2013

Environmental Economics: A Case Study for the Big Cottonwood Canyon Watershed

Robert Hull
Pomona College

Environmental Economics: A Case Study for the Big Cottonwood Canyon Watershed

Robert Hull

In partial fulfillment of a Bachelor of Arts Degree in Environmental Analysis, 2012-13 academic year, Pomona College, Claremont, California

Readers:
Bowman Cutter
Char Miller

Acknowledgements

First, I would like to thank my readers, Bowman Cutter and Char Miller for all of the wonderful help and insight they have provided throughout this entire process. From the beginning, their comments and ideas have been an instrumental part in the successful completion of this thesis. I would also like to thank Pomona College and the Career Development Office for the summer internship funding they offered.

I would like to thank Laura Briefer, Tammy Wambeam, and the Salt Lake City Department of Public Utilities for the summer internship opportunity. Without their support and help with GIS, this thesis would not have been completed.

Finally, I would like to thank my parents, Carol Clawson and Steve Hull. Their overall support has been amazing, and they have been very helpful with the editing process and have guided me through roadblocks along the way.

Table of Contents

Chapter 1
Introduction

Environmental economics is the application of economic principles to the study of how natural resources are developed and managed. The methodologies used attempt to value ecosystem services provided by healthy, functioning natural lands and ecosystems. Ecosystem services attributed to natural lands contribute significant human welfare benefits that go largely undervalued or misrepresented in the decision-making process for the development of land. As environmental valuation methodologies and techniques continue to advance, policy decisions will be better able to create outcomes that maximize benefits for targeted populations and landscapes. While the science of environmental economics is still improving, studies from around the world have used its methods to optimize decisions, creating both short-term and long-term rewards that may otherwise have been ignored.

The purpose of this paper is to first describe the methodologies used in environmental economics. These methodologies will then be applied to the Big Cottonwood Canyon Watershed located to the east of Salt Lake City, Utah. The case study will describe the ecosystem services provided by the watershed and value them. Using these values, the study focuses on the proposed development of SkiLink, a gondola system that would connect two separate ski resorts in two separate canyons – the Solitude Mountain Resort, located in Big Cottonwood Canyon, and Canyons Resort, located near Park City, Utah. The debate over the proposed SkiLink focuses on weighing its potential contribution to Utah's economy against its potential environmental consequences. Based on a detailed analysis of the economic benefits and ecosystem losses created by the proposal, a cost-benefit analysis of the project will be presented along with recommendations for further study of potential development that would likely accompany the building of SkiLink.

The Big Cottonwood Canyon Watershed case study is unique in the field of environmental economics. Many previous studies have focused on specific habitats and their contribution to a surrounding area. Few, however, offer a complete assessment of a watershed. Although the more specific studies offer valuable insights, an all-encompassing study provides decision-makers with the “full picture” of environmental and economic benefits and consequences. While this study can be used in the final decision regarding the construction of SkiLink, it also serves as an outline for future studies of its type. As this type of analysis becomes more available, the field of environmental economics will become an increasingly useful tool for policy decisions. If this case study can contribute to the progression of environmental valuation, it has served its purpose.

Chapter 2
Environmental Economics

Traditional economics uses market-based approaches to reveal consumer and producer preferences for goods available in the market. Supply and demand schedules can accurately portray price signals to consumers and producers for specific goods and allow each group to define the best bundle of goods that produces the highest level of utility or, put another way, happiness or satisfaction. This market structure makes for easy assessment of the value of goods produced, linking consumer and producer surplus to the benefits of a free and open market.

From an ecological standpoint, the simple market structure tends to leave out goods and services that are not easily quantified or priced. In this study on the Big Cottonwood Canyon Watershed, the services provided by natural capital, or the natural landscape and its corresponding biological and chemical functions, are outside of this market structure – they are not given a price or value that can be easily translated into a market system. Identified as "ecosystem services," these functions are "the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfill human life" (Yung En Chee, 2004, p. 549). Historically, ecosystem services have been transformed by human, financial, and manufactured capital for our benefit and were believed to be "free" and abundant. With little to no property rights, ecosystem services are threatened by overuse and degradation (Postel and Thompson, 2005; Yung en Chee, 2004).

The goal of environmental economics is to better define ecosystem services and give these services a direct value that can be incorporated into a market system. By applying externalities to a standardized market structure, policy makers can better estimate the worth of natural capital. Policy decisions can be better structured to provide humans with the maximum benefit, taking into account both the common forms of economic activity from growth and

development (job creation, spending, tax revenue) and the newly valued ecological economy derived from conserving and protecting the natural capital found within the Big Cottonwood Canyon Watershed (Bingham, Gail et al., 1995; Bockstael, N., 1995; Boyd and Banzhaf, 2007; de Groot, Rudolf S., 1987; Wackernagel, Mathis et al., 1999).

There are a multitude of environmental valuation methods that offer accurate value estimates for ecosystem services in watersheds and other ecosystems alike. These methods are described below as an overview and later applied to value the Big Cottonwood Canyon Watershed.

I. Revealed Preference Methods

Revealed preference methods value environmental benefits from an inferred willingness-to-pay (WTP) based on differing expenditures for private goods. In many cases, expenditures for private goods vary due to the fluctuation of environmental services. These variations can be used to derive values for the ecosystem services that contribute to the market price of the final goods. For example, recreational visits to a lake or reservoir are directly dependent on the water level of the lake and the flow of water into the lake from surrounding streams. During times of low water levels, visits to the reservoir may diminish, lowering recreational revenue. This monetary value can be attributed to the services that provide for water levels adequate to derive recreational benefit (Young, Robert A., 2005).

Revealed preference models are usually derived from one of two types of valuation methodologies. First, the travel cost method infers value of recreational sites from the costs of travel consumers must incur to reach their destinations of choice. Second, the hedonic pricing method places a dollar amount on environmental services based on the differences in property values that arise due to varying environmental qualities located in the areas surrounding the

properties. As a whole, the major advantage of revealed preference methods is that they tend to reflect true consumer choices (Bingham, Gail et al., 1995; Young, Robert A., 2005).

a. Travel Cost Method

The travel cost method applies access and travel expenditures to ecosystem services to represent their market value. Generally, this value is derived as an annual value based on per person visits to the recreation site. In generating these values, a variety of factors are assumed to influence the number of yearly visits. The cost and time of travel can include other costs, including the quality of the recreation site, income of the recreationalist, and opportunity cost of recreation in the form of wages forgone. Further, travel cost methods look at the preferences of recreationalists and how they choose between various sites of similar quality (Young, Robert A., 2005).

