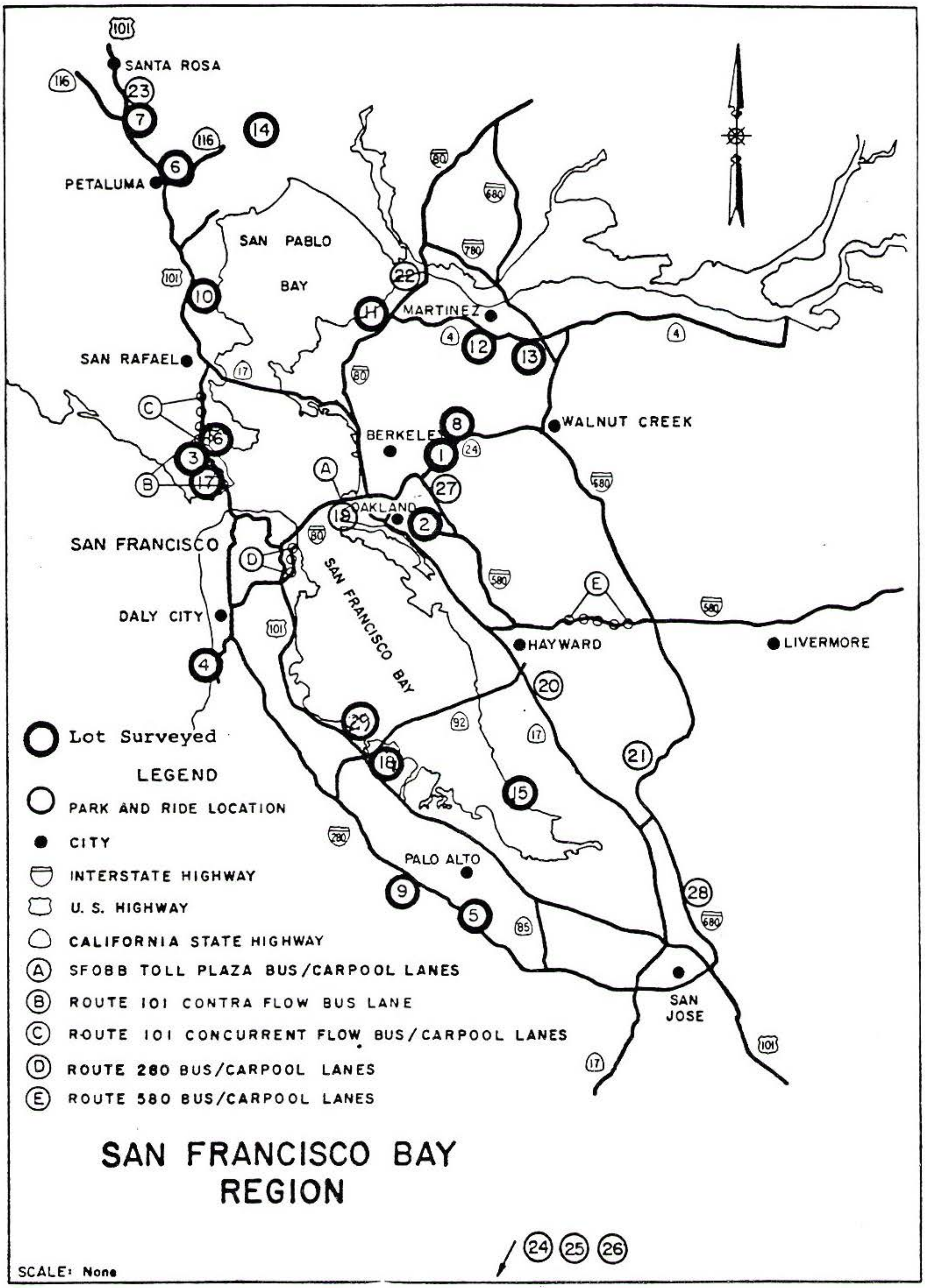


Fig. 5 - Lots Surveyed in the San Francisco Bay Area

TABLE 1 - LIST OF SURVEYED LOTS - SAN FRANCISCO BAY AREA

No.	Location	Highway Interchange	Owner	Notes
1	Orinda	SR 24 @ Gateway Blvd	State	Isolated interchange (Gateway Blvd not constructed).
2	Oakland	I 580 @ Fruitvale Ave	State	Airspace under freeway; also used by shoppers.
3	Manzanita	US 101 @ SR 1	State	Airspace; major transit stop.
4	Pacifica	SR 1 @ Linda Mar Blvd	State	Mostly used for transit access.
5	Los Altos	I 280 @ Page Mill Rd	State	Gravel lot.
6	Petaluma	US 101 @ SR 116 E	State	Recently expanded.
7	Cotati	US 101 @ SR 116 W	State	Recently expanded; circuitous access.
8	Orinda	Near SR 24 @ Camino Pablo	Private	Abandoned since survey.
9	Woodside	I-280 @ Woodside Blvd	State	
10	Marinwood	US 101 @ Lucas Valley Rd	State	
11	Hercules	I 80 @ Willow Ave	State	
12	Martinez	SR 4 @ Alhambra Ave	City	Gravel lot.
13	Pacheco	SR 4 @ Pacheco Blvd	State	
14	Schellville	SR 121 @ SR 116	State	Paved island in center of at-grade intersection.
15	Dumbarton Bridge	SR 84 @ Toll Plaza	State	
16	Mill Valley	US 101 @ Seminary Drive	State	Gravel lot along both sides of freeway; serves bus pads.
17	Sausalito	US 101 @ Spencer Ave	State	Two gravel lots; serve bus pads.
18	San Mateo	US 101 @ SR 92	State	Abandoned since survey because of interchange reconstruction.
29	San Mateo	US 101 @ 3rd Ave	State	Former maintenance yard.

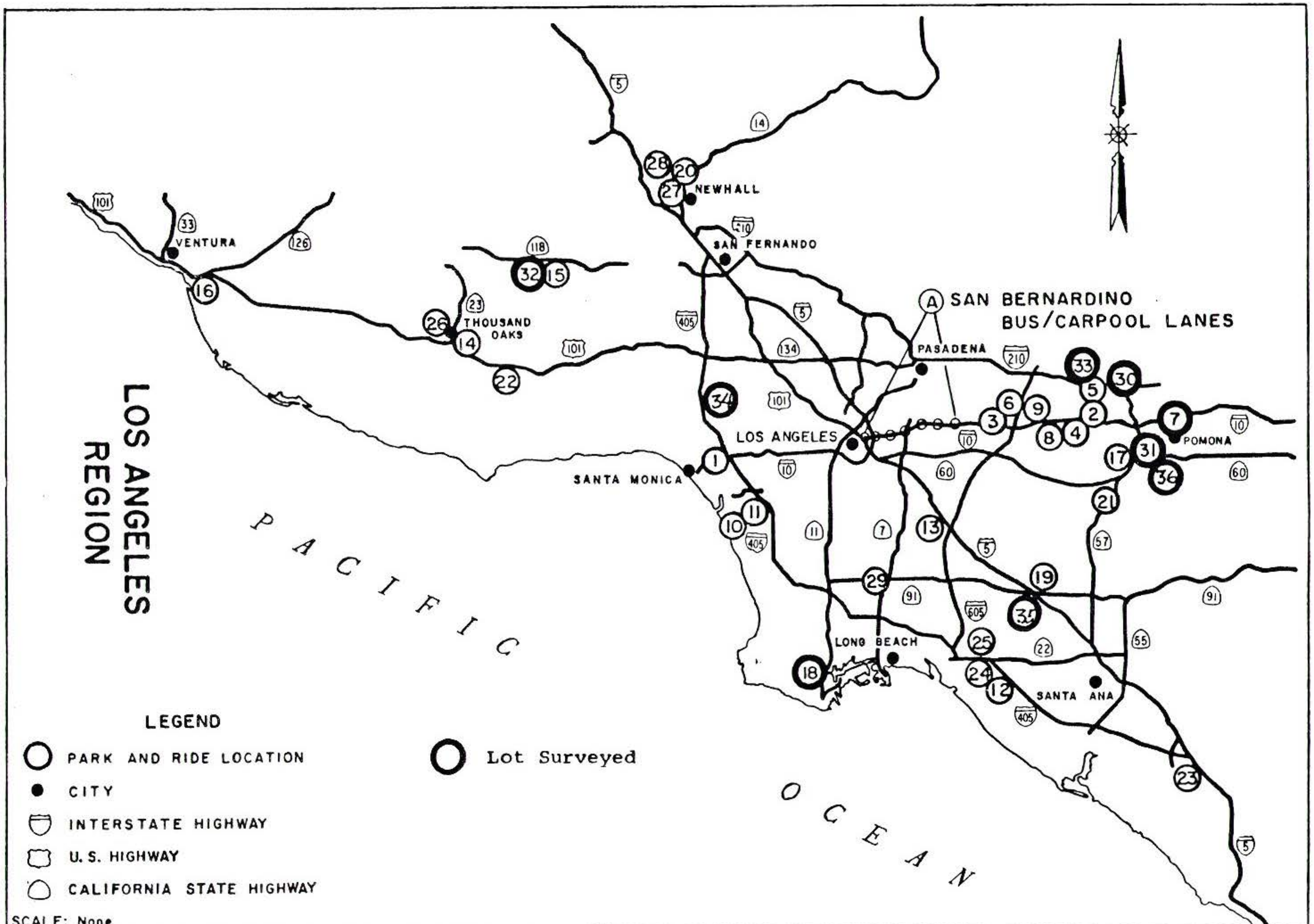


Fig. 6 - Lots Surveyed in the Los Angeles Area

TABLE 2 - LIST OF SURVEYED LOTS - LOS ANGELES AREA

No.	Location	Highway Interchange	Owner	Notes
7	Pomona	I 10 @ Carey Ave	State	Airspace.
18	San Pedro	SR 11 @ Gaffey St	State	Airspace; set up to serve express bus stop.
30	Glendora	I 210 @ Lone Hill Rd	State	Airspace.
31	Diamond Bar	SR 60 @ Diamond Bar Blvd	State	Near intersection of SR 60 and SR 57.
32	Simi Valley	SR 118 @ Stearns St	State	
33	Glendora	I 210 @ Grand Ave	State	
34	Sherman Oaks	I 405 @ Rimerton Rd	State	Newly opened at time of survey.
35	Fullerton	SR 91 @ Magnolia Blvd	State	Adjacent to large transit lot.
36	Pomona	SR 60 @ Carey Ave	State	Newly opened at time of survey.

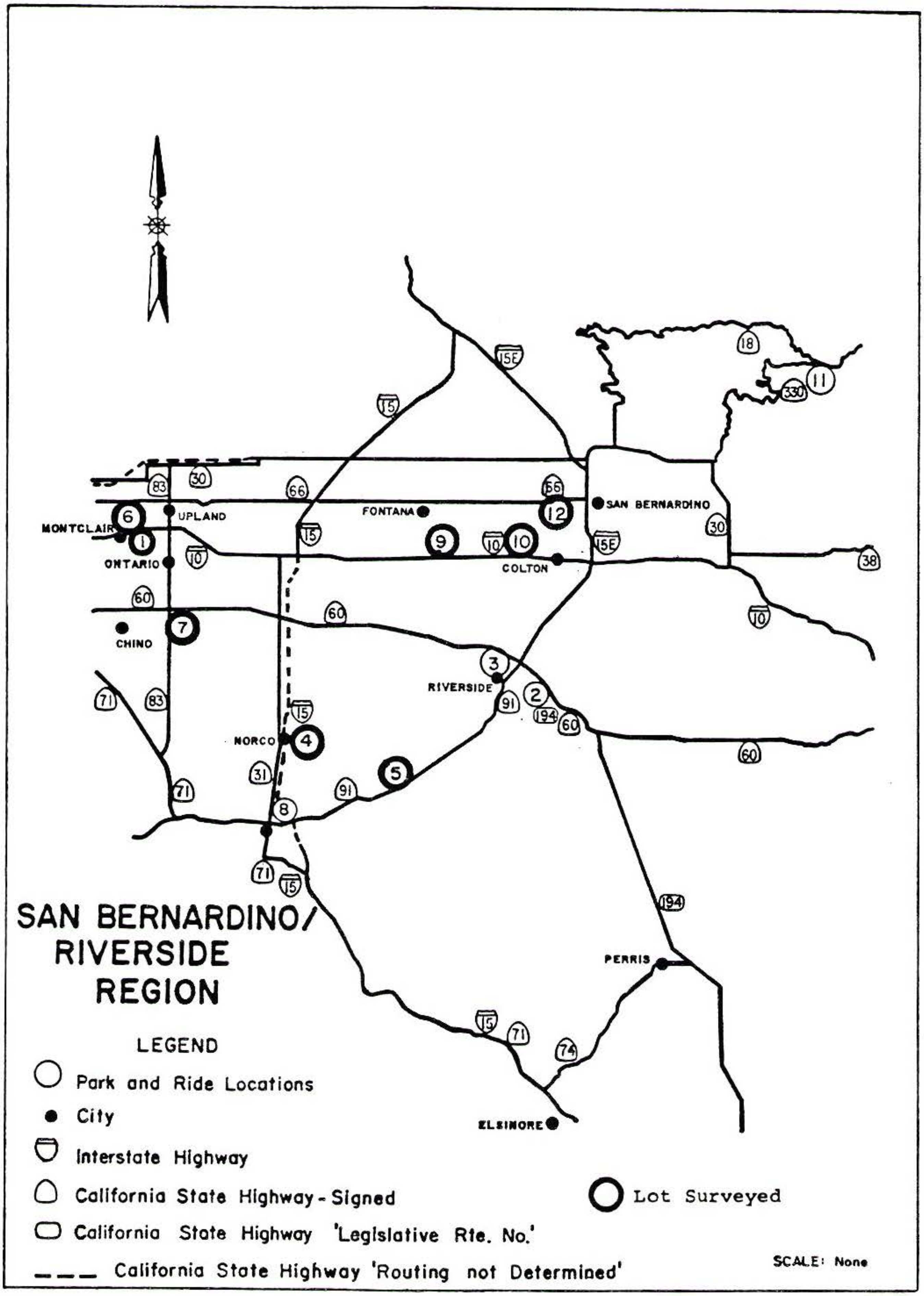


Fig. 7 - Lots Surveyed in the San Bernardino-Riverside Area

TABLE 3 - LIST OF SURVEYED LOTS - SAN BERNARDINO AREA

No.	Location	Highway Interchange	Owner	Notes
1	Ontario	I 10 @ Mountain Ave	Private	Bowling lanes.
4	Norco	SR 31 @ City Hall	City	Designated stalls at city hall.
5	Riverside	SR 91 @ Tyler St.	Private	Tyler Mall shopping center.
6	Montclair	I 10 @ Monte Vista Ave	Private	Montclair Plaza shopping center.
7	Ontario	SR 60 @ Euclid Ave	Private	K-Mart parking lot.
9	Fontana	I 10 @ Sierra Ave	Private	Hospital parking lot.
10	Bloomington	I 10 @ Cedar Ave	County	
12	Rialto	SR 66	Private	Bowling lanes.

week. The last question requested users to indicate the extent to which the availability of the lot influenced their decision to use their present commuting mode.

Questionnaires were handed to 91 percent of all persons counted as entering the lots; 75 percent of these were returned, and of these 88 percent were filled out completely. (To be considered complete, the form had to include an estimate of the change in weekly vehicle miles traveled.) These complete questionnaires account for about 60 percent of all the users of the surveyed lots.

2.1.1 Survey Data

Table 4 displays the number of vehicles and persons observed using each lot. The number of vehicles is based on observations of midday lot occupancies and may not be the same as the number counted during the morning surveys. Some of the lots were surveyed when they were relatively new, and patronage has increased since the survey was conducted. The most recently available observations were used whenever possible.

The number of persons is based on the tallies of all persons entering and leaving the lot during the morning survey period. These tallies were difficult to make at some lots and are therefore of questionable accuracy. They do, however, provide an adequate basis for expanding survey results to represent the total population of lot users.

