ATTACHMENT B

ATTACHMENTS TO COMMENT LETTER AL072

EXHIBIT 1

Map of Federal, State and Privately Owned Lands in GEA

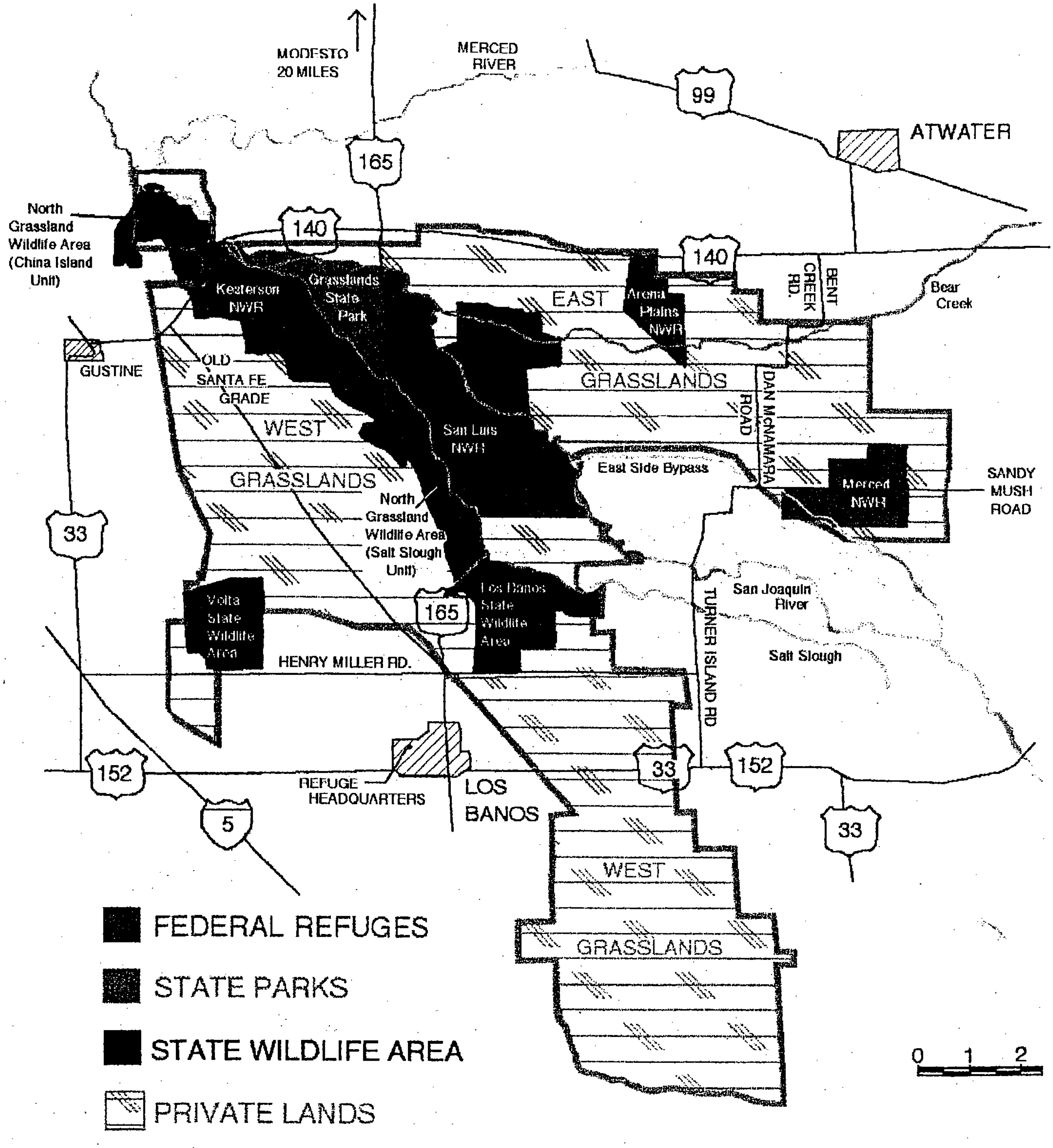
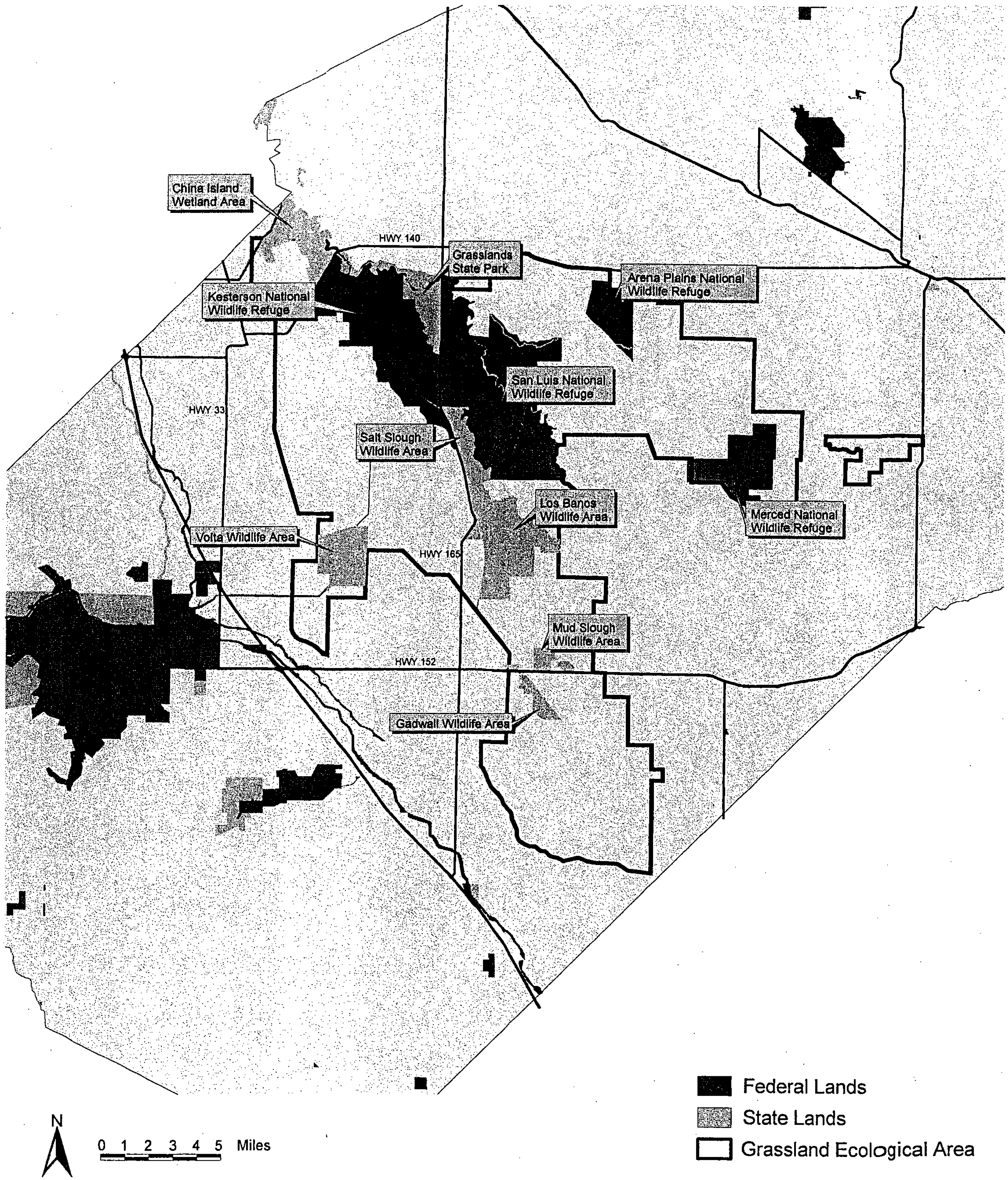


