

TRANSPORTATION & REGIONAL GROWTH

a study of the relationship between transportation and regional growth

*A
collaboration
among:*

University of Minnesota
Center for
Transportation Studies

Center for Urban
and Regional Affairs

Minnesota Department
of Transportation

Metropolitan Council
of the Twin Cities

Minnesota Local Road
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A Systems Thinking Perspective on the Transportation and Regional Growth Study

Report #12 in the Series:
Transportation and Regional Growth Study

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Preface

The Transportation and Regional Growth Study is a research and educational effort designed to aid the Twin Cities region in understanding the relationship of transportation and land use. Many regions of the country are experiencing rapid commercial and residential development, often accompanied by population growth and growth in the total area of land developed. This has caused a range of concerns, including the direct costs of the infrastructure needed to support development and the social and environmental side effects of development patterns.

This study is an effort to better understand the linkages between land use, community development, and transportation in the Twin Cities metropolitan area. It is designed to investigate how transportation-related alternatives might be used in the Twin Cities region to accommodate growth and the demand for travel while holding down the costs of transportation and maximizing the benefits. The costs of transportation are construed broadly and include the costs of public sector infrastructure, environmental costs, and those costs paid directly by individuals and firms. Benefits are also broadly construed. They include the gains consumers accrue from travel, the contribution of transportation and development to the economic vitality of the state, and the amenities associated with stable neighborhoods and communities.

The University of Minnesota's Center for Transportation Studies is coordinating the Transportation and Regional Growth Study at the request of the Minnesota Department of Transportation and the Metropolitan Council. The project has two components. The first is a research component designed to identify transportation system management and investment alternatives consistent with the region's growth plans. It has six parts:

1. Twin Cities Regional Dynamics
2. Passenger and Freight Travel Demand Patterns
3. Full Transportation Costs and Cost Incidence
4. Transportation Financing Alternatives
5. Transportation and Urban Design
6. Institutional and Leadership Alternatives

The first three research areas are designed to gather facts about the transportation system and its relationship to land use in the Twin Cities metropolitan area. The other three research areas will use these facts to investigate alternatives in financing, design, and decision making that could have an impact on this relationship. Results of this research is and will be available in a series of reports published for the Transportation and Regional Growth Study.

The study's second component is a coordinated education and public involvement effort designed to promote opportunities to discuss the relationship between transportation and growth based on the research results. It is believed that this dialogue will help increase knowledge and raise the level of awareness about these issues among the study's many audiences including decision makers who make policy, agency professionals who implement policy, stakeholder groups who try to influence policy, and members of the general public who experience the consequences of those policies.

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Executive Summary

This report integrates the findings of the individual reports that comprise the Transportation and Regional Growth Study (TRGS) into a comprehensive “systems thinking perspective” on the Twin Cities’ transportation and land use system. This document explores the findings and rationale in TRGS reports by principal investigators John Adams, Gary Barnes, David Anderson, Barry Ryan, Lance Neckar, and Barbara Lukermann.

The purpose of this report is to use systems thinking tools and methods in a consistent and disciplined way, to generate new insights that are valuable for policy makers, and to surface the systemic assumptions underlying the research of the principal investigators.

Chapter 1 introduces the research objectives of the report, the expected benefits, and the intended users of the report.

Chapter 2 identifies the specific TRGS reports – along with their principal investigators – that are covered by this report’s systemic perspective, and which are the sources of research “nuggets,” or key findings. These eighteen nuggets are summarized as useful background for the following chapter.

Chapter 3 aims to integrate the findings of the principal investigators within the scope of the Nine Principles of Planning and Development that were formulated jointly by the Minnesota Department of Transportation (Mn/DOT) and the Metropolitan Council (Met Council) in March 2002. This chapter introduces the causal loop diagram (CLD), which is a systems thinking tool for explicitly describing the causal linkages and feedback structures connecting significant variables of the Twin Cities’ transportation and land use system. As such, these CLDs are intended to capture and display core elements of the common mental model of these two agencies regarding how the land use and transportation system works. A primer for reading and using causal loop diagrams can be found at the beginning of this chapter.

Chapter 4 offers more elaboration on the eighteen nuggets and their implications for the land use and transportation system. As such, this chapter focuses on the key findings of each principal investigator.

Chapter 5 provides a comprehensive systems thinking perspective on only the first three TRGS reports by Adams, Barnes, and Anderson. This part of the report was first delivered to Mn/DOT in May of 2001 as the initial TRGS integration project. It remains a foundation component of the entire report.

Chapter 6 is the lengthiest section of the report. It presents a detailed systems thinking perspective on each individual TRG report. The methodology for the integration project required that, first, this author and each principal investigator agree that the systems thinking perspective on their individual report would accurately and fairly represent their findings and the logic that supported those findings. This chapter is for readers who want to really dig into the systemic structures that are driving the behaviors we see in land use and transportation systems.

Key Findings

The research results of the principal investigators' reports are best summarized in the three pages of nuggets listed in Chapter 2 and will not be repeated here. The findings below are those of this author and are based on the integrated systems thinking perspective developed over the course of the project, as well as the several TRGS reports that are the components of the integration effort.

Government and civic leadership have been successful.

Government and civic leaders in Minnesota and the Twin Cities have, in most cases, been successful over the past several decades in making the necessary public and private investments to grow the economic vitality of the region and the productivity of its people. They and the people living in Minnesota and the Twin Cities have created an attractive place to live, work, consume and learn. The evidence for this finding includes sustained population growth and consistently increasing levels of real per capita and household income.

Low cost land and good quality water enable rapid growth in edge locations.

Minnesota and the Twin Cities are fortunate to have abundant amounts of relatively low cost land and good quality water resources, which enable the development of attractive residential and commercial properties in "green field" places. The costs of development in these suburban and edge locations are less than the costs to re-develop sites in the city centers or inner suburbs. However, while there may be no practical limits on the availability of low cost land, Neckar's research suggests that there is a limit on the amount of good quality water – from both surface and underground sources. The accelerating consumption rate of high quality groundwater could result in growth constraints in some places and lead to extended regional interest in water controls.

The decentralization of jobs is a core driver for the decentralization of the region's population.

Census statistics demonstrate that growth in the outer suburbs is faster than growth in either the inner suburbs or the central cities of the Twin Cities. The "agglomeration benefits" that used to be attractive to employers and workers in the center cities are no longer dominant. Instead, the rapid growth in specialized and service jobs, along with the increase in self-employed persons, has meant that people can choose to work closer to home. The population of the suburbs that used to work and shop in the center cities can, instead, be attracted to work and shop in new office parks and malls nearer their own neighborhoods. Statistics show that the majority of commuting travel is now suburb-to suburb, and not suburb to center city.

The decentralization of jobs and population are, in large measure, the consequences of increasing affluence. Decentralization will continue as long as income levels increase and current incentives are in place.

When residents of a region attain higher per capita income levels, they exhibit some very common behaviors, regardless of the country in which they live. Household size gets smaller as newly employed people can move out, and go on their own. Thus, there is a demand for more homes. The number of autos increases with income because more members of a household can afford them. Consequently, there are more vehicles on the roads, and more miles are driven daily. Increasing income results in the development of more shopping and recreational destinations, attracting even more travel. Families seem to desire additional privacy, and therefore seek to live in single-family homes when they can afford them. Further, when they have the choice, people want more living space, and therefore choose to live in larger homes on larger lots. Affluence enables people to fulfill their desires for larger private single-family homes and for travel, especially by private vehicles. Federal, state, and local tax policies support the continuation of the affluence effects described above, and there is little incentive for changing them.

The growing power of local communities and neighborhoods to establish and enforce their own zoning controls has limited the capability of regional authorities to achieve what some believe is a greater common good.

The decentralization of jobs and population into relatively affluent communities, along with enabling legislation, has enhanced local control over land use and transportation options. There is not yet a sufficient constituency in the region that sees the need to override local control in favor of a centralized regional authority to decide on land use.

Some behavior patterns in the land use and transportation system are not fair to some residents of the region.

The behavior patterns of the current system seem inequitable to some residents of the region. Transportation options are not sufficiently available to those who do not have a private vehicle. Many residents of inner suburb and center city neighborhoods do not believe they receive the same value for their tax dollars as those in newer edge location residents. External costs seem disproportionately higher for center city residents.

You get what you measure.

The principal recommendation of this author is this: all of the key variables in the Twin Cities land use and transportation system should be measured, monitored, and routinely communicated to the public and governmental policy makers. In that way, the public and its civic leaders can begin to recognize how those variables are related to each other and can begin to prioritize them according to their values and the vision they share for the future. This integration report has shown what those key variables are and has presented a rich hypothesis on how they are causally related to each other.

Chapter 1: Introduction

In an earlier integration report, dated May 8, 2001, the first three of the TRGS components have been addressed. This report examines the final components of the TRGS and incorporates them into a comprehensive Systems Thinking Perspective on all of them.

The objectives of the continuing work remain essentially as they were for the first program, namely:

- Make visible the mental models of the researchers and thus the theories and assumptions that are imbedded in the research design
- Understand the linkages between the mental models – where conflicts may occur; where there are gaps in research coverage; where convergence is apparent.
- Continue to suggest the critical questions that policy makers must address.

In summary, the purposes are to generate new insights that are valuable for policy makers and to surface and test the assumptions underlying the research designs of the Principal Investigators.

Expected Benefits

The most significant benefits from this final technical report will include:

- Sustained community dialogs around the *interactions* of land use and transportation policies and practices. Examples include the well-attended CTS Workshops on May 24, 2001 and May 23, 2002. The first workshop addressed the topic: Transportation and Land Use in 2050. The second addressed the “Root Causes” of transportation and land use behavior patterns in the Twin Cities region.
- A richer understanding about the challenges of achieving an equitable balance of the costs and benefits of transportation and land use investments.
- The creation of a “common ground” for policy makers as they consider decisions that must be made today in order to create a high performing system for tomorrow.
- Steps toward creating a “balanced scorecard” for measuring the performance of the region’s transportation and land use system.
- Use of the report’s causal loop diagrams and commentary as the foundation for a useful computer simulation model for more extensive systemic explorations.

Users of This Research

The intended audience for the integration project includes influencers and policy makers throughout the State, but especially for the Metropolitan Region around the Twin Cities.

Chapter 2: The Research “Nuggets”

The first phase of the TRGS “systems thinking integration” project explored the first three relevant research reports by University of Minnesota principal investigators associated with the University’s Center for Transportation Studies (CTS) . Included were:

- John Adams et al: *Synthesizing Highway Transportation, Land Development, Municipal and School Finance in the Greater Twin Cities Area, 1970-1997* (TRG #4, 2000)
- David Anderson and Gerald McCullough: *The Full Cost of Transportation in the Twin Cities Region* (TRG #5, 2000)
- Gary Barnes and Gary Davis: *Land Use and Travel Choices in the Twin Cities, 1958–1990* (TRG #6, 2001)

The May 8, 2001 final report addressing those three reports included nine summary “nuggets” designed to capture key findings and to stimulate further conversation about land use and transportation dynamics in the Twin Cities.

The second and final phase of the TRGS systems thinking integration project encompasses four more research reports. They are:

- Barry Ryan and Thomas F. Stinson: *Road Finance Alternatives: An Analysis of Metro Area Road Taxes* (TRG #9, 2002)
- Lance Neckar, principal investigator: *Transportation, Urban Design and the Environment, Highway 61/Red Rock Corridor* (TRG #13, 2003).
- Barbara Lukermann and Thomas M. Scott: *Public Policy, Transportation, and Regional Growth* (TRG #16, 2003).
- John Adams et al. *Urbanization of the Minnesota Countryside: Population Change and Low-Density Development Near Minnesota’s Regional Centers, 1970-2000* (TRG #10, 2003).

These reports provided nine more “nuggets.” Below is a summary of all eighteen nuggets. The summary is useful background prior to reading the next section.

Nugget 1: A person’s daily travel time budget is the dominant determinant of that individual’s travel behavior. (Barnes)

Nugget 2: While there are limits on developed infrastructure resources, including transportation systems, there are no practical limits on the land available for edge location development. (Adams)

Nugget 3: Eighty-four percent of known transportation costs are internal costs, borne by the people who travel. Nevertheless, the absolute size of governmental and external costs, plus a likelihood that external costs are considerably underestimated, calls for public and policy makers’ attention. (Anderson)

* Ed Note: A complete listing of Transportation and Regional Growth Study reports, including several not covered in this report, is included in the Appendix.

Nugget 4: Cities and metropolitan areas will naturally experience cycles of investment and disinvestments due, in part, to “success to the successful” and “escalation” dynamics. Further, transportation investments to enhance mobility will not, by themselves, mitigate these cycles. (Adams)

Nugget 5: The relative attractiveness for investment (of time or money) in a location is influenced as much by the expectation of future change in the value of the capital stock as it is by the current value of the capital stock. (Adams)

Nugget 6: The nature of commercial development can go a long way to influence the attractiveness of a location, and hence its capacity to create demand for travel in and to there. (Barnes)

Nugget 7: The Region is at risk when policy makers fail to identify and preserve resources held “in common.” (Adams)

Nugget 8: Technology and the new economy may have a significant, but only now emerging, impact on land use and transportation. (Ward)

Nugget 9: There appear to be some deep-seated assumptions about the past and the future that influence the thinking exhibited in some of the reports. Some of these mental models are very explicit; but others are not. In any case, they have a significant presence in the work we do together. (Ward)

Nugget 10: The adoption of more efficient road tax policies – like substantially higher motor fuel taxes or mileage taxes – will increase the net present value of transportation costs for commuters driving long distances and would likely delay the pace of exurban land development. (Ryan)

Nugget 11: For the 1996 study period, 71% of the \$993 million Twin Cities Metro Area (TCMA) road-related taxes collected were from fixed or hidden taxes that are unrelated to travel behavior. (Ryan)

Nugget 12: If, over the next 25 years, the state wishes to maintain the same level of transportation services available today, then road funding must become even more reliant on property taxes and the state’s general fund. (Ryan)

Nugget 13: Conventionally developed suburban places, which are designed around the “Genetic Code of the Subdivision,” inevitably will lead to serious and long-lasting depletion and damage to quality of the area’s water – both surface water and ground water. (Neckar)

Nugget 14: The region’s comprehensive plan for land use preserves low local density limits, which reinforces the growth of an unstratified transportation network, thereby reducing non-auto access options from and to higher-density places. (Neckar)

Nugget 15: The current patterns of land development and transportation investment within the Metro region are the consequences of powerful systemic government, social, and economic structures and are designed to grow the total property value of the region. (Lukermann)

Nugget 16: The growth in local control over land use has weakened the opportunity for region wide or statewide planning to coordinate and complement – and therefore maximize the overall common good – land use and transportation across all local governments. (Lukermann)

Nugget 17: Growth in average per capita income in Minnesota will inevitably result in “affluence effects” on land use and transportation patterns, including continued development of low-density suburban places around both regional and metro cities and pressure for greater auto-friendly investment in roads and highways. (Lukermann)

Nugget 18: The historical growth and settlement patterns demonstrated by the greater Twin Cities are being mirrored in the growth of regional center cities throughout the state. (Adams)

Chapter 3: A Systems Thinking Perspective on the Nine Principles of Planning and Development

In the spring of 2002, members of the Met Council and Mn/DOT agreed to Nine Principles of Planning and Development. Those principle statements also identify important factors or conditions that are “key variables” in the larger land use and transportation system that has been the subject of the Transportation and Regional Growth Study led by the Center for Transportation Studies. The nine principles are repeated below, but the selected “key variables” appear in bold type.

1. **Planning at the corridor level should be coordinated** to insure the **use of consistent investment and design principles**. The agencies recognize that “centers” along corridors are defined differently in metropolitan planning versus statewide planning.
2. Incorporating the principles of **livable streets** and **context-sensitive design** is an important and necessary part of planning and project development processes.
3. **Integrating transportation and land use planning** is necessary if we are to protect **the region’s resources** and ensure long-term **social and economic vitality**.
4. **Modeling and forecasting** must be improved to help plan for a future that focuses on **all transportation modes**.
5. The state and the region need a **balanced transportation system** that provides **choices to users** if we are to meet the growing **demand for people and goods movement** in coming decades.
6. Serving **job-rich destinations** with **improved access** should be a priority for both agencies. **New land use patterns** are needed that connect work and residential opportunities. Creating **housing near job-rich destinations** – along with **transit access** – will provide additional choices for people.
7. Significant **transportation investments** are needed to reduce **congestion** and improve Twin Cities residents’ **quality of life**.
8. Transportation funding should be increased, and there should be a **dedicated source of revenue for highways and for transit**.
9. **Road pricing** and **impact fees** should continue to be considered as possible transportation revenue sources among a range of alternatives. Great care should be given to selecting the right time and the right opportunity to propose these tools.

Thus, a high-level composite systems thinking perspective on land use and transportation must include these variables and illustrate the systemic relationships among them. Why? Because this perspective is intended to make explicit the “mental model” of the agency representatives who articulated, adopted, and now share these principles. Below is a list of specific variables, taken from above, that are included in a systems diagram of the shared mental model:

1. Coordinated planning at the corridor level
2. Use of consistent investment and design principles
3. Livable streets
4. Context-sensitive design
5. Integration of transportation and land use planning
6. [Quality of] the region’s resources
7. Social vitality

8. Economic vitality
9. Improved modeling and forecasting
10. Range of transportation mode choices for users
11. Balance in the transportation system
12. Demand for people and goods movement
13. Job-rich destinations
14. Access to job-rich destinations
15. New land use patterns
16. Housing near job-rich destinations
17. Transit access to job-rich destinations
18. [Tax and fees revenues] available for transportation investments
19. [Highway] Congestion
20. Quality of life
21. Fraction [of tax and fees revenues] to non-auto investment
22. Fraction [of tax and fees revenues] to private vehicle-oriented investment
23. Road use price
24. Impact fees [on conventional development]

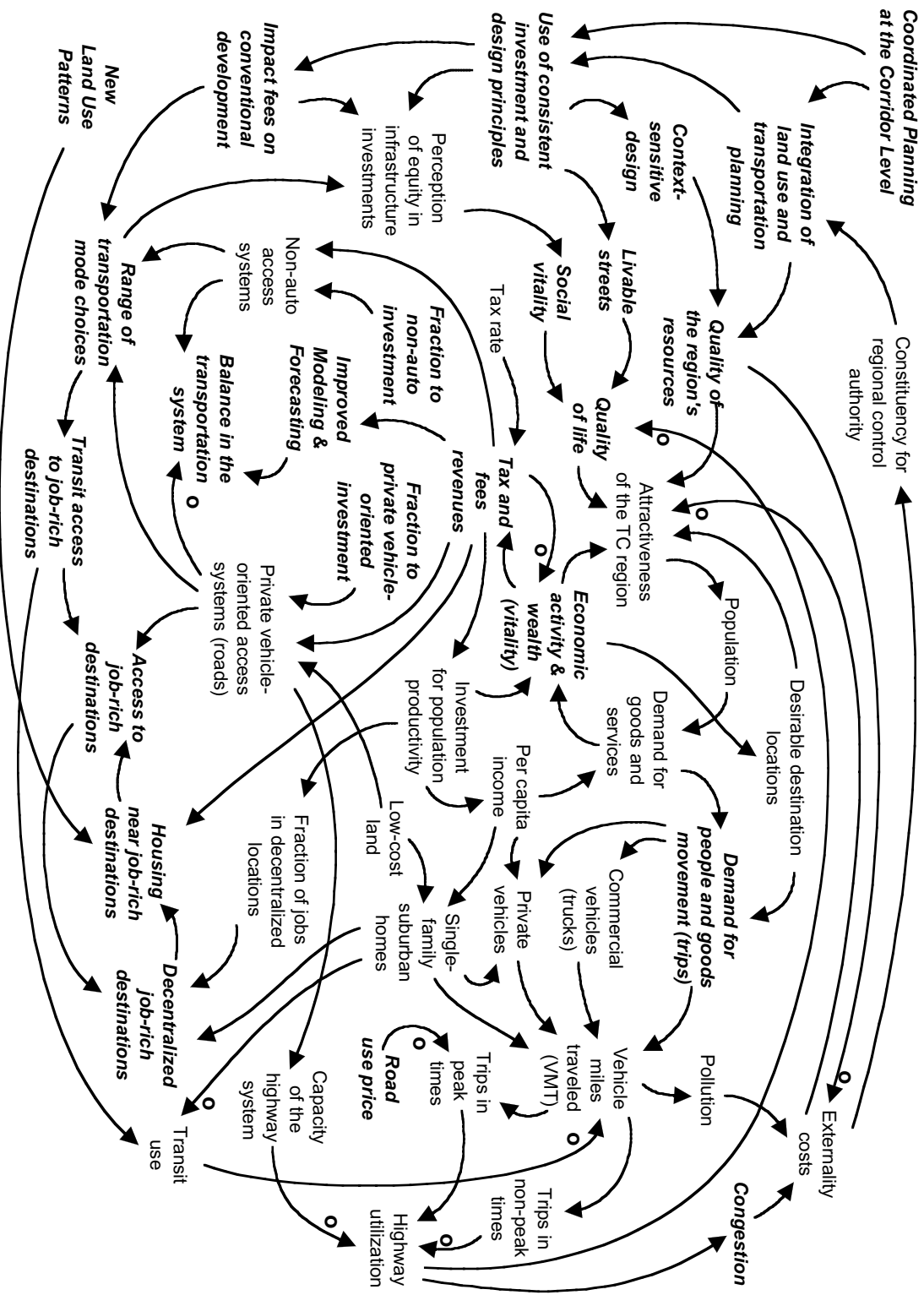
The nine principles suggest that at least twenty-four key variables are present in the mental models of Met Council and Mn/DOT policy makers and their staffs. ***Further, identifying these key variables suggests that the policy makers are interested in how they change over time.*** Are those changes moving in the right direction? Are the values of those variables approaching explicit or implicit “goals” for each? As such, these variables can be considered ***performance measures*** for the system they are attempting to manage or influence. In other words, for each of the above twenty-four measures, a person could ask: how many, how much or to what degree?

A simple list of some of the key variables is not sufficient to describe this complex system. How are the variables related to each other – and to other variables that are essential to the system? What sort of feedback relationships are either reinforcing or balancing behavior patterns? Where are high-leverage policy intervention opportunities?

The six parts of the TRG Study have identified scores of other important variables and causal relationships, including what many consider the “root causes” for the current patterns of land use and transportation dynamics in the Twin Cities region. Some additional variables, taken from these other TRG Study reports, are needed to adequately describe the shared mental model suggested by the nine principles.

The page that follows presents the full causal loop diagram (CLD) that is intended to offer a full system diagram of the shared mental model that serves as the foundation of the agreement on the nine principles. The twenty-four variables listed above are shown in bold italics.

Full System Diagram



The entire diagram, at first view, seems quite complex. It is, in fact, because it describes the high-level structure of a very complex system. For now, the value of the whole diagram is twofold: first, it shows additional variables that may need to be considered and measured; and second, it offers a preliminary hypothesis for how all the variables are connected in “cause-effect-cause” systemic feedback relationships.

A Primer for Reading Causal Loop Diagrams

How does one read a CLD? The words or phrases in a CLD are “variables,” or things that can change over time and are therefore important to many different constituencies. The variables in the CLD are connected by causal links to explicitly show the cause-effect relationship between the variables. The “cause” is at the foot of the arrow, while the “effect” is at the head of the arrow. The direction of causality is assumed to be “the same,” i.e., if the cause variable increases, then the effect variable also increases, or, conversely, if the cause variable decreases, then the effect variable decreases. If an “o” is positioned at the head of a causal link arrow, then the effect moves in the “**opposite**” direction from the change the cause variable.

What is a feedback loop? The dynamics of a complex system are generated by the feedback loops that comprise the system’s structure. A feedback loop is formed whenever a series of two or more causal links form a pathway that comes back to the variable from which that path began. A single variable can be a part of many feedback loops, and thus be influenced by many other variables – some close in time and distance and others quite far away. Feedback loops can be either “reinforcing” loops or “balancing” loops.

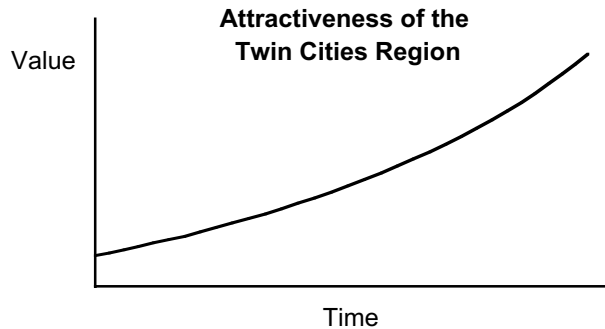
Reinforcing feedback loops try to amplify or accelerate change in all of the variables in the loop in the current dominant direction. In other words, reinforcing feedback loops are the sources of either “virtuous cycles” (when things are going well and getting better) or “vicious cycles” (when things are going from bad to worse). Balancing feedback loops are formed when there is an odd number of “opposite” causal links in the feedback loop.

Balancing feedback loops introduce stability and equilibrium within a system. They dampen the dynamics of the system. For example, a balancing loop is involved whenever there is a limit on the availability of a resource when that same resource is a source of growth. To explain, let’s assume that the availability of low cost land and good quality water are important variables within the reinforcing feedback loop that generates population growth in the Twin Cities region. If low cost land and good quality water are unlimited, then population could grow exponentially indefinitely. However, if there are limits to the variables, low cost land and good quality water, then the future availability of those variables will be reduced as consumption of them continues, and population growth will slow until it eventually stops when no more low cost land and good quality water are available. The causal link from the cause (consumption) to the effect (availability) is an “opposite,” because as total consumption increases, current availability decreases.

What is the value of a CLD? A CLD augments a narrative that describes how things work. A CLD insures that the rationale around “why a system works the way it does” is clearly displayed for others to examine, challenge, and improve.

A Shared Goal: Improve the Attractiveness of the Twin Cities Region

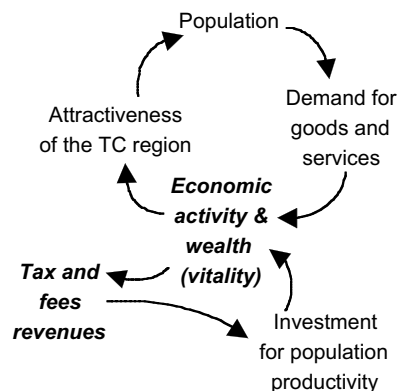
Initially, all of the variables in the diagram appear to be of equal importance. Yet, some may represent a higher level of significance than others. For example, the variable “Attractiveness of the TC [Twin Cities] region,” which is near the center of the diagram, is very important to the people who currently live there as well as potential future residents. *This variable has a direct causal effect on the number of persons who choose to remain in, move to or move away from the Twin Cities region.* It is probable that almost every policy maker would like to see this variable demonstrate a pattern of consistent positive growth, as shown in the behavior over time graph below.



The full diagram explicitly shows that the Attractiveness of the TC region is the effect of five specific cause variables. They are:

1. Economic activity and wealth [vitality],
2. Quality of life,
3. Quality of the region’s resources,
4. Externality costs (a negative impact), and
5. Desirable destination locations.

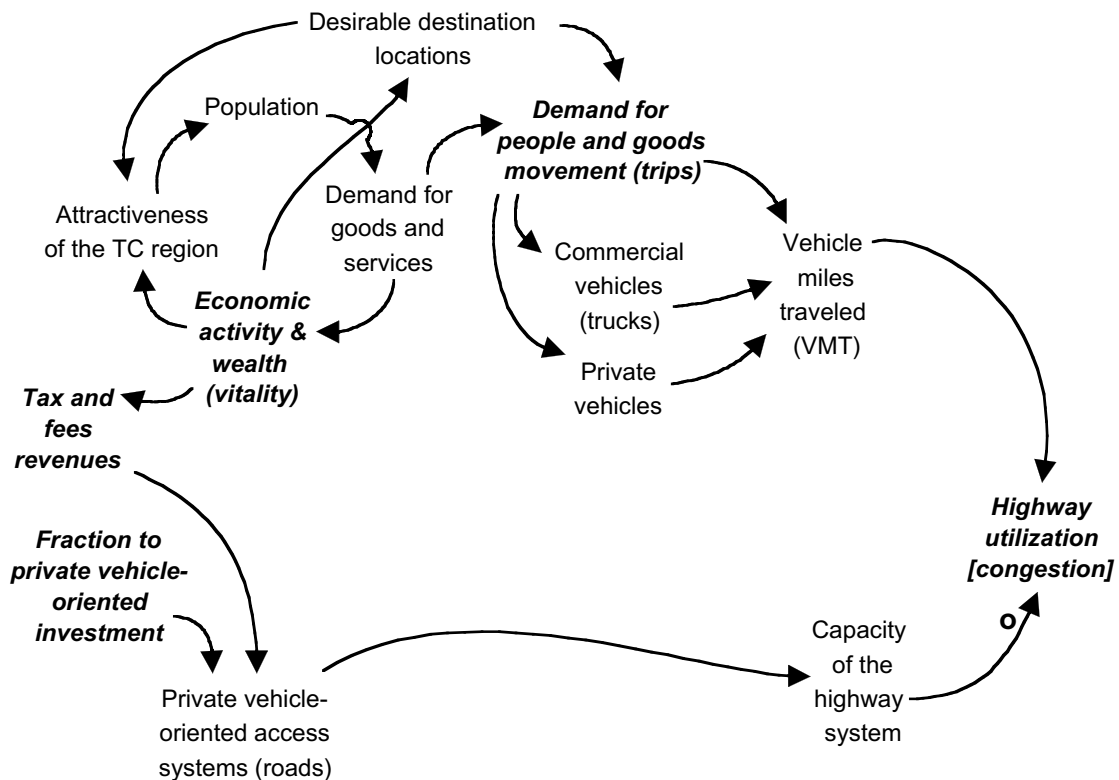
The region’s economic vitality is important because it has a direct influence on the amount of tax and fees revenue that governments can collect for investment in the region’s infrastructure or



social services. This relationship is shown in the feedback loops above.

These two reinforcing feedback loops share the variable representing economic vitality. The upper loop is the basic loop suggesting that population follows economic activity. The lower loop denotes that the taxes and fees that governments collect are also dependent on the level of economic vitality.

The TRGS investigators have shown that public investment in transportation infrastructure, especially for highways and roads, which increase mobility and access, has a powerful reinforcing impact on economic vitality by providing access to job-rich destinations. That systemic structure is shown below.



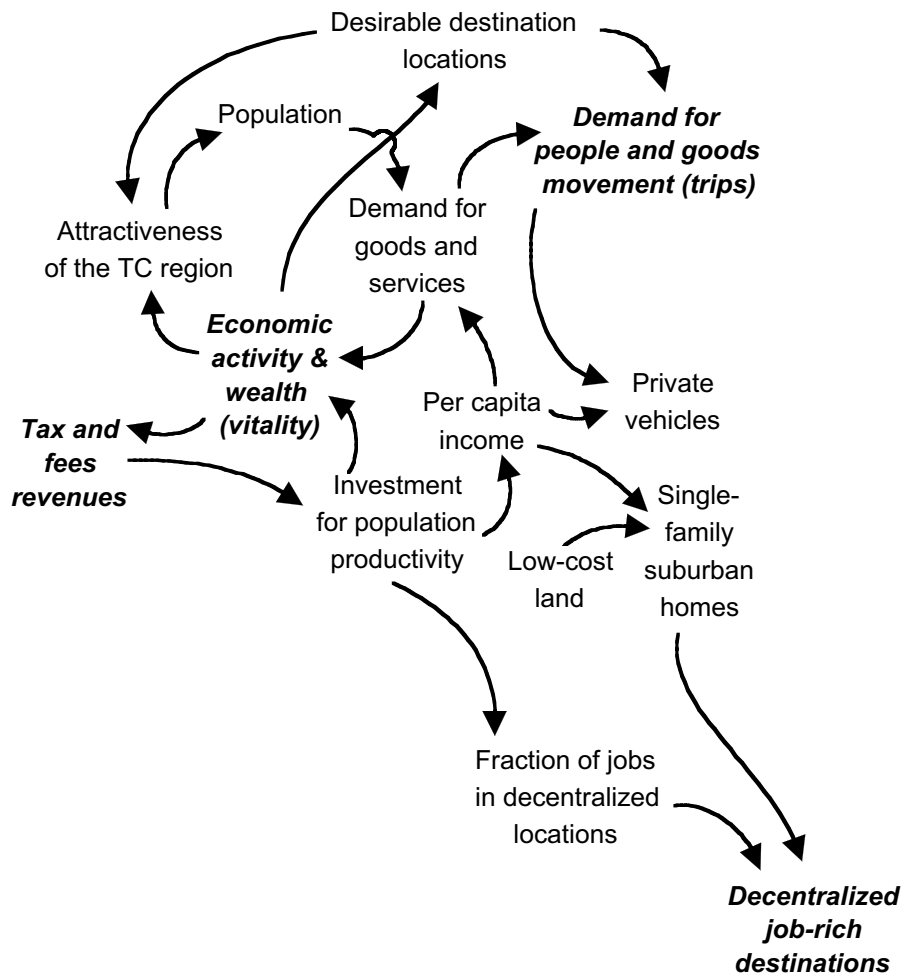
This structure illustrates that as economic activity (vitality) increases, its effect is to create a more attractive region, which leads to a greater population that, in turn, increases the demand for goods and services, which accelerates the pace of economic activity. Further, as the demand for goods and services grows, the demand for people and goods movements (trips) also grows. More cars and trucks are needed to handle the increased demand, and they contribute to an increase in vehicle miles traveled (VMT) on the region's roads.

To meet the actual and forecasted growth in VMT, Mn/DOT and other local governmental agencies have been authorized to spend a specific fraction of tax and fees revenues to provide private vehicle-oriented access systems (roads) in order to increase the capacity of the highway system. The aim is to deliver highway capacity in time to accommodate the growing number of VMT and do so while keeping the highway utilization fraction at a satisfactory (non-congested) level. Note the "o" next to the causal link from capacity of the highway system to highway

utilization. This means that as capacity increases, and if VMT stays the same, then highway utilization decreases (or moves in an “opposite” direction from its cause variable).

The diagram on the previous page suggests that as long as economic activity continues to increase and to produce more desirable destination locations, then the challenge for government is to simply provide highway capacity at a satisfactory level.

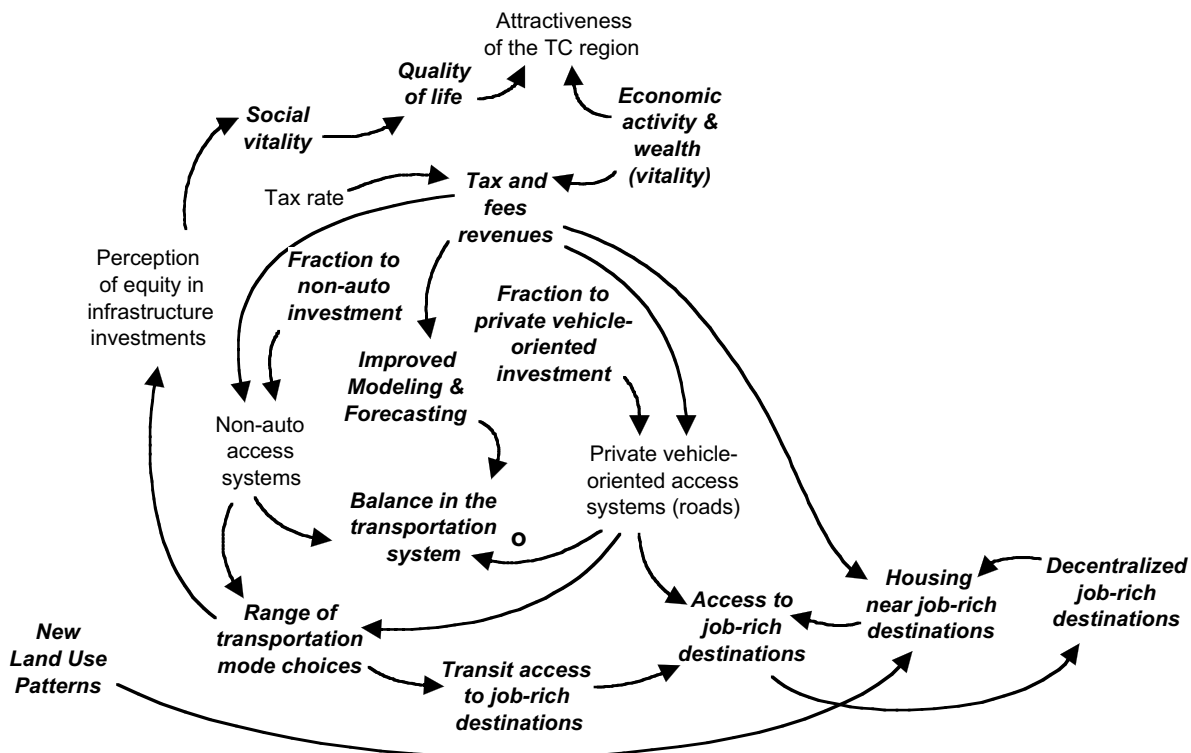
However, there are other powerful systemic, root cause forces at work in the Twin Cities land use and transportation system that stimulate the decentralization of jobs and population. They are included in the following structure diagram.



The region’s private and public investment (schools, training, health, access, etc.) to improve the population’s productivity has, and likely will continue to have, the long-term effect of increasing the per capita income level of the region. One consequence of population productivity is the opportunity (and need) for people to work in more diverse jobs that are situated in more decentralized locations. In addition, the growth in per capita income has some significant “affluence effects,” which include an increase in per capita vehicle ownership, greater demand for goods and services and the growth in larger single family homes. The effect of decentralized jobs, combined with more single-family suburban homes, is an increase in decentralized job-rich

destinations. The pattern of decentralization of the population into the suburbs is also enabled by the availability of low cost land on the edges of the metro area.

While much of the region’s population seem to enjoy the benefits of increasing affluence, others, who are equally important, perceive growing levels of infrastructure inequity and externality costs like pollution and congestion, which will – in the long run – reduce the overall attractiveness of the Twin Cities region for themselves and for potential future residents. In particular, the policy makers who are attentive to this concern argue that the transportation system – now tilted toward users of private vehicles – must be more balanced by offering a wider range of transportation mode opportunities to Twin Cities residents. In order to arrest the potential decrease in the area’s attractiveness, they point out that social vitality has a direct positive impact on quality of life, which is a major determinant of the region’s attractiveness. Social vitality requires the perception that there is equity in the region’s infrastructure investments, including transportation systems. Equity in transportation requires, they argue, a full range of transportation mode choices to attractive destinations, especially jobs. These relationships are shown below.