TABLE 4 - NUMBER OF VEHICLES AND PERSONS AT PARK-AND-RIDE LOTS

Lot Number	Location	Number of Stalls*	Number of Vehicles*	Number of Persons	Complete Responses
San Francisco Bay Area (District 4)					
1	Orinda-Gateway Blvd	110	11	36	21
2	Oakland-Fruitvale Ave	164	98(128)	147	85
3	Manzanita-US 101	290	303	365	239
4	Pacifica-Linda Mar	200	86	263	107
5	Los Altos-Page Mill Rd	28	22	27	23
6	Petaluma	47	63	102	53
7	Cotati	186(60)	63 (41)	61	43
8	Orinda	10	4	8	5
9	Woodside	31	28	42	26
10	Marinwood-Lucas Valley Rd	212	45 (38)	49	28
11	Hercules-Willow Rd	36	31	57	36
12	Martinez-Alhambra Rd	21	22 (20)	34	14
13	Pacheco-Pacheco Blvd	40	22 (14)	27	18
14	Schellville	47	53 (48)	77	46
15	Dumbarton Bridge	37	10 (7)	10	7
16	Mill Valley-Seminary Dr	100	98	219	117
17	Sausalito-Spencer Ave	45	50 (34)	67	42
18	San Mateo-Route 92	30	26	30	21
29	San Mateo-3rd Ave	18	13 (8)	9	7
Bakersfield (District 6)					
5	Bakersfield	15	13	17	11
Los Angeles Area (District 7)					
7	Pomona-Route 10	58	81	(na)	78
18	San Pedro	106	92	(na)	57
30	Glendora-Lone Hill	77	65	(na)	61
31	Diamond Bar	150	166	(na)	192
32	Simi Valley-Stearns	55	53 (47)	99	53
33	Glendora-Grand	110	57	(na)	33
34	Sherman Oaks	30	9 (6)	13	6
35	Fullerton-Magnolia	100	81 (70)	100	49
36	Pomona-Route 60	150	57 (44)	59	36
San Bernardino (District 8)					
1	Ontario-Route 10	30	83	156	108
4	Norco	6	13	37	16
5	Riverside-Tyler Mall	50	173	287	190
6	Montclair Plaza	100	106	191	113
7	Ontario-Euclid Ave	30	37	72	50
9	Fontana-Sierra Ave	20	10	27	6
10	Bloomington-Cedar Ave	20	34	68	40
12	Rialto	41	5	8	6

* Number at time of survey is shown in parentheses if different from the most recent available number.

2.1.2 Access Modes

The access modes for all park-and-ride lot users is shown in Table 5. There were no significant differences between individual lots, although a few had higher incidences of walking access and "kiss-and-ride" access. These lots were generally transit-oriented and located in residential areas.

TABLE 5 - ACCESS MODES TO PARK-AND-RIDE LOTS

Access Mode	Number	Percent
Drove to lot, parked car	1520	66.2
Drove to lot, did not park car	150	6.5
Carpooled to lot, parked car	242	10.5
Carpooled to lot, did not park car	124	5.4
Vanpooled to lot	69	3.0
Was dropped off (kiss-and-ride)	101	4.4
Arrived by bus	17	0.7
Bicycled	8	0.3
Walked	56	2.4
Other	10	0.4
Total respondents	2297	100.0

The response to this question may underrepresent carpool and vanpool drivers. Although survey personnel tried to include all such drivers in the sample, they were not instructed to include persons or vehicles which picked up passengers outside the lot.

2.1.3 Mode of Travel to Destination

Table 6 shows the travel modes of survey respondents in each lot. Some park-and-ride lots are oriented to transit connections, usually an express bus service to a central business district or other major employment center.

TABLE 6 - MODES USED TO DESTINATION

Lot Number	Location	Number of Respondents	Percent Using Carpool	Vanpool	Transit	Other
—	**All surveyed lots**	**2299**	**47**	**22**	**26**	**6**
San Francisco Bay Area (Dist. 4)		**1064**	**45**	**10**	**39**	**6**
1	Orinda-Gateway Blvd	22	100	0	0	0
2	Oakland-Fruitvale Ave	97	22	26	46	6
3	Manzanita-US 101	271	37	5	52	5
4	Pacifica-Linda Mar	122	5	2	93	0
5	Los Altos-Page Mill Rd	23	61	35	0	4
6	Petaluma	66	86	14	0	0
7	Cotati	52	56	40	2	2
8	Orinda	6	100	0	0	0
9	Woodside	31	84	13	0	3
10	Marinwood-Lucas Valley Rd	31	52	10	35	3
11	Hercules-Willow Rd	42	74	19	5	2
12	Martinez-Alhambra Rd	14	93	7	0	0
13	Pacheco-Pacheco Blvd	19	100	0	0	0
14	Schellville	53	51	9	6	34
15	Dumbarton Bridge	7	100	0	0	0
16	Mill Valley-Seminary Dr	129	29	5	52	14
17	Sausalito-Spencer Ave	46	37	0	52	11
18	San Mateo-Route 92	24	96	0	4	0
29	San Mateo-3rd Ave	9	11	0	78	11
Bakersfield (District 6)						
5	Bakersfield	12	100	0	0	0
Los Angeles Area (District 7)		**651**	**59**	**30**	**11**	**0**
7	Pomona-Route 10	87	30	52	18	0
18	San Pedro	70	14	11	74	0
30	Glendora-Lone Hill	76	74	26	0	0
31	Diamond Bar	215	69	30	0	1
32	Simi Valley-Stearns	59	61	39	0	0
33	Glendora-Grand	42	98	2	0	0
34	Sherman Oaks	6	100	0	0	0
35	Fullerton-Magnolia	54	37	57	6	0
36	Pomona-Route 60	42	88	12	0	0
San Bernardino (District 8)		**572**	**37**	**35**	**17**	**11**
1	Ontario-Route 10	118	73	25	0	2
4	Norco	16	50	19	0	31
5	Riverside-Tyler Mall	205	25	44	4	27
6	Montclair Plaza	119	13	11	76	1
7	Ontario-Euclid Ave	59	46	54	0	0
9	Fontana-Sierra Ave	7	86	14	0	0
10	Bloomington-Cedar Ave	41	39	54	5	2
12	Rialto	7	0	100	0	0

However, these transit-oriented lots still serve a significant number of carpoolers and vanpoolers.[1] Other parking lots are used only for ridesharing.

The "other" classification often refers to a subscription bus or a company-owned vehicle. Subscription buses were not separated from other modes in the survey, and may have been considered to be transit or vanpools by some respondents.

The results from this question were compared to modal percentages from the tallies of persons leaving each lot (Appendix B). In most cases survey results agree with the observations, although carpool users were often undersampled (probably attributable to missing drivers in the survey). The largest discrepancies arose from the above-mentioned problem of classifying subscription buses, and from persons who drove out of the lot alone; the latter group might have been dropping off passengers, in which case they should not have been counted at all, or they perhaps intended to park in the lot but found that they had missed their connection to an HOV.

2.1.4 Previous Mode of Travel

Respondents were asked to identify the mode by which they traveled to their destination before using the park-and-ride lot. The results are shown in Table 7. About one half of the respondents drove alone before using the lot; 45 percent already had been using ridesharing or transit, and the remaining five percent had not made that particular trip in the past.

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[1]The Bay Area Rapid Transit (BART) District has also experienced use of its suburban station lots for pool vehicle meeting.

TABLE 7 - PREVIOUS TRAVEL MODES FOR PARK-AND-RIDE LOT USERS

Previous Mode	Number	Percent
Drove Alone	1119	49.0
Public Transit	312	13.7
Carpool	590	25.8
Vanpool	97	4.2
Motorcycle	12	0.5
Other	49	2.1
No such trip	107	4.7
Total	2286	100.0

2.1.5 Changes in Driving Mileage

Respondents were asked whether their mileage as drivers had changed since using the park-and-ride lot. Seventy percent felt that the lot had enabled them to decrease their driving mileage, while 25 percent believed that the lot had had no effect. Only five percent reported an increase in driving mileage. There was considerable variation in these percentages at some lots (first three numerical columns of Table 8).

The responses to this question are broken down by previous mode of travel in Table 9. Persons who drove alone prior to using the park-and-ride lot felt strongly (88 percent) that the lot had helped them decrease their mileage. Those who already carpooled or vanpooled were more likely to say that the lot had no effect on their driving mileage. It is probable that many of these persons were already meeting their pools at these locations before the lots were built. Sixteen percent of previous transit users, most of whom still use transit, thought that their mileage had increased since they began using the lot. This may be attributed to changes in bus route and stop locations over time, or to users who stopped using buses all the way from their homes because

TABLE 8 - CHANGES IN MILES TRAVELED SINCE USING PARK-AND-RIDE

Lot Number	Location	Percent of Respondents Who Reported Driving			Mean Weekly VMT Reduced	Distance to Job Centers (Miles)
		Less	Same	More		
—	**All surveyed lots**	**70**	**25**	**5**	**121.5**	**28**
San Francisco Bay Area (District 4)		**64**	**30**	**6**	**71.4**	**25**
1	Orinda-Gateway Blvd	87	9	4	77.1	16
2	Oakland-Fruitvale Ave	64	23	13	51.4	13
3	Manzanita-US 101	63	28	9	47.8	12
4	Pacifica-Linda Mar	65	30	5	65.3	18
5	Los Altos-Page Mill Rd	91	9	0	216.4	40
6	Petaluma	68	29	3	118.7	39
7	Cotati	54	37	10	89.7	48
8	Orinda	80	20	0	42.0	19
9	Woodside	80	20	0	110.9	34
10	Marinwood-Lucas Valley Rd	71	26	3	102.6	23
11	Hercules-Willow Rd	61	39	0	54.9	25
12	Martinez-Alhambra Rd	71	29	0	78.6	35
13	Pacheco-Pacheco Blvd	74	26	0	96.5	31
14	Schellville	58	38	4	133.8	42
15	Dumbarton Bridge	86	14	0	88.0	19
16	Mill Valley-Seminary Dr	56	39	5	50.3	13
17	Sausalito-Spencer Ave	57	32	11	43.8	10
18	San Mateo-Route 92	67	29	4	93.1	19
29	San Mateo-3rd Ave	33	56	11	17.4	17
Bakersfield (District 6)						
5	Bakersfield	42	58	0	5.1	(na)
Los Angeles Area (District 7)		**73**	**23**	**4**	**127.3**	**26**
7	Pomona-Route 10	71	26	3	121.9	26
18	San Pedro	72	27	1	120.6	27
30	Glendora-Lone Hill	74	17	9	101.6	27
31	Diamond Bar	77	20	3	142.6	21
32	Simi Valley-Stearns	79	16	5	163.4	37
33	Glendora-Grand	69	31	0	87.6	27
34	Sherman Oaks	100	0	0	98.3	18
35	Fullerton-Magnolia	60	33	7	104.0	23
36	Pomona-Route 60	67	31	2	136.8	25
San Bernardino (District 8)		**77**	**18**	**5**	**208.0**	**40**
1	Ontario-Route 10	80	17	3	164.2	31
4	Norco	88	13	0	154.7	38
5	Riverside-Tyler Mall	82	14	4	267.3	41
6	Montclair Plaza	68	27	5	174.0	30
7	Ontario-Euclid Ave	70	20	10	145.6	32
9	Fontana-Sierra Ave	71	29	0	207.1	46
10	Bloomington-Cedar Ave	78	17	5	183.1	48
12	Rialto	100	0	0	540.0	53

driving to the lot was more convenient. A plurality of transit users (44 percent) reported no change in their driving mileage.

TABLE 9 - CHANGES IN DRIVING MILEAGE, BY PREVIOUS MODE

Travel Mode Prior to Using Park-and-Ride Lot*	Percent of Respondents who Indicated		
	Decrease	No Change	Increase
Drove alone (1107)	88	9	3
Public transit (308)	40	44	16
Carpool (581)	63	33	4
Vanpool (95)	43	50	7
Motorcycle (12)	100	0	0
Other (49)	39	55	6
No such trip (101)	Answers not relevant		

* The numbers of respondents are in parentheses.

Respondents were also asked to estimate the number of miles they saved as drivers by using the park-and-ride lots. The answers were estimated on the spot and probably are not very accurate. However, they do seem to relate consistently to the distance between the lot and the major job location. They also represent the users' perceptions of their benefits in reduced driving which they gain from using the park-and-ride lot. Perceived VMT savings are not as useful as actual VMT savings for exact calculations of benefits, but they are helpful in understanding users' mode choices.

The average weekly vehicle-miles saved per user were calculated for each lot. If a user indicated an increase in mileage, this was included in the calculations as a negative savings. The results are shown in the last two columns of Table 8 (page 24). Only respondents who gave a numerical answer to this question are included--about 60 percent of all lot users.

Section 2.3 includes further analysis of vehicle-mile savings and the associated benefits.

2.1.6 Influence of Park-and-Ride Lots

Respondents were asked how much influence the availability of a park-and-ride facility had on their decision to use ridesharing or transit. The percentages for each response are shown in Table 10. A slight majority of users were highly or completely influenced by the availability of park-and-ride facilities, except in the Los Angeles area. There were several lots where a plurality of respondents indicated that they were completely influenced or where a very large plurality reported that they were completely or highly influenced. These lots are usually oriented towards an express bus service.

The parking lots where a large number of respondents indicated that the lot had no influence on their decision do not have good transit service, if any at all. Several of these lots are used by a significant number of persons who parked in the general vicinity before the lot was built (e.g., lots in Cotati, Schellville, and Pacheco in District 4). It would be expected that these people would not attribute their decision to the existence of a parking lot, since they made their decisions before the lot was built.

Breaking the responses down by mode (Table 11) confirms that transit passengers are much more influenced by park-and-ride availability than are carpoolers and vanpoolers. This was especially true in Los Angeles and San Bernardino, where 54 percent and 50 percent of transit users, respectively, stated that their decisions to use transit were <u>completely</u> influenced by the availability of a park-and-ride lot. In these areas, new express bus service became available in conjunction with new lots, thus attracting persons who previously had no access to transit. In the Bay Area, much of the commuting population lives within walking distance of good transit service, so park-and-ride is not as important a factor in mode choice decisions.

TABLE 10 - INFLUENCE OF PARK-AND-RIDE LOT AVAILABILITY ON THE DECISION TO RIDESHARE OR TO USE TRANSIT

Lot Number	Location	Degree of Influence			
		None	Partial	High	Complete
—	**All surveyed lots**	**25%**	**23%**	**31%**	**21%**
San Francisco Bay Area (District 4)		**25**	**22**	**34**	**19**
1	Orinda-Gateway Blvd	9	27	50	14
2	Oakland-Fruitvale Ave	20	10	34	36
3	Manzanita-US 101	19	23	40	18
4	Pacifica-Linda Mar	24	14	38	24
5	Los Altos-Page Mill Rd	8	29	42	21
6	Petaluma	28	32	27	13
7	Cotati	36	21	34	9
8	Orinda	0	33	33	33
9	Woodside	7	62	28	3
10	Marinwood-Lucas Valley Rd	28	21	34	17
11	Hercules-Willow Rd	47	18	18	18
12	Martinez-Alhambra Rd	29	43	7	21
13	Pacheco-Pacheco Blvd	50	33	6	11
14	Schellville	42	12	34	12
15	Dumbarton Bridge	0	57	43	0
16	Mill Valley-Seminary Dr	29	18	33	20
17	Sausalito-Spencer Ave	27	20	29	24
18	San Mateo-Route 92	27	32	32	9
29	San Mateo-3rd Ave	14	43	14	29
Bakersfield (District 6)					
5	Bakersfield	33	0	42	25
Los Angeles Area (District 7)		**28**	**24**	**28**	**20**
7	Pomona-Route 10	17	21	39	23
18	San Pedro	8	12	26	54
30	Glendora-Lone Hill	27	39	20	14
31	Diamond Bar	32	24	26	18
32	Simi Valley-Stearns	41	29	26	4
33	Glendora-Grand	40	19	24	17
34	Sherman Oaks	14	43	29	14
35	Fullerton-Magnolia	31	15	33	21
36	Pomona-Route 60	32	24	34	11
San Bernardino (District 8)		**21**	**25**	**31**	**24**
1	Ontario-Route 10	23	32	32	13
4	Norco	38	19	6	38
5	Riverside-Tyler Mall	17	26	35	22
6	Montclair Plaza	9	10	33	47
7	Ontario-Euclid Ave	37	31	20	12
9	Fontana-Sierra Ave	57	29	14	0
10	Bloomington-Cedar Ave	27	34	29	10
12	Rialto	29	14	0	57

Note: The highest percentage in each row is underlined.

TABLE 11 - INFLUENCE OF PARK-AND-RIDE LOT AVAILABILITY, BY MODE

Mode	Degree of Influence			
	None	Partial	High	Complete
Carpool/Vanpool Users	**27%**	**28%**	**29%**	**16%**
San Francisco	25	28	30	16
Los Angeles	30	26	28	16
San Bernardino	25	31	30	14
Transit users	**19**	**13**	**36**	**32**
San Francisco	25	14	38	23
Los Angeles	6	10	30	54
San Bernardino	10	8	32	50

There is some flexibility in the locations where ridesharers arrange the meeting places for carpools and vanpools, so park-and-ride lots are usually more of a convenience than a necessity. Still, a plurality of carpoolers and vanpoolers were highly influenced in their decisions to rideshare by the availability of the lot.

