



A Report from the University of Vermont Transportation Research Center

# Bicycles, Transportation Sustainability, and Quality of Life

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## **Bicycles, Transportation Sustainability, and Quality of Life**

### **UVM Transportation Research Center**

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## **Disclaimer**

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the UVM Transportation Research Center. This report does not constitute a standard, specification, or regulation. See also:

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## 1. Introduction

The research presented in this report focuses on the exploration of a variety of objective and subjective quality of life indicators and approaches for bicycle transportation using a mixed methods approach. The authors have created a conceptual framework for assessing the relationship between quality of life, sustainability, and transportation, within the context of utility bicycling. In addition, this research serves to evaluate the opportunities and limitations of varied methodological tools useful for understanding these relationships. Two overarching questions drive this study:

- What relevance does the quality of life concept have for understanding the motivation, practice, perceptions, and experience of transportation cycling?
- What attributes of bicycle transportation enhance or detract from subjective perceptions and objective measures of quality of life, and how might those be studied?

Four aspects of bicycling and quality of life explored in this research are as follows:

- 1.) In order to analyze environmental challenges to bicycle commuters, we examined issues surrounding bicycle commuting in Vermont through in-depth content analysis of focus groups and individual interviews. Precipitation, cold temperatures, inclement road conditions, limited daylight hours, and wind were identified as uncontrollable deterrents to bicycling year-round, deterring many potential cycling trips. The treatment of these issues was found to be unique to individual cyclists based on their perceptions of the effects of subtle differences in climatic conditions on personal comfort and safety.
- 2.) The development of methods for modeling the impact of greenhouse gas mitigation in the transportation sector on the quality of life in Burlington, Vermont, is presented with respect to bicycling. While many people consider such a shift to be unfeasible in Vermont's northern climate, many of the world's most cycle-dependent cities have similar climates. This pilot study modeled the economic, ecological, and health impacts on quality of life under four different scenarios for bicycle use in Burlington: 6%, 15%, 55%, and 80% of all trips.
- 3.) In a third component of this research project we explored in detail the quality of life concept with a series of residents and bike users in Burlington, Vermont, using both interview and ethnographic methods. Burlington is a small city that ranks high on many popular "Best of..." lists, including most livable cities, best college towns, best outdoor towns, healthiest cities, best cities for retirees, etc., each of which draws from or emphasizes some set of assumptions or indicators related to "quality of life." Not coincidentally, many of the urban, social, and landscape characteristics that these lists prioritize are related closely to opportunities for everyday bicycle use. Further, as a university city with thousands of automobile-free students and as a tourist destination with outstanding recreational cycling and touring opportunities along the city's lakefront bike path and in surrounding towns and landscapes, bicycles are common if not ubiquitous on city streets and bike paths. In this part of the study we examined the quality of life concept in a small city with an orientation towards increasing bike modal share.

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4.) Addressing the question, “Do green values drive evolution of bicycle transportation and culture?” a study in Portland, Oregon, drew on three principal sources of information: urban bicycle planning documents, interviews with planning professionals and bicycle commuters, and participant observation. While bicycling is often touted as a green solution to energy use and climate change, it has not been clear whether this actually motivates people to choose bicycle commuting as their main work transportation.

Overall, this project evaluates the relative possibilities of transportation-related applications of the quality of life concept within the context of the experience of bicycle transportation. Exploration of this relationship has been largely absent in the literature connecting quality of life, transportation, and transport sustainability. By studying the social perceptions of bicycle use and its related impacts on quality of life, this project furthers the understanding of the viability of bicycles as a sustainable alternative to motorized vehicles (Environmental Protection Agency, 2011) and supports the facilitation of bicycle transportation through relevant changes to policy, public perception, and infrastructure to promote health, environmental, economic, and community benefits of cycling.

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## **2. Background**

### **2.1 Quality of Life**

Quality of life, often defined as a sense of wellbeing stemming from various aspects of life that are important to an individual person or community, as well as methods for measuring it, have long been discussed and debated within scholarship on the provision of healthcare services (Farquhar, 1995; Ferrans, 1996; Hirth et al. 2000; Donaldson et al. 2011) and to a lesser extent, the settlement dynamics of urban neighborhoods (Blomquist, Berger and Hoehn, 1988). Early quality of life studies were largely quantitative and focused on potential wellbeing among a variety of scenarios in a certain realm of life, whether related to economics (Morris, 1979), environment (Baumol and Oates, 1975), or health (Strauss et al., 1984; Croog et al., 1986; Guyatt, Feeny and Patrick, 1993). The original use of the phrase focuses on human health (Farley, Costanza and Templet, 2002), as the medical community led quality of life research through the 1980s and beyond. As the concept has spread into other fields, its definition has expanded to “how well human needs are met or the extent to which individuals or groups perceive satisfaction or dissatisfaction in various life domains” (Costanza et al., 2007).

The concept of quality of life spans environmental, social, and economic contexts that are dependent on time, geography, and demographics (Doi, Kii and Nakanishi, 2008; Steg and Gifford, 2005). The maximization of quality of life is considered to be an underlying motive for many short- and long-term decisions, and is often balanced with a desire to minimize costs (Blomquist et al., 1988). Quality of life can be measured using both quantitative and qualitative methods, including through comparative economic values over time (Hirth et al., 2000). The multitude of possible quality of life inputs and their widely varying characteristics make even the most rigorous measurements of quality of life somewhat subjective (Donaldson et al., 2011). Recent research on quality of life suggests that built, natural, human and social capital all make substantial contributions to perceptions of quality of life and should be integrated into any suitable quality of life indicator (Costanza et al., 2002; Costanza et al., 2007; Costanza et al., 2008; Farley et al., 2002).

### **2.2 Transportation in Quality of Life Studies**

Within transportation scholarship, interest in quality of life has also grown in recent years, primarily as a means to consider how transportation systems relate to issues of community livability, levels of service, user satisfaction, and system accessibility. Relevant studies have focused on how increased transportation options can improve quality of life (Feng and Hsieh, 2009); the role of infrastructural modifications, including greenways, multi-use pathways, pedestrian amenities, and streetscape redesign, in enhancing community and individual perceptions of quality of life (Shafer, Lee and Turner, 2000; Leslie et al., 2007; Coulson et al., 2011); normative goals of accessibility and livability as they relate to transportation (Doi et al., 2008); the quality of life dimensions of transportation systems for the elderly (Metz, 2000; Banister and Bowling, 2004; Spinney, Scott and Newbold, 2009; Webber, Porter and Menec, 2010); the impacts of sustainability-related behavioral changes in transportation on perceptions of quality of life (Steg and Gifford, 2005); and the potential that quality of life studies have to shape transport pricing and to inform the construction of sustainable transportation legislation and other policies (deGroot and Steg, 2006; Howard, 2007). Transportation, as one among many factors

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affecting quality of life, interacts and contributes to satisfaction in other domains, thus impacting overall wellbeing (Banister and Bowling, 2004; Sirgy, Lee and Kressmann, 2006).

Research in sustainable transportation systems has increasingly recognized the quality of life dimensions and impacts of distinctive forms of mobility, particularly the negative impacts of automobile usage on quality of life. Despite this knowledge, many factors have prevented bicycling from becoming a major transportation system in the United States as it has parts of Europe and Asia (Pucher et al., 2011; Heinen, van Wee and Maat, 2010) due to issues impacting bicycle ridership, including bicycle and motor vehicle ownership, safety, connectivity, environmental context, perceived distance, and attitudes toward cycling (Emond and Handy, 2012; Pucher et al., 2010; Southworth, 2005; Xing, Handy and Mokhtarian, 2010). Although in popular discourse bicycles have gained a reputation for enhancing quality of life, little systematic research exists on the actual relationships between bicycles, transportation sustainability, and quality of life. Many aspects of quality of life are affected by transportation cycling, and those aspects are highly individualized based on both the experiences that cyclists have had on their bicycle and the circumstances leading to their adoption of active transportation. Cycling presents a different set of experiences than any other type of transportation, including unique sets of preparations, concerns, and gratifications.

### **2.3 Active Transportation**

Active transportation improves both physical and mental health, and associated reductions in air pollution further decrease morbidity and mortality (Ganten, Haines and Souhami, 2010; Bassett et al., 2008; Shephard, 2008; de Nazelle et al., 2011; Bopp, Kaczynski and Campbell, 2013). Specifically, active transport contributes to “reductions in the prevalence of ischaemic heart disease, cerebrovascular disease, depression, dementia, and diabetes” (Woodcock et al., 2009: 1930). While increased cycling may initially expose more cyclists to collisions with automobiles, broad increases in cyclist numbers have also been shown to increase driver awareness of cyclists and in turn reduce accidents per mile ridden. Indeed, beyond a certain level of ridership, there is likely to produce a net safety improvement (Wei and Lovegrove, 2012), though where that “tipping point” is continues to be poorly understood. While driving is associated with stress and “road rage” (Smart, 2007), and commuting ranks as one of the most unpleasant experiences during a typical day (Kahneman and Krueger, 2006), aerobic exercise is associated with short-term mood improvements and lasting improvements in psychological wellbeing for the clinically anxious or depressed (de Geus et al., 2007). The average U.S. household spends over \$12,000 a year on car ownership (U.S. Department of Labor, 2011), while a bicycle costs an estimated \$390 per year, or \$975 for a “typical” 2.5-person household (Motavalli, 2009). Because bicyclists can park almost anywhere, biking can be faster than driving when parking sites are remote or scarce, and time savings increase when bicycle commutes replace time spent on other exercise. In addition, there is abundant empirical evidence that major reductions in CO<sub>2</sub> emissions by shifting to active transport (walking and cycling) is compatible with a higher community quality of life, financial health (Enkvist, Nauclér and Rosander, 2007), social capital (Rissel, 2009), the health of our natural environment (Rodrigue, 2013), and subjective wellbeing (Kahneman and Krueger, 2006).