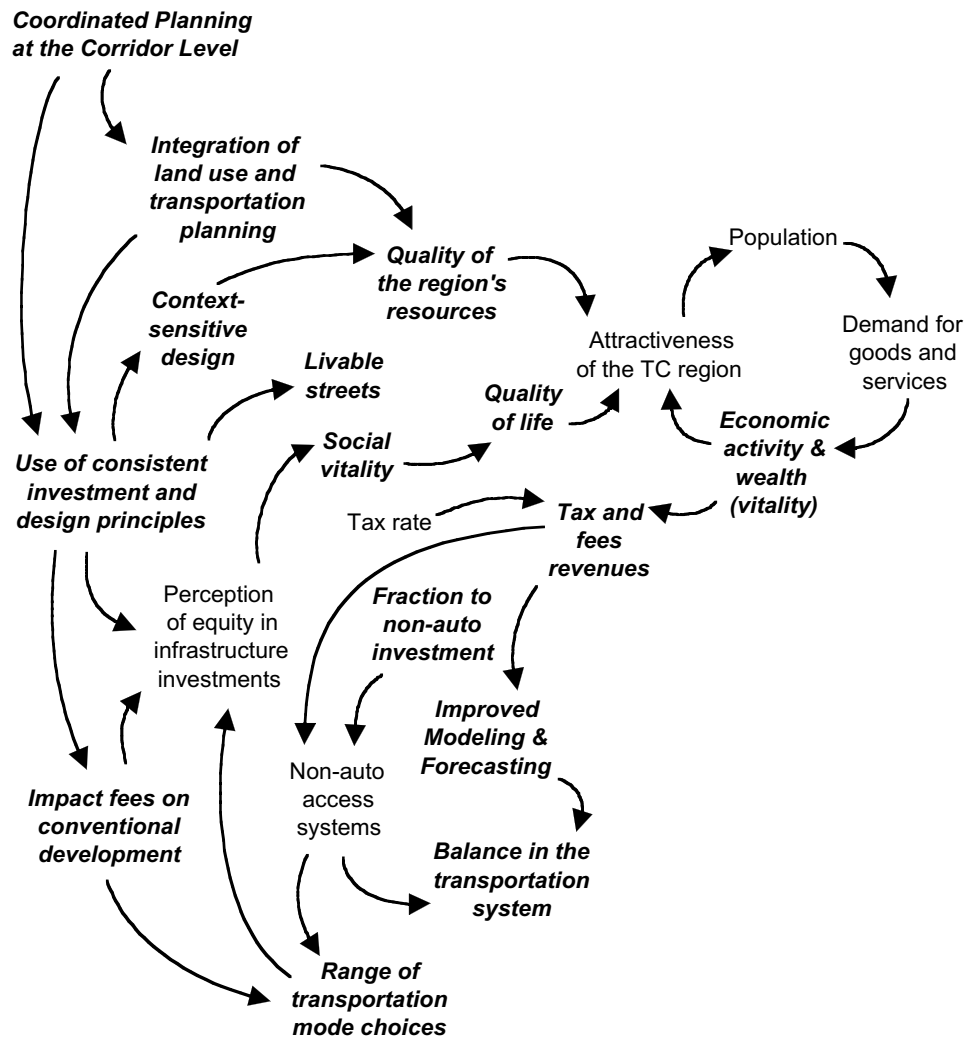


Principle 4 explicitly introduces improved modeling and forecasting as a key intervention to achieve a better balance in the transportation system by effectively anticipating future needs and then designing robust policy responses that survive challenging scenarios.

As Principle 8 suggests, the tax rate on economic activity must be increased to provide more funding for transportation investments, plus there should be a dedicated fraction of collected revenues for non-auto access systems in order to offer a full range of transportation mode choices, including transit. Further, Principle 6 suggests that public investment be made to stimulate housing near decentralized as well as centralized job-rich destinations. The idea is to

amplify the reinforcing feedback loop where access leads to more jobs, more jobs lead to closer housing, and closer, higher-density housing enables even more access choices.

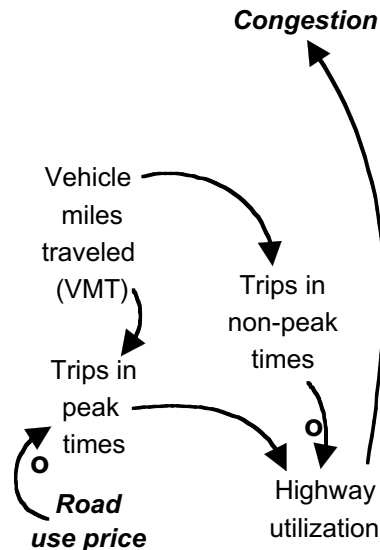
Many who want to preserve or grow the long-term attractiveness of the Twin Cities region, including those who developed the Nine Principles of Planning and Development, point out the need to make progress on three fronts: first, as noted on the previous pages, to reduce externality costs like congestion; second to preserve or increase the quality of the region's resources, especially natural and ecological resources, by reducing pollution from vehicle travel; and third, to increase the quality of life by building more livable streets and neighborhoods. They created a mental model including the structure below.



What would have to happen for the structure shown above to become dominant? The answer involves the presence of a sufficiently powerful constituency for regional control authority that could override the current primacy of local control over land use, and which would assure the integration of land use and transportation planning at a comprehensive and expanded regional level. The author of this integration report believes that will happen only when the “pain of the

present overcomes the fear of the future.” Namely, when the perceived direct and externality costs become great enough to seriously threaten the economic and social attractiveness of the region. It will then be politically possible to do something.

What about road pricing as a policy tool for reducing congestion? Principle 9 suggests that there may be a right time for its use. The structure for it is shown below.



In this system, congestion is a direct result of *over-use* of a previously popular highway’s design capacity during a specific daily time span. Road pricing will have little, if any, effect on the amount of vehicle miles traveled. In fact, alternative, less-congested routes are often longer than the congested route. A road use price is designed to reduce trips on the congested highway during peak demand times and to shift travel to less utilized routes during that same time of day.

Road use pricing may have some interesting effects. First, it may reduce congestion on some highly used highways, and, consequently, contribute to a perception of higher quality of life for many residents. Second, it may transfer pollution or other vehicle-based externality costs to some previously under-used roadways. Third, it may reduce *perceived* externality costs, and thereby decrease a constituency for regional control authority.

At this point in these remarks, we have explored how the Nine Principles interact with each other in a larger system of land use and transportation.

The TRGS investigators have pointed to powerful root causes that, they believe, sustain the current patterns of land use and transportation, which reinforce decentralization and increased use of private vehicles, and which may – in the long run – increase externality costs and social inequity. It is particularly interesting to consider how each root cause is captured or represented in the full systems diagram on page 9.

Root Causes Offered by Investigators Adams, Barnes, Ryan, Neckar, and Lukermann on May 23, 2002

- Fragmentation of local government, each with land use zoning control
- Substantial federal and state subsidies for residential development on or beyond the suburban edge
- Underpricing of services and utilities serving newly developed areas
- Increasing job specialization
- Increasing product diversity
- Increasing wealth (property and income)
- A constant “time for travel budget”
- Road travel in the Metro area is cheap
- Too much transportation funding from fixed or hidden tax mechanisms
- Households don’t pay full costs of travel
- A buy-now, pay later (by others) mentality
- Desire for personal privacy and mobility
- The Genetic Code of the conventional sub-division: impact on water and roads
- Massive public investments in waste treatment and transportation to accommodate growth
- Primacy of local control over land use
- Increasing affluence of the middle class
- Community values for home ownership and low density
- Capital markets and underwriting standards

Conclusion

Each of the 24 variables identified in the Nine Principles should be measured and routinely monitored. In addition, the others on the systems map should be measured and tracked, too. Do the suggested causal links hold true? What is the delay time between cause and effect? What other important variables should be on the systems map?

Chapter 4: Elaboration and Implication of the Eighteen Nuggets

Nugget 1: A Person's Daily Travel Time Budget is the Dominant Determinant of that Individual's Travel Behavior. (Barnes)

Elaboration:

The daily travel time budget behaves as an implicit, or tacit, “tendency,” even when considering other time allocation demands. While the TCMA value of the budget is, on average, 70 minutes per day, how might it vary by demographic group or by lifestyle preference? The answer: very little, even among people of significantly different economic status. The research suggests that the variable that most closely correlates to travel time budget is city size.

A person's daily travel “budget” is not measured in miles, but in minutes.

Possible Implications:

To the extent that travel to desirable destinations cannot be easily satisfied by walking or by alternative modes, then the time budget gap will be filled with travel time in autos and will sustain associated travel problems and costs associated with autos.

Travel habits of people are not determined as much by congestion as by their personal travel time budget. Time spent traveling in excess of the budget is more of a factor influencing habits than congestion experiences. In other words, people will more readily adjust their travel behaviors to seek compliance with their desired travel budget than they will in response to congestion issues.

Congestion may be a temporary symptom of above-normal growth and could be expected, over time, to self-correct based on the impact of personal travel time budgets. For example, if travelers perceived that no significant transportation capacity infrastructure additions to alleviate congestion were forthcoming, then they may be much more willing to create and use alternative non-auto modes of travel or to promote development that would tend to make more efficient and effective use of their travel time budgets.

Nugget 2: While there are limits on developed infrastructure resources, including transportation systems, there are no practical limits on the land available for edge location development. (Adams)

Elaboration:

The “limits to growth” system archetype is at work throughout the dynamics of transportation and regional growth. It is therefore important to identify the resource conditions required to sustain current economic growth and community vitality and then assess the degree and pace at which they are being consumed. It is also useful to try to anticipate what different enabling resources may be necessary in the future.

One clear example of the presence of a limit to growth is congestion dynamics. Congestion occurs when the demand for roadway space by drivers closely approaches or exceeds the capacity of roadway space available for drivers at that time. In this sense, the available roadway capacity is the “limit.”

However, the amount of low-cost land surrounding the Metropolitan area that is within reasonable travel time from developing attractive destinations is almost without limit.

And, as Adams concluded from research offered in an earlier report (which considered the various laws and regulatory frameworks that shape the geographical patterns of development in new areas and the redevelopment of older, settled areas), “As a result of the legal and regulatory frameworks, developers usually find it easier in time and money, and ultimately less risky and more profitable, to develop on greenfield sites on the built-up metro edges than to develop older areas of the central cities or suburbs.”

Possible Implications:

The combined impact of a fixed daily travel time budget and congestion dynamics suggests that as congestion increases, then the range (in distance) available in which to satisfy needs from desirable trip destinations will decrease. For the auto commuter that means “I need to either get a job closer to home or move somewhere where I can get to work in a reasonable time.” For the employer in a central city location, congestion means a reduction in the range from which to draw employees. Thus, edge-location, greenfield sites, because of lower land costs, are consequently more attractive to both employers and commuters.

When faced with increasingly congested roadways that consume a greater fraction of a person’s travel time budget, a driver is less likely to stop at intermediate destinations to purchase things. Consequently, less demand for goods will lead to declining investment in commercial developments intended to meet these needs. For the driver, that means “it is no longer worth it to stay on the road another ten minutes just to drop off my laundry at the regular place. Instead, I’ll try to go somewhere else, easier to get to.” As a result, over time, businesses near congested areas may close, or may move closer to growing, but less congestion-impacted locations.

Nugget 3: Eighty-four percent of known transportation costs are internal costs, borne by the people who travel. Nevertheless, the absolute size of governmental and external costs, plus a likelihood that external costs are considerably underestimated, calls for public and policy makers’ attention. (Anderson)

Elaboration:

The good news is that an apparently high fraction of total transportation costs are internal costs borne by the drivers/auto owners. It is likely, however, that external and governmental costs are not borne proportionately by drivers and non-drivers, and therefore produce inequities. And, if external costs, like air pollution, are closer to the high end of the range of estimates, then this potentially greater inequity calls for policy makers’ attention.

Fiscal impacts of transportation are not considered as costs of transportation. Anderson defines fiscal impacts to be “the costs that transportation imposes on units of government by promoting inefficient land use.” He argues that transportation and land use serve separate needs – mobility and shelter respectively. While the markets are separate, they are, however, linked in a special way. For example, auto transportation and low density, dispersed housing are complements, i.e., goods that are consumed jointly. Anderson uses a mathematical model to suggest that present

transportation subsidies provide a bonus for some housing markets. He states, “Setting transportation policies to improve the efficiency of the transportation market alone may produce important social gains. These gains may be augmented by gains in the land use market. Beyond this, it may be very difficult to do anything with transportation pricing policies to improve the efficiency with which land is used.” (p.79). An example, perhaps, of attempting to improve the efficiency of the transportation market is the use of privately owned toll roads, as in Denver.

Possible Implications:

We might see most “internal” costs as “controllable” costs, which are incurred at the traveler’s discretion. Thus, the attractiveness of community lifestyles, which are supported by easy non-auto access to desirable locations, could reduce internal transportation costs as well as some external costs like congestion and air pollution from auto emissions.

Consider the relationship between the travel time budget and these cost estimates. Because people seem to willingly seek to consume their budgeted travel time, they implicitly consider that time as a *benefit* and not a cost. Thus, if we were to remove the imputed travel time costs from Anderson’s Total Internal Costs (Mid estimate, 1998), then internal costs would account for 76%, not 84% of the total. Thus, while the absolute size of external costs may remain the same, its relative size and impact on the creation of inequitable conditions may be greater.

Further, it may be useful to consider the distinction between fixed and variable costs. Drivers make daily discretionary choices about how far and how long (time) to travel based on the incremental cost for each unit of time or distance. If the variable of travel time is removed, as suggested above, then internal variable costs are only 70% of transportation costs, the other 30% being governmental and external variable costs which, it is suspected, are not being fairly borne by the drivers. This means that actual transportation subsidies for auto travelers could be much higher than may be currently apparent. It is unlikely that these external costs are equitably apportioned, thereby creating very unfair burdens on population segments, especially in the central cities or inner suburbs, which do little or no traveling by auto.

Nugget 4: Cities and metropolitan areas will naturally experience cycles of investment and disinvestments due, in part, to “success to the successful” and “escalation” dynamics. Further, transportation investments to enhance mobility will not, by themselves, mitigate these cycles. (Adams)

Elaboration:

The delay between when a desirable capital stock offers benefits to a community (sooner) and the time when its full costs are felt (later) is so long that imbalances in relative attractiveness are created that produce “success to the successful” behaviors. The risk of these consequences, or their actual presence, may produce “escalation” dynamics between competing cities and towns, each trying to delay or prevent a period of disinvestments due to rising costs. Adams says, “Much of the increase in business and real estate wealth in some parts of the metropolitan area are being offset by declines in other parts. Many of the incentives influencing business and household behavior inadvertently create instability within neighborhoods, undermining their livability.”

Further, the research suggests that there is no clear correlation between major highway infrastructure improvements and the land development process. Infrastructure improvements have both led and lagged the development process.

Possible Implications:

We may not yet know fully how these cycles of investment and disinvestments really work. But, it is very conceivable that public policies with regard to low-cost housing, transit subsidies, zoning, environmental and other regulations, plus taxing strategies may amplify these cycles.

Nugget 5: The relative attractiveness for investment (of time or money) in a location is influenced as much by the expectation of future change in the value of the capital stock as it is by the current value of the capital stock. (Adams)

Elaboration:

This is not unlike the behaviors of buyers or sellers of securities in the stock market. This is a corollary to Nugget 4. The same reinforcing feedback structures that produce positive exponential growth will generate collapse. Expectation about the rate of appreciation or depreciation amplifies the change in capital stock value.

Possible Implications:

Given (a) the availability of relatively low-cost edge-location land for future development and (b) no indication of any movement to change the systemic structures that offer both explicit and implicit incentives to develop greenfield sites, then important consequences may be inferred.

First, expectations for future returns will be greater for edge-location investments than for investments in more urbanized, high-density areas. Thus, the perceived present and future value of central city capital stocks will be reduced. Rather than invest to rehabilitate or renew central city sites, investors (public or private) will continue to expect more returns from new capital stock in the edge locations.

Second, the reductions in the present and future values of central city capital stocks will be experienced, most acutely, by the current owners of that capital stock. As property values (and prices) move lower, residential and commercial locations there become relatively more attractive to lower income populations. Because these persons are often in greater need of public support, the social costs recovered by higher property taxes or fees become another negative influence on current and expected future capital stock values.

Thus, the criteria used by both private and public investors when considering where to locate new capital stock may be strongly influenced by current systemic structures that inequitably subsidize the edge locations at the considerable expense of central city owners and residents. It all has to do with expected future returns.

Nugget 6: The nature of commercial development can go a long way to influence the attractiveness of a location, and hence its capacity to create demand for travel in and to there. (Barnes)

Elaboration:

It is a matter of both size and diversity of commercial development, plus integrating features that stimulate walking and alternative, non-auto access. Barnes cites the Minneapolis downtown area and the University of Minnesota campus as examples where commercial development has promoted attractive high-density development, which has resulted in the reduction of auto use and its associated transportation costs.

Possible Implications:

Commercial development is intended to create destinations that are attractive spending, earning, or learning opportunities. The question is: To what demographic groups are they attractive? What makes them sufficiently desirable for a person to use up some of his or her travel time budget? Are the newly developed or redeveloped destinations attractive to random individuals in a very large demographic group, or are they designed to attract a specific “community” of people with strongly shared aspirations or practices where living close to each other is desirable? Which comes first: people or development? What can investment in public infrastructure do to stimulate development that results in less of a person’s travel time budget used up by auto travel?

Nugget 7: The Region is at risk when policy makers fail to identify and preserve resources held “in common.” (Adams)

Elaboration:

The “tragedy of the commons” system archetype describes the consequences when individuals – each pursuing their own legitimate and compelling interests – put an unsustainable stress on a commonly owned community resource.

It may be that public capital, including already paid-for infrastructure plus the taxation authority to sustain or grow it, is such a *common* resource. Evidence for this perspective comes from observing the competition among cities and towns for new development where tax rebates or tax holidays are offered to lure an investment away from competing locations. In these cases, each competing town can create a compelling case, even involving survival, to justify its individual actions. However, especially when slowing economic growth rates reduce property values and tax revenues throughout a region, then more and more locations may compete for fewer and fewer investment possibilities. The unintended consequence is a reduction in the entire region’s total (common) value of public capital due to both (a) under-investment in necessary new stock (such as schools and other public service functions) and (b) deterioration of the quality and effectiveness of current infrastructure stock due to insufficient ongoing tax revenues.

Possible Implications:

The Metropolitan Council seems to be one “authority” empowered to address how to best manage the commons. Does it have sufficient power to do so? What is the role of the state or the federal government? What other common resources are suggested by the research? Are they closely related to external or government costs as suggested by Anderson? Is, for example, a

high level of public health a common resource to be protected from transportation-induced air pollution?

Nugget 8: The new economy and technology may have a significant, but only now emerging, impact on land use and transportation. (Ward)

Elaboration:

We are at risk in considering only plausible futures that are based on past systemic structures and behaviors. The risk is that we are (a) unable to see the possibilities that otherwise might present themselves or (b) that we do not discover in time the unintended or unanticipated consequences of our decisions or actions, especially when they are difficult to reverse. It seems that the new economy, involving new technology, new working relationships, and new expectations about how we will treat one another, will have significant influence on all aspects of our future, including the dynamics of transportation and regional growth.

Many workers in the new economy may have more flexibility in meeting their travel demands. For example, as they need to spend less time on routine commuting travel time, will they spend more travel time in fulfillment of an implicit “social time budget?”

Possible Implications:

Roads are planned and built to handle “peak demand.” Could the new economy cause the peak to diminish or to diffuse the peak in some new way? Maybe we won’t have to build any more major new roads.

Should more research be done on this issue?

Nugget 9: There appear to be some deep-seated assumptions about the past and the future that influence the thinking exhibited in some of the reports. Some of these mental models are very explicit; but others are not. In any case, they have a significant presence in the work we do together.

Elaboration:

Our individual and shared mental models are the sources of all of our decisions and actions. These mental models determine what new input will enter our minds and how we will value it. These mental models provide our own personal explanation about how the world works, and what we consider important.

A major purpose of seeking a “systems thinking perspective” on the issues of transportation and land use is, we believe, to help people more fully articulate and share their individual mental models. By doing this, we believe that the citizens and policy makers in Minnesota will – together – create the powerful and useful *shared* mental models that will form the foundation for improved public policies.

Possible Implications:

All of us involved with this study may benefit by increasing our awareness of our own relevant mental models.

We may also benefit by the mutual sharing of our mental models. What are the common models? What are the differences? What can we learn that will improve the quality of the models we use, either individually or as members of a community, to make decisions or take actions?

“Mental Models” as Modified by Conversations on September 7, 2000 with PIs

- Sprawl is bad!
- Sprawl is natural and inevitable.
- The costs of sprawl are not distributed equally.
- Whatever is familiar is necessary.
- We live in a market economy.
- Whatever happens is a consequence of natural market forces.
- Congestion is a cost.
- Unmanaged growth is bad!
- The best land use decisions are made at the local level.
- The transportation and land use problems we see today should have been solved before now. Somebody should have known better!
- Local communities must compete or die.
- Communities shouldn't be “boutiques.”
- High-density locations are better than low-density locations.
- Mixed-use density is better than low-density.
- Center city residents pay more than their fair share of transportation and land use costs.
- Even in the future, automobiles will be the primary source of air pollution.
- Travel time and distances by trucks are not significant to regional transportation dynamics.
- No, trucks are a huge part of the models.
- There is a perpetual underclass, and we need to keep them in the cities because that's where their jobs are.
- Mn/DOT is responsible for the wise evolution of the transportation structure of the state.
- It's good that we've got Northwest Airlines here because of its advantages for the region.

Nugget 10: The adoption of more efficient road tax policies – like substantially higher motor fuel taxes or mileage taxes – will increase the net present value of transportation costs for commuters driving long distances and would likely delay the pace of exurban land development. (Ryan)

Elaboration:

The adoption of more efficient road tax policies – like substantially higher motor fuel taxes or mileage taxes – will increase the *net present value of transportation costs* for commuters driving long distances. To the extent that this higher travel cost is more than the “development premium” for parcels of land at the urban/rural fringe, then development in those fringe areas, and the adjoining rural areas, will be less attractive and would likely delay the pace of greenfield land development. The development premium is the market value per acre of a parcel for non-farm use less its value for agricultural use.

In those potentially exurban properties (we use the term exurban to denote the urban/rural development fringe area), an increase in the net present value of transportation costs of commuting to and from there of \$5000 could well make it (temporarily at least) impossible to find a developer willing to bid more for the land than its agricultural value. Thus, the result of higher variable pricing for roads may well cause development to proceed in a more measured, concentrated manner. Whether or not there will be any impact on development will depend on the change in the net present value of transportation costs and the development premium the market formally assigns to the property.

Nugget 11: For the 1996 study period, 71% of the \$993 million TCMA road-related taxes collected were from fixed or hidden taxes that are unrelated to travel behavior. (Ryan)

Elaboration:

While Minnesota policymakers have a wide variety of tax options available to fund state and local roads, reliance on local property taxes, sales taxes, and income taxes for road funding effectively hides many of the costs of vehicle travel from the public. In fact, for the 1996 study period, 71% of the \$993 million TCMA road-related taxes collected were from fixed or hidden taxes that are unrelated to travel behavior.

If policymakers chose to charge the full costs of transportation, including externality costs like pollution or congestion, then, based on a CTS study of 1998 costs, “charging households for these externalities would take an equivalent of a \$0.67 per gallon increase in the motor fuels tax.”

Nugget 12: If, over the next 25 years, the state wishes to maintain the same level of transportation service as available today, then road funding must become even more reliant on property taxes and the state’s general fund. (Ryan)

Elaboration:

The current variable taxes on travel will be inadequate to keep up with road related expenditures. “When the projected revenues from the three taxes are combined for the 2025 period, there is a shortfall of nearly \$400 million compared to the inflationary cost increases. Again this means that without changes to current law, road services will have to be reduced, or the property tax and/or state general fund contributions will need to increase. This is not necessarily a bad thing; the point is to recognize where the long term revenue weaknesses are in the system. The question of what portion of revenues should be variable, fixed, or hidden is still unresolved.”

Nugget 13: Conventionally developed suburban places, which are designed around the Genetic Code of the Subdivision, inevitably will lead to serious and long-lasting depletion and damage to quality of the area’s water – both surface water and ground water. (Neckar)

Elaboration:

Low quality water will significantly reduce the attractiveness of the place for current and potential residents or businesses. Consequently, population and economic activity will eventually decrease, and the area could fall into a vicious cycle of decline and decay. It is possible, however, to mitigate or reverse these patterns of behavior by the adoption and aggressive

application of water-friendly designs and regulations for subdivision and supporting public infrastructure, especially transportation.

Why is it important to seek to reverse the impacts of conventional development in the metro area? Neckar's report notes the following. "Every city in the metropolitan area has its own water source, but more than 75% of the drinking water in the metropolitan area comes from surface waters in the region's three major river watersheds: the Mississippi, the Minnesota, and the St. Croix. Minneapolis and St. Paul draw water from the Mississippi River, the latter through a reservoir system of protected lakes. In a drinking water system that depends on surface waters in such reservoirs, all types of runoff must be controlled. Normally, reservoir systems are buffered by substantial public land holdings. However, contaminated runoff that seeps into shallow groundwater layers (such as outwash) can move over distances and be discharged above or in the upper layers of sedimentary formations.

"The remaining 25% of the region's water comes from groundwater resources. As suburban growth begins to move farther away from the rivers and up into their watersheds, the use of groundwater will be more prevalent."

Neckar, therefore, contends that the Twin City Metropolitan Area governance structures must consider management of its hydrological system as a regional matter, not left up to individual, local authorities. And, that regional policy intervention should involve two areas of initiatives: First is the application of water-friendly design practices for residential settlement that result in reduction of impervious surfaces and the creation of surface features and public infrastructure that increase the infiltration rate of precipitation. Second is continued adoption of water-friendly regulations that aim to reduce the levels of contaminants that are introduced into collected water.

Nugget 14: The region's comprehensive plan for land use preserves low local density limits, which reinforces the growth of an unstratified transportation network, thereby reducing non-auto access options from and to higher-density places. (Neckar)

Elaboration:

Neckar sees the need for explicit policy intervention to advance and implement transit-oriented design (TOD), high-density, mixed use development strategies within the metro area. The most essential step, he argues, is to increase local density limits within the metro area.

What are the consequences of low-density limits in land use controls? How could those limits be changed to stimulate more high-density residential developments that shed the current genetic code of the suburban subdivision?

The development of traditional subdivisions, which involves the developer-designed and built residential streets and connector roads to serve the place, creates an auto-dependent population that demands higher levels of public investment in an unstratified auto-oriented transportation network. A well-stratified transportation network would provide, according to Neckar, the area's population with multi-modal travel options, including commuter rail and transit.

Neckar points out that the growing number of traditional low-density subdivisions in the region's suburbs has two significant effects that impact transportation system dynamics. First is the need for private cars as the primary mode of travel. Second is the greater number of developer-built collector and residential roads that are not effectively linked to arterial roadways. As more and more people live in traditional subdivisions and use private cars, they require from government a greater public funded investment in arterial roadways to provide more rapid, auto-oriented access to nonresidential destinations like jobs or shopping.

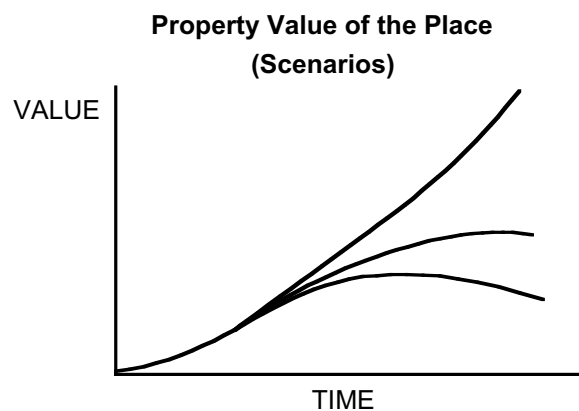
In our current system of land use regulation, low local density limits sustain the economic attraction to develop land for the traditional suburban subdivision. And, as described in other sections of this integration report, the growing number of traditional subdivision homeowners and residents form a powerful constituency to increase or, at least, preserve the property values of their low-density places. They perceive that low-density limits are important policy controls for achieving that purpose.

Nugget 15: The current patterns of land development and transportation investment within the metro region are the consequences of powerful systemic government, social, and economic structures and are designed to grow the total property value of the region. (Lukermann)

Elaboration:

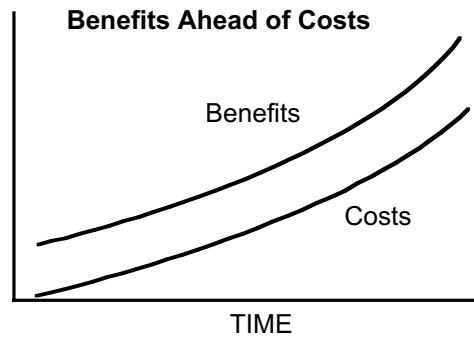
Is the property value of a place a “fair” measure of the goodness of a place? Perhaps. Is it the only appropriate measure of the goodness of a place? No. Is it a useful long-term measure of the goodness of a place? Yes. Why, because in our society, where we value individual freedoms and competitive market-based economics, the dollar value we ascribe to a parcel of real property is its “present value,” an amount based on the expected flow of future value to those who will use or own it. The higher the expected flow of future value, then the higher is the parcel's present market value. Conversely, if the future value of the parcel is expected to decline, then the present value is lower. It is this logical relationship in the real estate market that justifies property taxes.

The chart below suggests three general scenarios for the property value of a place over time. First, value could grow exponentially and consistently; second, value could grow exponentially, but then level off or flatten out; or third, value could grow for a while, flatten out, and then decline over time. What could cause these different patterns of growth behaviors?

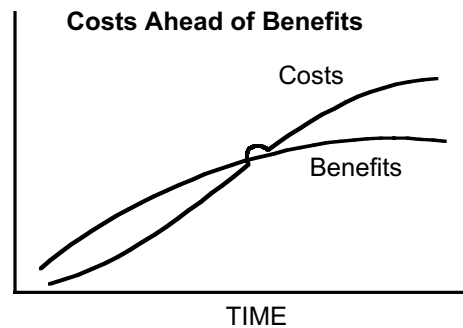


The property value of a place is one of many factors, or variables, which interact with each other in a complex economic, demographic, and social system.

Fundamentally, the system of the place (a city or town) produces both costs and benefits to the people who live and work there. A place is competitive in attracting and retaining population if its net benefits (total perceived benefits minus total perceived costs) are substantially positive. This dynamic is represented in the diagram below:



However, if the net benefits are either negative or very small, then other places will be more relatively attractive, and some of the population of the place will move away. This situation is illustrated below.



The challenge for the community's elected or appointed leadership group is to make and implement governance decisions such that the benefits of the place are consistently greater than the costs of the place.

For policy makers and government executives, their mission is to initiate and manage the flow of public investment in order to build and sustain a high relative value of the place so that people will want to live and work there. To do so, they manage the mix of investment in place features and capacity. The scope of investment includes, but is not limited to the items shown in the table on the next page.

INVESTMENT IN ...	CREATED BENEFITS
Schools	Education
Roads and Transit	Access
Police and Fire Departments	Security
Water, Sewer, Environmental Quality	Health
Telephone and Cable	Communication
Governance	Democracy
Courts	Justice
Administration	Policy and Controls

As noted on the previous page, the public investment rate is intended to build and sustain created place benefits, which increase or maintain the relative value of the place for those who live there. But government executives and policy makers do not control the whole system. In fact, increasing the demand for homes in the place leads to higher home prices, which, after some delay, reduces the relative value of the place, thereby reducing demand. This is a balancing feedback loop at work. Similarly, the growing population of the place creates indirect costs (reduced environmental quality, congestion, etc.) that can reduce the relative value of the place by mitigating the original natural benefits of the place. In addition, as the infrastructure features and capacity of the place age, the direct costs to maintain or replace them increase. Often, tax revenues shift from financing new investments to simply maintaining the old. Indirect and direct costs combine to create other balancing loops that will slow down, or even reverse, property value growth.

Thus, what are the key take away messages related to this nugget?

- First, in America, land use policies and decisions must always consider the impact on the total property value of a place.
- Second, citizens and policy makers in a place should recognize that they are players in a complex system, made up of powerful reinforcing and balancing feedback loops that influence property values.
- Third, they should take steps to identify and routinely measure the key variables that are relevant to that system.
- Fourth, they should articulate, examine, share, and validate the “mental models” that they have about how these variables are related to each other.
- Fifth, because the system is so complex, with such a variety of interests and long delays between causes and effects, policy makers should use simulation tools to communicate and practice policy interventions before actually putting them in place.

Nugget 16: The growth in local control over land use has weakened the opportunity for region wide or statewide planning to coordinate and complement – and therefore maximize the overall common good – land use and transportation across all local governments. (Lukermann)

Elaboration:

Lukermann and others, including Lance Neckar, point to the consequences of the growing power of local planning authorities to control residential density limits.

As long as the property value growth rate is positive, then property owners will exert pressure for a lower density limit. Why? Because the density limit seems to produce an apparent benefit in the minds of potential buyers, and because lower limits will eventually produce an apparent shortage of homes, thus sustaining or increasing property values. However, if the property value growth rate stalls or goes negative, then the place has reached the point where the costs of the place are beginning to overcome the benefits of the place, and a rapid downward cycle of declining property values can ensue. To offset this, owners are willing to open up the place for more residents who will help share the burden of increasing costs of the place, and thus avoid property tax increases.

As homes in a place age, along with public infrastructure, direct maintenance costs increase. Indirect costs also increase with the maturity of a place, and parts of these costs are often shifted to others outside the locality, affecting non-local interests who seek to impose more region-wide controls to mitigate the impact of those external costs. They too become a constituency for increasing density limits as a tool for increasing or maintaining the tax paying population of the place.

What then have we learned from the systems thinking perspective of Lukermann's summary?

- First, existing low-density limits are used by home builders and home owners to sustain a relative scarcity of available space for residential development, thus stimulating higher home prices.
- Second, as available space is consumed with homes – based on lower-density limits – the property owner constituency grows in power to manage the growth in demand for public services of the place.
- Third, as places grow older, or if public investment does not yield benefits in excess of costs of the place, then property values will flatten or decline. At this point, local owners will allow an increase in density limits in order to attract more tax paying residents, and thereby share the burden of higher relative costs.

Nugget 17: Growth in average per capita income in Minnesota will inevitably result in “affluence effects” on land use and transportation patterns, including continued development of low-density suburban places around both regional and metro cities, and pressure for greater auto-friendly investment in roads and highways. (Lukermann)

Elaboration:

Some key points that emerge from a systemic perspective on Lukermann’s list of driving forces and factors include:

- The continued ability of public and private investment to produce value, wealth, and jobs in the area is essential for sustained competitive attractiveness.
- Regional growth in population and per capita affluence is a good thing for most people who live and work in Minnesota.
- But growing affluence creates effects that result in the decentralization of the population into lower density suburbs and in higher demand for VMT in private cars. Reports show that there are external costs associated with these effects, and that they are not borne equitably everywhere.
- Lacking stringent centralized controls that limit the freedom of people to pursue their economic interests, the decentralization of jobs and population will continue.
- Commute and freight flows will increase from suburb-to-suburb and around non-metro regional centers faster than from suburbs to the central cities.
- The affluence effects, along with decentralization effects, all reduce the demand for transit.

Nugget 18: The historical growth and settlement patterns demonstrated by the greater Twin Cities are being mirrored in the growth of regional center cities throughout the state. (Adams)

Elaboration:

Historical and ongoing growth patterns in Minnesota have resulted in the urbanization of the countryside. The minor civil divisions (MCDs), or small towns nearest a regional center city, are growing faster than the MCDs farther away from the regional center.

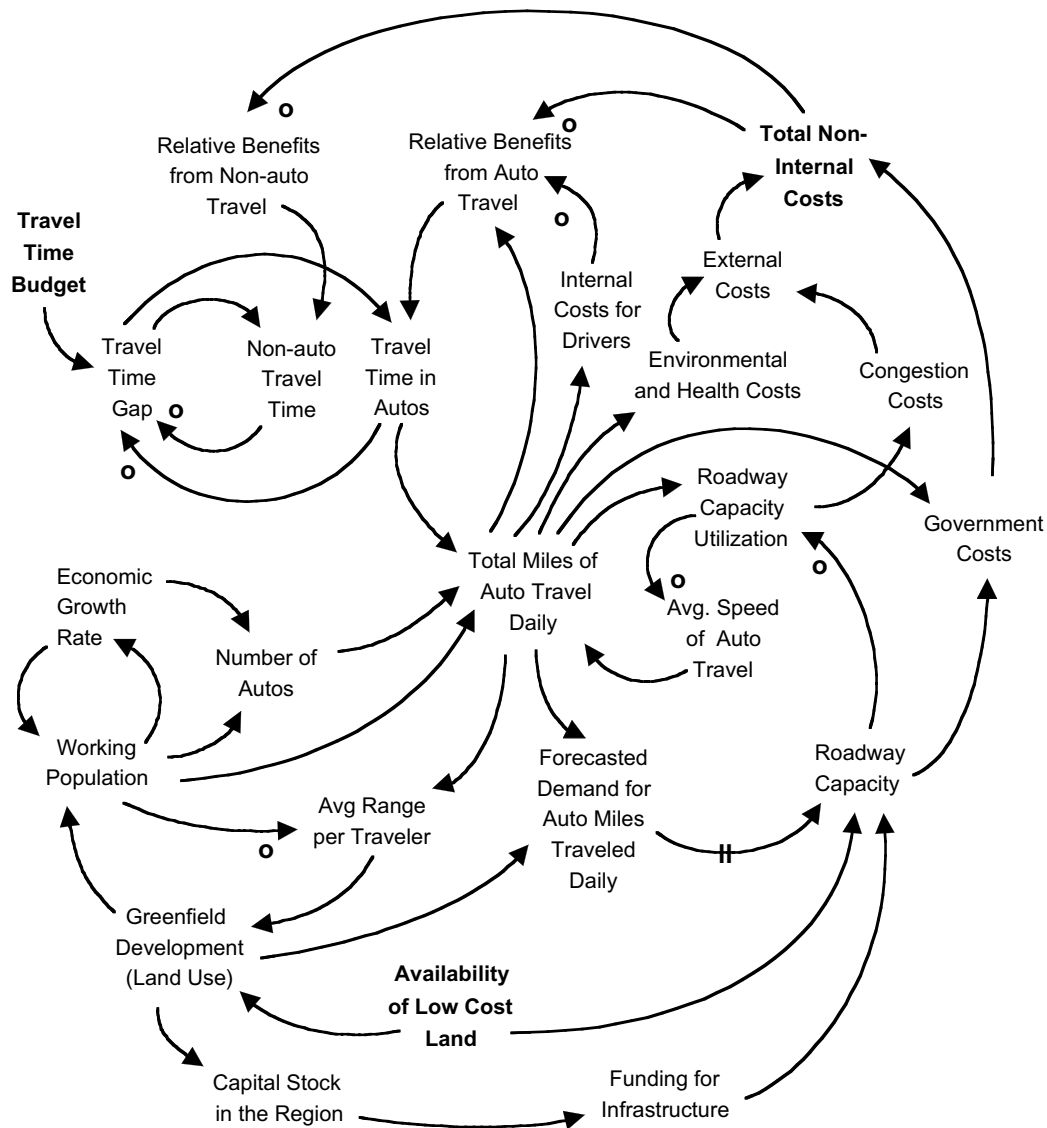
A majority of Minnesotans seems to share a cultural bias toward living in places that offer an environment evocative of open spaces and green spaces, with a favorable identification with “the land.”

The cycles of growth and decline seen in places within the greater Twin Cities metro area are also present among the state’s regional centers. Some are experiencing fast growth, while some others are stagnating or declining in population and relative attractiveness to new investment.

The nature of settlement patterns around currently growing regional centers was once present within the Twin Cities. However, it seems that the greater Twin Cities metro area has moved to a more mature phase, involving pressures for decline within its inner core suburbs.

Chapter 5: A Composite Causal Loop Diagram from the First Three Parts

The causal loop diagram (CLD) below suggests some of the important feedback relationships that are described in the first nine nuggets previously discussed. These nuggets were developed in the first phase of the systems thinking integration project, involving the work of Barnes, Adams, and Anderson. The findings of the subsequent four reports support these relationships. A more complete and detailed perspective is to be found in the systems thinking perspectives prepared for each of these three individual research reports. At this time, however, do not try to absorb the entire “map” at once. The remarks that follow will offer a “build-up” of some key sectors of the system diagram. As you read them, note whether you agree or disagree with the causal relationships presented. But, first, let’s review some conventions for reading a CLD. These conventions apply to all of the causal loop diagrams in this document.

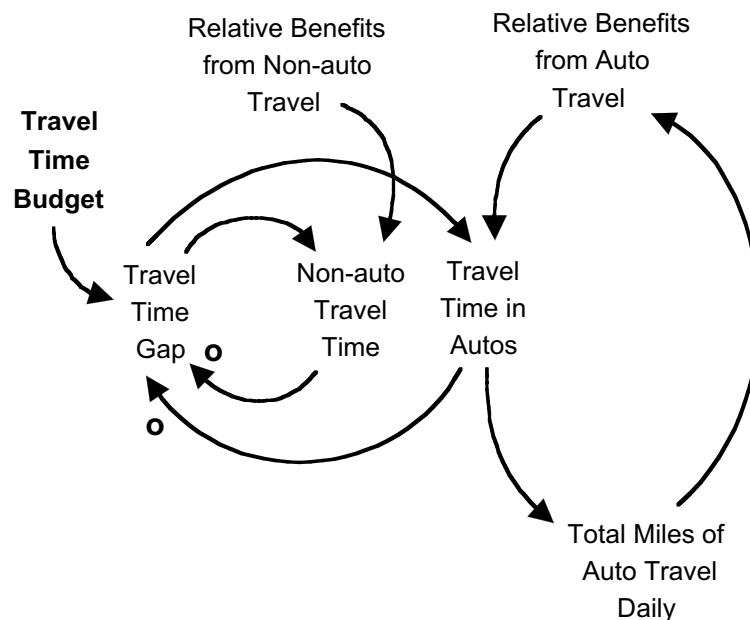


The variables in the CLD are connected by causal links. The “cause” is at the foot of the arrow, while the “effect” is at the head of the arrow. The direction of causality is assumed to be “the same,” i.e., if the cause variable increases, then the effect variable also increases, or, conversely, if the cause variable decreases, then the effect variable decreases. If an “o” is positioned at the head of a causal link arrow, then the effect moves in the “opposite” direction from the change the cause variable.