Table 12 shows to what extent present ridesharers credited the availability of the lot for their decision to use carpools or vanpools, stratified by mode of commuting before the lot was available. A majority of those who switched from driving alone reported being influenced by the lot in making this change. About one third of those who were already in carpools and vanpools were highly or completely influenced by the lot. These findings indicate that park-and-ride lots help existing ridesharing arrangements to continue, as well as attracting new persons to ridesharing. Several of the survey comments make the same point.

TABLE 12 - INFLUENCE OF PARK-AND-RIDE LOT AVAILABILITY, BY PREVIOUS MODE OF TRAVEL

Previous Mode	Degree of Influence among Ridesharers			
	None	Partial	High	Complete
Drove alone	16%	30%	34%	20%
Carpool	42	27	23	8
Vanpool	47	19	28	7
Transit	25	20	34	21
Motorcycle	20	40	30	10
Other	40	40	10	10
No such trip	21	26	32	21
All modes	27	28	30	15

The extent to which persons were influenced by the availability of park-and-ride facilities should correlate with the amount of benefits which they believed they would gain by using the facilities; those who expect to save most in mileage and costs ought to have reported that a lot's availability influenced them strongly to use it. The perceived VMT saved are compared to the perceived importance of the lot in Table 13. A clear pattern is evident for transit users; the average VMT saved increases with the increase in the influence exerted by the availability of the lot. Carpool and vanpool riders who were influenced at all by the lot all reported somewhat similar VMT savings; those not influenced had smaller VMT reductions.

2.1.7 Changes in Mode

The most important objective of a park-and-ride program is to attract commuters who previously drove alone to ridesharing or transit. There are, of course, secondary benefits to persons already ridesharing or using transit by the provision of a secure and convenient parking area.

TABLE 13 - MEAN WEEKLY VEHICLE-MILE REDUCTIONS COMPARED TO DEGREE OF INFLUENCE OF PARK-AND-RIDE LOT AVAILABILITY

Present Mode	Mean Weekly VMT Reductions by Users Reporting Degree of Influence to Be			
	None	Partial	High	Complete
Carpool or Vanpool	86	148	147	139
Transit	40	98	108	152

The changes in mode for those commuters who began to use park-and-ride lots are shown in Table 14. Almost half of all the users previously drove alone, which indicates a high degree of success in the lot construction program; of these, the majority switched to carpools. Another third (the underlined numbers in Table 14) were already using HOVs and did not change mode when the lots became available. Five percent switched from carpools to vanpools, another desirable mode change. Of those not commuting in the area before, the majority became transit users.

TABLE 14 - TRAVEL MODES BETWEEN LOT AND WORK PLACE BEFORE AND AFTER USING PARK-AND-RIDE LOT (NUMBER OF ALL SURVEY RESPONDENTS)

Previous Mode	Present Mode				
	Carpool	Vanpool	Transit	Other	Total
Drove alone	572	244	223	75	1114
Carpool	<u>407</u>	108	50	25	590
Vanpool	7	<u>84</u>	3	2	96
Transit	45	48	<u>213</u>	5	311
Other	12	5	30	14	61
No such trip	25	11	62	8	106
All respondents	1068	500	581	129	2278

Note: Underlined figures indicate no mode change.

In order to determine more specifically which type of lot is successful in persuading solo drivers to switch to an HOV mode, the surveyed lots have been ranked in Table 15 by the percentage of users who previously drove alone. The lots at the top of the table have been most successful, while those at the bottom are mostly serving people who were already ridesharing or using transit. The three lots at the top of Table 15 are all small, and the percentages shown are based on survey responses from only six or seven users. While most of these users are new to ridesharing, the total benefit from these lots is small. The Orinda-Gateway Blvd. lot also has a high percentage of new carpoolers, but it is underutilized because of its poor location, operating at less than 20 percent of its capacity.

In Southern California, transit lines have attracted high percentages of increased patronage at some park-and-ride lot locations because these express bus services had recently been inaugurated. On the other hand, express transit lines in the San Francisco Bay Area were well established and had already attracted a large ridership before the lots were built; hence, the <u>percentages</u> of ex-drivers on transit at such lots as Manzanita, Mill Valley, or Pacifica are lower than those at San Pedro, Montclair Plaza, and Pomona-Route 10, even though the actual numbers of persons involved are of the same order of magnitude.

Two lots near the bottom of the list--Schellville and Cotati--were built at interchanges where large numbers of vehicles had parked "ad hoc" previously (50 and 100 respectively). Again, the numbers of persons who had previously driven alone and who changed to ridesharing are as large here as at some lots which, in Table 15, show larger percentages of ridesharers being converted from driving alone.

TABLE 15 - PERCENT OF PARK-AND-RIDE LOT USERS WHO PREVIOUSLY DROVE ALONE: TOTAL, AND BY RIDESHARE MODE

Dist.	Lot Location[a]	Percent Who Drove Alone	Percent Who Drove Alone of All Users of		
			Carpool	Vanpool	Transit
	All surveyed lots	**49**	**54**	**49**	**38**
4	San Francisco District	43	51	46	30
7	Los Angeles District	52	54	45	65
8	San Bernardino District	57	61	54	54
7	Sherman Oaks (13)	86	83	d	d
8	Rialto (8)	86	d	86	d
4	Orinda (8)	83	83	d	d
4	Orinda-Gateway Blvd (36)	83	82	d	d
8	Norco (37)	75	100	c	d
7	San Pedro (71[b])	63	50	63	65
4	Marinwood (49)	61	75	c	45
8	Ontario-Route 10 (156)	61	66	43	d
8	Riverside-Tyler Mall (287)	60	59	64	63
4	Petaluma (102)	58	64	c	d
7	Diamond Bar (216[b])	58	61	52	d
8	Fontana-Sierra Ave (27)	57	c	c	d
7	Pomona-Route 60 (59)	55	54	c	d
8	Montclair Plaza (191)	53	33	69	54
4	Sausalito-Spencer Ave (67)	52	65	d	39
4	Los Altos-Page Mill Rd (27)	52	50	63	d
4	San Mateo-Norfolk (30)	50	52	d	c
4	Martinez-Alhambra Rd (34)	50	54	c	d
7	Glendora-Lone Hill (79b)	49	50	45	d
7	Simi Valley-Stearns (99)	47	39	61	d
7	Fullerton-Magnolia (100)	46	47	43	c
7	Pomoma-Route 10 (87b)	45	65	27	63
4	Pacheco-Pacheco Blvd (27)	44	44	d	d
8	Ontario-Euclid Ave (72)	44	48	41	d
8	Bloomington-Cedar Ave (68)	44	75	27	c
4	Woodside (42)	43	48	c	d
4	Hercules-Willow Ave (57)	43	52	c	d
4	Dumbarton Bridge (10)	43	c	d	d
4	Oakland-Fruitvale Ave (147)	41	48	64	16
4	Manzanita-US 101 (365)	39	50	79	27
4	Mill Valley-Seminary Dr (219)	38	43	c	29
4	Pacifica-Linda Mar (263)	37	c	c	36
7	Glendora-Grand (42[b])	36	37	c	d
4	Schellville (77)	35	27	c	c
4	Cotati (61)	33	24	43	c
4	San Mateo-3rd Ave (9)	25	c	d	c

Notes: a. Numbers in parentheses are number of lot users observed (from Table 4), except those marked otherwise.
b. Number of surveys returned; number of lot users not available.
c. Less than five responses; percentages not meaningful.
d. No pooling activity or no transit service at this lot.

2.2 Survey of Ad Hoc Park-and-Ride Locations

The Caltrans survey included only officially designated park-and-ride lots. A significant amount of ad hoc park-and-ride activity also occurs at unofficial locations, and it was considered desirable to obtain information about this. Fortunately, a survey of such parking in the San Francisco Bay Area was carried out by personnel from the Caltrans District 4 office between January and May 1982. Several of the more popular sites included in this survey were selected for analysis.

The survey was conducted by leaving postage-paid questionnaires on the windshields of each vehicle parked at an ad hoc park-and-ride location. Respondents were asked to identify their trip origin by nearest intersection and the city of their destination, which travel mode they used to the destination from the parking location, and whether they thought that off-street parking should be provided there. A sample questionnaire is found in Appendix C.

2.2.1 Survey Locations

The sites chosen for analysis (Figure 8 and Table 16) represent a variety of ad hoc park-and-ride situations. The lots in Aptos, Scotts Valley, and El Cerrito have since been designated as joint-use lots under agreements with the property owners. The site in Novato was surveyed when commuters were parking along the side of the road; the state has now constructed a lot there. One hundred vehicles are parked in legal curbside spaces around the interchange at the Lafayette location. In Petaluma and Mill Valley, vehicles park on unpaved shoulders. The survey response rates are tabulated in the first two numerical columns of Table 17; all vehicles at each location received questionnaires.

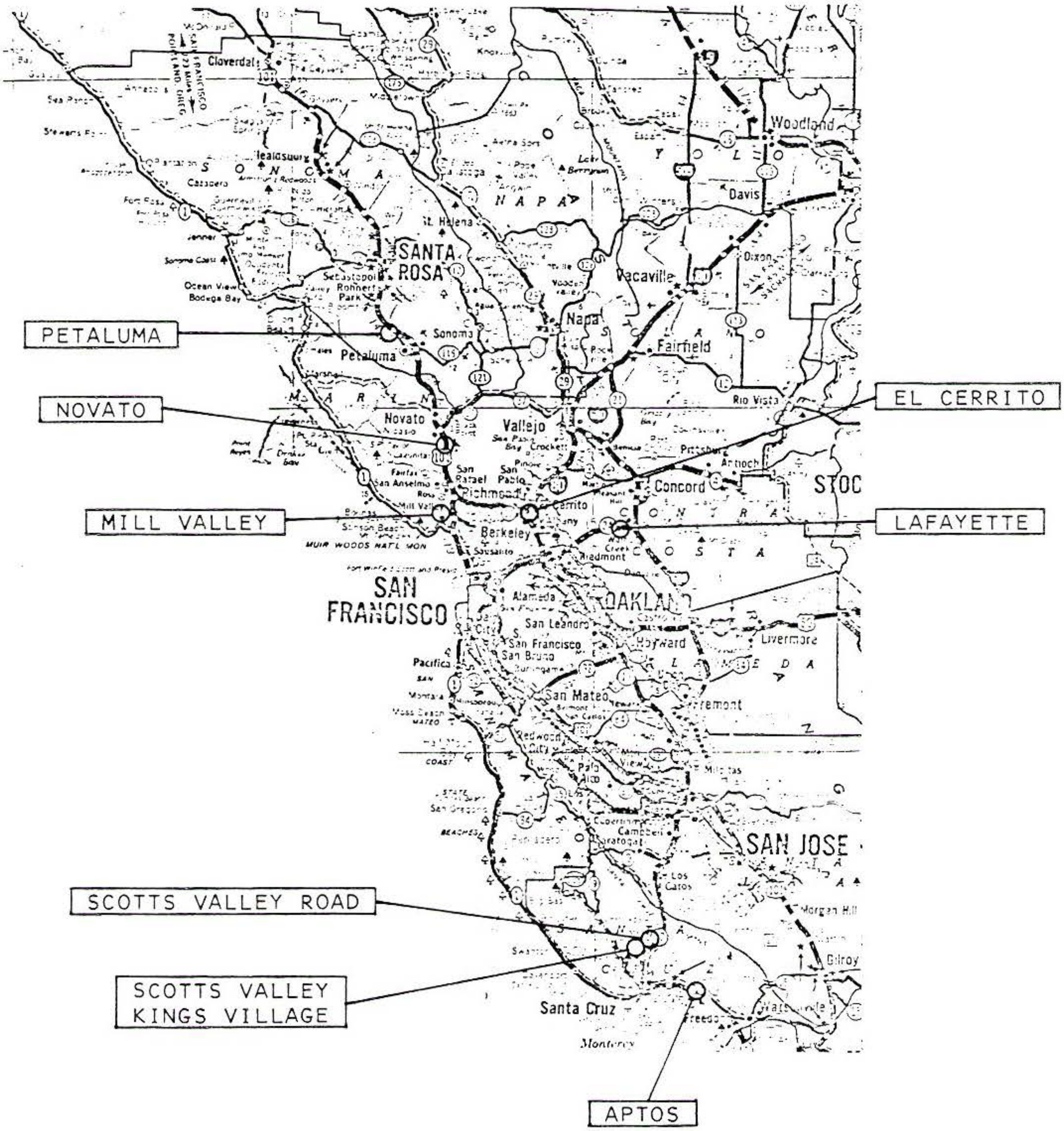

Fig. 8 - Surveyed Ad Hoc Parking Locations
(Base map courtesy of Mobil Oil Corporation)

TABLE 16 - DESCRIPTION OF SURVEYED AD HOC PARKING LOCATIONS

Location	Highway Interchange	Physical Characteristics	Usage Characteristics
Mill Valley	Near SR 1 @ Almonte Blvd and Miller Ave	Dirt shoulder and island at intersection	Transit stop.
Novato*	US 101 @ Alameda del Prado	Paved shoulders	Serves freeway bus pads.
Petaluma	US 101 @ Petaluma Blvd and Stony Point Rd	Dirt shoulder	Transit stop.
El Cerrito**	Near I 80 @ Central Ave	Furniture store parking lot	Transit stop.
Lafayette	SR 24 @ Pleasant Hill Rd	Curbside parking spaces	Important carpool and vanpool staging point; near junction of 2 freeways.
Scotts Valley	SR 17 @ Scotts Valley Rd	Gravel road next to restaurant	Transit stop; staging point for private bus and pools to Santa Clara County.
Scotts Valley	SR 17 @ King's Village & Mt. Hermon Rds	Privately owned gravel lot 1 mile from freeway	Ridesharing to Santa Clara County.
Aptos**	SR 1 @ Stone Park Dr	Church parking lot	Private bus and ridesharing to destinations in both directions.

* Off-street park-and-ride lot constructed at this location since survey.
** Designated as joint-use park-and-ride lot since survey.

2.2.2 Travel Modes

Each ad hoc park-and-ride location tends to be dominated by users of one "line haul" travel mode (Table 17). Very few carpoolers or vanpoolers park at express bus stops (in contrast to most transit-oriented off-street park-and-ride lots which also serve significant ridesharing activity). Outlying ad hoc locations are frequently staging points for subscription buses and vanpools, but have no transit service.

TABLE 17 - SURVEY RESPONSES AND "LINE HAUL" TRAVEL MODES FROM AD HOC PARK-AND-RIDE LOCATIONS

Location	Total Vehicles Surveyed	Total Replies	Number Using		
			Carpool	Vanpool	Bus
Mill Valley	50	27	3	0	24
Novato	79	26	2	1	23
Petaluma	68	36	8	0	28
El Cerrito	115	32	7	0	25
Lafayette	99	42	34	5	3
Scotts Valley Rd	56	20	8	4	8*
Scotts Valley-King's Village	35	20	8	12	0
Aptos	43	20	9	3	8*

* Indirect public transit service at these locations; some or most riders use private or company-sponsored buses.

Information on travel modes at ad hoc parking locations is very useful for planning park-and-ride improvements. If a transit-oriented location is being considered, the involved transit agency should be consulted about latent transit demand of which it might be aware. If a new lot is planned at a location presently used for meeting subscription buses or HOV pools, then similar information should be requested from agencies organizing and promoting ridesharing in the area.

2.2.3 Origins and Destinations

The origins and destinations for survey respondents at each of the ad hoc park-and-ride locations are shown in Figures 9 through 16. Origins are represented by the nearest street intersection. Some plotted points represent two respondents who reported the same location. Several origins are beyond the limits of the maps. Destinations are shown by city only. Travel modes are indicated by lines from the parking locations to the destinations. A mode is shown in a diagram if at least one respondent uses it.

For the first five locations, San Francisco is by far the most popular destination; no more than four respondents at any location indicated any other destination. Sunnyvale was the most common job destination for the parking locations in Santa Cruz County, but not by a wide margin.

Figs. 9-16 illustrate that most persons parking at these locations drive short distances from their origins; the majority of origins are within five miles and, at some locations such as Mill Valley, within two miles. The mean access distances are usually larger than the median values because a few users at each location come from up to 40 miles away. The median access distance is more representative of actual travel patterns.

The trips from origins to the parking locations are usually much shorter than the "line haul" trips to destinations. The ratio of these distances seems to be more important than the numerical difference; locations which are farther from major destinations have longer access trips. The Mill Valley, Novato, and Petaluma locations--14, 25, and 43 miles respectively from San Francisco--illustrate this phenomenon.