For example, travel costs for recreational fishing would include license fees, on-site fees, and expenditures on fishing equipment (Yung En Chee, 2004). Additional examples could incorporate visitor fees or access fees for hiking, biking, or camping on delineated trails and campsites. While the travel cost method is often favored because it reflects direct consumer preferences, it does have some limitations. First, travel costs are typically only used for recreational ecosystem services or other services that contribute to recreation. Nutrient cycling and disturbance regulation would be difficult to value using this method. Further, data collection for the travel cost method is highly specialized and requires a large budget (Young, Robert A., 2005).

b. Hedonic Pricing Method

The other form of revealed preference methods is hedonic pricing. Hedonic refers to the attributes of a marketed good and the utility of these attributes. Therefore, the hedonic pricing

method assumes that the price of a marketed good is a function of the characteristics associated with that good and that each characteristic has its own value that adds to the total value of the good. Traditionally, the hedonic pricing method has been applied to housing and land values. Here, environmental benefits, or ecosystem services, are valued based on their contribution to the property's value. Typical environmental benefits include soil quality, water rights, and proximity to clean water and recreational opportunities. As the ecosystem services that provide for these benefits are degraded (or protected), the corresponding property values fall (or rise) in general. These price fluctuations can be applied to directly value the environmental conditions of the area (Young, Robert A, 2005; Yung En Chee, 2004).

The hedonic pricing method requires two steps to value the environmental benefits of a study area. First, a hedonic price function is estimated by regressing property characteristics on property values. From this regression, the implicit marginal prices of each specific characteristic are found, which are then used as part of a demand function to find the total WTP for the characteristic in question. The demand function allows for each property owner's marginal price to be summed together calculating the full value of the environmental characteristic (Poor, Pessagnob, and Paul, 2007; Young, Robert A., 2005). For example, if property values dropped as a result of degraded water quality, the falling price could be applied to the per unit change in water quality (total suspended solids, fecal matter) and the corresponding ecosystem services that provide for the normal regulation and filtration of that water supply.

As with the travel cost valuation method, hedonic pricing values ecosystem services using actual consumer preferences. This method, however, can be responsible for inexact results if the pricing function is based on faulty information. The method assumes buyers have completely reliable information regarding the environmental variables being considered in the

valuation. If information is lacking or incomplete, a strong possibility in real world situations, the values applied to ecosystem services will be inaccurate (Yung En Chee, 2004).

II. Expressed Preference Methods

In some circumstances, environmental values cannot be derived from market choices, as they were in the revealed preference methods previously described. Many goods and services provided by the environment cannot be valued using market transactions, yet they still contribute to human benefit. When these situations arise, services can be valued by directly questioning the population about possible environmental policy actions (Young, Robert A., 2005).

In expressed preference models, respondents are questioned about environmental policy options and their WTP for current or future environmental conditions associated with the policies. Two of the major models used for expressed preferences are the contingent valuation method and choice modeling analysis. Contingent valuation infers WTP by using respondents' answers to questions regarding their movement from a given state of environmental conditions to a more desirable state. Choice modeling analysis requires respondents to rank policy options based on the environmental conditions present in each option and the cost of implementing the policy. Based on the rankings, statistical analysis is used to infer WTP values for each environmental condition (Young, Robert A., 2005).

a. Contingent Valuation Method

The oldest and most common expressed preference method is the contingent valuation method. The technique uses surveys and questionnaires to ask people directly about how much they would be willing to pay "*contingent* on some hypothetical change in the future state of the world" (Young, Robert A., 2005, p. 135). The questionnaires describe the environmental amenity, both in its current condition and the proposed future condition. Additionally, the

surveys collect information on the socioeconomic characteristics of the respondents, such as age, education, and income, which are used to shift demand variables in the final statistical analyses (Young, Robert A., 2005).

While contingent valuation has been used in many studies covering a variety of different environmental characteristics and ecosystem services, the method has been highly criticized. Questionnaires and surveys are subject to a multitude of biases that obscure the WTP values reported by the studies. Both the information presented in the questionnaire and the order in which the questions are asked can influence respondents' answers. Further, prior knowledge and opinions about the environmental characteristic in question can alter the results. Compliance bias occurs frequently; respondents provide responses they think will please the interviewer. Finally, if respondents believe their WTP values will actually be collected, they may understate their "true" WTP for ecosystem services (Yung En Chee, 2004). Because contingent valuation uses hypothetical markets, respondents may not be incentivized to respond carefully and thoughtfully. Contingent valuation studies are widely used due to their ability to value goods and services that are not marketed, but the results must be analyzed with an understanding of the format used to create the WTP values.

b. Choice Modeling

Choice modeling analysis is another form of an expressed preference valuation method. As with contingent valuation, the goal of this method is to quantify people's willingness-to-pay to avoid environmental degradation or strengthen environmental protection. In order to achieve these objectives, choice modeling analyzes respondents' utility for goods and services by looking at the tradeoffs they are willing to make when choosing between alternative options (Young, Robert A., 2005).

Choice modeling is nearly identical to contingent valuation, except for one key difference in how respondents are asked about their preferences. In choice modeling, a set of choices and corresponding alternatives are presented to the respondent. The respondent is then asked to rank the "choice sets" based on the multiple characteristics described in the option. Using the responses, statistical analysis derives utility functions and values specific environmental attributes (Young, Robert A., 2005).

Compared to contingent valuation, choice modeling provides greater detail for utility functions derived from responses to policy options. Various levels of environmental characteristics are described in choice modeling questionnaires, offering a higher degree of accuracy for WTP values. As this method continues to be refined, it is likely that it will be used at an increasing rate to value ecosystem services that are not linked to marketed goods (Young, Robert A., 2005).

III. Other Valuation Methods

a. Replacement and Restoration Costs

The replacement costs and restoration costs methods value ecosystem services by applying the costs it takes to replace or restore a degraded service to its pre-damaged state to the direct value of that service. The goal of these approaches is to recapture lost consumer surplus. For these methods to derive accurate results, the attributes to be restored must be defined precisely. Without such definition, the population cannot be described as willing to incur the replacement/restoration costs of the project. Therefore, value estimates must be taken as overvalued, because some portion of the population will not be willing to pay for the replaced or restored services (Bingham, Gail et al., 1995; Holl and Howarth, 2000; Yung En Chee, 2004).

b. Defensive Behavior and Damage Cost

In valuing ecosystem services, defensive behavior and damage cost methods attempt to measure WTP by looking at the actions people take to avoid adverse environmental effects, usually pollution of resources. The defensive behavior approach infers ecosystem service values from expenditures made by people and households to avert exposure to pollutants or to offset the negative effects of exposure. The assumption is that rational actors will employ defensive behavior methods if the value of the damage avoided is greater than the cost of the defensive action (Young, Robert A., 2005).

