

Systems Thinking in Communities:

Understanding the Causes of Inactivity, Poor Diet/Nutrition, and Childhood Obesity in Houghton County, Michigan



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Introduction

Copper Country Healthy Kids, Healthy Communities (HKHC) is one of 49 community partnerships participating in the national *Healthy Kids, Healthy Communities* program of the Robert Wood Johnson Foundation (www.healthykidshealthycommunities.org). The purpose of this *Copper Country HKHC* project was to introduce systems thinking at the community level by identifying the essential parts of the Houghton County, Michigan system and how the system influences policy and environmental changes to promote healthy eating and active living as well as to prevent childhood obesity. To accomplish this goal, community partners and residents participated in a group model building session and discussions. The group model building exercises were designed by staff from Transtria LLC and the Social System Design Lab at Washington University in St. Louis, Missouri as part of the *Evaluation of Healthy Kids, Healthy Communities* funded by the Robert Wood Johnson Foundation. These exercises actively involved a wide range of participants in modeling complex systems and provided a way for different representatives (e.g., residents, foundations, community-based organizations, academic institutions, government agencies, policy/advocacy agencies) to better understand the systems (i.e., dynamics and structures) in the community (see the *Healthy Kids, Healthy Communities Group Model Building Facilitation Handbook*, www.transtria.com/hkhc). Overall, the evaluation was designed to assess policy, system, and environmental changes as a result of the community partnerships' efforts to increase healthy eating and active living in order to reduce childhood obesity.

Houghton County, Michigan : Background and Local Participation

Houghton County sits at the tip of Michigan's western Upper Peninsula (U.P.), a rugged, sparsely populated forest region bordered on two sides by Lake Superior. Residents are accustomed to long, snowy winters. Houghton was a prosperous mining town in the 1940s and 1950s but the population declined when the mining companies closed in the 1960's. Houghton County, with 34,000 residents living on more than 1,000 square miles of mostly forested land on the south shore of Lake Superior, receives 250 to 300 inches of snow per year. High rates of poverty and unemployment, lack of YMCAs or park districts that sponsor recreational activities, and long snowy winters are factors that contribute to the prevalence of child and adult overweight and obesity, and attendant high rates of chronic disease. Most residents (95%) are white, with Native Americans making up the largest minority population. The Copper Country's median household income in 2012 was \$34,453, two-thirds less than Michigan's median of \$48,471. The county's three population centers are the City of Houghton, City of Hancock, and Village of Calumet, but nearby Lake Linden was also impacted by HKHC.

The Houghton County partnership predates Copper Country HKHC. The partnership started in 2004 with the BHK (Baraga, Houghton, and Keweenaw) Child Development board, a non-profit agency that provided child and family services such as Head Start and the Preschool Obesity Prevention Series (POPS) grant, a rural health outreach grant that was facilitated under the Western Upper Peninsula District Health Department (WUPDHD). In 2008, the Healthy Families Coalition was started, with a focus on child and family environment and preschool obesity.

WUPDHD was the lead agency for the Copper Country Healthy Kids, Healthy Communities (HKHC) partnership. The health department served five counties. Contracted partners included representatives from the National Park Service and Houghton County Civil and Environmental Engineering, and Planning Departments. The health department played a lead role in community efforts to reduce childhood obesity. The health department also helped organizations bring in outside funding and leverage volunteer efforts between groups.

The Healthy Families Consortium served as an advisory group for this project, with members from BHK Child Development Board, the Copper Country Intermediate School District, Michigan Tech University, area hospitals, cities, townships, and community-based volunteer groups. Healthy Families Coalition was one of the paid programs in the community that focused on active living, healthy eating, obesity, and chronic disease prevention.

Copper Country HKHC's Priorities and Strategies

The partnership and capacity building strategies of *Copper Country HKHC* included:

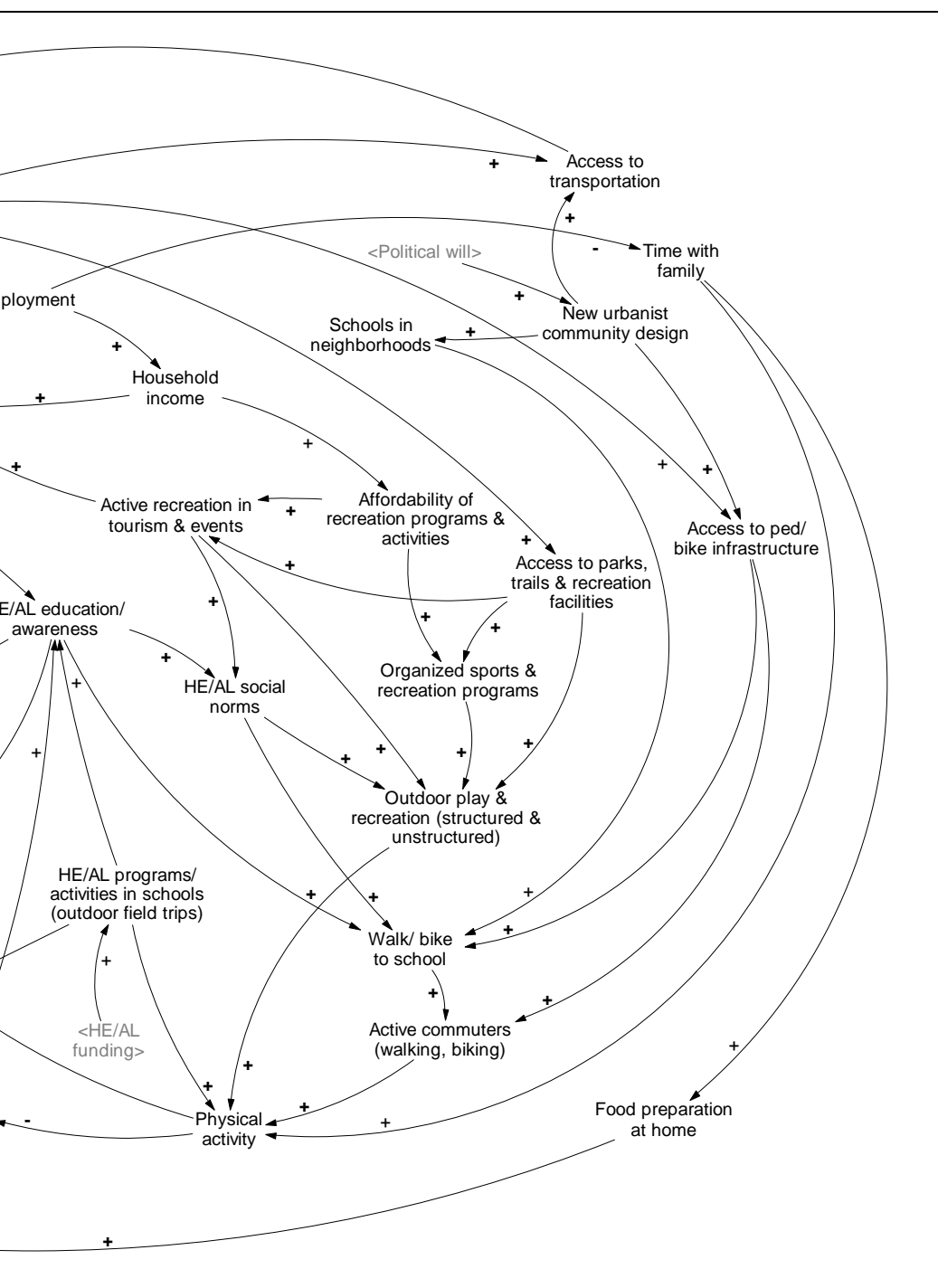
- **Western Upper Peninsula Food Hub and Food Policy Council (WUP Food Hub):** Led by WUPDHD, WUP Food Hub aimed to bring food producers and consumers together to grow the supply of, and demand for, local foods. The vision for the WUP Food Hub was to be a convener of dialogues and partnerships leading to plans, policies, and systems that improve access to affordable and healthy foods for residents of Baraga, Gogebic, Houghton, Iron, Keweenaw and Ontonagon counties.²
- **Bike and Pedestrian Committee:** The partnership helped broaden the focus of the Bike and Pedestrian Committee and build capacity with other partners, schools in particular. The Committee started in 2006 and worked on improving and implementing bike and pedestrian routes. Original members included City Council members, the Mayor, and the Chief of Police. The committee turned into a regional committee and added community members from Hancock. Membership applications went out to two other communities, Calumet and Laurium.

The healthy eating and active living strategies of *Copper Country HKHC* included:

- **Active Transportation:** Efforts for this initiative focused on passing a Complete Streets ordinance and securing approval of a new, non-motorized transportation plan. Development of Safe Routes to School plans and a new recreational trail authority group were completed. In addition, highway repaving projects were planned for 2014.
- **Community Gardens:** Healthy food access has been increased in Houghton County by the addition of community and school gardens.
- **Farmers' Markets:** Area farmers' markets were equipped with Electronic Benefit Transfer (EBT) payment systems in an effort to increase the accessibility of local, fresh produce.

For more information on the partnership, please refer to the Houghton County case report (www.transtria.com/hkhc).

this illustration for money spent on trails and sidewalks, the amount of funds for trails and sidewalks has increased since 1960 and the participant hopes that this increase will continue into the future. Each graph is a tool to increase the use of common, specific language to describe *what* is changing in the community as well as *when*, *where*, and *how* it is changing. The graphs capture participants' perceptions of the influence, or



variable, and through the graph, the participant tells their story. These perceptions are based on actual data or evidence, or they are part of the participants' lived experience.

Causal Loop Diagram

To examine the relationships among the variables from the behavior over time graphs, participants worked together and with facilitators to develop a causal loop diagram. In Figure 1, the words represent variables of quantities that can increase and decrease over time (i.e., the behavior over time graphs). These variables are influenced by other variables as indicated by the lines with arrows. The lines with arrows represent causal relationships - this is what is known about the system and how it behaves.

One feedback loop is: healthy eating (HE)/ active living (AL) education/ awareness → advocacy → political will → HE/AL education/ awareness.

What is important to notice is that there are other feedback loops interacting simultaneously to influence or to be influenced by HE/AL education/ awareness. Some variables may increase HE/AL education/ awareness while other variables limit it. Determining the feedback loop or loops that dominate the system's behavior at any given time is a more challenging problem to figure out, and ultimately, requires the use of computer simulations.

Based on this preliminary work by the *Copper Country HKHC* partnership, this "storybook" ties together the behavior over time graphs, the participants' stories and dialogue, and feedback loops from the causal loop diagram to understand the behavior of the system affecting health in Houghton County, Michigan and to stimulate greater conversation related to Houghton County's theory of change, including places to intervene in the system and opportunities to reinforce what is working. Each section builds on the previous sections by introducing concepts and notation from systems science.