Fig. 3. Federal, State and private owned lands in the Grasslands area.

EXHIBIT 2

Map of GEA and Public Lands

Figure 2
Grassland Ecological Area and Public Lands



Source: MDSS
Map: Thomas Reid Associates, 6/20/01

EXHIBIT 3

Terry Watt Comments and Attachments A - E

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GROWTH INDUCING IMPACTS OF THE HIGH SPEED TRAIN PROJECT ON THE GRASSLAND ECOLOGICAL AREA

The DEIR/S fails to analyze the growth inducing impacts of the HST project on the Grassland Ecological Area in Merced County.[1] The Grassland Ecological Area is an irreplaceable, internationally significant ecological resource located just north and east of Los Banos. The proposed Pacheco Pass Alignment would bisect this area causing fragmentation and other direct impacts. More ominously, the growth-inducing impacts of locating a train station, the Los Banos Station, in Santa Nella would most likely result in urban encroachment and development pressures that could doom this area. The protection of this area has been the result of private and public partnerships. Much of the area is privately owned managed wetlands used for duck hunting clubs. The DEIR/S makes no mention of this area and fails to address the significant growth inducing impacts of HST alternative on this area.

CEQA requires that an EIR contain an analysis of a project's growth inducing impacts. Growth-inducing impacts are those that encourage or facilitate other activities or projects that could significantly affect the environment. The "detailed statement" setting forth the growth inducing aspects of a project must "[d]iscuss the ways in which the proposed project could foster economic growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment." CEQA Guidelines Section 15126.2(d). It must also discuss how a project may "encourage or facilitate other activities that could significantly affect the environment, either individually or cumulatively" or remove obstacles to population growth. Population growth in turn may impose new burdens on existing or planned community services. Similarly, NEPA requires that agencies consider the indirect effects of a proposed action, such as growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate. 40 CFR 1508(b).

The general analysis of growth inducement that is included in the DEIR/S fails to accurately analyze and document the likely growth that could be induced and erroneously concludes that growth induced by HST will be beneficial after mitigation strategies are imposed. Lead agencies

[1] Ed Thompson, Esquire, President of American Farmland Trust California, contributed to this section. In preparing her comments, Terrell Watt reviewed the applicable general plans and zoning for the proposed Los Banos station and Pacheco alignment in the Grasslands area.

must not assume growth induced in an area is beneficial or of little consequence until it has completed open minded analysis. CEQA Guidelines section 15126.2, subd.(d). Here the DEIR/S conclusions concerning growth inducement are not supported by evidence. The exercise of analyzing growth inducement is technically feasible and must be included in a revised DEIR/S.

Major flaws in the DEIR/S approach to growth inducement include but are not limited to the following:

First, the DEIR/S fails to provide any analysis of the growth inducing potential of the proposed alternatives and in particular of the HST alignment and rail station in the Merced Grasslands area. In fact, this important ecological area is not mentioned in the DEIR/S discussions of land use, loss of agricultural land or economic growth and related impacts. The proposed Los Banos station is actually located in the small unincorporated community of Santa Nella in the County of Merced, near the small city of Los Banos. The station location is currently general planned for and zoned A-1, General Agricultural in the Merced County General Plan and is adjacent to the Grassland Ecological Area. The Merced County General Plan describes the uses in agricultural areas as follows:

> The Agricultural Residential land use designation is generally applied to areas considered appropriate for the construction of single-family dwelling units on large lots in a semi-rural environment, with less than a full range of public services. General Plan Land Use Element page I-19.

The General Plan land use map shows a range of large-lot rural parcel sizes in the A-1 areas. While the DEIR/S fails to analyze growth inducing impacts on this specific area, it does conclude that HST would make it possible for people living almost anywhere in the Central Valley to commute to employment centers in Sacramento, the Bay Area and Los Angeles. "Transportation investments can lead to reduced travel time or cost [and] improved accessibility to regions." DEIR/S page 5-1. With respect to the general growth inducing impacts on Merced County, the DEIR/S is clear that the most dramatic increases in employment and population willoccur in that County:

- ...while under the HST Alternative, Merced, San Francisco, and Sacramento Counties are projected to exhibit the highest growth rate. DEIR/S page 5-14.
- Significant increases in both employment and population would occur with HST in Merced County over 2002 and No Project conditions. See Table 5.3-5 and Figures 5.3-2 to 5.3-4.
- ...the HST Alternative could be a strong influence in attracting higher-wage jobs to the Central Valley. DEIR/S page 5-18 and Tables 5.3-5 to 5.3-7.
- The largest increase in population and employment (4%) would occur in the Northern Central Valley region under the HST Alternative. DEIR/S page 5-23. For example, Merced County would exhibit the largest relative increase in both

population and employment with implementation of the HST Alternative. DEIR/S page 5-25.

- Increased employment opportunities should lead to personal income growth in all regions of the state; this growth might be most pronounced in counties of the Northern Central Valley under the HST Alternative, since that region is projected to experience the largest employment gain. DEIR/S at 5-26.