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## 2.4 Impacts of Climate and Climate Change

Since the cyclist is open to the elements in ways that differ substantially from users of automobiles, buses, or trains, bicycle transportation is especially sensitive to weather and climate dynamics. The interaction of weather variables plays a role in deciding whether to commute by bicycle, and hesitant riders may not be swayed to increase cycling by the improvement of one factor alone (Dill and Voros, 2007). Flynn et al. (2012) surveyed 163 commuters over a 10-month period to identify the impacts of seasonality on bicycle commuting in Vermont, highlighting the fact that bicycle commuting in a northern environment comes with specific obstacles and weather variations that may not be a concern in warmer and drier climates. Temperature has been identified as a factor affecting bicycle ridership (Bergström and Magnusson, 2003; Hanson and Hanson, 1977; Parkin, Wardman and Page, 2008; Flynn et al., 2012; Thomas, Jaarsma and Tutert, 2013) and cycling frequency (Brandenburg, Matzarakis and Arnberger, 2004). Darkness is a prevalent factor contributing to cycling decreases during winter months (Nankervis, 1999; Cervero and Duncan, 2003). Previous studies have also identified sunshine, cloud cover, and street lighting as influences on bicycle ridership and safety (Hanson and Hanson, 1977; Klop and Khattak, 1999; Kim et al., 2007; Thomas et al., 2009; Thomas et al., 2013). The presence of precipitation, in all forms, influences bicycle ridership (Nankervis, 1999; Bergström and Magnusson, 2003; Cervero and Duncan, 2003; Parkin et al., 2008). Duration and intensity of precipitation affect cycling volume (Thomas, Jaarsma and Tutert, 2009; Thomas et al., 2013), although rain can be mitigated to some extent with waterproof clothing (Rietveld and Daniel, 2004). While rain may be uncomfortable, winter precipitation such as snow and ice are seen as dangerous or unappealing to cyclists (Stinson and Bhat, 2004; Flynn et al., 2012), and can result in higher injury rates for women than men (Nyberg, Björnstig and Bygren, 1996). Additionally, various road conditions have been found to affect bicycle ridership, including snow clearance, ice treatment, and driver interactions (Eilert-Petersson and Schelp, 1997; Bergström, 2003; Bergström and Magnusson, 2003). While measures such as snow removal, road salting, or sanding could mitigate cycling declines due to freezing conditions (Bergström and Magnusson, 2003; Winters et al., 2007), driver behavior (Horton, 2007; Mullan, 2012) and inclement conditions (Bergström, 2003) are difficult to control and cause concern about road safety. Differences in treatment of cyclists by drivers based on gender appear to exist (Walker, 2007), as well as differing perceptions of male and female cyclists regarding on-road safety (Garrard, Rose and Lo, 2008; Emond, Tang and Handy, 2009). Wind speeds also affect bicycle ridership (Thomas et al., 2009; Flynn et al., 2012; Tin Tin et al., 2012) due to the difficulty wind can add to riding (Nankervis, 1999; Rietveld and Daniel, 2004), with higher wind speeds affecting bicyclists more than pedestrians (Thomas et al., 2009; Heinen, Maat and van Wee, 2011; Flynn et al., 2012; Saneinejad, Roorda and Kennedy, 2012).

The scientific evidence for anthropogenic climate change grows stronger every year, as do concerns for its impact on human society and the planet (Barriopedro et al., 2011; Kerr, 2008; Costello et al., 2009; IPCC, 2007; Hansen et al., 2008). There is widespread agreement that temperature increases greater than two degrees Celsius over pre-industrial levels could prove catastrophic, disrupting agriculture, causing mass extinctions and inundating coastlines, among other ills, but less agreement about the level of atmospheric CO<sub>2</sub> concentrations that will trigger such change. Some scientists call for limiting CO<sub>2</sub> to 350 parts per million (ppm) of CO<sub>2</sub> equivalent (CO<sub>2</sub>e) (Hansen et al., 2008), while others believe we can risk up to 450 ppm CO<sub>2</sub>e (IPCC, 2007; Jowit and Wintour, 2008). Regardless of the final stock of atmospheric CO<sub>2</sub>, the

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emissions flow cannot exceed the net capacity of planetary ecosystems to absorb CO<sub>2</sub>, and hence must be reduced by at least 80% (Stern, 2006; IPCC, 2007). Current concentrations are now 400ppm CO<sub>2</sub> and 478 CO<sub>2</sub>e (Oceans at MIT, 2013). Immediate and dramatic emissions reductions to below the absorption capacity, at least temporarily, are required if we hope to reach even the larger target and stabilize the climate.

Unfortunately, we are currently doing almost nothing to address CO<sub>2</sub> concentration problems (Rogelj et al., 2010; Jasny, 2011; Davis, Caldeira and Matthews, 2010), and emissions, warming and impacts convincingly linked to climate change now significantly exceed the worst-case scenarios predicted by the IPCC's 1995 report (IPCC, 2007; Raupach et al., 2007; Kerr, 2008). There are many reasons that society has failed to respond to the threat of climate change, ranging from widespread denial of the scientific evidence (Jasny, 2011) to economists' claims that it will have little impact on economic welfare because it primarily affects agriculture, which accounts for only 3% of GDP (Schelling, 2007; e.g. Beckerman, 1996). Another reason may be the perception that doing so would have an unacceptable impact on quality of life. By addressing the role of transportation in emissions problems, we look to help mitigate current issues and move toward established air quality goals.

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### **3. Research Methodology**

#### **3.1 Approaching Quality of Life through Mixed Methods**

Despite growing interest in quality of life as it relates to transportation, this field remains generally under-researched, and methods for assessing the relationship between livability and sustainability goals need further development (Steg and Gifford, 2005; Carse, 2011). In a recent paper, Carse (2011) addresses this point by reintroducing the notion "Transport Quality of Life" (TQoL), an older concept which was once discussed as a means of assessing, appraising, and informing decision-making about transport policies and programs, but was hobbled by the perception of its left-leaning politics in Britain (Buchan, 1992; Hart, 1993). Carse applies the concept to users of public transportation, defining TQoL as the experience encountered by passengers as they travel. The strength of the TQoL concept, he asserts, lies in its holistic attention to the diverse factors that combine to shape user experience, which he conceptually divides into four domains: Economic (employment, vehicle travel, travel costs, congestion, etc.), Social (transport diversity, safety, disabilities, etc.), Environmental (global air pollution, local quality, noise pollution, etc.), and Personal (quality, access, availability, affordability, etc.). He observes that a passenger may not value his/her experience only on the cost of a journey, how quickly it takes, or how safe he/she feels, but on the basis of a much wider range of considerations that cross these domains (Carse, 2011: 1038). TQoL can be measured in objective and subjective terms, though Carse argues that "true" (subjective) measurements are especially powerful for eliciting the multiple considerations users make in appraising their experience, but recognizes that in-depth qualitative research capabilities are necessary for such research to generate rich and effective data.

Our research project departs from Carse's insistence on framing the quality of life concept in specific terms, in this case, how it relates to transportation experience. The broader issue here is

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that a critical understanding of transportation and mobility experience in everyday life begins with recognizing the plurality of modes, technologies, skills, and infrastructures related to movement (Jensen, 2009; Vannini, 2009: xvii). As one scholar observes, "...means of transportation are not mere conduits of space. Ships, buses, bicycles, yachts, trains, and training spaceship stations are the contexts of unique performances, dramas, experiences, and interactions" (Vannini, 2009: 11; Vivanco, 2013). In each of these contexts, the kind of movement possible (fast or slow, tracked or untracked, open or closed to the elements, collective or individual, etc.) is shaped by the technology involved as well as the environment in which it takes place, not to mention the physical and social infrastructure (roads, streets, ports, laws, regulations, institutions, etc.) and skill sets necessary to facilitate that movement (Pelzer, 2010). Different mobilities thus carry the potential for knowing, sensing, and interacting with the world in specific ways (Vivanco, 2013).

This project focuses on a mixed methods approach to understanding a holistic view of quality of life within the context of bicycling. It is motivated by a desire to better understand, contextualize, and test the validity of the widely held belief, reflected in popular discourse about bicycles, that riding a bicycle improves quality of life. To understand how the relationship between bicycle transportation and quality of life actually intersect, we must employ both qualitative and quantitative methods to form a complete understanding of the values behind this notion. By identifying and exploring the aspects of bicycling that contribute to and detract from perceived and actual wellbeing, we frame an approach for policymakers to effectively address nonmotorized transportation needs.

Mixed methods were used in this project in order to provide a holistic and multidisciplinary understanding of the relationship between quality of life and bicycle transportation. Qualitative methods used in this study include review of bicycle planning documents, interviews with planning professionals and bicycle commuters, and ethnographic participant-observation research in a range of social settings, including public streets, bicycle-oriented community events, and bicycle merchandizing settings. Quantitative methods include estimating impacts of cycling on health, monetary savings, pollution, and subjective wellbeing under various bicycling mode share scenarios.

### **3.2 Understanding Bicycling in Burlington, VT, and Portland, OR**

Interviews with utility bicyclists and transportation professionals were conducted in Burlington, Vermont, and Portland, Oregon, to elicit personal histories of bicycle transportation and perspectives on cyclist experience, practice, and perceptions of quality of life. The goal of this research was to offer a rich body of data, coded and analyzed for content and patterns, in order to understand quality of life with respect to cyclist experience and perception. Burlington and Portland display vast differences in climate (see Table 3-1 and Table 3-2), which is known to affect bicycle mode share (Flynn et al., 2012).

Table 3-1. Burlington Climate Statistics (National Weather Service, 2010)

	<b>Average High Temperature (°F)</b>	<b>Average Low Temperature (°F)</b>	<b>Average Number of Precipitation Days</b>
<b>January</b>	27.2	10.2	15
<b>June</b>	80.9	60.3	12

Table 3-2. Portland Climate Statistics (National Weather Service, 2012)

	<b>Average High Temperature (°F)</b>	<b>Average Low Temperature (°F)</b>	<b>Average Number of Precipitation Days</b>
<b>January</b>	45.6	34.2	17
<b>June</b>	72.7	52.6	9

Portland, Oregon, is one of three cities to receive a platinum rating by League of American Bicyclists, and has a long history of transportation planning, having passed a Bike and Pedestrian Bill in 1971 and its first bike plan in 1996. Portland currently has over 315 miles of bike lanes, 20% bike commuters in some neighborhoods, and over 100 bike shops and businesses. The city is known for its extensive best-practice infrastructure, including bike boxes, bike corrals, bike signals, bike lane markings, designated bike boulevards, and bike mileage signs. Free bike maps are available for all sections of the city and have been translated into five languages for New American communities. Various groups offer education programs for schools, SmarTrips workplace options, and bicycle legal clinics. Additionally, the 2030 Bicycle Plan, a comprehensive planning document, provides detailed guidelines to meet the city’s goal of at least 25% of all daily trips by bicycle by 2030.

Bicyclists in Burlington, Vermont, encounter a wide variety of daily and seasonal variations in weather, yet bicycling is an important aspect of the city’s recreational, cultural, and transportation networks, earning the city a Silver Level Bicycle Friendly Community designation (League of American Bicyclists, 2012). Transportation accounts for 27% of GHG emissions in the U.S. (U.S. Environmental Protection Agency, 2013) and 47% in Vermont (VT Agency of Natural Resources, 2011), and globally emissions are growing faster than in any other energy sector (Woodcock et al., 2009). An estimated 56.3% of commuters in Burlington drive to work alone in cars, trucks, or vans, 9.7% carpool, 20.5% walk, 4.6% use public transportation, and 4.5% use other means of transportation (USA.com, 2013). The average commute in Burlington is 16.4 minutes, one-third less than the U.S. average (USA.com, 2013) and Burlington is a relatively small city (16 square miles), suggesting that bikes could provide a practical low-carbon transportation alternative. In terms of energy use, a bicycle is the most efficient form of transportation known. While there is common perception that winter biking in Burlington is

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impractical, there is an appearance of growing numbers of year-round cyclists in the city, and many of the cities with the greatest level of bicycle use have climates similar to Burlington's (Ligtermoet, 2009).