Significant user savings are possible only if the HOV portions of trips are long. Park-and-ride lots should be located near enough to residential

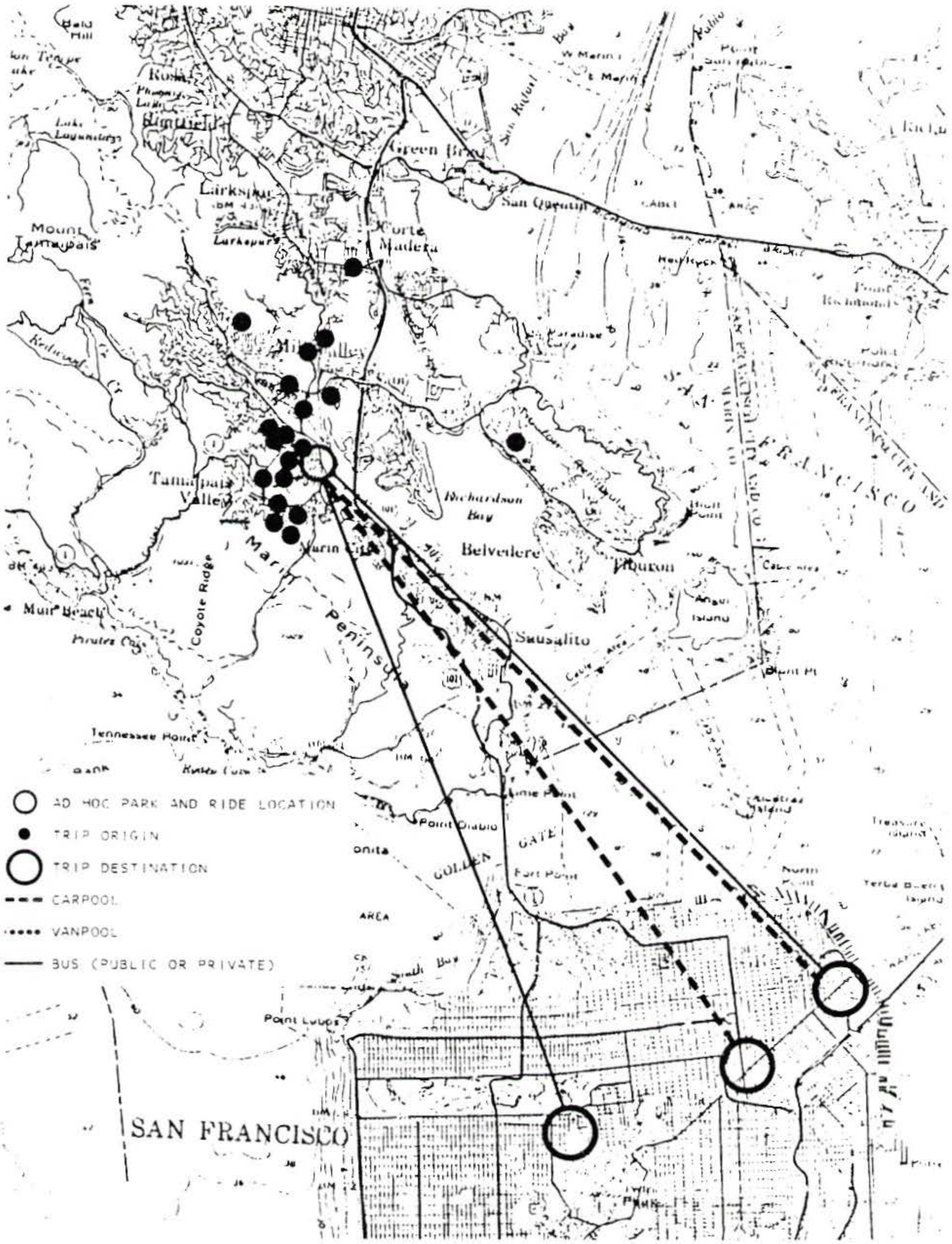

Fig. 9 - Origins and Destinations of Ad Hoc Parkers: Mill Valley

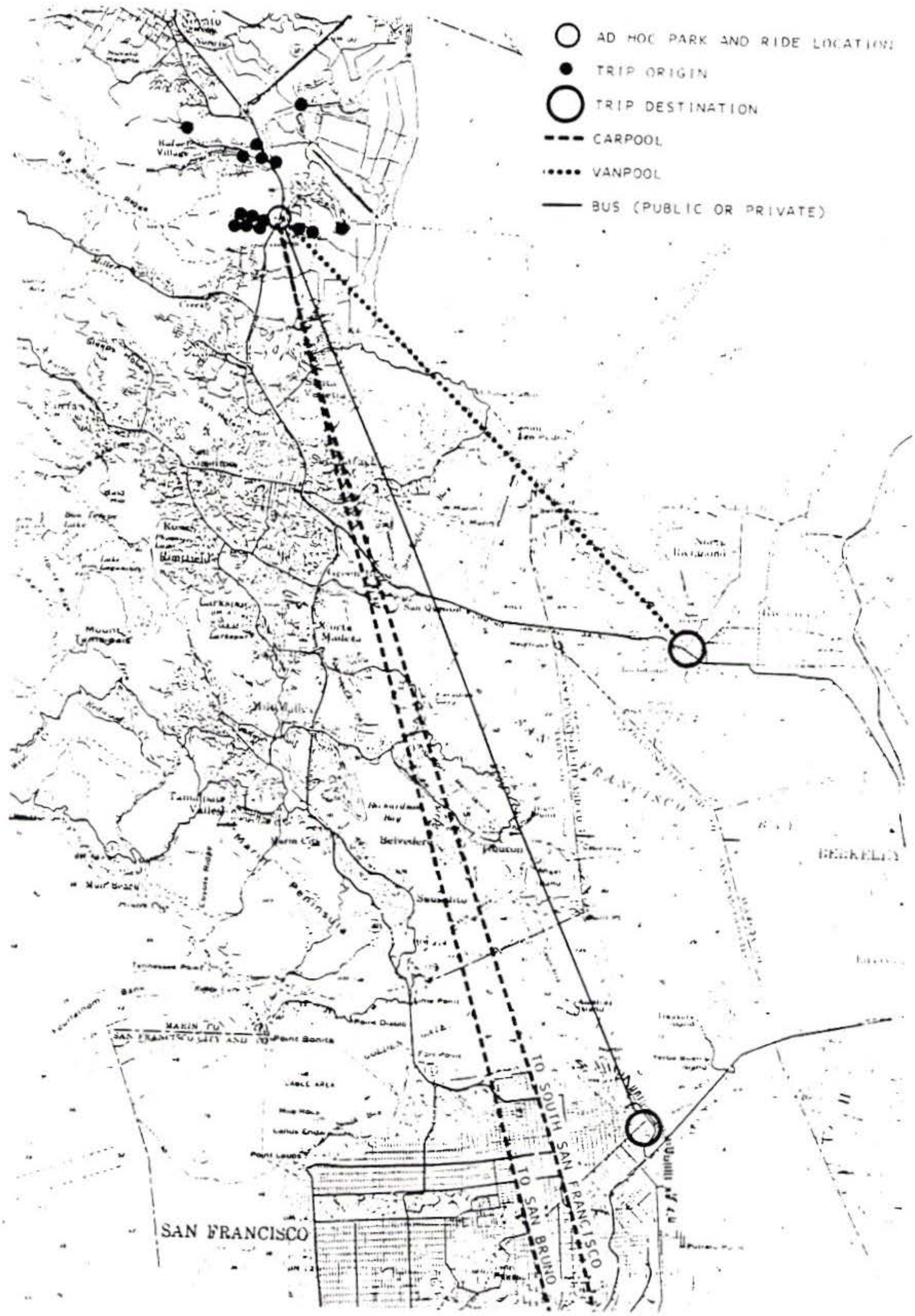

Fig. 10 - Origins and Destinations of Ad Hoc Parkers: Novato

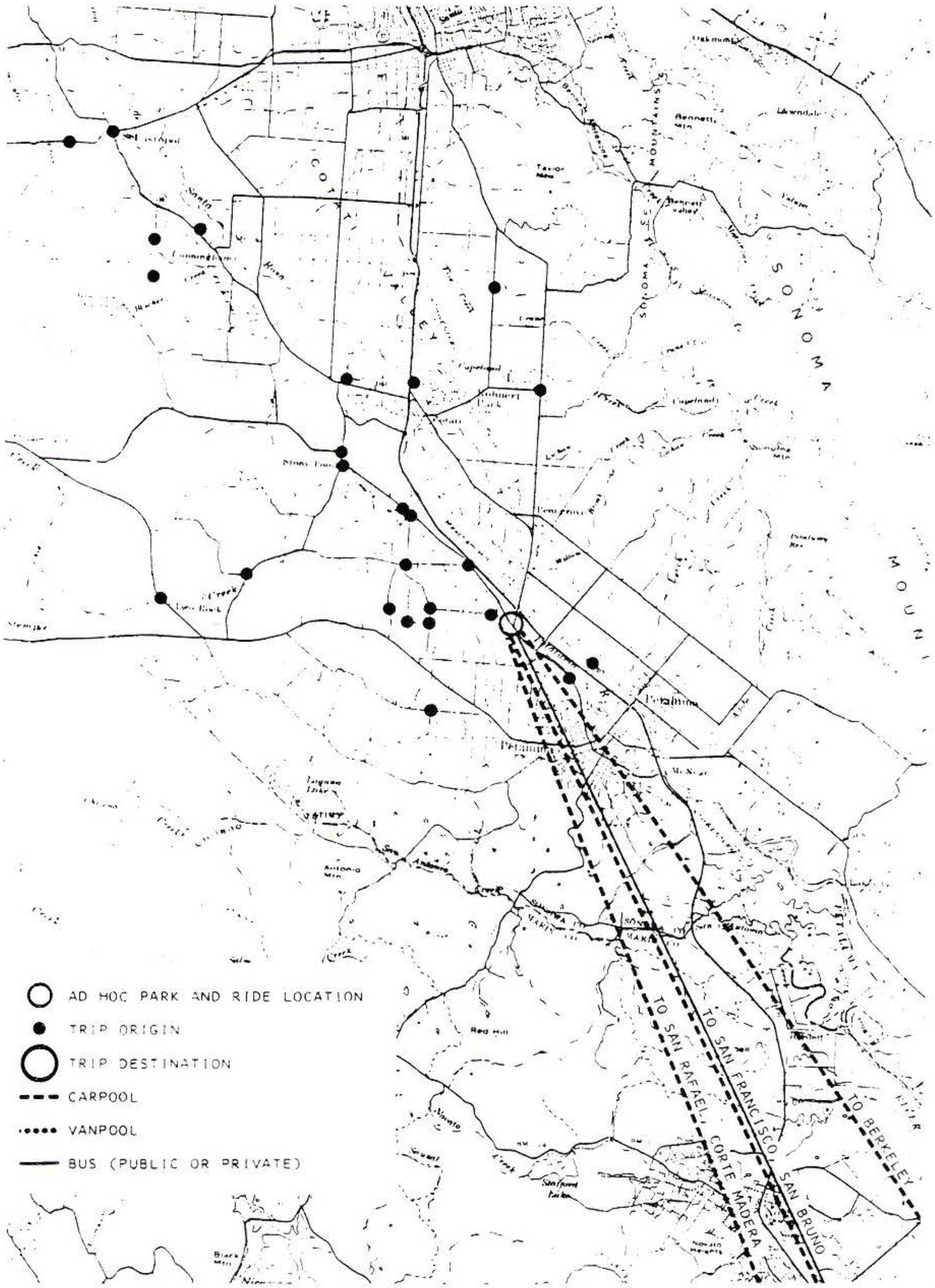

Fig. 11 - Origins and Destinations of Ad Hoc Parkers: Petaluma

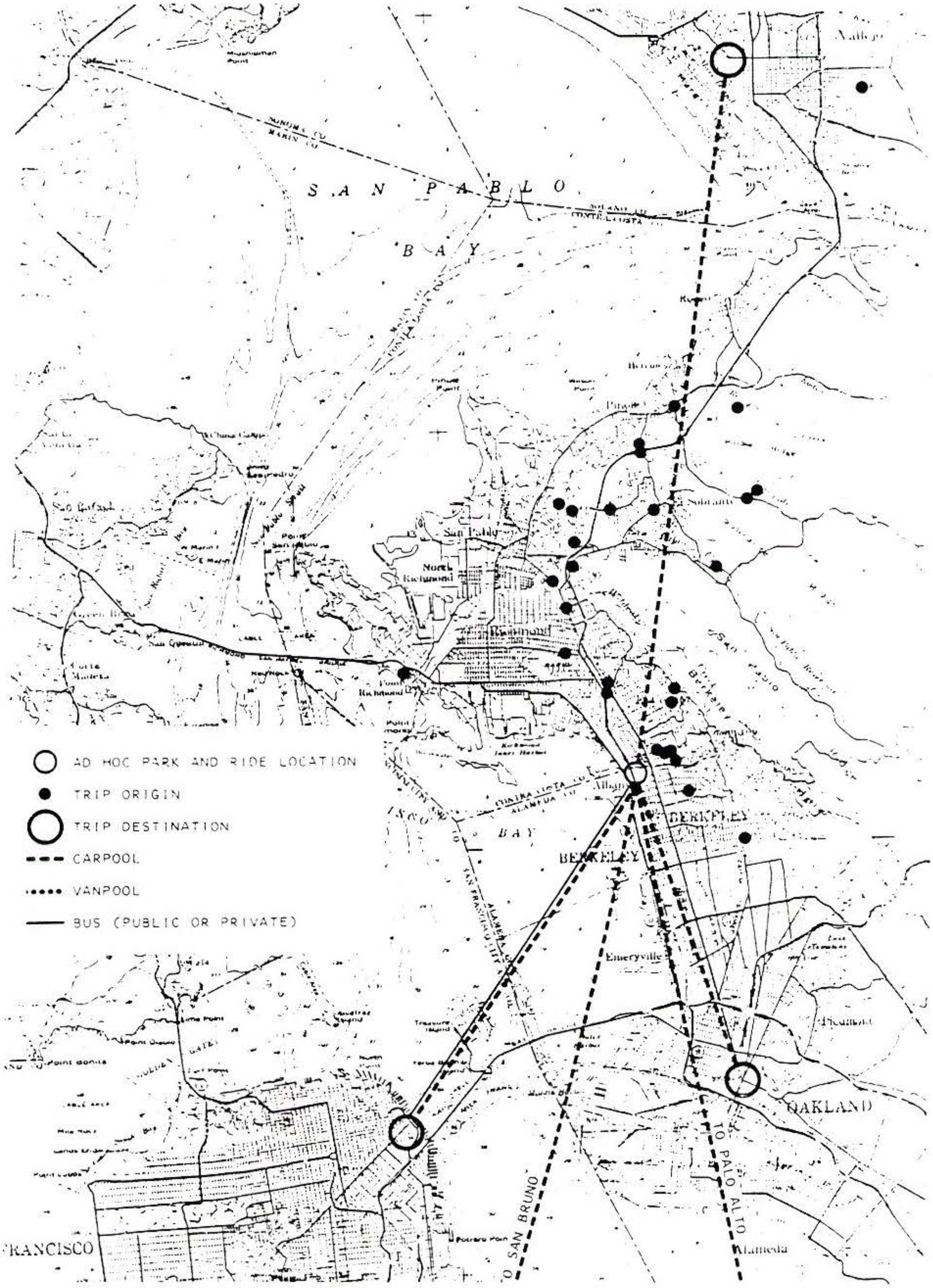

Fig. 12 - Origins and Destinations of Ad Hoc Parkers: El Cerrito

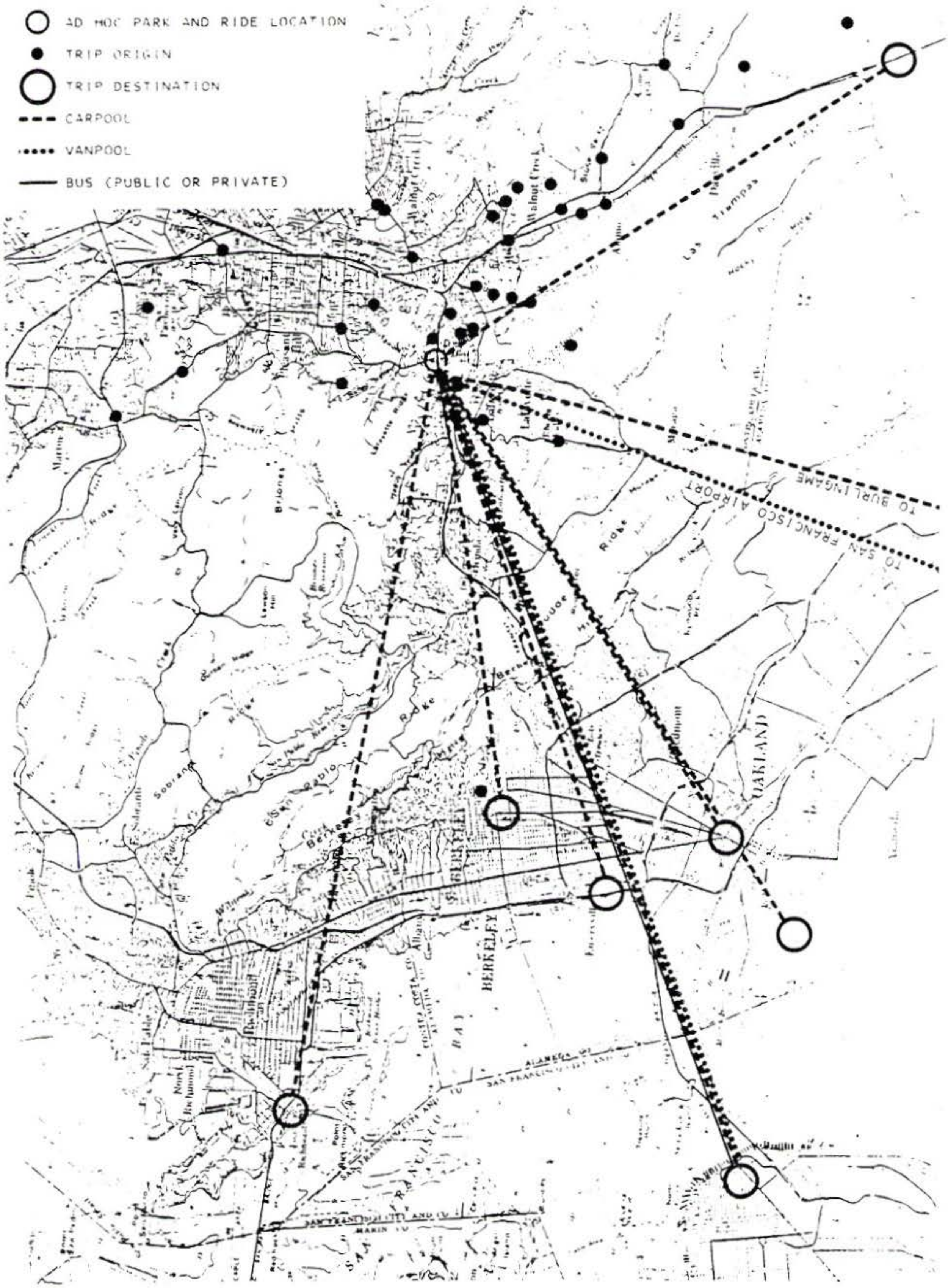

Fig. 13 - Origins and Destinations of Ad Hoc Parkers: Lafayette

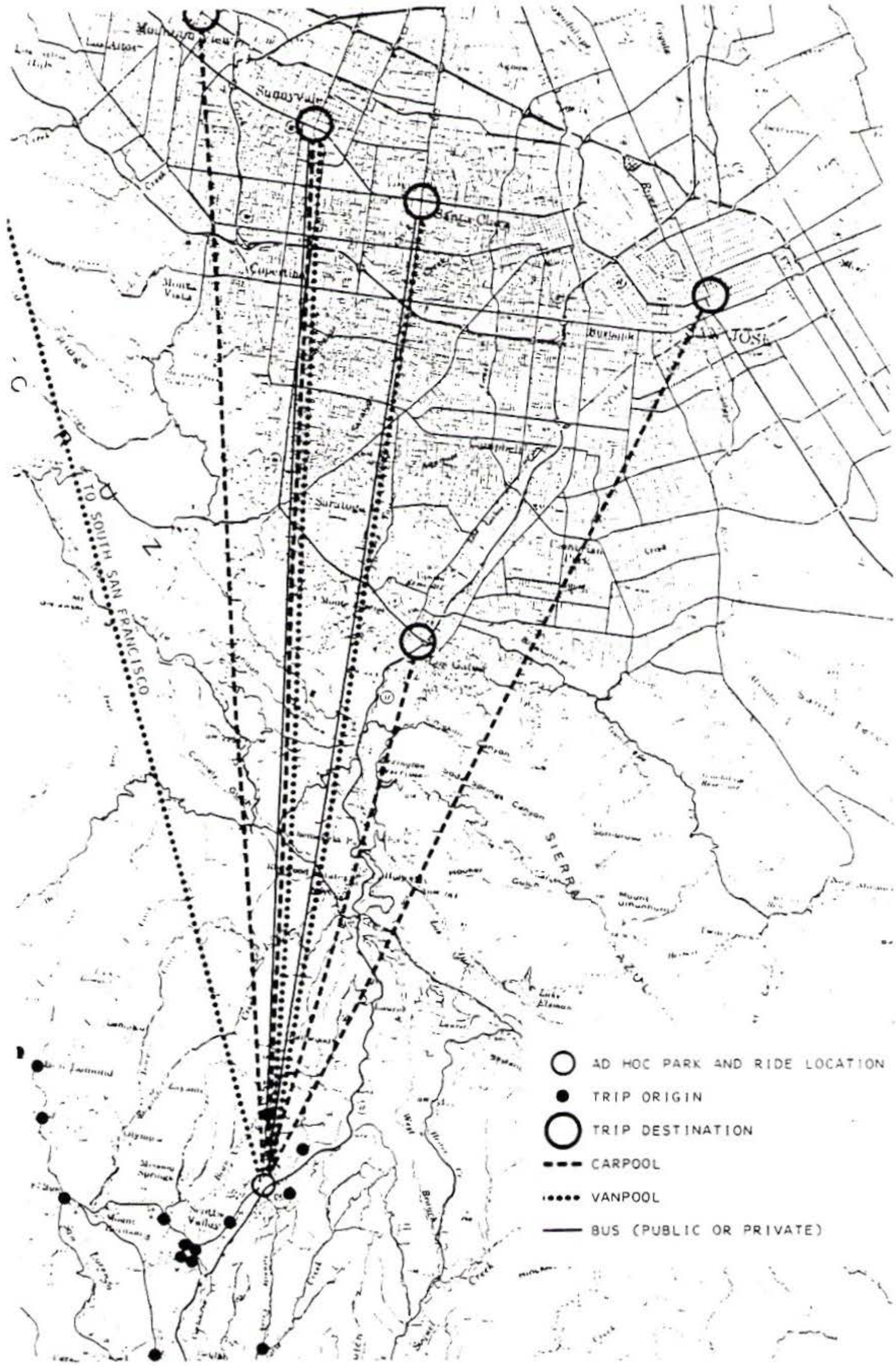

Fig. 14 - Origins and Destinations of Ad Hoc Parkers: Scotts Valley Road

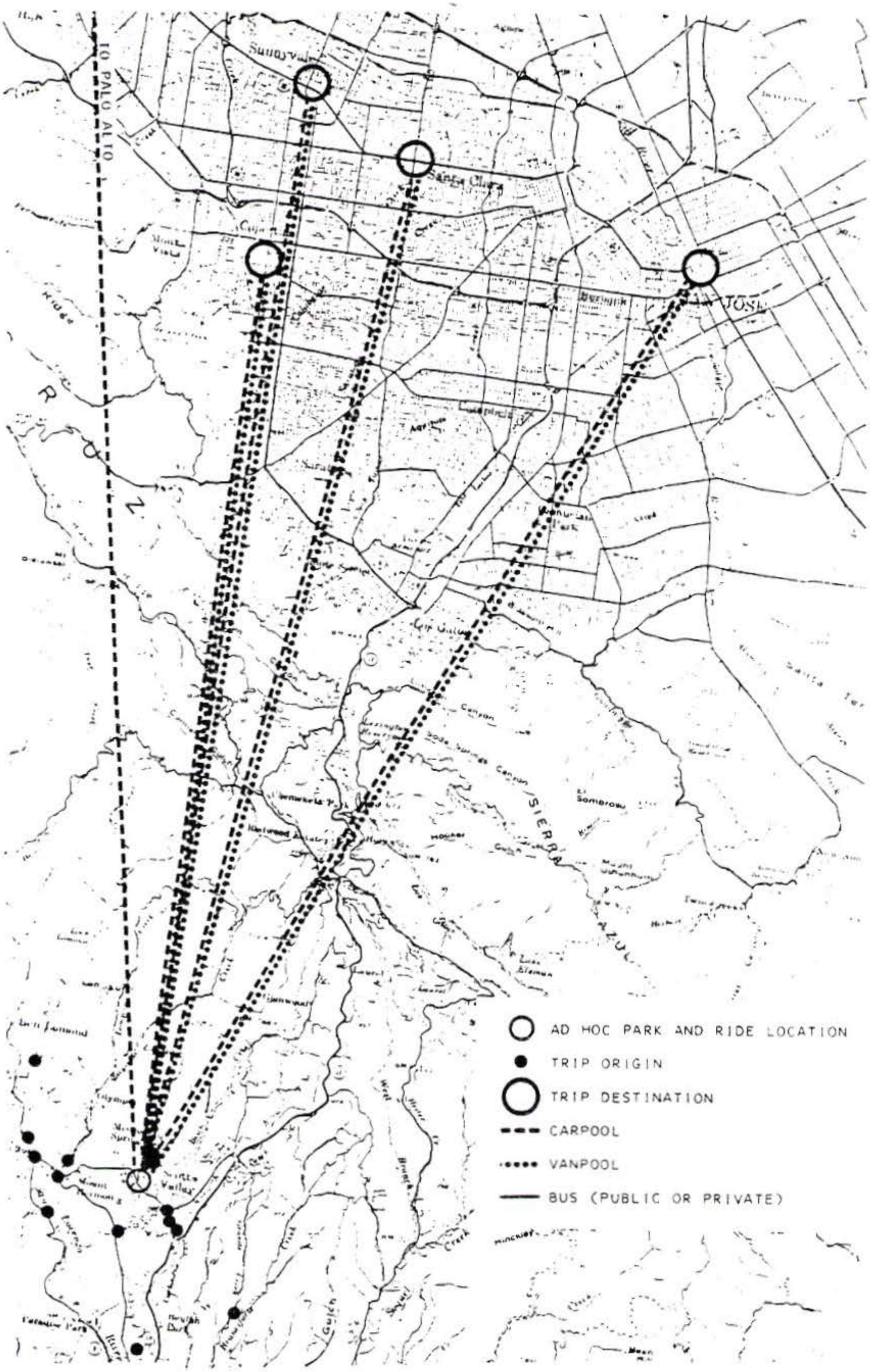

Fig. 15 - Origins and Destinations of Ad Hoc Parkers: King's Village

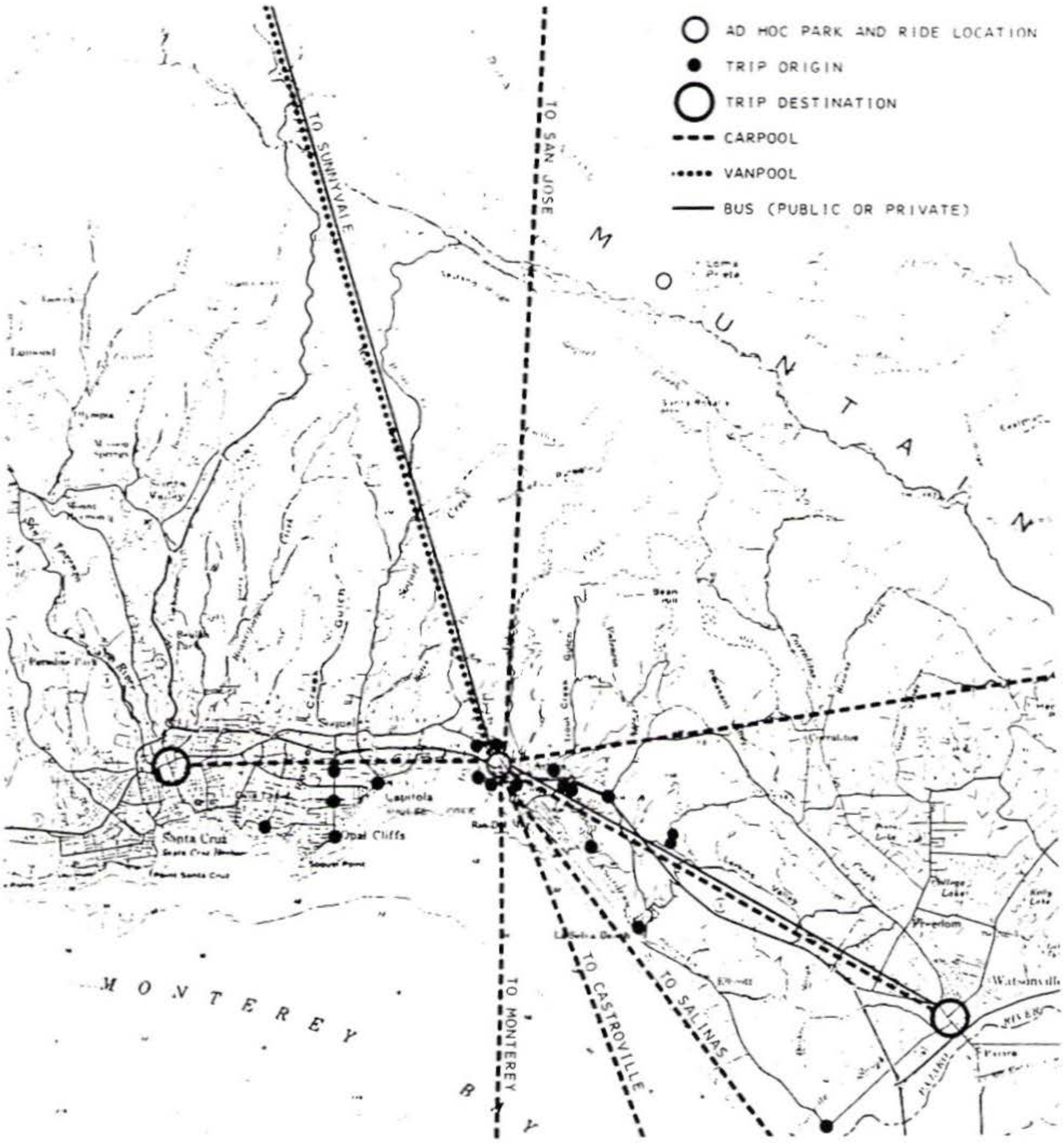

Fig. 16 - Origins and Destinations of Ad Hoc Parkers: Aptos

areas so that relatively short access is possible. However, proximity to residential areas becomes less important as locations farther from job destinations are considered, since the savings of the longer "line haul" trips more than compensate for longer access journeys.

2.3 Analysis of Park-and-Ride Locations

The data on existing park-and-ride locations were analyzed to determine whether they can predict the use of future lots and therefore provide information which will be useful for planning purposes. Important characteristics of locations may be identified which are associated with extensive park-and-ride activity. This section of the report describes a quantitative analysis of the correlations between characteristics of park-and-ride locations and selected quantifiable measures of benefits.

There are three stages of park-and-ride planning at which choices must be made, based on available information about locations. First, feasible park-and-ride locations must be chosen from all possible freeway interchanges, major intersections in commuting corridors where no freeways exist, and other potential sites. These selections are based mostly on general knowledge of the region and its commuting patterns, and on availability of land which is preferably already in public ownership. Second, locations which are likely to be successful park-and-ride lots must be chosen from the list of feasible sites for further design work. Third, priorities for construction must be set according to estimated costs and benefits. Some form of numerical analysis would be most useful for the latter two decisions.