Elsewhere, the DEIR/S concludes that HST will increase population by only 162,000 more than the 6.5 million new residents expected to be in the Central Valley by 2035, accounting for only 3% of the projected increase (above). The "blackbox" growth model by Cambridge Systematics, Inc., (CSI), which underlies the DEIR/S analysis, bases its conclusions concerning growth inducement on the number of jobs within a 90-mile radius. Notwithstanding the overwhelming evidence that this approach applied to remote areas like the Grasslands would result in tremendous growth pressure, the DEIR/S concludes that HST will make little difference in the future population of the Central Valley. This conclusion is simply wrong.

As recent growth patterns have indicated elsewhere in California, accessibility to major employment centers has triggered tremendous new growth.[2] The introduction of HST to the Grasslands area will make it possible for Bay Area residents to easily commute to and from them affordable suburban and rural housing in and around the Grasslands area and create significant pressure for growth of housing and new services in the area. That pressure will extend to the privately held lands in and around the Grasslands that are not permanently protected. Additional growth in the area also poses significant indirect threats as a result of increased population and pressure on farmlands and open space. The Merced County General Plan and Los Banos General Plan's lend themselves to a pattern of suburban and rural sprawl due to the predominance of low density general plan and zoning. The relative affordability of homes and property in the area will be a tremendous draw for Bay Area workers to move to the area.[3] A revised DEIR/S must disclose and analyze the likely growth inducing impact of HST on the area including how introduction of the station is likely to accelerate growth and increase demand for subdivisions and development.

Second, the DEIR/S conclusions that HST will lead to more efficient use of the land and higher densities are simply not supported by the general plans or by evidence in the DEIR/S. Incredibly, the DEIR/S concludes that the HST Alternative will result in significant land use efficiencies over both the No Project and Modal Alternatives:

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[2] Examples include the Auburn corridor as major new employers moved to the Sacramento region and north; the Truckee area which is approximately 1 hour from the major new job growth in the Auburn Corridor and Reno. Historical growth patterns in California clearly demonstrate that the close proximity of a major job center inevitably leads to growth inducement for housing within commute range. HST will render the Grasslands area within close commute range to major job centers in the Bay Area.

[3] As of the 2nd quarter of 2004, a median priced home in Merced County cost $228,000 and in Los Banos cost $265,500. By comparison, during the same quarter a median priced home in San Jose cost 507,750, nearly twice the cost of median priced home in the area near the proposed Los Banos station. In Gilroy during the same period, a median priced home cost $550,000. See Attachment A hereto, California Real Estate Statistics for Merced and Santa Clara counties.

Without analysis of facts the DEIR/S concludes that HST will minimize a variety of impacts normally associated with growth due to its inherent incentives for directing urban growth:

> "In short, the HST Alternative provides a strong incentive for directing urban growth and minimizing a variety of impacts that are frequently associated with growth. This outcome would be seen in results for resource topics such as farmland, hydrology, and wetlands, where the indirect effects of the HST Alternative are less than the Modal Alternative, and in some cases less than the No Project Alternative, even with more population and employment expected with the HST Alternative." DEIR/S page 5-34.
>
> "Nonetheless, the results indicate that the HST Alternative would be able to accommodate more population and employment growth on less land than the other alternatives." DEIR/S page 5-10.

The DEIR/S continues on to conclude that the growth potential with HST is "potentially beneficial" with mitigation strategies. DEIR/S Table 7.3-1. These conclusions are not supported by adequate and transparent analysis or substantial evidence. Review of the applicable general plans in the Merced Grasslands area suggests that the introduction of HST will not only induce significant new growth but that the growth will occur in suburban and rural sprawl patterns most harmful of habitat areas and farmland. Major studies have also shown that the introduction of transportation facilities redirects growth. In this case, if alignments and stations are located in rural areas, growth and development in California could actually be redirected away from existing urban areas and into more remote rural areas where high value agricultural and habitat lands occur. See Attachment B. This would be far from a "smart growth" or beneficial effect of HST. A revised DEIR/S must indicate the likely increase in subdivisions of rural land and map those privately owned lands that will be subject to growth and development pressures.

Third, the DEIR/S fails to disclose the likely increase in demand in areas served by HST for second homes. The spectacular open space setting in and around the Grasslands area is highly attractive for a second home market. The DEIR/S is silent on this potential growth inducing impact. The market for second homes has increased along with disposable income of the large baby boom segment of the population.[7] A revised DEIR/S must include analysis of this potentially significant impact on rural areas proposed to be served by HST.

Fourth, the new Los Banos station is likely to require major new infrastructure and services. The DEIR/S fails to reveal the extent of these facilities nor does it analyze the growth inducing impact these new facilities will have in the immediate area of the station. A revised analysis must include information about the types of services and infrastructure needed for the station and how the extension of those facilities will remove an existing barrier to growth in the area. Specifically, the DEIR/S should describe the current general plan and zoning of the station site and surrounding areas; the existing status of services and infrastructure; services and infrastructure that will be provided to serve the station; and the likely growth inducing effect of the station and those facilities on adjacent lands.

[7] See Attachment C, Baby Boomer Investors Fueling Second Home Market Sales.

- Establishment of urban growth boundaries in communities traversed by HST and stations are located;
- Limits on new subdivisions outside of urban growth boundaries and the like.

Even with these measures identified in a revised DEIR/S, additional evidence must be provided that they would actually have the desired affect in rural areas.

If they are wrong, CSI concedes that the model would produce a very different result, presumably a much greater impact on the Central Valley.

> "While the exact role of particular factors [shaping land development patterns] varies by region, several influences are consistently important, including proximity to freeways, access to jobs, site slope and site incorporation status. To the extent that these factors are less important in the future, or are important in different ways – or, as is even more likely, that other factors become important – the model results will vary widely than [sic] what is presented here." CSI, at H-5

Based on empirical evidence, highly regarded academic studies of the relationship of transportation and growth and proximity of job centers to growth, the introduction of an HST alignment and station will have a substantial and adverse growth inducing impact on the Los Banos, Merced area. Stated in clear terms, the DEIR/S and CSI have incorrectly concluded that the growth inducing effects of HST will be insignificant and possibly even beneficial. A revised DEIR/S must include a completed revised and transparent analysis of the significant and likely adverse growth inducing impacts of HST where it is located in rural areas of California, including the Los Banos, Merced area. The new analysis must include effective mitigation measures capable of reducing or eliminating these significant effects, such as those listed above. The benefits of HST may be realized, but only if the project is redirected to serve existing urban corridors and strong land use policies are required in advance of its construction to ensure that HST does not lead to sprawling suburban and rural development and loss of high value California landscapes such as the irreplaceable Grassland Ecological Area in Merced County.

