

Cost-Benefit Analysis of Alternative Transportation in Fort Collins, Colorado

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Honor Pledge: “I have not given, received, or used any unauthorized assistance.”

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EXECUTIVE SUMMARY

Our cost-benefit analysis of alternative transportation in Fort Collins, Colorado evaluates the implementation 2.9 miles of both painted and protected bicycle lanes within a 12 mile area around the campus of Colorado State University. Painted and protected bike lanes offer more protection for bicyclists and encourage more residents to ride bikes around the city based on the increased perception of perceived safety. After looking at the current Fort Collins bike map, it was decided that adding a protected bike lane from Prospect to Laurel on Shields, Shields to College on Prospect, Constitution to Shields on W. Elizabeth, and Laurel to Mountain on Shields would help fill in some of the gaps that exist within biking lanes and begin to address strategic initiatives from the Fort Collins Strategic Plan from 2016.

To analyze whether this project is feasible, we researched the construction costs and previous bike lane/path implementations that Fort Collins has done as well as looking at traffic delays during construction. Our analysis also looks at the benefits that come from riding a bike such as saving money from accident costs - both injury and fatal accidents - travel time costs for students and residents of Fort Collins, environmental costs from carbon emission from cars, and health benefits from transitioning from car to bike. As a result, our cost-benefit analysis to construct these proposed bike lanes was found to be beneficial and should be implemented in the City of Fort Collins.

SECTION 1

Description of Strategic Initiative and Policy to be Studied

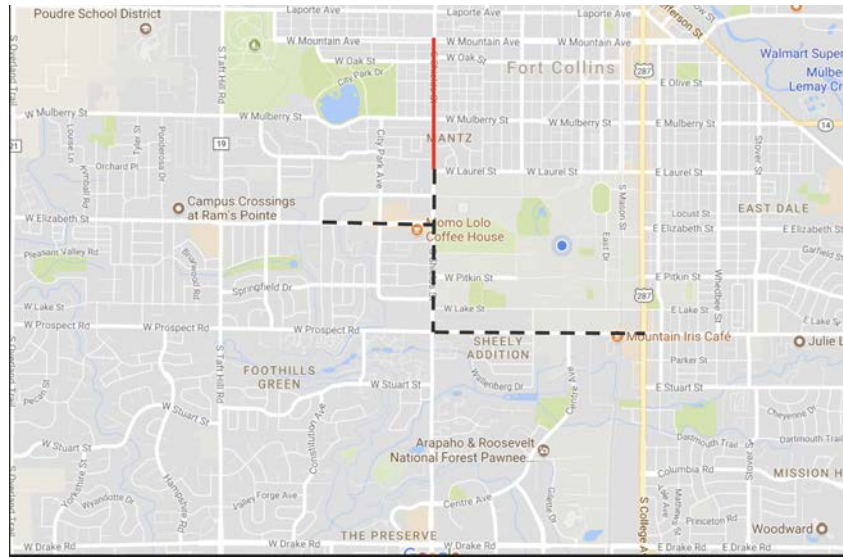
The cost-benefit analysis of alternative transportation in Fort Collins, Colorado focuses on two strategic initiatives from the Fort Collins Strategic Plan from 2016. These two initiatives come from the transportation section of the plan and are defined as:

- 6.1 - Improve safety for all modes of travel including vehicular, pedestrian and bicycle.
- 6.5 - Fill the gaps for all modes of travel and improve the current transportation infrastructure while enhancing the aesthetic environment.

It was from these strategic initiatives that the policy proposal was developed.

The goal of our policy proposal is to increase forms of alternative transportation in Fort Collins via increased bike lane availability in a 12 square mile area around Colorado State University. More specifically, we would like to implement new protected bike lanes on high-density traffic streets in northern Fort Collins. Protected bike lanes will also increase the safety and use of bicycle transportation in the 12 square mile bike network area. By increasing the use of bicycle lanes in Fort Collins, we will also be lowering the environmental impacts of automobile traffic and increasing the cultural benefits of Fort Collins through increasing cycling participation. Our proposed policy will also increase the demand for bicycles and bicycle related products- as part of our secondary markets. Lastly, we aim to lower average health care costs related to chronic health problems that could be reduced through moderate-intensity exercises.

The bike paths that are being proposed through the study are demonstrated in the map of the 12 square mile area below:



The red line along Shields Street demonstrates the painted bike lanes we are proposing to add, and the dashed black lines represent the addition of protected bike lanes.