The data sample for this analysis includes all designated park-and-ride lots included in the Caltrans survey, and the eight ad hoc parking locations which were described in Section 2.2. Most of the data for approximate benefits came from the surveys. The data on characteristics of each location came from other sources, including personal observation. A standard statistical computer package was used to calculate correlation coefficients between variables. Linear regression equations were used to estimate the relationships between these variables and the significance of the results in the usual manner.

The numerical results of this analysis are inconclusive. Correlations between benefits, such as VMT reductions, and locational characteristics, such as the distance from the region's central business district, were usually very weak. Therefore, no attempt has been made to construct a mathematical model for setting priorities of park-and-ride lot development projects. However, useful conclusions may be drawn from the fact that certain seemingly important characteristics appear to have little actual effect on the success of park-and-ride lots.

2.3.1 Measures of Success for Park-and-Ride Lots

Several variables might represent measures of success or effectiveness for a park-and-ride lot, including benefit-cost ratios, total or average VMT savings, number of vehicles using the lot, or percentage of users attracted from single-car driving. The choice of measures depends on which objectives of the ridesharing program are considered most important. In this analysis, six different measures were tested to identify the most significant lot characteristics. Each was used separately as a dependent variable in the linear regression analysis. The following descriptions of each variable are also summarized in Table 18.

o AVMT--The average weekly VMT reduction: the average of the responses given in the Caltrans survey. This variable measures an average benefit for each lot user.

o TVMT--The total weekly VMT reduction: AVMT multiplied by the number of persons observed using the lot. This variable measures a total benefit of the lot's availability.

o WVMT--The total weekly VMT reduction, counting only those persons who reported being strongly influenced in their decision to use buses or pool vehicles. Individual VMT savings were counted fully for respondents who indicated that they were "completely" influenced and at 50 percent of the actual value for those who were "highly" influenced. This variable measures the benefits derived in terms of users' perception of the lots' availability.