CAR statistics

	2nd Qtr 2004	2nd Qtr 2003	
Merced County	$228,000.00	$188,000.00	21.3%
Atwater	$217,000.00	$177,000.00	22.6%
Los Banos	$265,500.00	$240,000.00	10.6%
Merced	$215,000.00	$185,000.00	16.2%

Santa Clara County	$540,000.00	$469,000.00	15.1%
Campbell	$566,000.00	$486,000.00	16.5%
Cupertino	$755,000.00	$674,000.00	12.0%
Gilroy	$550,000.00	$470,000.00	17.0%
Los Altos	$1,350,000.00	$1,115,000.00	21.1%
Los Gatos	$920,000.00	$735,000.00	25.2%
Milpitas	$503,000.00	$419,000.00	20.0%
Morgan Hill	$624,000.00	$520,000.00	20.0%
Mountain View	$575,000.00	$500,000.00	15.0%
Palo Alto	$857,500.00	$699,250.00	22.6%
San Jose	$507,750.00	$440,000.00	15.4%
Santa Clara	$535,000.00	$487,500.00	9.7%
Saratoga	$1,175,000.00	$1,108,000.00	6.0%
Sunnyvale	$575,000.00	$500,000.00	15.0%

Median home prices contained in this chart were generated from DataQuick Information Systems. The price statistics are derived from all types of home sales – new and existing, condos and single-family. Movements in sales prices should not be interpreted as changes in the cost of a standard home. Median prices can be influenced by changes in cost, as well as changes in the characteristics and size of homes sold. Due to the low sales volume in some cities or areas, median price changes may exhibit unusual fluctuation. N.A. = Not available.

May 8, 2003

New Study Finds Roads Just Redistribute Growth

Changes in Transit-Oriented Development Could Balance Disparities

WASHINGTON, DC — Highway critics have focused on the way new roads increase congestion when they should be looking at how road improvements redistribute regional growth, contends Robert Cervero, a University of California at Berkeley planning professor and author of a groundbreaking study published in the Spring 2003 issue of the *Journal of the American Planning Association* (JAPA).

- Click here to read the complete article

"Roads induce growth at a corridor scale; however they don't do so at a regional scale," Cervero found. "Induced growth along [highway] corridors is really redistributed regional growth."

The article is titled "Road Expansion, Urban Growth, and Induced Travel: A Path Analysis," and was supported by a grant from the University of California Transportation Center.

Cervero's findings could have significant impact on billions of dollars of road projects as traffic forecasters try to unscramble the tangled interaction between congestion and new development. Many regional transportation plans have been mired in political squabbles over whether new roads increase sprawl and the extra vehicle trips associated with it. Highway critics have long claimed that improved roads fuel "induced demand" — additional travel or diverted trips from parallel routes. Cervero's new research indicates that the claim might be exaggerated.

"The contention that capacity additions are quickly absorbed by increases in traffic and that "you can't build yourself out of traffic congestion" might not hold in all settings," he found.

How road expansions induce development along highways — a phenomenon Cervero calls "induced growth" — may be more important than whether highway expansions decrease congestion.

"Congestion relief ... does not necessarily make for a sustainable and livable metropolis," Cervero observed. "Thus residents of places that are able to build themselves out of traffic congestion might not necessarily like what they get."

"This is an important article on a very complex topic," said Stuart Meck, FAICP, a senior research fellow with the American Planning Association (APA). "State transportation departments often claim that they are only serving existing development, but this study shows that capacity improvements actually make matters worse in some cases, although the time frame is longer than many believe — as long as five to six years."

Cervero found that, over time, road improvements and the resulting swifter travel speeds spur building activities along highway corridors. That growth fuels more traffic which then erodes most of the speed benefits of added capacity.

"The dominant effect of building roads is likely to reshuffle growth within a region, not to add jobs and households," he concluded.

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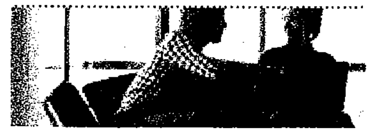

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Cervero's findings point up the need to do a much better job in managing regional development to balance the growth induced through highway expansions, Meck said.

One solution may be better planning of transit-oriented development (TOD). In an article in the May issue of *Planning* magazine, Cervero suggests that TOD in the United States is deterred by the huge parking lots surrounding metropolitan transit hubs.

"Not only do the big lots consume real estate near stations, but they also create unpleasant and sometimes unsafe walking environments," he notes.

Cervero touts "Green Connectors" — networks of pedestrian and bicycle friendly avenues that feed into major transit routes — as replacements for the asphalt jungles that take up valuable space that could be used for TOD. Green connectors have had enormous success in Europe and parts of Latin America. Cervero believes that carefully crafted public policies and planning visions can make them work here.

"If cities as varied as Stockholm and Bogota can successfully implement green connectors to trunk-line transit, so can American cities and suburbs," he claims.

Skeptics contend that experiences from Europe and Latin America cannot be imported successfully to the U.S. with its culture of independence and long love affair with the automobile.

That's hogwash, responds Cervero.

"Americans reveal their distaste for walking in unappealing environs by going great lengths to find a parking spot close to a shopping mall entrance. Yet they think nothing of walking one or two miles once inside," he notes.

"The difference is that malls are generally dreary on the outside but engaging on the inside — a useful lesson for other places."

Whether highway expansions will redistribute regional growth and whether green corridors can jump start the kinds of TOD that can offset those effects will all depend on strategic transportation planning based on sound econometric modeling. Cervero's studies and creative ideas provide a starting point in developing robust models for creating more livable communities.

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Road Expansion, Urban Growth, and Induced Travel: A Path Analysis

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July 2001

Abstract

Claims that roadway investments spur new travel and thus fail to relieve traffic congestion, known as induced demand, have thwarted road development in both the United States and abroad. Most past studies point to a significant induced demand effect. This research challenges past results by employing a path model to causally sort out the links between freeway investments and traffic increases, using data for 24 California freeway projects across 15 years. Traffic increases are explained in terms of both faster travel speeds and land-use shifts that occur in response to adding freeway lanes. While the path model confirms the presence of induced travel in both the short- and longer-run, estimated elasticities are generally lower than those of earlier studies. This research also reveals significant "induced growth" and "induced investment" effects – real-estate development has gravitated to improved freeway corridors and road investments have been shaped by traffic trends in California. Fighting road projects on the grounds of induced-demand should be carefully considered. Energies might be better directed at curbing mis-pricing in the highway sector and managing land-use changes spawn by road investments.