Damage cost methods value services based on the resource costs of environmental degradation. Like defensive behavior, damage costs are typically applied to pollution or contamination of resources. Therefore, most damage cost studies use the "cost of illness" approach. This approach sums medication costs and doctor visit expenditures and applies them to value the ecosystem services that provide for healthy resources. The assumption is that households and individuals would be willing to pay up to the "cost of illness" that would result from environmental degradation to avoid similar costs in the future. Generally, this value is a lower bound, as people would likely pay extra to avoid the experience (Young, Robert A., 2005).

IV. Benefit Function Transfer

Benefit function transfer relies on evidence from previous research to value other specific sites when the resources or time available for an on-site study are limited (Young, Robert A., 2005). In this case, an economic valuation of the Big Cottonwood Canyon Watershed would require a vast amount of resources and time. The various valuation methods described above have all been used in a number of studies covering ecosystems that are similar to the Big Cottonwood Canyon Watershed. Therefore, this study applies values from other studies to Big

Cottonwood Canyon using benefit transfer methodology. Benefit transfer offers realistic and accurate estimates of the true value of the watershed and can be done in a more efficient manner.

Chapter 3
Big Cottonwood Canyon

I. The Canyon

Big Cottonwood Canyon is located to the east of Salt Lake City in the Wasatch Mountain Range. Of the seven watersheds located in this mountain range, Big Cottonwood Canyon is the second largest. The watershed area comprises 50 square miles (32,000 acres) and elevation in the canyon ranges from 5,000 feet to 10,500 feet. The lower portion of the canyon is steep and winding, due to natural stream cutting processes that have helped form the canyon. The upper portion of Big Cottonwood Canyon is broad and open as a result of glaciation processes. Land in the canyon is predominately held and managed by the U.S. Forest Service, although some areas are owned by private parties (*Salt Lake City Watershed Management Plan*, 1999; *Wasatch Canyons Tomorrow*, 2010).

The canyon is home to Big Cottonwood Creek, which originates in the canyon's upper basins, including the Twin Lakes and Lake Mary reservoirs. Water from the creek is the main source of water to the Salt Lake City Public Utilities service area, accounting for 51,532 acre-feet of water, or 22% - 24% of the total water supplied by the utility each year. Water supply from the canyon is reliant on high snowpack levels and snowmelt runoff following the winter months. Flow rates in the canyon are typically stable due to the topography and width of the canyon; flooding only occurs as a result of intense storms, typically in May and June (*Salt Lake City Watershed Management Plan*, 1999; *Wasatch Canyons tomorrow*, 2010).

As with other canyons and watersheds located in the Wasatch Range, Big Cottonwood Canyon is home to a variety of recreational opportunities. Cycling, hiking, skiing, snowboarding, climbing, picnicking, camping, and fishing are all outdoor recreational activities that take place in the canyon throughout the year. Downhill skiing is the most popular winter activity, while

cross-country skiing and tubing are also common during the snow season. Economically, skiing is a major contributor to Utah's economy, generating millions of skier and snowboarder visits each year. Big Cottonwood Canyon is home to Solitude Mountain Resort and Brighton Ski Resort (*Salt Lake City Watershed Management Plan*, 1999; *Wasatch Canyons tomorrow*, 2010). Brighton Ski Resort was the first ski resort in Utah, and one of the first in the country. Opening in 1936, the resort has grown to a skiable area of 1,050 acres (brightonresort.com). Solitude Mountain Resort began construction in 1956 and opened the next year. Today, the resort contains 1,200 acres of skiable terrain (skisolitude.com).