Notice that three of the variables appear in **bold** print: the Travel Time Budget, the Availability of Low Cost Land, and Total Non-Internal Costs. These variables are the principal focus of the first three nuggets.

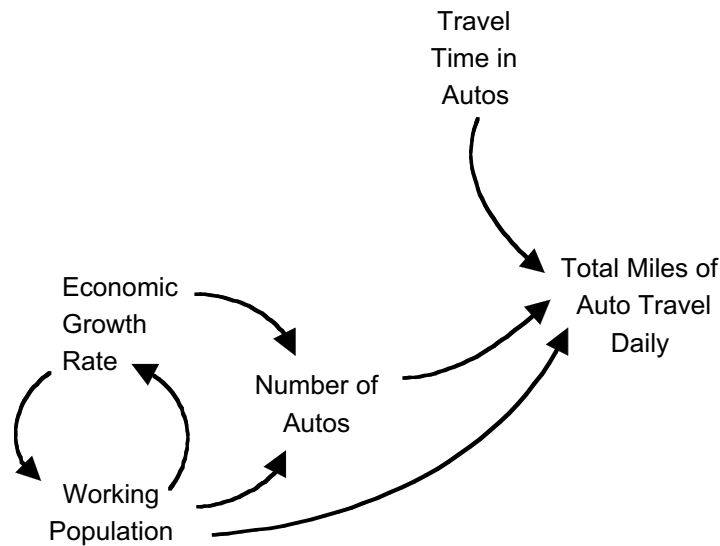
Notice, also, that the travel time budget and the availability of low cost land are the only two variables in the diagram that are not effects of any other variables. As such, they are exogenous variables, and have considerable impact as “constants” in this system.

The travel time budget serves as a “goal” that creates a “gap” that is filled, each day, by time spent in either auto or non-auto travel, usually to work and back, or on other needs. The travel time minutes allocated to either auto or non-auto travel is determined by the relative benefits to the person offered by each mode. The net benefits (benefits minus costs) of each mode are evaluated, and one mode is assigned a higher value *relative* to the other, and that mode is chosen if it can be utilized. This systemic structure, found in the CLD, is illustrated below.



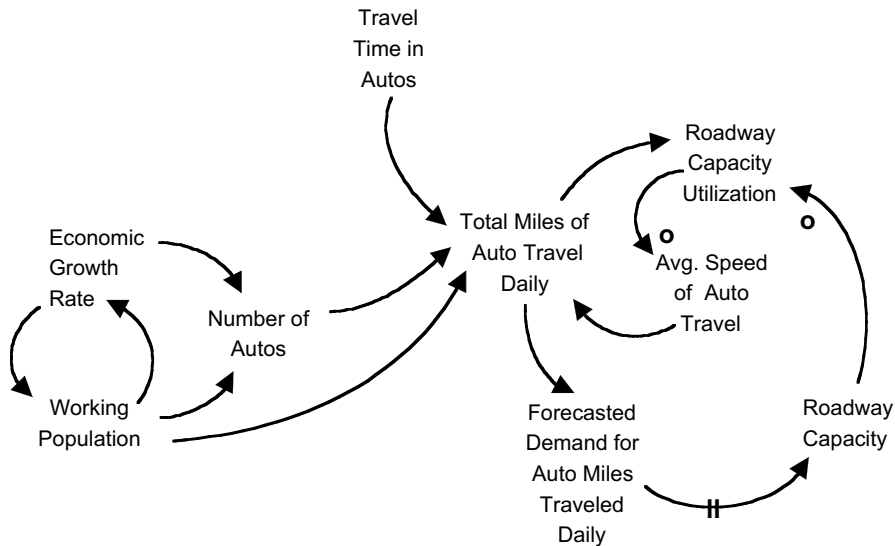
Travel time in autos spent by travelers is a direct contributor to the variable Total Miles of Auto Travel Daily in the region. The capability of people to travel significant distances to desirable destinations is the source of the Relative Benefits from Auto Travel. Implicit in the diagram is the corresponding idea that many people find sufficient Relative Benefits from Non-auto Travel to allocate some or even their entire travel time budget accordingly.

The next sub-diagram illustrates additional factors that cause Total Miles of Auto Travel Daily to change.



The number of people working, the number of cars or trucks they have, and the overall pace of economic activity are important causes of the total miles of auto travel daily. The working population and the region’s economic growth rate are connected in a reinforcing feedback loop.

The challenge for policy makers, especially at Mn/DOT, is to be aware of behavior patterns in the region’s travel demand in order to forecast, justify, fund, and build an appropriate level of Roadway Capacity. This dynamic is shown in the sub-diagram below.

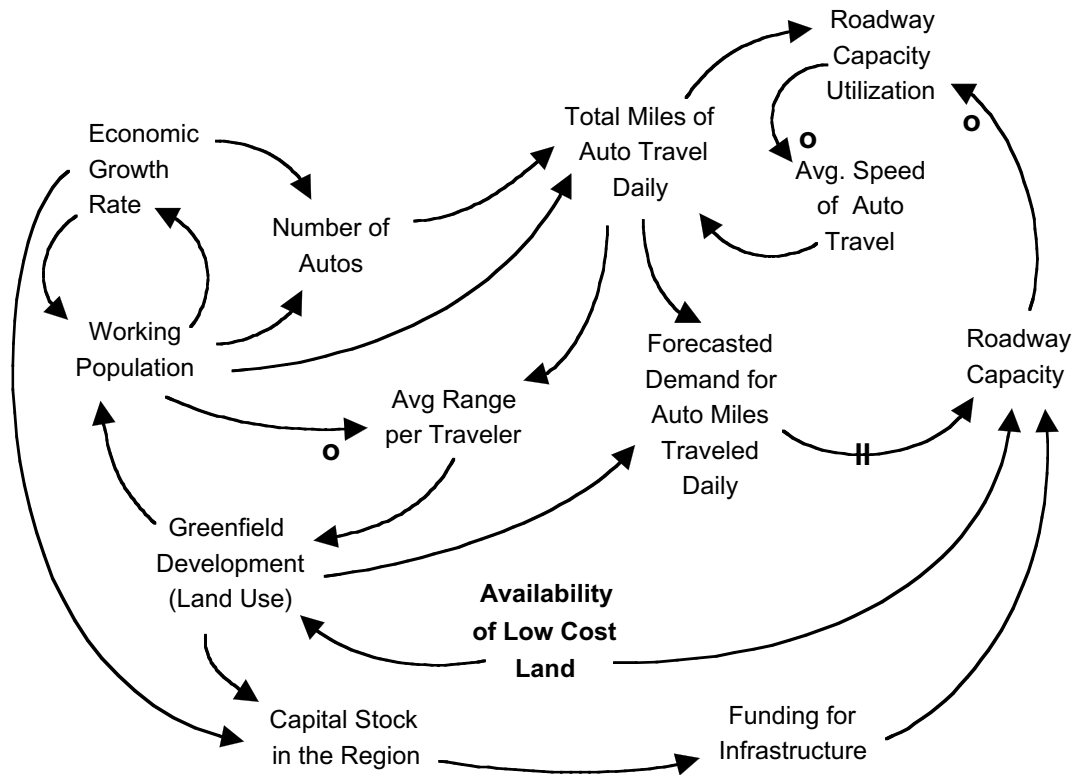


The policy aim, according to the diagram, is to provide sufficient transportation infrastructure such that travel demand can be met without exceeding design capacity utilization targets, and thus provide travelers with a satisfactory average speed to their destination. Change, over time,

in the hour-by-hour average usage rates that make up Total Miles of Auto Travel Daily is used to forecast future needs for Roadway Capacity.

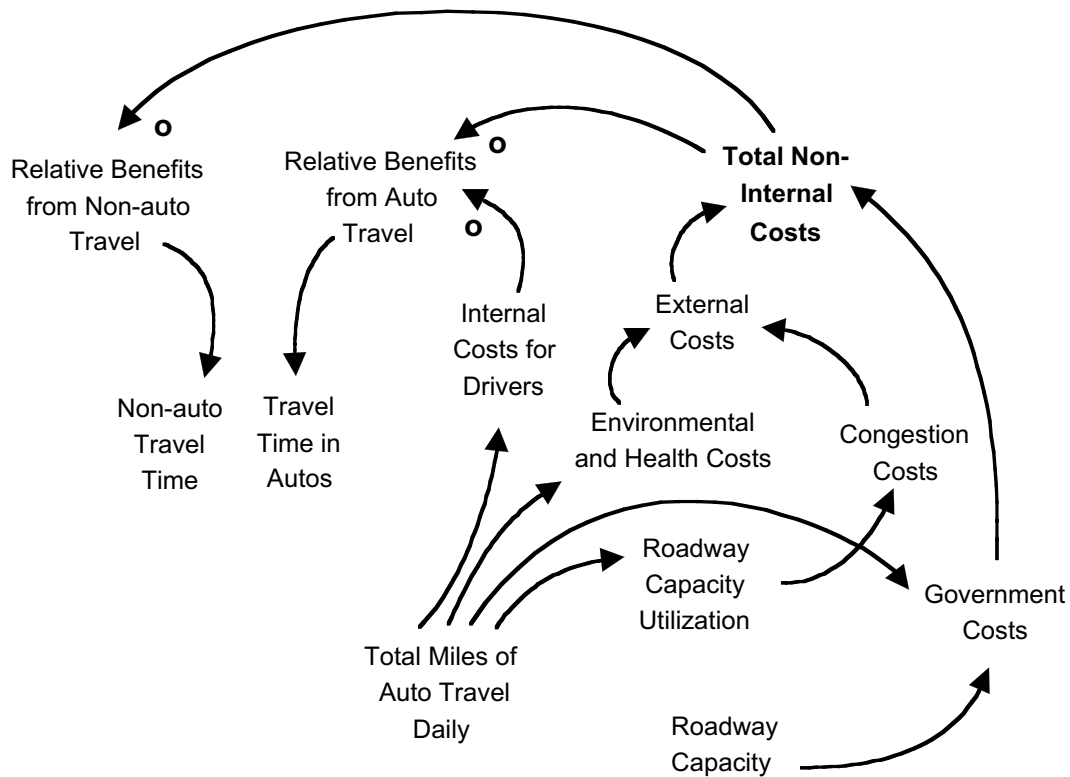
As the research shows, however, a very significant factor influencing regional growth and the transportation system is the Availability of Low Cost Land in edge locations.

The sub-diagram below suggests some of its systemic impacts.



The availability of low cost land has two major effects. First, it makes the development of edge-location greenfield locations more attractive to investors. Second, the cost of adding roadway capacity in edge locations is much less than in central city or inner suburb locations. As a result of increased roadway capacity to edge locations, roadway capacity utilization is reduced and average speeds can increase to allow greater travel distances, and thereby increase the Average Range per Traveler. The increase in range brings new greenfield developments (residential or non-residential) into the travel time budget of more people. New development stimulates jobs, more population, and an increase in the value of capital stock in the region. This “engine of growth” justifies funding for transportation infrastructure improvements.

The build-ups thus far suggest how benefits are produced from transportation infrastructure within the region. What about the costs involved? The sub-diagram on the next page suggests the systemic sources and effects of those costs.



The issue here is the magnitude and equity of distribution of Total Non-Internal Costs of transportation among those who must decide the allocation of their travel time budget between non-auto travel modes and auto travel. Yes, most of the transportation costs are internal costs borne by the auto travelers. Nevertheless, are the costs associated with putting in place and maintaining the region's roadway capacity being borne equitably by the region's residents? The research suggests that they are not.

At this point, all of the variables introduced in the sub-diagrams have been accounted for. Now, go back to the whole CLD to see the big picture perspective.

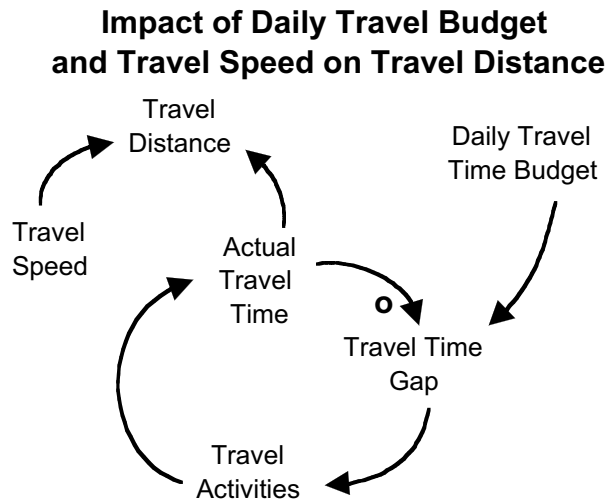
Chapter 6: Systems Thinking Perspectives on Each Research Report

Gary Barnes and Gary Davis: *Land Use and Travel Choices in the Twin Cities, 1958–1990*
(TRG #6, 2001)*

Primary Finding

The primary finding of the Barnes research project is that “there is still a daily ‘budget’ for time spent traveling” in the metro region, and that when people travel, they “spend on average about 70 minutes” doing so. Further, people like to travel, but can be constrained from doing so because of economic or social limitations.

The following diagram is a simple causal loop diagram offering a systems thinking perspective on the primary finding. It is a causal loop diagram describing the balancing feedback structure that generates “goal-seeking” behavior, namely daily travel activities.



As Barnes describes in his report, *travel distance* is not an effective measure of travel activity. More important is the daily travel time budget. The traveler does not seek to either reduce or eliminate the need to travel longer distances. Instead, the traveler is most content when he or she is able to make the time to travel to a variety of desirable destinations. As the diagram suggests, the daily travel distance traveled is a function of travel speed.

The powerful insight from this research is that the daily travel time budget is really a “goal” that drives travel behavior. To understand travel behaviors, one must understand how different people are willing to satisfy this goal.

* Ed. Note: Barnes and Davis explored the policy implications of traffic forecasting models in *Understanding Urban Travel Demand: Problems, Solutions, and the Role of Forecasting* (TRG #2, 1999).

Secondary Finding

The secondary finding is that “while there are variations in travel behavior across the region, these differences arise more from specific locations and the people who live in them, rather than from the way land is developed.”

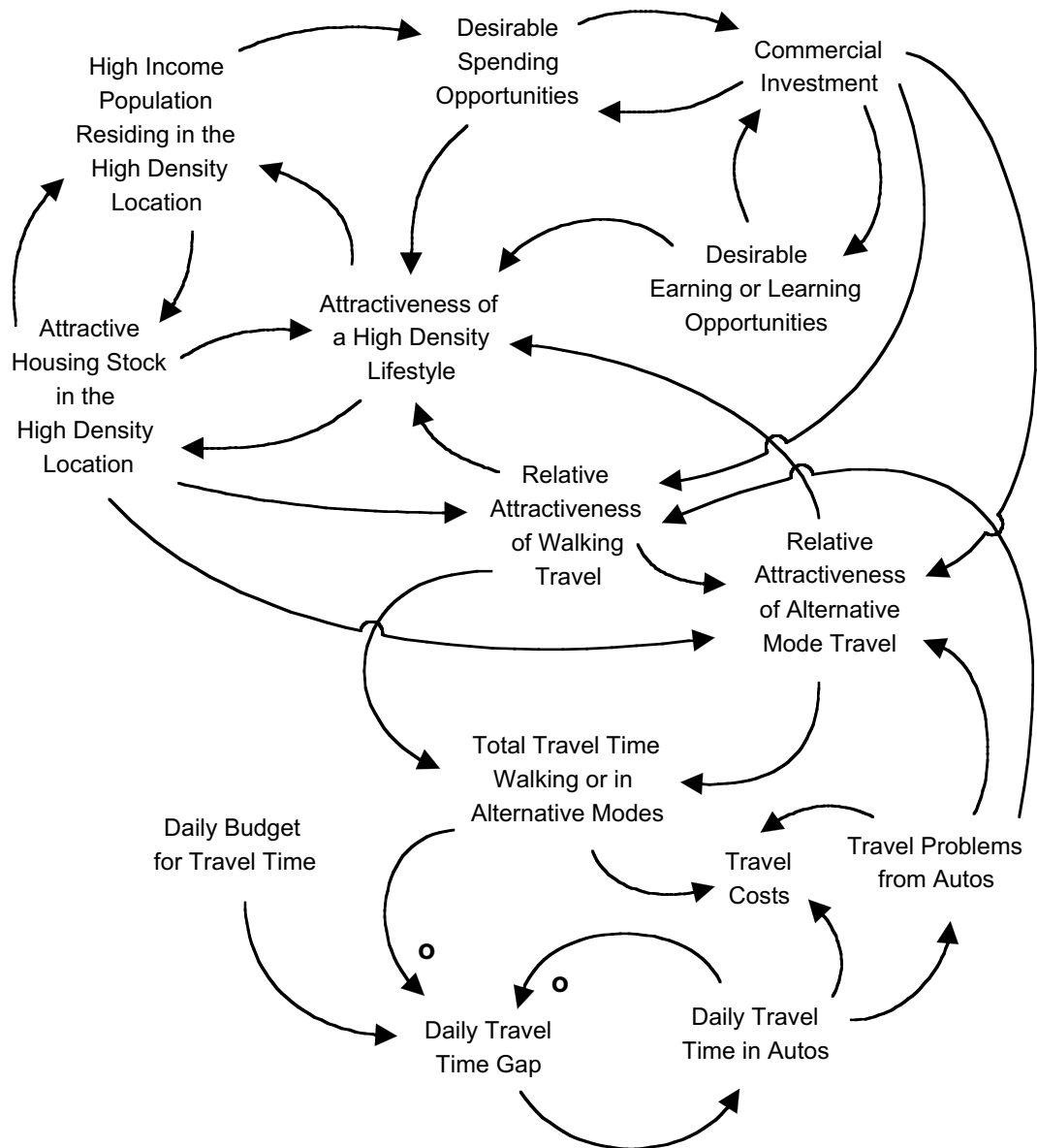
Therefore, if we consider that travel behaviors almost always involve leaving an origin and moving to a destination, then land use policies in the origin location would have little impact. However, land use policies in the trip destination location can have a big impact.

To arrive at this finding, Barnes considered four categories travel behavior sources. They are: land use, location, transportation system, and the people themselves, including their preferred lifestyles.

The principal conclusion Barnes reaches, based on his findings, has two dimensions. “First, that the increasing density of commercial development is much more likely to have a significant impact on travel behavior than is higher density in residential neighborhoods.” The second is “that auto-related problems are unlikely to be solved by a general reduction in auto use, because this is unlikely to happen. However, we feel that significant localized reductions in car use are entirely possible; investments in land use and alternative modes that are directed at the right people and places may very well have a considerable positive impact.”

To illustrate the above, we suggest a scenario with a systemic structure that produces a high level of attraction to people who are comfortable with a high-density lifestyle. A causal loop diagram and a brief narrative are presented on the following page.

**Land Use Influences on Travel Mode Choices:
A Favorable High-Density Development Scenario**



Core story: Commercial Investment to sustain/increase density in the location yields desirable "spending" destinations, desirable "earning or learning" destinations, plus higher "relative attractiveness" of alternative mode or walking travel. The consequence is a higher level of Attractiveness of a High Density Lifestyle, which, in turn, stimulates an increase in residential investment to raise the level of attractive housing stock in the high density location. Attractive nearby housing co-located with desirable commercial opportunities increases the relative attractiveness of walking, especially if non-auto transit facilities are also available. The result is that residents and nearby neighbors who learn or work there will spend more time walking or in non-auto travel, and less time fulfilling their "travel time budget" traveling in autos.

The findings and conclusions of the report are based on a thorough exploration of the potential sources of travel and land use behaviors. In the systems map that follows, is a more detailed “generic” diagram illustrating the interrelationships of many of the key variables Barnes suggests influence and/or measure travel behaviors. We have organized them in the four categories he uses. The (L) following a variable denotes it as a “level” or a “stock.” An (R) following a variable denotes a “rate” or a “flow,” and can also denote a component of a “rate equation.”

Location:

- Quality of the schools (L)
- Public resources in the location (government and non-government) (L)
- Proximity to desirable “spending” opportunities (L)
- Proximity to desirable “earning” (and learning) opportunities (L)
- Ease of access to destinations in the location (L)
- Relative attractiveness of walking travel in the location (L)
- Relative attractiveness of alternative mode travel in the location (L)
- Relative attractiveness of auto travel in the location (L)

Land Use:

- Residential development subsidies (R)
- Commercial development subsidies (R)
- Commercial development investment for ... (R)
 - Desirable spending opportunities (L)
 - Desirable earning opportunities (L)
 - Ease of access to suppliers (L)
- Residential investment in the location for ... (R)
 - Attractiveness of new housing stock (L)
 - Attractiveness of mature housing stock (L)

Transportation System:

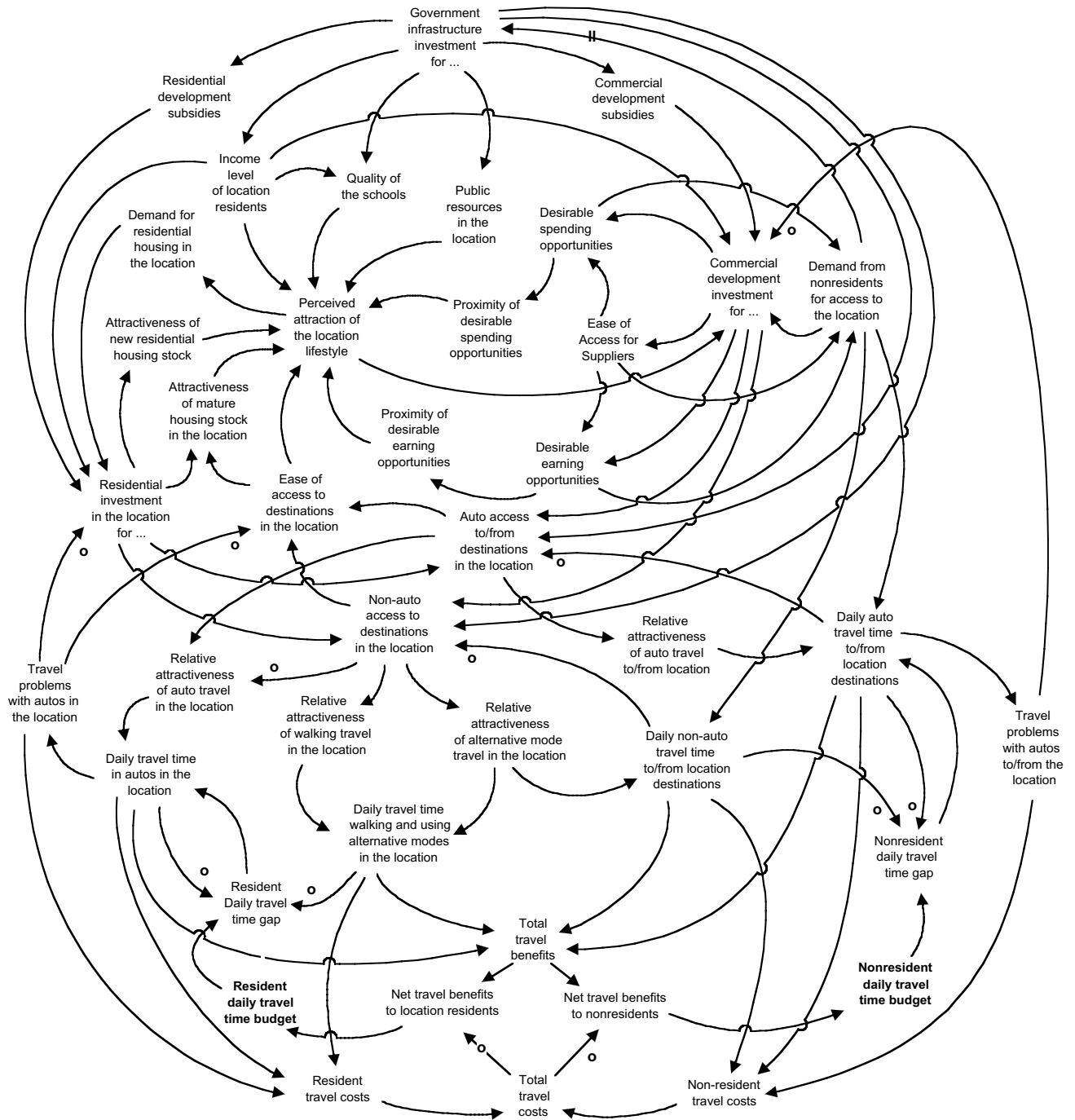
- Auto access to destinations in the location (L)
- Non-auto access to destinations in the location (L)
- Daily travel time in autos in the location (R)
- Daily travel time in autos to/from location destinations (R)
- Daily travel time walking and using alternative modes in the location (R)
- Daily non-auto travel time to/from the location (R)
- Travel problems with autos in the location (R)
- Travel problems with autos to/from location destination (R)

People Themselves:

- Income level of local residents (L)
- Demand for residential housing the location (R)
- Perceived attractiveness of the location lifestyle (L)
- Demand from non-residents for access to the location (R)
- Resident daily travel time budget (R)
- Resident daily travel time gap (R)
- Non-resident daily travel time budget (R)

- Non-resident daily travel time gap (R)
- Net travel benefits to location residents (R)
- Net travel benefits to non-residents (R)

Impact of Daily Travel Time Budgets on Travel and Land Use Behaviors



*John Adams et al.: Synthesizing Highway Transportation, Land Development, Municipal and School Finance in the Greater Twin Cities Area, 1970–1997 (TRG #4, 2000)**

The Executive Summary of the Adams research project describes how the TRG Study goes to the core question: “What can Mn/DOT and regional government do in the next few years to support livability and sustainability?”

This question is posed in the context of regional dynamics that involve, according to Adams, economic and social incentives, land use patterns and transportation activity, and how they are connected together in a continuing process of circular and cumulative causation.

Primary Finding

After thoroughly examining the forces at work producing the regional dynamics of transportation and land use, Adams concludes: “The benefits of land development and transportation improvements accumulate disproportionately within one set of geographic areas, while many of the costs are imposed through time and space on others.”

Elsewhere, he reinforces this finding by these remarks: “Much of the increase in business and real estate wealth in some parts of the metropolitan area are being offset by declines in other parts. Many of the incentives influencing business and household behavior inadvertently create instability within neighborhoods, undermining their livability.”

The consequences of the perceived inequitable distribution of costs will become more severe in the future. Adams says, “It is unlikely that the livability we currently enjoy can be maintained if present development trajectories are not redirected. Efficient use of the present system seems to be declining, and trends are worrisome if we are to have an efficient, equitable, and environmentally sustainable metropolitan system in the decades ahead.”

What, then, in a state that prides itself on its equitable treatment of people, are the systemic structures producing these disappointing outcomes? Why are the policies that seemed to work so well in the past now becoming ineffective, or even worse, counterproductive? How is it that well-intentioned interventions lead to these unintended or unanticipated consequences? The answer, we suggest, lies in the complexity of the “whole system” of which we are a part.

Linkages and Feedback that Drive the Development Process

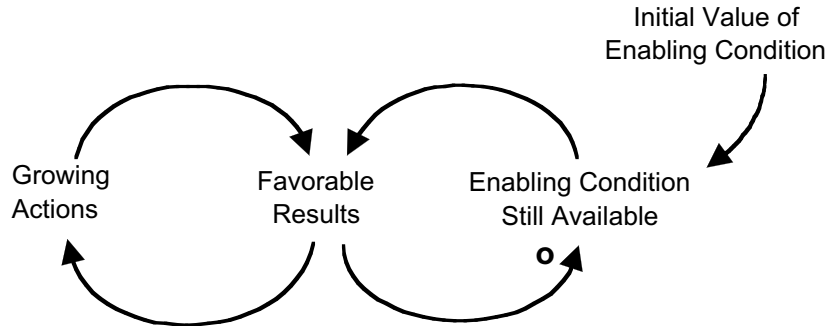
Adams introduced the report with direct reference to the “linkages among the elements that structure the metropolitan system, and the feedbacks that make the system dynamic.” In that these causal relationships are described so specifically, it makes sense for us to integrate them into a causal loop diagram that makes the interconnections very explicit. We will do that after the introduction of the “limits to growth” archetype on the following page.

* Ed. Note: For additional TRGS reports authored by Adams *et al.*, see the Appendix.

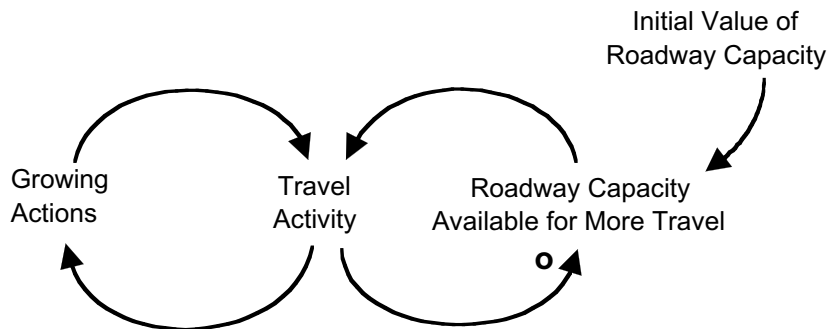
Limits to Growth

It seems to us that there is one system archetype that is at work in a very profound way, and that is imbedded in the larger systems map we will describe below. That is the Limits to Growth archetype. The archetype's structural template is shown below, along with a simple but relevant example.

Limits to Growth Structure



Example: Limits on Travel Activity



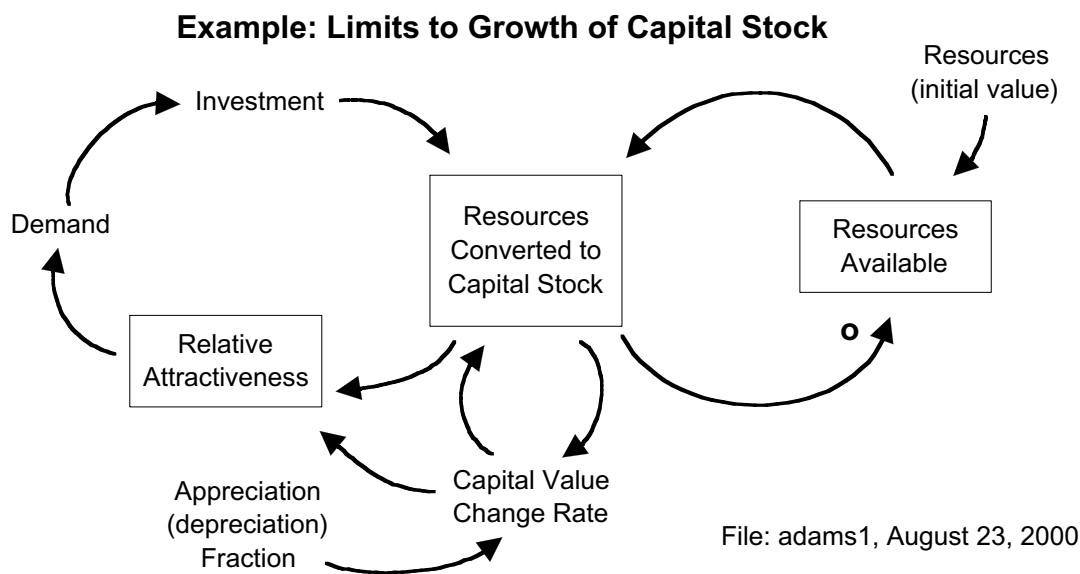
This archetype's structure explains the dynamics of diminishing returns, saturation, and collapse. The feedback loop on the left of the diagram represents the growing actions and conditions that constitute a reinforcing "engine of growth." It is this engine that produces the forces that drive toward success in the system. The challenge for policy-makers and for citizens is to design and implement a systemic structure that will continually generate favorable results. But, like any "engine," the reinforcing structure needs to consume "fuel" to sustain its activity. And, because the engine is expected to always do better than before, it consumes its fuel at increasingly rapid, but often undetected or unexpected rates.

An example of this rapid consumption is found in nature. Let's assume it is early spring, and that lily pads beginning to grow in a tranquil pond need both water and space to reproduce, and that they naturally double the area they cover every day. At first there are two pads, and then there are four the next day, and so on. A fisherman in a boat might notice seemingly gradual growth of the lily pads. After some weeks, he might become alarmed that a lot of the pond is already covered. He becomes particularly worried on the day that half the pond is covered and thinks

something should be done to save his fishing area. When he returns the very next day, how much open water remains? Correct, none. Yet, everything seemed manageable just the day before. He simply could not detect in time the exponentially growing rate at which the plants multiplied and, in doing so, consumed all the water he needed for fishing. The plants stopped spreading only when they had completely consumed the resource they needed to fuel their growth: water surface.

So, it is important to understand how fast things are growing and what resources they are consuming as they do so. Plus, it becomes essential to discover how much of the resource remains. In other words, from now on, whatever is left is a “limit” to further growth. The earlier example of the consumption of roadway capacity illustrates this point. As Adams points out in his research, “travel demand has begun to exceed what highway infrastructure can accommodate, and congestion is becoming an increasingly public concern – one of the several prices that the state and region pay for developing and dispersing in the current manner.” Now, due to the vitality of economic activity in the region, the structure that is producing only annoying congestion yesterday might generate gridlock tomorrow. And, does that gridlock, like the lily pads, which completely consume the entire roadway resource in many places, bring further growth to a halt?

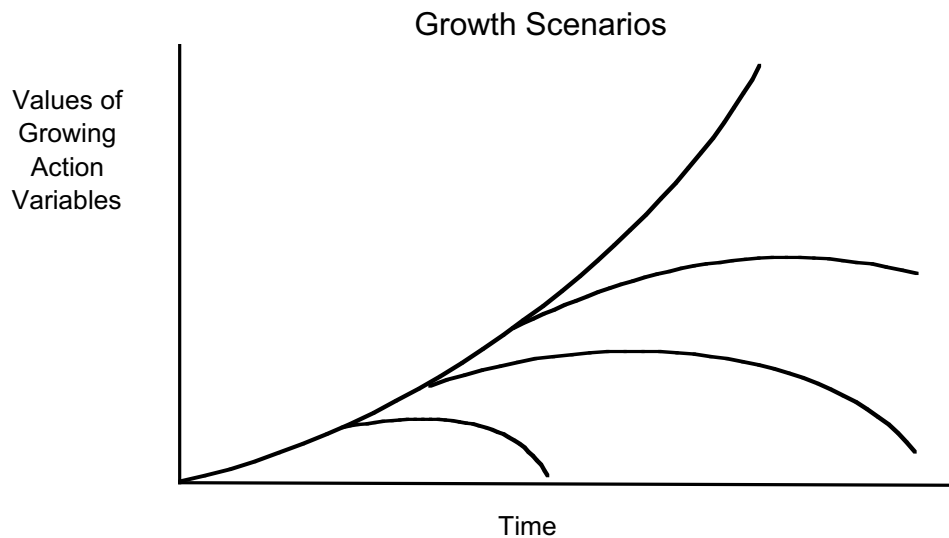
Adams describes dynamics that create and use “capital stocks” including transportation systems, housing stocks, office space, factories, schools, schools, universities, shopping malls, and all of the other locations where we live, work, play, spend, or learn. He points out that one of the resource types that has been, in the past, abundantly available to fuel the economic growth that built the region’s capital stock is the *amount of developable edge location land in the metropolitan area*. Think of that land as the “Resources (initial value)” in the diagram below.



In the above limits to growth structure, the growing actions are the demand and investment that result from the relative attractiveness of the benefits and features associates with the capital stock built up in the region. Further, when the pace of demand and investment is generating positive

growth, the expectation is that that growth will continue, and that the capital stock value will continue to appreciate in the future due to the reinforcing nature of the interrelationships involved. That expectation of future net positive benefits is what it takes to accelerate the demand rate that justifies further investment, and which also accelerates the pace at which resources are converted to capital stock. What happens to the pace at which the enabling “resources available” are consumed? Correct, they are used up faster than ever before.

The behavior over time (BO) graph that follows illustrates alternative growth scenarios for dynamic behavior of the growing action variables (like demand investment or relative attractiveness) that could plausibly emerge from the structure shown on the previous page.

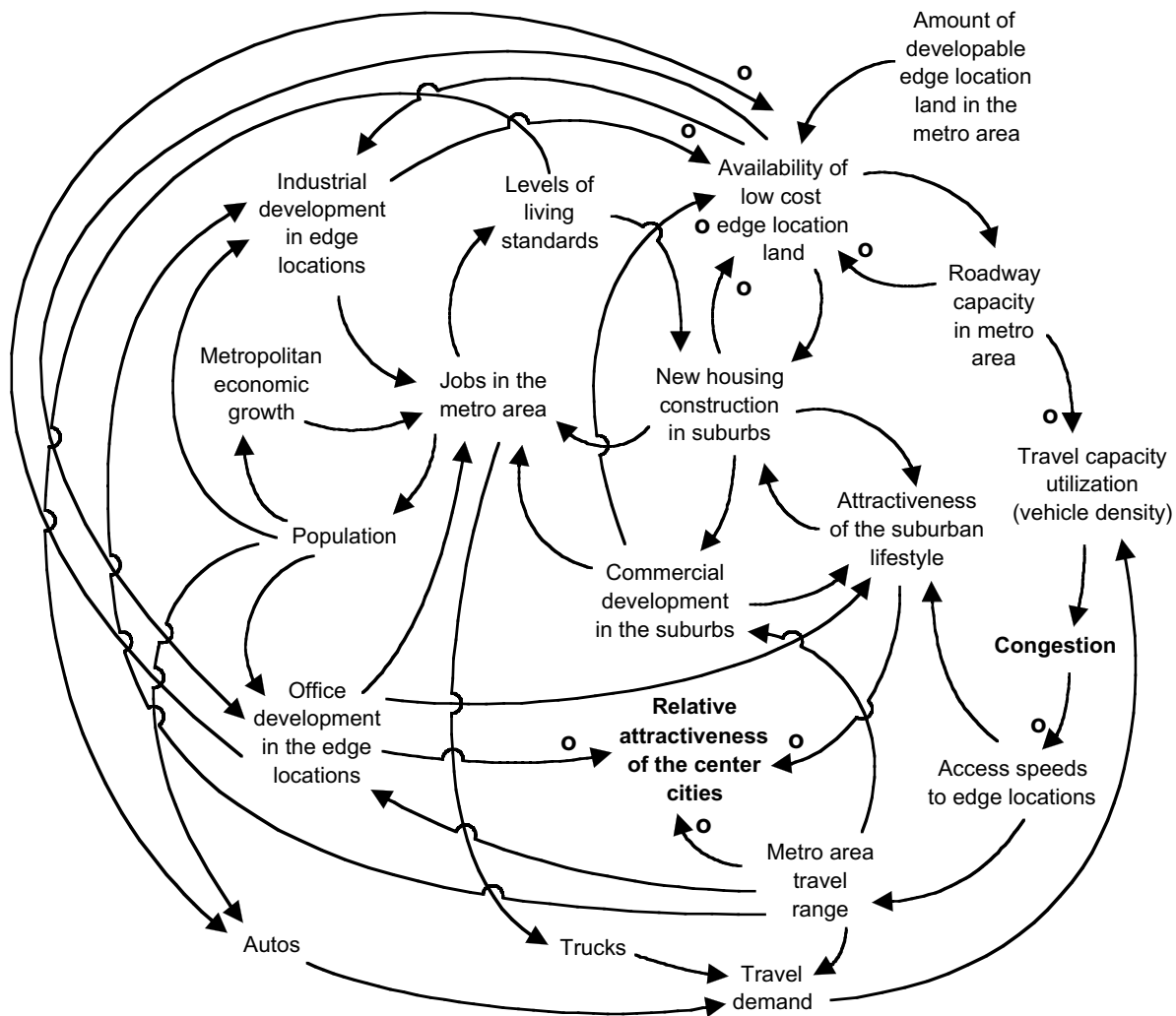


If the enabling resources are abundant over the future scenario time horizon, then exponential growth can continue because the engine of growth can remain dominant. If the pace of growth begins to slow, or even becomes stagnant, then the “balancing” feedback loop (where resources available are becoming less abundant) becomes stronger. The other two patterns show the impact of a fully dominant balancing feedback loop where the limits to the available resources have caused a collapse and a corresponding negative growth rate.