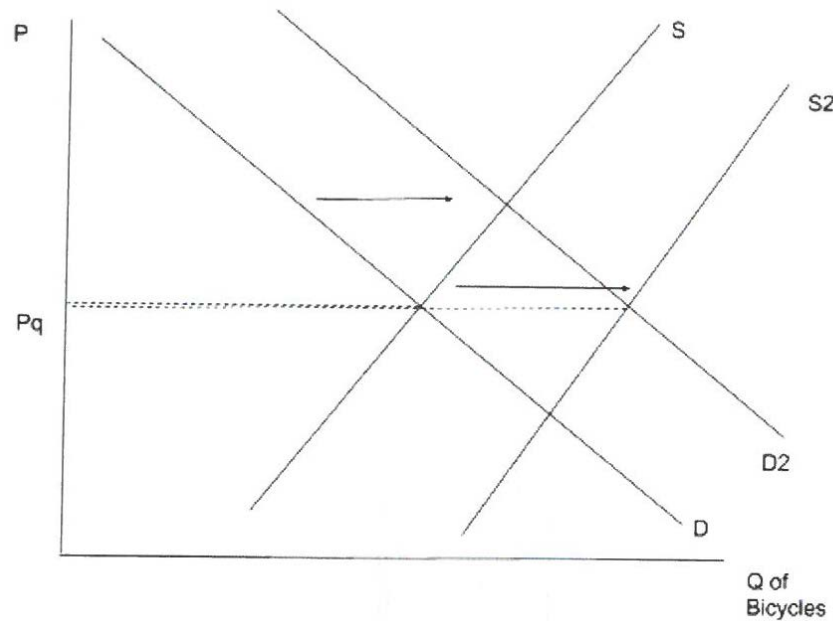
SECTION 2

Theoretical Modeling and Identification of Benefits and Costs

The primary market in this proposal is the Alternative Transportation Market, specifically the demand for infrastructure that reinforces bicycle commutes to work and school. The main focus of our policy is to increase the comfort and safety of cyclists on downtown streets in Fort Collins. Through an infrastructure change, we hypothesize that people that commute everyday to work and school by car, will change to bikes if they perceive that biking is safe. A proxy model was used to determine which kind of infrastructure would have the highest effect. “One of the primary benefits of protected bike lanes is that they may provide a higher level of comfort than a standard bike lane that is only delineated by an inches-wide painted stripe. Indeed, previous research has shown that people prefer bicycling facilities that are physically separated from traffic to standard bike lanes” (Foster 1). The model used was on an experiment that was

conducted in Portland Oregon through video surveys. It was aimed at explaining which type of protected bike lane would have the greatest impact on cyclist comfort, especially on streets with heavy traffic flow. The top ranked types were in order: One-way lane with Planter Buffer, one-way lane with pylon buffer, one-way lane with parked cars buffer, and one-way lane with no buffer but raised surface above the street. Of those options, the Planter buffer was too expensive to implement on the street sections that we wanted, but the plastic pylon buffers had the same effect and would cost less to implement. Another research model was used when calculating the number of increased bike commuters due to our policy. A university study conducted in Madrid Spain determined the main significant variables that determined whether or not to commute via bicycle. There were seven statistically significant variables that affected the dependent variable (Probability of commuting by bike), ranging from Lifestyle to capability. The variable that was directly applicable to our policy was that of Safety and Comfort. This variable had a positive impact on the dependent variable and indicated that when people perceive bike travel as safe and stress-free in high-density areas, they are more likely to commute via bike. Statistically significant at the 5% level of significance, people are 28% more likely to commute to work or school by bike if they perceive biking as safe and comfortable. Using that rate, we can predict how many people will shift the manner in which they commute to work and school and monetize some of the benefits talked about later in this CBA.

Graph of our Theoretical Supply and Demand Model:



The previous graph describes the theoretical supply and demand model that our proposal is founded around. If more protected and painted bike lanes are implemented in Fort Collins then demand for bicycles will increase. This increase in the demand for bicycles, due to the increase in bike lanes will also lead to an increase in the supply of bicycles in order for supply to meet the increasing demand. However, due to the fact that both the demand and the supply curves will be shifting, the equilibrium price stays at about the same place.