While Portland is a larger city with a much more developed bicycling system, interest in bicycling in Burlington has grown rapidly in recent years. Vermont's various emissions reduction goals (see Section 4.2 of this report) make it an ideal location to grow alternative transportation, despite challenges such as a relatively small population and a harsh climate. Meanwhile, Portland is seen as the highest standard for bicycling in the United States. The goal of researching both cities was not develop a point-by-point comparison of how cycling and quality of life intersect with each other in the two cities. The differing social, economic, infrastructural, and climatic conditions of the cities, which in turn produce differing experiences and perceptions among people of cycling as an activity, in part prevents such point-by-point comparison. In addition, although researchers working in Burlington (Vivanco, Watts and Spencer) and Portland (Kaza) developed and employed the same open-ended questionnaire (see Table A-4 in the Appendix), the emergent nature of qualitative interviewing and participant observation, as well as differences in researcher investment in the community and epistemologies, resulted in differing data, interpretations, and emphases. However, by using these two different bicycling contexts, we are better able to consider the current and potential impacts of bicycling on quality of life under a wide variety of conditions.

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## 4. Results

### 4.1 The Effect of Environmental Factors on Bicycle Commuters in Vermont: Influences of a Northern Climate

In order to address climatic issues relating to quality of life, we examined how bicycle commuters perceived and represented the ways their bicycling practices were impacted and shaped by northern environmental conditions through content analysis of in-depth interviews and focus groups. This rich examination of environmental impacts on cycling allow for the identification of distinctions that create a lexicon specific to bicycle commuting in northern regions. To draw out the details of the environmental context, we focused on two questions:

- What role does individual preference for environmental conditions play in cycling to work?
- What environmental factors affect the experience and desire to ride for bicycle commuters in a northern community, and do these factors have the same consequences on cycling regardless of severity?

This study focused on developing the understanding of the behavior and attitudes of bicycle commuters in response to specific weather conditions within the context of the greater Burlington region of Vermont. Results of this study are instructive to policy-makers seeking to increase bicycle commuting in similar regions experiencing a wide range of weather conditions. Previous studies of environmental impacts on cycling in the Burlington area found that morning precipitation, low temperatures, increased wind speeds, and snow negatively impacted the likelihood of commuting by bicycle (Flynn et al., 2012; Sears et al., 2012).

A total of 24 adult bicycle commuters, age 22 to 64 years, were interviewed in four focus groups (n=19) and five personal interviews during 2008 and 2009 as an initial phase of a survey study (Flynn et al., 2012). A combination of focus groups and interviews allowed for the expression of ideas regarding bicycle commuting in both individual and group settings. Participants were recruited using posters and newsletter notices at selected local businesses and were paid a modest incentive. Individual interviews and focus groups were conducted using a semi-structured guide over 60 to 90 minutes. All sessions were audio recorded for subsequent transcription. Two individual interviewees were female and three were male. The focus groups were divided by gender, with two women's groups (n=7) and two men's groups (n=12). The methods used in this research were reviewed and approved by the Institutional Review Board at the University of Vermont.

Interview and focus group facilitators asked similar questions of participants, with varying order and clarification questions specific to the flow of each session. All participants were asked specifically about their likes and dislikes concerning bicycle commuting, factors influencing their decision to bicycle commute, daily and seasonal commuting habits, personal definitions of trips by bicycle, policies and procedures that would facilitate year-round bicycle commuting, workplace support of bicycling, opinions on existing infrastructure, and how to recruit other bicycle commuters for the study. Transcripts were manually coded for discussion of environmental factors rather than using search criteria in order to ensure thorough data collection and interpretation. Environmental coding categories were determined by participant discussions

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rather than predetermined solely by previous indicators compiled from other studies. The following environmental categories were identified and coded: precipitation (rain, snow, and ice), light conditions, temperature, road conditions (plowing, road salting, and driver interactions), wind, and a category for “general weather,” referring to interactions between unspecified weather variables. The categories of precipitation, light conditions, wind, and temperature were consistent with the environmental variables identified by previous studies. The inclusion of ice as part of the precipitation category and the entire road conditions category were added because they were identified as important recurring environmental topics across transcripts. All variables were coded at the individual thought level, rather than by sentence, to allow for better representation of the issues discussed by interviewees and focus group participants.

Study limitations include the subjective nature of transcript coding, the exclusion of non-cyclists from the data set, and a relatively small sample size. The results of this study may not reflect the views of all bicycle commuters in the Burlington area, and it is likely that other regions would pose unique environmental barriers to active transportation.

Temperature, general weather conditions, snow, and rain were mentioned in all focus groups and interviews (see Table 2-1). Consistent identification of these issues by all participants suggests that these issues may affect a broader group of bicycle commuters in Burlington, despite the small sample of bicycle commuters in this study. All focus groups touched on plowing, general weather, rain, snow, light conditions, and temperature. Ice was discussed in all focus groups except Women’s Focus Group 1. The only focus group to discuss road salting was Men’s Focus Group 2. Wind was discussed in one men’s focus group and one women’s focus group. Road salt was the only environmental indicator identified by one gender and not the other. For interviewee quotations demonstrating the importance of the identified factors, see Appendix (Table A-1).

Safety was seen as a major issue among all identified environmental variables. While some commuters identified certain conditions in which they would ride during the winter, others saw winter as fundamentally closed to cycling. Collision and injury fears were not unfounded—over 51,000 bicycle injuries were reported in the U.S. in 2010, with many more unreported (Pedestrian and Bicycle Information Center, 2012). The view that drivers might be out of control in the winter greatly influenced the cyclists’ decisions about whether to commute in non-ideal environmental conditions.

While previous research indicated that differences in bicycle commuting patterns do exist between genders (Garrard et al., 2008; Krizek, Johnson and Tilahun, 2005; Heinen et al., 2010), the findings presented here indicate that these disparities do not arise from environmental conditions (see Table 3-1-A). Previous bicycle and gender studies have found that women’s low rate of cycling in the U.S. may be connected to safety concerns and risk aversion (Garrard et al., 2008). We concluded that weather and environment affected commuting regardless of gender because exposure to various environmental conditions was a personal choice rather than a gendered one.

Table 4-1. Gender Differences in Environmental Factor Discussion in Transcripts

	<b>Men</b>	<b>Women</b>
Weather Condition	% of Total Segments Coded for Environment	% of Total Segments Coded for Environment
Combined Weather	10.7%	15.6%
Plowing	7.4%	3.9%
Rain	19.8%	18.2%
Snow	14.0%	10.4%
Ice	8.3%	11.7%
Light Conditions	15.7%	14.2%
Temperature	17.4%	18.2%
Road Salt	3.3%	0%
Wind	3.3%	7.8%

Temperature was discussed in both exact values and general comfort levels. Temperatures were often compounded by other factors such as less daylight, freezing precipitation, and variable road maintenance. While riders discussed mitigating cold through clothing adaptations, it was the combination of weather factors that motivated each individual. Temperature was considered in a variety of ways because it referred to a variety of conditions. Unlike in warmer areas where heat-related illness could be a danger to cyclists, upper temperature limits for bicycle riding were rarely discussed. Cold temperatures specifically were seen as either a negative factor or an unimportant issue, depending on the participant. While earlier studies have documented negative effects from cold temperatures (Nankervis, 1999; Winters et al., 2007; Flynn et al., 2012), commuters in this study exhibited a broad range of attitudes regarding acceptable temperature ranges for riding.

Light conditions were often a determining factor in the decision to commute by bicycle. If lighting was deemed insufficient, cyclists may have chosen to use another form of transportation. Some commuters described specific times of year that lacked sufficient daylight hours to allow them to bicycle safely and comfortably, while others expressed concern when factors such as precipitation were compounded by darkness, suggesting that a combination of environmental factors limited bicycle commuting. Lighting was primarily a safety concern, revealed through anecdotes of other cyclists crashing or having near-misses on roadways. While light conditions were not a worry for all cyclists, their role as a decisive factor for some showed the importance of

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considering roadway lighting when developing transportation networks. Feelings about riding in darkness were negative or indifferent. Unlike in previous studies (Bergström and Magnusson, 2003; Krizek et al., 2005; Heinen et al., 2011), we did not observe a meaningful difference in the treatment of light conditions between men and women.

Precipitation (rain, snow, and ice) was discussed in a more detailed manner than expected from previous literature. Rain and wind were not always viewed negatively, but rather seen as refreshing or helpful by some participants. Snow was described only as a negative condition for bicycling, while reactions toward ice were indifferent as well as negative. These much more defined reactions from commuters toward winter conditions often resulted in the use of other modes of transportation or clear changes in commuting behavior. The effect of precipitation on commuting patterns reflected the view that while summer conditions such as rain could be uncomfortable, winter conditions caused serious safety issues. This conclusion about negative effects of rain and snow follows the findings of Flynn et al. (2012), although our findings regarding tolerable rain conditions deviated from previous studies. Safety issues perceived in winter conditions aligned with previous research findings (Stinson and Bhat, 2004). Both genders discussed all precipitation categories and had similar reactions to discomfort and safety concerns. The treatment of weather as a constantly changing entity with distinct morning, afternoon, and evening conditions was clear in attitudes toward precipitation.

Road plowing and salting allow for safer driving conditions during winter months, but these road treatments are not designed to benefit cyclists in the same way. While few of the study participants believed they lacked control in inclement conditions, motor vehicle drivers were seen as out of control and unpredictable on snowy and icy roads, posing an additional threat to on-road cyclists who could be struck or forced out of safe conditions, supporting earlier studies of cyclist and driver interactions (Horton, 2007; Mullan, 2012). Male and female commuters reported similar sentiments regarding this issue. In addition to citing winter road conditions as being dangerous and messy for cyclists, participants expressed discontent regarding inconsistent off-road path plowing. Road plowing and salting, when discussed, were seen as factors that needed improvement. Future extensions of this research could assess the potential efficacy of increasing levels of service on bicycle lanes and paths to boost bicycle trips in winter in northern Vermont, following similar studies in other regions (Bergström and Magnusson, 2003; Winters et al., 2007). Road salt was never described positively for commuting, but was one of the least frequently discussed topics overall.