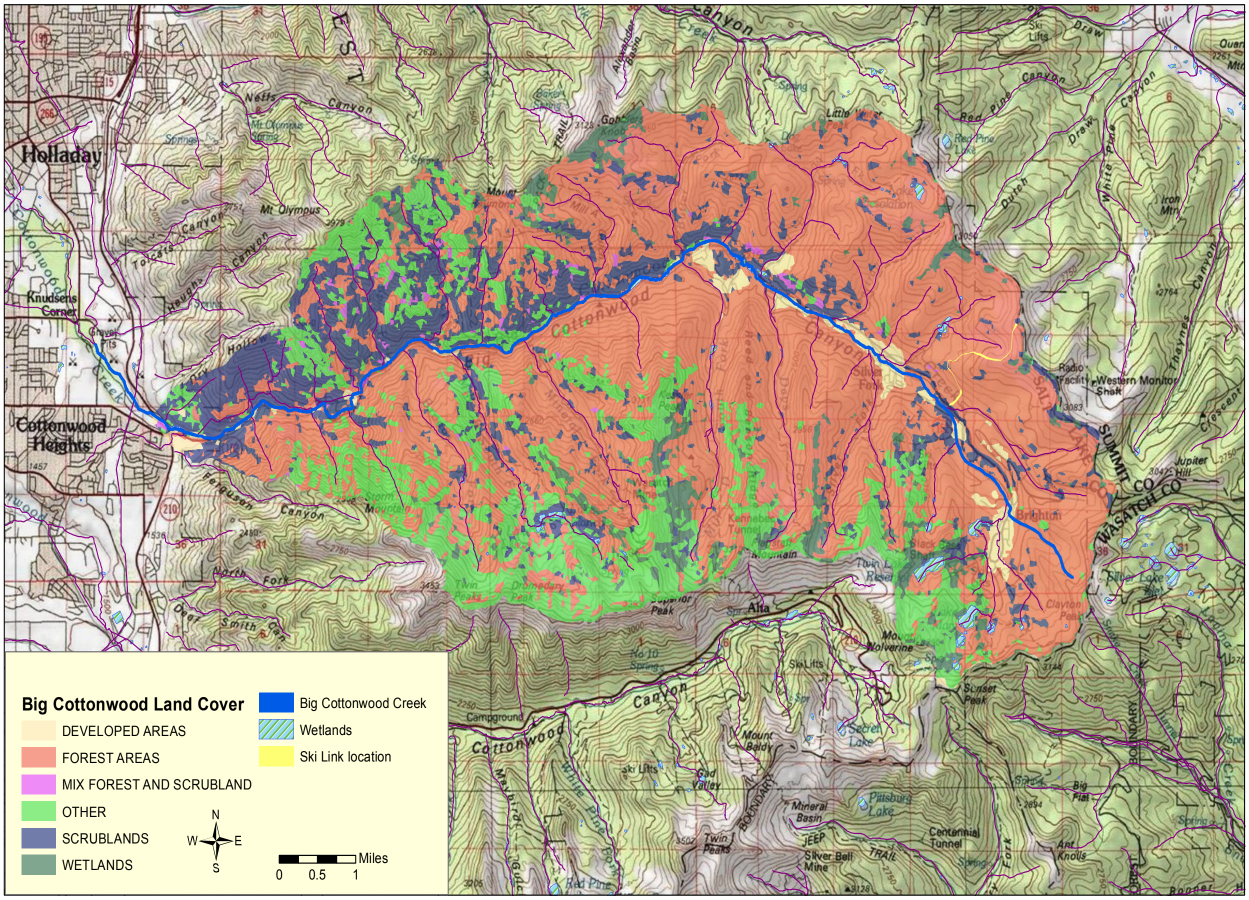
II. The Big Cottonwood Canyon Watershed

A watershed is defined as a geographical or geological area of land that catches rain and snow drainage and funnels it into a single river system. A watershed area includes all surface water and groundwater sources that contribute to the stream system of that area (Salt Lake City Department of Public Utilities). For Salt Lake City, watersheds are designated as protected because of the important drinking water they supply. The Big Cottonwood Canyon Watershed is considered a "Protected Watershed Area." Because human activities and actions in areas around water sources can affect the quality of water, these activities and actions are regulated in protected areas. Protected Watershed Areas, for example, prohibit dogs and horses in order to protect against fecal waste entering the stream system. Swimming and boating are prohibited in drinking water sources, and fishing requires the use of waders. Finally, off-road motorized vehicles are only allowed on roads or designated trails to protect against erosion (Salt Lake City Department of Public Utilities).

The Big Cottonwood Canyon Watershed is home to a wide variety of land cover and vegetation types. For simplicity's sake, these types have been grouped into larger categories,

specifically forested areas, scrublands and shrub lands, wetlands and wet meadows, and riparian buffer zones. Forested areas have high scenic value and are important to the wildlife inhabiting the canyon. Scrublands are found between 3,000-9,000 feet in elevation. Like forests, they are home to a multitude of wildlife, offering cover and food for animals in this transition zone. Wetlands and wet meadows are home to grasses and marsh plants. These areas are saturated with water for most of the year and allow for a wide variety of plants and animals to take advantage of their water abundance. Wetlands, however, are rare in Utah and occupy only a small area in the Big Cottonwood Canyon Watershed. Finally, riparian buffer zones refer to the streamside habitat created by vegetation that surrounds Big Cottonwood Creek. These areas tend to be highly productive and support a healthy array of wildlife. The riparian zone is defined as the 100-foot buffer area surrounding each side of the creek. The 100-foot zone was chosen based on the characteristics of the canyon as a whole. The steep slopes allow for abrupt land coverage changes and, therefore, a 100-foot buffer reduces possible overlap between riparian zones and other types of vegetative cover (*Wasatch Canyons Tomorrow*, 2010).

Figure 1: Land Cover in the Big Cottonwood Canyon Watershed[1]



[1]Provided by the Salt Lake City Department of Public Utilities

III. Ecosystem Services in Big Cottonwood Canyon

The vegetation and land cover in Big Cottonwood Canyon is vital to the proper functioning of the ecosystem services provided by the watershed. Developed areas destroy and degrade the natural land, hurting the processes that allow for the survival of the habitats located within the watershed. While the canyon is home to a large recreational footprint, the protected status of the watershed and the relatively small amount of developed land has allowed for the canyon to remain in a highly pristine and natural condition. Human activities, however, threaten many areas in the canyon, particularly riparian buffer zones and wetlands. These land types make up a relatively small portion of the total land cover in the canyon (see Table 4), but they provide

for vital services that help maintain habitats within the canyon. Additionally, human activity tends to break up contiguous habitat areas, a violation as severe as the degradation of natural lands (*Wasatch Canyons Tomorrow*, 2010).

Habitat areas and vegetation cover provide for a multitude of ecosystem services within the watershed. Services are typically grouped as provisioning, regulating, habitat, and information services. For the Big Cottonwood Canyon Watershed, provisioning services include basic goods. The water supply service is the only provisioning service valued in the canyon (Schmidt and Batker, 2012). It provides for the reliable delivery of clean drinking water for Salt Lake City's residents. The most important feature of the water supply service is the quality of the water itself. Because Salt Lake City has a diverse portfolio of water supply options, and development within the canyon is not currently threatening the amount of available water, the quality of the water is carefully monitored. Without such high quality levels, treatment costs would quickly rise, and the increasing costs would be transferred to consumers in the form of higher priced water.

The regulating services in the watershed include gas and climate regulation, disturbance regulation, water regulation, waste treatment, soil formation and erosion control, pollination, and nutrient regulation, all of which come from the natural processes and functions of the ecosystem. While these regulating services do not provide for direct, consumable goods, their benefits allow for functioning processes that keep the watershed healthy and protect its users (Schmidt and Batker, 2012). For example, gas and climate regulation includes the maintenance of a favorable climate and clean and breathable air. Without regulating services, ecosystems would cease to function properly. Imagine an environment without pollination – reproduction would stop and

local plant species would disappear. This failure would cause large-scale collapse, including animal losses, soil erosion, and declining water quality.

The only habitat service provided for by the Big Cottonwood Canyon Watershed is biodiversity, which offers protection and conservation of diversity in the area. This diversity is the basis for most other ecosystem services, as diversity protects against major disturbances typically related with invariability. Consider, for example, the problems of disease resistance and nutrient depletion faced by monoculture. Biodiversity provides for a diverse group of plant and animal species, including soil microbes, all of which protect against sudden collapses from diseases and pathogens (Schmidt and Batker, 2012).

Finally, the information services of the watershed include recreation and cultural services. Both of these services provide humans with a positive connection to nature, an important function of the watershed (Schmidt and Batker, 2012). With respect to recreation, it may be the largest contributor to the welfare benefits stemming from the watershed's services. Utah residents consider recreation as part of their identity, a major reason why they chose to call the state home. For this reason, the relative value of the recreation service is likely larger than it is in other area studies covering environmental economics. Moreover, it requires the use of a more site-specific method that involves the number of recreational site visits within the watershed, something that will be discussed further in the recreation service section.

While it has been alluded to above, the connectivity of ecosystem services merits further discussion. Each service is not independent of the others. Instead, the services work together to create a healthy and functioning ecosystem. Water quality depends on healthy soils, diverse plant life, and natural drainage. Other services are equally reliant on similar connections.