TABLE 18 - VARIABLES USED IN QUANTITATIVE ANALYSIS

Measures of Effectiveness (Dependent Variables)		**Units**
AVMT	- Average weekly VMT reduction	Miles/week/user
TVMT	- Total weekly VMT reduction	Miles/week
WVMT	- Total weekly VMT reduction weighted by degree of influence of the lot availability	Miles/week
VEH	- Typical number of vehicles using the lot	Vehicles
BCR	- Benefit-cost ratio	Miles/week/$1000
DRALN	- Percent of users who previously drove alone	Percent
Location Characteristics (Independent Variables)		**Units**
PKB4	- Number of vehicles parked prior to lot implementation	Vehicles
CBD	- Distance to central business district or major employment center	Miles
POP5	- Population in selected areas within 5 miles	Persons
VOL	- Peak hour volume on adjacent highway links	Vehicles/hour
TRANSIT	- Quality of transit service	Scale from 0 to 1
INT	- Importance of interchange	Scale from 0 to 1
PROX	- Proximity to residential areas	Scale from 0 to 1
ACCESS*	- Ease of access from highway	Scale from 0 to 1
VIS*	- Visibility from highway or streets	Scale from 0 to 1

* These factors only applicable if design of lot is already known.

o VEH--Number of vehicles: the typical number of vehicles parked at a location during the day; the most recent counts available were used to reflect the increased usage of some of the newer lots since the time of the Caltrans survey. This variable measures the expressed demand for the lot.

o BCR--Benefit-cost ratio: TVMT divided by the capital cost of the corresponding lot. User benefits of ridesharing programs are usually calculated by multiplying average cost per mile by VMT reductions. (The total benefits for the lifetime of a lot can be calculated by multiplying weekly benefits by a factor representing discounting over an assumed life of the lot. Since each of these factors is a constant for all lots, it was not considered necessary to include it in the analysis.) The benefit-cost ratio is a commonly used measure of the overall merit of a project.

o DRALN--Percent of lot users who reported that they drove alone to and from work prior to the availability of the park-and-ride lot. This variable measures the ability of a lot to attract new users to ridesharing or transit.

2.3.2 Characteristics of Locations

The characteristics of locations used in the analysis were chosen according to relevance and availability of data. Each characteristic was thought to have some effect on the success of park-and-ride, based on preliminary observations and previously published studies.

Availability of data was important both for this analysis and to make the results useful for future use. For some variables, such as highway traffic volume, numerical data were available; other characteristics were quantified by rating them subjectively for each lot on a scale from 0 to 1, using certain guidelines to ensure consistency. To permit use of the same factors in future planning, only variables not requiring a special survey were used. For example, it was assumed that actual destinations or travel costs of users would not be known during planning.

The following factors were used as independent variables in the regression analysis; they are also summarized in Table 18. The last two of these (ACCESS and VIS) are used only if the layout of the lot is already known.

- PKB4--Amount of ad hoc parking: the typical number of vehicles observed in the general vicinity where park-and-ride lots were subsequently constructed or designated. These data were not available for the Los Angeles area because the design of freeway interchanges militated against nearby ad hoc parking.
- CBD--Distance from the central business district (CBD); the distance, in miles, along the best (often only) route between each lot and an appropriate employment center. In the San Francisco Bay Area, downtown San Francisco was used as the employment center except for Santa Clara County lots, for which the centroid of jobs was assumed to be Sunnyvale. In Southern California, an average of the distances to downtown Los Angeles and an industrial section of Orange County was used for most lots, reflecting the major destinations reported in the survey.
- POP5--Population within five miles: the 1980 U.S. census population in appropriate census tracts located within a five-mile radius circle centered on the interchange near each lot. The distance of five miles was based on typical maximum access distances reported in the survey. Areas were excluded if the route between them and the lot involved significant detours--for example, tracts more than one mile closer to the CBD than the lot location, or areas much closer to another park-and-ride facility or to another freeway corridor.

o VOL--Volume on the adjacent highway link: the average peak hour traffic volume in both directions, based on Caltrans data. It was thought that this variable might be an alternative indicator of overall commuter travel demand.

o TRANSIT--Quality of transit service: a zero-to-one rating of the existing transit service at the location. Directness of service between the lot and the job locations and the proximity of the bus stop to the lot were each rated between 0 and 0.5. For example, an express bus service from a stop in or immediately adjacent to the lot to the CBD was scored 1.0; a feeder service to a transit transfer point from a stop a block away might score 0.4; complete absence of transit service scores, of course, zero.

o INT--Importance of interchange. Most park-and-ride lots are adjacent to freeway interchanges. This variable rates the importance of the crossing street or highway at this point on a zero-to-one scale. An interchange between two major state highways would receive the highest score, whereas an interchange with an arterial street would score 0.3.

o PROX--Proximity to population: a zero-to-one rating of the proximity of the park-and-ride location to residential development. An interchange surrounded by a dense residential area is scored 1.0, one on the fringe of a community 0.5, and a rural interchange 0.2.

o ACCESS--Accessibility: a zero-to-one rating of the ease of access from the main highways to the lot. The scale is based on the number of turns required to reach the lot entrance, adjusted for the distance and the difficulty of turning movements. A lot with an entrance on the main cross arterial, which requires a left turn into the lot from at least one direction, is scored 0.5; a lot with a direct entrance from a freeway ramp or other state highway receives the highest score.

o VIS--Visibility: a zero-to-one rating. A lot which is clearly visible from the freeway or state highway is scored highest (1.0); one visible only from the crossing street is assigned a value of 0.4.

2.3.3 Direct Correlations of All Variables

Table 19 is a matrix of direct correlation coefficients between all dependent and independent variables. Only a few of the coefficients (those underlined) exceed 0.5, suggesting even a modest degree of correlation. VOL correlates negatively with CBD as would be expected; freeway traffic volumes increase with decreasing distance from the CBD of a metropolitan area. PROX correlates with POP5, which merely confirms the expectation that more populous areas also tend to be more closely developed along freeway interchanges. Lots which are easily accessible also tend to be more visible (ACCESS correlates with VIS).

2.3.4 Characteristics Associated with VMT Reductions

Linear regressions were used to determine the significance of each characteristic. Variables were removed from the equations if they proved to be statistically insignificant. Separate regressions were used for average weekly vehicle-miles reduced (AVMT), total weekly vehicle-miles reduced (TVMT), and weighted total vehicle-miles reduced (WVMT). The *t* statistic indicates that in most equations all but one or two of the independent variables proved to be insignificant.

The following equation was obtained for average weekly vehicle-miles reduced (*t* statistics in parentheses):

TABLE 19 - CORRELATION COEFFICIENTS FOR VARIABLES USED

	AVMT	TVMT	WVMT	VEH	BCR	DRALN
AVMT	1.000					
TVMT	0.302	1.000				
WVMT	0.275	0.929	1.000			
VEH	-0.092	0.614	0.583	1.000		
BCR	0.659	0.252	0.252	-0.028	1.000	
DRALN	0.426	0.023	0.025	-0.244	-0.037	1.000
PKB4	-0.124	0.448	0.506	0.670	0.028	-0.392
CBD	0.681	0.140	0.077	-0.324	0.596	0.064
POP5	0.228	0.227	0.287	0.131	-0.010	-0.024
VOL	-0.365	0.043	0.083	0.283	-0.470	0.082
TRANSIT	-0.289	0.250	0.357	0.472	-0.014	-0.258
INT	-0.101	0.132	0.073	0.360	0.056	-0.415
PROX	0.198	0.273	0.307	0.228	-0.022	-0.158
ACCESS	0.104	0.334	0.280	0.111	-0.225	-0.018
VIS	0.394	(na)	0.173	-0.030	0.171	-0.051
	AVMT	TVMT	WVMT	VEH	BCR	DRALN
	Measures of Benefits (Dependent Variables)					

SEE BELOW FOR MATRIX CONTINUATION

	PKB4	CBD	POP5	VOL	TRANSIT	INT	PROX	ACCESS	VIS
PKB4	1.000								
CBD	-0.039	1.000							
POP5	0.029	-0.008	1.000						
VOL	0.029	-0.636	0.438	1.000					
TRANSIT	0.488	-0.432	0.141	0.351	1.000				
INT	0.381	-0.010	0.333	0.187	0.166	1.000			
PROX	0.118	-0.112	0.535	0.129	0.277	0.195	1.000		
ACCESS	0.120	-0.137	-0.090	(na)	-0.016	-0.003	(na)	1.000	
VIS	0.000	0.171	-0.166	(na)	0.024	(na)	(na)	0.557	1.000
	PKB4	CBD	POP5	VOL	TRANSIT	INT	PROX	ACCESS	VIS
	Location Characteristics (Independent Variables)								

NOTE: Values of R^2 greater than 0.5 are underlined.

$$\text{AVMT} = \underset{(-2.14)}{-80.6} + \underset{(2.12)}{73.7 \cdot \text{PROX}} + \underset{(5.84)}{5.5 \cdot \text{CBD}} \quad . . . \; R^2 = 0.53$$

The coefficient for distance from the CBD may at first glance appear to be low; in a two-member carpool the weekly savings per extra mile of pooling per occupant equals 10/2 = 5 VMT, in a three-member pool 20/3 = 6.67 VMT, in a four-member pool 30/4 = 7.5 VMT,....up to 10 VMT for transit passengers. The weighted average for the distribution of carpool and vanpool sizes and the proportion of transit passengers indicates a weekly saving of 8.3 VMT per ridesharer. However, the data in this survey include many respondents who were ridesharers already before lot construction and who, therefore, reported zero savings. The above formula therefore indicates an average of 5.5 VMT saved per week for the entire mix of prior and new ridesharers. There is no particularly good reason why proximity to residential concentrations appears in this regression while other variables do not.

Using total weekly VMT reductions as the dependent variable produced the following equation:

$$\text{TVMT} = \underset{(-0.90)}{-4655} + \underset{(2.66)}{250 \cdot \text{PKB4}} + \underset{(2.26)}{129 \cdot \text{POP5}} \quad . . . \; R^2 = 0.34$$

The number of vehicles already parking at a location appears to be a good indicator of total VMT savings if a lot is built at that site. The size of the surrounding population is also an important factor. The constant term is statistically insignificant.

If the total VMT reductions are weighted according to the influence the lot had on users' decisions to rideshare, the following equation is obtained:

$$\text{WVMT} = \underset{(-1.81)}{-3656} + \underset{(3.31)}{121} \cdot \text{PKB4} + \underset{(2.97}{66} \cdot \text{POP5} \quad . . . \quad R^2 = 0.46$$

This equation is similar to the preceding one, but has a slightly higher regression coefficient.

The low values of R^2 indicate that none of the above equations are strong enough to be used to predict benefits of, or to rank, proposed park-and-ride projects. However, the equations do indicate which factors appear important or unimportant in determining VMT reductions. Average benefits are highest at lots which are far from major job destinations and close to residential areas. Total user benefits are greatest at lots with large surrounding populations and a significant amount of ad hoc park-and-ride activity. Other characteristics, such as traffic volume or transit service quality, do not seem to be reliable indicators of these user benefits.

2.3.5 Characteristics Associated with the Number of Vehicles Using Lots

The purpose of this analysis was to determine which characteristics of a location could be good indicators of the demand for park-and-ride facilities. Demand is measured as the typical number of vehicles at a lot during the day. The following equation was obtained from linear regression using the number of vehicles as the dependent variable:

$$\text{VEH} = \underset{(0.18)}{2} + \underset{(3.34)}{1.18} \cdot \text{PKB4} + \underset{(2.38)}{54} \cdot \text{TRANSIT} \quad . . . \quad R^2 = 0.54$$

The number of vehicles already parking at a proposed park-and-ride lot site is a strong indicator of the demand for the lot. At most locations, the number of vehicles has increased after the lot was built--by a factor of about 1.2 according to the coefficient of the PKB4 term above. Increases have been even greater at sites with good transit service.

If the ad hoc parking variable, PKB4, is omitted, then the importance of the interchange becomes a significant factor. However, the lower value of R^2 indicates that this equation explains less of the variation in the number of vehicles:

$$\underset{}{VEH} = \underset{(0.18)}{3} + \underset{(2.19)}{57} \cdot INT + \underset{(3.21)}{55} \cdot TRANSIT \quad . . . \quad R^2 = 0.30$$

2.3.6 Benefit-Cost Ratio

The ratio of total benefits to total costs is a commonly used measure to evaluate the worth of a project or the relative worth of competing projects. It is not a perfect measure, because actual benefits and costs can rarely be calculated accurately. However, for this analysis, the benefit-cost ratio can be used to identify which characteristics are associated with cost-effective park-and-ride lots.

The benefit-cost ratio used is the total VMT reduction divided by the capital cost of each lot. Most user benefits, such as fuel cost savings, are proportional to vehicle-mile reductions. More general benefits, such as reduced traffic congestion or air pollution, have not been included because they are difficult to calculate or, in the case of air pollution for example, probably negligible. Capital cost does not include maintenance or administrative costs. These inaccuracies are not important when the results are used only to compare relative cost effectiveness.

Joint-use lots were not included in this analysis because their capital costs are virtually zero to the state. A regression, using benefit-cost ratios for the 24 state-constructed lots, produced the following equation:

$$\underset{}{BCR} = \underset{(-1.16)}{-97} + \underset{(3.49)}{10 \cdot CBD} \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; R^2 = 0.36$$

The constant term is of questionable significance. In general, the lots which are further from employment centers are more cost-effective, irrespective of the number of vehicles using them, the size of tributary population, or the quality of transit service. Therefore, if the goal of a park-and-ride program is to obtain the greatest VMT reduction per dollar, the priorities of lot construction should be based on the distances of prospective sites from major employment centers.

Interestingly, if the weighted VMT reductions are substituted as the measure of park-and-ride benefits, there is no statistically significant solution. Distance from the CBD does not seem to matter when the influence of lot availability on the user's decision is taken into account. A possible explanation is that persons with the longest commute distances are more likely to choose ridesharing regardless of the availability of parking lots--because the benefits are greatest for this group of commuters.

2.3.7 Characteristics Associated with Percent of Converts from Driving Alone

The percent of park-and-ride lot users who formerly drove alone is a measure of the success of a lot in attracting new HOV users. The following equation results from a linear regression using this percentage as the dependent variable:

$$\text{DRALN} = \underset{(12.4)}{68.9} - \underset{(-2.38)}{22 \cdot \text{INT}} - \underset{(-2.02)}{13.7 \cdot \text{TRANSIT}} \quad . \; . \; . \quad R^2 = 0.35$$

This result is not surprising. Lots built at minor interchanges with poor transit service have a higher percentage of new HOV commuters because these locations would not ordinarily attract park-and-ride activity.

2.4 Recommendations for Park-and-Ride Locations

The analysis of the available data did not provide conclusive quantitative results. It is unlikely that the regression results could be used to predict accurately the demand for parking or the VMT saved if a lot is built at a particular location.[2] The results also proved unsuitable for the formulation of a mathematical methodology for ranking potential locations. Although no specific quantitative models have been developed, several useful recommendations may be made.

The amount of ad hoc parking at a location seems to be the best indicator of the success of a future park-and-ride lot. Parking lots built at locations where ad hoc parking occurs have consistently been able to attract new users. The number of new users depends partially on the prevailing modes of travel between the location and the work places. Lots built at transit stops can attract a significant number of new users, especially if transit service is improved in conjunction with the opening of the lot. Locations which are used primarily for vanpools and subscription buses will usually have difficulty in attracting new users to these modes, although a lot which is in a good location will attract carpoolers.

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[2]As indicated earlier, "vehicle-miles saved" is not an entirely satisfactory measure of effectiveness in any case.

Locations are more difficult to evaluate if ad hoc parking is not feasible--for example, if parking near an interchange is illegal. Park-and-ride lots will rarely be effective if they are close to the CBD or other job destinations. Distances as small as 10 miles may work as fringe parking locations for transit users if parking in the CBD is scarce and/or expensive. A more typical distance is from 20 to 40 miles. At these distances, HOVs can provide significant savings in travel cost and driving effort.

The other factors which are associated with successful locations are the size of the populations within easy access distance (up to about five miles) and the quality of the transit service. Good transit service is shown in this study to generate demand for parking spaces, but may not result in substantial savings of VMT. This is because a new lot in an area where transit service is already developed will not usually attract many new transit users; instead, it will often attract present transit users to the park-and-ride lot because it is more convenient.

Another important consideration is the location in a well-defined travel corridor. This factor was not included in the analysis because it is difficult to quantify or scale. Park-and-ride only succeeds when commuters with origins in the same general area have the same area of destination. For example, there is park-and-ride activity at nearly all interchanges along US 101 in Marin and Sonoma Counties because the highway runs through a narrow corridor and nearly all work locations are in San Francisco. In this situation, park-and-ride works even though the population density is relatively low.