Wind was seen as an additional issue to deal with, but not a main determinant of whether or not to ride a bicycle. Wind was generally viewed as a negative aspect of riding because it made temperatures feel lower than they actually were and required more effort to pedal against. However, one interviewee suggested that wind was also a “friend” at times, presumably when it pushed a cyclist along. Wind was discussed by both genders, although infrequently overall. The mixed and indifferent feelings toward wind were less definitive than the clearly negative results of wind identified in previous studies (Nankervis, 1999; Rietveld and Daniel, 2004; Thomas et al., 2009; Flynn et al., 2012; Tin Tin et al., 2012). It is possible that wind would be more of a deterrent if paired with other inclement conditions such as precipitation, as the bicycle commuters participating in this study indicated that weather as a whole shaped their commuting practices.

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By identifying environmental factors, we see that both the perceptions and realities of commuting by bicycle are impacted by interacting variables related to weather, safety, and comfort. Subtle changes in weather conditions resulted in commuting shifts based on personal comfort and safety preferences, regardless of gender. The highly individualized effects of environment and weather on bicycle commuters seen in these results reflect the personal nature of the bicycling experience rather than generalized perceptions within a broader bicycling community that might be obtained from a survey approach.

#### **4.2 The Quality of Life Impacts of Achieving 350 ppm Atmospheric CO<sub>2</sub> in the Burlington Transportation Sector**

We hypothesized that a dramatic increase in bicycle transport in Burlington, Vermont would have positive impacts on quality of life, and developed detailed methods for scientifically testing and delivering preliminary estimates of these impacts. Using existing data and models, this research assessed the economic, ecological, and health impacts on quality of life under four different scenarios for bicycle use in Burlington, corresponding to levels of use in other cities: 6% of all trips (Portland, OR), 15% (Davis, CA), 55% (Copenhagen), and 80% of all trips (a number of cities in Europe between 1930 and 1960) (Ligtermoet, 2009). Scientific evidence that significant increases in cycling would improve quality of life could reduce political resistance to the transformation of regional systems of agriculture and transportation.

A number of factors make Burlington an excellent place to undertake this study. Vermont has an explicit goal of reducing emissions 25% below 1990 levels by 2012 and 75% below by 2050, which cannot be accomplished without dramatic reductions in transportation emissions, though negligible progress has been made so far (Vermont Agency of Natural Resources, 2011). Vermont is part of the Regional Greenhouse Gas Initiative to reduce emissions from the electricity sector, and has recycled 99% of the resulting revenue into energy efficiency measures (RGGI Inc., 2011). Vermont State Senate Bill 44, recently reintroduced as House Bill 385 (2011), proposes the creation of a Vermont Common Assets Trust (VCAT). This bill would “make it clear that state policy is to protect certain common assets (such as air and water) for the benefit of present and future generations, and to establish a framework pursuant to which certain users of those common assets may be assessed fees that would be deposited into a common assets trust fund, which would be managed so as to protect those assets and serve the interests of present and future people of the state” (Senate Bill 44, 2007, p. 1). The goal of protecting air as a common asset for the benefit of present and future generations implies restricting CO<sub>2</sub> emissions to no more than ecological absorption capacity. Though too small to have any significant impact on greenhouse gas emissions by itself, Burlington could serve as an important example as we transition toward a low-carbon future.

In order to assess the impacts on quality of life in Burlington for alternative scenarios concerning bicycle use, the following objectives must be met:

1. Estimation of the impacts of cycling on health, via the pathways of increased exercise, collisions and accidents, and reduced pollution;

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2. Estimation of the monetary savings to individuals of shifting from automobile to bicycle transportation, and (tentatively) the decrease in public sector maintenance costs for transportation infrastructure;
  3. Estimation of the reduction in CO<sub>2</sub> emissions and other forms of pollution associated with automobile use;
  4. Estimation of the impact on subjective wellbeing of increased bicycle use.

We use the same scenarios for all objectives: levels of Burlington cycling corresponding Portland (6% of all trips), Davis (15%), Copenhagen (55%), and select European cities from the 1930s-1950s (80%). We use the 2009 Vermont supplement to the National Household Travel Survey for much of our data requirements.

### 1. Health impacts

In order to estimate the health impacts of cycling, we adopt an appropriate combination of the methods applied in two related studies: Grabow et al.'s (2012) "Air Quality and Exercise-Related Health Benefits from Reduced Car Travel in the Midwestern United States" and Woodcock et al.'s (2009) "Public Health Benefits of Strategies to Reduce Greenhouse Gas Emissions: Urban Land Transport," which are carefully described in on-line appendices.

Grabow et al. used the Community Multiscale Air Quality (CMAQ) model from the EAP to simulate changes in hourly pollutant concentrations from a reduction in automobile use. They then used the U.S. Environmental Protection Agency Benefits Mapping Analysis Program (BenMAP) to estimate the impact on health. For the impacts on health of increased exercise, they applied the simple-to-use WHO Health Economic Assessment Tool for cycling and walking, which translates reduced mortality from bicycle use into monetary values.

Woodcock et al. used the comparative risk assessment (CRA) module of the Global Burden of Disease (GBD) 2000 study. This module allows for a "systematic evaluation of the changes in population health which would result from modifying the population distribution of exposure to a risk factor or a group of risk factors" (Murray et al., 2004, p. 3). The module is specifically designed to estimate the disease burden over time in response to a change in exposure to risk factors, and translates this into a summary measure of population health, and can be used to assess the impacts of both pollutants and physical inactivity (Ezzati et al., 2004).

Concerning the impacts of accidents resulting from increased bicycle travel, we assess the potential for using Woodcock et al.'s methods, which involve translating data on collisions between bicycles and cars and individual bicycle accidents into accidents per mile travelled by both cars and bicycles. Alternatively, we can assume that accidents per mile travelled will be the same as in the cities used for our comparative scenarios.

### 2. Monetary Savings

There is a wealth of studies on the economic costs of transportation alternatives, ranging from simple expenditures by individuals (U.S. Census Bureau, 2012) to full cost accounting (Garceau

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et al., 2013). A review of these studies can determine appropriate methods or simply present a range of possible costs.

### 3. Environmental impacts

There is also a wealth of studies on the environmental impacts of automobile use (e.g. Harrington and McConnell, 2003), which can be used to estimate environmental impacts.

### 4. Impacts on SWB

The study and assessments of subjective wellbeing (SWB) have become increasingly common in recent decades, and comprise a booming field in economics (see Boyce et al., 2010; Diener and Oishi, 2005; Easterlin and Angelescu, 2009; Kenny, 1999; Lane, 2000; Layard, 2005). The nation of Bhutan pursues Gross National Happiness, and even England has begun to track this variable. In the U.S., ongoing projects including the World Values Survey and the General Social Survey (GSS) collect cross-sectional and time series assessments of numerous social indicators, including questions on satisfaction with life and happiness.

Studies assessing subjective wellbeing find that commuting in a single-occupancy vehicle is the least pleasurable of typical daily activities, while socializing and exercising are among the most pleasurable ones. Commuting with another person increases pleasure to average daily levels (Kahneman and Krueger, 2006). This study hypothesizes that active transport will generate the highest levels of SWB, especially if done with a friend, followed by car-pooling then public transportation (assuming interaction with fellow passengers), with driving alone generating the lowest levels. Studies also show that exercise provides a boost in mood for some time afterward (de Geus et al., 2007) and improves learning outcomes in children. The study therefore also hypothesizes that active transport will boost overall levels of SWB and increase self-assessed measures of productivity.

Accurately measuring SWB is a challenge. Likert scale surveys of overall happiness or satisfaction with life as a whole are the most common approach, and survey results generally correlate fairly well with more objective quality of life indicators. However, results are also affected by mood, other short-term events, the sequence of questions on a survey, and so on. To overcome these problems, researchers have proposed a variety of methods known collectively as Evaluated Time Use. For example, the approach known as the Experience Sampling Method is designed to collect information in real-time natural settings. Subjects carry a handheld computer that alerts them at various times during the day, whereupon they must answer a series of questions about the activities they are engaged in and estimate their subjective wellbeing, typically on a Likert scale. In an alternative known as the Day Reconstruction Method, respondents must fill out a diary summarizing the day's events, provide key information about each experience, then report the intensity of their feelings for selected affective dimensions, both positive and negative. The Day Reconstruction Method has been found to reproduce the results of the Experience Sampling Method, but is easier to do with a larger sample size. One can reduce multiple affective dimensions into a single net affect, by subtracting the average score on negative effects (e.g. depressed, angry) from the average score of positive affects (e.g. happy, satisfied). One problem with intensity measures of affect is that it is difficult to compare stated levels of intensity by different people. Also, people experience positive affect far more often than

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negative affect. A solution to this is the U-index, which simply measures the proportion of time that the highest-rated affect is negative (Kahneman and Krueger, 2006).

The development and testing of a series of questions for use in the Day Reconstruction Method determine if it is a suitable method for comparing the impacts of different modes of transportation on SWB. We estimate the net effect of different forms of transportation as well as a U-index, which can be used to determine if modes of transportation affect the length of time during a given day that a negative affect dominates. The selection of a random sample is a significant challenge, as it is not possible to randomly assign individuals to different modes of transportation. Quite possibly, levels of positive or negative affect influence the mode of transportation people adopt, which would bias results. Burlington's severe winter weather presents one possibility, in that many people who engage in active transport, particularly biking, stop doing so in the winter. This gives us the opportunity to compare SWB when people switch modes of transportation. However, since inclement weather occurs at the same time as seasonal affective disorder (SAD), SWB could potentially change for all survey participants. We hypothesize that SWB decreases more for those who stop biking than for those who continue doing so. For future iterations of this study, we will try to recruit volunteers to change their mode of transportation, in particular finding volunteers for undertaking active transport in the winter.

There exist innumerable studies of the impacts of climate change on ecological and physical processes and on steps we can take to mitigate change, but far fewer on the specific impact of mitigation on quality of life. One notable exception to this is a special issue of the prestigious British medical journal *The Lancet*: "The Impacts of Climate Change and Climate Change Mitigation on Human Health" (Costello et al., 2009), which has significantly influenced this research. There are also many studies on the economics of climate change, but most of these reduce quality of life to the single indicator of GDP, with frequently absurd results. For example, in assessing the potential impacts of climate change, 2005 Nobel Laureate Schelling concludes that "[a]griculture and Forestry are less than 3% of total output, and little else is much affected. Even if agricultural productivity declined by a third over the next half century, the per capita GNP we might have achieved by 2050 we would still achieve in 2051" (Schelling, 2007). However, even the Stern review concludes that losing eight months of income growth is too high a price to pay for dramatically reducing the chances of ecological catastrophe. Such studies strongly influence the policy debate, and politicians are unlikely to take the necessary measures to address climate change if they believe they will cause misery. Furthermore, few studies focus on the impacts of mitigation for a specific city, and none that we know of on Burlington, Vermont. This project will provide a much more comprehensive assessment of quality of life impacts, focusing on health, personal finances, social capital, and SWB.