Road Expansion, Urban Growth, and Induced Travel: A Path Analysis

Few issues in the urban transportation field have sparked as much controversy and threatened proposed road projects as claims of "induced demand". For decades, highway critics have charged that building new roads or expanding existing ones to relieve traffic congestion is a futile exercise. Improved roads simply spur additional travel or divert trips from parallel routes, quickly returning a facility to its original congested condition. Traffic is thought to behave more like a gas than a liquid – it expands to fill available space. Regional transportation plans, such as in the San Francisco Bay Area, have been mired in legal and political squabbles on the very grounds that they failed to account for the possibility that new roads might induce sprawl and the extra trips associated with it. Claims of induced demand have spawned such clichés as "build it and they will come" and "you can't pave our way out of traffic congestion".

The preponderance of empirical evidence to date suggests that induced effects are substantial. A widely cited study by Hansen and Huang (1997), based on 18 years of data from 14 California metropolitan areas, found every 10 percent increase in lane miles was associated with a 9 percent increase in vehicle miles traveled (VMT) four years after road expansion, controlling for other factors. Another study of 70 U.S. metropolitan areas over a 15-year time period concluded that areas investing heavily in road capacity fared no better in easing traffic congestion than areas that did not (Surface Transportation Policy Project, 1998). Based on a meta-analysis of more than 100 road expansion projects in the United Kingdom, Goodwin (1996) found that proportional savings in travel time were matched by proportional increases in traffic on almost a one to one basis, a finding that prompted the U.K. government to jettison its longstanding policy, "predict and provide", of responding to traffic-growth forecasts by building more motorways.

With the cumulative weight of evidence on induced demand threatening road projects in many parts of the United States, it bears noting that past research has recently come under fire on methodological grounds. Many studies can be faulted for failing to introduce a normative behavioral framework for tracing impacts, one that accounts for

intermediate steps between road improvements and traffic growth and that allows for two-way causality (DeCorla-Souza and Cohen, 1999; Cohen, 2001; Pickrell, 2001; Cervero, 2001).

Using data for a panel of California freeways, this paper aims to fill past methodological gaps by postulating and empirically testing a path model of induced travel. A short-run model, which focuses on relationships within a one-year time frame, holds that changes in road supply affect travel speeds, which nearly instantaneously affect traffic levels. In contrast to most recent analyses of induced demand that measure VMT growth as a direct function of lane-mile additions, this analysis introduces an important intermediate step – namely, that road improvements confer benefits, in the form of higher travel speeds, and that it is changes in operating conditions that influence demand, not the physical attributes (e.g., lane miles) of a project. A longer-run model traces how road investments induce major building activities over a multi-year time horizon, and how resulting land-use shifts in turn lead to increased travel. A feedback loop is also modeled, capturing how traffic growth influences road investment decisions.

Econometric models are called upon to sort out the relative influences of land-use shifts in stimulating traffic vis-à-vis travel behavioral adjustments that are normally associated with induced demand. To the degree that induced travel is found to be a consequence of long-term structural adjustments, land-use management and planning gains all the importance as a tool for managing traffic levels.

1. The Anatomy of Induced Demand

Road improvements are thought to have distinct near- and longer-term impacts. In the short run, increased capacity prompts *behavioral* shifts – some formerly suppressed trips are now made (i.e., latent demand), and some motorists switch modes, routes, and times of travel to exploit available capacity, what Downs (1962, 1992) calls "triple convergence". For example, those who previously patronized transit to work might decide to drive once they see traffic flowing more smoothly. Some who previously commuted on the shoulders of the peak might start filling freeway slots that are vacant in the heart of the peak. Over the longer term, *structural* changes can be expected. Notably, people and firms locate to exploit the accessibility benefits created when freeways are upgraded. The consequences dot America's landscape: fast-food restaurants, gas stations, and other auto-oriented uses cluster around interchanges, warehouses align themselves along frontage roads, and new residential subdivisions spring up along connecting arterials (Hartgen and Kim, 1998; Hartgen and Curley, 1999).

Some of the traffic gains spawn by a new or improved road are *generative* in nature and some are *redistributive*. The former represents new travel that did not previously exist in any form. Included here are formerly suppressed trips, longer trips as motorists opt to travel farther because of freer flowing traffic, and modal shifts. Route and schedule changes, on the other hand, are redistributive in the sense that they do not increase total miles traveled (assuming trips do not become more circuitous).

Short of placing an electronic tag on each traveler affected by a new road and monitoring his or her travel, disentangling the many contributors to increased travel – at least to a high degree of precision – can be a futile exercise (Bonsall, 1996). For this reason, many past studies have examined the magnitude of traffic increases following a road improvement for *all* sources combined. Some studies have employed county- or metropolitan-level data to trace the influences of aggregate increases in lane-miles on aggregate increases in vehicle miles traveled (VMT) (for example: Hansen and Huang, 1997; Noland and Cowart, 2000; Fulton, *et al.*, 2000). This helps to net out redistributive trips since route diversions occur largely within the unit of analysis, although the downside of such aggregate analyses is they are more easily prone to ecological fallacies when drawing statistical inferences.

Many past empirical studies have applied simplified model structures to gauge "induced demand" effects. Often, traffic increases are treated as a direct consequence of lane-mile additions. It is not the lane miles of roads that prompt people to travel more, however. Rather it is the benefits that the lane miles confer. Only if travel speeds increase and travel times fall will motorists gravitate to an improved corridor. Adding a 12-foot lane matters along a highly congested urban corridor; adding one to a lightly trafficked exurban stretch really does not. A firmer econometric framework is needed to help unravel the imbedded, often intricate relationship between road investments and traffic conditions.