The connectivity is extremely important and allows ecosystems to survive, but it is also cause for serious concern. Destruction and degradation of natural lands and their associated ecosystem services plays into this connective idea. Small, incremental damages may represent little marginal loss in the normal functioning of the services, but there is a tipping point. In other words, full collapse does not require complete and absolute destruction of an ecosystem. The incremental damages may reach a point in which one service loses its ability to function properly. As this service stops, many of the services connected to it will begin to stop functioning properly as well, depending on the level of connectivity. If, for example, a major service like biodiversity were destroyed to a point of failure, nonlinear and widespread collapse of the ecosystem services in the surrounding area could occur, resulting in a total loss, not merely a marginal loss. For this reason, the protection of natural lands from development is paramount.

Although there is relatively little development in the Big Cottonwood Canyon Watershed, it is difficult to know the amount of land that must be converted before the tipping point is reached. Additionally, the value of the land and vegetation cover in Big Cottonwood Canyon and its ecosystems tends to go unnoticed due to the lack of information on the ecosystem services supplied by natural lands. For these reasons, the value of the specific types of land cover in the Big Cottonwood Canyon Watershed must be calculated to provide information on the value of the watershed that can be understood by policy makers and the public. With this data, decision-makers can better formulate policy regarding expansion and development in natural areas. Without it, ecosystem services remain an externality, leaving them undervalued or ignored.

Chapter 4
Valuation of Watershed Services

I. Water Supply

Water supply is a vital ecosystem service provided by the Big Cottonwood Canyon Watershed. The water supply service encompasses water availability and water quality, a major concern for the well-being of Salt Lake City residents. As noted, runoff leaving Big Cottonwood Canyon accounts for 22% - 24% of the water supply for residents surrounding the watershed area, the largest share of water supplied by the Salt Lake City watersheds. According to the Salt Lake City Watershed Management Plan (1999), annual water runoff yield for Big Cottonwood Canyon totals 51,532 acre-feet (*Wasatch Canyons Tomorrow*, 2010).

Within Big Cottonwood Canyon, forested areas, wetlands, riparian buffer zones, and scrublands all contribute to the quality of the water supply. Snowmelt runoff recharges Big Cottonwood Creek, the major water source for the canyon. In this study, however, the creek will not be directly valued due to its small size and status as a protected creek, only allowing for “non-contact” recreational uses and restricting development (Salt Lake County Public Works Engineering, 2003). Additionally, the proposed development of SkiLink does not threaten water availability, and the purpose of this study is to analyze the effects of development on the watershed (Cirrus Ecological Solutions, LC, 2010). Due to these considerations, the water supply service will be valued primarily through the water quality and purification benefits provided by forested areas, riparian zones, scrublands, and wetlands. These varied ecosystems allow for reliable flows of clean water that maintain aquatic and terrestrial habitats in addition to being used for human consumption.

Conservation of the ecosystems that contribute to water supply is more cost effective than replacing or fixing the service once it has been lost or altered. For example, conserving an

upstream forest to protect water quality will often be cheaper than building or upgrading water treatment plants. Studies in Oregon, Maine, and Washington have found that every $1 invested on watershed protection measures saves $7.50 to $200 in water treatment facility costs. New York City's Catskills Range protection measures have saved the city $4 to $6 billion on infrastructure that would have otherwise been required to maintain water quality supplied to its residents (Emerton and Bos, 2004). Furthermore, watershed protection measures focused on preserving forest cover can prevent unnecessary treatment costs, according to Ernst, Gullick, and Nixon's study covering data reported by 27 water utilities across the nation. Specifically, for every 10% increase in forest cover, treatment costs decrease by approximately 20% for water suppliers (2004).

Expensive water treatment investments illustrate the importance of water supply in a watershed. The watershed's ecosystem services filter water to levels that require little treatment before delivery to residential areas, avoiding what would otherwise be high treatment costs. Direct human consumptive benefits must be valued to be protected. Alteration of the water supply ecosystem service could prove costly to Salt Lake City, particularly due to the current high water quality and reliable supply enjoyed by its population.

The economic contribution of water supply is dependent on the type of ecosystem that controls quality and availability and the indirect benefits that accompany that supply. Seyam, Hoekstra, Ngabirano, and Savenije found that agriculture use, fish and wildlife support, grazing, and forest resources capture the direct value of water supply from wetlands ecosystems in the Zambezi Basin of Southern Africa, totaling $48 per hectare per year (1990 dollars) (qtd. in Emerton and Bos, 2004). The Zambezi Basin study uses direct market values of tradable goods to reach this approximation (Seyam, Hoekstra, Ngbirano, and Savenije, 2001). Transferred to

wetlands located within the Big Cottonwood Canyon Watershed, this result poorly estimates the value of the watershed's contribution to water supply because, in the Zambezi Basin study, a major contributor to the estimation is the value added by agricultural products produced in the basin. Agriculture is not a mainstay in Big Cottonwood Canyon. The final wetlands contribution to water supply for Big Cottonwood Canyon must therefore depend on other services within the canyon. Additionally, applying direct market rates for crop production to water supply favors availability over quality. Big Cottonwood Canyon values its water supply service for the quality of the water, and benefit transfer methods must use studies that also place high value on quality over quantity.

An ecosystem service valuation study from the Mackenzie Watershed located in western Oregon values the water supply service in forests, grasslands, lakes and rivers, pasture and hay areas, scrublands, urban green space, wetlands, agricultural lands, and riparian buffer zones. For the Big Cottonwood Canyon Watershed, only forests, wetlands, and riparian buffer zones are applicable. Similar to the Big Cottonwood Canyon Watershed, the population surrounding the McKenzie Watershed relies on the water supplied by the watershed for drinking water. Additionally, the water is of high quality due to filtration through natural lands instead of intensive treatment. According to the McKenzie study (values in 2010 dollars), water supply in forested areas is valued at $9.81 - $47.04 per acre per year based on turbidity levels affecting water quality in native lands that had been restored after degradation. This study offers accurate estimates of the water supply value in Big Cottonwood Canyon due to the effect that forested areas have on the high quality of water supplied (Dodds, W.K. et al., 2008).

The McKenzie Watershed study valued the wetlands' contribution to water supply at $10.01 - $4,289.38 per acre per year. For wetlands, the price of the cheapest alternative way of

obtaining the service was used to value water supply. In this case, the treatment costs of treating polluted waters were the best alternative to natural filtration of the water supply (Woodward and Wui, 2001).

Riparian buffer zones contribute $67.30 - $267.81 per acre per year to the value of the water supply service in the McKenzie Watershed (Schmidt and Batker, 2012). Riparian zone values were adapted from a study covering the invasive plant species, Tamarisk, which degrades water quality levels. The study used restoration costs associated with removal of this harmful species to value the buffer zones (Zavaleta, 2000). Applied to the Big Cottonwood Canyon and a 100-foot riparian buffer zone surrounding the creek, Tamarisk removal and restoration costs can be used to accurately value the canyon's buffer zone due to the possibility of Tamarisk invasions within the Big Cottonwood Canyon system. In the end, because each study adapted to the McKenzie Watershed study uses water quality as the main concern for the water supply service, these values can be similarly transferred to the Big Cottonwood Canyon Watershed.