The outcome of this project is a rigorous scientific assessment of the quality of life impacts of the necessary transition to a low-carbon transportation sector on citizens of Burlington, Vermont. A study by the Union of Concerned Scientists found that food and transportation are the most harmful environmental choices we make (Brower & Leon, 1999).

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### **4.3 Burlington Quality of Life Study.**

Burlington, Vermont, is a small city that ranks high on many popular “Best of...” lists, including most livable cities, best college towns, best outdoor towns, healthiest cities, best cities for retirees, etc., each of which draws from or emphasizes some set of assumptions or indicators related to “quality of life.” Not coincidentally, many of the urban, social, and landscape characteristics these lists prioritize are related closely to opportunities for everyday bicycle use. Further, as a university city with thousands of automobile-free students and as a tourist destination with outstanding recreational cycling and touring opportunities along the city’s lakefront bike path and in surrounding towns and landscapes, bicycles are common if not ubiquitous on city streets and bike paths. The city also boasts a strong, nationally-recognized nonprofit organization, Local Motion, promoting “people-powered transportation and recreation for healthy and sustainable Vermont communities,” and a series of municipal governments that have made varying commitments to improving or sustaining conditions for everyday use of bicycles through certain (mostly minor) infrastructural and programmatic investments. All of these factors contributed to the city’s designation at the Silver level in the League of American Bicyclists “Bicycle Friendly Communities” Program in 2012.

Yet for transportation cyclists in Burlington, patterns of auto-dominated city traffic and inconsistency in infrastructural conditions to support cyclists’ particular needs and patterns produce a complex and heterogeneous mix of conditions. There is also heterogeneity among those who utilize bicycles for everyday transportation purposes, ranging from students without cars or middle-class individuals running errands by bicycle to low-income people working in the informal economy (such as bottle collectors) or refugees from various countries resettled by the federal government in Burlington, as well as bike commuters who live in the suburbs, who use the bicycle at different times of the day or night to get to and from work. Across these groups, levels of skill, commitment to transportation cycling, and the quality and condition of the bicycle itself and other equipment all vary, sometimes substantially. As a result, bicycle transportation is a highly contextual activity. Perceptions of the relationship between quality of life and the actual practice of getting around by bicycle are similarly contextual and heterogeneous, and are complicated by the inherent multidimensionality of the quality of life concept itself.

During the summer of 2012, twelve formal in-depth interviews ranging between 30 minutes and two and a half hours were conducted with professionals and committed volunteers involved in transportation planning and infrastructure management, bicycle advocacy, bicycle production and merchandising, and health research. Additionally, participant-observation research and informal interviews were conducted among bicycle commuters and utilitarian cyclists in numerous ethnographic settings, including community bicycle events/bike rides, a community bike shop serving low-income residents, and bicycle advocacy meetings and activities. Formal interviews and ethnographic data were coded and analyzed for relevant data related to quality of life.

#### **Defining “Quality of Life” and Articulating its Multidimensionality**

In Burlington, a connection between bicycling and “quality of life” is widely recognized among the range of informants we interviewed both formally and informally, yet there is no singular or universally accepted definition of quality of life or its actual relationship with bicycling.

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Some individuals carry an idealized and abstract notion of the concept of quality of life that ranges from a perception of individual utility, comfort, or satisfaction (such as the informant who defined it as “satisfaction with how you’re living,” interview 4) to setting an apparently higher bar of “enjoyment” or “happiness” with one’s life (such as the informant who defined it as “your average happiness throughout your day or your year or some timespan,” interview 3).

Others indicated that quality of life is a matter not reducible to individual or personal perception, however, but instead refers to systemic, infrastructural, or social conditions and factors beyond the individual that align to produce a certain kind of personal or community experience or character. As one informant (interview 11) explained “I guess I would think about it as whatever environmentally outside of one’s home affects their comfort, their happiness, their satisfaction with their home life, in a way. So it could be anything from their transportation, it could be the aesthetics of their surroundings, infrastructure, crime, it’s a really broad array of things... I think it also comes down to how much somebody really enjoys their life given the surroundings that are somewhat out of their control.” The reference here to “external conditions,” and the concrete impacts of those conditions on peoples’ lives, implicitly imagines quality of life less as a matter of subjective dynamics than the other definitions described above, and more as a set of objective characteristics and dynamics that shape subjective understandings.

To some extent, definitional differences align with social and professional position, as professionals involved in transportation and urban planning were more likely to emphasize external matters (viewing quality of life as a potential outcome, even target, of their labors), while those most closely involved in the activity as daily bicycle transportation riders themselves often approached the definition through a more abstract language of comfort or happiness.

There is a marked tendency among informants to not dwell on definitional matters, however, recognizing a kind of practical, if not also productive, multidimensionality in the concept of quality of life. Instead, informants were usually quick to identify specific dimensions, values, and informal indicators drawn from their own personal and professional experience that they believe lay the groundwork for or contribute to their notion of how bicycle transportation relates to quality of life. These dimensions can be categorized through their association with the following themes:

*Distinct phenomenological experience of transportation and sense of self:*

Most informants reported or recognized that the phenomenological experience of transportation is distinctive on a bicycle. This was captured by one individual who observed that by bicycle, “getting places was sometimes as interesting as where I was going... the actual transportation became something that was interesting and pleasurable, or interesting and difficult” (interview 5), adding that bicycle transportation is “endorphin producing, the fresh air, all the effects of moving your body as opposed to not moving your body.” Indeed other modes of transportation (such as walking and/or driving) can constitute, as described by interview 2, “a chore” set against the contrast of riding a bicycle, and do not engage the body in similar ways. That phenomenological dimension also touches on the bicycle’s role in exposing individuals to community and landscape aesthetics (interviews 1, 4, 11).

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Further, an association was often made between a positive sense of self and bicycle transportation. As one informant (interview 5) reflected, bicycle transportation produced self-reliance, a “counter-action to a depressive mindset,” and required “an act of will to do it...It gets me out of my shell a little bit. It was hard to relate to people through it but I could have a conversation about it.” The experiential difference of the bicycle, and the sense of self that derives from it is often contrasted with the sense of self that comes with the use of an automobile. As one informant expressed (interview 6), “not having access to automobile causes me to reshape my thinking. My philosophy of life is holistic; there’s always interplay between public health, safety, economics, environmental justice...I apply this to my personal life—I won’t drive a car to the gym. My quality of life is infinitely better when I’m just exercising and not thinking about it. It’s better, cheaper, healthier, greener...I use an analogy of the body is like a diesel engine: you’re always glowing, and when you fire it up it starts working...” It is not uncommon to hear such language connected to a language of personal “empowerment” (interviews 5, 6), as individuals noted the sense of self improvement, self-control, and flexibility in daily life introduced by the bicycle.

Several informants (interviews 2, 6, 7) distinguished a “sense of community” associated with transportation cycling, at the same time sharing the perception that it’s weaker than the sense of community among those who primarily ride for sport (referred to derisively by several informants as an elitist group). As interview 6 expressed, “There is a racing community yes, not so much commuter community. But I think it’s on the verge of getting bigger because I’m definitely seeing more people biking longer into winter months.” This informant followed up with a story about the people he has met on his daily commute who also ride bicycles, and he now feels a sense of connection with them. Several informants commented on the political potential of this growing sense of community (interviews 1, 4, 6, 7, 8, 10) but also felt that the bicycle transportation sector is still politically weak in Burlington.

This political weakness has important implications for quality of life, because as numerous informants described, there is also a strong sense of social marginalization associated with the bicycle, based on a lack of respect given to the activity by the mainstream community and/or other transportation users (interviews 3, 4, 5, 6, 7). As one informant (interview 6) who has been hit by automobiles while on a bicycle four times observed, “as a cyclist I experience a double marginalization. Bicyclists are subjugated in current reality, making it an inherently more dangerous activity. We’re also second-class road users...I have infinitely more at stake getting around by bike than a car driver...To categorize these things as the same legally is preposterous. That big lethal thing can kill me.” The positive sense of “empowerment” is thus tempered and/or complicated by a contravening sense of personal vulnerability and social marginality.

*Accommodating to a range of motivations, purposes, and practices:*

Informants commonly pointed to bicycle transportation as a flexible activity that accommodates a range of motivations, purposes, and practices. The bicycle, as expressed by one informant, “creates more flexibility in peoples’ lives and more empowerment...You’re taking yourself and moving yourself forward in that moment, in your life...it’s really different than taking a bus...you’re literally using your own energy to move yourself.” That flexibility was viewed as a matter of route choice and allowing individuals to bypass slower forms of transportation or

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circuitous routes (interviews 2, 3, 6), matters of convenience in parking (interviews 1, 7, 9, 12), and the open-access nature of the technology itself that make it affordable to keep running properly (interviews 5, 6). The bicycle was also singled out as a more “reliable” form of urban transportation since it is self-powered and doesn’t rely on others to organize it as a transportation activity (interview 2). At the heart of this dimension of flexibility for some is the notion that the bicycle affords one to exercise “choice” and “options” which are viewed as inherently connected to individual quality of life (interviews 3, 4, 6, 11).

The affordability and general financial and physical accessibility of the activity was identified as a key motivational factor by all informants, and especially singled out by those (e.g., interviews 5 and 6, as well as participant observation) directly involved in a community bike shop serving low-income residents. Affordability and accessibility were often closely connected to the type of work one did and/or access to a job, connecting in several cases to matters of community social justice (interviews 5, 6). Interestingly, affordability was often combined with other positive qualities (including speed, facility, and convenience) in one simple overarching description of how bicycles relate to quality of life: as summarized by interview 2, in addition to being cheap “it’s convenient, I don’t have a parking pass, it’s not that far, it’s quick.”

The improvement and/or maintenance of health was also universally identified as a major motivational factor associated with the bicycle, with most informants singling out bicycling for its transformative potential not just for the individual body but for public health. As interview 1 stated simply, “It is like medicine” by providing a less impactful (than running, for example) and more practical way of integrating exercise into daily life (making it a form of “multi-tasking”). At least two informants (interviews 1, 6) described bicycle transportation as an alternative to paying for and attending a gym. Several informants (interviews 5, 9) also described the bicycle’s role in maintaining mental health. Nevertheless, as one informant noted (interview 6), “The bike keeps me healthy. [But i]t also almost kills me... With the current layout of infrastructure it’s inherently more dangerous... you’re not protected, you’re vulnerable.” Another informant pointed to the dynamics of age that also shape bicycling: as he’s aged, cycling has become a more difficult and dangerous activity.