SECTION 3

Monetization of Benefits

Implementing these protected and painted bike lanes will increase safety for bicyclists, thus, decreasing the amount of bicycle accidents and fatalities, resulting to the benefit of saving money from these accidents.

Accident Costs:

Since this policy focuses on 3 streets, the calculations will be from data focused on these streets. To calculate the accident costs of these streets – Shields Street, W. Elizabeth Street, and Prospect Road – the following formula was used:

$$\text{Minor Crash Cost} = (\text{Bike count} * \text{accident rate}) * \text{accident cost}$$

$$\text{Fatal Crash Costs} = ((\text{Bike Count} * \text{accident rate}) * \text{fatal rate}) * \text{fatal accident cost}$$

$$\text{Total Accident Costs} = \text{Minor Crash Costs} + \text{Fatal Crash Costs}$$

The estimate for the accident costs came from using the Value of a Statistical Life (VSL). According to the U.S Department of Transportation, the VSL for base year 2016 is \$9.6 million dollars. The target streets have minor injuries. Using that information, the U.S Department of Transportation recommended that the injury cost of a minor injury is 3/1000, or .003, of VSL, which comes out to be \$28,800 (U.S Department of Transportation).

Bike counts refer to the number of bikes that go through these streets. The numbers came from the Fort Collins mapping tool of the bikeway systems. Looking at the map the numbers obtained for Shields, W. Elizabeth, and Prospect are 20,374; 18,373; and 19,811 respectively.

The Annual Roadway Safety Report (or Traffic Safety Summary Report) of 2016 reported a total of 795 bicycle crashes, only 3 of those crashes were fatal (Traffic Safety Summary). This came to the assumption that the fatality rate is .00378

According to the document, The State of Bicycling in Fort Collins (2014), from The City Fort Collins, it was reported that the average crash rate per mile from 2008 – 2013 was 27.3 on Shields, 24.3 on W. Elizabeth St, and 9.4 on Prospect (State of Bicycling of Fort Collins). To calculate the crash rate for each of these streets, the total crashes of each street was found and then used to find the average crash rate from average of 6 years to per year. For Shields the rate was $.0449 = ((27.3/142)/(6))*1.4$. The 1.4 represents the length of the street/lane that would like to be implemented and account for the extra .4 mile to crashes per mile. W. Elizabeth came to be .0277 and Prospect .0320.

Using collected information the estimates for accidents costs for these streets are:

Shields Street:

$$\text{Minor Injury: } (20374 * .0449) * \$28800 = \$26,346,026$$

$$\text{Fatal Crash: } ((20374 * .0449)*.00378) * \$9.6\text{mil} = \$33,195,993$$

W. Elizabeth St:

$$\text{Minor Injury: } (18373 * .0277) * \$28800 = \$14,657,244$$

$$\text{Fatal Crash: } ((18373 * .0277)*.00378) * \$9.6\text{mil} = \$18,468,127$$

Prospect Rd:

$$\text{Minor Injury: } (19811 * .0320) * \$28800 = \$18,257,817$$

$$\text{Fatal Crash: } ((19811 * .0320)*.00378) * \$9.6\text{mil} = \$23,004,849$$

$$\textbf{\underline{Accident Costs = \$133, 930,056}}$$

However, recently an underpass was built on the intersection of Shields and Elizabeth. With this underpass, it prevents “right hook” (overtaking turn) and approach turn accidents. These crashes make up about 31% of bike crashes (Traffic Safety Summary). With that, the

assumption is made that the total accident crash costs would decrease by 31% or \$41,350,917.36.

This would then make accident costs **\$92,039,138.64**

Environmental Cost:

The environmental benefit would also be an important aspect to consider in the CBA because of the transfer of preferences of commuters from cars to bicycles in the area. This impact would decrease carbon emissions by car, but the question is, by how much? By using the Commute Cost & Carbon Emissions Calculator from Stanford University of a 2014 Toyota Yaris and imputing values for average daily roundtrip commute mileage, average number of days commuted per month, average miles per gallon in the vehicle, and average cost per gallon of fuel, it was able to determine the average cost of carbon for the vehicle to be ~\$9.3 per metric ton of carbon (Commute Cost & Carbon Emissions Calculator). Research through the 2015 Carbon Community Inventory in Fort Collins then helped to provide an estimate of the per capita emissions of carbon to be 13.5 metric tons of carbon per person (2015 Community Carbon Inventory). This would be useful in determining the amount of carbon each person contributes and would be applied to the number of people we expect to utilize the bike paths in our policy as they perceive biking to be safer after the policy is implemented .