If the benefit-cost ratio is more important than total benefits, e.g., if planners are concerned about the amount of time it takes for a lot to pay for itself in user benefits, the distance from the CBD or major employment center becomes the most significant factor. This ratio is often used as a criterion for establishing project priorities. Accordingly, the most distant feasible lot would have the highest priority. Of course, other criteria, such as mitigating hazards where ad hoc parking is unsafe, relieving traffic congestion, or utilizing excess transit capacity, might also be considered.

3. DESIGN OF PARK-AND-RIDE FACILITIES

The proposed design of park-and-ride lots depends more on general principles of parking lot design and common sense than on rules or guidelines specifically and uniquely applying to this type of lot. However, specific constraints are caused by the availability of only small, often awkwardly shaped pieces of land at freeway interchanges, and by the traffic conditions on the roadways bordering these parcels. It is rarely possible to use "ideal" or "standard" designs with neatly aligned aisles and stalls, easily accessible entrances and exits, and ample room for circulation and landscaping.

Certain special considerations should, however, be included in the design of park-and-ride lots. The most important of these relate to what users consider to be important characteristics or amenities. The lots must be easily accessible so that their use involves minimal delay; this affects the optimum location of a lot within an interchange area and placement of entrances and exits. The lot must also appear to be a secure and attractive place in which to leave a car all day; security requires good visibility and lighting, as well as consideration of the type of neighborhood in which the interchange is located. Paving and landscaping may not directly influence people's decisions to use the lot, but it does add to users' satisfaction with the program. A shelter from inclement weather is an obviously attractive amenity.

3.1 Size of Lot

The size of a lot is often limited by the size of available parcels of land at an interchange. In such a case, the lot is designed with the maximum number of stalls which can be fitted into the limited space, consistent with geometric standards based on vehicle dimensions and turning ability. Where there is an abundance of available land, the appropriate lot size must be determined from an estimate of the ultimate demand; a good basis for this estimate is the amount of ad hoc parking near the site being planned.

If an off-street parking lot is proposed at a site where ad hoc parking space had been inconvenient (e.g., on road shoulders or unkempt open land) or scarce, lot patronage has been found to increase to about double the number of cars previously observed. Where ad hoc parking had been convenient (e.g., where a shopping center lot or extensive on-street parking were available) a new lot has done little to increase park-and-ride activity. The average increased use generated for both types of situations was about 20 percent, as shown in the equation in Section 2.3.5.

If the construction of a park-and-ride lot at a transit stop is coordinated with new or improved commuter transit service, as was the case at several Southern California locations, future usage of the lot may be from twice to four times the prior level of activity.

Of course, any estimate of demand is subject to inaccuracy. Many factors affect people's decisions to park and ride, such as fuel prices, transit fares, parking charges at the job locations, and changing attitudes towards ridesharing, and these may be difficult to forecast. Where uncertainties are substantial, stage construction of a lot is an obvious suggestion.

3.2 Location at the Interchange

State-constructed park-and-ride lots will almost always be located at highway interchanges, as this is where state-owned land is most likely to be available. Proximity to an interchange also allows quicker access between the lot and the state highway.

The location of a lot at a selected interchange depends on land availability and access considerations. Whenever possible, the lot should be on the same side of a freeway as the morning commuter flow. Time is a more important consideration to users on the way to work than on the way home.

3.3 Access

Park-and-ride lots must not have direct access to freeways or freeway ramps. Lots must be located so that entrances and exits may open onto an arterial, frontage road, or side street. Exits from park-and-ride lots should never be located opposite freeway off-ramps, since such an alignment might encourage wrong-way entry into the freeway.

Most park-and-ride lots will require only one entrance and exit. These may be separated if space limitations require one-way circulation through the parking lot. In some cases, two exit lanes will be needed so that vehicles wishing to turn left out of the lot will not block those planning a right turn on leaving.

It is often possible to place lot entrances and exits on the main arterial crossing the freeway at the interchange in question. If the arterial is fully developed or traffic is very heavy on it, the lot should be connected to a side street or freeway frontage road instead. Parking lot access should not create congestion or hazards. Turning lanes for left turns into the lot should be provided where traffic conditions warrant.

Access to park-and-ride lots may be impaired by existing traffic conditions at a site. A typical problem is shown in Figure 17. A left turn lane

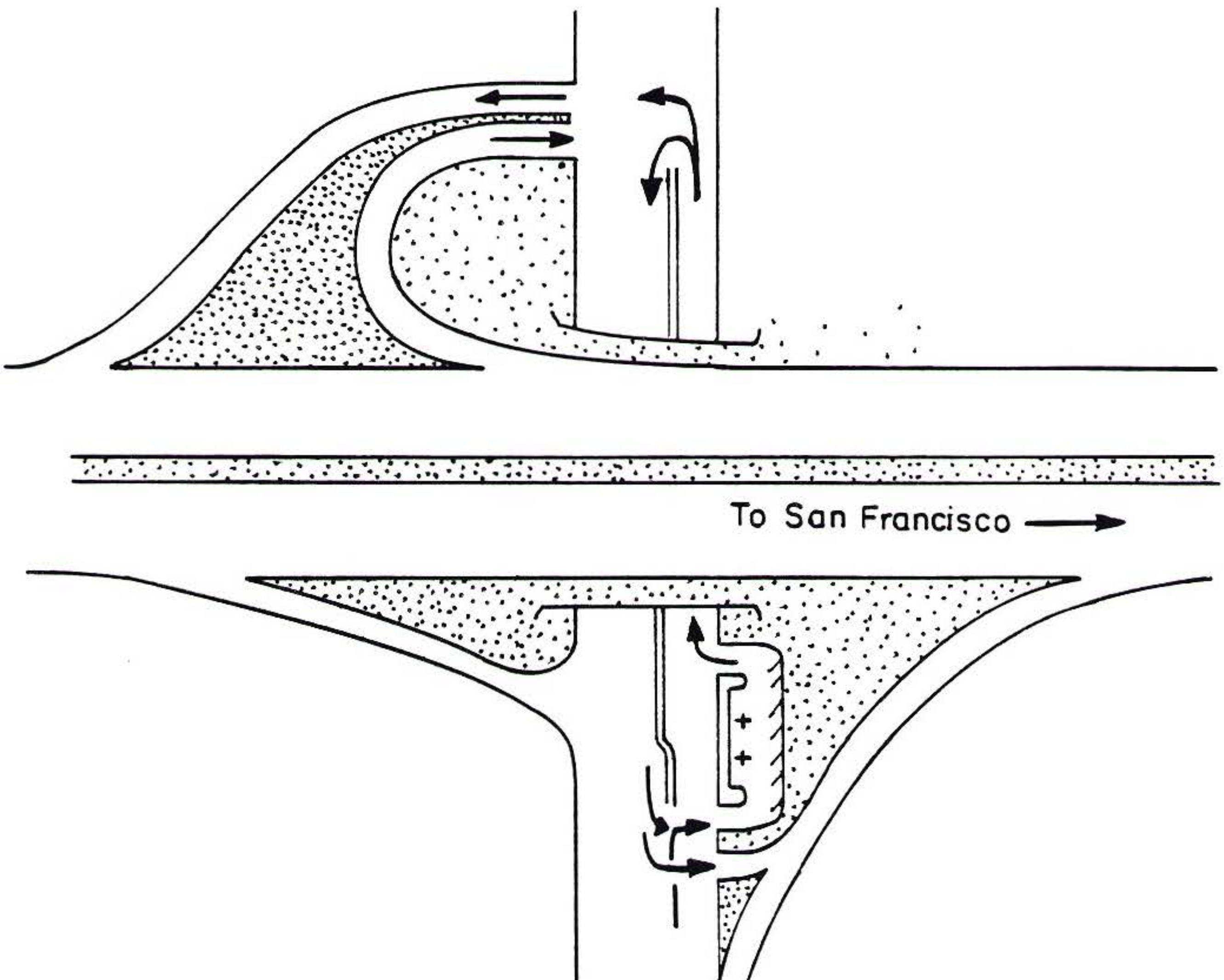


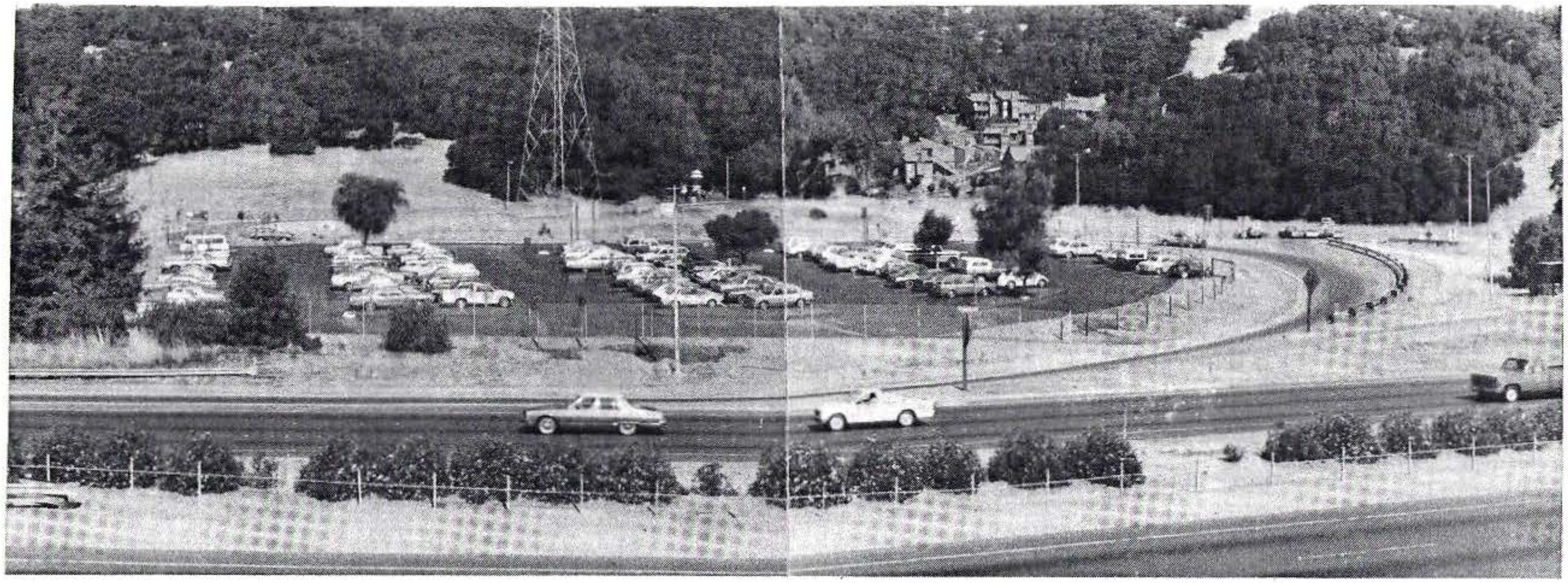
Fig. 17 - Park-and-Ride Lot with Left Turn Prohibited at Exit

has been provided on the arterial for access into the lot. However, left turns out of the lot are prohibited because of sight distance problems. The lot exit therefore does not connect directly to the eastbound on-ramp. Lot users who wish to travel east on the freeway must exit to the right, find a way to make a legal U-turn beyond the interchange, and then turn left onto the ramp. Such situations are not uncommon, especially for parking lots located on major arterials with raised medians. Difficult access may not necessarily discourage use of the lot, but it may encourage illegal or unsafe turning maneuvers. Every effort should be made to work out satisfactory traffic patterns for the lot users (Fig. 18).

3.4 Visibility

Park-and-ride lots should be clearly visible to passing motorists, both to increase security and to advertise the availability of park-and-ride services. Lots should not be set back too far from major streets or placed behind buildings. Landscaping should allow clear sight lines into parking lots. It is desirable, but not necessary, for lots also to be visible from freeways.

Security is a major concern of park-and-ride lot users, as indicated by comments on the 1982 Caltrans survey forms. The California Highway Patrol has conducted a study of enforcement and security service at selected state-owned park-and-ride lots. No serious problems have been reported in this study. However, commuters indicated in the Caltrans survey that they would be unwilling to leave their cars in parking lots which are isolated and difficult to patrol.



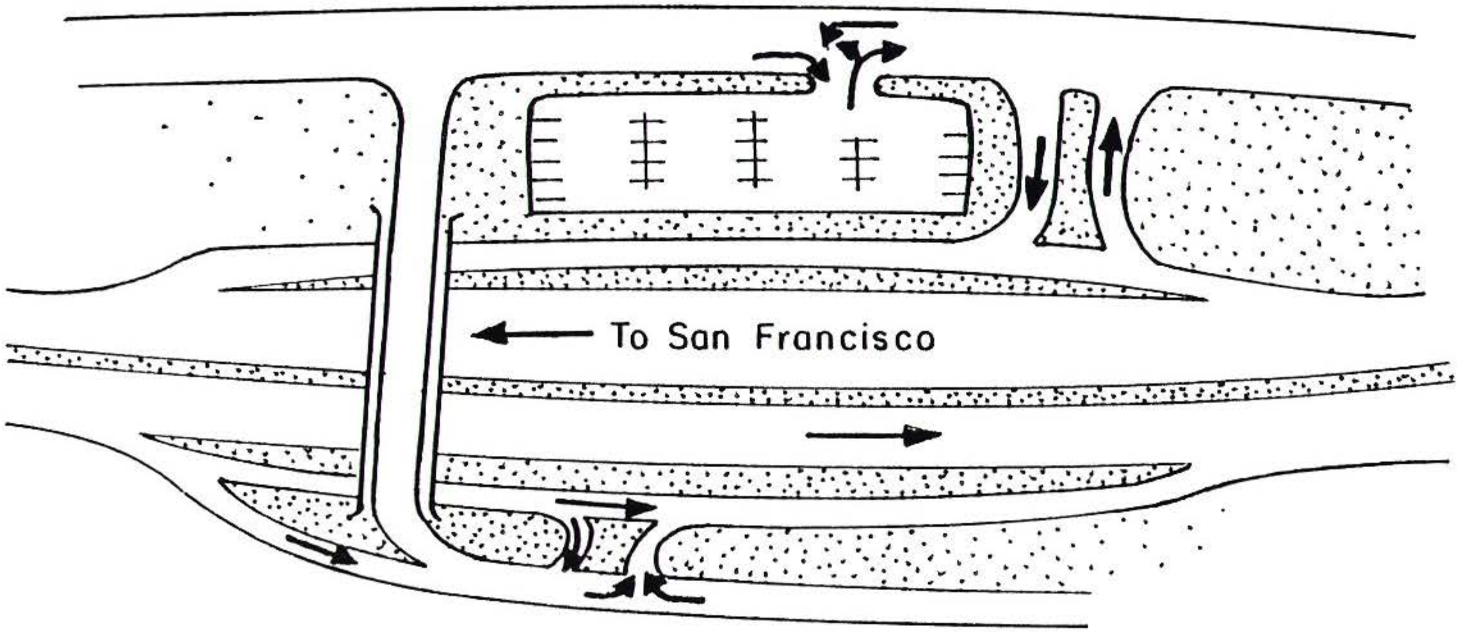


Fig. 18 - Park-and-Ride Lot with Convenient Access via Frontage Roads

A clearly visible lot may also attract new users. If commuters who presently drive alone can see others using the lots, and that parking spaces are still available, some attitudinal barriers to ridesharing may be broken down.

3.5 Signing

Park-and-ride lots should be identified by signs at and leading to their entrances. Signs assure motorists that it is legal to leave their cars in the lot. Standard signs (e.g., sign D4-2 of the Manual on Uniform Traffic Control Devices for Streets and Highways or sign G95 in the specification sheets of the California Department of Transportation, should be used.

Trailblazer signs help users find lots until they become familiar with the routes to their entrances. These signs are especially useful where the park-and-ride lot must be accessed from a frontage road or side street. Even where the lot is adjacent to a main arterial, signs can identify the exact location of entrances and the turning maneuvers required to use them.

A sign should be placed along the freeway in the downtown-bound direction to announce the availability of a park-and-ride lot at the next interchange. Even a lot which is already used to capacity should be identified in such a manner, since carpool membership often changes, and new users should be made aware of the existence of the lot. In any case, such signs are another general form of advertising ridesharing.

3.6 Landscaping

Landscaping can help reduce the adverse visual impacts of parking lots, and adds to user satisfaction with the program. It may also increase feelings of security for lot users: a lot which is obviously being maintained appears to be a safer location than a patch of untended gravel or broken pavement.

The most important consideration for landscaping is its appropriateness for the site; unnecessary landscaping means unnecessary capital and maintenance costs. There is no point in planting a botanical garden at a parking lot which is surrounded by nothing but brush and freeway. On the other hand, landscaping should not be neglected in residential and other urban areas, especially where the community shows signs of objecting to the intrusion of the new facility. At no time should landscaping interfere with important sight lines, especially at lot entrances and exits. Existing vegetation can be used effectively in many locations.