Feedback Structures That Influence the Relative Attractiveness of the Center Cities

The diagram on the next page begins to portray the linkages that Adams is concerned with. Other diagrams that tell the rest of the story will follow it.

Linkages and Feedbacks that Drive the Development Process and Influence the Relative Attractiveness of the Center Cities



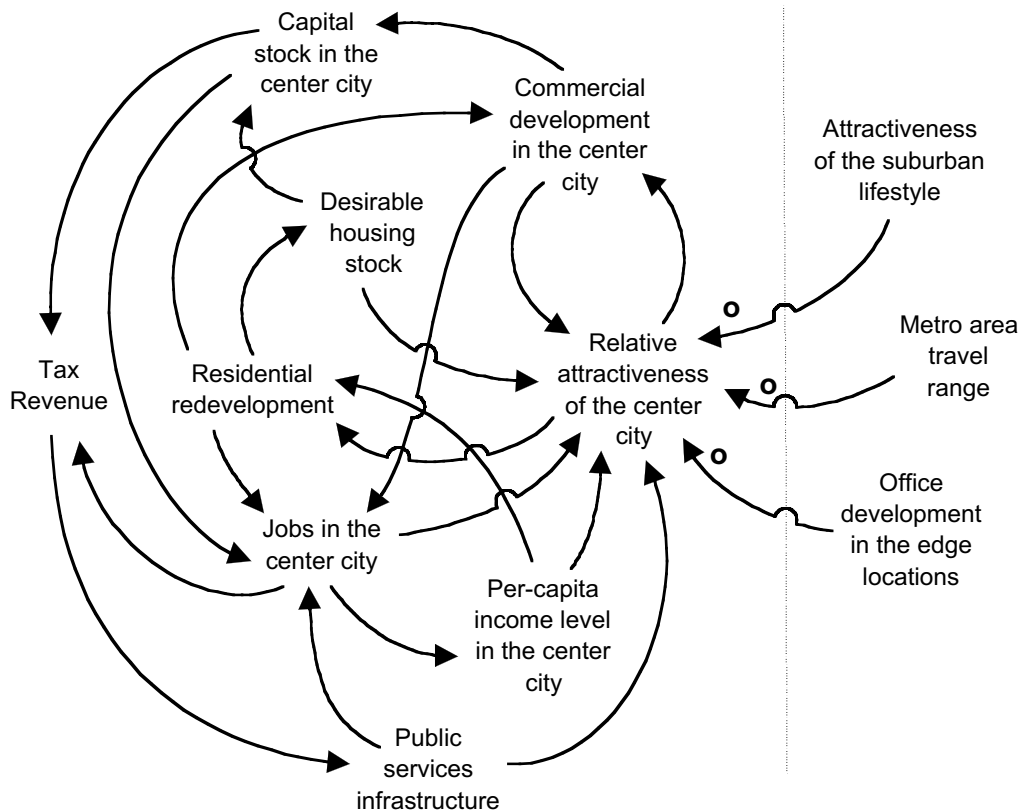
File: Adams2, August 23, 2000

We suggest that the reader examine this causal loop diagram equipped with the two pages in Adams' report that explain these relationships in words. The first appearance of them is on pages 2 and 3 of his report.

This diagram explicitly suggests that the amount of developable edge location land in the metro area is a key enabling resource which, when converted to attractive capital stock in suburban locations, has fueled dynamics that have reduced the relative attractiveness of the center cities and increased congestion in the transportation system.

But, what are the more detailed structural relationships within the center cities that may be reinforcing the decline in attractiveness? The following diagram answers that question.

**Impact of Low Density Development in Suburbs
Reduces Attractiveness of Center Cities**



Reinforcing Feedback Structure Produces either Virtuous Cycle of Growth or Vicious Cycle of Decay

File: Adams3, August 23, 2000

In the systems map above, all of the reinforcing feedback loops that would otherwise seek to accelerate positive growth in the center cities are becoming unstable due to the strengthening forces identified on the right side of the diagram. If they become sufficiently strong to *reverse* the growth in attractiveness of the center city, then they will precipitate a rapid collapse of the value of the capital stock in the center cities.

Competition Between the Center Cities and the Edge Locations

Adams' report concludes that the land use and transportation dynamics in the region over the past three decades have resulted in an inequitable allocation of "costs" to center city residents and of "benefits" to edge-location dwellers. The following page suggests how that has happened by portraying the linkages that Adams suggests from the research.

The diagram on the previous page illustrates the dynamic structures of three important system archetypes: Limits to Growth, Success to the Successful, and Escalation.

Limits to Growth Again

In each location, the limit to further growth in investment, capital stock, and relative attractiveness is Costs, i.e., the costs of maintaining and depreciating the value of the capital stock. When and if the expected net returns from the efficient and effective utilization of the capital stock becomes negative (costs exceeding expected future returns), then growth in relative attractiveness will decline, and decay will set in. As shown in the diagram, the local policy-makers will likely attempt to block that dynamic through local development incentives to stimulate or sustain investment. In other words, the local government will seek to stimulate increased future returns by reducing current development investment requirements, or costs.

The limits to growth structure is evident in another way. Think of the capital stock value in the location as the Resource Available to enable the engine of growth to continue at a satisfactory pace. The economic life (or depreciation rate) of the components of the capital stock determines the pace at which the capital stock is used up or consumed. Up to now, the net favorable expected returns from the center cities' capital stock have stimulated a rate of investment and reinvestment that has exceeded the pace at which costs occur. If investors, even when offered incentives, believe that the net appreciation rate has moved, or will soon move, into negative territory, i.e., become *depreciation*, then the capital stock (seen as resources available) is consumed even faster.

Success to the Successful

Notice that the success of the edge locations in improving their relative attractiveness causes the relative attractiveness of center cities to decrease. These two powerful attractiveness variables are locked in a reinforcing feedback loop where once an advantage is achieved over the other, then that advantage is amplified over time. Hence, success goes to the successful: the rich get richer, and the poor get poorer. The consequence is expressed in the relative differences between costs as a percent of per capita income in each location. If that difference is significantly large, then residents at one of the locations will perceive an inequity

Escalation

If the differences in relative attractiveness between two locations – here, the center cities and the edge locations – become too threatening, then an “Incentives War” can ensue. Like the dynamics of an “arms race” or a “price war,” few good things happen in the long run due to these escalation structures. Ironically, if the incentives come too late to stimulate investment, or if they have to be so large that they can't likely be recovered, then their use only makes matters worse. Why? Because, these incentives become a new cost that is added to the other costs of a reduction in the capital stock value.

Variables Introduced in the Causal Loops Associated with the John Adams' Research (excludes the “escalation” diagram)

Location

- Jobs in the Metro area
- Metropolitan economic growth
- Relative attractiveness of the center cities
- Capital stock
- Desirable housing stock in the center cities
- Local center city or edge location development incentives
- Tax revenue
- Jobs in the center cities
- Public services infrastructure
- Expected net revenues
- Investment in capital stock
- Costs (of capital stock)

Land Use

- Industrial development in edge locations
- Amount of developable edge location land in the metro area
- Availability of low cost edge location land
- New housing construction in the suburbs
- Commercial development in the suburbs
- Office development in the edge locations
- Residential development in the center cities
- Commercial development in the center cities

Transportation System

- Roadway capacity in the Metro region
- Travel capacity utilization (vehicle density)
- Congestion
- Access speed to edge locations
- Metro area travel range
- Travel demand
- Trucks
- Autos

People

- Level of living standards
- Attractiveness of the suburban lifestyle
- Population
- Per-capita income (all locations)
- Mid to high income population
- Social costs

*David Anderson and Gerard McCullough: The Full Cost of Transportation in the Twin Cities Region (TRG #5, 2000)**

In the May 2000 CTS workshop, Anderson cited three preliminary conclusions from his research work, which is aimed at estimating the full costs of transportation in the Twin Cities for 1998 and 2020

- Most transportation costs are *internal*, so the people of the region must believe that they receive tremendous benefits from transportation.
- Governmental and external costs are large in absolute terms, but are *not so large* that efficient pricing would lead to many people giving up their cars.
- Policies should generally focus on changing *how* people use their vehicles, not on reducing total use.

In his work, Anderson described three types of transportation costs:

1. **Governmental Costs** that are borne by any level of government. Examples include roads, highways, public transit, and the highway patrol.
2. **Internal Costs** that are borne by the person(s) who cause them. Examples include fixed and variable vehicle expenses, traveling time, crashes, and parking.
3. **External Costs** that are neither governmental costs nor costs borne by those who cause them. Examples include pollution, noise, some crashes, and congestion.

He provides tables that offer ranges of even more detailed sub-categories of costs within the three major types. Especially important, however, are the percentages of the total estimates allocated to each major type: governmental costs are 8.8% in 1998, falling slightly to 8.6% in 2020; external costs are 6.8% in 1998, rising slightly to 7.1% in 2020; and, internal costs are 84.4% in 1998, and remain relatively flat at 84.3% in 2020. Of the internal costs, it is very significant that about 63% are variable costs in 1998, rising to 65% in 2020. These internal variable costs are time and distance dependent and can be influenced, Anderson believes, by policy and pricing initiatives.

Projecting Costs from 1998 to 2020

The research documents available to us at this time, namely the Executive Summary of Anderson's research report, describe a number of dynamics in the factors that he believes influence growth in the three types of travel costs. These dynamics over the 22-year horizon are described below.

- In general, total transportation costs will grow only slightly more rapidly than the region's total output, thus the share of the region's resources allocated to transportation costs will remain about the same.
- The construction and maintenance of roads and highways will become more efficient.
- Government costs not associated with constructing and maintaining roadways will grow in direct proportion with regional income.

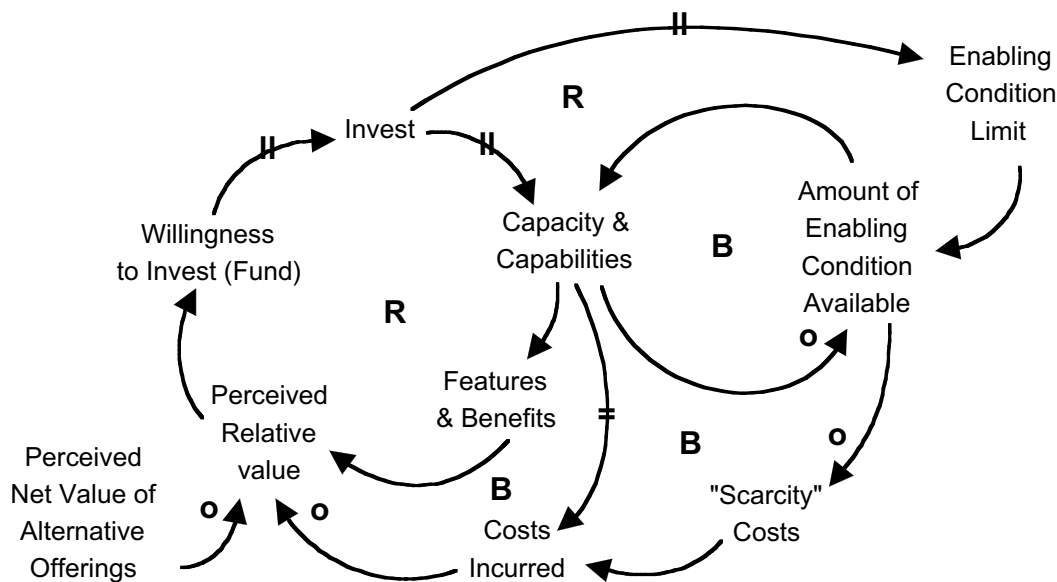
* Ed. Note: Anderson and McCullough continued their research in *The Distribution of Transportation Costs in the Twin Cities Region* (TRG #15, 2003).

- The fixed costs of automobiles will rise more slowly than some other internal cost categories due to technological progress in auto-making.
- Because the relative cost of fuel will rise, variable costs of operating motor vehicles will increase at a rate faster than regional income.
- The costs of transportation-related services such as parking, which have land as a major input, might rise in relative terms because land prices usually rise faster than regional output.
- A significant increase in congestion will occur, increasing external costs.
- If air pollution reduction measures continue to improve air quality, then costs of air pollution per mile traveled will not increase. The potential pollution costs due to significant increases in travel, and in the number of vehicles, will be offset by making cleaner vehicles.
- Vehicles will be made safer, causing the relative costs of crashes to decline.
- External costs related to petroleum consumption (for example, the costs of producing plastics) will increase due to expected increases in oil costs.

Although these projections are very interesting and plausible, the documentation available to us does not describe in sufficient detail how they interact with each in a systemic way. Rather than make ungrounded assumptions about these potential relationships, we elect to offer a “generic” structural framework for addressing transportation costs.

Cost and Benefit Producing Structures

One systems thinking perspective on “costs” and “benefits” is illustrated in the following causal loop diagram. We believe it may be useful in our conversations together, especially why thinking about how different demographic groups might determine the net benefits (or costs) of transportation.



The “R” feedback loop on the left is a reinforcing structure that produces either exponentially increasing or decreasing values of each variable in the loop. The “B” feedback loop on the left,

formed by the inclusion of Costs, is a balancing structure that reduces the Perceived Relative Value suggested by the presence of Features and Benefits. In this diagram, Costs are equivalent to the “price” of the features and benefits offered. If the perceived value of the Features and Benefits is greater than the price of those advantages, then there is a positively valued outcome to be gained from investing in the Capacity and Capabilities that produce those advantages. However, the Willingness to Invest is also dependent on the Perceived Net Value of Alternative Offerings.

The right side of the diagram, involving two other balancing feedback loops, generates other cost-impacting dynamics. The marginal cost of an incremental unit of capacity or capability is not fixed. It can vary depending on the costs of the input resources needed to create the incremental unit. Usually, the cost of an input resource increases as it becomes scarcer. These Scarcity Costs add to total Costs. Recognizing these systemic limits can lead to an investment strategy to increase the Enabling Condition Limits, thereby increasing the Amount of Enabling Condition Available while simultaneously reducing Scarcity Costs.

Barry Ryan and Thomas F. Stinson: Road Finance Alternatives: An Analysis of Metro Area Road Taxes, (TRG #9, 2002)

Ryan offers this major “nugget” on the matter of transportation policy and land use: The adoption of more efficient road tax policies – like substantially higher motor fuel taxes or mileage taxes – will increase the *net present value of transportation costs* for commuters driving long distances. To the extent that this higher travel cost is more than the “development premium” for parcels of land at the urban/rural fringe, development in those fringe areas, and the adjoining rural areas, will be less attractive and would likely delay the pace of greenfield land development. The development premium is the market value per acre of a parcel for non-farm use less its value for agricultural use.

In those potentially exurban properties, an increase in the net present value of transportation costs of commuting to and from there of \$5000 could well make it (temporarily at least) impossible to find a developer willing to bid more for the land than its agricultural value. Thus, the result of higher variable pricing for roads may well cause development to proceed in a more measured, concentrated manner. Whether or not there will be any impact on development will depend on the change in the net present value of transportation costs and the development premium the market formally assigns to the property.

In his Executive Summary of the subject report, Ryan offers the following principal findings:

- While Minnesota policymakers have a wide variety of tax options available to fund state and local roads, reliance on local property taxes, sales taxes, and income taxes for road funding *effectively hides* many of the costs of vehicle travel from the public. In fact, for the 1996 study period, 71% of the \$993 million TCMA road-related taxes collected were from fixed or hidden taxes that are unrelated to travel behavior.
- Variable tax mechanisms would send users a clearer signal about the true cost of travel, leading to better, more efficient travel decisions.
- The way MCTA residents pay for roads affects household budgets and creates location incentives. This is demonstrated by models developed in the study that consider road tax cost impact for a range of households, each with different location, income, and travel attributes. These models consider three taxation scenario strategies:
 - First, the baseline, as-is policy, where 71% of road-related taxes are unrelated to variable travel behavior.
 - Second, shift 70% of road tax collections to the motor fuels tax by raising the rate to 50 cents per gallon, up from 20 cents.
 - Third, shift 70% of road tax collections to a three-cent vehicle mileage tax.
- As a consequence of these scenarios, and to repeat the nugget, it can be argued that road tax policy can affect land development at the urban/rural fringe. “Land values there are typically based on agricultural use, but as the region grows, land prices increase above the value for farming. For much of the region’s farmland, this development premium is less than the discounted present value of the road taxes described above [in the 70% variable cost scenarios]. This implies that under the proper conditions, increased reliance on variable pricing tax policy can slow conversion of the region’s farmland to non-farm use.”

- If policymakers chose to charge the full costs of transportation, including externality costs like pollution or congestion, then, based on a CTS study of 1998 costs, “charging households for these externalities would take an equivalent of a 67-cents a gallon increase in the motor fuels tax.”
- If, over the next 25 years, the state wishes to maintain the same level of transportation services as available today, then road funding must become even more reliant on property taxes and the state’s general fund. The current variable taxes on travel will be inadequate to keep up with road related expenditures.

In their Study Conclusions section of their report, Ryan and Stinson reiterate the following:

1. Minnesota road revenues are heavily reliant on fixed charges that are unrelated to road use, and taxes are hidden from travelers all together.
2. Road taxes must be more transparent if road users are going to value road services appropriately.
3. Alternative tax policies should shift revenue collection from the current focus on household economic status to measures of household travel behavior.
4. Development of the rural urban fringe is likely to slow if the discounted net present value of road tax increases is greater than the development premium of farmland.
5. Tax policy should reflect full cost accounting and include the damaging effects transportation has on households not responsible for causing the problem.
6. Policy reforms are needed if road tax revenues are to keep pace over the next 25 years with the rising cost of building and maintaining roads.
7. A broad public discussion of tax policy choices and their potential economic and social consequences would improve understanding and support for tax reform.

The Urban/Rural Fringe Land Development System

Ryan’s findings, of course, play out in a large and complex social and economic system involving transportation investment and land use policies.

In section six of the Ryan report, he introduces components and sectors of a comprehensive, systemic description of how urban/rural fringe development works. In this integration report, we will take on a “systems thinking perspective,” including the use of causal loop diagrams that will make explicitly describe the systemic structures that connect the key variables of the system. The system will be explained in a narrative, build-up approach.

There are four key player groups in a large system of this type involving areas around large, attractive metropolitan places: (1) the households who are prospective buyers of homes in the fringe area, (2) the home builders, (3) the land developers who wish to sell lots to the prospective buyers/builders and to commercial or retail service providers, and (4) land investors or speculators who buy or take options to buy fringe land on the expectation that it can be sold later at a substantial profit.

Prospective Buyers

Prospective buyers of new homes in the urban/rural fringe areas are, generally, seeking to maximize the current *and future* benefits that will flow from their relocation decision. After becoming aware of an option, among other relocation alternatives, of buying to a home in a greenfield exurban area, they – either rationally or emotionally – weigh the benefits and costs of such a relocation. They perceive, uniquely to their household, both the benefits and costs of such a move. Typically, in assessing costs, they might include the following near-term “cash flow” factors in their homesite selection:

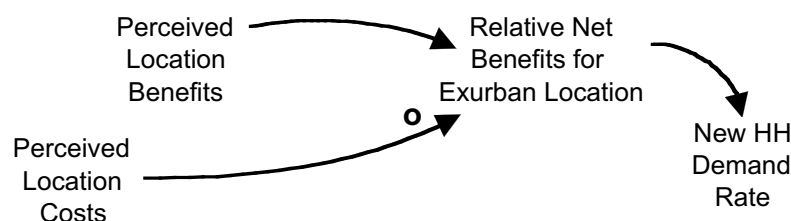
- Change in mortgage payments (principal and interest) or monthly rent
- Changes in federal or state income taxes due to mortgage interest deductions
- Local property taxes and fees
- Changes in insurance fees for property or auto
- Variable vehicle travel costs (gas, maintenance)
- Fixed vehicle costs (insurance, local excise or registration taxes, the need for another car)
- Any incremental differences in the costs of routine household purchases.

Although not directly a cash flow cost, the prospective buyers also consider whether the move would alter their “travel time budgets.” Would commute times still seem reasonable? Would travel times to other desirable destinations make sense? Any amount of time required beyond what the household considers reasonable would also be a “cost.”

Based on an analysis like this, the prospective buyer would project future monthly cash outflows, and contrast that value to an explicit or implicit future monthly cash budget allowance for travel, housing, and other related costs. Then, the future monthly cash outflows would be contrasted to the perceived expected *future* benefits. Typically, benefits of a move to an exurban place are forward-looking, and might include:

- Perceived increase in the “quality of life,” including better schools
- Lower new home financing costs (lower down payments and interest rates)
- Lower federal or state income taxes due to mortgage deductions
- Lower property tax rates
- Lower auto insurance rates
- More rapid appreciation of the new home’s resale value
- Proximity to newer shopping facilities

If the relative net benefit is sufficiently high, they will want to move there and contribute to an increasing new household demand rate for homes in that location. We begin building our systems diagram with the following relationships, intended to depict the rationale previously described.



Notice the “o” next to the arrowhead of the causal link flowing from Perceived Location Costs to Relative Net Benefits for Exurban Location (again, exurban denotes the urban/rural development fringe area). The “o” means that the causal relation between these two variables moves in an “opposite” direction. Thus, if perceived location costs increase, then the net benefits for moving to the exurban location decrease. Where no “o” is present, the causal link describes the cause variable and its effect variable (at the arrowhead), which move in the same direction. Thus, in the diagram above, as net benefits increase, the new household demand rate also increases. On the other hand, if the perceived net benefits decrease, then the demand rate also decreases.

The Land Investors or Speculators

These players in the system are the people who own – or have options to buy – the “agricultural-oriented” properties that may have future potential for larger scale residential, retail, commercial, industrial, or public infrastructure development. The players might be individual farmers or property owners in rural towns, or they might be large land speculation companies who actively acquire options to buy from local owners. They make money when they can sell substantial amounts of land to developers at, for them, a sufficiently attractive “development premium.” The development premium is the market value per acre of a parcel for non-farm use less its value for agricultural use.

The Land Developers

Land developers/investors in this system operate to create a land market for potential users of developable land. Those users could be potential homeowners, businesses, governments, homebuilders, or others who will value the land more highly for non-farm activities.

To determine whether or not there could be a non-farm market for the land, the land developer must assess the potential future value of the subject properties from the perspective of each class of potential users. Large land development companies are constantly on the lookout for opportunities near and around attractive, growing metropolitan areas. The potential developer may, initially, ask questions like these:

- “What is the size of the total developable land in the market area?”
- “How much of the total land has already been purchased by builders and/or their home buyers?”
- “Thus, what is the size of available developable land open to investment?”
- “What are the current and future likely zoning scenarios?”
- “What are the infrastructure costs to be paid by the developers?”
- “What are the regulatory burdens involved, especially time-associated costs such as permitting and entitlement process approvals?”
- “What would it cost to acquire sufficient land to launch the type of development we intend to create?”

These questions relate to the following systemic relationship.

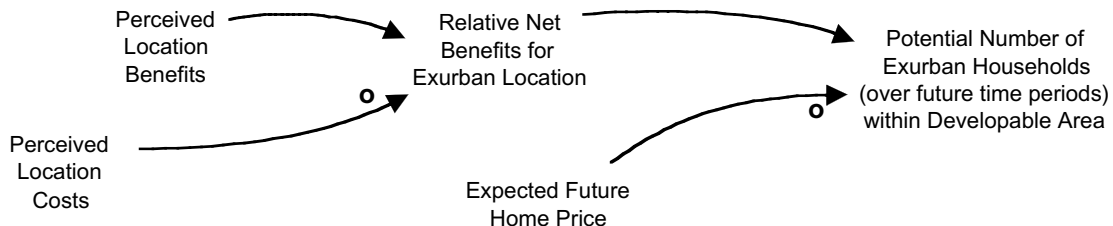


The diagram on the previous page is read like this: The amount of Available Developable Land is the Total Developable Land in Market Area less the Builder/Buyer Land Purchases already made. As noted earlier, the “o” next to the causal link going from Land Purchases to Available Land means that as Land Purchases increase the Available Developable Land moves in the “opposite” direction, i.e., decreases. If no land purchases by builder buyers have been made, then the available developable land equals the total developable land in the target market area.

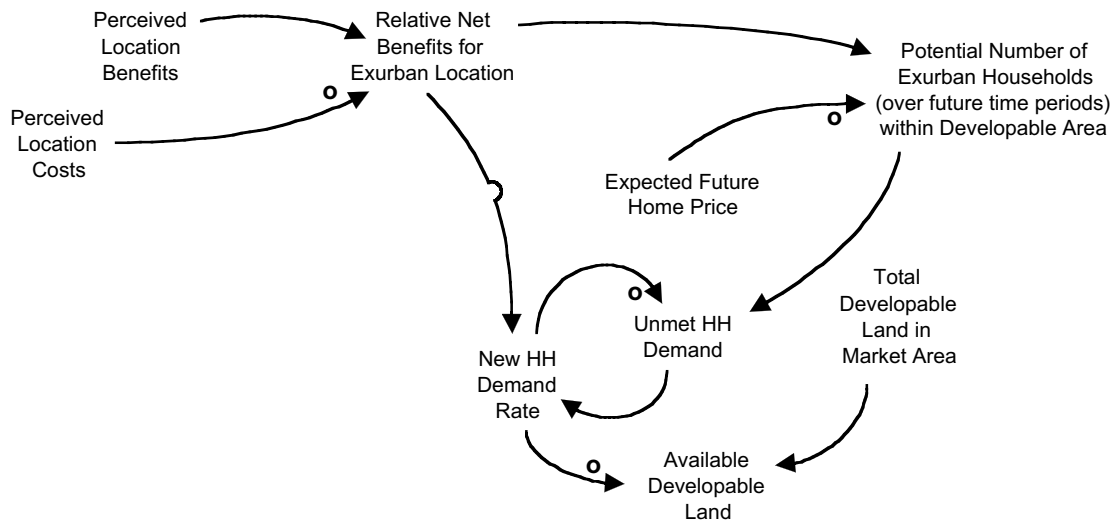
But the developer also considers other equally important questions, including:

- “What could be the perceived *net* benefits of this location in the minds of prospective future users of the land?” To answer this question, the investor must assess the positive benefits of the location for a target market, and then also evaluate the disadvantages or perceived costs associated with the location.
- “What is the potential number of households that can be attracted to this location in the future?” It is in his interest to discover and develop land where the development premium can be influenced to continually increase.
- “What are the prices that homes would sell for, given the benefits and features that could reasonably be offered, in this location? How would these products and prices fit with the demographics of target market buyers?”
- “What is the likely speed of absorption?” The rate at which lots will be purchased is a critical factor in deciding to acquire land for development.
- “What are the potential commercial or retail businesses that would wish to locate in the area as the number of households increases?”

The relationships implicit in the questions are shown in the diagram below.



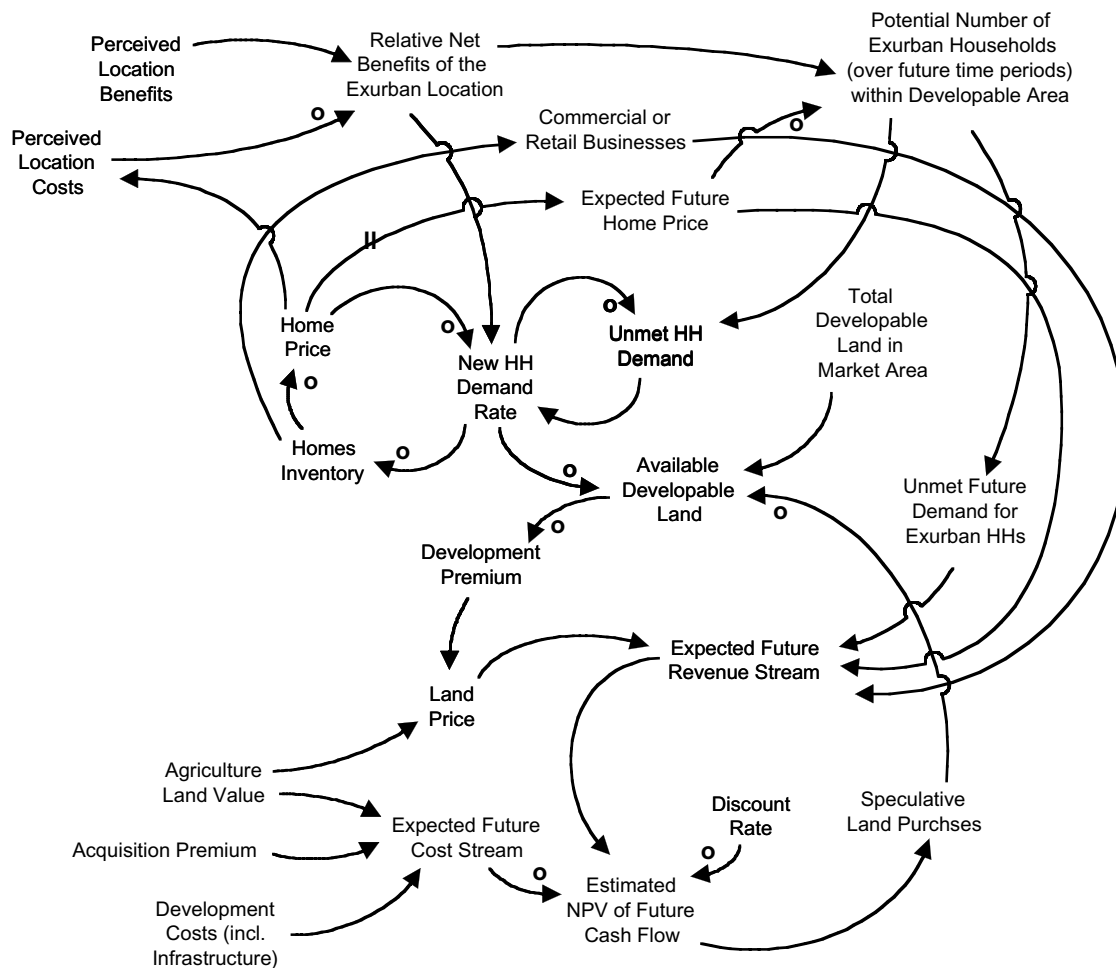
Let’s combine the relationships described thus far into the larger diagram below. Notice that there are variables that do not have arrows coming in to them, but only outgoing causal links. These are, as of now, independent variables within the system we’re describing. One of them is a physical “limit” in the system, namely the Total Developable Land in the Market Area. The available developable land at any point in time is the total developable land in the market area, minus the land that is purchased as a result of the new household demand rate. The causal link from the new household demand rate to available developable land will be replaced in subsequent diagrams by a more detailed, multi-variable relationship involving the homebuilder.



As land developers see the new household demand rate increase in the exurban, along with a decrease in the available developable land in a target market area, they accelerate their land investment decision-making process. The diagram on the next page suggests that the potential developers seek to make a confident estimate of the net present value of the future cash flow that will result from the decision to purchase significant amounts of the yet-available developable land. They expect that continuing demand by potential non-farm users of the land will decrease the amount of available land, and correspondingly increase the development premium, and thus increase future land prices, including the acquisition premium they must pay per acre to secure new land to meet their development projections.

The land developer, if not already owning or having options to buy the desired land, will initiate contact with potential sellers to assess land prices, including any development and/or acquisition premiums. If the deals can be made that meet the developer's investment return criteria (a discount rate hurdle), then development moves forward.

Note that the developer's revenue projections also include the sale or lease of property to businesses that want to establish a presence in or near the development. The newly introduced variables are shown in the diagram on the next page.



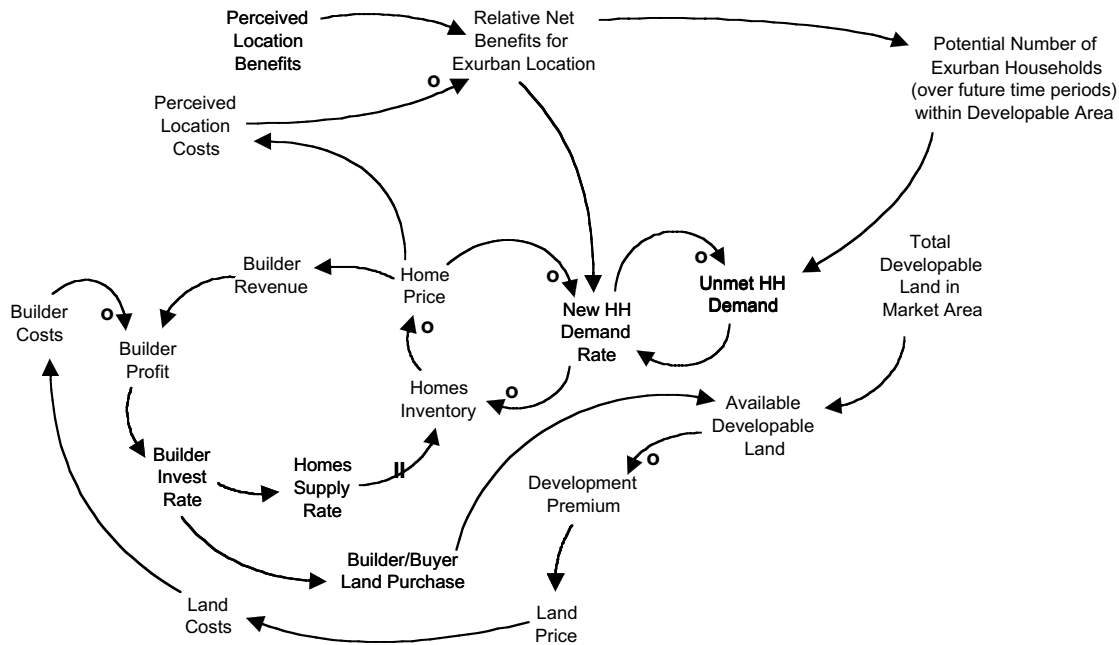
The Homebuilders' System

In the systems we're describing, the builders are considered as service providers to the developers. The land developer essentially contracts with one or more homebuilders to offer a specific range of home models at specific price points. The land developer and the homebuilding companies will co-market the property.

Now, let's look at the homebuilder's system. Notice that the single causal link from the new household demand rate to available developable land has been replaced by a link from Builder/Buyer Land Purchase. This new link begins from the Builder Invest Rate. In this example, we are assuming that residential homebuilders and the land development are the principal marketers of the benefits of relocation to the target market areas.

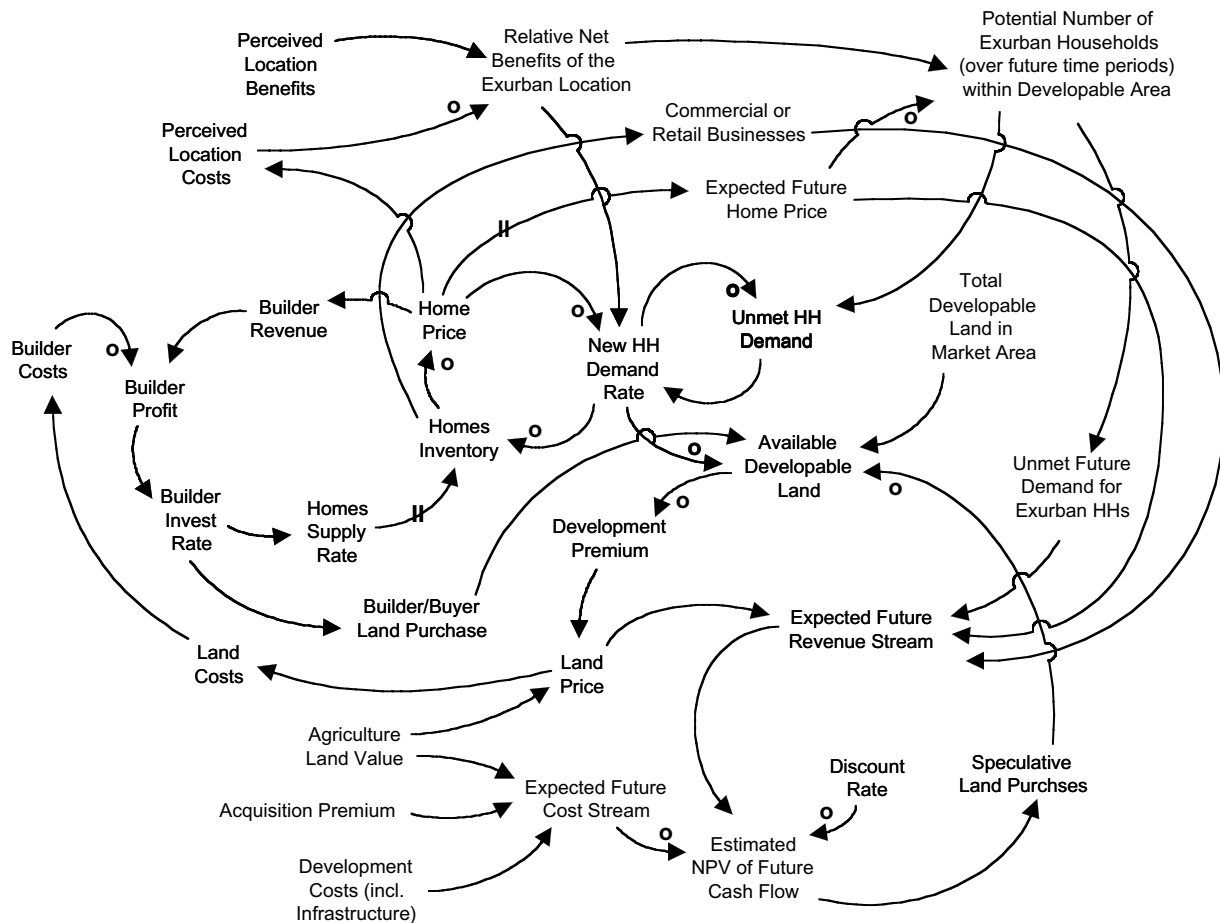
Where land on the urban/rural fringe has already been purchased and built on for homebuyers, the Homes Supply Rate is beginning to increase, and there may already be some Homes Inventory available or about to become available. Given a New Household Demand Rate seeking

to acquire the Homes Inventory, a Home Price has been established by the market. If the home selling price is sufficient to generate Builder Revenue that is Greater than Builder Costs, then a Builder Profit will stimulate an increase in the Builder Invest Rate. More land will be opened up by the developer for new home construction, and after some delay to build new homes, the Homes Inventory will increase.



This systemic structure illustrates a typical “supply vs. demand” relationship associated with “commodity” products, of which housing is a class. Home price is a powerful controlling variable. Notice how home price controls two key balancing feedback loops: the first involves the new households demand rate for homes, and the second is the second loop involves the new homes supply rate from builders. Simply put, if the selling prices of homes are not sufficient to produce builder profits, then the homes supply rate will decline toward zero. But, if, due to homes inventory shortage, home prices rise too high, then the net benefits to prospective buyers will be zero or negative, and the new households demand rate will decline to zero.

Below is the systems diagram that deals with the variables introduced so far.