Causal Loop Diagram for the Childhood Obesity System

The causal loop diagram (CLD) represents a holistic system and several subsystems interacting in Houghton County, Michigan. In order to digest the depth and complexity of the diagram, it is helpful to examine the CLD in terms of the subsystems of influence. Because of this project's focus on healthy eating, active living, and childhood obesity, this system draws attention to a number of corresponding subsystems, including: healthy eating policies and environments (red), active living policies and environments (blue), health and health behaviors (orange), partnership and community capacity (purple), and social determinants (green).

From the group model building exercises, several variables and causal relationships illustrated in Figure 2 were identified within and across subsystems. This section describes the subsystems in the CLD.

Healthy Eating Policies and Environments (Red)

The healthy eating policy and environmental subsystem includes food production, food distribution and procurement, and food retail. During the behavior over time graphs exercise, the participants generated eleven graphs related to policy or environmental strategies (e.g., healthy eating vending policies) or contexts (e.g., government nutrition assistance standards) that affected or were affected by the work of *Copper Country HKHC*. The variables represent participants' conversations from the behavior over time graph and causal loop diagram exercises.

Active Living Policies and Environments (Blue)

The active living policy and environmental subsystem includes design, planning, construction, and enforcement or maintenance related to access to opportunities for active transportation and recreation. For this topic, the group model building participants developed 16 graphs related to policy or environmental strategies (e.g., access to pedestrian and bike infrastructure) or contexts (e.g., access to transportation) that affected or were affected by the partnership's work.

Health and Health Behaviors (Orange)

The subsystem for health and health behaviors includes health outcomes (e.g., obesity), health behaviors

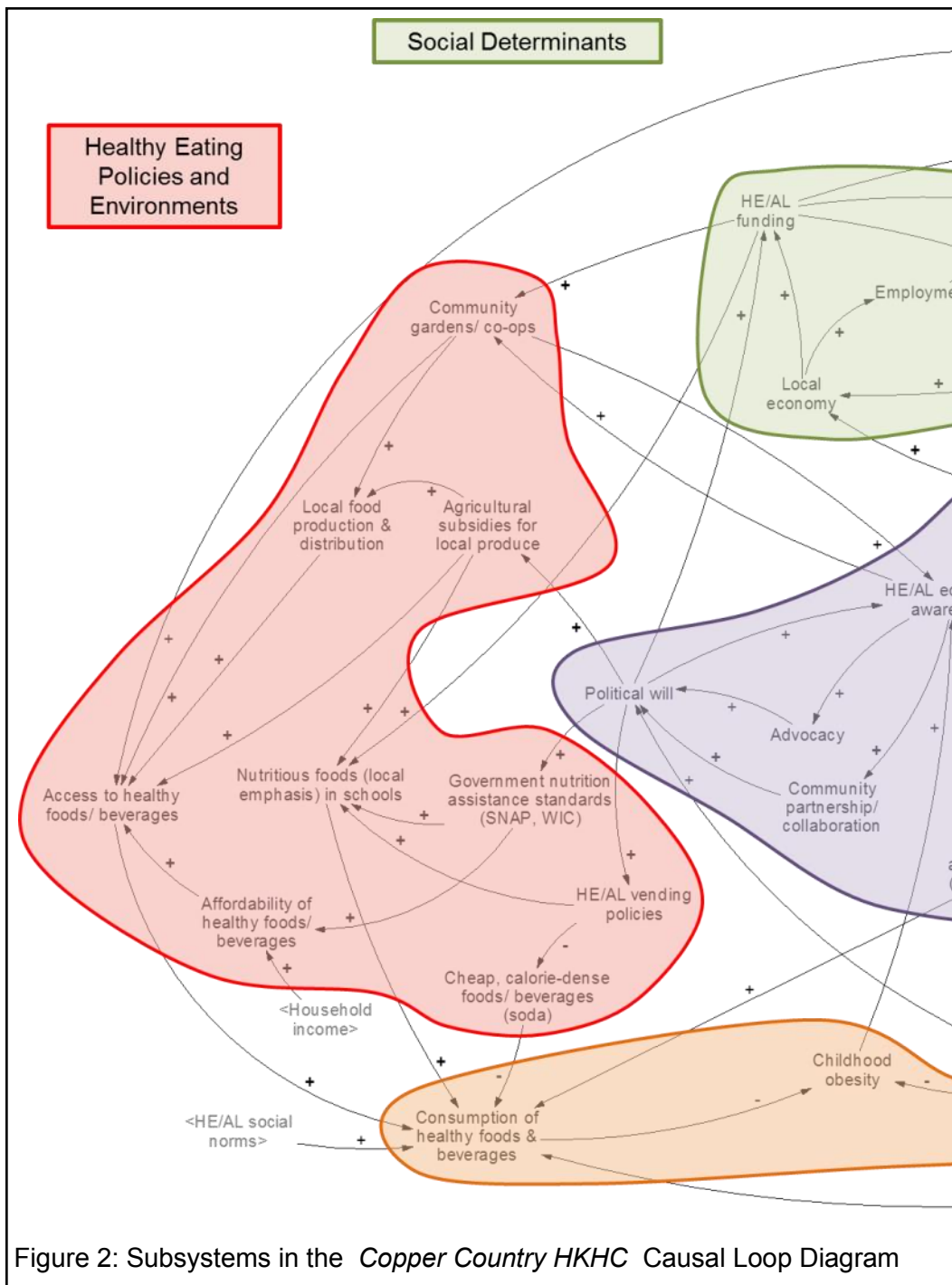
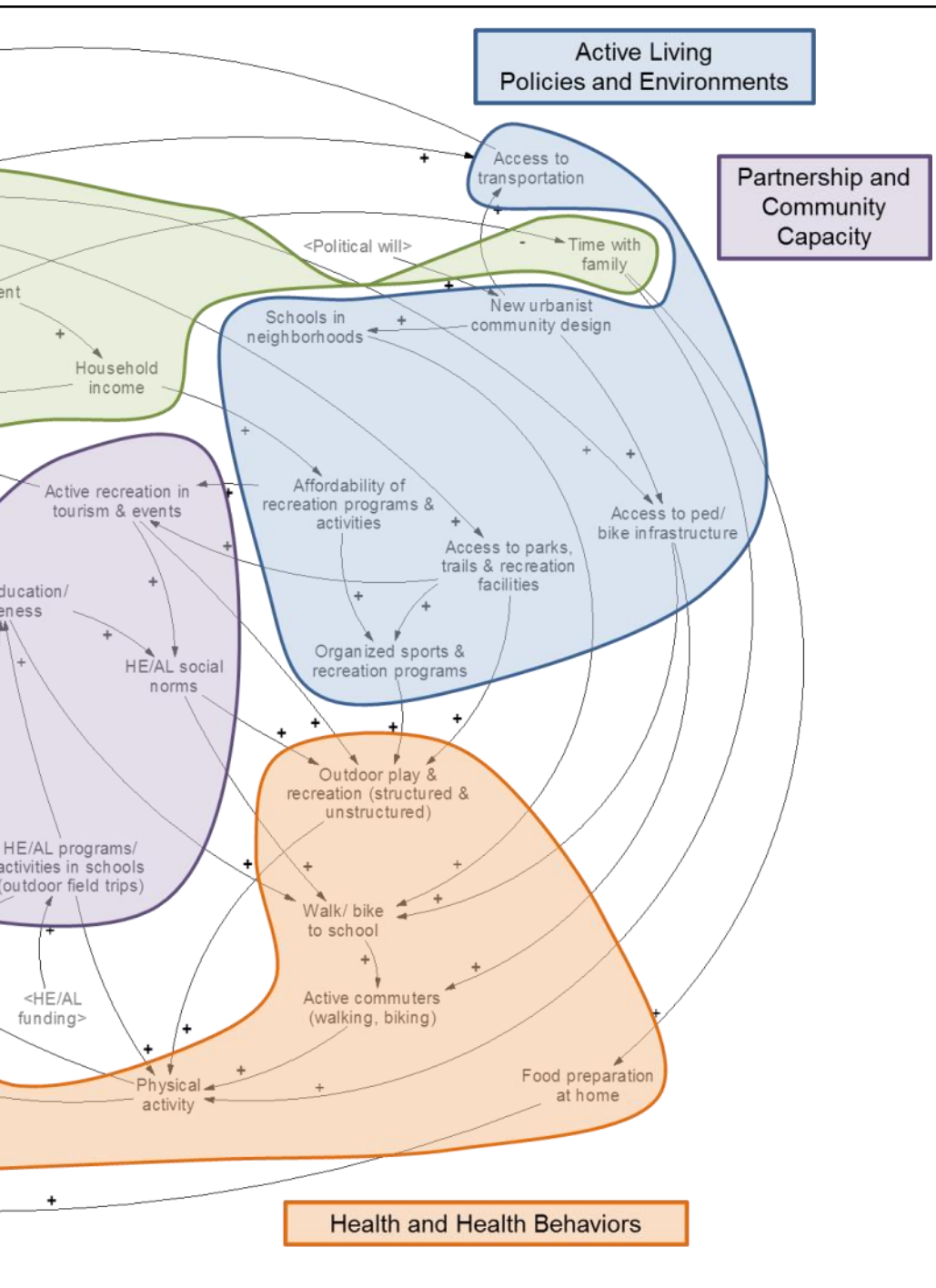


Figure 2: Subsystems in the *Copper Country HKHC* Causal Loop Diagram

(e.g., healthy eating, physical activity), and behavioral proxies or context-specific behaviors (e.g., food preparation at home, outdoor play and recreation, walk or bike to school).

Partnership and Community Capacity

The partnership and community capacity subsystem refers to the ways communities organized and rallied for



changes to the healthy eating and active living subsystems. For instance, *Copper Country HKHC* worked to build political will through a food policy council. This subsystem also includes community factors outside the partnership that may influence or be influenced by their efforts, such as healthy eating and active living social norms.

Social Determinants

Finally, the social determinants subsystem denotes societal conditions (e.g., local economy) and psychosocial influences (e.g., time with family) in the community that impact health beyond the healthy eating and active living subsystems. In order to achieve health equity, populations and subgroups within the community must have equitable access to these resources and services.

Each one of these subsystems has many more variables, causal relationships (arrows), and feedback loops that can be explored in greater depth by the *Copper Country HKHC* partners or by other representatives in Houghton County, Michigan. Using this CLD as a starting place, community conversations about different theories of change within subsystems may continue to take place.

The next sections begin to examine the feedback loops central to the work of *Copper Country HKHC*. In these sections, causal relationships and notations (i.e., arrows, “+” signs,

“-” signs) from Figure 2 will be described to increase understanding about how systems thinking and modeling tools can work in communities to increase understanding of complex problems that are continuously changing over time, such as childhood obesity. At the end of this CLD storybook, references to other resources will be provided for those interested in more advanced systems science methods and analytic approaches.