3.7 Illumination

Park-and-ride lots should be adequately illuminated, unless the remoteness of the nearest power source would raise the capital cost beyond what is feasible. Lighting, like good visibility, helps people feel secure about using the lot and leaving their cars for long periods of time.

Many lots rely on illumination from adjacent streets and interchanges. This lighting should be checked at the site to ascertain its adequacy.

3.8 Shelters

Shelters are a desirable amenity, if their construction and maintenance are financially feasible. If the lot is transit-oriented, the transit agency may be able to provide the shelter as a part of its total program of deploying shelters at important bus stops.

Specifications for the design of shelters are fairly standard; examples are found at many transit bus stops and at shuttle bus stops in remote airport parking lots. When a shelter is to serve persons awaiting pool vehicles, it should be located in such a fashion that a pool car or van loading passengers does not block other traffic and does not have to follow a circuitous route through the lot.

To be useful, a shelter must be maintained in a clean and sanitary condition, and free from graffiti and broken or scratched window panels. If illumination is provided for the lot generally, the shelter should also be lighted; this lighting should be controlled to operate during commute periods in darkness only, but including the evening commute hours when the shelter might be used by persons waiting to be picked up for the ride home.

3.9 Bicycle Lockers

Bicycle access to park-and-ride lots should be encouraged, since this mode of access uses no petroleum fuel, does not add to air pollution, and requires less vehicle storage space at the lot. However, it must be possible to bicycle safely to the lot.[3]

Bicycling is most likely to occur at lots which are near residential areas, as contrasted to those at rural interchanges. It seems to be especially popular at transit-oriented lots. Mean access distances will probably not exceed two or three miles. Topography and local street conditions will also affect demand; bicyclists avoid steep hills and busy roads with unpaved shoulders.

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[3]For example, there is no feasible bicycle access to the lot located at the Dumbarton Bridge toll plaza.

However, bicyclists also will be reluctant to use this mode of access unless bicycle lockers are provided. Even if bicycles are securely locked to a fence or post, they are subject to vandalism during the long midday hours when the lot is not frequented, and they are, of course, subject to the elements. Lockers should be clearly visible from outside the lot; the best location is probably adjacent to the lot entrance, where many lockers have already been placed at existing lots.

3.10 Telephone

A public telephone is a highly desirable feature of any park-and-ride facility, both for normal use--such as making calls if a connecting vehicle does not appear--and for emergencies.

4. CONCLUSIONS

This study corroborates previous reports showing that park-and-ride lots constructed along state highways in commuting corridors are well patronized and make a substantial contribution to saving vehicle-miles with related travel costs, fuel consumption, and--in very congested corridors--probably also total travel time for all motor vehicles.

Transit riders and participants in ridesharing programs follow the normal tendencies (Wardrop's Law) and attempt to minimize their individual travel times and costs. Therefore, they seek the most convenient locations to join the HOV involved, which often are along a major radial highway near their homes. Where no formal parking lot is provided in which they can leave their cars during the day, they will park at the nearest convenient spot--the curb or shoulder of intersecting or frontage roads, an empty lot, or a nearby parking lot intended for some other purpose. As mentioned in this report, this is often an unsatisfactory and, at times, an unsafe arrangement.

Benefits and, therefore, use increase with increasing length of the "line haul" portion of the commute trip in the HOV. Hence, another conclusion is that highest priority should be given to lots more than 20 miles from major employment centers for ridesharing programs, and more than 10 miles from such centers for transit-related lots.

The first step in lot design (and, in fact, when determining the suitability of a parcel of land for parking purposes) is to locate the entrance and exit in such a manner that circuity of access is minimized and that difficult turning maneuvers in and out of the lot are eliminated. The lot should be clearly visible from the highway(s) interchanging with the freeway and, if possible, from the freeway itself. Trailblazer signs should be used to guide new users to the lot.

Where possible, lots should be paved (with well-maintained stall and aisle markings), landscaped, lighted, provided with passenger shelters, bike lockers, and public telephones, and maintained in a clean condition. They should be observed by police patrols from adjacent highways and occasionally patrolled directly. Occasional midday surveys should ascertain whether a lot is becoming overcrowded and warrants expansion or construction of a new lot at a nearby location.

The total benefits or benefit-cost relationships of a program of constructing park-and-ride lots cannot be quantified reliably from available data. There is no doubt that benefits exceed costs, especially because the latter are relatively low if land is already owned by the public or if a joint-use contract with the owner of an existing lot is being signed. New surveys eliciting more precise data on user benefits should be conducted if such quantitative analyses are desired.

Particular attention in future research should be paid to identifying the reduction in peak period traffic flow on the highway links between the park-and-ride lots and employment locations, and the concomitant change in the level of service and average travel speeds on these highways. Such research, for which available traffic flow simulation models might be used, could identify aggregate benefits for the general public traveling on these highways as great as or greater than those reaped by the participants of the ridesharing programs. For example, the combined effect of all lots strung out along US 101 north of San Francisco is probably a reduction in delays on the Golden Gate Bridge and its approaches of a magnitude whose value (in terms of person-hours saved and lower vehicle operating costs) far exceeds the benefits perceived by the users of these lots.

It is therefore a conclusion of this report that the benefits of a park-and-ride lot construction and operation program are very substantial, but that it still remains to be seen just how great they are.

APPENDIX A

Caltrans
CALIFORNIA DEPARTMENT OF TRANSPORTATION

FOR OFFI[illegible]
SERIAL NO. (1-7) 08713
DISTRICT ☐☐ (8-9)
FACILITY ☐☐ (10-11)

Month	Day	Year
☐☐	☐☐	☐☐
(12-13)	(14-15)	(16-17)

☐ D, R, L, O
(18)

Dear Park and Ride Lot User:

This survey is being conducted to help Caltrans evaluate the effectiveness of the Park and Ride Program.

Your cooperation in filling out this form and leaving it with the survey attendant before leaving the lot today will be especially appreciated. It should take no longer than five minutes to complete the questionnaire. In case you cannot take a few minutes now, another survey attendant will be here after 3:30 p.m. to pick up the questionnaire on your return trip.

Please answer all questions on both sides of this form by filling out the requested information or by checking the appropriate box.

1. How did you travel to this Park and Ride Lot this morning? *(Check one box only.)*

(19)
- a. ☐ Drove alone - parked car
- b. ☐ Drove alone - did not park car
- c. ☐ Carpooled with others - parked car
- d. ☐ Carpooled with others - did not park car
- e. ☐ Vanpooled with others
- f. ☐ Dropped off
- g. ☐ Bus
- h. ☐ Bicycle
- i. ☐ Walked
- j. ☐ Other ______________ *(Please specify)*

2. Approximately how many miles is your trip origin from this Park and Ride Lot? __________ (miles) *(If you do not know the exact mileage, please record your best estimate.)*
(20-21)

3. How are you traveling from this Park and Ride Lot to your destination this morning? *(Check one box only.)*

(22)
- a. ☐ Carpool with others
- b. ☐ Vanpool with others
- c. ☐ Public transit
- d. ☐ Other ______________ *(Please specify)*

4. Before using this Park and Ride Lot, how did you usually travel to your destination? *(Check one box only.)*

(23)
- a. ☐ Drove alone
- b. ☐ Public transit
- c. ☐ Carpooled with others
- d. ☐ Vanpooled with others
- e. ☐ Motorcycle
- f. ☐ Bicycle
- g. ☐ Taxi
- h. ☐ Other ______________ *(Please specify)*
- i. ☐ Did not make such a trip

5. What is the purpose of the trip to your destination this morning?

(24)
- a. ☐ To go to work
- b. ☐ To go to school
- c. ☐ To go shopping
- d. ☐ Other purpose ______________ *(Please specify)*

6. Since starting to use this Park and Ride Lot, have your miles PER WEEK as a driver to and from your destination decreased or increased?

(25) 1. ☐ Decreased 2. ☐ Increased 3. ☐ No change

(26-28) By approximately how many miles? __________ **PER WEEK** *(If you do not know the exact mileage, please record your best estimate.)*

(PLEASE COMPLETE THE REVERSE SIDE ALSO)

If you travel from this lot in a carpool or vanpool, answer Question 7.

7. Please check the box below that most clearly indicates how much influence the existence or availability of the Park and Ride facility played in your decision to join, form or expand a carpool or vanpool.

The existence or availability of the Park and Ride facility:

(29)

a. ☐ Did not at all influence my decision to join, form or expand a carpool or vanpool.

b. ☐ Partly influenced my decision to join, form or expand a carpool or vanpool.

c. ☐ Highly influenced my decision to join, form or expand a carpool or vanpool.

d. ☐ Completely influenced my decision to join, form or expand a carpool or vanpool.

If you ride a bus from this lot, answer Question 8.

8. Please check the box below that most clearly indicates how much influence the existence or availability of the Park and Ride facility played in your decision to take a bus to your destination in the morning.

The existence or availability of the Park and Ride facility:

(30)

a. ☐ Did not at all influence my decision to take the bus to my destination in the morning.

b. ☐ Partly influenced my decision to take a bus to my destination in the morning.

c. ☐ Highly influenced my decision to take a bus to my destination in the morning.

d. ☐ Completely influenced my decision to take a bus to my destination in the morning.

9. Please write any comments or suggestions you have concerning the Park and Ride Program in the space below.

PLEASE RETURN THE COMPLETED QUESTIONNAIRE TO THE SURVEY ATTENDANT.
THANK YOU VERY MUCH FOR YOUR COOPERATION.

APPENDIX B - COMPARISON OF SURVEY RESPONSES TO TALLY OF OBSERVED USERS (BY MODE)

District	Lot	Total		Carpool		Vanpool		Transit		Other		Comments
		Surveyed (upper entry) and Observed (lower entry) Numbers and Percentages										
4	1	22	100%	22	100%	0	0%	0	0%	0	0%	OK
		24	100%	24	100%	0	0%	0	0%	0	0%	
4	2	97	100%	21	22%	25	26%	45	46%	6	6%	Carpools underrepresented
		137	100%	47	34%	21	15%	62	45%	7	5%	in survey.
4	3	271	100%	101	37%	14	5%	142	52%	14	5%	Transit underrepresented
		352	100%	98	28%	17	5%	218	62%	19	5%	in survey.
4	4	122	100%	6	5%	2	2%	114	93%	0	0%	OK
		242	100%	22	9%	0	0%	220	91%	0	0%	
4	5	23	100%	14	61%	8	35%	0	0%	1	4%	*Observation tally
		16*	100%	9*	56%	7*	44%	0	0%	0	0%	is inaccurate.
4	6	66	100%	57	86%	9	14%	0	0%	0	0%	*Probably people walking
		95	100%	78	82%	9	10%	0	0%	8*	8%	out of the lot to meet pool vehicles.
4	7	52	100%	29	56%	21	40%	1	2%	1	2%	*Observation tally
		55	100%	41	75%	14*	25%	0	0%	0	0%	missed vanpoolers.
4	8	6	100%	6	100%	0	0%	0	0%	0	0%	OK
		5	100%	5	100%	0	0%	0	0%	0	0%	
4	9	31	100%	26	84%	4	13%	0	0%	1	3%	*See comment for Lot 4/6
		42	100%	31	74%	0	0%	0	0%	11*	26%	above.
4	10	31	100%	16	52%	3	10%	11	35%	1	3%	OK
		46	100%	23	50%	1	2%	21	46%	1	2%	
4	11	42	100%	31	74%	8	19%	2	5%	1	2%	OK
		50	100%	40	80%	8	16%	2	4%	0	0%	
4	12	14	100%	13	93%	1	7%	0	0%	0	0%	OK
		32	100%	31	97%	1	3%	0	0%	0	0%	

District and Lot		Surveyed (upper entry) and Observed (lower entry) Numbers and Percentages: Total		Carpool		Vanpool		Transit		Other		Comments
4	13	19 23	100% 100%	19 23	100% 100%	0 0	0% 0%	0 0	0% 0%	0 0	0% 0%	OK
4	14	53 76	100% 100%	27 37	51% 49%	5 2	9% 2%	3 37*	6% 49%	18* 0	34% 0%	*These numbers probably include subscription bus.
4	15	7 9	100% 100%	7 9	100% 100%	0 0	0% 0%	0 0	0% 0%	0 0	0% 0%	OK
4	16	129 214	100% 100%	38 71	29% 33%	6 8	5% 4%	67 95	52% 44%	18 40	14% 19%	OK
4	17	46 67	100% 100%	17 22	37% 33%	0 0	0% 0%	24 38	52% 57%	5 7	11% 10%	OK
4	18	24 30	100% 100%	23 25	96% 83%	0 0	0% 0%	1 0	4% 0%	0 5*	0% 17%	*See comment for Lot 4/6 above.
4	29	9	100%	1 - - - - - No observation tally data - - - - -	11%	0	0%	7	78%	1	11%	
6	5	12 17	100% 100%	12 17	100% 100%	0 0	0% 0%	0 0	0% 0%	0 0	0% 0%	OK
7	7	87	100%	26 - - - - - No observation tally data - - - - -	30%	45	52%	16	18%	0	0%	
7	18	70	100%	10 - - - - - No observation tally data - - - - -	14%	8	11%	52	74%	0	0%	
7	30	76	100%	56 - - - - - No observation tally data - - - - -	74%	20	26%	0	0%	0	0%	
7	31	215	100%	149 - - - - - No observation tally data - - - - -	69%	65	30%	0	0%	1	1%	

District and Lot		Surveyed (upper entry) and Observed (lower entry) Numbers and Percentages										Comments
		Total		Carpool		Vanpool		Transit		Other		
7	32	59 96	100% 100%	36 63	61% 66%	23 33	39% 34%	0 0	0% 0%	0 0	0% 0%	OK
7	33	42	100%	41	98%	1	2%	0	0%	0	0%	
				- - - - - - No observation tally data - - - - - -								
7	34	6 12	100% 100%	6 12	100% 100%	0 0	0% 0%	0 0	0% 0%	0 0	0% 0%	OK
7	35	54 89	100% 100%	20 28	37% 31%	31 56	57% 63%	3 5	6% 6%	0 0	0% 0%	Vanpools underrepresented in survey.
7	36	42 55	100% 100%	37 48	88% 87%	5 7	12% 13%	0 0	0% 0%	0 0	0% 0%	OK
8	1	118 152	100% 100%	86 94	73% 62%	30 58	25% 38%	0 0	0% 0%	2 0	2% 0%	Vanpools underrepresented in survey.
8	4	16 34	100% 100%	8 13	50% 38%	3 14	19% 41%	0 7*	0% 21%	5* 0	31% 0%	*These numbers probably are subscription bus.
8	5	205 274	100% 100%	51 54	25% 20%	90 134	44% 49%	8 86*	4% 31%	56* 0	27% 0%	*These numbers probably include subscription bus.
8	6	119 174	100% 100%	15 38	13% 22%	13 18	11% 10%	90 118	76% 68%	1 0	1% 0%	Carpools underrepresented in survey.
8	7	59 71	100% 100%	27 21*	46% 30%	32 50	54% 70%	0 0	0% 0%	0 0	0% 0%	*Observation tally missed carpoolers.
8	9	7 26	100% 100%	6 13	86% 50%	1 13	14% 50%	0 0	0% 0%	0 0	0% 0%	Vanpools underrepresented in survey.
8	10	41 66	100% 100%	16 32	39% 48%	22 31	54% 47%	2 3	5% 5%	1 0	2% 0%	Carpools underrepresented in survey.
8	12	7 8	100% 100%	0 8	0% 100%	7 0	100% 0%	0 0	0% 0%	0 0	0% 0%	Survey or observation tally misclassified users.

APPENDIX C

Caltrans
CALIFORNIA DEPARTMENT OF TRANSPORTATION

Dear Commuter:

The California Department of Transportation is taking a survey to find out if there is a need for "Park and Ride" lots in this area. These are free lots that are built to encourage carpooling, vanpooling, and public transit use.

We would appreciate your help. Would you kindly take a few minutes to fill out and mail in the postage free card below.

Thank you for your cooperation.

California Department of Transportation

(Detach and Mail)

QUESTIONNAIRE

When you park here, what city or area are you going to? ____________________

How do you travel from here?
Carpool ☐ Vanpool ☐ Bus ☐ Other: ____________________

What is the purpose of this trip?
Work ☐ School ☐ Shopping ☐ Other: ____________________

What is the nearest intersection to where you live?
____________ Street at ____________ Street. City: ____________________

Have you had any problems parking here? Yes ☐ No ☐

Type of problems: ____________________

Is there any other highway interchange where you would rather park but can't?
Yes ☐ No ☐ Location: ____________________

Do you think that off-street parking should be built near this location? Yes ☐ No ☐