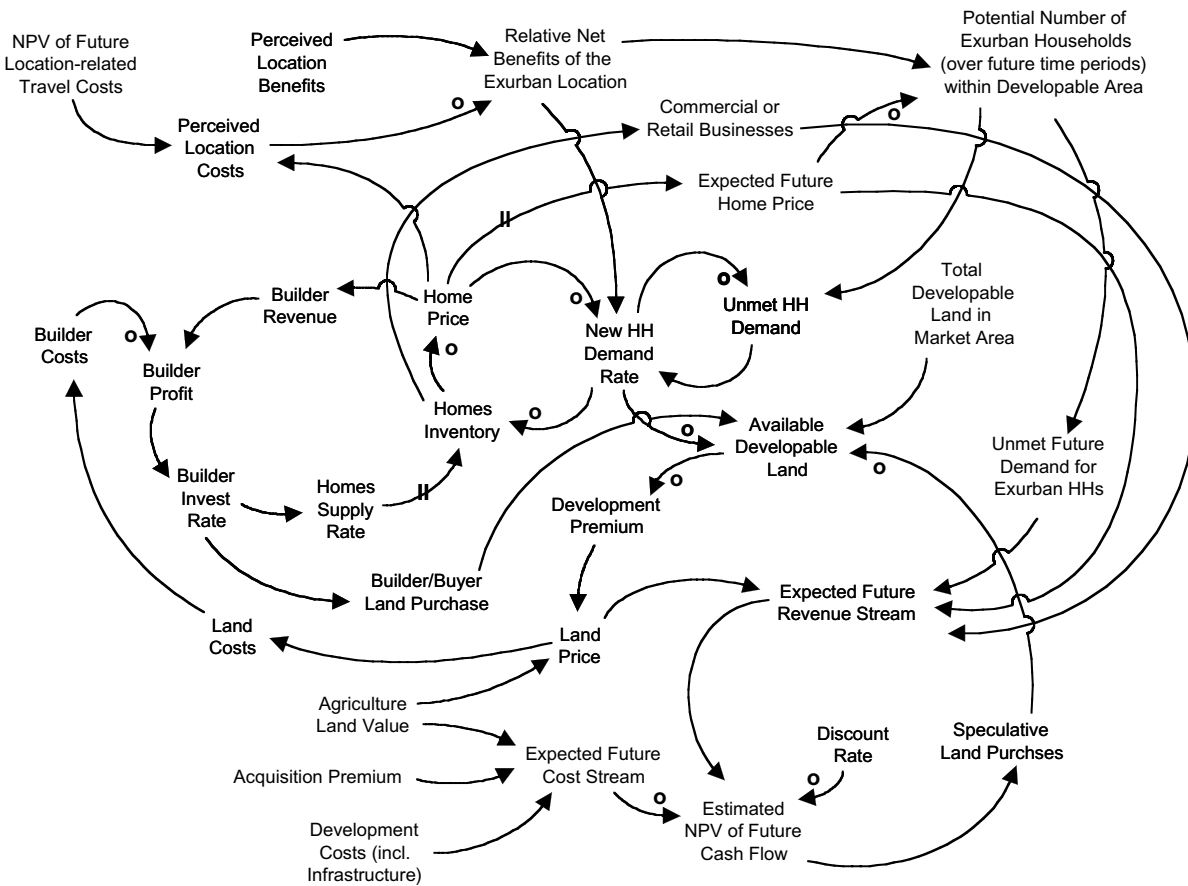


The Impact of Higher Travel Costs

If this is the system, where does Ryan's assertion that new tax policies (increased fuel tax or mileage tax) will slow exurban development fit in? It directly impacts the Perceived Location Cost in the minds of prospective homebuyers. Whether the buyer sees the incremental taxes as ongoing monthly cash flow costs, or sees them, as Ryan hopes they would, as a significantly larger net present value, is unclear. In any case, it is a cost increase, and thereby, reduces the Relative Net Benefits for Exurban Location. The new variable is added to the diagram on the next page.

The Big Picture

The systems diagram presented on the next page summarizes the system in which Ryan's findings are considered.



Conclusion

The diagram makes clear that, in this system, the primary driver of growth of development in exurban places is the variable “relative net benefits of the exurban location” in the minds of potential buyers. To the extent that the NPV of future location related travel costs will increase perceived location costs, then the relative net benefits will be reduced, and the demand rate for new households to relocate there will be lessened. Less demand means less exurban development.

Ryan's Report Summary

In the introduction of their report, Ryan and Stinson posed six questions they would answer:

1. What are the tax choices for generating road revenues?
2. Where does current state and local road funding come from?
3. How are different Twin City households affected by current road tax policy?
4. If road tax policy changes, who wins and who loses?
5. What influence can road tax policy have on housing location decisions?
6. Will road taxes keep pace with future trends?

The following pages summarize their answers.

Question 1: What are the tax choices for generating road revenues?

Ryan outlines ten tax choices, and then evaluates each on three criteria: efficiency, equity, and simplicity, and balance. The criteria are explained below.

Efficiency – is there a strong and accurate price signal? ... In matters of public policy, the price charged for a public service must equal the opportunity cost of producing it. The more closely costs are related to use, and the more responsive they are to change, the more efficiently public infrastructure will be constructed and used. ... For drivers to respond appropriately, they must receive clear and accurate information about the cost of their travel behavior. Weak or false price signals can lead to economic distortions inside and outside of the transportation economy.

Equity – is the tax fair? Tax equity is a societal decision about fairness rooted in the politics of governing and the election process. Ryan summarizes six different types of equity that, in the matter of transportation and land use policy, merit consideration:

- Vertical income equity: distributed fairly across people with differing abilities to pay, i.e., progressive.
- Horizontal income equity: Purchase choices made should have equal tax consequences, regardless of one's ability to pay. An example is a percentage sales tax on an items price.
- Geographic equity: Does the tax collection and allocation practice favor or disadvantage any region?
- Modal equity: Is it fair that tax collections on one mode of travel are used to subsidize another mode of travel?
- Environmental equity: issues that range from individual social justice concerns to global implications of pollution.
- Intergenerational equity: are the costs of an investment fairly distributed over the useful life of the investment?

Simple and Balanced – is the tax transparent and responsive to change? A transparent tax allows taxpayers to see the relationship between taxes and services. Implementing the tax should also be direct and cost effective. Does the tax promote accountability, where there are few, if any, exemptions? Is the tax adequate to generate present and future revenue needs? Is the tax competitive, meaning that it does not put the region at a competitive disadvantage.

The ten choices, along with an evaluation of each vs. the criteria are shown in the table below.

Tax Type	Efficient?	Equitable?	Simplicity & Balance?
1. Motor vehicle registration taxes	Weak price signal	Regressive	Appropriate degree of record keeping
2. Motor vehicle sales tax	Unrelated to vehicle travel	Likely regressive, as with general sales taxes	Responsive to inflation and the business cycle
3. Property taxes	Unrelated to travel	Regressive with vertical and horizontal inequities	No detail on road costs
4. Income and sales taxes	Unrelated to roads	Income tax is progressive; sales tax is regressive	Hidden fiscal transfer; No feedback on travel
5. Motor fuels excise tax	Amount paid varies with fuel use; Influences travel and fuel economy	Regressive with some vertical equity features	Impacts business and modal equity; Some of tax is exported
6. Vehicle mileage tax	Tax varies with distance traveled; Revenue increase with travel	Likely regressive with vertical equity potential	Privacy issues may be barrier to implementation
7. Pavement damage fee	Variable fee related to vehicle weight	Modal (vehicle) equity improves	Provides incentive to reduce weight
8. Congestion fees	Fees increase with peak period travel	Rationing of overcrowded roads may not seem fair to all users	Technical and privacy issues could be barriers to implementation
9. Parking fees	Varies with parking event; Need not apply only to downtowns	May have negative income equity and geographic equity impacts	Reduces trips to, and congestion in, parking tax districts
10. Emission fees	Varies with pollution emitted from vehicle travel	May hurt income equity; Vehicle equity and geographic equity improved	Encourages lower emission vehicles, not fewer trips or less congestion

Question 2: Where does current state and local road funding come from?

In the Budget Summary of section three, Ryan presents “Table 3.4 – Total road revenues and tax price transparency.” It relates to the Twin Cities Metropolitan Area (TCMA) for 1996. It is reproduced on the following page:

TCMA 1996 – Sources	Variable	Fixed	Hidden	
Federal Highway Grants	105			Federal
Motor Fuels Excise Tax	240			State
Vehicle Registration Tax		245		State
Property Taxes			242	Local
State General Purpose Aid			105	Local
Special Assessments			56	Local
Totals in \$ Millions	345	245	403	993
Total, less Federal and Assessments	240	245	347	832
Percent of Adjusted Total	29%	29%	42%	100%

Questions 3 & 4: How are different Twin City households affected by current road tax policy? And, if road tax policy changes, who wins and who loses?

Ryan addresses questions three and four with the following approach. First, he selects four households, each representing a significantly different demographic group in the TCMA region. Next, he uses available data to consider the current road related tax impact on each representative household based on four locations: (1) within the Central Cities, (2) in locations on a 10-mile ring outside of the Center Cities, (3) in locations on a 20-mile ring outside of the Center Cities, and (4) in locations on a 30-mile ring outside of the Center Cities.

Each household vehicle is driven a minimum of 7500 miles each year. The retiree does not commute to work. A commuter on the 10-mile ring will commute 250 days per year and travel an additional 5000 miles. A worker on the 20-mile ring will commute an additional 10,000 miles, and a commuter on the 30-mile ring will drive an additional 15,000 miles.

Ryan first calculates the road-related tax impact on each household based on 1996 tax policies, where 71% of the taxes are not directly related to travel behavior. Then, he considers two tax policy change scenarios. In both alternative Scenarios A and B, the reliance on local property taxes is cut in half, no general purpose state aid is spent on roads, and the vehicle registration tax is cut in half. In Scenario A, the motor fuels excise tax is raised from 20 cents to 50 cents per gallon. In Scenario B, a three-cent mileage tax is levied on TCMA household drivers.

TCMA 1996 – Tax Sources	Variable	Fixed	Hidden	
Total, less Federal and Assessments	240	245	347	832
Percent of Adjusted Total	29%	29%	42%	100%
Scenarios A and B	589	122	121	832
	70%	15%	15%	100%

The tables on the following pages present the scenario outcomes.

Contrasting the household budget impacts of road-related taxes under three tax policy scenarios:

Household	Home	Vehicles	Scenario	Annual Road Related Taxes			
				Center	10M Ring	20M Ring	30M Ring
HH1 Parent Couple, Median income \$55,000	High value (1) Taurus for commuting (2) Pick-up for local		Baseline	790	782	980	1197
			Fuel Tax	715	749	887	1036
			Mileage Tax	740	839	1042	1254
HH2 Single Retiree Median income \$11,600	Low value (1) Civic for local		Baseline	235	201	237	279
			Fuel Tax	199	182	200	221
			Mileage Tax	319	302	320	341
HH3 Single Parent Median income \$19,000	Average (1) Civic for both		Baseline	307	266	364	472
			Fuel Tax	233	264	367	473
			Mileage Tax	353	469	654	846
HH4 Single Parent Median income \$19,000	Average (1) Pick-up for both		Baseline	464	456	585	726
			Fuel Tax	437	551	731	920
			Mileage Tax	400	516	701	893
HH1 Parent Couple, Median income \$55,000	High value (1) Taurus for commuting (2) Pick-up for local		Baseline	1.42%	1.41%	1.77%	2.16%
			Fuel Tax	1.29%	1.35%	1.60%	1.87%
			Mileage Tax	1.33%	1.51%	1.88%	2.26%
HH2 Single Retiree Median income \$11,600	Low value (1) Civic for local		Baseline	2.03%	1.73%	2.04%	2.41%
			A: Fuel Tax	1.72%	1.57%	1.72%	1.91%
			B: Mileage Tax	2.75%	2.60%	2.76%	2.94%
HH3 Single Parent Median income \$19,000	Average (1) Civic for both		Baseline	1.62%	1.40%	1.92%	2.48%
			A: Fuel Tax	1.23%	1.39%	1.93%	2.49%
			B: Mileage Tax	1.86%	2.47%	3.44%	4.45%
HH4 Single Parent Median income \$19,000	Average (1) Pick-up for both		Baseline	2.44%	2.40%	3.08%	3.82%
			A: Fuel Tax	2.30%	2.90%	3.85%	4.84%
			B: Mileage Tax	2.11%	2.72%	3.69%	4.70%

Scenario Results, Continued

Household	Home	Vehicles	Scenario	Center	10M Ring	20M Ring	30M Ring	30M Ring	30M Diff	30M D %
HH1 Parent Couple, Median income \$55,000	High value (1) Taurus for commuting (2) Pick-up for local		Baseline	790	782	980	1197	407	52%	
			A: Fuel Tax	715	749	887	1036	321	45%	
			B: Mileage Tax	740	839	1042	1254	514	69%	
HH2 Single Retiree Median income \$11,600	Low value (1) Civic for local		Baseline	235	201	237	279	44	19%	
			A: Fuel Tax	199	182	200	221	22	11%	
			B: Mileage Tax	319	302	320	341	22	7%	
HH3 Single Parent Median income \$19,000	Average (1) Civic for both		Baseline	307	266	364	472	165	54%	
			A: Fuel Tax	233	264	367	473	240	103%	
			B: Mileage Tax	353	469	654	846	493	140%	
HH4 Single Parent Median income \$19,000	Average (1) Pick-up for both		Baseline	464	456	585	726	262	56%	
			A: Fuel Tax	437	551	731	920	483	111%	
			B: Mileage Tax	400	516	701	893	493	123%	
Tax Savings from Civic			A v. As is	-6%	21%	25%	27%			
			B v. As-is	-14%	13%	20%	23%			
			Baseline	157	190	221	254			
	A: Fuel Tax	204	287	364	447					
	B: Mileage Tax	47	47	47	47					

Ryan concludes the section with the following remarks regarding the scenarios. “Household budget impacts were little changed by the two policy alternatives, despite cuts on the fixed side of road revenues – in property taxes, income and sales taxes, and vehicle registration fees – and higher variable pricing. For most households, the tax price of moving away from the central cities is higher. And, there are significant differences in the total road tax paid by households under the two scenarios. One obvious, quick lesson is that it pays to have a fuel-efficient car when commuting long distances. Another is that lowering the fixed share of taxes and raising the variable portion will send travelers a strong price signal. Raising the gas tax encourages greater fuel efficiency and increases the cost of commuting. A vehicle tax can penalize long commute households, particularly those with fuel-efficient vehicles.”

With regard to the likely impact on travel behavior, Ryan says: “Alternative road tax policies can affect household budgets and reduce (or increase) the amounts available for spending on all other items, yet, as this analysis has shown, the changes will be modest. With tax increases of a few hundred dollars per year or less, some might argue that they are too small to affect household location decisions.”

Question 5: What influence can road tax policy have on housing location decisions?

Ryan, however, does not agree with the above assertion. He says, “When examining the impact on location decisions, one cannot focus on the annual cost increase alone. A more appropriate framework for analyzing the tax change impacts is to examine the long-term cost or discounted present value of the tax change over a long period of time. This concept assumes that households see the annual increase as a continuous stream of taxes, which extend years into the future. A tax increase does not cost just \$200 this year, but \$200 every year. And, since a dollar next year is worth slightly less than a dollar today, the household discounts out-year dollars by some interest rate.”

To illustrate his point, Ryan offers the net present value of tax increase at two discount rates:

Annual Tax Increase	\$100	\$200	\$400
Discount Rate	Long term value	Long term value	Long term value
10%	\$1000	\$2000	\$4000
5%	\$2000	\$4000	\$8000

He points out that “the net present value of a tax policy change shows the lump sum cost of the tax difference over the long run.” The important inference is this: “The household, when calculating the amount it is willing to pay for housing further away from the central cities, should use this longer term impact of the tax impact.”

Continuing to address the relationship between road taxes and location decisions, Ryan, in his section six, introduces the issue of road taxes and urban fringe development. He poses the policy question: “Can transportation financing can be an effective tool for regional growth management?” The question is the subject of current interest and has not been settled.

Ryan, as an economist, argues that there is at least one way to identify the likely impact of higher transportation costs on development patterns on the urban-rural fringe. It is based on the “land-rent” gradient, which “shows how land values change with distance from an economic center. Those changes in land value capture the trade-off households (and businesses) make between travel expenses and housing costs.”

In section six, Ryan describes the transportation and land use system in which the land-rent gradient relationship is at work. The system centers on developable land in and around what he calls the urban/rural fringe, “where farming is typically the land’s best commercial use. But, as the region develops and its population grows, some farmland is converted to non-farm use. This starts an irreversible process that over the years will claim the most desirable, easily developed land for more highly valued non-farm uses. Locations where sale prices begin to exceed the agricultural value are on the active development frontier, and it is there that changing road tax policy might affect regional growth patterns.”

“The effectiveness of a change in tax policy in shaping – or changing – development patterns depends on the differential between the [current] market value and the underlying agricultural value of any particular parcel, and on the change in net present value of travel costs (NPVTC) from that location.” The difference between the non-farm use value, determined by market conditions, and the agricultural use value is expressed as the “development premium” in dollars per acre.

The development premium per acre conceptually captures the value of perceived *benefits* that arise from the land’s non-farm use. Therefore, prospective households would not be attracted to move to that location if their NPVTC exceed the development premium. If, however, the development premium substantially exceeded a household’s NPVTC, then an increase in road taxes would have little impact. Ryan, to this point, concludes, “Within reasonable limits, higher road taxes appear unlikely to affect the pace of development on the active development frontier where development values substantially exceed agricultural values.”

Importantly, however, Ryan comes to his major finding on this matter: “But, as we move beyond the area where development is actively underway, development premiums fall quickly. For those properties, an increase in the net present value of transportation costs of \$5000 could well make it (temporarily at least) impossible to find a developer willing to bid more for the land than its agricultural value. Thus, the result of higher variable pricing for roads may well cause development to proceed in a more measured, concentrated manner. Whether or not there will be any impact on development will depend on the change in the net present value of transportation costs and the development premium the market formally assigns to the property.”

Question 6: Will road taxes keep pace with future trends?

In section seven of his report, Ryan asks: “Will the current road tax policies provide sufficient revenue to sustain the current level of statewide road repair and construction through 2025?” Ryan cites a DRI estimate of inflation for road repair and construction costs for 2025 of 88% over the 2000 level. Thus, in 2025, it would cost 88% more than *current* spending to simply sustain the current (2000) level of road repair and construction activity.

Next, Ryan asks: “Will current revenue sources for road repair and construction merely keep pace with inflation – even if we do only the level of work performed in the year 2000?”

The results of his analysis are summarized in the table below.

Revenue from: (\$millions)	2000 Base	2025 Fcst.	Growth %	2025 @ 88% Infl.	Shortfall To Infl.
Registration Fees	597	858	+44%	1122	-264
Fuel Excise Tax	611	823	+35%	1149	-326
Vehicle Sales Tax (32% to Roads)	173	538	+311%	325	+213
Total	1381	2219	+61%	2696	-378

Ryan concludes this section with the following remarks. “Without changes to current tax policy it will be impossible to devote the same real resources to road maintenance and construction in the future. There will be a road-funding deficit well before 2025... In addition, property taxes, income taxes, and general sales taxes are experiencing trends and policy changes of their own that may leave them unavailable for road purposes.”

In subsequent commentary on this section of his report, Ryan offers this expanded insight: “When the projected revenues from the three taxes are combined for the 2025 period, there is a shortfall of nearly \$400 million compared to the inflationary cost increases. Again this means that without changes to current law, road services will have to be reduced, or the property tax and/or state general fund contributions will need to increase. This is not necessarily a bad thing; the point is to recognize where the long term revenue weaknesses are in the system. The question of what portion of revenues should be variable, fixed, or hidden is still unresolved.”

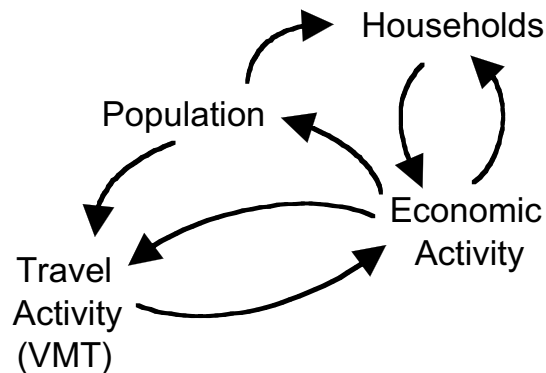
*Lance Neckar, Principal Investigator:
Transportation, Urban Design and the Environment, Highway 61/Red Rock Corridor
Task I[a] – The Baseline Condition [Emphasis on Water Quality Issues] (TRG #13, 2003) **

It is Neckar’s primary finding that conventionally developed suburban places, which are designed around the Genetic Code of the Subdivision, inevitably will lead to serious and long-lasting depletion and damage to quality of the area’s water – both surface water and ground water. Low quality water will significantly reduce the attractiveness of the place for current and potential residents or businesses. Consequently, population and economic activity will eventually decrease, and the area could fall into a vicious cycle of decline and decay. It is possible, however, to mitigate or reverse these patterns of behavior by the adoption and aggressive application of water-friendly designs and regulations for subdivision and supporting public infrastructure, especially transportation.

The remarks that follow use a systems thinking perspective, including the use of causal loop diagrams, to present the rationale for Neckar’s conclusion.

Metro Area Engines of Growth

The following causal loop diagram depicts some of the reinforcing feedback structures that studies indicate are fundamental sources of growth in the Twin Cities Metropolitan Area.



These key variables, Population, Households, Economic Activity, and Travel Activity all interact causally with each other to produce exponential growth in each. As such, when things are good, they are “virtuous cycles.” Generally speaking, population follows from economic activity, and economic activity depends on a population that can travel within the region. Travel activity itself stimulates and enables economic growth. Population and economic activity combine to generate households. As a productive economy grows, creating more affluence, then the number of households grows more rapidly than the population. Adams and Barnes address these systemic structures and their behaviors in detail in other TRGS reports.

* Ed. Note: The material referenced in this section and in the following section was published as *Transportation, Urban Design, and the Environment: Highway 61/Red Rock Corridor* (TRG #13, 2003).

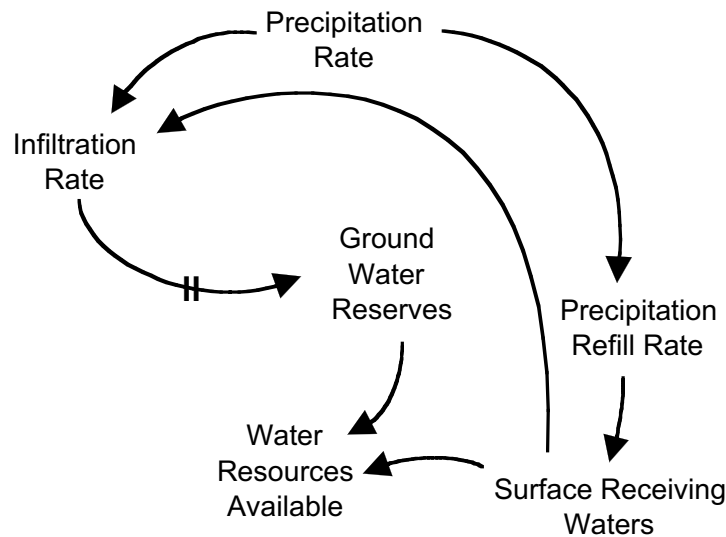
It is clear, we believe, that these engines of growth are producing patterns of behavior like the following:

- Increased productivity of the region’s workforce
- Greater affluence
- A decrease in the average household size
- More vehicles per household
- More vehicles on the road
- More travel activity

The Area’s Water Resources

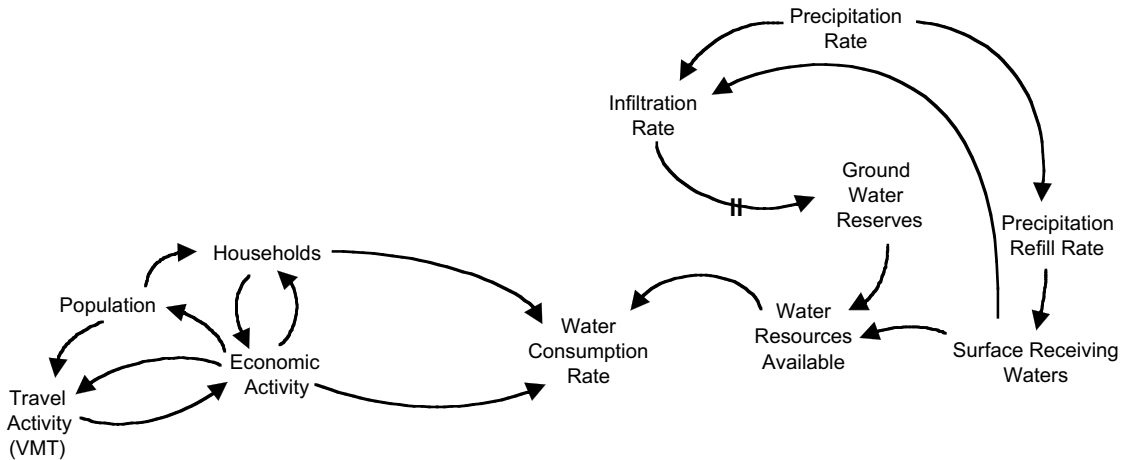
In his report, Neckar strongly suggests that we must consider other systems as well, including our natural environmental systems, and especially the region’s hydrological system. He asks, “What is the interaction between the engines of growth above, which are the primary drivers of suburban and exurban development in the Twin Cities area, with the areas natural water resources system?”

The simple diagram below captures some of the key variables in the natural hydrological system.



The precipitation (rain or snow) rate, over the extremely long run, is the primary natural source of water for the region. Precipitation directly refills surface waters like lakes, rivers, and ponds. And, in nature, a large fraction of precipitation infiltrates into the soil and is collected, after a long filtration delay, in underground water reserves, like aquifers. Some surface water also naturally infiltrates into ground water reserves.

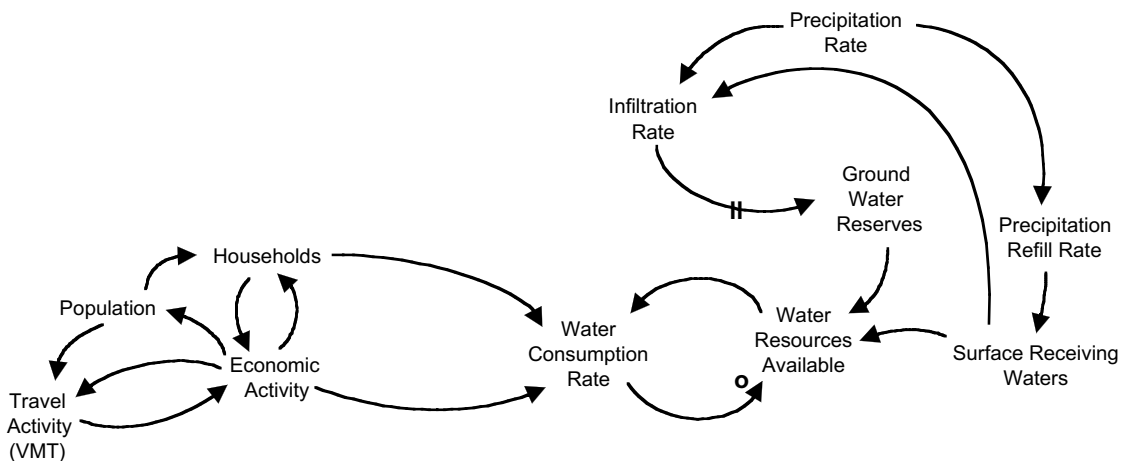
The Water System and the Population/Economic System are Both Part of a Larger Whole
 The area's engines of growth cannot operate without water. The primary link between the two sub-systems is the variable, Water Consumption Rate. The diagram below brings the two parts together.



Simply stated, the area's available water resources allow what seems to be an almost unlimited water consumption rate. It seems like there is no limit to water, either from ground resources or from surface water.

A Limit to Growth

But just because a limit isn't obvious, doesn't mean it isn't real. From the study of systems, and from real life, we know that the water resources of a region are a "stock," and that a stock has an initial, finite quantity (the initial limit), and that it can be changed only by inflows (additions) or outflows (subtractions.) The diagram below introduces this dynamic.



Clearly, the water consumption rate, driven by human activity in the region, depletes the stock of water resources available. The "o" next to the arrowhead of the causal link from the consumption rate to the water resources available denotes that as the consumption rate increases, the stock of water resources available decreases.

In some regions of the country, especially in the West, available water resources are a powerful limit to growth – a condition that is evident to almost all.

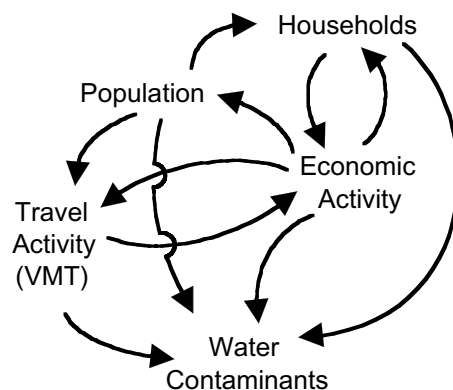
Water Contaminants: A Product of Growth

The area’s human settlement system and the area’s hydrological system interconnect in ways beyond the consumption rate. In Chapter 2 of his report, entitled “Land Use, Transportation, and Water: Nested Concerns,” Neckar cites the influence that the traditional suburban subdivision design for household development has had on precipitation runoff water. He states, “Urban runoff is by its very nature contaminated. Its most problematical sources in a neighborhood context are:

- Paved parking and storage areas
- Automobile service areas
- Driveways
- Streets, highways and freeways
- Landscaped areas
- Paved freeway and highway shoulders
- Roofs also contribute certain classes of contaminants”

He goes on to say, “Organic contaminants of chief concern in runoff have been in the three classes: pathogens such as enteroviruses; bacteria such as shigella and salmonella; and nutrients, especially nitrogen, which is a major constituent of street and highway runoff and a principal source of groundwater contamination... Eutrophication of surface water is a problem for all recreational uses, especially swimming and fishing. Not only is the water unsightly and organically underdeveloped, but the nutrient loads themselves present problems with bodily contact. Most of the attractive edible and game fish do not tolerate eutrophic waters.” Neckar then lists a number of non-organic contaminants found in residential area runoff, plus other chemical toxicants and road salt.

In our diagram, we show these Water Contaminants in the following way:



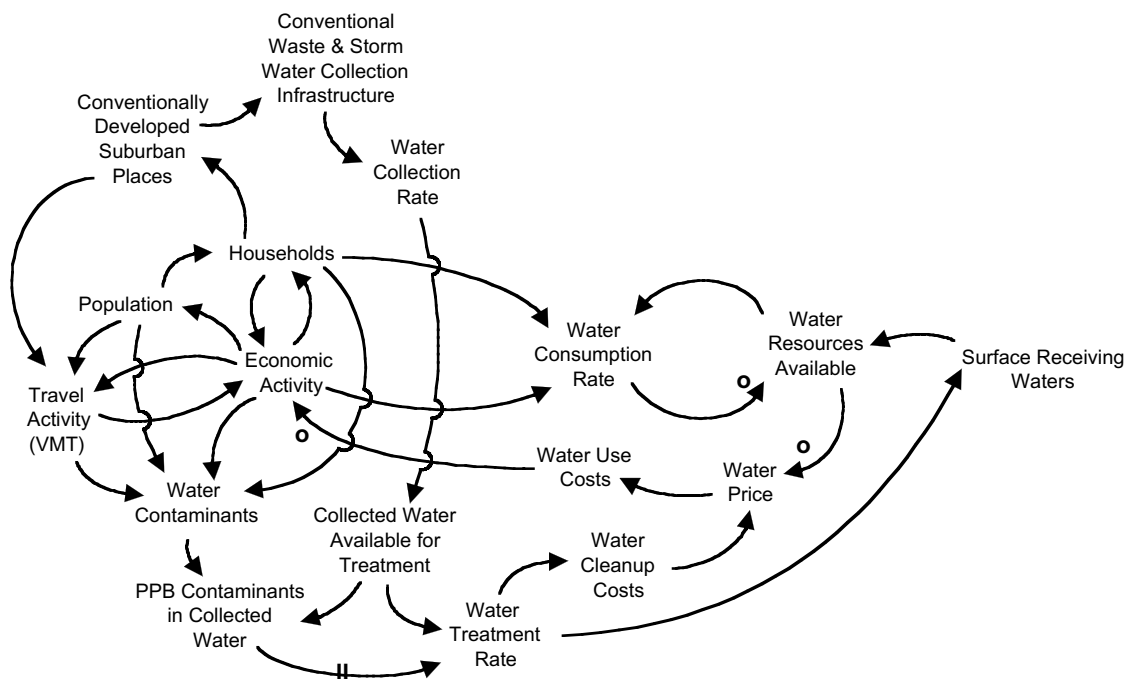
Our urban and suburban settlement system, in the normal course of everyday living, generates contaminants that are introduced into the water system from all four sources: the population of our people, their work or school activities, the operation of their households, and their travel

without any treatment that would reduce suspended solids or other contaminants, to receiving waters farther downstream. In the meantime, the ground water, which prior to this pattern of development had been recharged by precipitation and runoff, receives only a small fraction of that water because of all the impervious surface necessary to such function.”

The net effect is an increase in the parts per billion (PPB) of contaminants in the runoff water that is collected by urban and suburban settlement infrastructure.

Water Treatment or Pre-treatment to Reduce Contaminants

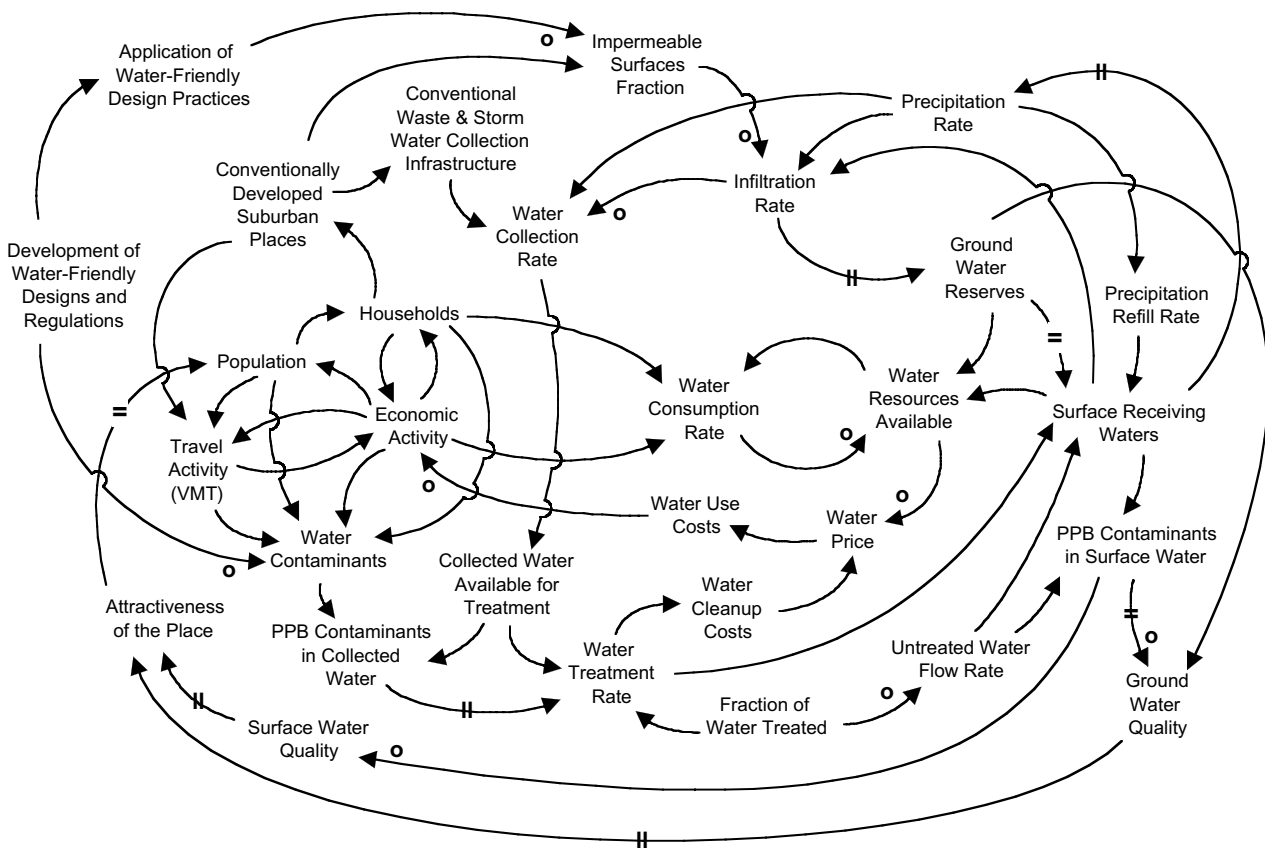
The increases in water contaminants have, over time, led to the development of runoff water treatment or pre-treatment practices and processes. These processes for water collection and clean-up cost money and lead to increasing water prices. These water clean-up costs introduce a significant balancing feedback loop into the system.



In particular, the impact of higher water use costs is to retard the growth of economic activity because businesses have fewer earnings to reinvest in growth. The diagram above shows two key factors influencing water price: the first is a growing scarcity of available water resources due to accelerating water consumption rates; the second is higher water clean-up costs due to higher levels of contaminants in collected water.

Neckar, therefore, contends that the Twin City Metropolitan Area governance structures must consider management of its hydrological system as a regional matter, not left up to individual, local authorities. And, that regional policy intervention should involve two areas of initiatives: First is the application of water-friendly design practices for residential settlement that result in reduction of impervious surfaces and the creation of surface features and public infrastructure that increase the infiltration rate of precipitation. Second is continued adoption of water-friendly regulations that aim to reduce the levels of contaminants that are introduced into collected water. These variables are shown in the final version of the causal loop diagram, shown on the next page.

A Systems Thinking Perspective on Urban Design and the Environment



A Suggestion for Policy Makers

Each variable in this causal loop diagram can be measured and monitored. The causal links between the variables represent hypotheses about cause-effect relationships at work in this complex system. The author of this integration report urges that policy makers assign their support staffs to perform this measurement and monitoring function and to improve on the hypotheses as new learning occurs.

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Task 1[b] – the Baseline Condition [Emphasis on Transportation Stratification]
*(TRG #13, 2003)**

The systems thinking integration effort first examined Neckar’s research relative to the impact of the “Genetic Code of the Subdivision” on water supply and quality in the MUSA region. With new material available, which Neckar sees as integrative of environmental and transportation elements, he identified more new variables and relationships related to land use and transportation. This part of the systems thinking view on Part V of the TRGS deals more directly with the stratification of the region’s transportation network as an integrative approach to dealing with VMT and water.

Neckar comes to the issues of land use and transportation with the hypothesis that conventionally developed suburban places – build according to the Genetic Code of the Subdivision – will inevitably lead to serious and long-lasting damage to the quality of the area’s water – surface and ground. Further, the development of conventional subdivisions, which involves the developer-designed and built residential streets and connector roads to serve the place, creates an auto-dependent population that demands higher levels of public investment in an unstratified auto-oriented transportation network. A well-stratified transportation network would provide, according to Neckar, the area’s population with multi-modal travel options, including commuter rail and transit.

At the core of Neckar’s new work is this question: Why and how do the region’s local units’ comprehensive plans for land use preserve low local density limits and separation of residential and other uses in the context of the provision of regional transit service? What are the consequences of those limits and Euclidean patterns in zoning? How could those limits be changed to stimulate more higher-density residential/mixed use developments that shed the current genetic code of the suburban subdivision?

From a systems thinking perspective, the “Local Density/Use Limit” of a place is a policy parameter and as such, is intended to influence or control the dynamics of a complex system. How does Neckar see that happening? What hypothesis does he offer for why the “as-is” or “baseline” system continues to reinforce low-density limits?

Our discussion of Neckar’s hypothesis examines several direct causes and effects that influence local density/use limits. They include:

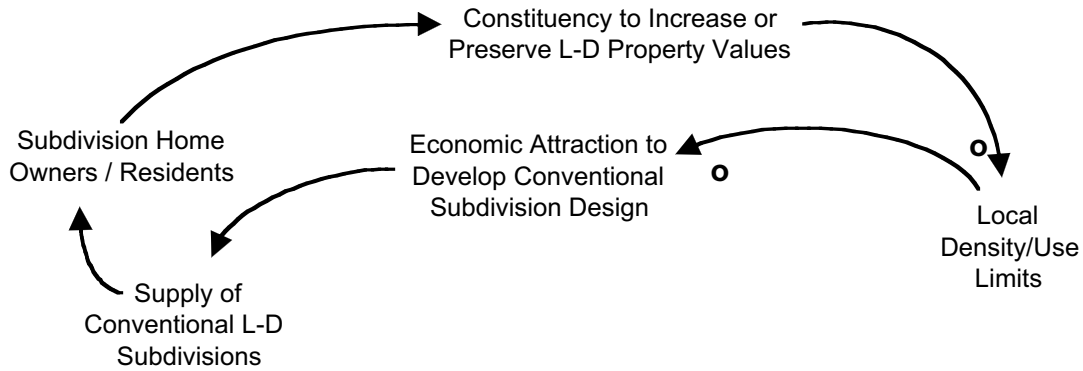
- The size of the constituency to increase or preserve low-density place residential-use property values
- The size of the constituency for higher density development, and
- The relative value to residents and owners of higher density developments
- The economic attraction to develop conventional subdivision design
- The attractiveness of conventional low-density residential subdivisions

* Ed. Note: The material referenced in this section and in the previous section was published as *Transportation, Urban Design, and the Environment: Highway 61/Red Rock Corridor* (TRG #13, 2003).