Various other quality of life values and purposes emerged in the interviews, including being outdoors in Vermont (interviews 1, 10, 12), feeling more engaged in the landscape through individual practice and tourism (interviews 1, 5), being able to connect to others in the community (interviews 1, 5, 6, 7), and as a rational and efficient use of public space (interviews 4, 7, 9, 11).

#### *Physical Conditions and Infrastructure as Facilitators and Deterrents*

Under current infrastructural and climatic conditions in Burlington, there is a strong sense among informants that there are both natural limits to the number of people who will get around by bicycle in the city (“we’re in a very fickle climate... you’re just not going to get a lot of people to bike in rain or snow... you get dirty...” interview 3), and that there is much that can and needs to be done to improve the level of service for cycling. It is felt that if these latter concerns are dealt with, the number of transportation cyclists and its perception as a legitimate activity that enhances quality of life will grow.

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Infrastructural issues are closely tied to perceptions about traffic danger and were often connected to concerns about safety. Their poor quality and/or absence were typically seen as having a negative influence on quality of life. As one informant expressed, “I think it takes some practice to know how to bike safely and not get into weird situations where you’re putting yourself in harm’s way” (interview 3). “Harm’s way” was almost inevitably referring to the fact that cyclists were often forced into sharing road space with motorists “jockeying left and right” (interview 4).

Most informants expressed support for some version of the “build-it-and-they-will-come” logic of transportation planning and infrastructure implementation in support of bicycles. Yet, significantly, one influential city transportation official did not, expressing “When I first started here, my basic philosophy was kind of like, if we build the infrastructure, people will come out and use it more. But that’s really only part of the piece we need to focus on, because, again, we can put a bike lane in, but it’s not going to attract everybody. You have to have the entire system...we now talk about engineering, education, encouragement, enforcement, and evaluation and planning. [Our goal is to] to create a system you can get more people out to bike.” At least one transportation official (interview 4) acknowledged that while support is in theory strong in the city for infrastructure improvements in support of bicycling, the combination of historically narrow streetscapes and the fact that “Neighbors don’t want to lose parking” produces practical and political problems for such changes, and, in his perception leads to a “chicken and egg” situation: “If we don’t provide the bike lane no one will go there, but until we provide it no one has gone there.”

Nevertheless, professionals involved in transportation and/or bicycle advocacy were typically quick to connect specific policies, such as “Complete Streets” (adopted by the city in 2011), and infrastructure treatments (including parking, traffic calming, bicycle lanes, cycle tracks, etc.) with enhanced quality of life for transportation cyclists (interviews 1, 4, 6, 7, 9, 11).

Not all transportation cyclists agreed with this position, however. As one informant expressed, “I didn’t need infrastructure. I don’t need bike lanes. I feel more comfortable taking the lane. Bike lanes give a false sense of security. I find that it is the condition of the pavement that affects cycling more.” This position is not necessarily surprising: this individual (as is true of various other informants) is already undertaking the activity and has figured out how to do it with minimal supportive infrastructural conditions. One cyclist (interview 6) adds a cautionary note about infrastructure-intensive approaches: “There are lots of ways to connect places. Some want to move on safe quiet streets and paths. For me, it’s like, f--k no, I’m not going to ride through six different neighborhoods and through a cul-de-sac on a bike path. It’s stupid. It’s like a road to nowhere...I would like a bike path right down the center greenbelt on Route 15...Put the bike first, then marginalize, subjugate the cars.”

It was universally acknowledged that while potential for bicycle transportation in Burlington is strong, its current realization is weak, especially vis-à-vis other cities (most of them much larger) that have made substantial financial and programmatic investments in recent years in promoting the activity. In Burlington, debate persists over how to move forward, especially how to unite a largely fragmented and diverse community into a strong voice for improving peoples’ quality of life through bicycling. What was not challenged, however, was the notion that bicycles intersect with quality of life in multidimensional ways, in some cases compromising individual quality of

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life but for the most part enhancing it. What makes this case study especially compelling is that people make strong associations between bicycle transportation and quality of life as a matter of course.

#### **4.4 Portland Quality of Life Study**

Portland is known as a bicycle haven in the U.S., and the city markets itself as bike-friendly in order to attract both people and industries for the high quality of life represented by support for bicycle commuting. One interviewee described the city's successful bicycling system aptly: "Portland makes it so easy to ride a bike" (interview 3). The contribution of bike-related businesses to Portland's economy has been documented by Alta Planning and Design (2008), and corporate interest in bike design and manufacture is on the rise (interview 21). United Bicycle Institute, the lead national training agency for bicycle mechanics, is based in Portland and is another draw for building bike-related business in the city. Bicycle tourism is supported by the city (Bureau of Transportation) and state (Ride Oregon Ride subdivision of Tourism) and is spreading to many areas of the state, turning cow towns into bike towns, and railways into bikeways.

While bicycling is often touted as a green solution to energy use and climate change, it has not been clear whether this actually motivates people to choose bicycle commuting as their main work transportation. In order to understand quality of life within the context of the Portland, Oregon, bicycling community, we asked, "Do green values drive evolution of bicycle transportation and culture?" Three principal sources of information were used to explore this question: urban bicycle planning documents, interviews with planning professionals and bicycle commuters, and participant observation during field research in fall 2011 and summer 2012.

Documents reviewed included the League of American Bicyclists Bicycle Friendly Community application (2008), the Portland Bicycle Plan for 2030 (2010), the Portland Plan (2012), the Bicycle Transportation Alliance 20-Year Strategic Plan (2011), and the BTA Blueprint for Better Biking (2005). This study is also informed by the social determinants of public health and the "5 E's" principles put forth by the Safe Routes to School National Partnership (2013), expanded in Appendix Figure A-1 and Table A-2.

Twenty-four interviews were conducted in June 2012, including 12 bicycle commuters, four bicycle-business-related professionals, seven urban planners and health professionals, and one bicycle advocate. Additionally, bicycle commuting to 13 of the interviews and participation in five bicycle events as part of Pedalpalooza 2012 provided firsthand experience to inform this study (for more information on Pedalpalooza, see Appendix Table A-3). Interviews were recorded, transcribed, and analyzed for relevant data regarding quality of life values.

##### **1) Quality of Life Values**

Safety and security values were discussed by 15 of 24 interviewees, which may indicate their prominence among quality of life values. Safety values included safe roads and infrastructure, being safe in relation to cars and drivers and other cyclists, and personal safety on a bicycle. As far as safe infrastructure, bicycle commuters value high visibility along the roadway, clear lighting for repairs as needed (interview 5), and green bike boxes and bike lanes, but may rely on

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them for more safety than they can guarantee (interview 1). Safety in relation to other vehicles was mentioned much more often, with one interviewee describing cars as “weapons” toward the human body (interview 14) and others pointing out the obvious fear of bike accidents and their consequences (interviews 5, 6). Distracted pedestrians (interviews 5, 9) and cyclists on sidewalks or other inappropriate places (interview 12) were also seen as problematic, although one commuter reported that drivers are generally attentive to bikes carrying children. Personal safety can also be increased by riding in groups or taking classes such as those offered through the Safe Routes to Schools program or at Portland State University (PSU). Security concerns related primarily to secure bike parking and storage, with some commuters choosing to use poor-quality bikes as a deterrent to thieves. Secure bike parking, especially that which is covered, caged, and/or guarded, as well as bike repair stations, encourage security in commuting.

The role of environment was primarily mentioned as a contributor to a valued sense of place in Portland, while benefits to pollution and other threats of degradation were mentioned the least and were apparently not a primary motivator for these interviewees. A PSU survey of bicyclists ranked environmental justice factors as low for student commuters (interview 23), though several riders did mention the value of clean air (interview 10) and their role in reducing carbon emissions (interview 6), as well as their satisfaction in not being as involved in the commodity chain (interview 11). A friend of one interviewee felt she was specifically providing an environmental service for her fellow citizens by not polluting and adding to the atmospheric carbon load. Bicycle commuting was seen as a way to learn the city, to gain a sense of one’s local community and neighborhood (interviews 10, 12): “I feel like you are just more in touch with your place when you start riding your bicycle” (interview 12), including the opportunity for an intimate experience with nature and exposure to the weather, the topography, and the river that shapes Portland: “When you get on your bike you’re immediately exposed to nature—mostly in the form of weather. I mean you know what the temperature is, and you know whether it’s raining, and you know whether it’s a little uphill or a little downhill” (interview 6). Most commuters felt the rainy and cold winter season was the most challenging, particularly motivation-wise (interviews 11, 13).

Economic benefits were reported at both the personal and the municipal levels, with seven interviewees offered financial incentives as a significant benefit for bicycle commuting, especially in comparison with vehicle ownership and maintenance or transit costs (interviews 11, 23). One person calculated he had saved thousands of dollars in gas purchases over his 13 years of commuting (interview 5), and another indicated the total cost of bicycle, trailer, and repairs over two years was under \$900. Specific financial incentives from businesses, as well as family lifestyle changes, were described as effective motivations for bicycling. Demand for housing close to the city center was also related to the increase in bike commuters, as that group relied less upon garage availability (interview 21). Community economic benefits that contribute to a supportive culture for bicycle commuting include revenue from a planned bike share program to open in 2014 that will offer rentable bikes for visitors and spontaneous lunch bike rides (interview 7), as well as bike-related events in cyclocross, mountain biking, road racing, triathlon, and touring (interview 3).

Convenience and self-reliance values were mentioned by nine interviewees, including topics such as travel-time improvement through avoidance of traffic congestion (interviews 5, 7, 13),

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availability of bicycle parking over car parking (interview 6), and increased ease when transporting a child (interview 19). Flat tires and other minor bike repairs can be fixed with relatively few mechanical skills, another time-saving convenience (interview 14). Self-reliance as a bicycle commuter was seen as practical and empowering. Portland bike commuters value having a choice of mobility options, from bike to public transit to walking. Bicycling is seen as the most efficient and self-reliant, not dependent on transit schedules or waiting for bus or train to arrive (interviews 14, 19). “Who wants that headache when you can get on your bike and get pretty much anywhere you need to in Portland?” posited one interviewee (interview 8). Portland bicyclists also exercised the freedom of bicycling through nonconventional activities such as moving an entire shop by cargo bike and bike trailer (interview 15) and pulling a house camper by bike (interview 16).