Active Transportation Feedback Loop

To simplify the discussion about feedback loops, several loops drawn from the Copper Country HKHC CLD (see Figures 1 and 2) are highlighted in Figures 3-5. While the CLD provides a theory of change for the childhood obesity prevention movement in Houghton County, Michigan, each feedback loop tells a story about a more specific change process.

Causal Story for Feedback Loop

Story A: In this case, the story is about the active transportation (orange highlighted loop in Figure 3).

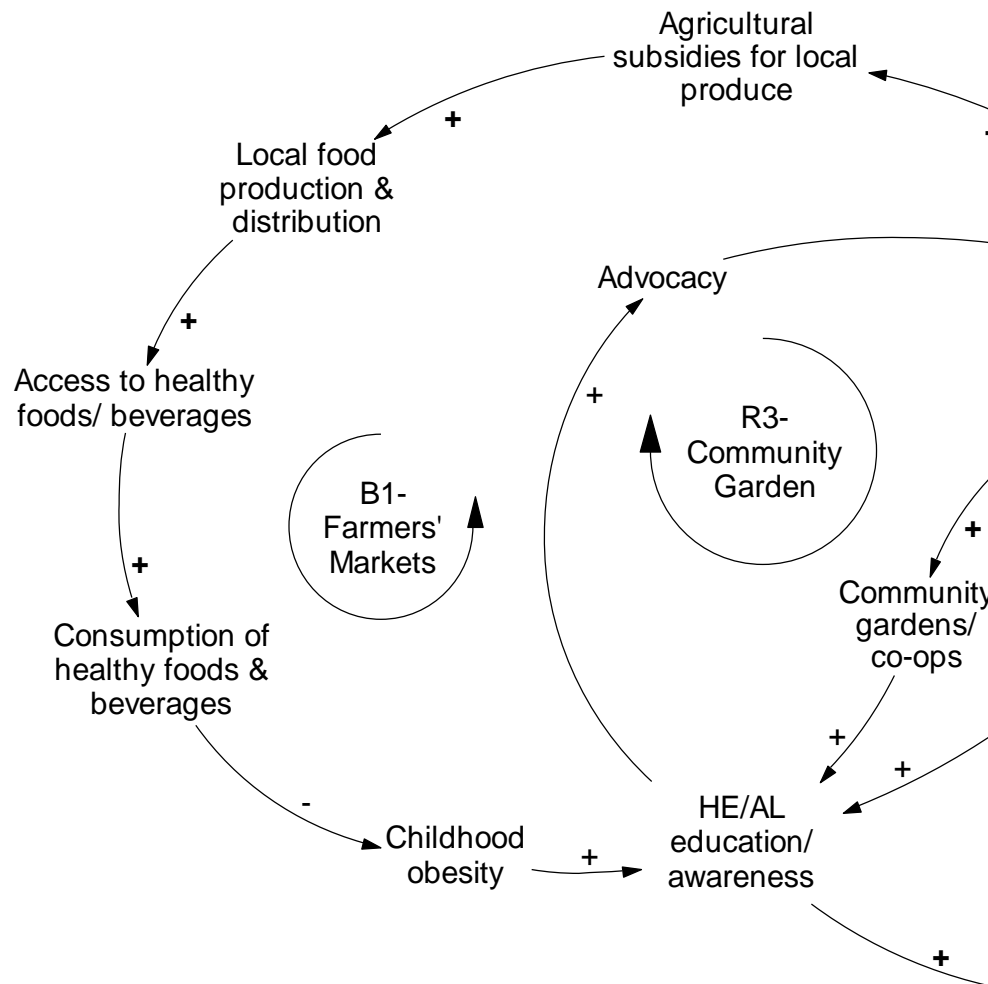
Houghton County, Michigan partners passed a Complete Streets ordinance, secured approval of a new, non-motorized transportation plan, and developed Safe Routes to School plans. Participants described how a new urbanist community design leads to better access to pedestrian and bike infrastructure. In turn, there are more active commuters, increasing overall physical activity. More physically active residents leads to greater political will to support these types of new urbanist community design approaches.

Story B: While the preceding story reflected a positive scenario for Houghton County, Michigan, the same feedback loop also tells the opposite story. Poor community design results in less access to pedestrian and bike infrastructure, leading to fewer active commuters and less overall physical activity. Consequently, there is less political will for new urbanist community design approaches.

Reinforcing Loop and Notation

These stories represent a reinforcing loop, and the notation in the feedback loop identifies it as a reinforcing loop (see “R1 — Active Transportation” and orange highlighted loop in Figure 3). The words represent variables of quantities that increase and decrease as illustrated in the stories above. These variables change over time and are influenced by other variables as

Figure 3: Active Transportation Feedback Loop

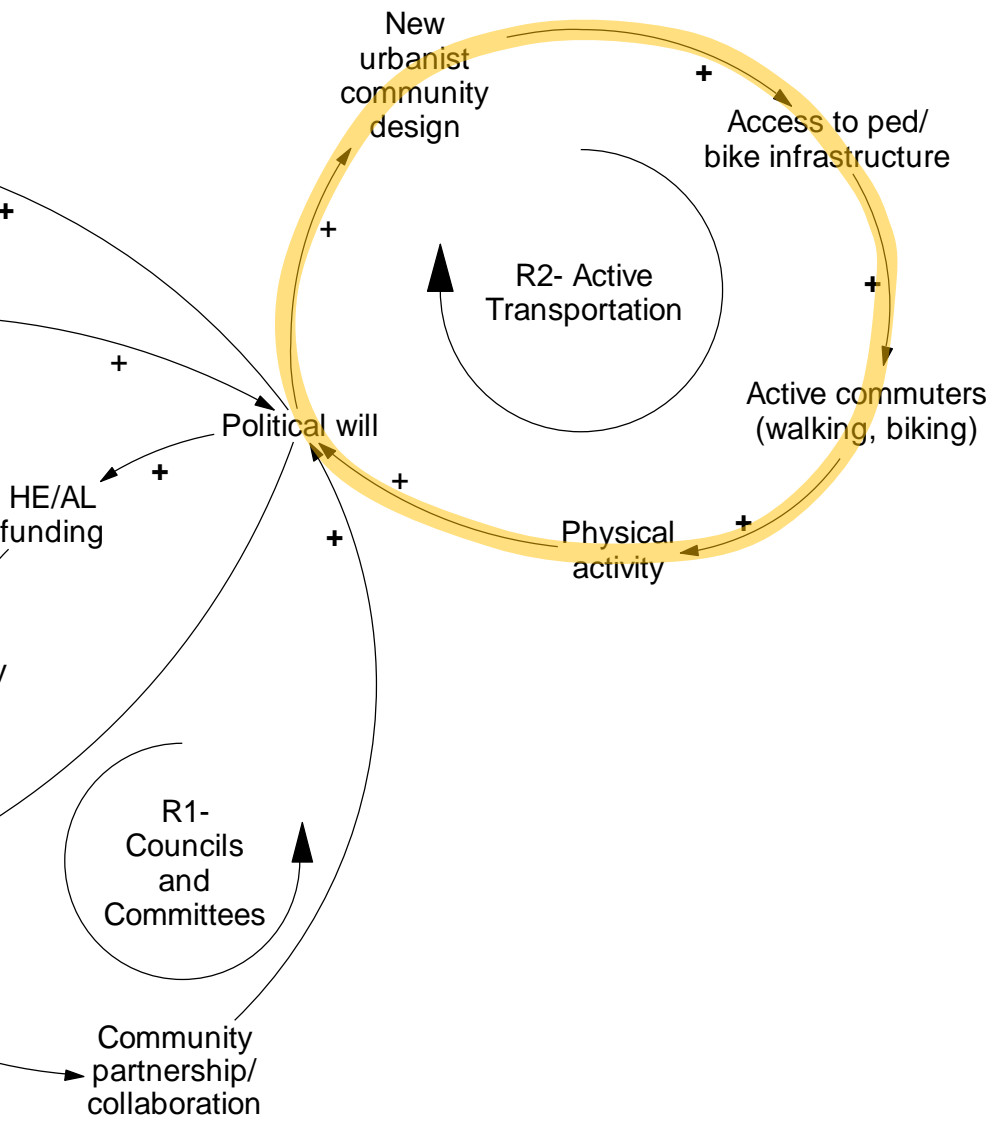


“My sense is that alternative transportation routes have gone from a low to moderate number with a slight upslope between ‘95, which is about the time that I moved to this area, to 2012. My hope is that it would dramatically increase... and my fear is that it would dramatically decline... largely based on possibilities related to funding, to overseeing the transportation bills, and the like. But, I’ll qualify that not all routes are equal either. The city of Houghton has a great waterfront trail, and I think that provides a nice separation. In a lot of cases, it’s simply a widened shoulder on a road, and that feels different on highway 55 than it does on a local street where there’s a dedicated lane.” (Participant)

indicated by the arrows. Each arrow represents a causal relationship, and the plus and minus signs on the arrows indicate whether or not the influence of one variable on another variable (1) increases/adds to (plus or "+" sign), or (2) decreases/removes from the other variable (minus or "-" sign). These signs are referred to as polarities.

In a reinforcing loop, the effect of an increase or decrease in a variable continues through the cycle and returns an increase or decrease to the same variable, respectively.

Looking specifically at the "+" or "-" notation, a feedback loop that has zero or an even number of "-" signs, or polarities, is considered a reinforcing loop. Balancing loops, with an odd number of "-" signs in the loop, are another type of feedback loop.



In isolation, this reinforcing loop represents a virtuous cycle in Story A as these assets positively support one another, or a vicious cycle in Story B as these challenges perpetuate a downward spiral. Yet, the influence of access to pedestrian and bike infrastructure likely levels off at some point when there are safe, accessible routes throughout Houghton. To understand other influences on these variables, it is important to remember that this reinforcing loop is only one part of the larger CLD (see Figures 1 and 2), and the other loops and causal relationships can have an impact on the variables in this loop.

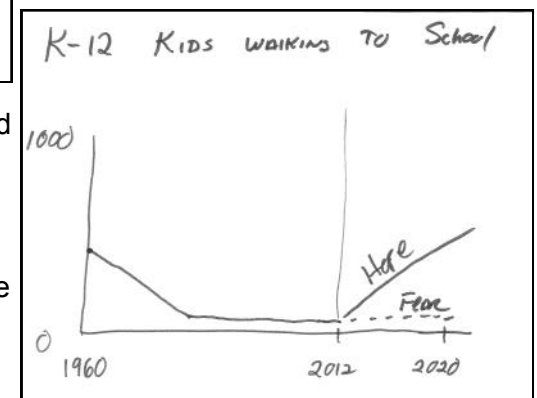
System Insights for Copper Country HKHC

Participants identified the number of elementary through high school kids walking to school has decreased to nearly zero over the last several decades in Houghton County, Michigan (see behavior over time graph).