- The opportunity for and economic attraction to build higher density, transit-oriented design, mixed use developments, and
- The opportunity for and economic attraction to build transit and commuter rail.

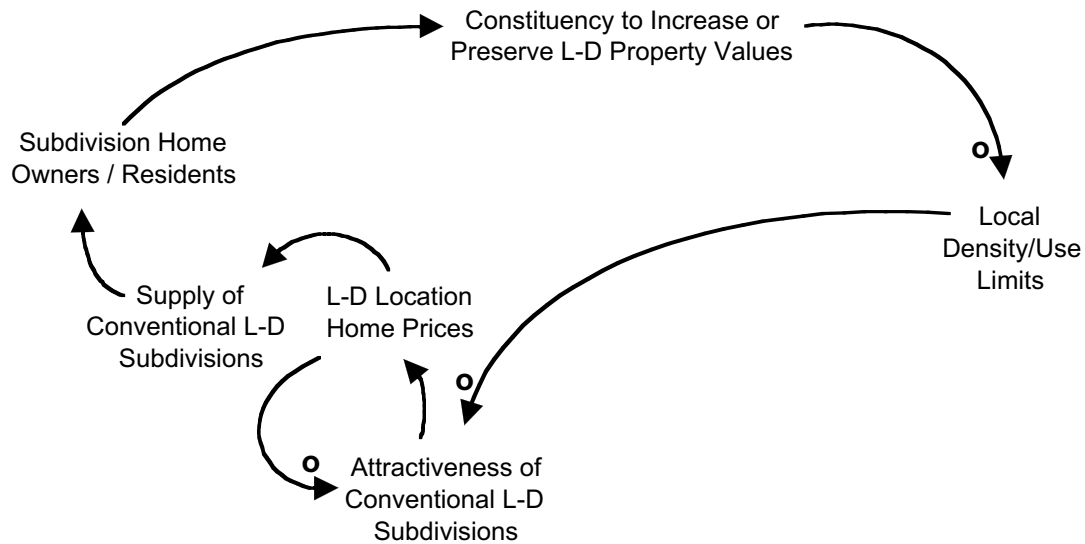
Current Local Density/Use Limits Create a Constituency for Preserving Low-Density/Use Limits

Neckar argues that local zoning powers in the region’s places impose density/use limits that stimulate and sustain the conventional low-density subdivision design. The causal loop diagram below illustrates this reinforcing structure.



In our current system of land use regulation, low local density/use limits sustain the economic attraction to develop land for the conventional suburban subdivision. And, as described in other sections of this integration report, the growing number of conventional subdivision homeowners and residents form a powerful constituency to increase or, at least, preserve the property values of their low-density places. They perceive that low-density/use limits are important policy controls for achieving that purpose.

Low Local Density/Use Limits Reinforce Low-Density Place Home Prices

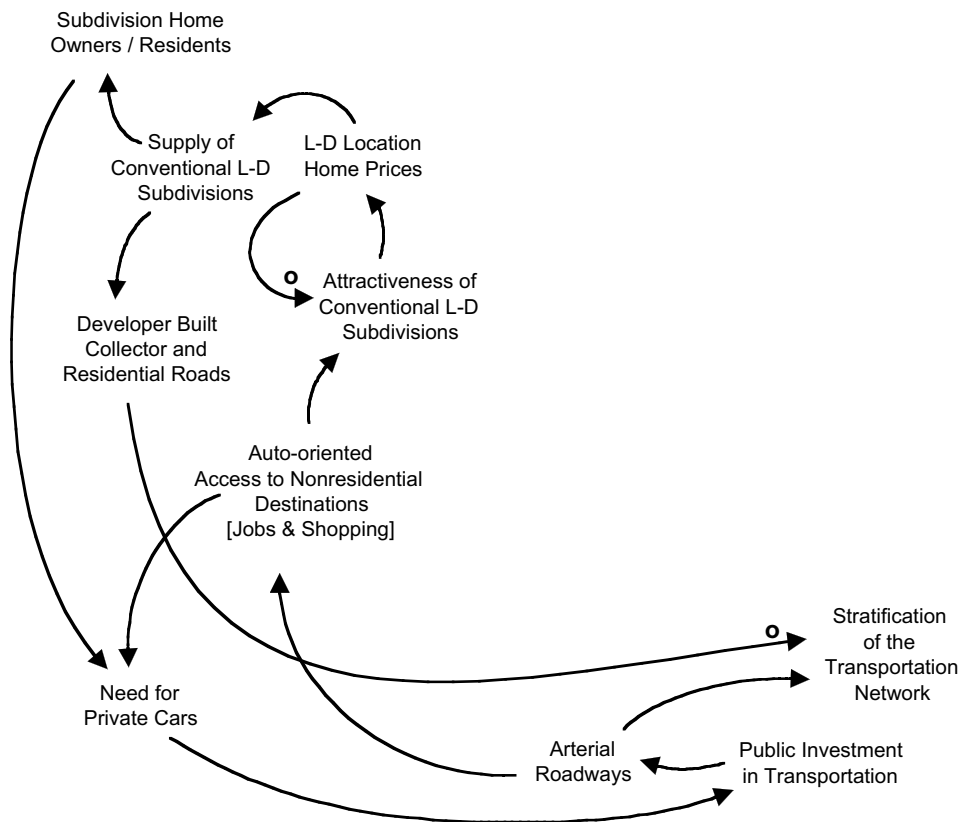


For a variety of reasons, low-density places with conventional subdivisions are perceived by many as more attractive than higher density locations. They point to newer schools, greater privacy, tax advantages, and other advantages of single-family homes on large lots. They do not have to travel to more dense central places for work, shopping, or entertainment. These factors are incorporated into the CLD shown on the previous page. The relative attractiveness of the conventional subdivision leads to higher demand and, therefore, higher prices for low-density subdivision homes. Those higher prices stimulate an increase in the supply of low-density developments by profit-motivated homebuilders.

Of course, rising home prices in the low-density places can also have a balancing effect on the relative attractiveness of the conventional subdivision. This is a result of the balancing feedback loop where rising home prices in the low-density locations reduce the relative attractiveness of living there.

The Impact of Low-Density/Single Use Development on the Transportation Network

Neckar points out that the growing number of conventional low-density subdivisions in the region's suburbs has two significant effects that impact transportation system dynamics. First is the need for private cars as the primary mode of travel. Second is the greater number of developer built collector and residential roads, often indistinguishable, which provide auto-oriented connections to arterials. As more and more people live in conventional subdivisions and use private cars, they require from government a greater publicly funded investment in arterial roadways to provide more rapid auto oriented access to nonresidential destinations like jobs or shopping. Notice the related variables in the diagram below.



Furthermore, the developer-built residential streets and collector roads are not designed to connect effectively with other subdivisions. A consequence is that there is less stratification of the publicly funded transportation network in the region. By “stratification,” Neckar implies a sufficient variety of travel modes (multi-modal) to effectively serve the region’s diverse population.

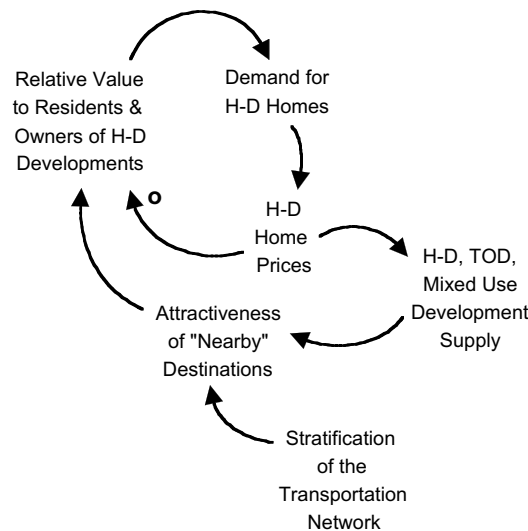
The diagram shows several important reinforcing feedback loops. First, the need for private cars increases the pressure for public investment in arterial roadways, which, in turn, increases access to auto-oriented destinations. The increasing attractiveness of these nonresidential destinations results in an even greater need for private cars to get to those locations. Second, public investment in arterial roadways to improve access to nonresidential destinations increases the attractiveness of conventional low-density subdivisions in the suburbs. All the developers have

to do is connect the subdivision to an expanding arterial network. Thus, even more conventional subdivisions are provided by developers to new residents, and, therefore, the need for more private cars increases, too. More residents who need to travel by private cars stimulate ever more investment in arterial highways.

With everything else being equal, namely without a proportional increase in non-auto travel capacity, the increasing capacity of developer-built residential streets and collector roads reduces the relative stratification of the region’s transportation network, and tends to fix the standards by which they are built—reducing both multi-modality and environmentally (hydrologically)-specific design and engineering solutions.

Reduced Transportation Network Stratification Impacts the Supply of Higher Density Development

The diagram below illustrates a reinforcing feedback structure that influences the supply of higher-density, transit-oriented design, mixed use developments in the region. Simply stated, the relative attractiveness of “nearby” destinations, including jobs, shopping, education, or entertainment, to residents in high-density locations determines the relative value associated with living there. If that value is increased, then the demand for higher-density home locations will

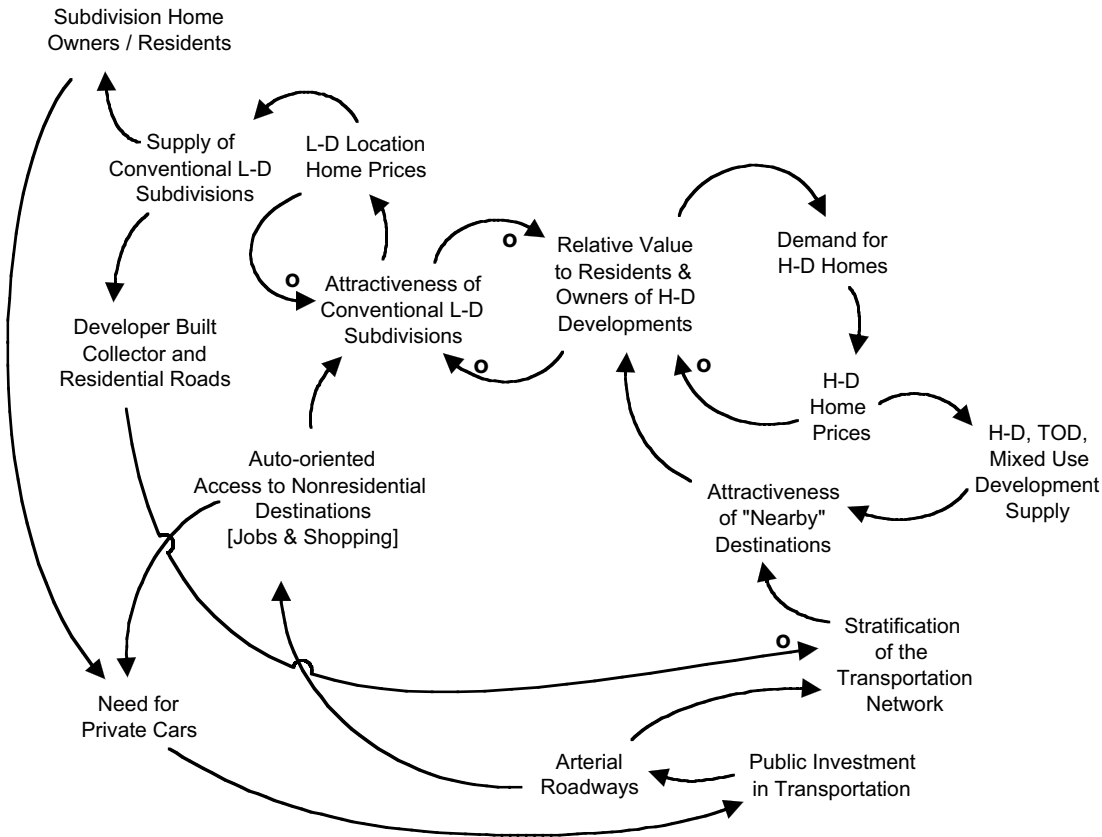


also increase, resulting in a greater supply of higher-density, mixed use developments. Those new developments will provide even more attractive nearby destinations. And so on and so on.

However, the nature of a reinforcing feedback loop is that if any one variable in the loop is slowed down or reversed in direction by the force of another variable outside the loop, then what has been perceived as a virtuous cycle can be changed into a vicious cycle, or vice versa. Neckar argues that is the case. He suggests that the reduced stratification of the transportation network, specifically the addition of more and more auto-oriented travel capacity without a proportional increase in multi-modal, commuter rail, or other transit capacity, reduces the opportunity for profitable private or public investments to increase the attractiveness of nearby destinations for residents in higher density places.

De-stratification Reinforces De-stratification

The variable, stratification of the transportation network, appears in both of the previous CLD diagrams. We've combined the two in the diagram below.

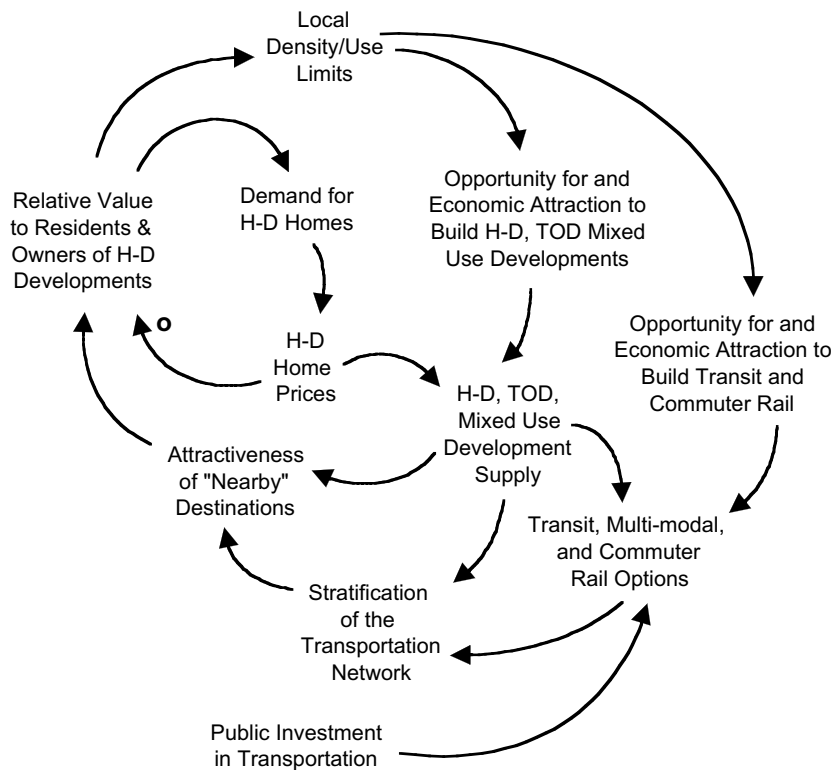


At the core of the diagram is a “success to the successful” system archetype, which involves the relative value and/or attractiveness of conventional low-density subdivisions versus the relative value of higher-density developments, especially in the context of low-density residential fabric. It is a “zero-sum” game: an increase in the value of one will decrease the value of the other, plus once a direction of causality is established, the pace and magnitude of the impact will be reinforced. In Neckar’s baseline situation, the relative attractiveness of low-density locations is growing and doing so at the expense of the relative value to residents and owners in some higher-density locations with few public amenities. The only mitigating factors which balance out the dynamics are the home prices in the locations. Neckar’s point is that the unstratified, auto-oriented street networks in low-density subdivisions artificially accelerate the attractiveness of those locations and reduce the attractiveness of the higher-density mixed use places because there are few choices in the largely unstratified suburban market.

Reversing De-stratification

Given Neckar’s hypothesis about the causes of the baseline condition, what would we have to change to reverse the “successful to successful” dynamics, i.e., increase the value of residing and owning homes in higher-density locations?

Neckar sees the need for explicit policy intervention to advance and implement transit-oriented design (TOD), high-density, mixed use development strategies within the metro area. The most essential step locally is to increase local density and use limits within the metro area. The diagram below illustrates the argument.



This is the “mental model” that many advocates of higher density/mixed use limits have in their minds. It is a model that redefines the idea of destinations and access. Policy interventions to increase local density/mixed use limits will have two powerful effects.

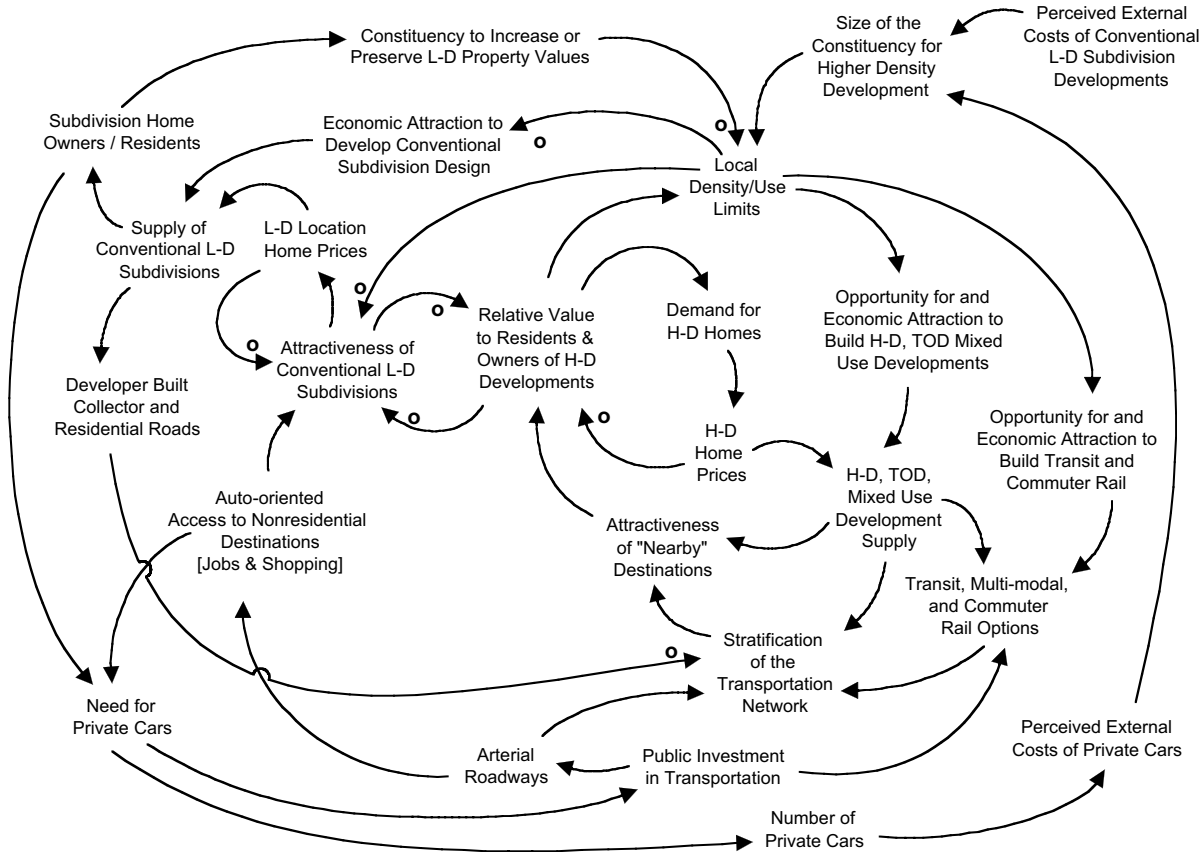
The first is to increase the opportunity for and economic attraction to build higher-density, TOD, mixed use developments. That will increase the supply of these higher-density locations and thereby increase the attraction of nearby (non-auto available) destinations. Because of that, the value of these high-density location homes will increase, and the demand for more homes like them will grow.

The second major impact of sufficiently higher density/use limits is to increase the opportunity for and economic attraction to build commuter rail and other transit capacity supported by multi-modal street networks. When public investment is shifted away from highways to transit, commuter rail, pedestrian, or other non-auto travel options, the stratification of the transportation network increases and thereby reinforces the attractiveness of nearby destinations.

To illustrate how this hypothesis works in reality, the advocates might point to metropolitan Boston or Portland, which have a mix of higher and low density developments based in a

Finding a Constituency for Higher-Density Limits/Mixed Use/Multi-Modality

How will advocates for higher density limits build a constituency to pressure local or regional governments to raise those limits? Their strategy is to point out what the economists call inequitable “external costs” that burden the current baseline situation. The diagram below adds those variables to the larger system.



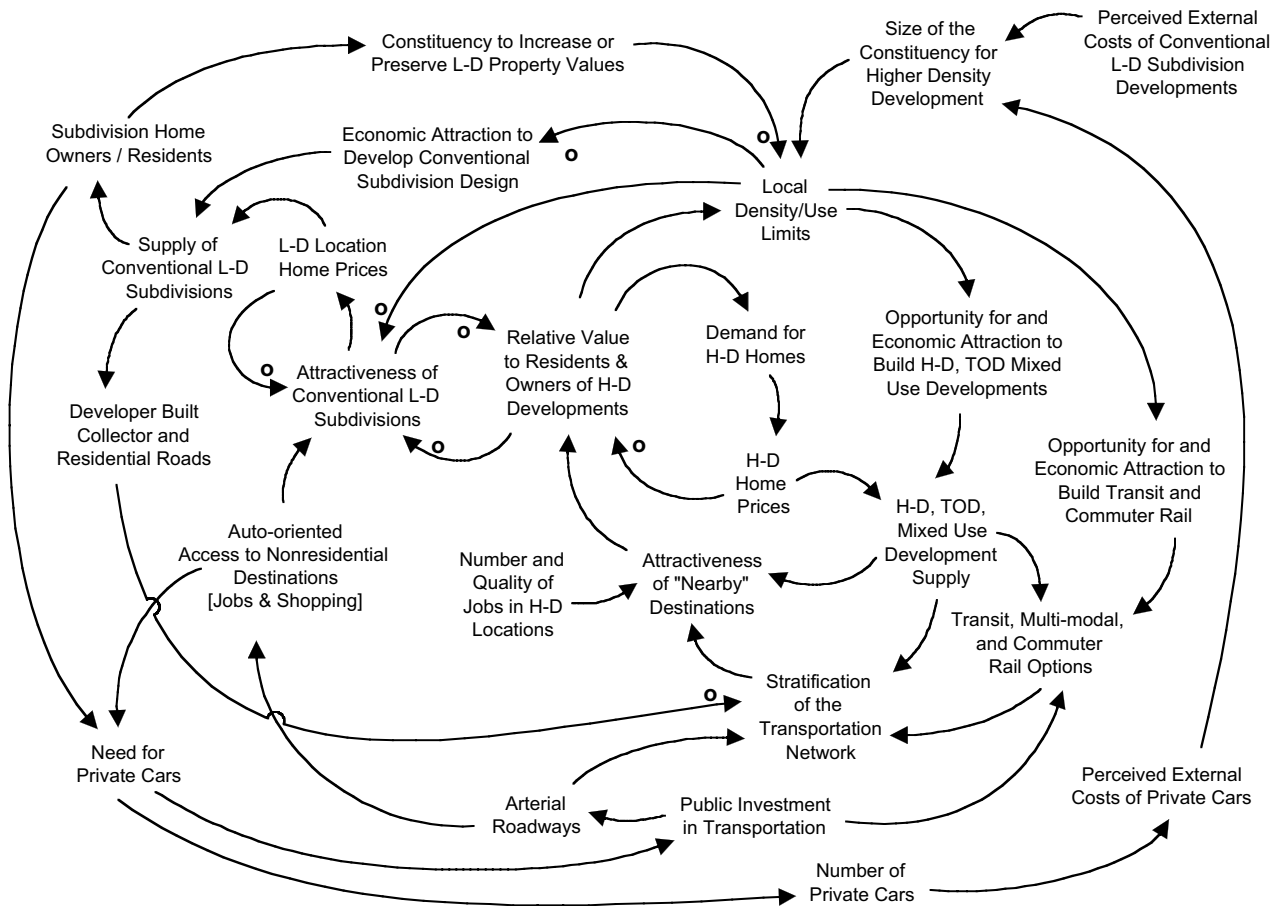
The first variable is the perceived external costs of private cars. It is, many say, caused by the growing number of private cars that are in use throughout the region. The second variable is the perceived external costs of conventional subdivision developments. Among these costs are, of course, those associated with fixing reductions in surface and ground water quality within the metro area. These costs can be projected, but since they are future costs dependent on future technologies of remediation in some cases, they are difficult to estimate. In the proposed model, these costs can be taken off the table by action now by shifts to design/planning and policy integration. Costs could be based on new imperatives by Mn/DOT for multi-modal development to match transit investments, including Met Council-mandated reciprocity by local units of government to change comprehensive plans and zoning limits in areas of transit provision and hydrological sensitivity.

What Else Can be Done?

Neckar is aware of the systemic issues that are preserving the Genetic Code of the Subdivision and discouraging more higher-density/mixed use development in central city areas. His approach for overcoming the resistance to limits is to encourage two fundamental dynamics. The first is to stimulate more job growth in the central city, especially downtown locations. Why?

Fundamentally, commuter rail, the future backbone of the area being studied, is dependent on a downtown job base. (Only in areas of high-intensity suburban campus employment does reverse commuting “work.”) A concentration of good jobs creates a very attractive nearby destination within a higher-density location and accessible via commuter rail from suburbs. Second, by expanding commercial tax base in the city, it puts the cities in a competitive position with the suburbs, on their own terms.

The final diagram, including the jobs variable, is presented below.



Barbara Lukermann, Principal Investigator:
*TRGS Part VI: Driving Forces and Institutional Arrangements that Impact the Relationship
Between Land Development Patterns and Transportation Investments*
*(March 18, 2002 and May 10, 2002)**

This systems thinking perspective is developed from two sources. The first is a four-page summary document that presented “key points” and a listing of “driving forces” by Barbara Lukermann at a CTS-TRGS workshop conducted by Ed Ward on March 26, 2002 in Minneapolis. The second is a May 10, 2002, memo from Tom Scott and Barbara Lukermann to Ed Ward, the author of this document, which responds to Ward’s interpretation of the March 18th document.

Lukermann’s document takes on a long term, historical view of the forces and factors that have brought us to the current patterns of transportation and land use dynamics in the metro area. They include many of the factors already identified in earlier parts of the TRGS contributed by John Adams, Gary Barnes, David Anderson, Barry Ryan, and Lance Neckar. Therefore, it offers the opportunity to explore transportation and land use relationships from a “30,000-feet” perspective.

The systems thinking perspective will be supported by causal loop diagrams that offer maps of parts of the complex system that includes land use and transportation dynamics in Minnesota’s Twin Cities metropolitan area. These CLDs explicitly identify what are considered key variables in the system, plus the major causal linkages between them. Further, they allow the reader to discover the feedback loops that are the sources of the dynamic patterns in the system’s variables.

As Lukermann points out, it would help the reader to make it clear that these CLDs attempt to explain the system primarily *from the perspective of local units of government* – the municipal corporations that are responding to state and federal policies and spending but making their own land use decisions in their own self interest. State and federal governments do indeed set the context for local decision-making, but then local units must deal with “ground truth” and deal with citizen complaints when property rights are invoked or the status quo is threatened.

Governments’ Roles and Responsibilities

The governmental institutions really have two major roles: the first is a legal and constitutional power granted to state and local governments to protect the public health, safety, and welfare; the second is a more traditional function of municipal government to protect the economic self interest of the local corporation. To this end, local governments impose taxes, adopt regulations, and use their powers to incur debt so that there is the necessary level of public investment in infrastructure and services that achieves both of the above goals. Taxing income and property and levying fees are the means by which their goals are achieved. The broader roles of state and federal government to tackle equity issues as well as economic efficiency by redistributing wealth are not very well developed at the municipal level. One of the few laws we have in the

* Ed. Note: The material referenced in this section was published as *Public Policy, Transportation, and Regional Growth* (TRG #16, 2003).

metro area that addresses equity is the Fiscal Disparities law that redistributes part of the local commercial and industrial tax base according to the per capita property values in each local unit of government. Who pays and who benefits tends to get hidden at the local level when economic vitality is the name of the game.

Forces and Factors at Work in the System

The forces and factors cataloged by Lukermann are really *variables* in highly complex economic, social, governmental, and other systems. Variables are terms we invent or select to describe *change-over-time* in the things that matter to us as both individuals and members of a larger society. While it is useful to list them, the challenge for creating a systems thinking perspective is to create a “shared mental model” of how they are connected to each other as causes or effects. Below is a simple numerical listing of the variables Lukermann includes and their general directional change in the recent past (a “+” suggests an increase in the variable’s value; a “-” suggests a decrease).

1. Transportation technology scope, modes, effectiveness, and efficiency (changes vary by mode of transportation).
2. Federal funding of public infrastructure improvement investments. (+)
3. The use of transportation and land use models to improve “systems planning.” (+)
4. The level of local citizenry participation in land use and transportation project decision-making. (+)
5. The level of federal influence on transportation and urban development policy. (-)
6. The level of local government influence in managing land use through local zoning powers. (+)
7. Comprehensive land use planning and zoning decisions to segregate land uses, to resist high-density residential development, and to stimulate new industrial parks, shopping centers, and office parks. (+)
8. Federal and state tax systems that support developers to meet the market demand for low intensity land use patterns. (+)
9. Availability of capital from private sources to fund large-scale private land developments. (+)
10. The power of governments to incur debt for public infrastructure and to subsidize housing and business development. (+)
11. The decentralization of jobs away from central city locations into suburbs. (+)
12. Expectation for standard of living, including living space. (+)
13. Geographical separation of place of residence and travel destination places, i.e., work, shopping, recreation, or entertainment. (+)
14. Separation of Minneapolis and St. Paul housing and business markets. (+)
15. Fraction of total federal transportation investment in new highways. (+)
16. Fraction of total federal transportation investment in transit. (-)
17. Demand for private, single-family homes. (+)
18. Availability of cheap land. (+ in the near future, but potentially – in the long run)
19. Population with Middle Class or above incomes. (+)
20. Attractiveness of auto ownership and use for travel. (+)
21. Women in the workplace. (+)
22. Trip destinations per household. (+)

23. Local government responsiveness to local activism in favor of for low-density. (+)
24. Citizenry pressure for centralized control of land use. (-)
25. Local citizenry activism for segregated land use. (+)
26. Centralization of retail activity into auto-friendly malls and shopping centers. (+)
27. Attractiveness of “streetcar era” structures in center cities. (-)
28. Highway and expressway capacity and speeds. (+)
29. Total time devoted to travel. (no change: a constant “travel time budget”)
30. Attractiveness of the roadway system for freight and commerce. (+)
31. Availability of capital for large public and private projects. (+)
32. Availability of capital for re-investment in the core cities. (-)
33. Availability of capital for investment in the urban fringe. (+)
34. Strength of region-wide management of highway systems investments. (-)
35. Public investment for transportation access to “opportunity sites” for business and industry.
36. Strength of regional regulatory power over natural resource protection and environmental factors. (-)
37. Willingness of the state to mandate statewide land use planning to insure complementary planning for local land use and transportation across all local governments. (-)
38. Constituency for expansion of Met Council land use control powers. (-)

The list Lukermann provides offers, of course, only a fraction of the variables included in the other research reports. Nevertheless, they do provide the opportunity to suggest a systems thinking perspective on how they are interrelated with each other. But, there are, many believe, other key variables that are involved with the dynamics of transportation, land use, and regional growth. These include:

- The urbanization of the countryside – the population shift from small communities to regional centers and their emerging suburbs (documented by Adams in the Regional Study). (+)
- Population growth in the past decade in the Minneapolis-St. Paul metropolitan was faster in the suburbs (20.4%) than in the region as a whole (16.9%). However, 17% of the region’s suburbs lost population, and the Minneapolis central city population increased by only 4.6%.
- Average per capita income. (+)
- Fraction of the population owning cars. (+)
- Number of private vehicles. (+)
- Worker productivity. (+)
- Technological capability of the population. (+)
- Capacity for economic output. (+)
- Workplace agglomeration benefits. (-)
- Household size. (-)
- Worker per household. (+)
- Level of economic activity. (+)
- Number of single-family homes. (+)
- Growth rate in suburban single-family home prices. (+)
- Growth rate in central city and inner ring suburban home prices. (-)
- Total property value of the metropolitan area. (+)

- Birth rate in the population. (-)
- Average size of new homes. (+)
- Number of desirable destination locations. (+)
- Vehicle miles traveled. (+)
- Fraction of the commuting population using transit. (-)
- Population density of the metropolitan region. (-)
- Suburb-to-suburb commute flow. (+)
- Suburb-to-central city commute flow. (-)

In the sections that follow, we attempt to weave these variables together into useful diagrams of the systemic structures that connect them in causal relationships. These diagrams do not purport to be the “truth,” but are the author’s attempt to document the relationships suggested by the researchers and to craft useful narratives to illustrate those connections.

Section A: Keeping Score—Measuring the Results of Public Investment

One of the challenges of the systems thinking integration work is to offer a perspective that gets at “why” the dynamics of transportation and land use in the Twin Cities mean something important. Perhaps the reason lies in the nature of a representative democracy, where elected or appointed authorities are given powers to tax and spend for the common good. In fact, we often evaluate the quality of our government officials by how well they manage the resources they obtain through taxes or public debt. How good are the results – both in the long and short run – from the public investments they make?

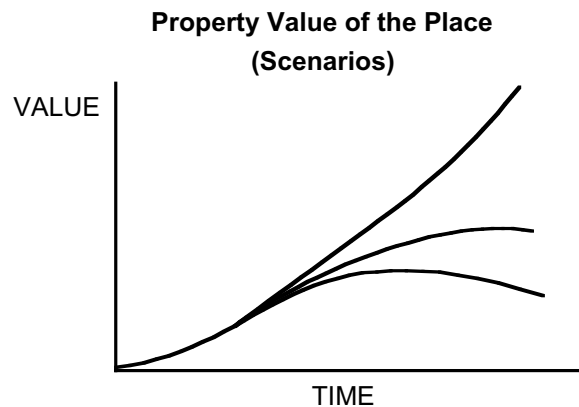
In her most recent remarks, Lukermann expands on “common good” to emphasize that protecting the “public health, safety, and welfare” is at the heart of why the public sector regulates as well as invests. Zoning is based on the police powers of the state, which in turn has devolved down to the local level through enabling legislation. What the state “giveth” it can also take away, but recent trends have been to give more away rather than rein it in. In other parts of the nation, state government is taking a second look at its responsibility to manage some of the tax and spending decisions across local municipalities.

What is the underlying rationale for public investment in a place? Why do people form into communities and then agree to tax themselves for the purpose of spending on the common good? Because they believe they, as individuals, and their heirs will be better off in the long run. But, how do they know if their tax revenues are producing the desired outcomes? How do they keep score? An answer: they track the change in the economic value of the whole place. Thus, they measure the total property value of the place, which is the sum of all of the market values of both private and public real property.

Is the property value of a place a “fair” measure of the goodness of a place? Perhaps. Is it the only appropriate measure of the goodness of a place? No. Is it a useful long-term measure of the goodness of a place? Yes. Why, because in our society, where we value individual freedoms and competitive market-based economics, the dollar value we ascribe to a parcel of real property is its “present value,” an amount based on the expected flow of future value to those who will use or own it. The higher the expected flow of future value, then the higher is the parcel’s present

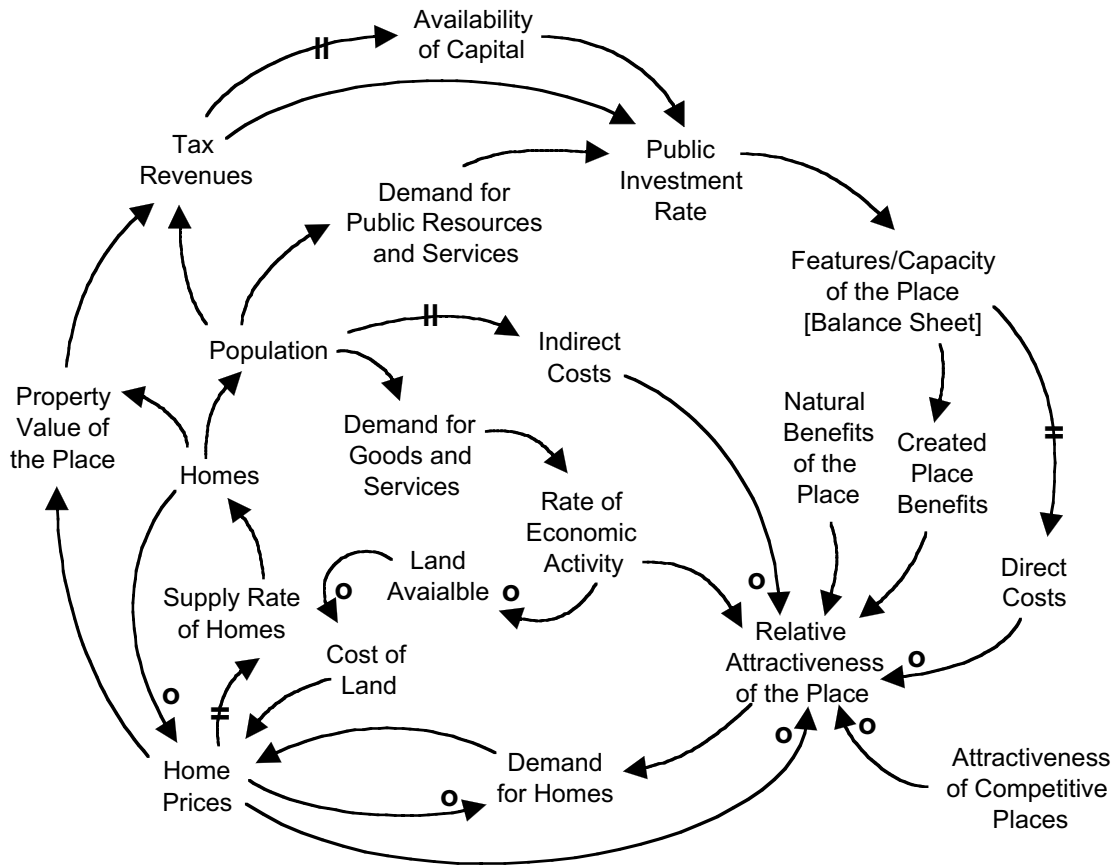
market value. Conversely, if the future value of the parcel is expected to decline, then the present value is lower. It is this logical relationship in the real estate market that justifies property taxes.

The chart below suggests three general scenarios for the Property Value of a Place over time. First, value could grow exponentially and consistently; second, value could grow exponentially, but then level off or flatten out; or third, value could grow for a while, flatten out, and then decline over time. What could cause these different patterns of growth behaviors?

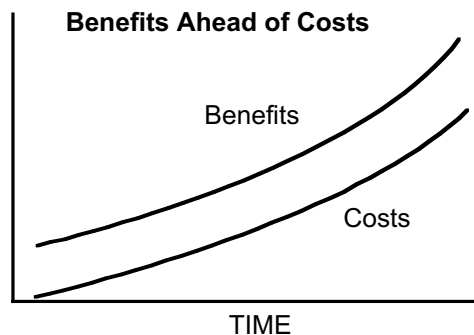


The property value of a place is one of many factors, or variables, which interact with each other in a complex economic, demographic, and social system. The system diagram on the next page is intended to illustrate the interrelationships at work among many key variables to produce change in those key variables.