2. Toward a Normative Theory: A Path Model

Figure 1 presents a path model for tracing the effects of road improvements on travel demand as well as urban development. The diagram's solid lines represent near-instantaneous impacts, occurring within a year's time. The dashed lines represent longer-term adjustments, signifying the need for a lagged model structure. In the transportation and land-use arena, delayed responses to "stimuli" like road improvements reflect

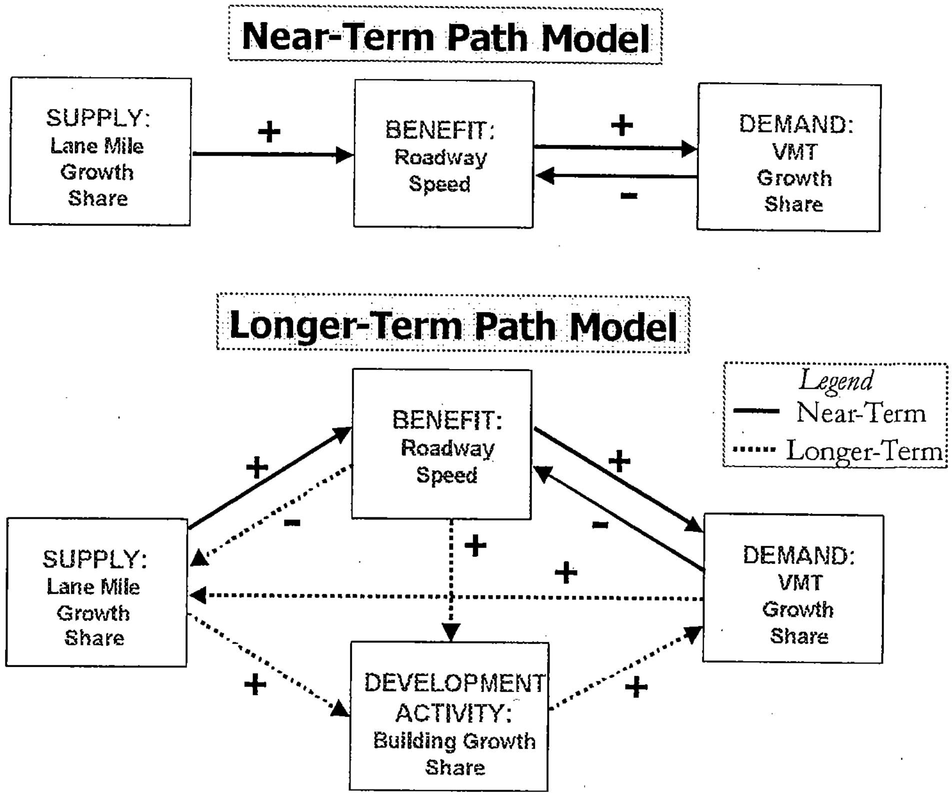

Figure 1. Hypothesized Path Model

institutional lags – such as the need for local planning agencies to rezone land to accommodate new growth or time spent by real-estate developers securing building permits and bank loans.

The path diagram also informs the model estimation process. In the case of uni-directional relationships (in both the near-term and longer-term models), ordinary least squares (OLS) provides efficient, unbiased estimates (as long as OLS assumptions are met). Estimation of two-way, co-dependent relationships hinges on the time structure. Where two variables, like travel speed and demand, nearly instantaneously influence each other, OLS will produce biased parameter estimates. This is because speed and demand are endogenously related. Accordingly, instrumental variables are needed to reduce simultaneous-equation biases. Where two variables are jointly related, and variable X influences variable Y nearly instantaneously but Y's effect on X is delayed over several years, OLS will generally provide suitable parameter estimates. Because the co-dependence is not contemporaneous, the value of one variable, by definition, will be pre-determined in relation to that of the other. For example, while a road improvement can be expected to have a near-immediate effect on travel speed, the effects of eroding speeds over time (once travel demand has risen) on the decision to further expand a facility unfold over a number of years. Econometrically, the values of travel speed in time period (t-n) are already known in relation to the values of road capacity in the current time period (t). Thus, wherever a solid path-line operates in both directions between two variables, multi-stage (e.g., two-stage or three-stage) estimation is called for. Wherever one path-line is solid and the other is dashed in a two-way relationship, instrumentation is unnecessary.

Effects of Road Improvements on Travel Speeds

This link is missing from most past studies of induced demand. Economic theory holds that road improvements spur behavioral changes in travel by reducing "generalized costs", expressed mainly in terms of travel times. Over a fixed distance, there is a one-to-one correspondence between changes in average travel times and average speeds. In this study, average recorded operating speeds over a one-year period for each study corridor is used to gauge reductions in generalized costs.

Effects of Road Improvements and Travel Speeds on Urban Development

In congested urban settings with reasonably vibrant economies, real estate developers scramble to acquire and develop properties with good regional roadway access. Parcels well-served by roads can yield handsome profits (Voith, 1993; Boarnet and Chalermpong, 2001). Two forces are set into motion that influence the decision to develop a parcel, and for modeling purposes help to define a time-lag structure. One is the announcement and construction of road improvements. Developers are well aware of roadway projects slated for construction under regional Transportation Improvement Programs and position themselves to take advantage of planned public improvements. Due to institutional delays, however, it can take several years before necessary permits are secured. A five-plus year time lag between project announcement and new development is not uncommon. The time lapse between when capacity is actually added and induced development occurs is likely shorter, often on the order of two to three years.

Besides the opening of new lanes, actual operating conditions are also thought to influence the scale of land-use changes, at least at the margin. Higher speeds provide confirmation, demonstrating first-hand that there are advantages to owning or leasing properties along a particular stretch of roads. The combination of past-year road investments and recent trends in operating speeds are thought to influence the amount of development added within a buffer zone of a freeway.

Effects of Travel Speeds and Urban Development on Travel Demand

It is this link of the path diagram that encapsulates the idea of induced demand. The model postulates that the combination of current operating speeds on a roadway and previous-year changes in urban development influence current-period demand levels. Both factors are thought to increase VMT -- the former in the near term, the latter over the longer run.

Effects of Travel Demand and Speeds on Road Improvements

Figure 1 also accounts for "induced investment" effects. Notably, changes in a project's share of countywide VMT over time can be expected to influence future shares of countywide road improvements targeted at the corridor, as will trends in travel speeds. Indeed, a criticism leveled at past induced demand studies is they ignored this feedback loop. Roads not only stimulate but also respond to demand. Using 60 years of data, a study by the Urban Transportation Center (1999) found that road improvements in metropolitan Chicago could be better explained by population growth a decade earlier than vice-versa. Over time, it is this combination of "induced demand" and "induced investment" effects that yields some degree of partial equilibrium between road supply and demand.

3. Methodology and Data

For purposes of empirically testing the hypothesized path model, a system of log-linear equations was specified and estimated. In this functional form, coefficient estimates represented elasticities, revealing the proportional change in one variable as a function of a proportional change in another, all else being equal. For the longer-run analysis, the within the four-mile buffer was determined. It was assumed that the share of a municipality's building activities within a four-mile buffer matched the share of that municipality's land area within the same buffer. This implicitly assumed that land-use densities were uniform within a municipality. This was felt to be a reasonable assumption given that densities tend to be fairly similar in most small-to-medium size suburban municipalities – the places traversed or bordered by the freeway projects that were studied. To the degree that errors were introduced in imputing building activities within four-mile buffers, there was no reason to suspect such errors were systematically biased.