From the systems thinking exercises, several insights can inform active transportation strategies. For

instance, identifying and partnering with current active commuters and those who are physically active can generate greater political will for new urbanist design approaches in the community.

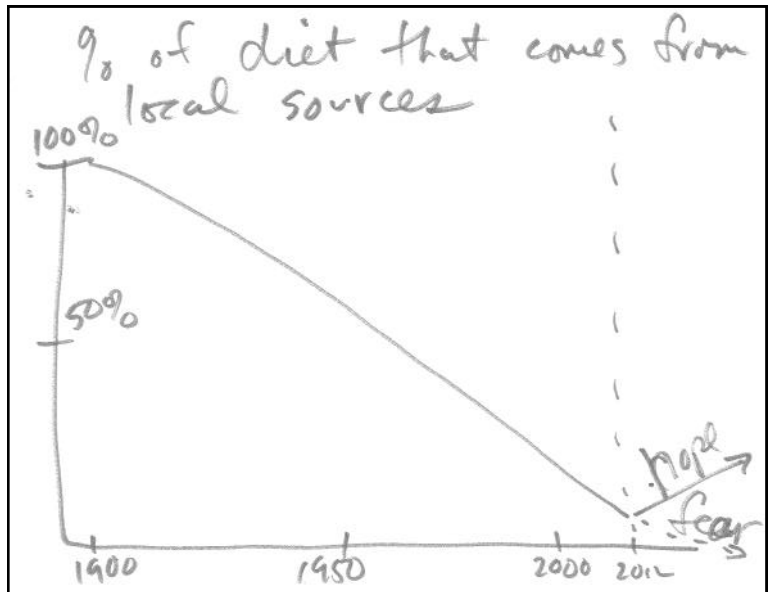
In addition to these insights, systems thinking can also help to pose key questions for assessment and evaluation, including evaluating the influence of safe, quality pedestrian and bike infrastructure effects on active commuting in Houghton.



Community Gardens Feedback Loop

The feedback loop highlighted in blue in Figure 4 reflects the same concepts and notation, and highlights healthy eating in Houghton County, Michigan. Like the active transportation loop in Figure 3, this one also represents a reinforcing loop (all “+” signs). In addition, it includes causal relationships representing more immediate effects (e.g., funding supports more community gardens and co-ops), and, potentially, delayed effects (e.g., advocacy and political will increases funding for healthy eating initiatives). Delayed effects are noted using two hash marks through the middle of the arrow line (not included in Figure 4).

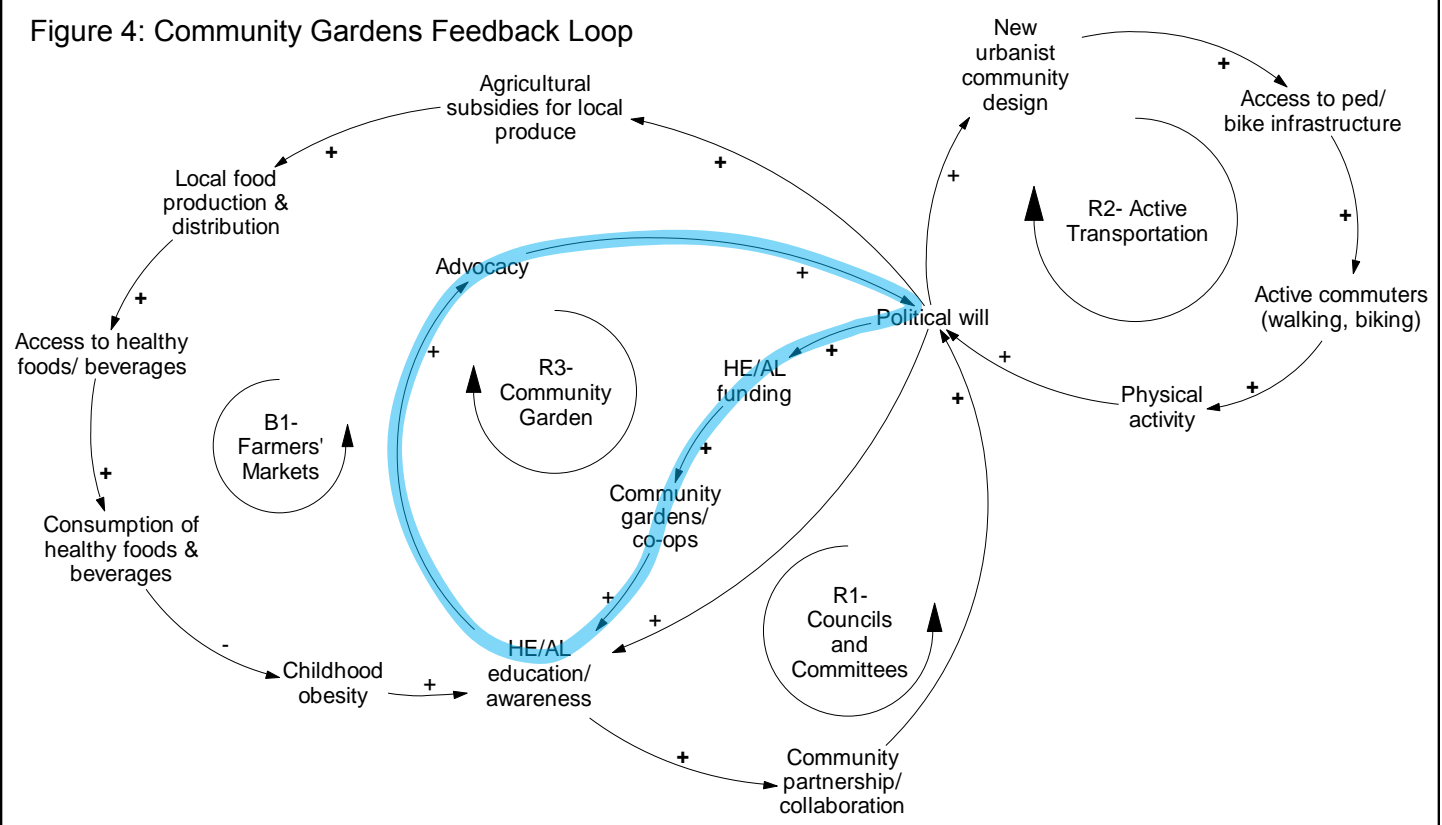
In the behavior over time graphs exercise, participants described a tremendous decline in the portion of residents’ diets that come from local sources, with the hope that this trend will reverse. (see illustration).



At the same time, participants described challenges sustaining gardens as well as partners supporting the gardens over time (see quote below). As illustrated in the loop in Figure 4, the success of the gardens in creating more local food sources for residents depends on the ability to create awareness of the gardens in order to gain advocates and political will to fund the development and maintenance of the gardens over time.

“In 2010, what our group decided to do was to start doing whole school activities that would get all 700 children involved with healthy living activities. We had a slight decrease in 2011 with our garden after we had some damage and then our school expanded. So with the construction project, we lost our whole west side of the garden. The other decrease was that we lost GE as our summer community partner. But now within the same year, we’re right back up at the top at 700.” (Participant)

Figure 4: Community Gardens Feedback Loop

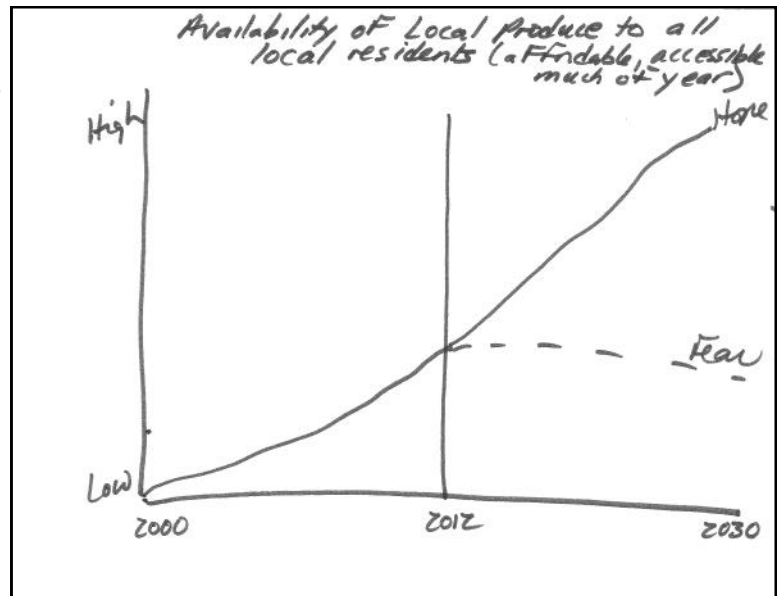


Farmers' Markets Feedback Loop

Highlighted in red in Figure 5, the farmers' markets feedback loop represents one of the *Copper Country HKHC* strategies to increase healthy eating in Houghton County, Michigan.