Since our policy is focused on improving the safety of the current transportation infrastructure, we can base our assumption that this increase in safety will cause about 28% of the target group to choose cycling over driving (Muñoz 14). By summing up the total number of parking permits for commuter students- defined as code Z and A on the Student and Staff Parking Options at the CSU Directory- adding up to 5,869 spots- we are also able to determine that our policy would push for 1,644 people to choose cycling (Parking Permits).

Based on the collected information, the following formula could be created for the monetized benefit for the reduction of carbon emissions from our proposed bike policy:

$$\text{Environmental Cost} = (\text{Cost per metric ton of carbon}) * (\text{per metric ton of carbon produced per person}) * (\text{Number of new bikers})$$

$$= (\$9.3 \text{ per metric ton of carbon}) * (13.5 \text{ metric tons of carbon per person}) * (1,644 \text{ persons})$$

$$\underline{\underline{\text{Environmental Cost} = \$206,404.20}}$$

Health Benefits Cost:

Our policy seeks to fill in the gaps of travel by improving the current transportation infrastructure and in doing so, we are assuming that there will be a general increase in the number of people riding bikes as well as the health benefits that are associated with biking. In the Economic and Health Benefits of Bicycling and Walking by the State of Colorado, biking comes to “...help prevent about 50 deaths per year [translating] to about \$511 million in annual health benefits from bicycling” (Economic and Health Benefits of Bicycling and Walking). This figure is relevant in that it represents the value of a healthy life because of the tie that active travel has with health benefits (i.e. lower obesity and diabetes rates) and the general money spent on healthcare. It is also important to note that, this figure comes with the idea that if bicycling was not replaced with another form of exercise that there would be approximately \$511 million in annual health benefits lost, so given that the policy is focused on improving safety, it is also tied to health. In order to make the comparison, an adjustment would need to be made to account for the total number of bicyclist in Colorado (462,000 Resident) in proportion to the health benefit of biking as previously mentioned- valuing a human life saved by bicycling at about

\$10,220,000. Now, an adjustment from the state level to the local Fort Collins level would be necessary to be able to determine how the policy might impact the health of riders.

When researching the amount of bikers that already exist in the city, an article from the Coloradoan was able to define Fort Collins as a medium size city and a biker population at about 6.3% of the population (Coloradoan Staff). By observing the current population in Fort Collins and using this statistic, we are able to determine that there are about 10,345 Fort Collins residents that are bicyclist. A comparison to the findings and numbers of bikers observed in the Economic and Health Benefits of Bicycling and Walking would come to estimate that in the study about 2 of the prevented deaths come from Fort Collins- or about \$20,440,000 million in annual health benefits. As mentioned earlier, the whole just of this policy is to impact rider ability and safety to where we are estimating an increase of about 1,644 new riders in the area- or about 15.89% of the 10,345 Fort Collins residents that are bicyclist already. We can assume that this 15.89% will also apply to the annual health benefits to the new addition of people riding bikes and result in an additional benefit in annual health benefits of **\$3,247,916.**

Travel Time Costs:

_____The decreased commuter travel time is another important aspect of our proposed project because it will be very beneficial to the Fort Collins community. In order to monetize time benefits the following calculations were made:

Tuition cost/credit = value of an hour

Average hourly wage = value of an hour

Off campus students:

In-state Undergrad: $\$25,424/15 = 1,694.93 / 60 = 28.25$ per minute - 73% of student body

Out-State Undergrad: $\$43,632/15 = 2,908.8 / 60 = 48.48$ per minute - 27% of student body

$$28.25(0.73) + 48.48(0.27) = 34.28 \text{ dollars per minute}$$

Laborers:

Average hourly wage: $\$23.44/60 = \0.39 dollars per minute

Average Value of a Minute:

$$0.39 + 34.28 = 34.67/2 = \$17.34$$

Within these calculations it was found that the value of a minute in Fort Collins, when taking into account both students and laborers is \$17.34 per minute. The average commuter time when driving in Fort Collins is 20 to 30 minutes. If the average is taken then the value of the average commute time is:

$$25(2) * 160 = 8,000 * 17.34 = \$138,720$$

When biking in Fort Collins, the average commute time is 8 to 10 minutes. If the average is taken then the value of the average commute time when biking is:

$$10(2)*160 = 3,200 * 17.34 = \$55,488$$

These commuter time benefits overall will end up totalling: **\$194,208.**

SECTION 4

Monetization of Costs

Construction Costs:

The majority of the costs of the project come from one time construction costs. These costs were calculated using data from the 2013 Fort Collins Paved Recreational Trail Master Plan and the 2014 Bicycle Master Plan.