Less useful here is the 2011 draft study covering the Cache La Poudre Watershed near Fort Collins, Colorado, which also applies benefit transfer methods to value its water supply service. According to the study, wetlands provide $180 - $1,985 per acre per year of water supply. While the Cache La Poudre Watershed is located in a Rocky Mountain environment, one similar to the Wasatch Front, the water supply service for this study is based on water supplied for agricultural use and is most likely based on the market values of agricultural products, which does not mirror the water supply service within the Big Cottonwood Canyon Watershed. The study lacks information regarding the exact source of their values, but the large value range for wetlands is likely due to differing degrees of crop values from agricultural practices. Thus, these values cannot be transferred to Big Cottonwood Canyon.

On a larger scale, Costanza et al. compiled multiple studies done worldwide to estimate a global value for ecosystem services by biome. According to the study, water supply values are as follows (1994 dollars): forests, $3 per hectare per year, and wetlands, $3,800 per hectare per year (1997). These values are unlikely to add much to a Big Cottonwood Canyon valuation due to their global scope; however, they do provide a basis for valuation, as the study was the first of its type and will be used as a backdrop for values for each of the following ecosystem services.

The water supply and quality services provided by the Big Cottonwood Canyon Watershed are valued similarly to other watersheds across the nation. Forested land in Big Cottonwood Canyon represents about 61% of the total watershed acreage. According to the study by Ernst, Gullick, and Nixon described earlier, annual treatment costs for a watershed with 60% forest coverage averages $297,110 across 27 U.S. water utilities. If the forested area drops to 50% coverage, annual treatment costs should rise by $72,270 (2004). Using the forest land type value for the water supply service (Table 3), a decrease of forested land in the Big Cottonwood Canyon Watershed from current levels to 50% coverage would translate to a loss in quality benefits of $38,789.27 - $186,009.66 per year that must be replaced with increasing treatment costs. This value range contains the value provided by the national study, supporting the accuracy of this case study and the use of benefit transfer methods for water quality within the Big Cottonwood Canyon Watershed.

II. Disturbance Regulation

Disturbance regulation refers to the important buffer that ecosystems provide to the local economy surrounding the natural landscape. In particular, disturbance regulation encapsulates flood control, landslide prevention, and storm protection created by environmental variability. These protections are due mainly to the vegetation cover of multiple types of environments,

including forests, riparian buffer zones, and wetlands. Each of these environmental zones contributes to flow reduction and control (Costanza et al., 1997; Schmidt and Batker, 2012).

As disturbance regulation control measures are degraded, destroyed, or altered, the ecosystem service loses its ability to control water flow. Natural capital that has been manipulated by development contributes to increasing runoff volume and speed, intensifying peak flows (Schmidt and Batker, 2012). As a watershed loses the complexity of its land cover, disturbance regulation declines in value. Healthy watersheds that include multiple land types are crucial to disturbance control and mediation. This is of particular importance in Big Cottonwood Canyon due to its narrow streambed and steep slopes. Without disturbance regulation, road and property repair could prove to be costly. A history of damaging floods in the canyon adds to the importance of sustaining this ecosystem service.

Adapting global values calculated by Costanza et al. (1997), Seidl and Moraes value the total disturbance regulation service at $1,747.19 per hectare per year in 1994 dollars. This specific value is slightly different than the Costanza et al. value ($1,779 per hectare per year) due to the specific area of Pantanal de Nhecolandia in Brazil and its unique characteristics (2000). Nevertheless, these high values illustrate the importance of disturbance regulation to the surrounding area. The Costanza et al. global study contributes $2 per hectare per year to disturbance regulation in forested areas and $4,539 per hectare per year in wetlands areas (1994 dollars) (1997).

Other specific case studies similarly value forested areas. In the McKenzie Watershed study, forested lands contribute $1.40 - $5.14 per acre per year (2010 dollars) to disturbance regulation based on restoration costs applied to runoff values dependent on vegetation cover and soil characteristics (Dodds W.K. et al., 2008). The values for wetlands are much higher. In the

McKenzie Watershed, researchers value wetlands at $433.78 - $7,757.92 per acre per year using avoided damage costs (Allen, J et al. qtd. in Schmidt and Batker, 2012). Finally, riparian buffer zones are valued at $43.31 - $3,884.40 per acre per year for disturbance regulation using avoided damage costs from Tamarisk removal and the elimination of Tamarisk channel narrowing effects that increase the likelihood of overbank flow (Schmidt and Batker, 2012; Zavaleta, 2000). These valuation methods – their use of vegetation cover, soil types, and avoided damage costs – are readily transferred to the Big Cottonwood Canyon because the watersheds in these studies have characteristics that are comparable to those found in the Big Cottonwood Canyon Watershed.

Land types in other areas of the world have also been economically valued for the disturbance regulation service. Specific to flood control and attenuation, a study done in Sri Lanka by Emerton and Kekulandala (2003) values wetlands' contribution to the service at $1,750 per hectare per year. The study uses mitigative expenditure methods based on the increased flooding intensity in settled areas from land zoning and increased development around the wetlands (qtd. in Emerton and Bos, 2004). The characteristics of the wetlands area in Sri Lanka differ from the much smaller tracts of wetlands within the Big Cottonwood Canyon Watershed. However, the value reported falls within the McKenzie study's value range, a more appropriate estimation, and therefore reinforces the reported value range.

In considering the valuation of disturbance regulation by different forms of land cover within an ecosystem, or here, a watershed, one must also consider the added protection provided by the service not always noted in acreage value ranges. While forested areas, wetlands, and riparian buffer zones contribute to the vegetation that provides water absorption and runoff reduction, damage avoided is not always taken into account. Real benefits to society go above and beyond acreage values for disturbance regulation in certain cases, for example the forest

values reported in the McKenzie study discussed above. In other circumstances, these avoided damage costs are accounted for as described in the McKenzie wetlands and riparian zone values. If the studies used for valuation do not include mitigative and avoided cost methods, the total disturbance regulation ecosystem service contribution will be undervalued. In the Big Cottonwood Canyon Watershed study, however, these valuation methods are included in value ranges, so the reported values in Table 3 can be viewed as a better approximation of the total value of the disturbance regulation service.