Health benefits of bicycle commuting included: weight maintenance (interview 20), mental clarity and stress relief (interview 5), general wellbeing and pleasure (interview 11), and a sense of personal success and independence (interview 13). For several people, bicycle commuting replaced the need for a gym workout by fitting exercise into everyday travel patterns (interviews 5, 6), which was also a strong motivator for student commuters (interview 23) and parents who have difficulty finding time for personal exercise (interview 19). Two bicyclists commented that city residents were more fit than those in the suburbs due to the ease of active transportation in the urban core (interviews 14, 16). The phrase “Portland-fit” was mentioned as being “from the waist down...rather athletic-looking, but from the waist to chest [indicating] the fact that we live in a city with a lot of good food and microbrews” (interview 14). Major health providers in the city, such as Kaiser Permanente and Providence, are working with the Northwest Health Foundation to build resilience as a preventive approach to health care that will reduce emergency room dependence.

The social benefits of bicycle commuting reflected in at least three different value sets. A number of people described how bicycle commuting, as a form of active transportation, was significantly higher in social encounters and communication on the street while riding. “[If you are a driver] you can go from your personal garage, and your personal car, to the garage of your work, so maybe you’ll share an elevator with people, but you don’t really have to have any sort of understanding of who else lives in your city (interview 8).” While many cyclists wish to reach their destination efficiently, many bicycle commuters see the opportunity to gain a sense of spontaneous community on the street as an added bonus: “The chance to have real interactions with real people is huge” (interview 20).

A second set of social values derives from the social networks that develop around bicycle commuting, which interacts and overlaps with a wide range of bicycle cultures (interview 3). Two large businesses support a Bike Buddies program to link up new and experienced commuters; online listserves also generate business-specific networks of bike commuters (interviews 9, 17). The bike room has become a new “water cooler” space for chatting with other commuters at work (interview 20). Particularly in large companies, employer support for bicycle commuting through shower and parking facilities, competitions, and employee listserves and regular reporting on numbers of bicycle commuters (interviews 9, 17) can make a big difference. There is great interest in competing for sustainability awards, from national honors such as from Practice Greenhealth, to community newspaper rankings of top bike-commuter-friendly businesses.

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Participation in large bike events with friends or family, such as the Providence Bridge Pedal, the Worst Day of the Year ride, and Bike to School programs engage bicyclists with a broader community. One person was very specific about the importance of traveling by bicycle to bike-related social events such as art openings or bike films (interview 12). Recreational interest in cyclocross and mountain biking are exploding in the Portland area and provide easy entry points for beginner cyclists, and there is interest in making a link between the Oregon Bicycle Racing Association and the Bicycle Transportation Alliance (interview 2). The alternative bike cultures that identify as bike “funniks” (interviews 18, 20) add theater, comedy, and entertainment into the mix (and often a lot of drinking, too). Zoo Bomb rides and Loud and Lit rides are open to anyone, adding a party element to bike riding that many young people find attractive. Although sometimes these user groups conflict, more often they have shared interests in maintaining support for bike riding of all kinds. In general there was a strong emphasis on the fun aspects of social networking, including the element of personal clothing style, wearing “bicycle chic” outfits or locally made bicycle products, as well as asserting character through rain gear (or lack thereof, with some choosing to carry dry clothes to change into at their destination [interview 11]) or helmet use, although at least two commuters (interviews 12, 20) felt the European model should be the standard, where cycling is safe enough to not need helmet protection.

The third area of social benefit reflected the value of citizen involvement in the transportation planning process. Two commuter veterans described the waves of bicycle activism in Portland as well as specific campaigns to address hazardous commute zones. With appreciation for the roles of the Bicycle Transportation Alliance (member non-profit) and the Bicycle Advisory Committee (city appointed), one activist felt that “Portland’s bicycle ridership population is under-empowered and is awfully quiet and docile” (interview 4). He attributed this to the fact that Portland had already achieved so much in support of cyclists that riders had become complacent, yet both BTA and the Portland Bureau of Transportation offer educational classes and events to encourage citizen bike literacy and advocacy.

## 2) Sustainability Values

Bicycle commuting was linked to sustainability initiatives in several large businesses and education systems, including Providence Health and Portland State University. Bike advocates served on internal sustainability councils where they could promote active transportation options as cost-saving and in line with an organization’s sustainability mission (interviews 9, 17). Through several city-wide planning networks such as the Portland Sustainability Commission, sustainability leaders reported a trend toward city-wide coordination. This includes planning for such complex city projects as a new transit- and bike-only bridge and integration of train, bus, and streetcar lines (interview 23). The Oregon Active Transportation Summit provides an opportunity to link bike and pedestrian issues through joint goals and projects (interview 3).

Informal sustainability networks are developing among diverse groups such as Safe Routes to School programs, those interested in accessibility to safe food in Portland, immigrant groups and advocates, and campus transit coordinators. Bicycle commuting advocates in Portland are actively promoting the evolution of sustainable practices in Portland businesses, especially by generating institutional pride and strengthening missions that support the values related to bike commuting. As more Portland businesses commit to sustainability values, active transportation becomes more highly incentivized as a contributor to Portland’s quality of life.

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### 3) Challenges to Quality of Life Values

While Portland is way ahead of most U.S. cities in its design solutions for bicycle commuting, interviewees involved in planning and advocacy urged the city to address bike congestion resulting from the significant increase in number of bicycle commuting trips (interviews 1, 7). Solutions include more citizen oversight and review of transportation design plans (interview 4), bike passing lanes, streamlined intersections, traffic calming, convenient self-repair stations, and attention to streetcar and train tracks for cyclists. Having an even more connected city with design solutions that allow bicycle commute traffic to flow easily in many directions will also require ongoing data collection to show use patterns and design effectiveness (interviews 8, 24) as well as commuter satisfaction.

Interviewees spoke clearly about the need to continue to normalize bicycle commuting as an everyday social option for Portland citizens through the maintenance and expansion of introductory cycling programs such as Sunday Parkways, cycling classes, and community cycling events. Interviewees felt that these need to be developed to reach college commuters, middle and high school students, women, and non-users in a wider range of cultural communities (interviews 2, 10). As in other cities, bike infrastructure improvements have disproportionately benefitted mostly white communities in the city to some extent, and engaging other communities may mean working more closely with health organizations on shared goals related to active transportation of all kinds.

Traffic conflicts reflect tension at points of congestion and higher hazard, such as areas where bicyclists “leapfrog” around bus stops and recreational trails that pose risks related to speed differences and congestion (interview 24). These risk points are crucial to future transportation planning and research in order to design effective solutions and take into account the expanding variety of bicycles in use for commuting (e.g. electric bikes, cargo bikes). Conflicts can also engage opinions and stereotypes of bicyclists and drivers, as well as historically reinforced privileges that even extend to specific neighborhoods (interview 19). Though Portland drivers are generally acknowledged as being more civil to cyclists than in many places (perhaps because many of these drivers are also cyclists), driver/cyclist behaviors and/or attitudes can still result in bike-car accidents, with blame placed in both directions. Bicycle commuters are generally committed to acting respectfully toward drivers as they want to receive respect and to counter general misperceptions of bicyclists, but interviewees acknowledged that bicyclists can be irresponsible too, particularly with non-commuter recreationists or tourists, or simply those who are less aware of the impact of their actions on others. Etiquette on the bike is valued by commuters, particularly those on tall bikes (interview 16), and it is not uncommon for commuters to keep each other in line or speak to cars that are encroaching on bicycle-designated space. As one transportation planner explained, the aim would be to increase the maturity of commuters generally, so all see themselves as part of a shared civil society which they are responsible for maintaining (interviews 8, 23).

As a leading city in bicycle commuting, Portland holds a leadership role and responsibility in testing new designs and policies that can be shared nationally (interviews 4, 7). However, engineering cannot untangle the attitudes and behaviors of commuters that have been well honed over years of experience and social conditioning. Legal compliance may be an important mechanism for changing hazardous bicycle behavior, just as it is for car drivers. Traffic citations

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for running a stop light or stop sign carry the same penalty for cyclist or driver (approximately \$250). A sympathetic Portland judge recently promulgated a Share the Road court, which allows those who have been ticketed to take a traffic awareness course (conducted by trauma nurses with vivid accident photos) and have their fines waived (interview 8). This program has since been adapted as an online course in Davis, California, and shows promise for reinforcing socially acceptable commute behavior as bicycle commuting grows in popularity.

Interviewees called for further support for and integration of broad cycling needs in the city as a way to increase bicycle commuting. Further community and business support, including involvement of company leaders as bike commuters(interview 5) and implementation of programs such as that at Portland State University, which have increased transit use by 40% by proactively helping students, staff, and faculty find alternatives to car commuting (interview 23), will encourage people to make the cycling commitment. To the extent that policy makers, advocacy groups, and transportation planners can hold the arena open for all types of cycling, bicycle commuting is likely to benefit as well.

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## 5. Conclusions

If bicycle transportation is to continue to become a more viable transportation option in northern climates, cyclists will need to feel safer, especially when interacting with motorized traffic. Whether this is accomplished through infrastructure improvements, policy changes, or societal shifts, it must be tailored to specific environments. Based on the findings of this project, we recommend that policy changes target bicycle safety on roadways in a variety of conditions, which can mitigate safety concerns regarding lighting, plowing, and snow and ice buildup. While weather cannot be altered through policy changes, bicyclist safety and comfort can be improved through proper infrastructure development and maintenance, as well as clearly defined laws for bicycle and motorist road use.

There is a virtual consensus among climate scientists that failure to stabilize atmospheric carbon stocks will lead to catastrophic climate change. We must reduce emissions by at least 80% globally or concentrations will continue to build. Many scientists believe that we should target 350 parts per million (ppm) atmospheric CO<sub>2</sub>, which would require even greater reductions, at least temporarily. Unfortunately, politicians and individuals have largely failed to respond to these warnings. One major obstacle to adopting the necessary policies is the belief that emissions reductions would lead to unacceptable reductions in quality of life. However, the impact of climate change on agriculture, biodiversity, sea level rise and weather-related disasters would likely have far worse impacts on quality of life than emissions reductions. While it is difficult to predict the impacts of climate change on quality of life, it is relatively simple to model the impacts of mitigation. In the transportation sector, for example, a switch from motorized to active transport (primarily cycling and walking) improves health, saves money, and offers numerous environmental benefits.

In Burlington, perceptions of the relationship between quality of life and the actual practice of getting around by bicycle are contextual and heterogeneous. They are also complicated by the inherent multidimensionality of the quality of life concept itself. Three prominent themes emerged in the course of studying these perceptions of bicycle transportation and notions of quality of life: 1) there are distinct phenomenological experiences of transportation and senses of self associated with bicycle transportation; 2) bicycle transportation is accommodating to a range of motivations, purposes, and practices; and 3) physical conditions and infrastructure can act as facilitators and deterrents. Each of these themes intersects with the concept of quality of life in certain ways, and carries certain associations with quality of life values, purposes, or practices. Not all dimensions of bicycle transportation are viewed uncritically as improving quality of life; nevertheless for many informants a good quality of life is directly tied to better conditions for riding bicycles. That such ideas vary is not surprising; perhaps what is more compelling is the mostly unquestioned existence of a strong association between the quality of life concept and bicycle transportation to begin with.