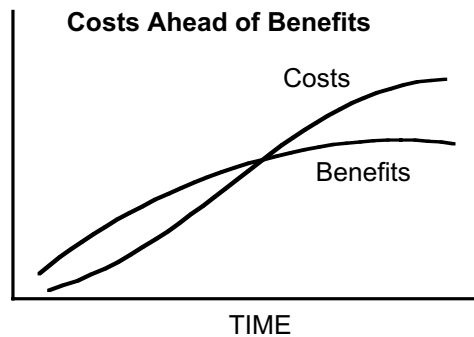
The diagram is a causal loop diagram. The arrows are known as causal links, which connect a cause and its effect(s). An effect is at the head of the arrow while the cause is at the foot of the arrow. The causal link is assumed to have the “same” causal direction: if the cause variable goes up, then the effect variable will go up, *or*, if the cause variable goes down, then the effect variable will go down, too. However, if there is an “o” at the head of the arrow, then the causal link denotes “opposite” causality: if the cause variable goes up, then the effect variable will go down, *or*, if the cause variable goes down, then the effect variable will go up.



Fundamentally, the system of the place (a city or town) produces both costs and benefits to the people who live and work there. A place is competitive in attracting and retaining population if its net benefits (total perceived benefits minus total perceived costs) are substantially positive. This dynamic is represented in the diagram below:



However, if the net benefits are either negative or very small, then other places will be more relatively attractive, and some of the population of the place will move away. This situation is illustrated on the next page.



The challenge for the community's elected or appointed leadership group is to make and implement governance decisions such that the benefits of the place are consistently greater than the costs of the place.

In the systems diagram, the summary variable representing net benefits is the Relative Attractiveness of the Place, which takes into account the following:

Attractiveness increasing variables (when increasing in value)

- Natural Benefits of the Place
- Created Benefits of the Place
- Rate of Economic Activity

Attractiveness decreasing variables (when increasing in value)

- Direct Costs
- Indirect Costs
- Home Prices for potential new buyers
- Attractiveness of Competitive Places

The principal effect of a higher relative attractiveness of the place is a higher demand for homes in the place. This variable represents the number of people who want to live there, including current residents as well as prospective residents. An increasing demand for homes in the place results in rising home prices, which, in turn stimulate homebuilders to increase the supply of homes to meet the demand. More homes and rising home prices combine to increase the total property value of the place.

But with the growth of the population living in the place comes an increasing demand for public resources and services, i.e., benefits. To produce these added "created benefits," the community governance group must increase the public investment rate. The rate at which investment for is converted into benefit-producing features/capacity of the place (what John Adams would call the "balance sheet" accounts of the place) is determined by the flow of tax revenues and the availability of capital made possible by that tax revenue stream.

From a systems perspective, the following variables are interconnected an underlying reinforcing feedback loop, which produces exponential growth in the property value of the place as well as all of the other variables in this loop.

- Public Investment Rate
- Features/Capacity of the Place
- Created Place Benefits
- Relative Attractiveness of the Place
- Demand for Homes
- Supply Rate of Homes
- Homes
- Property Value of the Place
- Tax Revenues
- Availability of Capital

The nature of a reinforcing feedback loop is such that a directional change in any of the variables tends to reverse the entire loop. In other words, a dramatic reduction in the public investment rate would, over time, result in moving from a virtuous cycle of positive growth to a vicious cycle of negative growth in place values.

For policy makers and government executives, their mission is to initiate and manage the flow of public investment in order to build and sustain a high relative value of the place so that people will want to live and work there. To do so, they manage the mix of investment in place features and capacity. The scope of investment includes, but is not limited to the items shown in the table below.

INVESTMENT IN ...	CREATED BENEFITS
Schools	Education
Roads and Transit	Access
Police and Fire Departments	Security
Water, Sewer, Environmental Quality	Health
Telephone and Cable	Communication
Governance	Preservation of Democracy
Courts	Justice
Administration	Policy and Controls

But the missions of government executives have changed over time. Lukermann argues that one of the problems we have with mental models is that one can lose sight of (or ignore) the way history changes the playing field on which government “plays out” its policies. For example, most of the functions listed in the table above were initially carried out by the private sector and then, as the costs to the private sector exceeded the benefits, these functions got shifted to the public sector.

As noted above, the public investment rate is intended to build and sustain created place benefits, which increase or maintain the relative value of the place for those who live there. But government executives and policy makers do not control the whole system. In fact, increasing the demand for homes in the place leads to higher home prices, which, after some delay, reduces

the relative value of the place, thereby reducing demand. This is a balancing feedback loop at work. Similarly, the growing population of the place creates indirect costs (reduced environmental quality, congestion, etc.) that can reduce the relative value of the place by mitigating the original natural benefits of the place. In addition, as the infrastructure features and capacity of the place age, the direct costs to maintain or replace them increase. Often, tax revenues shift from financing new investment to simply maintaining the old. Indirect and direct costs combine to create other balancing loops that will slow down, or even reverse, the property value growth loop detailed above.

Thus, what are the key take away messages from this commentary?

- First, in America, land use policies and decisions must always consider the impact on the total property value of a place.
- Second, citizens and policy makers in a place should recognize that they are players in a complex system, comprised of powerful reinforcing and balancing feedback loops that influence property values.
- Third, they should take steps to identify and routinely measure the key variables that are relevant to that system.
- Fourth, they should articulate, examine, share and validate the “mental models” that they have about how these variables are related to each other.
- Fifth, because the system is so complex, with such a variety of interests and long delays between causes and effects, policy makers should use simulation tools to communicate and practice policy interventions before actually putting them in place.

Section B: The Impact of Powerful Local Zoning Controls

Lukermann argues that the growth in local control over land use has weakened the opportunity for region wide or statewide planning to coordinate and complement – and therefore maximize the overall common good – land use and transportation across all local governments. She, and others like Lance Neckar and Carol Swensen, point to the power of local planning authorities to control residential density limits.

How do local zoning regulations that control the local density limit become so powerful? Why does the system work that way? What has to happen in a maturing place to increase density limits?

In the Key Points Summary of her report, “Driving Forces and Institutional Arrangements that Impact the Relationship Between Land Development Patterns and Transportation Investments (Part VI of the TRGS),” Lukermann offers the following directly relevant “Driving Forces” for sustaining the current bias toward low density housing limits with the metro area:

- Local government decision making that met priorities of current local residents for low density; enhanced role of neighborhoods and citizens in project approvals that maintain the current values attached to low density housing and segregation of land uses within neighborhoods.
- State reluctance to mandate statewide land use planning and thus insure complementary planning for local land use and transportation across all local

governments. Inability for regional goals for reinvestment in the core to extend beyond the jurisdiction of seven counties.

- Regional governance that relies primarily on its role for sewers and transportation to moderate outward sprawl ... weak impact on housing markets. Met Council senses the reluctance of state government to extend the regional powers over land use – looking to financial incentives rather than regulation to guide local land use decision-making and housing markets.
- Conventional subdivision regulations that reinforce low density. (Added May 10, 2002)
- Engineering standards for highway design that reinforce current low density and encourage additional VMT. (Added May 10, 2002)

The diagram on the following page suggests many of the key variables involved – and how they are interrelated – in the complex system that influences zoning controls over the density limits of a place.

Notice how many variables on the left side of the diagram were already introduced in the Keeping Score section. Many new variables are introduced on the right side of the diagram. In systems thinking terms, the core dynamics of the system are driven by a “Limits to Growth” system archetype. There is a reinforcing feedback loop (called the property value growth loop in the Keeping Score section), which strives to deliver exponential growth in the number of homes (and their owners) in a place. This growth, either positive or negative, is influenced by the variable, Relative Value of the Place. When the relative value is positive, the demand for residential development in the place increases, and home prices also increase. More homes are built, and the result is a higher property value of the whole place.

In the Keeping Score section of the report, we pointed to the Property Value of the Place as one useful measurement of the goodness of a place. We concluded that the only way to grow the property value of the place is to guide public investment so that place benefits are consistently greater than place costs.

the building and occupancy of new homes. As home prices increase due to accelerating demand, the property values of current owners also increase and are reflected in assessed values, too. This growth in property values – combined with a growing number of homeowners – generates exponential growth in a variable called Local Owner Constituency for Value Appreciation and/or Preservation. This constituency of local owners produces increasing pressure for local zoning controls to mitigate any land use that could slow down or reverse the growth rate of the value of their property or which might add pressure for more local services that would have to be paid for by higher taxes. In most places, especially in suburbs, the introduction of high-density and mixed use developments are believed to have a negative impact on the value of nearby properties and to increase demand for local services for newer residents. Thus, the local owner constituency establishes zoning controls to minimize or neutralize any pressure to build high density, mixed use projects.

The other factor in the diagram influencing local density limits is the property value growth rate. As long as the property value growth rate is positive, then property owners will exert pressure for a lower density limit. Why? Because the density limit seems to produce an apparent benefit in the minds of potential buyers, and because lower limits will eventually produce an apparent shortage of homes, thus sustaining or increasing property values. However, if the property value growth rate stalls or goes negative, then the place has reached the point where the costs of the place are beginning to overcome the benefits of the place, and a rapid downward cycle of declining property values can ensue. To offset this, owners are willing to open up the place for more residents who will help share the burden of increasing costs of the place, and thus avoid property tax increases.

As homes in a place age, along with public infrastructure, direct maintenance costs increase. Indirect costs also increase with the maturity of a place, and parts of these costs are often shifted to others outside the locality, affecting non-local interests who seek to impose more region-wide controls to mitigate the impact of those external costs. They too become a constituency for increasing density limits as a tool for increasing or maintaining the tax paying population of the place.

What then, have we learned from this systems thinking perspective?

- First, existing low density limits are used by land developers and homeowners to sustain a relative scarcity of available space for residential development, thus stimulating higher home prices.
- Second, as available space is consumed with homes – based on lower density limits – the property owner constituency grows in power to manage the growth in demand for public services of the place.
- Third, as places grow older, or if public investment does not yield benefits in excess of costs of the place, then property values will flatten or decline. At this point, local owners will allow an increase in density limits in order to attract more tax paying residents, and thereby share the burden of higher relative costs.

Section C: What is in Store for the Future?

For most of the residents of the Twin Cities metropolitan area, the history of the region is positive, and the near future looks bright, too. They have been part of a good thing. Still, some – especially those who live near the city centers – are worried about demographic and economic patterns that seem to be moving in the wrong direction. They see:

- Pressure to increase local taxes to cover costs that are rising faster than benefits.
- Threat of cutbacks of municipal services. Fees for things that used to be free.
- Property values growing faster in outlying suburbs than in their neighborhoods.
- Traffic congestion overflowing into neighborhoods.
- Job growth faster in the suburbs than in the center cities.
- Attractive travel destinations being built away from the center cities.
- And other perceived threats to their economic security.

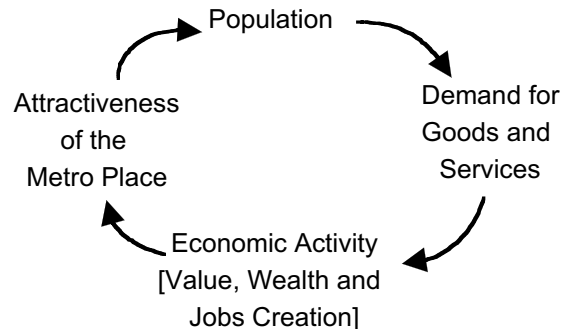
On the other hand, many more residents see:

- The benefits of home ownership in newer suburbs.
- The opportunity to purchase more living space.
- Higher incomes, allowing for the satisfaction of greater demand for goods and services.
- Jobs in successful companies that are growing.
- Rising expectations in the standard of living.
- The opportunity for children to move out of the home earlier than before.
- And other opportunities that emerge from personal and location-related wealth.

What are the fundamental, systemic relationships that are causing these patterns of behavior to occur within the Twin Cities area?

The Twin Cities Engine of Growth

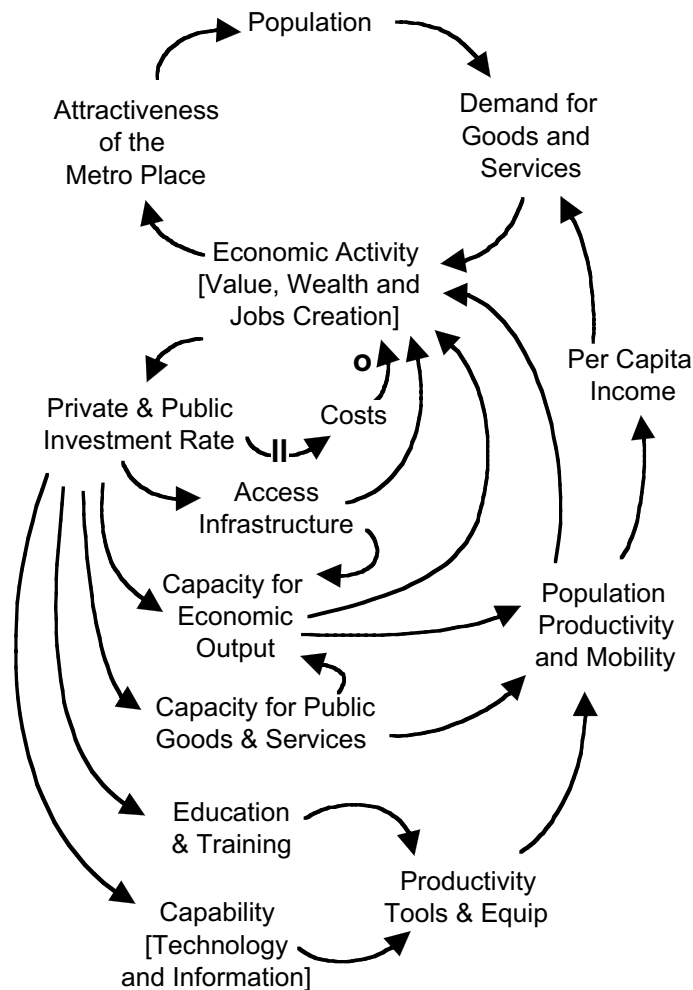
At the core is the reinforcing feedback loop representing John Adam’s tenet that “population follows economic activity” in “circular causality.” This is illustrated in the diagram below.



As long as economic activity grows, then the attractiveness of the place also grows and stimulates more population that will, in turn, generate demand that accelerates economic activity. If, however, as is the some places, economic activity declines over a long period, then the place becomes less attractive, and a vicious cycle of decline will set in and be very difficult to halt.

Creating and Sustaining a “Virtuous Cycle” of Regional Growth

How do public policy makers and government officials respond to the need to sustain positive growth in the variables that make their place more attractive than its competitors? As described in the Keeping Score section, they make public investments and attempt to influence private investment in their place. They use their taxing and local land use policies to do so. Their underlying purpose is to create an environment where the people who live or work in the place can become more productive, and thereby have a higher per capita income and a higher quality of life. The system diagram below shows these relationships.



And, as noted in an earlier section, the challenge for both public and private managers is to invest such that the benefits of the investments – productivity and mobility – stay ahead of the costs that arise from those investments.

Lukermann emphasized, in Section B, the impact that the exogenous supply of public-serviced land has on stimulating and sustaining patterns of low-density development. What she refers to,

as “an expanding supply of public serviced land” is included in the variable “Capacity for Public Goods and Services” in the diagram on the previous page.

The Beginning of a “Balanced Scorecard” for the Twin Cities

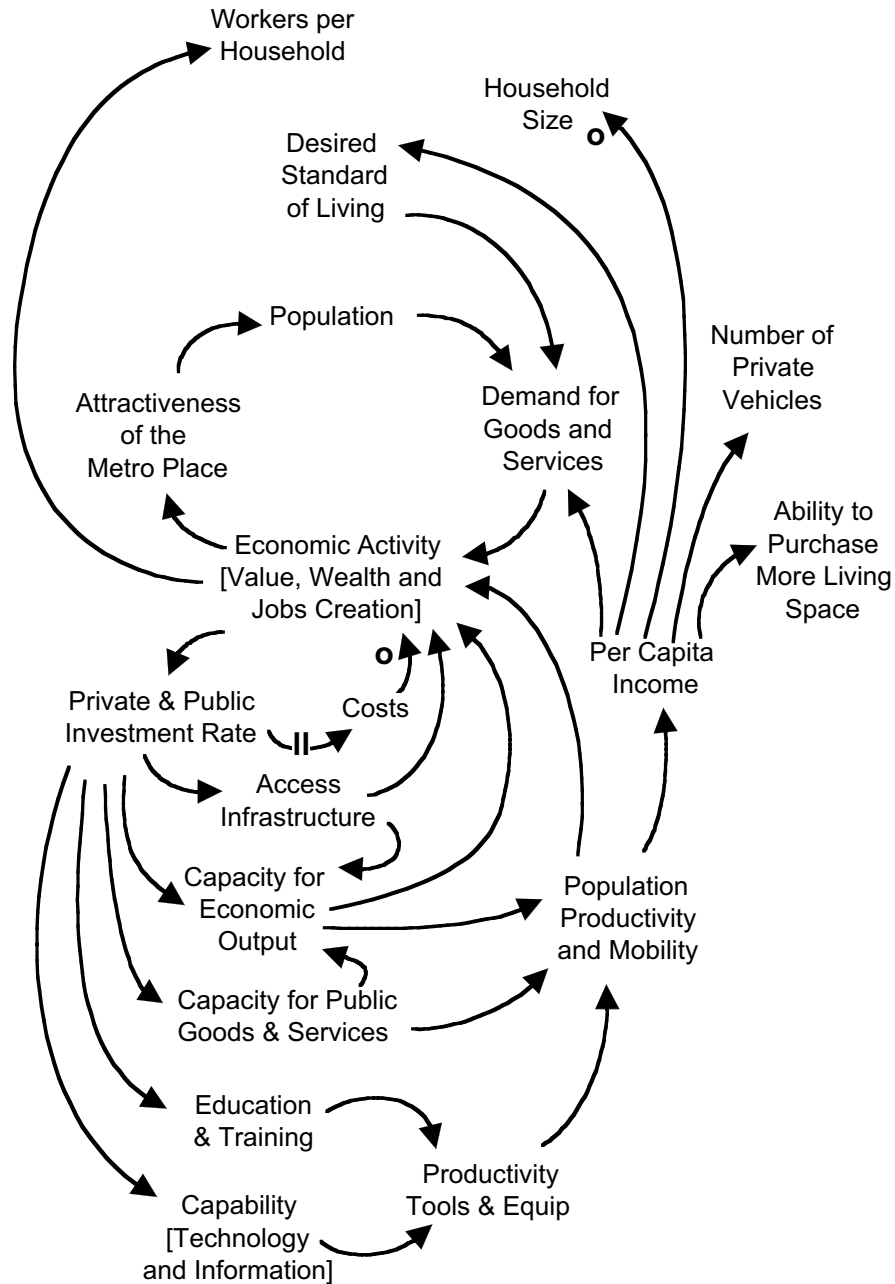
In the Keeping Score section, we suggest that the change in the total Property Value of the Place, expressed in dollars, is a useful and reasonable measure of the return on public investment. In the diagram on the previous page, property value would be among the variables that measure the level of economic activity, along with jobs and other wealth indicators. But, clearly there are other performance indicators that should be monitored regularly to measure the direction and pace of change. In fact, all of the variables on the systems diagram should be routinely tracked. Also, knowing the ratio of one variable to another is very important. For example, let’s use the ratio of the growth rate of per capita income to the growth rate of costs arising from public and private investments. If the ratio is positive, then wealth is being created. If the ratio is negative, then wealth and value of the place is declining.

Affluence Effects: The Consequences of Increasing Per Capita Income

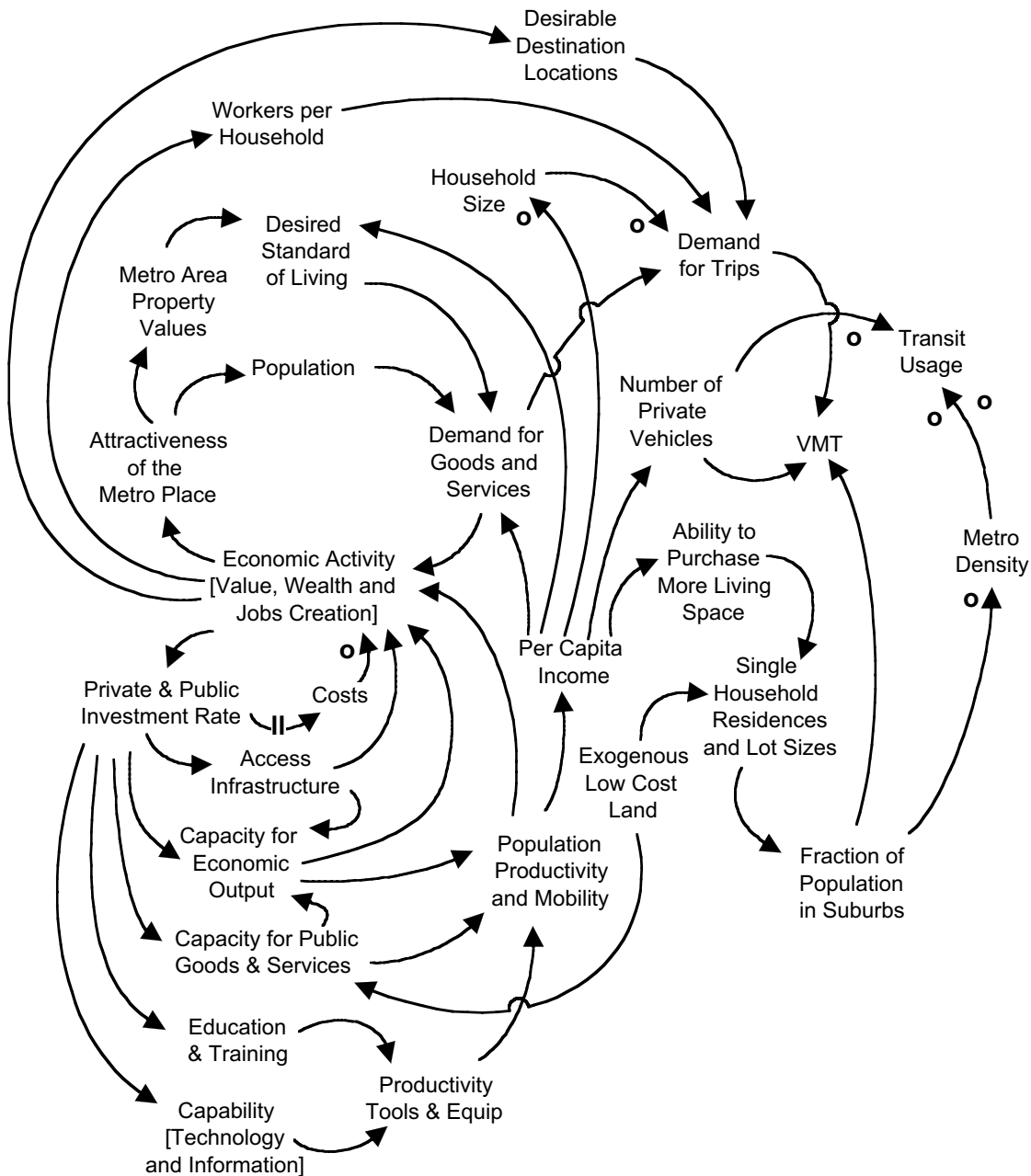
Data from the TRGS researchers and others in their fields suggests that around the world, an increase in a place’s per capita income has significant impact on land use and transportation dynamics. Specifically, an increase in the average per capita income (a useful measure of affluence) directly leads to (causes) the following changes:

- An increase in the demand for goods and services
- An increase in the desired standard of living
- A decrease in household size
- An increase in the number of private vehicles (fraction of auto owners)
- An increase in the ability to purchase more living space.

These influences are shown in the diagram on the next page.



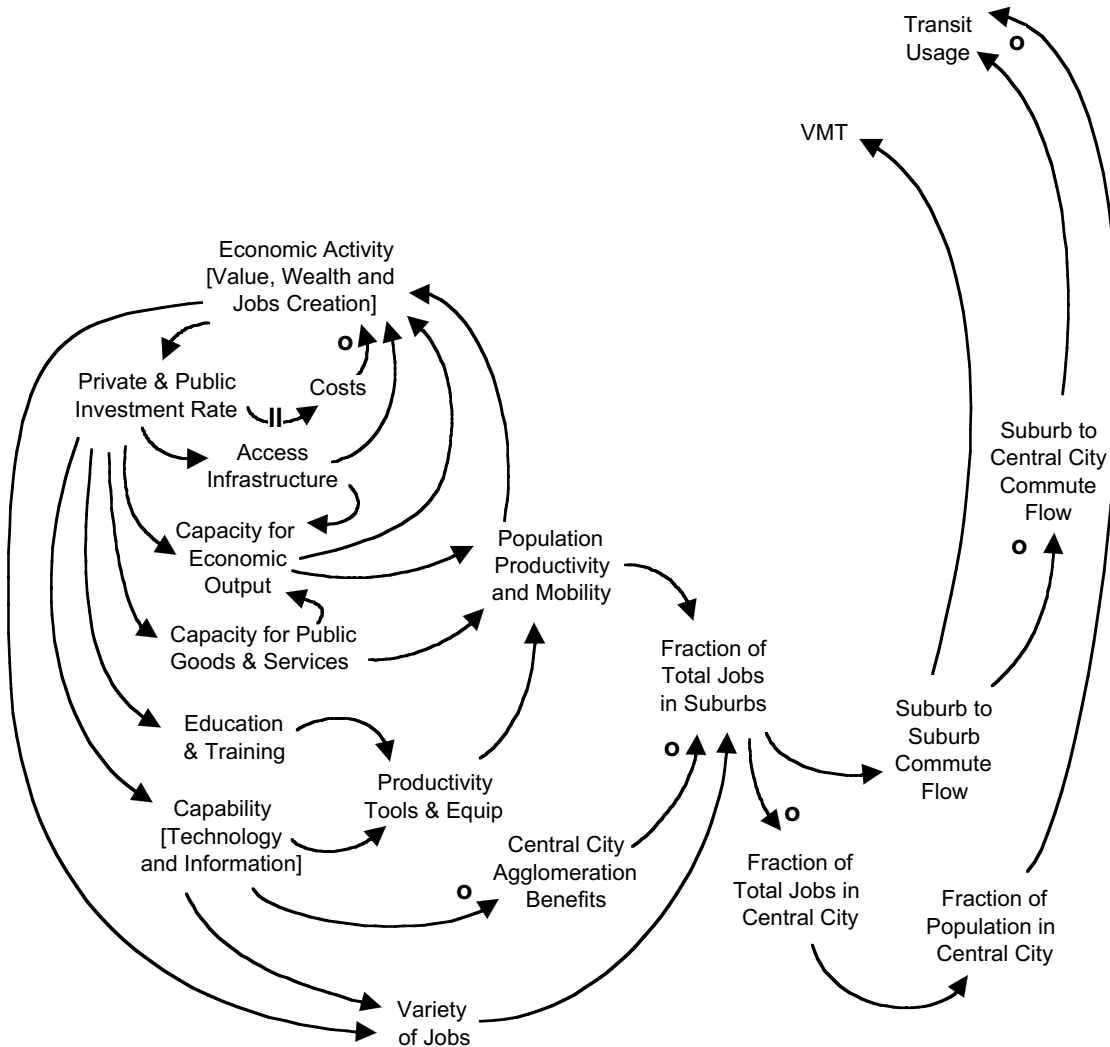
Furthermore, a related dynamic is that an increasing level of value, wealth, and jobs creation in a place is associated with an increase in the number of commuting workers per household. Thus, our system diagram is modified to include those variables. These additional variables in the system have effects, too. They are shown in the expanded diagram on the next page where they help to explain the decentralization of the population, represented by the variable, Fraction of Population in Suburbs.



The ability of people to purchase more living space increases the demand for more single-family residences and often on larger lot sizes. Because of a variety of incentives, most new single-family homes are available in the suburbs in conventionally designed subdivisions. Lukermann points explicitly to the availability of exogenous low cost land as a strong enabling factor for patterns of decentralization in the larger Metropolitan Twin Cities region (i.e., well beyond the MUSA limits). As shown in the diagram, it has two powerful effects. First, low cost land is available as sites for public goods and services like transportation infrastructure, government employment centers, universities or colleges, and other public facilities. Second, and simultaneously, it is available for development of new single household residences.

Suburban residents must rely on the car to travel longer commute distances, leading to more vehicle miles traveled in the area. And as the fraction of population increases, the overall density in the metro area declines. Lower metro density and more VMT result in less transit use. There are other factors increasing VMT and reducing the demand for transit. The increase in auto ownership due to increases in per capita income directly leads to more VMT. Plus, the demand for trips increases for a variety of reasons, as shown on the diagram.

There are also strong causal structures leading to the decentralization of jobs. Examine the new variables in the diagram below.



The fraction of total jobs in the suburbs has increased significantly over the past few decades. In the diagram above, three key causes are identified. First, the increase in workforce capability due to improvements in technology and information has reduced workplace agglomeration (workforce scale) benefits. Automation has reduced the number of direct labor and clerical employees needed in a single large workplace. Second, Education and Training, combined with Technology, have increased the population's aggregate productivity and mobility. Less centralized capital equipment is needed, and thus jobs can be spread out into more places. Third,

the growing pace and level of economic activity has led to a wider variety of jobs – especially in the service sector that must be near a decentralized population.

This impact of these variables on the transportation network is to increase the suburb-to-suburb commuter flow and to reduce the fraction of jobs in the central city, and, correspondingly, the fraction of population residing in the central city. As illustrated in the diagram, the effects of these dynamics include an increase in VMT and a decrease in demand for transit.

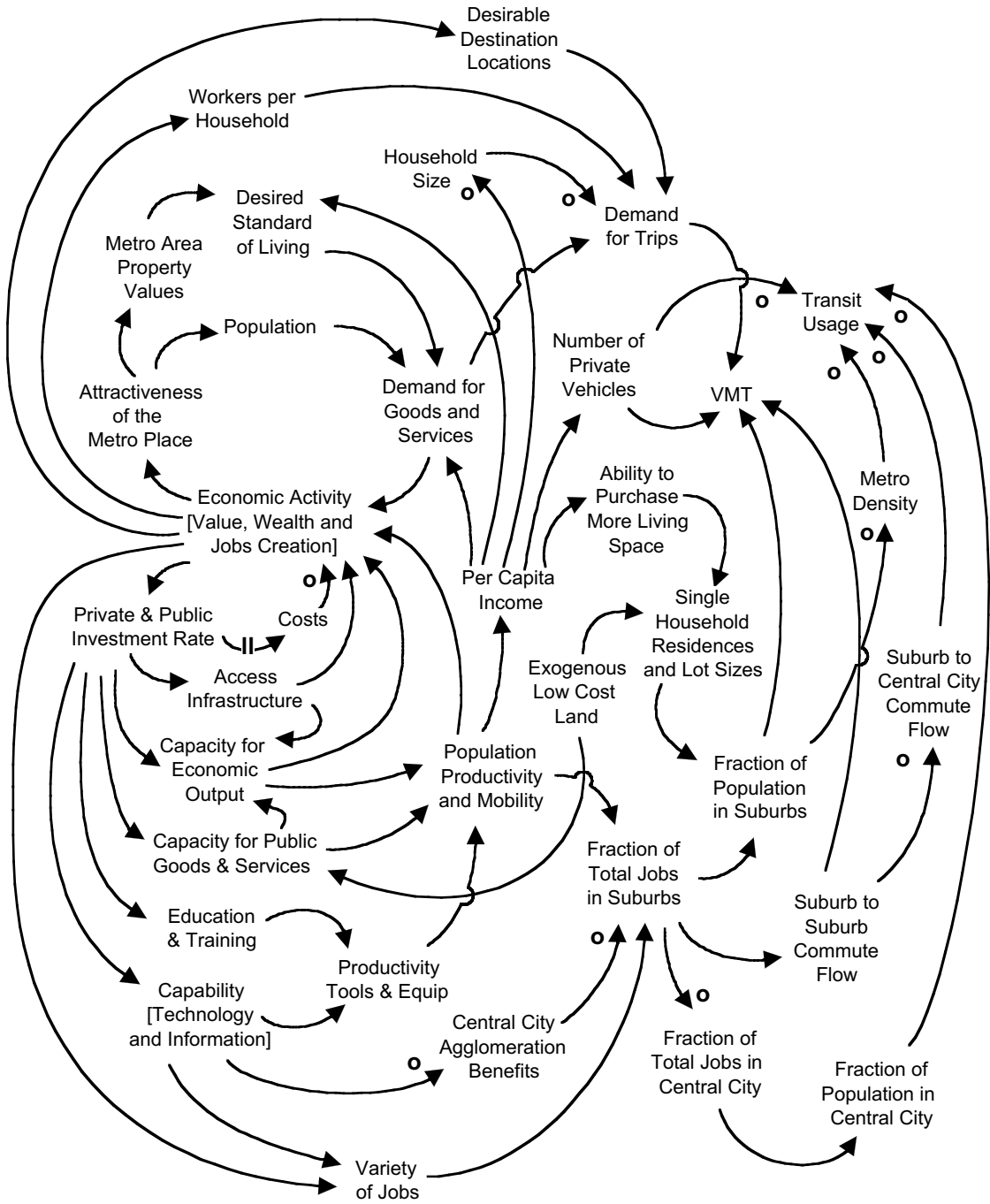
Final Observations

The diagram on the next page includes all of the variables selected for this final commentary on Lukermann's set of variables. What are some reasonable conclusions that can be taken from this hypothesis of how the variables interact with each other?

- The continued ability of public and private investment to produce value, wealth, and jobs in the area is essential for sustained competitive attractiveness.
- Regional growth in population and per capita affluence is a good thing for most people who live and work in Minnesota.
- But growing affluence creates effects that result in the decentralization of the population into lower density suburbs and in higher demand for VMT in private cars. Reports show that there are external costs associated with these effects, and that they are not borne equitably everywhere.
- The availability of exogenous low cost land that is within a reasonable travel distance from desirable locations of the Twin Cities metro area will stimulate the continued decentralization of jobs and population. Thus, lacking stringent centralized controls that limit the freedom of people to pursue their economic interests, the decentralization patterns will continue.
- Commute and freight flows will increase from suburb-to-suburb and around non-Metro regional centers faster than from suburbs to the central cities.
- The affluence effects, along with decentralization effects, all reduce the demand for transit.

In her most recent updates to her work (the May 10, 2002 document), Lukermann notes that her work identifying the forces and factors of land development and transportation patterns does not identify all related consequences. She asks: “[How could we] address the impact on the system by considering who pays and who benefits from public and private investments to keep the economy going? How does the system (as described in the final diagram) provide for the broad public health, safety and welfare for those least well off in society? Or, do you assert that this does not enter into the mental models of local governments? The decentralization of jobs together with spreading out of homes and public services is not really a problem if more people can access the good life and [the ultimate costs and benefits of private and public investments is directly and equitably linked to a place.]”

A Big Picture View of the Metro Regional Growth System



*John Adams, et al: Urbanization of the Minnesota Countryside: Population Change and Low-Density Development Near Minnesota's Regional Centers, 1970-2000 (TRG #10, 2003)**

The settlement patterns and transportation dynamics that led to the emergence of the Twin Cities as the dominant place in Minnesota are working in a similar way in the state's significant regional centers, outside of the metro area. Just as near the Twin Cities, the "urbanization of the countryside" is occurring and being driven by continued industrialization, communication, technology, and demographic-related factors.

Population growth and its associated economic activity around many of the state's regional centers are two factors creating attractive places for in-migration by former residents in neighboring towns, by former metro area residents, and by immigrants from outside the state. As the regional centers nearer to the Twin Cities continue to grow, they will become relatively more attractive destinations for many Twin Cities workers and shoppers, and that shift in economic activity will reinforce the decline of the central cities and inner suburbs of the metro area.

Throughout the course of Minnesota's history, accessibility has been a powerful factor influencing and enabling growth of population and economic activity of a place. The populations in successfully growing places can create strong arguments to legislators and government executives for investments in travel infrastructure to create even greater accessibility to and within their places.

In the CTS study, "Population Change and Low-Density Development Near Minnesota's Regional Centers, 1970-2000," Adams his co-authors ask these two key questions:

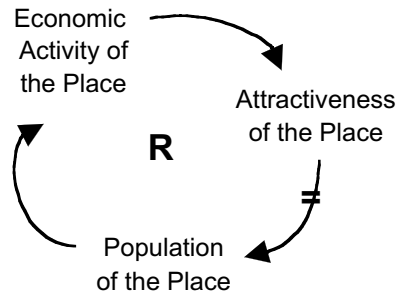
1. Why are some regional centers growing and others declining?
2. Why are the MCDs that are closer-in to regional centers growing faster than those farther-away from the regional centers?

These remarks attempt to answer these questions from a systems thinking perspective.

Adams introduces the term "cumulative and circular causation" to help explain the urbanization of the countryside. At its core is the simple, but profound reinforcing feedback loop shown on the next page. It is this dynamic feedback structure that produces either exponential positive growth or leads to the economic decline of a place. It is particularly important to note that this reinforcing loop *does not* promote any stability. In fact, each of the three variables in the loop are, at any point in time, either becoming more favorable or are becoming less favorable to the place.

* Ed. Note: For other TRGS reports authored by Adams *et al.*, see the Appendix.

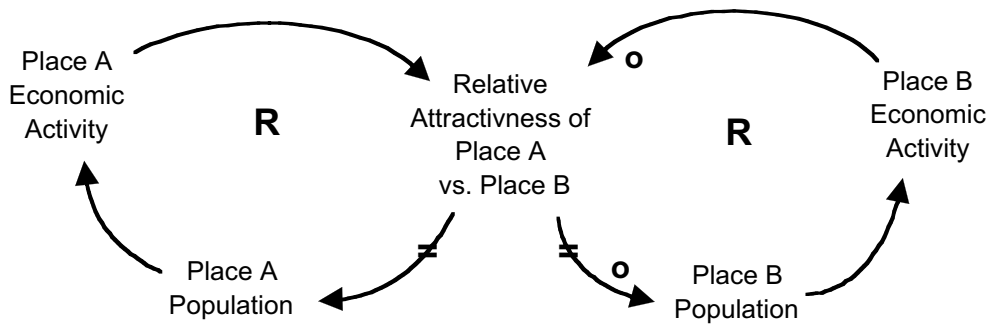
Population Follows Economic Activity



The diagram introduces the variable, “Attractiveness of the Place.” Simply put, people come to a place because it offers net benefits that are sufficiently attractive to move them to act. The primary source of attractiveness is, we believe, the economic vitality of the place. Thus, as Adams asserts, “population follows economic activity.”

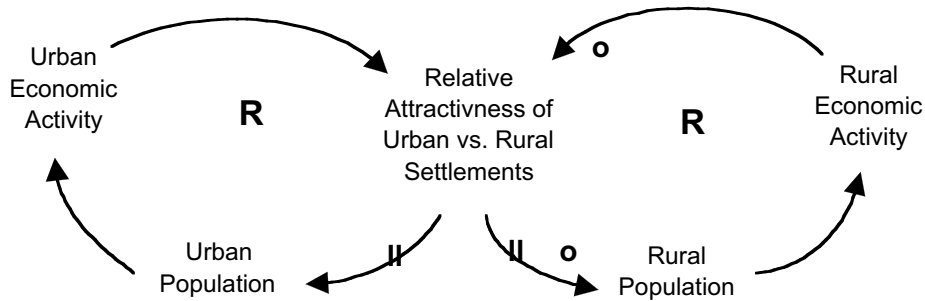
Places Compete for Population and Economic Vitality

But a place does not exist alone. It is part of a larger system wherein it must compete to become more attractive to sustain its positive growth. In the diagram below, we introduce the concept of Relative Attractiveness of one place versus another place. The systemic structure is two reinforcing feedback loops that share a common variable. This type of structure is so common in complex natural, social, and economic systems that it is known as the “success to the successful archetype.”



If, for almost any reason, Place A gains a competitive advantage in economic activity over Place B, then Place A becomes more attractive, and after a delay (symbolized by the hash marks on the causal links between relative attractiveness and population), it will stimulate a migration from Place B to Place A. As Place B loses population, its economic activity will decline, making it even less relatively attractive than Place A. The population shift will accelerate. As shown on the next page, this structure is at the core of the shift of Minnesota’s population from the rural countryside to urban settlements.