III. Recreation

Recreation as an ecosystem service provides for eco-tourism, sport fishing, and other outdoor recreation activities. Big Cottonwood Canyon is home to many forms of recreation, including fishing, hiking, camping, sightseeing, mountain biking, hunting, and skiing (*Wasatch Canyons Tomorrow*, 2010). Recreation is a defining feature of Salt Lake City's identity, while also being an important part of Utah's economy. Many of the recreational activities in the canyon are dependent on the health of the natural land. Fishing requires in-stream flows and high water quality, while hiking, sightseeing, and camping derive benefit from the aesthetics of the surrounding area. In 2003, campgrounds recorded around 107,000 visitors, while forest trails totaled an estimated 934,000 site visits. Wilderness area visits were estimated at 86,000, picnic areas at 195,000, forest roads at 386,000, and scenic byways at 151,000 (*Wasatch Canyons Tomorrow*, 2010). These values are for all of the canyons surrounding Salt Lake City, but Big Cottonwood Canyon is likely to provide a large percentage of visits due to its size, popularity, scenic values, and variety of recreational activity options.

In aggregate yearly value, skiing brings in the most recreation capital to the state's economy. For the 2007-2008 ski season, the industry recorded over 4 million skiers and

snowboarders at the resorts totaling $1.06 billion in contributions to the state's economy. The 2009-2010 season generated $1.26 billion in ski and snowboarder expenditures (H.R. 3452, 2012; *Wasatch Canyons Tomorrow*, 2010). Ski resorts, however, will not be considered in the recreational ecosystem service valuation. While the other recreational activities require healthy ecosystems and natural land, ski resorts are a function of land conversion that alters and degrades the natural capital to clear forested areas for ski runs, buildings, and parking lots. Effectively, ski resorts contribute to a loss in ecosystem service value to the watershed by destroying forests, wetlands, and other parts of the ecosystem. Other outdoors sports may not contribute to the state's economy at the same level as the ski industry, but they are still a large contributor to the state's economy. For example, a Colorado study concluded that Colorado rivers contributed between $164 - $360 per acre-foot of water to the fishing and rafting industry, both multi-million dollar industries in Colorado (Roberts and Grossman, 2008). Additionally, visits to Utah canyon campgrounds, forest trails, and other areas are expected to double from 2003 to 2030. By 2050, site visits are estimated to reach over 4 million, potentially bringing millions of dollars to the state from campground fees and other charges (*Wasatch Canyons Tomorrow*, 2010).

The value of the recreation ecosystem service for the Big Cottonwood Canyon Watershed will not come from recreation income in every circumstance. While many of the following studies take economic gains and transform them into acreage values, other studies value recreation using the innate benefits of the land. Further, as natural land is degraded or converted, the processes and functions that contribute to human recreational benefit are lost. It is also important to consider the detrimental effect of increased use of recreation services. As site visits grow, increased use poses a major problem of potential overuse and strain of the natural land, leading to degraded habitat and watershed qualities. However, development of the watershed is a

form of rapid and irreversible land conversion, a much more harmful threat to the Big Cottonwood Canyon Watershed.

Globally, Costanza et al. value recreation at $66 per hectare per year for forests in 1994 dollars. The same study values the recreation ecosystem service at $574 per hectare per year for wetlands (1997). Adapting these values to a regional scale, Seidl and Moraes total the recreational service value at $157.37 per hectare per year, again in 1994 dollars (2000). This total value in Seidl and Moraes' regional value is likely to be much lower than the total value in the Big Cottonwood Canyon Watershed due to the high value Salt Lake City residents place on recreation within the surrounding canyons.

Schmidt and Batker's McKenzie Watershed study also values the recreation ecosystem service at the acreage level (2012). Using contingent valuation methods, economic gains from recreation activities, and travel cost methods for forested areas similar to those in the McKenzie Watershed and Big Cottonwood Canyon, forests were calculated to contribute $0.18 - $875.43 per acre per year in 2010 dollars to recreation (Boxall, McFarlane, and Gartrell, 1996; Dodds, W.K. et al., 2008; Shafer, E.L. et al., 1993). Scrublands provide $0.19 - $1,991.64 per acre per year using similar travel cost, contingent valuation, and willingness-to-pay methodologies in scrubland areas surrounding forested lands (Bishop, K., 1992; Boxall, McFarlane, and Gartrell, 1996; Shafer, E.L. et al., 1993). Finally, wetlands contribute $1.67 - $4,984.78 per acre per year to recreation, and riparian buffer zones contribute $76.90 - $1,169.41 per acre per year. Wetlands values were calculated based on travel cost methods, economic gains, and hedonic pricing. The high value comes from hedonic pricing of property values based on proximity to wetlands areas and the associated recreational opportunities provided for by the natural landscape. The high value associated with the hedonic pricing study is unlikely to be of specific use for the Big

Cottonwood Canyon Watershed study as houses are not located relatively near the wetlands areas (Dodds, W.K. et al., 2008; Doss and Taff, 1996; Woodward and Wui, 2001). Riparian zones were valued based on hedonic pricing and contingent valuation, using housing values and willingness-to-pay for riparian zone protection, with a particular focus on the recreational and aesthetic benefits of such areas (Kulshreshtha and Gilles, 1993; Shafer, E.L. et al., 1993; Qui, Z. et al., 2006).

In addition to the McKenzie study, the Cache La Poudre draft study estimates recreation service values. Based on the watershed, forests and scrublands each value recreation at $96 - $532 per acre per year. Wetlands contribute $2,603 per acre per year (2011). These estimates are based on the principal forms of recreation in the Cache La Poudre Watershed. While the area has similar land characteristics to Big Cottonwood Canyon, fishing, rafting, and hunting are the main contributors to recreational income in the Colorado watershed. Therefore, these values may not accurately represent the contribution of recreation to the Big Cottonwood Canyon Watershed.

The recreation ecosystem service is a unique service with respect to valuation methods. While land type acreage is an effective way to value the natural functions and processes that provide for the qualities humans desire in recreational opportunities (water quality for fishing, biodiversity for hunting), willingness-to-pay or consumer surplus methods must also be considered specifically for the recreation service to calculate a per annum value for the residents surrounding the watershed area. Optimally, consumer surplus and WTP methods should be given preferential treatment when available. Some areas do not have the required data to calculate the per annum value of the recreation service and, therefore, acreage values must suffice for accurate modeling. The Big Cottonwood Canyon, however, has site visit data that can be used to estimate a more accurate reflection of the value added by the recreation ecosystem service to the area.