Census records contained fairly detailed information (e.g., square-footage, number of units) on building activities, drawn from municipal and county building-permit records, across major residential and commercial land-use categories. To empirically test the "induced growth" hypothesis, a composite variable of "building activity" was created for each freeway corridor, gauging the relative degree of countywide development that occurred within a four-mile-wide impact zone. Creating such a variable was necessary since VMT changes were thought to be less sensitive to particular land uses than the overall amount of building activity that took place within a corridor. Because building-permit data on the "scale" of activities reported by the Census Bureau differed among land uses, a composite variable was needed. (For example, residential development is report by number of housing units whereas industrial growth is tracked in terms of building square footage.) The composite represented a weighted average of countywide proportions of each of the six land-use categories: single-family residential; multi-family residential; offices; retail; industrial; and other (representing mainly public and institutional uses). Weights were based on total square footage estimates for each land-use category. Local data on average building sizes were used to estimate total square footage of housing units, offices, and retail establishments.[i]

Induced Travel Versus Induced Demand

As noted previously, not all of the changes in VMT that occur along an improved roadway are truly "induced demand" since some of the traffic growth migrates from other facilities, and will thus be redistributed. The term "induced travel" is often used to represent all changes in trip-making that are unleashed when a road is improved, not only in terms of newly added traffic but also in terms of diverted trips from other routes (Hills, 1996; Lee, *et*

Operating Speed Model

The left-hand side of Table 3 presents a best-fitting log-linear model that predicts operating speeds for any time period as a function of predictor variables for the same time period. The coefficients for all but the fixed-effect control variables represent point elasticities. Values of the endogenous variable "VMT proportion" were estimated using instrumental variables (consisting of all exogenous and fixed-effect variables used in the simultaneous predictions of "operating speed" and "VMT proportion"). The estimated model explained over two-thirds of the variation in operating speeds across the 360 pooled time series and cross-sectional observations.

The results clearly show that operating speeds increased in step with gains in the share of countywide lane-miles along the study corridors. On average, every 10 percent increase in a facility's share of countywide freeway lane mileage was associated with a 4.2 percent increase in mean operating speed on that facility. As hypothesized, rising travel eroded some of the speed benefits conferred by a road. Based on elasticity values, however, it appears that VMT increases were not totally offsetting – that is, the speed-enhancing benefits of freeway expansions exceeded the speed-eroding impacts of rising VMT.

Consistent with theory, Table 3 also shows that operating speeds tended to fall in higher density settings. Moreover, there appeared to be secular declines in average freeway speeds, reflected by the consistent negative signs of time-series fixed effect variables (relative to the prior-year suppressed categories of 1980 and 1981).

Induced Travel Model

The near-term model that predicted VMT shares as a function of mean operating speeds is shown in the left-hand column of Table 4. Two-stage least squares (2SLS) estimation was used to provide instrumental-variable estimates of the endogenous variable, "operating speed", to reduce possible simultaneous-equation biases.

Statistically significant and positive induced travel effects were found, though it is noted that the estimated elasticity of 0.238 is considerably smaller than elasticities estimated in previous county-level studies drawn from California experiences that used lane-miles as a direct predictor (e.g., Hansen, *et al.*, 1993; Hansen and Huang, 1996; Cervero and Hansen, 2001). It is also smaller than "induced demand" elasticities estimated using project-level data

Table 3. Operating Speed Model: Natural Logarithm of Mean Operating Speed on Freeway, 24 California Freeway Segments, 1980 to 1994; 2SLS Estimation; See Tables 1 and 2 for Variable Definitions

	NEAR-TERM MODEL			LONGER-TERM MODEL		
	Coefficient	Std. Error	Prob.	Coefficient	Std. Error	Prob.
Natural Log of:						
Lane Mile Proportion	0.418	0.033	0.000	0.385	0.085	0.000
VMT Proportion	-0.184	0.027	0.000	-0.165	0.078	0.036
Employment Density	-0.173	0.011	0.000	-0.173	0.016	0.000
Time-Series Fixed Effects:						
1982	-0.032	0.024	0.198	0.247	0.221	0.272
1983	-0.045	0.025	0.069	0.201	0.183	0.280
1985	-0.091	0.025	0.000	0.161	0.144	0.276
1986	-0.047	0.025	0.064	0.212	0.170	0.226
1987	-0.046	0.025	0.069	0.214	0.169	0.220
1988	-0.037	0.025	0.142	0.224	0.170	0.217
1989	-0.058	0.026	0.024	0.206	0.181	0.267
1990	-0.056	0.025	0.028	0.204	0.180	0.269
1991	-0.046	0.025	0.070	0.210	0.177	0.248
1992	-0.037	0.026	0.147	0.226	0.178	0.212
1993	-0.052	0.026	0.050	0.219	0.183	0.239
1994	-0.038	0.027	0.142	0.245	0.185	0.195
Project Fixed Effects:						
Project1	0.188	0.035	0.000	0.199	0.051	0.000
Project2	0.315	0.036	0.000	0.304	0.052	0.000
Project3	0.453	0.039	0.000	0.430	0.057	0.000
Project4	0.494	0.040	0.000	0.452	0.063	0.000
Project5	0.473	0.067	0.000	0.340	0.140	0.016
Project7	-0.219	0.039	0.000	-0.191	0.059	0.001
Project9	0.377	0.040	0.000	0.356	0.067	0.000
Project10	0.380	0.041	0.000	0.324	0.070	0.000
Project11	0.300	0.035	0.000	0.304	0.036	0.000
Project15	0.099	0.034	0.004	0.112	0.050	0.026
Project16	0.176	0.038	0.000	0.167	0.054	0.002
Project17	0.102	0.034	0.003	0.109	0.050	0.028
Project18	-0.071	0.031	0.021	-0.074	0.033	0.023
Project19	0.122	0.031	0.000	0.109	0.045	0.016
Project20	0.191	0.032	0.000	0.161	0.050	0.001
Project21	-0.117	0.029	0.000	-0.119	0.042	0.005
Project22	-0.126	0.030	0.000	-0.125	0.043	0.004
Constant	5.630	0.107	0.000	5.223	0.374	0.000
Summary Statistics						
No. of Cases		360			360	
F Statistic (prob.)		21.22 (.000)			9.47 (.000)	
R Square		.675			.632	

Operating Speed Model

From the right-hand side columns of Table 3, model outputs for predicting mean operating speeds paralleled those of the near-term model. Differences in coefficient estimates reflect the influences of a different (and larger) set of instrumental variables in the longer-term model. In the longer-term specification, the elasticity of operating speed as a function of relative road capacity and traffic levels was slightly smaller.