Lane Location	Distance	Protected/Painted	Cost	Adjusted for Inflation
Prospect to Laurel on Shields	0.8 miles	Protected	$\$96,000 \times 0.8$ miles = \$76,800	$\$76,800 \times 0.06 = \$4,608$ $\$76,800 + \$4,608 = \$81,408$
Shields to College on Prospect	1 miles	Protected	$\$2,000,000 +$ 96,000 = \$2,096,000	$\$2,096,000 \times 0.06 = \$125,760$ $\$2,096,000 + \$125,760 =$ \$2,221,760
Constitution to Shields on W. Elizabeth	0.5 miles	Protected	$\$96,000 \times 0.5$ = \$48,000	$\$48,000 \times 0.06 = \$2,880$ $\$48,000 + \$2,880 = \$50,880$
Laurel to Mountain on Shields	0.6 miles	Painted	$(\$2,000,000 \times$ 0.6) = \$1,200,000	$\$1,200,000 \times 0.06 = \$72,000$ $\$1,200,000 + \$72,000 =$ \$1,272,000

The calculations above have been adjusted for inflationary forces since 2014. The costs above include supplies, worker wages, and the cost of the additional land needed to expand the roads.

The total construction costs end up totaling: **\$3,553,048.**

Cost of Traffic Delays:

_____ Additional costs that are related to construction include the traffic delays and increased commuter time due to road construction. In a study completed at Texas A&M, it was found that average traffic delays across the nation are about 10-30 minutes. In Fort Collins, specifically, the average length of road construction per project is 6 months. Due to the construction projects that would be undertaken (Prospect, Shields and W. Elizabeth), the total length of construction time will be 18 months. Due to the length of construction, the monetization of the cost can be made using the cost of travel time found earlier in Section 3. If the average commute time is 20 minutes, twice a day when driving then the cost of construction delays can be calculated as:

$$20(2) \times 360 \text{ days} \times 17.34 = \$249,694$$

This makes the total cost of construction delays: **\$249,694.**

Next we looked at the net present value of the project and discounted the benefits. Looking at other bike lane CBA, it was recommended to use the discount rate of 5%. Using the NPV formula below, we found the NPV of the project after 5 years.

$$NPV = \frac{B_0 - C_0}{(1+i)^0} + \frac{B_1 - C_1}{(1+i)^1} \dots \frac{B_t - C_t}{(1+i)^t}$$

$$\text{Total Benefits} = 92,039,138.64 + 206,404.20 + 20,440,000 + 3,247,916$$

$$\text{Total Costs} = 3,553,048 + 249,694$$

Year	Total Benefit	Total Cost	Net Benefit	5% discounts
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0	0	3,802,742	-3802742	-3802742
1	115,933,458.84	0	115,933,458.84	110,412,817.94
2	115,933,458.84	0	115,933,458.84	105,155,064.71
3	115,933,458.84	0	115,933,458.84	100,147,680.67
4	102659750	0	102659750	95,378,743.50
5	102659750	0	102659750	90,836,898.57

Since total NPV = 498,128,463.39, the project should go on.

SECTION 5

Policy Recommendations and Discussion

Due to the results of our analysis, i.e. that the benefits outway the costs, our policy proposal should be implemented. If a painted bicycle lane is added onto Shields, and protected bicycle lanes are added onto W. Elizabeth, Shields and Prospect it would benefit the Fort Collins community. The initial construction costs and the cost to the public of traffic delays are small in comparison with the benefits of increasing the bicycle friendly cultural climate of Northern Colorado. The benefits of the project include: decreasing the cost of bicycle related accidents, decreasing environmental costs surrounding pollution, increasing health benefits, and decreasing commuter time. If the proposed policy is implemented it would benefit the city and its population by \$498,128,463.39 over the span of five years. If the policy is successful in improving the living

conditions and quality of life within the 12 mile area in Fort Collins, we propose expanding protected bike lanes to other areas of Fort Collins to continue bridging the gaps that exist in the bike lane network, specifically areas with a higher traffic flow.

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