Competition Between Places



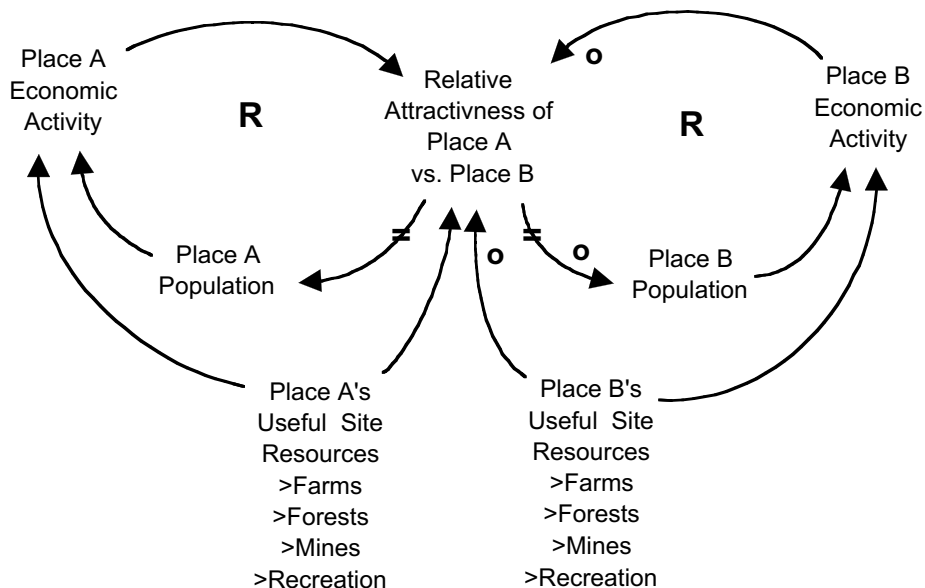
Adams remarks on page 175 of his report, "Population follows economic activity. For almost half a century, population has shifted away from extensive resource-based economic activity and toward urban-based jobs."

But, as the following diagrams and remarks illustrate, Adams suggests that there are other variables involved that affect the relative attractiveness of one Regional Center place versus another.

Attractive and Useful Resources of a Place

In the beginning, before urban settlements, the principal sources of a place's potential economic activity were the natural resources nearby. This situation is illustrated in the diagram below.

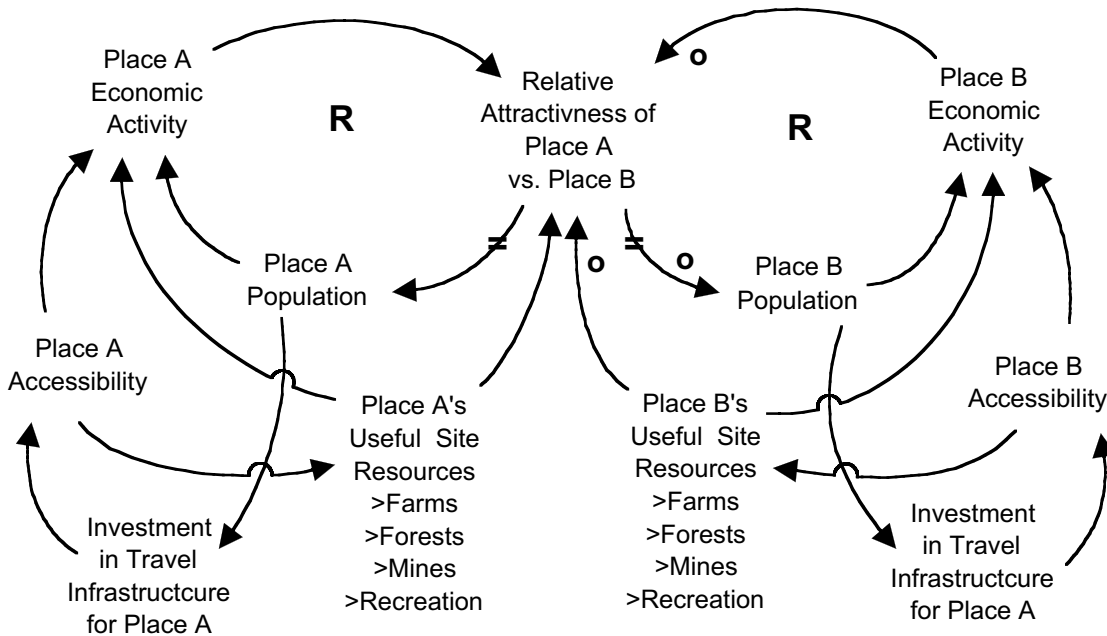
The useful site resources of a place influenced the relative attractiveness both directly and indirectly. First, there is its immediate appeal that stimulates population growth. Secondly, useful site resources, when exploited, generate more economic activity in a place.



In his study, Adams suggests reasons why regions grow at different rates. He says, “The slow-growth regions are disadvantaged by location: they are remote from population centers. Additionally, they are disadvantaged by their site resources: a weak farm economy, weakness in forestry and mining, and limited in the recreational opportunities they can offer compared with the offerings of other places.”

Investments to Increase Accessibility

As noted in the diagram below, a place’s investment in accessibility is an important competitive factor. Accessibility allows the more rapid and productive use of a place’s resources.



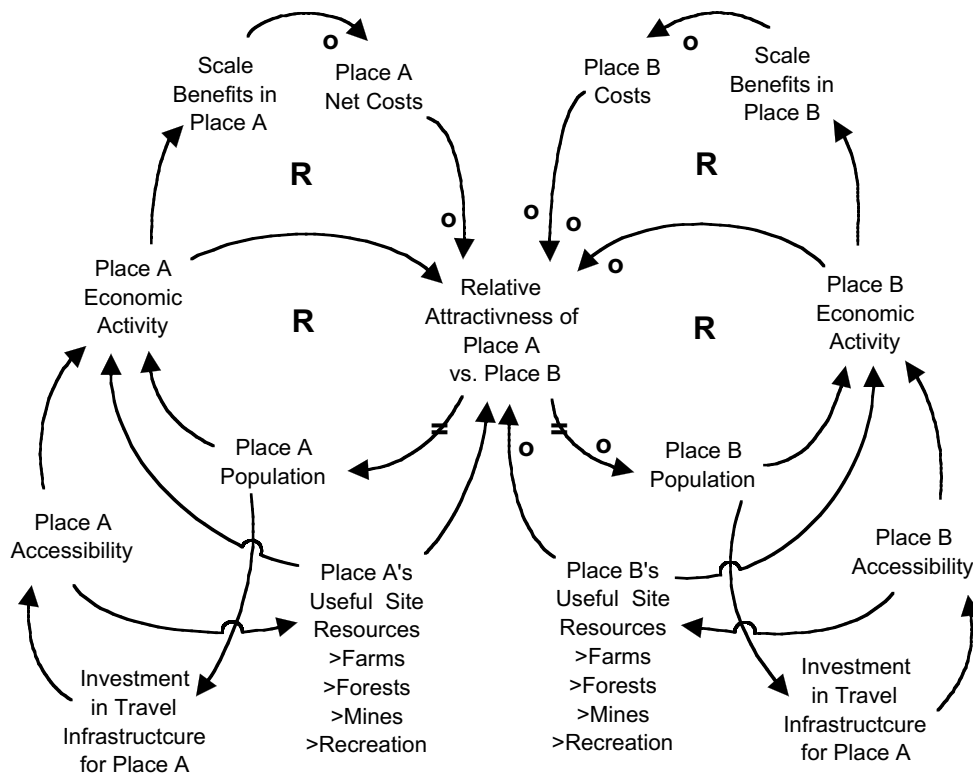
Superior accessibility to the resources of a place makes those resources more useful, and therefore makes the place more attractive. Thus, investments to increase accessibility to a place can offer a “leverage point” to amplify the growth and vitality of a place, and thereby start a virtuous cycle of success there and a corresponding vicious cycle of decline to a competitive place. In the report’s Executive Summary, Adams writes, “Modern economic activity depends on accessibility, which is the ability to move people, products, capital and information among places of production, investment and consumption. Other things being equal, places endowed with superior accessibility to other places enjoy advantages over those places in economic development prospects.”

The Scale Benefits of a Place

In addition to the accessibility to its useful resources, another competitive “success to the successful” variable is the amount of what Adams calls “scale efficiencies.” These are the perceived benefits that can arise from bigness.

To this point, Adams (178) states, “The places that have experienced moderate or fast growth enjoy advantages of relative location closer to prosperous and growing population centers and to site resources and can capitalize on scale efficiencies that are unavailable to smaller and declining places. There are cumulative and circular advantages that accompany growth and that promote further growth. Once underway, and for a variety of reasons, advantages flow to places that grow faster than their competitors. This process of *cumulative and circular causation* works in reverse as well for when a place stops growing or goes into decline, the negative economic and demographic effects of stagnation feed off one another and promote further decline.”

The systems structures that generate the dynamic behavior Adams describes are illustrated in the diagram below.



Future Economic Activity

The relative attractiveness of a place also depends on a perception of the pace of future economic activity. Which location is likely to experience the most rapid pace of economic growth? This is a key question for those considering relocation options, whether they are potential residents or businesses. In the report, Adams make note of the following competitive advantages of economic growth – and the expectation for it to continue improving.

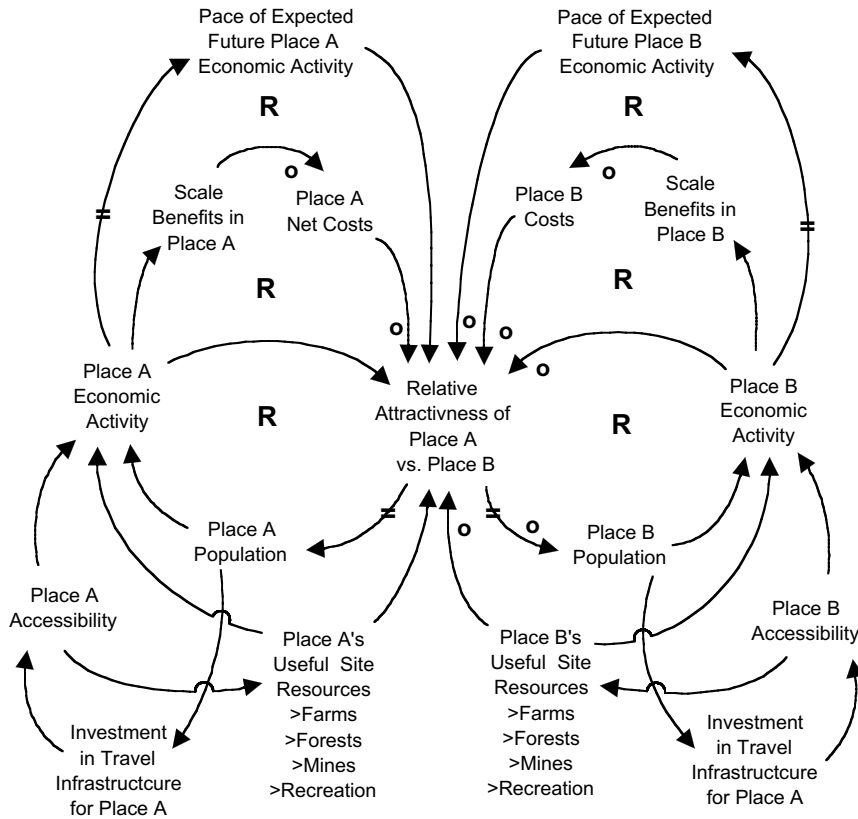
“Once a place gained an edge over the others, it kept going while others fell behind and some disappeared. There are many reasons. Costs to producers are lower when volume buying is possible. In growing places there is a better matching with workers and jobs. When places are growing, it is easy for an employee to leave an unsatisfactory job and find another, so all are

better off – the worker, the former employee, and the new employer. Employers are better off when poor or dissatisfied workers leave, and it is easier for an employer to fire a poor worker if it is obvious that worker can find other employment. Skills and attitudes can improve in a fast-changing growth situation, and employers may try harder to keep good employees knowing that they can and will leave for better opportunities elsewhere. In growing places, new competitors arise, so all must sharpen up, and those that do will do better. Businesses feel free to invest in new plant and equipment when growth prospects are good, and new plant and equipment can improve productivity and profitability.

“But the opposite occurs when population and economy of a place slow or go into reverse. The average cost of each transaction rises in the drug store, the county clerk’s office, the hardware, and the doctor’s office. Investments are postponed. Revenues drop faster than costs. The more talented, educated, and ambitious risk takers leave, and those that are left behind face a harder time. As costs rise, ability to pay declines, and the cumulative and circular process goes negative.”

The effects of the pace of expected future economic activity are shown in the diagram on the next page.

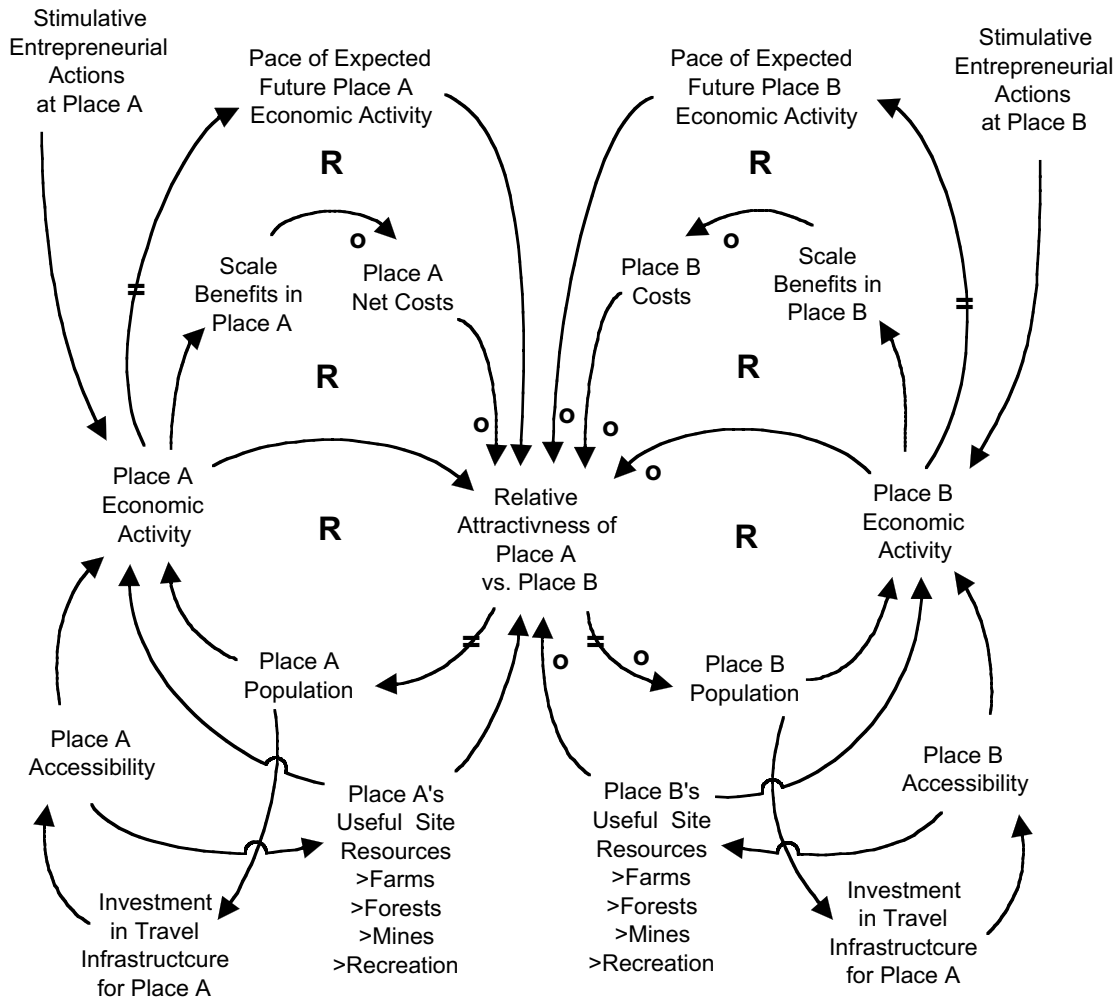
The Reinforcing Power of Expected Future Economic Activity



Adams also remarks, “New businesses in growing areas such as the suburbs of the Twin Cities metro area or in growing regional centers have special advantages because their revenues in the short run can rise faster than costs in both good-producing industries and in services. As the map of economic opportunity slowly is transformed, residents relocate, and newcomers to the state – immigrants and domestic migrants – settle in places of promise and opportunity. In the process, human capital relocates from places where it is less productive to places where it is more productive, magnifying the advantages of the growing places and making it even harder for places left behind.”

The Impact of Stimulative Entrepreneurial Actions

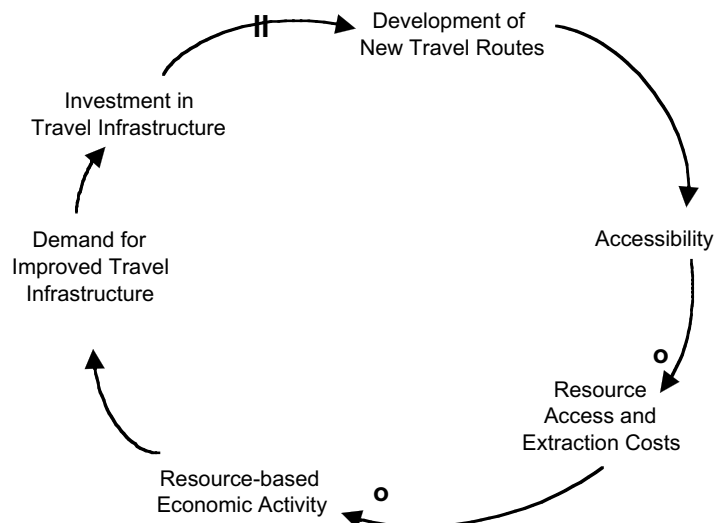
In the Executive Summary of the report, Adams says, “There is some arbitrariness at the outset as to the places that are destined to emerge as economic leaders. Successful entrepreneurship is a key ingredient in determining which ones succeed and which fall behind.” This impact is shown in the diagram on the next page and completes this systems thinking perspective of the Regional Growth System.



The Land Use and Transportation System in Minnesota History

The following remarks, based on Adams' report, offers a systems thinking perspective on the land use and transportation history of Minnesota from the early days of settlement by European-Americans. With each additional CLD presented, more variables are added to the story. Following each CLD are quotes extracted from Adams' report, which augment the diagram.

Accessibility Reinforces Resource-Based Economic Activity



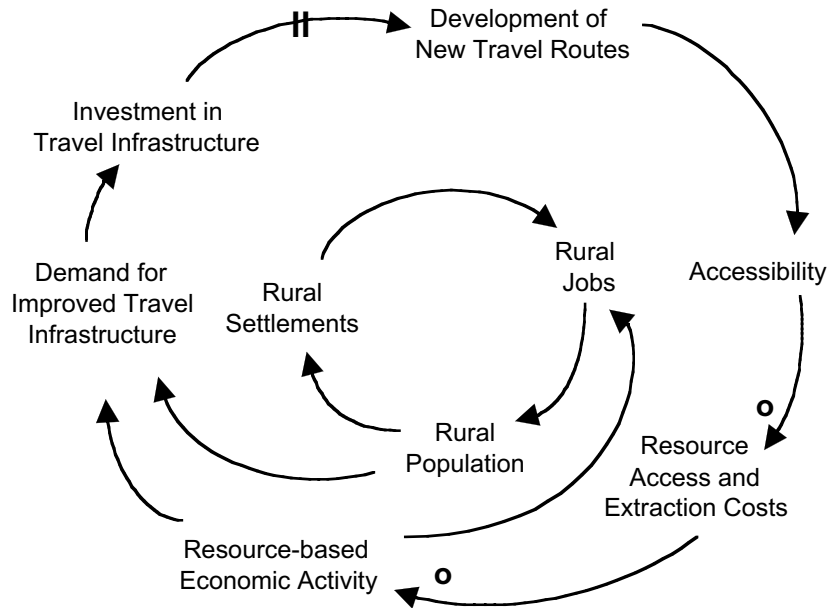
Early European immigrants, who were attracted by resource extraction industries (trapping, forestry, mining, and agriculture), invested in new travel routes to improve accessibility.

In his report, Adams states, “Economic activity depends on accessibility, and accessibility facilitates economic development. From earliest days of Minnesota, exploration by European-Americans, there has been a close and reciprocal relationship between transportation and development. Early transportation routes (rivers, lakes, and trails) were developed to exploit the resources of the natural environment (furs, timber, and agriculture) then used to pursue economic activity.”

The Emergence of Rural Settlements

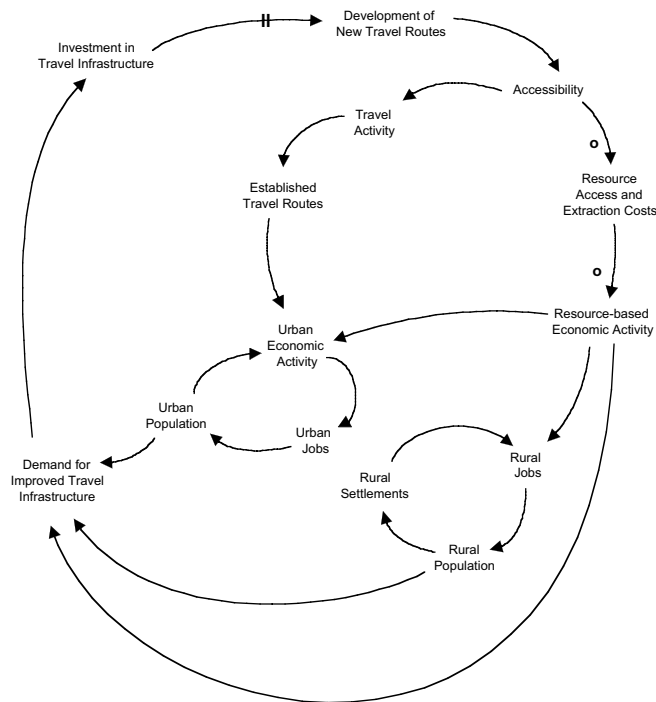
Increased resource-based economic activity stimulated growth in self-sustaining rural settlements nearby. The growth in rural population in and around the rural settlements generated demand for even more improved travel infrastructure, including railroads, canals, and roads.

The emergence of these rural settlements is shown in the diagram on the next page. The settlements were the direct result of the resource-based economic activity near the settlement.



Emergence of “Urban” Settlements

Concurrent with the rapid growth of resource-based industries, the increased travel activity that followed from increased accessibility to resource industry areas resulted in established travel routes. Towns emerged along and at the intersections of these established travel routes to serve as “central places.” These locations became useful “service centers” to the area, offering more specialized activities, i.e., meat packing houses, banks, shipping centers, etc. Population growth in these more “urban” central places accelerated the demand for improved travel infrastructure capacity.



expanded much faster than resource-based extractive employment has declined. One result is that Minnesota's settlement patterns and employment profiles across Minnesota have become almost entirely of an urban type."

Adams also says, "In the decades that followed World War II, Minnesota's agricultural, mining, and forest areas have undergone a profound transformation that includes the steady consolidation of farms, industrialization of agriculture, and a convergence of lifestyles of what we have traditionally thought of as farm families and the families and other households living in cities and towns."

Elsewhere, he says, "The problem is that the resource-based economies and ways of day-to-day life of the 1940s have been overshadowed and largely supplanted by new forms of economic activity and in many cases have almost entirely disappeared from Minnesota's agricultural and mining areas outside the greater Twin Cities area."

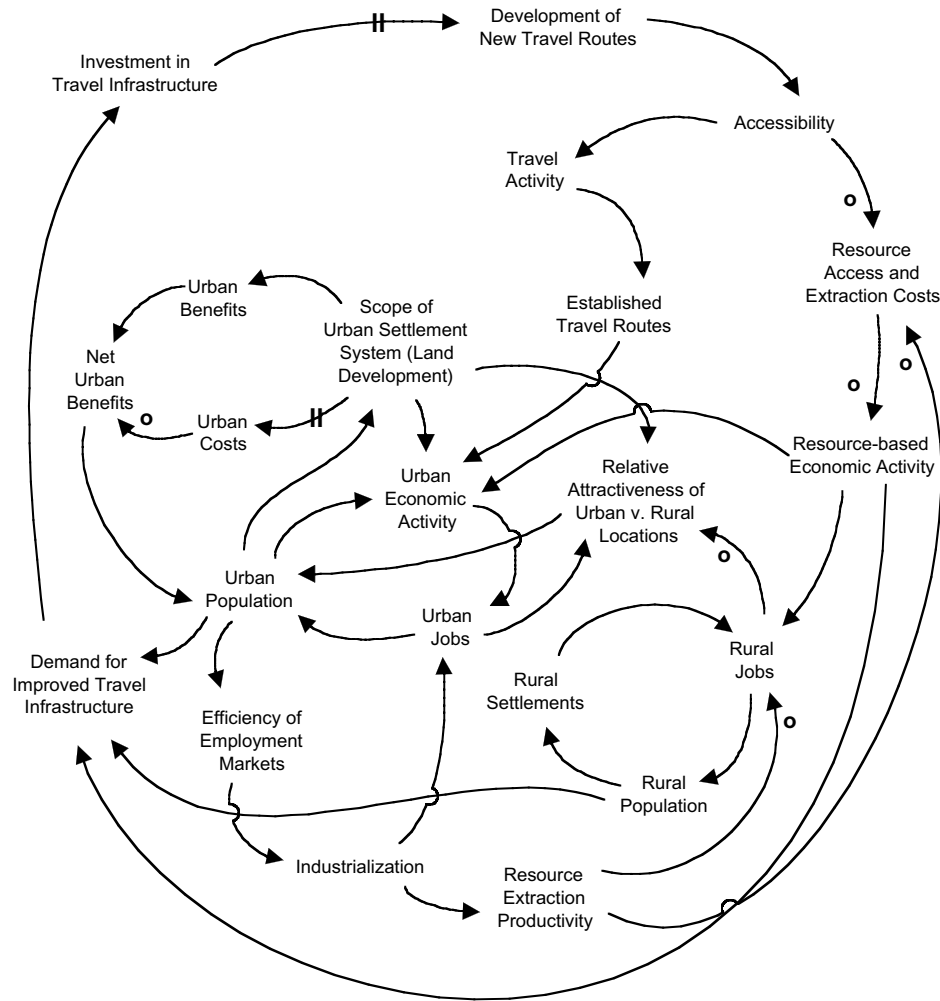
The Twin Cities Offer Highly Efficient Employment Markets

Rapid growth in urban areas, especially in the Twin Cities, was driven by industrialization and its attendant transportation, commercial services, education, and residential industries. The rapid growth of population within the urban area, coupled with expanding economic activity of the region, led to more efficient employment markets. Higher productivity and lower costs stimulated even more economic growth. The growing scope of urban settlement, including transportation accessibility, in the Twin Cities yielded attractive urban benefits at a pace much faster than the emergence of apparent costs of urbanization.

The attractiveness of working in the Twin Cities led to the growth of nearby surrounding suburbs accessible on established travel routes into and out of the cities.

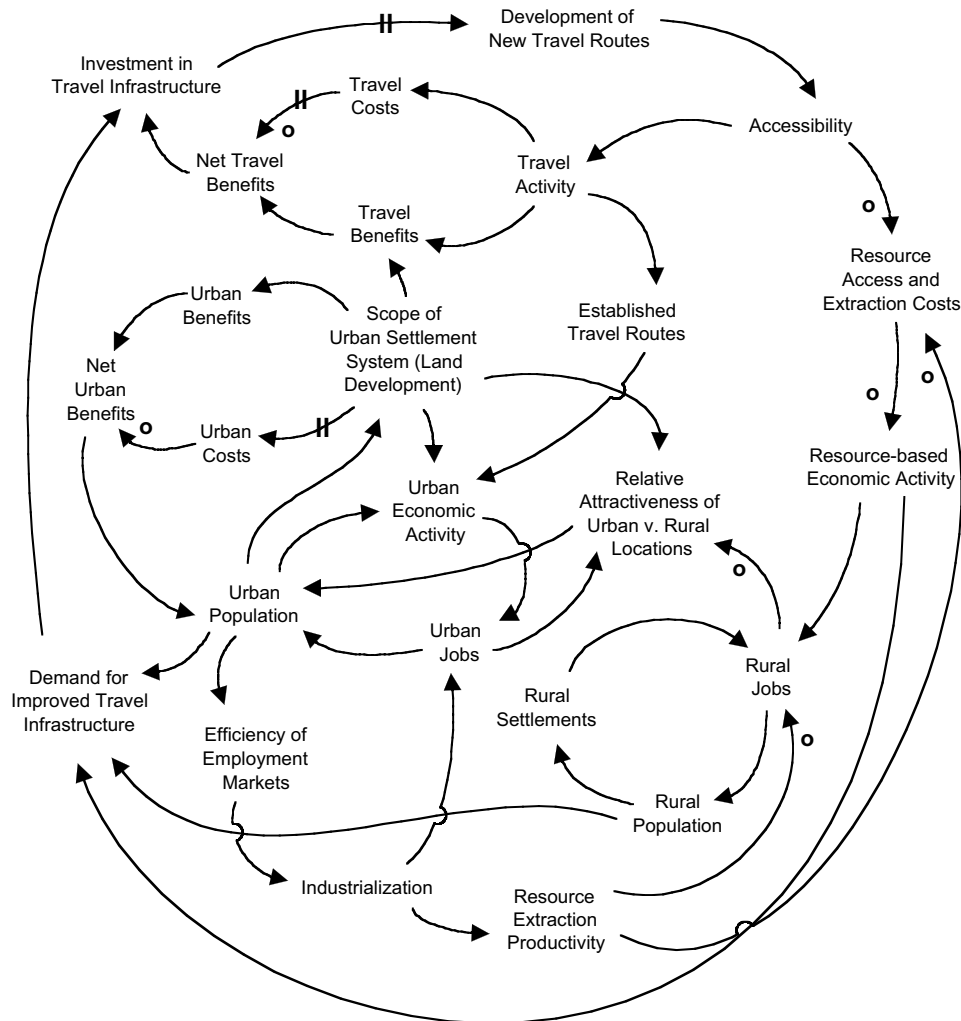
"New businesses in growing areas such as the suburbs of the Twin Cities metro area or in growing regional centers have special advantages, because their revenues in the short run can rise faster than costs in both good-producing industries and in services. As the map of economic opportunity slowly is transformed, residents relocate, and newcomers to the state – immigrants and domestic migrants – settle in places of promise and opportunity. In the process, human capital relocates from places where it is less productive to places where it is more productive, magnifying the advantages of the growing places and making it even harder for places left behind."

In his report, on page 175, Adams summarized, "Population follows economic activity. For almost half a century population has shifted away from extensive resource-based economic activity and toward urban-based jobs."



Factors Influencing Outward Development

The expanding availability of low cost land and water for residential, commercial, and infrastructure development enabled the Twin Cities metro population to grow into lower density communities. The land development patterns created more and more highly desirable travel destinations outside of the central city areas. Further, governmental policy has created subsidies that encourage outward development.



As these structural changes (demographic changes since WWII) have occurred, there has been a corresponding reshaping of the state's settlement patterns and intensification of flows on the state's principal highways.

Conclusions from the Report on Population Change and Low-Density Development Near Minnesota's Regional Centers, 1970-2000

The report asked these questions: "Are the patterns of low-density development that have sprawled beyond the built-up Twin Cities area during recent years being duplicated near Minnesota's regional trade centers? And if so, are traffic volumes on trunk highways in the vicinity of the centers rising in response to recent patterns of development in and around those centers?"

Adams concludes: “Like the greater Twin Cities area ... the smaller cities and towns in Minnesota have been doing the same whether or not their populations are increasing. The towns, villages, and hamlets within highway commuting ranges of regional centers seem to be becoming bedroom suburbs, and depending on the incomes, brought hope from those jobs that there can be renewed vitality on Main Street. Meanwhile, in the unincorporated townships surrounding the regional centers, new houses are going up along major and minor highways and country roads to meet the want for country living so households are within a convenient automobile ride to work, school, Main Street, and Wal-Mart.

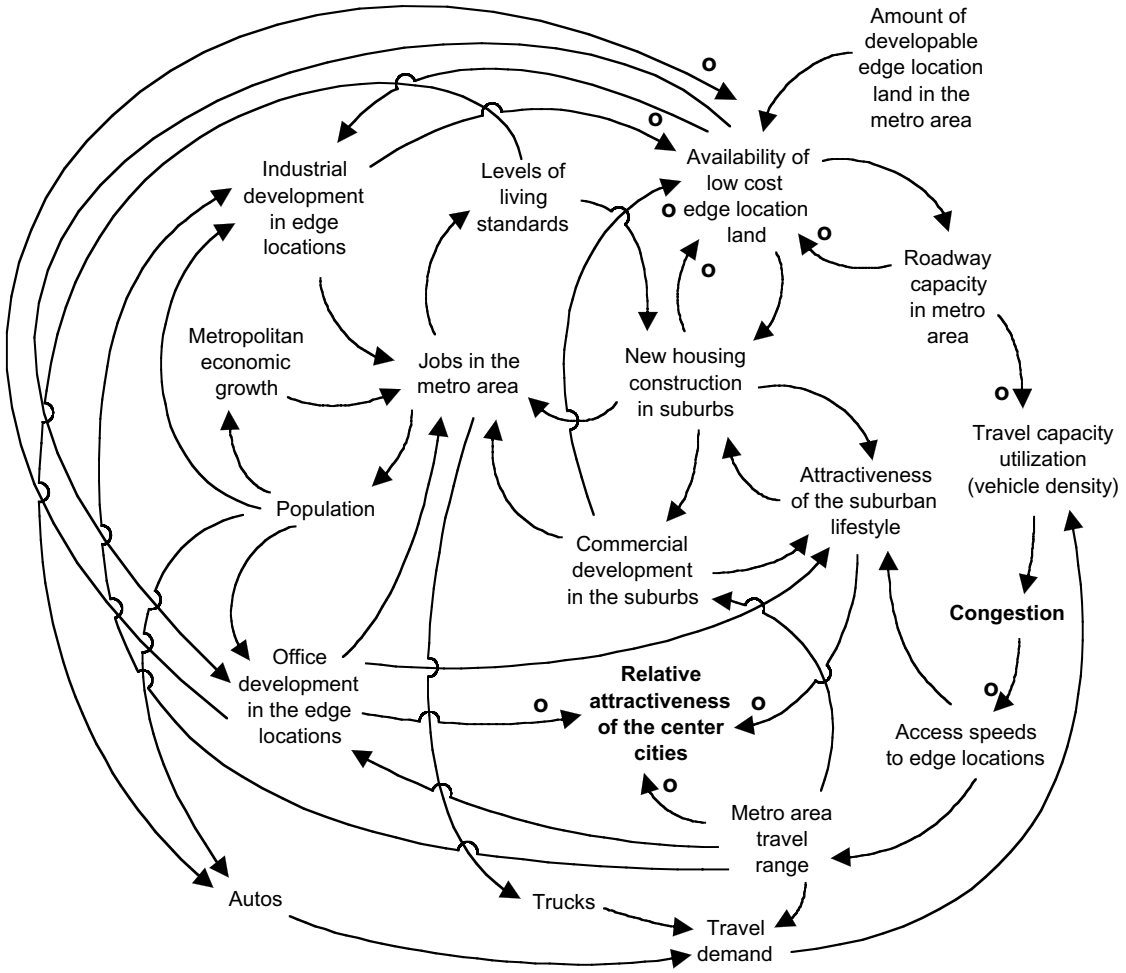
“Traffic volumes generally increased on all major highway segments in the 1980s and 1990s. To some extent, traffic occasionally dropped on minor road segments as traffic apparently shifted to superior parallel routes. The combination of larger populations, number of households increasing faster than a population, increasing distances between home and work, multiple job holding by workers, higher discretionary incomes and more recreational shopping, more leisure, more complex household life styles, more cars and trucks, greater participation by women in the paid workforce, better highways, and other factors all contributed to the enhanced traffic loads on the trunk highways in our study areas.

“In general, our findings are consistent with expectations. Population increases during each decade were greater in MCDs closer to regional centers and small or negative farther away. For regional centers and parts of Minnesota experiencing slow growth or decline, places closest to the regional center are doing better than places farther away. For regional centers and parts of Minnesota within the “crescent of growth,” the patterns of growth are more mixed, with growth not necessarily corresponding to distance from regional centers. On the other hand, many of those fast-growing study areas are in lake and outdoor recreation areas of the state, so the location of the amenities provides a pull in the opposite direction and dilutes to some extent the affect of highway distance from the regional centers.”

What is Different Today in the Twin Cities?

While the historical patterns of development growth that were seen in the Twin Cities are being duplicated in growing regional centers, it could be argued that the metro area is now experiencing a more mature dynamic. That is, the decline of investment in the center city and inner ring suburbs as documented in Adam’s first report in the Transportation and Regional Growth Study. The consequences are described below and shown in the diagram on the next page.

Rapid growth in the emerging suburbs around the Twin Cities, coupled with slow or negative growth in the central cities and inner ring suburbs shifted infrastructure investments, both public and private, toward the metro edge locations and away from the central city areas. As a consequence, governmental and social costs seem to accrue disproportionately on residents and owners of central city and inner ring suburb properties. As more of these costs are known or felt, the perceived value of central city places will decline, and the pace of investment there will decline even further.



Appendix: Transportation and Regional Growth Study Reports

All reports published by the Center for Transportation Studies (CTS), University of Minnesota. Available online at <http://www.cts.umn.edu/trg>.

1. *The Role of Housing Markets, Regulatory Frameworks, and Local Government Finance*. John S. Adams, Mark D. Bjelland, Laura J. Hansen, Lena L. Laaken, and Barbara J. VanDrasek. 1998. CTS 98-01.
2. *Understanding Urban Travel Demand: Problems, Solutions, and the Role of Forecasting*. Gary Barnes and Gary Davis. 1999. CTS 99-02.
3. *Development Impact Fees for Minnesota? A Review of Principles and National Practices*. John S. Adams, Julie L. Cidell, Laura J. Hansen, Hyun-joo Jung, Yeon-tack Ryu, and Barbara J. VanDrasek. 1999. CTS 99-04.
4. *Synthesizing Highway Transportation, Land Development, Municipal and School Finance in the Greater Twin Cities Area, 1970–1997*. John S. Adams, Julie L. Cidell, Laura J. Hansen, and Barbara J. VanDrasek. 2000. CTS 00-01.
5. *The Full Cost of Transportation in the Twin Cities Region*. David Anderson and Gerard McCullough. 2000. CTS 00-04.
6. *Land Use and Travel Choices in the Twin Cities, 1958–1990*. Gary Barnes and Gary Davis. 2001. CTS 01-01.
7. *House Price Changes and Capital Shifts in Real Estate Values in Twin Cities-area Housing Submarkets*. John S. Adams, Julie L. Cidell, Laura J. Hansen, and Barbara J. VanDrasek. 2002. CTS 02-01.
8. *Highway Improvements and Land Development Patterns in the Greater Twin Cities Area, 1970–1997: Measuring the Connections*. John S. Adams, Julie L. Cidell, Laura J. Smith, and Barbara J. VanDrasek. 2002. CTS 02-03.
9. *Road Finance Alternatives: An Analysis of Metro-area Road Taxes*. Barry Ryan and Thomas F. Stinson. 2002. CTS 02-04.
10. *Urbanization of the Minnesota Countryside: Population Changes and Low-Density Development Near Minnesota's Regional Centers, 1970–2000*. John S. Adams, Joel A. Koepp, and Barbara J. VanDrasek. 2003. CTS 03-01.
11. *Urban Design, Transportation, Environment, and Urban Growth: Transit-Supportive Urban Design Impacts on Suburban Land Use and Transportation Planning*. Carol J. Swenson and Frederick C. Dock. 2003.

12. *A Systems Thinking Perspective on the Transportation and Regional Growth Study*. Ed Ward. 2003. CTS 03-05.
13. *Transportation, Urban Design, and the Environment: Highway 61/Red Rock Corridor*. Lance M. Neckar. 2003. CTS 03-04.
14. *Case Studies of Development in the Minneapolis-St.Paul Metropolitan Region*. John S. Adams and Barbara J. VanDrasek. 2003.
15. *The Distribution of Transportation Costs in the Twin Cities Region*. David Anderson and Gerard McCullough. 2003. CTS 03-03.
16. *Public Policy, Transportation, and Regional Growth*. Thomas M. Scott and Barbara Lukerman. 2003.
17. *Market Choices and Fair Prices: Research Suggests Surprising Answers to Regional Growth Dilemmas*. Curtis Johnson. 2003. CTS 03-02.