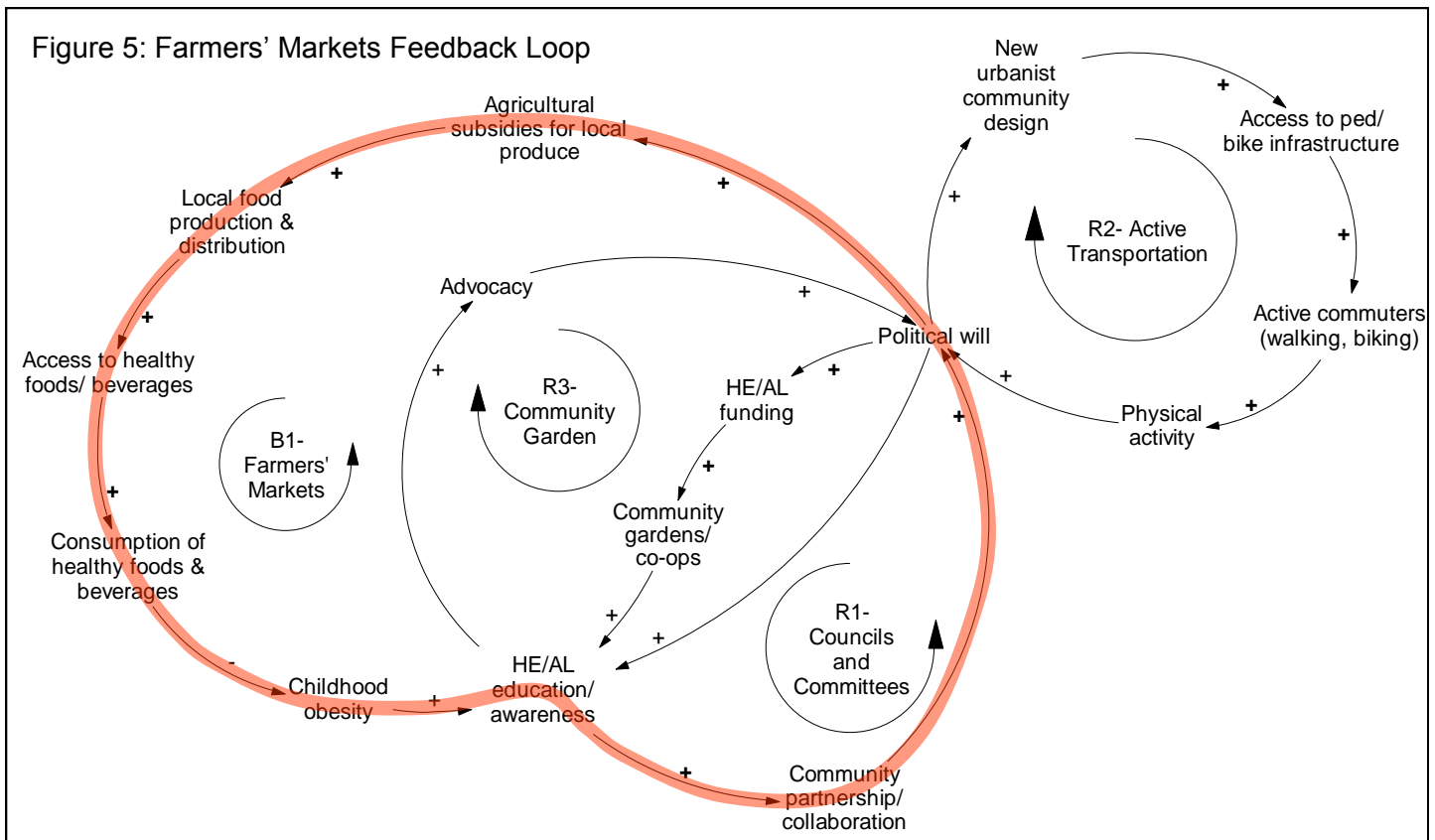
In contrast to the previous loops (see Figures 3-4), this is a balancing loop (one "-" sign). In addition, it includes causal relationships representing more immediate effects (e.g., access to healthy foods and beverages increases consumption of these products), and, potentially, delayed effects (e.g., political will increases agricultural subsidies for local produce).

In the behavior over time graphs exercise, participants described an increase in the availability of local produce to all local residents since 2000 with the hope that this trend will continue into the future (see illustration). Additionally, participants described how this access to healthy foods and beverages supports working parents' capacity to provide healthy foods to their families (see quote below).



Partners' efforts to equip farmers' markets with Electronic Benefit Transfer (EBT) payment systems increased the accessibility of local, fresh produce. As identified in the loop in Figure 5, agricultural subsidies to support local produce can, in turn, support distribution of these products through farmers' markets alongside other efforts to increase access to healthy foods and beverages.

"What I observed around me as I was raising my kids, I had available healthy foods in the school systems and the communities; availability of whole and organic foods in the community via gardens and co-ops, etc. But really what it all led to was the support for working parents for healthy eating." (Participant)



Opportunities for Systems Thinking in Houghton County, Michigan

This storybook provided an introduction to some basic concepts and methods for systems thinking at the community level, including: causal loop diagrams, variables, causal relationships and polarities, reinforcing feedback loops, and balancing feedback loops, among others. For the *Copper Country HKHC* partners, this storybook also summarized the healthy eating, active living, partnership and community capacity, social determinants, and health and health behaviors subsystems in the Houghton County causal loop diagram as well as six specific feedback loops corresponding to the partnership's primary strategies.

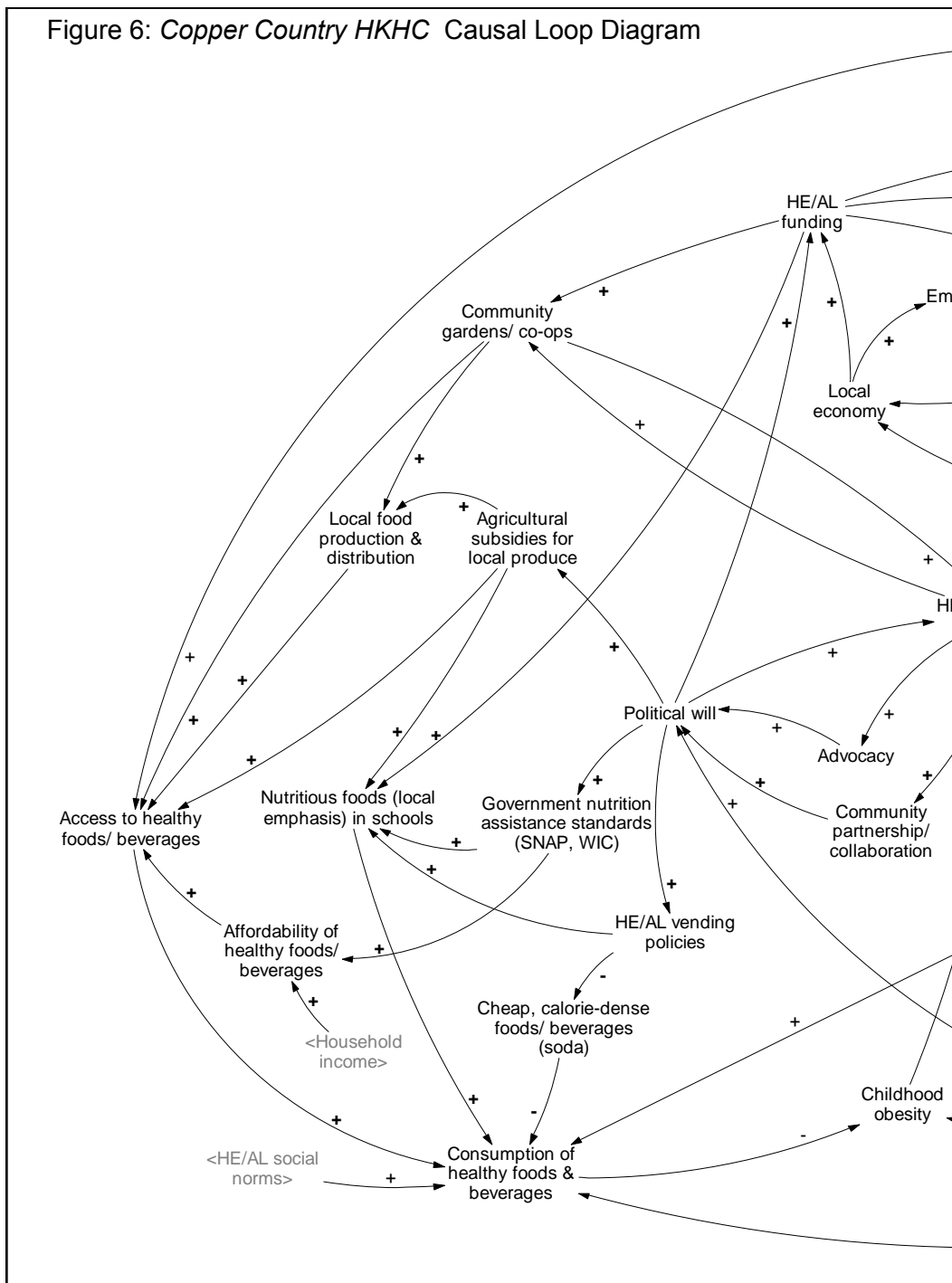
This causal loop diagram reflects a series of conversations among partners and residents from 2011 to 2013. Some discussions probed more deeply into different variables through the behavior over time graphs exercise, or causal relationships through the causal loop diagram exercise.

This represented a first attempt to collectively examine the range of things that affect or are affected by policy, system, and environmental changes in Houghton County, Michigan to promote healthy eating and active living as well as preventing childhood overweight and obesity.

Yet, there are several limitations to this storybook, including:

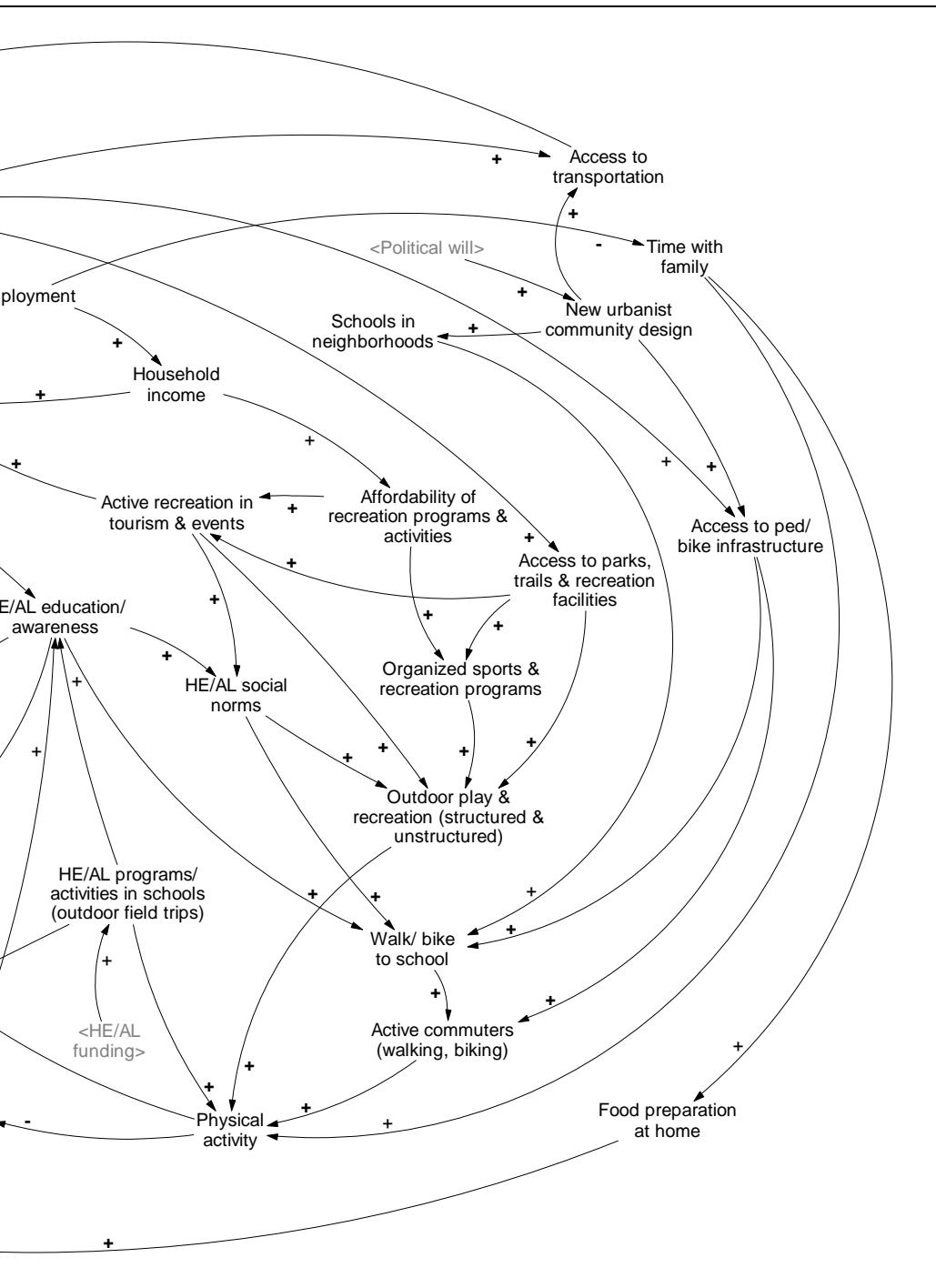
- the participants represent a sample of the *Copper Country HKHC* partners (organizations and residents) as opposed to a representative snapshot of government agencies, community organizations, businesses, and community residents;
- the behavior over time graphs and the causal loop diagram represent perceptions of the participants in these exercises (similar to a survey or an interview representing perceptions of the respondents);
- the exercises and associated dialogue took place in brief one- to two-hour sessions, compromising the group's capacity to spend too much time on any one variable, relationship, or feedback loop; and
- the responses represent a moment in time so the underlying structure of the diagram and the types of feedback represented may reflect "hot button" issues of the time.