Induced Growth Model

The hypothesis of "induced growth" – i.e., road improvements and the resulting swifter travel speeds spur real-estate construction along a corridor -- was substantially confirmed. The model presented in Table 5 represents the lagged structure that yielded the best-fitting statistical results. The model, which explained around two-thirds of variation in total building activity as a share of countywide totals, reveals the presence of institutional delays, as postulated. Notably, the share of countywide building square footage and valuations along a corridor increased with the share of countywide freeway lane-mileage added three years earlier. Building activities were also highly responsive to average operating speeds two years before. Evidently, lane-mile additions in previous years, confirmed by increased operating speeds, spurred developers to build more housing, offices, shops, and other establishments within several miles of improved freeways. Based on elasticity estimates, the influences of operating speeds on the decision to build were more than twice as great as the influences of lane-mile additions. Far more important than either factor was the control variable "personal income". All things being equal, growth among the California municipalities studied tended to gravitate to areas with relatively high incomes.

As noted, a composite variable was created to represent "building activities" within the two-mile buffers. While this variable proved to be statistically robust, it masked the relative influences of capacity expansions and speed improvements on development activities for specific land uses. To shed light on which uses were most sensitive to road improvements, individual OLS regression models were also estimated that predicted the shares of countywide units, valuations, or building square footage within freeway impact zones for specific land uses. The same variables considered in estimating the best-fitting "building activity" model were candidates for entry into each of the specific land-use models.

The longer-term model also reveals that a smaller but nonetheless appreciable increase in VMT is attributable to heightened development activity along impacted corridors. Notably, traffic generated by new residential and commercial-industrial-institutional development accounted for some of the VMT gains, with the additive elasticity for building activities two and three years previously estimated to be 0.172. The output suggests that the influences of behavioral shifts (e.g., latent trips, modal changes, route diversions) are nearly four times as strong as those of structural changes (e.g., land-use shifts).

While longer-run induced travel effects were corroborated by the model, it is worth noting that other "control" factors, such as population density and racial-economic attributes (presumably as proxies for income and cultural factors), tended to exert even stronger influences on VMT shares. All else being equal, dense corridors made up predominantly of non-black and non-Hispanic households tended to account for relatively high shares of countywide VMT.

Induced Investment Model

To bring the analysis of freeway demand-supply relationships full circle, a model was estimated on how road investments respond to traffic increases. Table 7 reveals a significant induced-investment effect. Every 10 percent increase in the share of countywide VMT on a corridor two years previously is associated with a 4.9 percent increase in the current share of countywide lane-mile capacity, *ceteris paribus*. While the induced-investment effect appears smaller than the induced-travel effect, the estimated elasticity is considerably larger than that estimated by Cervero and Hansen (2001) using countywide data from California over a similar time span. This finding further suggests an over-statement of induced demand effects from past studies. That is, a significant share of the statistical correlation between travel demand and road supply has long been assigned to induced demand effects; however, when a path-model framework is adopted that accounts for intermediate steps and induced investment effects, longer-run elasticities of VMT growth tend to be smaller, matched by higher "induced investment" elasticities.

Besides VMT levels, previous-year operating speeds were also statistically associated with freeway expansion. The fact that variables measuring both VMT and operating speeds appeared as direct and statistically significant predictors of freeway expansion could reflect

the influences of multiple criteria in investment decisions – that is, a combination of both traffic growth and performance levels could have played into political decisions to expand freeway capacity. Table 7 also shows that concerns over air-quality may have deterred freeway expansion, possibly out of fear that freeway-induced growth would ultimately exacerbate air quality. This stands in contrast to research by Cervero and Hansen (2001) that found deterioration in air-quality tended to spur road investments in California under the premise that congestion relief ultimately produces cleaner air. The fact that these two studies were carried out using different grains of analysis – county-level data in the case of the Cervero and Hansen study versus project-level data for this current study – could partly explain the differences.

Longer-Term Model Summary

Overall, the longer-term model performed fairly well in accounting for VMT growth along sampled California freeway segments. Evidence of "induced travel", "induced growth", and "induced investment" was uncovered. Elasticity estimates of induced travel were lower than what was found in most previous studies, including those focused on California freeways.

The long-run model suggests that it takes around 5 to 6 years before the full-brunt of traffic increases spurred by land-use shifts to be felt. Based on model outputs, it generally takes 2 to 3 years for development activity to respond to the addition of lane miles, and another 3 years for VMT to respond to development activity. The model also suggests that VMT growth feeds back to influence freeway investments several years later. The entire lagged structure, then, covers a 7 to 8 year period.

Based on beta weights, about 55 percent of the association between freeway expansion and VMT growth was accounted for by the path model.[ii] Thus while the postulated path model was supported by empirical analysis, more research is needed in different settings and at different resolutions of analysis to further refine our understanding of the co-dependencies between road investments, land-use shifts, and induced travel – hopefully research that is firmly rooted in behavioral and economic theories, and that adopts a casual modeling framework.

induced demand, but rather only through a full accounting and weighing of social costs and benefits.

Critics of any and all highway investments, even those backed by credible benefit-cost analyses, should more carefully choose their battles. Energies might be better directed at curbing mis-pricing in the highway sector and managing land-use changes spawn by road investments.

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Notes

[i] Square footage statistics were already known from the census source for industrial and "other" land uses.

[ii] This was based on the application of "Wright's Rules" for decomposing correlation coefficients, as reviewed in Asher (1983). For the long-term model, the Pearson Product-Moment correlation between the natural logarithms of the "lane mile" variable and the "VMT" variable lagged by 5 years (to reflect the 2-year lag in lane-miles influencing building activities and the 3-year lag in building activities influencing VMT) was 0.898. If the model were completely specified, this correlation could be re-expressed as the sum of the products of beta weights (i.e., standardized regression coefficients) across all bona fide indirect paths. For the four indirect paths, the products of beta-weights are: Lane-miles → Speed → VMT [(1.294*0.265) = 0.342]; Lane-miles → Development Activity → VMT [(0.239*0.284) = 0.068]; Lane-miles → Speed → Development Activity → VMT [(1.294* 0.218*0.284) = 0.080]; Lane-Mile → Speed → VMT → Speed → Development Activity → VMT [(1.294* 0.265* 0.337*0.218*0.284) = 0.007]. Thus, the total product of beta weights among indirect path equals 0.497, or 55 percent, of the total correlation of 0.898.