Quality of life values reported by interviewees in Portland were distributed among seven areas, with some values receiving significant emphasis in contrast to others. These areas are: 1) safety and security, 2) economic benefits, 3) convenience and self-reliance, 4) health benefits, 5) social benefits, 6) sense of place, and 7) environmental benefits. Challenges to supporting these quality of life values included five areas for attention: 1) continued infrastructure support, 2) further

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support for making bike commuting a social norm, 3) bicycle/driver conflicts, 4) incentives and awards, 5) support for a wide range of bicycle cultures.

In order to ensure that policy changes and infrastructure development are achieved, policymakers must take into account the needs of a community while understanding the potential for the bicycle to improve upon the holistic wellbeing of the population. Bicycling is certainly not a complete solution for social, health, or economic issues faced by the U.S., but when effectively implemented and promoted, it can play a role in alleviating these issues while providing an enjoyable experience.

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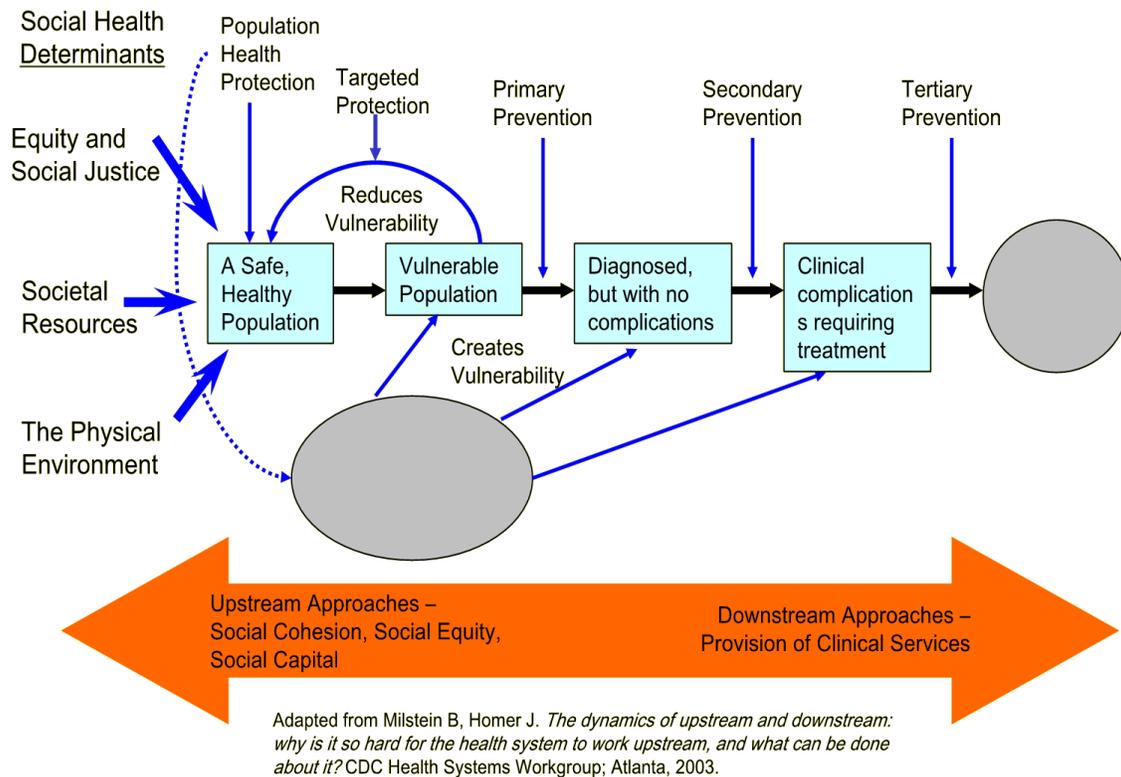
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## Appendices

Table A-1. Interviewee Quotations Demonstrating Importance of Environmental Factors to Bicycle Commuting

Factor	Demonstrative Quote
Temperature	“If it was 10 [degrees] below [zero Fahrenheit] November 1 and I was still riding, and there was no snow at all, no ice, I mean, I might think twice but, say down to 10 degrees is fine. Below 10 degrees tends to be tough because my fingers freeze up and then I don't feel safe.” –Women’s Focus Group 2
	“Once the weather's consistently under 40-30 degrees [Fahrenheit], at both ends of the day, I usually stop riding.” –Interview 4 (male)
Light Conditions	“In the winter, there's not nearly as much light. A lot of the bikers I know who have been hit have been in the winter months.” –Men’s Focus Group 2
	“I mean it would be only when it's sort of dusk that I might bike, and I don't have a good sense of how well I'll be seen.” –Interview 2 (female)
Precipitation	If it's summer, and there's a chance of rain, I'm more likely to bike. It's easier to just take a rain coat than if it's cold in the late fall or early spring and also wet. In the winter, snow is snow.” –Interview 3 (male)
	“The only [time] I don't go is the day after a big snowstorm because I know they're going to plow all the snow right to the sides of the roads or into the bike path and I could technically, legally ride in the road and I don't feel safe there. It's not because of me, I have studded tires and I know my abilities and I ride within that, but I can't stop a car from running into me.” –Men’s Focus Group 1
Road Conditions	“For me it depends on how well the roads are plowed ... If the snow has just fallen and my tire can't really grab on to anything it just kind of pitches all over the place.” –Women’s Focus Group 1
	“It gets up in the chain—the salt, all that muck—gets up in the chain which makes shifting kind of a pain” –Men’s Focus Group 2
Wind	“You know where the wind is from because it's always friend or foe.” –Men’s Focus Group 1
	“I think it's colder to really bike into wind than just walk through it.” –Interview 5 (female)



**Figure A-1. Opportunities for Public Health Interventions, a Social Determinants Framework**

Table A-2. E Categories in Portland

<b>E Category</b>	<b>Values</b>	<b>Examples</b>
<b>Engineering</b>	design solutions, collaboration	Steel Bridge bike path addition, Eastbank Esplanade, business wait list for bike corrals
<b>Education</b>	self-reliance, family, share the road	Safe Routes to Schools, PSU citizen class, BTA work with driver education classes
<b>Encouragement</b>	teamwork, comfort, support	Bike Commute to Work Challenge, SmarTrips program, covered bike storage
<b>Evaluation</b>	accountability	Bicycle Network Gap Analysis, League of Am Bicyclists application, bicycle counts, intersection studies
<b>Enforcement</b>	responsibility, safety	tickets for running stop lights, diversion class for offenders
<b>Equity</b>	fair share, equal opportunity	program expansion to New Americans neighborhoods, maps in relevant languages, Sunday Parkways rides to attract new riders
<b>Economics</b>	cost effectiveness	cargo bike boom, Move by Bike, high modal split at Portland State University
<b>Exercise</b>	health, thriving	Bike to Work challenge
<b>Energy/Environment</b>	stewardship, personal action	Tabor to River project to mitigate stormwater via bioswales on bike boulevards
<b>Effective Leadership</b>	civic service, community	Mayor Sam Adams, Rep Earl Blumenaur, engineer Rob Burchfield, Mia Birk, Bicycle Transportation Alliance
<b>Exuberance</b>	imagination, fun, vision, creativity, resourcefulness	ZooBomb, Pedalpalooza, Multnomah County Bike Fair

Table A-3. Pedalpalooza Event Categories (N=302)

Theme	#	%	Examples
<b>Family friendly</b>	48	16%	Mr. Mom Ride, Goatlandia Ride, Kidical Mass
<b>Costume</b>	38	12.6%	Batman Ride, Hogwarts Express, Dinosaur Ride, Bike Love Fashion Show, Unicorn Ride
<b>Food</b>	38	12.6%	Gluten Free Ride, Food Carts Ride, Ice Cream Ride
<b>Special Destination</b>	37	12.5%	Sauvie Island, Cascade Locks campout, Rocky Butte Sunset Dance Party
<b>Special bike type</b>	35	11.6%	Schwinn Swap, Folding Bike Tea, Tall Bike Tour, Heavy Bike Challenge, Recliner Ride
<b>Games</b>	29	9.6%	Alleycat Ride, Hands Free Olympics, Bikey Trivia by Bike, Scrabble Dabble, Bike Polo
<b>Drink</b>	23	7.6%	Wine Country Ride, Wild Whiskey Ride
<b>Party/Dancing</b>	22	7.3%	Dropout Bike Club Prom Ride, Solstice Flash Mob, Dirty Diablo's Wild Ride
<b>Nature</b>	18	6.0%	Heritage Trees, Portland's Reservoirs, Birds and Bees
<b>Special Group</b>	17	5.6%	LGBTQ Pride, Luddite Ride, Ginger IV Ride, Paddlepaloosa (boats and bikes)
<b>Film/Art</b>	16	5.3%	Portlandia Ride, Bicycle Documentary Filmmaking
<b>Workshops</b>	16	5.3%	Bike Commuting Basics, Unicycles for Noobs
<b>Activism</b>	15	5%	Shut Down the CRC, No Way No Coal, Dead Freeways Ride, BTA Legal Clinic
<b>Built Environment</b>	13	4.3%	Tiny Home Tour, Tram Anniversary Ride, West Hills Architectural Tour
<b>Bike Repair</b>	13	4.3%	Bikes for Humanity, Open Wrench Night
<b>Women Only</b>	11	3.6%	Sprockette Girls Camp, Cool Chicks on Cycles, Pregnant Pedal, Bike Touring for Women
<b>Music/Drama</b>	11	3.6%	Music for 111 Bicycles, Invasion of the Bicycle Snatchers (street play)
<b>Literature/Poetry</b>	9	3.0%	Dead Poets Society Ride, Zine Bike Tour
<b>Religion/Ritual</b>	8	2.65%	Blessing of the Bikes, Joy of Sects, Buddhas by Bike
<b>Naked Bike Rides</b>	6	2%	Naked 10K Off-Road Ride, World Naked Bike Ride
<b>Exercise</b>	5	1.65%	Yogi Cycle, Swim Across Portland, Hammercise

Table A-4

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Interviewers in Burlington and Portland drew on the following questions in their qualitative, open-ended interviews of cyclists and professionals.

What primary things has your organization done/accomplished to enhance quality of life in the community?

What is quality of life – how do you define it and how does it relate to your work?

How would you characterize your position within the broader efforts to promote bicycle transportation?

Where does your work intersect with other key agencies or groups in bike culture?

What do you think are critical actions to promote or grow bicycle culture or transportation here?

What do you think is the future of bicycle transportation/culture and what critical issues might emerge?

What does your bike do for you?

Is there a social aspect to your bicycling?