Figure 6: *Copper Country HKHC* Causal Loop Diagram



example:

- having conversations to discuss existing feedback loops to ensure that the appropriate variables and relationships are represented accurately;



- reviewing the behavior over time graphs (see also Appendix E) to confirm that the trends reflect common perceptions among residents and compare these trends to actual data;

- revisiting variables removed because they were not part of feedback loops, including fast food restaurants, events & program sponsorships, global food production & distribution, reimbursement for preventable care, screen time (tv, video games), gas prices, suburban sprawl, automobile culture, maintenance (condition, weather), perception of safety, medical training, breastfeeding support; and

- starting new conversations about other variables (behavior over time graphs exercise) or relationships (causal loop diagram exercise) to add to this diagram.

In addition, different subgroups in Houghton County may use this causal loop diagram to delve in deeper into some of the subsectors (e.g., healthy eating, active living) or feedback loops, creating new, more focused causal loop diagrams with more specific variables and causal relationships.

Use of more advanced systems science methods and analytic approaches to create computer simulation models is another way to take this early work to the next level. The references section includes citations for resources on these methods and analytic approaches, and it is necessary to engage

professional systems scientists in these activities.

Please refer to the Appendices for more information, including:

- Appendix A: Behavior over time graphs generated during site visit
- Appendix B: Photograph of the original version of the *Copper Country HKHC* Causal Loop Diagram
- Appendix C: Original translation of the causal loop diagram into Vensim PLE
- Appendix D: Transcript translation of the causal loop diagram into Vensim PLE
- Appendix E: Behavior over time graphs not represented in the storybook

References for Systems Thinking in Communities:

Group model building handbook:

Hovmand, P., Brennan L., & Kemner, A. (2013). Healthy Kids, Healthy Communities Group Model Building Facilitation Handbook. Retrieved from <http://www.transtria.com/hkhc>.

Vensim PLE software for causal loop diagram creation and modification:

Ventana Systems. (2010). Vensim Personal Learning Edition (Version 5.11A) [Software]. Available from <http://vensim.com/vensim-personal-learning-edition/>

System dynamics modeling resources and support:

Andersen, D. F. and G. P. Richardson (1997). "Scripts for group model building." System Dynamics Review 13(2): 107-129.

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System Dynamics in Education Project. (1994). Road maps: A guide to learning system dynamics. Retrieved from <http://www.clexchange.org/curriculum/roadmaps/>

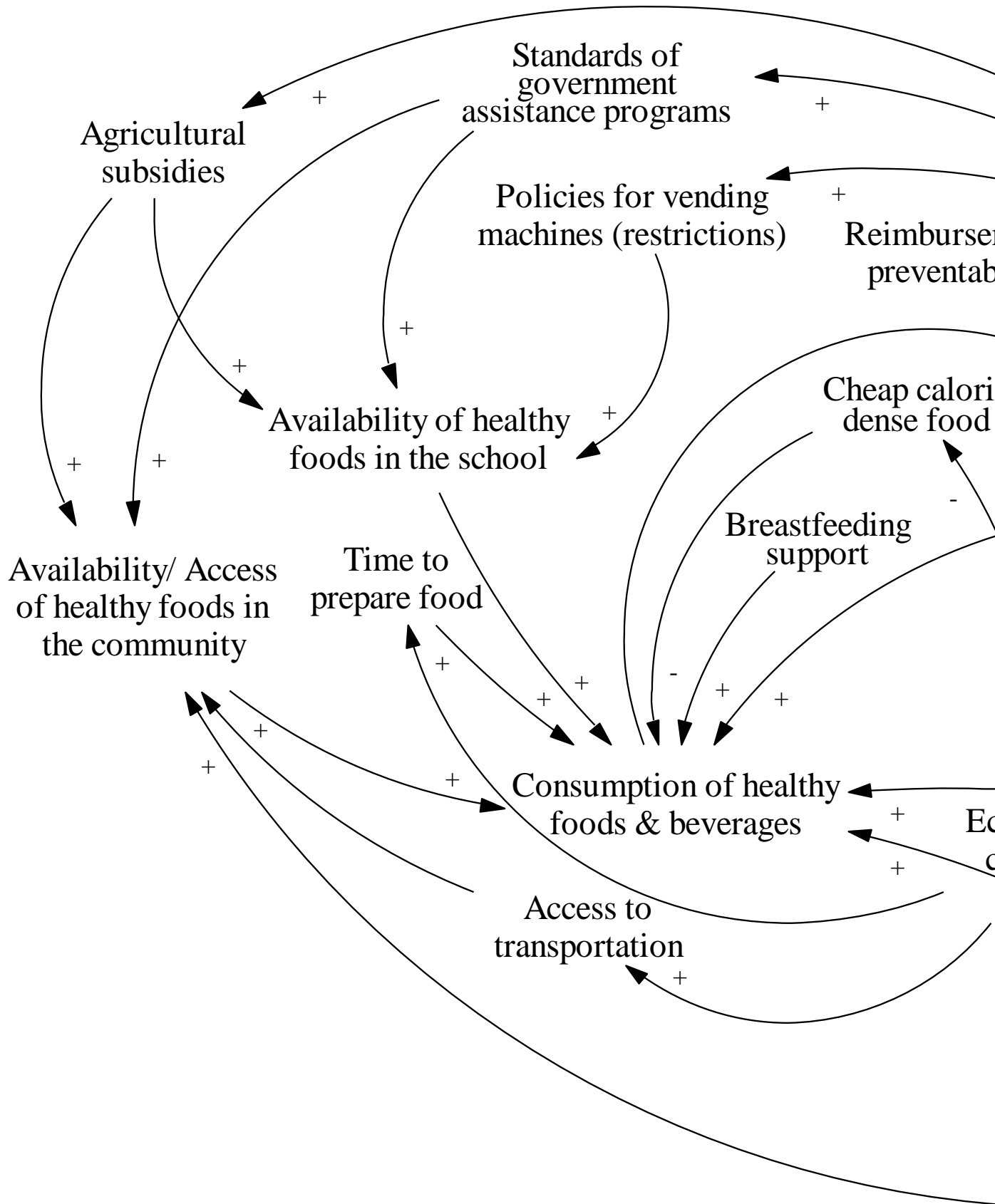
Vennix, J. (1996). Group model building. New York, John Wiley & Sons.

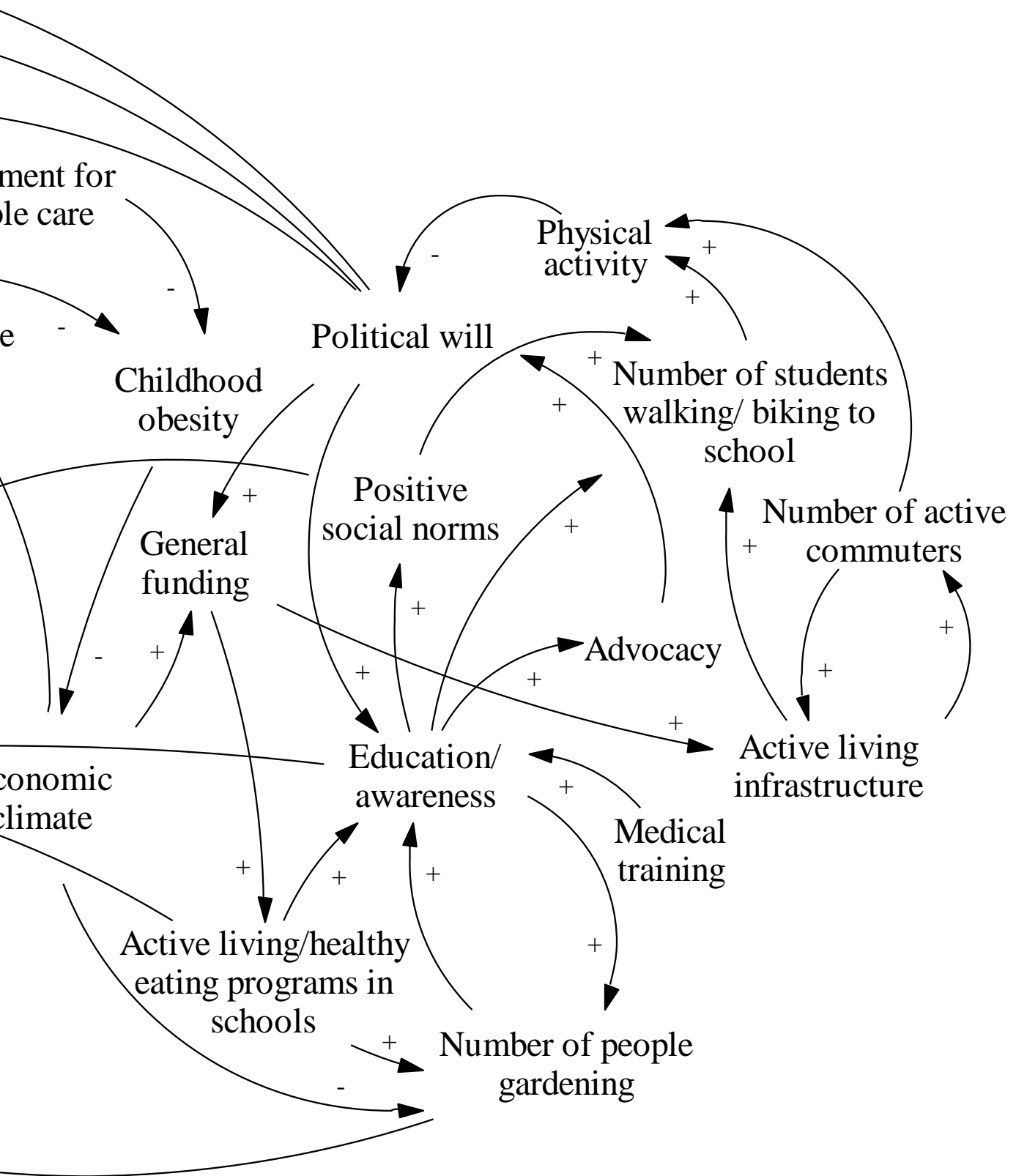
Zagonel, A. and J. Rohrbaugh (2008). Using group model building to inform public policy making and implementation. Complex Decision Making. H. Qudart-Ullah, J. M. Spector and P. I. Davidsen, Springer-Verlag: 113-138.

Appendix A: Behavior Over Time Graphs Generated during Site Visit

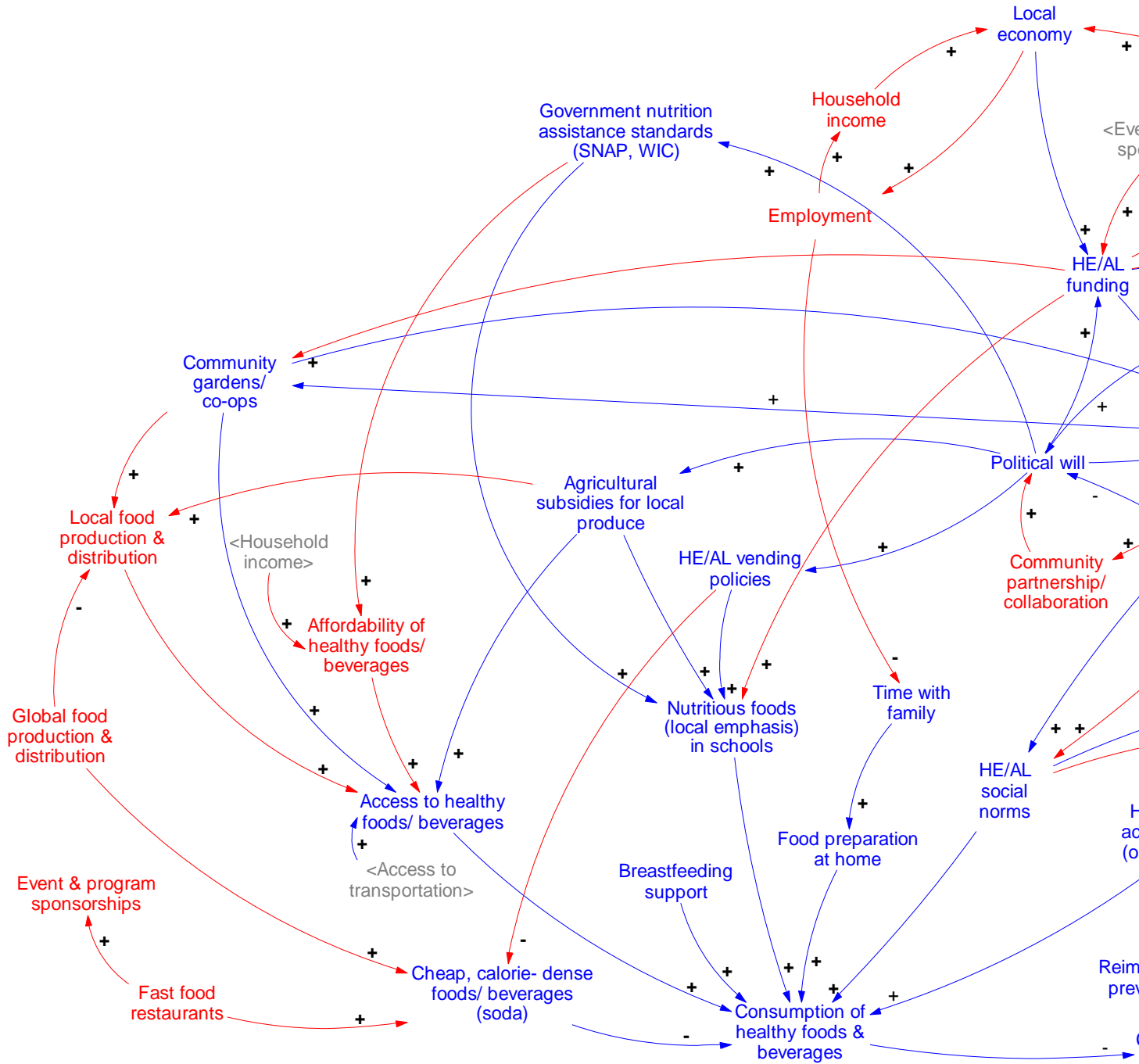
Houghton County, Michigan: <CP name>	
Categories	Number of Graphs
Active Living Behavior	14
Active Living Environments	2
Funding	4
Healthy Eating Behavior	5
Healthy Eating Environments	6
Marketing and Media Coverage	0
Obesity and Long Term Outcomes	1
Partnership & Community Capacity	0
Policies	1
Programs & Promotions (Education and Awareness)	6
Social Determinants of Health	0
Total Graphs	39

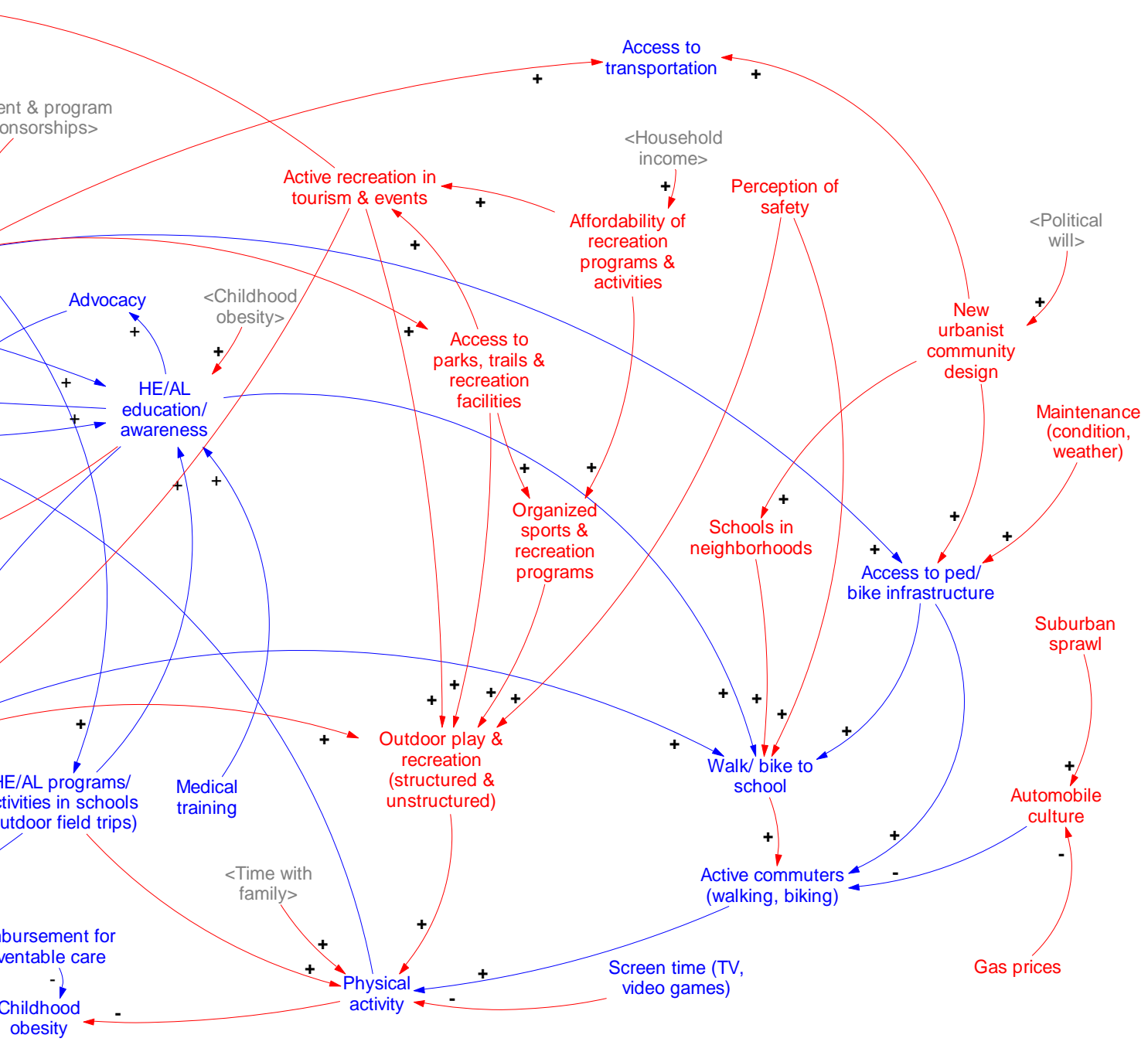
Appendix C: Original Translation of the Causal Loop Diagram into Vensim PLE





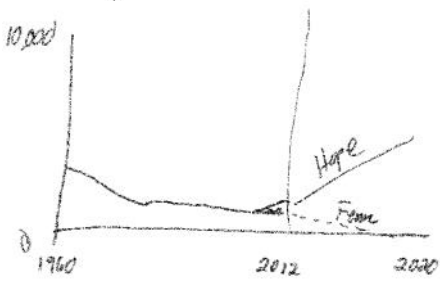
Appendix D: Transcript Translation of the Causal Loop Diagram into Vensim PLE



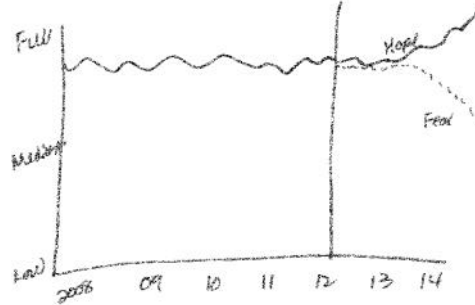


Appendix E: Behavior Over Time Graphs not Represented in the Storybook

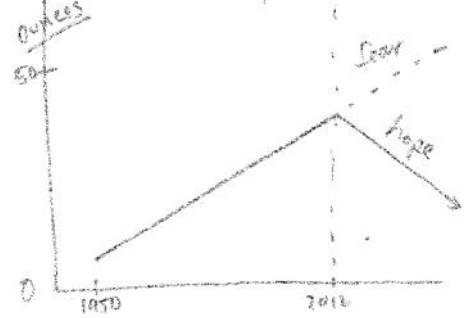
Number of People walking & Biking to MTU/work



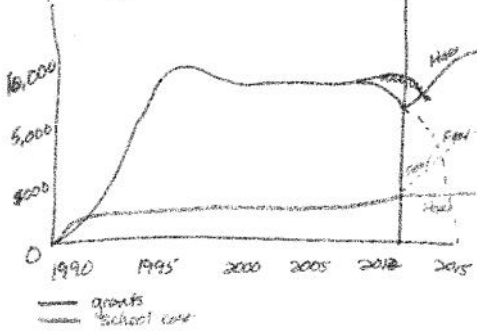
Funding for PD + leadership team, Outdoor + watershed ed.



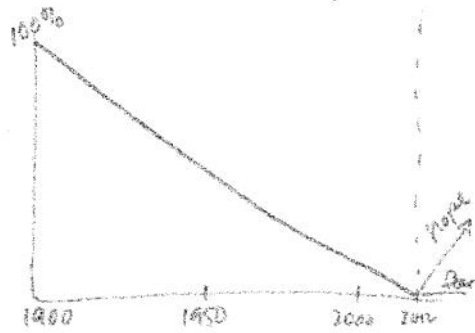
Child daily soda consumption



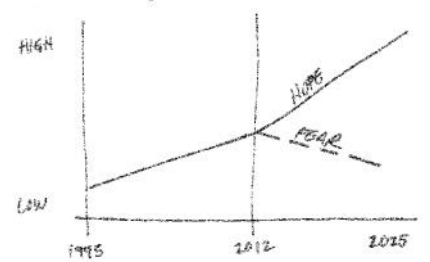
Funding for outdoor field trips



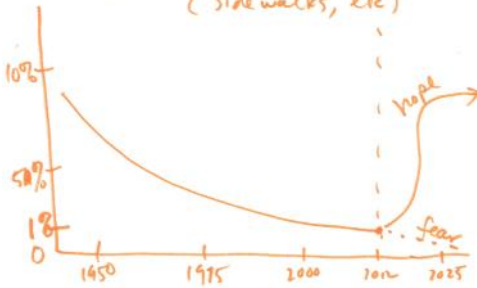
Children work in gardens



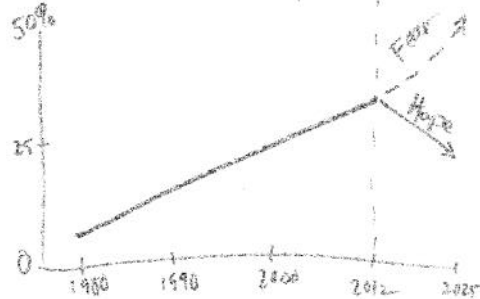
NUMBER OF VISITORS SEEING ACTIVE RECREATIONAL OPPORTUNITIES (NON-MOTORIZED)



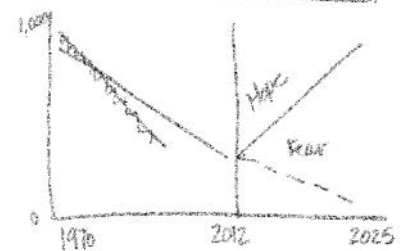
% of transportation funding dedicated to non-motorized (sidewalks, etc)



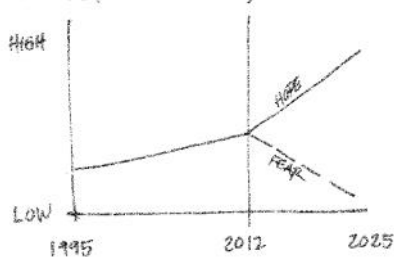
Childhood Obesity



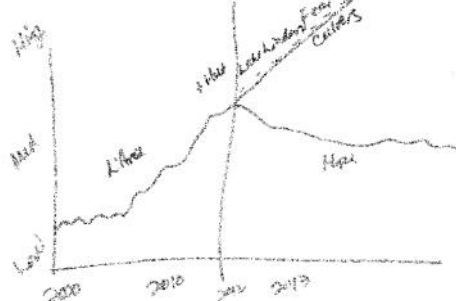
Children's Physical Activity Levels - Tennis Play



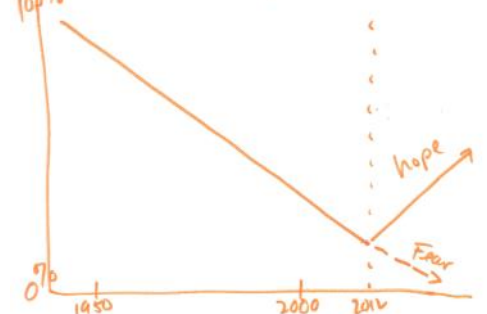
MILES OF ALTERNATIVE TRANSPORTATIONAL ROUTES (NON-MOTORIZED) CONSTRUCTED

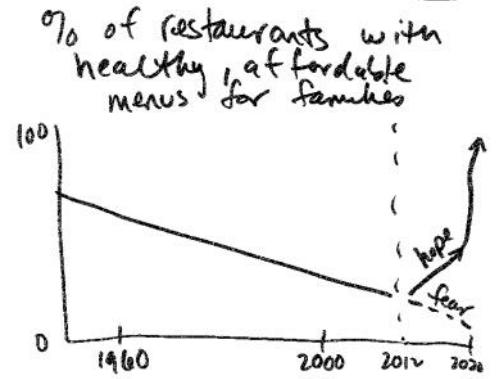
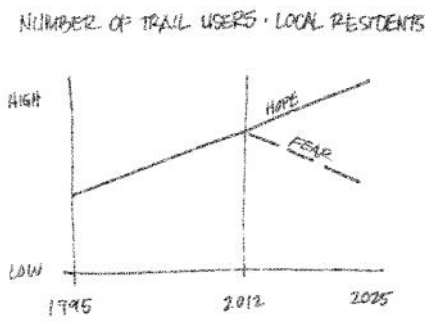
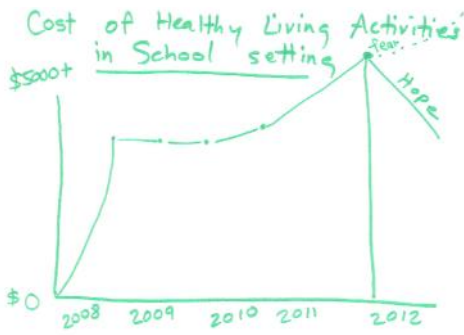


Calories consumed through frozen custard in St. Louis, Mo

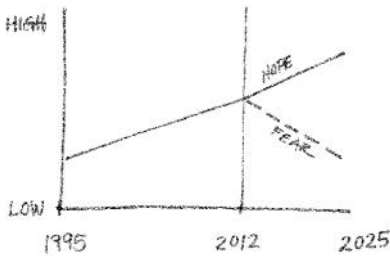


Students walk / bike to school

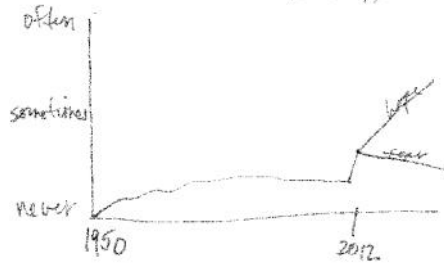




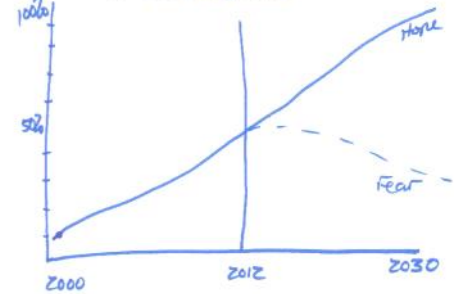
MILES OF RECREATIONAL TRAILS (NON-MOTORIZED) CONSTRUCTED/MAINTAINED



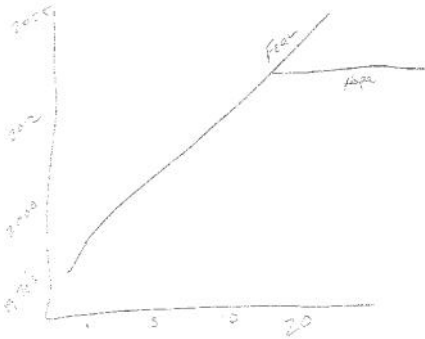
Availability of whole/organic foods in schools (in addition to junk food)



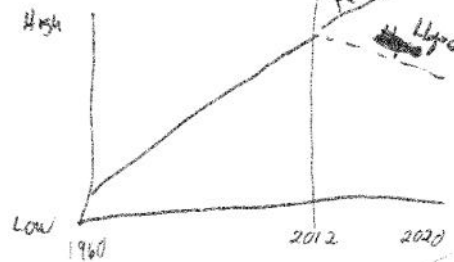
% of food served in schools that is nutritious, non-calorie dense, with local emphasis.



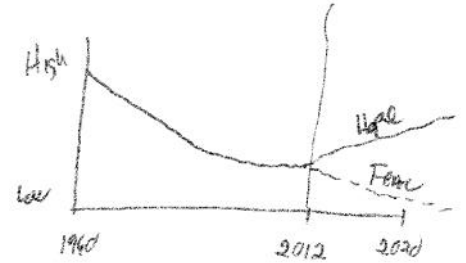
Fast Food Availability



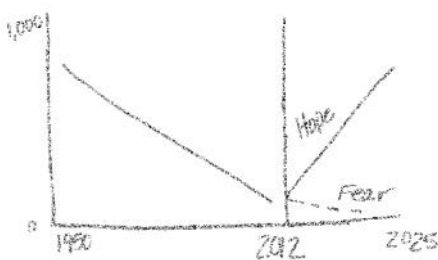
Amount of Time Kids Spend watching TV, Computer use etc



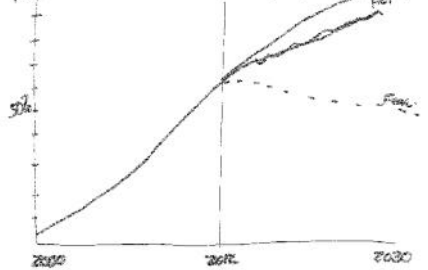
Number of Kids THAT Have To Shovel Snow Before School



Children walking to school



Awareness of Obesity as an important health problem affecting our community and solutions (nutrition)



Nutrition Education in Schools