Site visit data reflects an estimate of all seven watershed areas east of Salt Lake City. Based on coverage area, the Big Cottonwood Canyon Watershed represents 26.32% of the total protected watershed area in the Wasatch Mountain Range. Applying the area fraction to annual non-winter based site visits, Big Cottonwood Canyon is responsible for 28,162 campground visits, 245,828 forest trails visits, 39,743 scenic byway visits, 22,635 wilderness area visits, 51,324 picnic area visits, and 101,595 forest road visits, annually.

To calculate a value for recreation within Big Cottonwood Canyon, site visit estimates must be accompanied by their corresponding dollar value. In 2003, Pam Kaval and John Loomis collected over one thousand consumer surplus estimates from almost six hundred studies for outdoor recreation activities in differenct regions of the United States. Values have been converted to dollars per person per day units and are based in 1996 dollars. The study breaks up recreation type into different region categories. Specific to the Big Cottonwood Canyon, Utah is located in the Intermountain region. Values are averaged based on the number of studies used and the number of estimates obtained for each recreation type. The following table highlights the recreation types consistent with the non-winter based recreation site visits in Big Cottonwood Canyon discussed above.

Table 1: Average Per Day Consumer Surplus Values by Activity and Region[1]

Intermountain Area Studies	**Consumer Surplus**
Camping	28.93
Hiking	32.11
Off-Road Vehicle Driving	19.01
Picnicking	23.56
Pleasure Driving	58.12
Wildlife Viewing	31.03

[1]Adapted from Kaval and Loomis (2003)

Loomis updated the study in 2005 to reflect changing values for recreation by region (2004 dollars). While it may seem easier to use the 2005 updated values as the only values for calculating the recreation total for Big Cottonwood Canyon, the reported values are still not site specific, only region specific. Thus, a range of values is more likely to contain the best estimated value for each recreation type specific to non-winter based sites in Big Cottonwood Canyon.

Table 2: Average Per Day Consumer Surplus Values by Activity and Region[1]

Intermountain Area Studies	Consumer Surplus
Camping	34.72
Hiking	38.53
Off-Road Vehicle Driving	22.81
Picnicking	28.27
Pleasure Driving	69.74
Wildlife Viewing	37.24

[1]Adapted from Loomis, 2005

After converting to 2012 dollars, recreation contributes $21,844,579.07 - $21,919,093.33 to the Big Cottonwood Canyon Watershed each year. The estimate multiplies the annual site visits by consumer surplus to reach the total. Campground visits correspond to the camping activity, forest trails are applied to hiking, scenic byway visits are used with pleasure driving, wilderness areas represent wildlife viewing, picnic areas correspond to picnicking, and forest roads are applied to off-road vehicle driving. It should be noted that the opportunity for off-road vehicle driving is limited in Big Cottonwood Canyon.

It is important to note that the benefits from the recreation service often vary due to the effect of substitution. Because Big Cottonwood Canyon is one of seven canyons located close to Salt Lake City, and a few of the other canyons offer similar opportunities for recreation, substitution is achieved fairly easily. While the studies above attempt to control for substitution

in their demand analysis, we must remember that the Wasatch Range may offer more chances to substitute than other areas. This does not mean the total recreation service value is overvalued. The Loomis studies take into account a great variety of outside studies for their calculations, strengthening their ability to control for the substitution effect.

IV. Soil Erosion Control/Soil Formation

Soil erosion control is an overlooked, yet important ecosystem service. Plant growth requires soil for a foundation and for nutrient supply. Additionally, soil is the home to millions of organisms that are integral components of a functioning ecosystem. Soil is also connected to other important ecosystem services. Robust soils play an important role in water flow regulation, nutrient storage, and pollution neutralization. Soil formation and retention prevent loss of soil from wind and water runoff, contributing to the disturbance regulation service that protects against landslides. Finally, healthy streamside soils improve downstream water quality (Costanza et al., 1997; Schmidt and Batker, 2012).

While some functions of soil erosion control and formation are very similar to the functions of disturbance regulation (landslide protection) and other services (nutrient cycling and waste treatment), many of the other functions within the soil ecosystem service are required for the survival of an ecosystem. Without healthy and strong soils, plants would not have a foundation in which to grow. Additionally, the organisms living within the soils help break down nutrients and create space in the soil for air and water infiltration. These important natural functions provide for a healthy soil ecosystem service; without them, there would be varying ecosystem service collapses due to the connectivity of watershed ecosystem functions. For these reasons, the soil erosion control and formation service must be considered with its own values instead of being a contributing factor in other ecosystem services.

On a global scale, Costanza et al. value erosion control in forests at $96 per hectare per year in 1994 dollars. Additionally, soil formation is valued at $10 per hectare per year in forests (1997). Seidl and Moraes' regional study in Brazil values erosion control at $63.41 per hectare per year and soil formation at $22.37 per hectare per year in 1994 dollars (2000). Once again, both of these studies represent a benchmark. Site-specific studies will more accurately reflect the values associated with the Big Cottonwood Canyon Watershed.

The McKenzie Watershed study also values soil formation and erosion control as separate, yet connected services. Soil erosion control is valued at $63.92 - $143.50 per acre per year and soil formation at $5.95 - $6.66 per acre per year in forests (2010 dollars). These values were obtained from studies using production approaches and restoration costs. Soil formation was valued using the production value of topsoil for agricultural use and the time it takes for natural processes to create healthy soils for plant growth (Pimental et al., 1997). Erosion control was priced by comparing native, degraded, and restored area soil losses and the value of conserved soil in restored areas (Dodds W.K. et al., 2008). In scrublands, erosion control contributes $19.30 per acre per year, while soil formation only contributes $0.66 per acre per year. Both of these values were adapted from the Costanza et al. study (1997), indicating that they are less reliable values or that scrublands contribute similar amounts to both services in different biomes throughout the globe. Finally, soil erosion control is valued at $0.10 - $83.33 per acre per year in riparian buffer zones using avoided cost techniques to value the benefits of using soil conservation measures in Iowa Farms (Schmidt and Batker, 2012; Zhou, X et al., 2009).

Even though the soils in Big Cottonwood Canyon are not used for agriculture, it seems that agricultural practices offer the best estimates of soil values due to the direct monetary

benefits of crop production that arise from healthy soils. Therefore, these values should be considered useful, as they are the best available and many studies use similar methods to value soils in varying ecosystems. This methodology may undervalue the soils, as crop production only takes into account the processes and functions of soil erosion and control that provide for healthy crop cycles. Nonetheless, using a value that is lower than what may be the true value of the soil system is more accurate than the alternative of disregarding the service as a whole.

Soil erosion control and formation provides a good example of an ecosystem service that is connected to other services within a watershed. It is important to note, however, that even though some services are linked, they each contribute separate acreage values that should be added together to calculate a final value, as long as practices that avoid double counting have been implemented (Yung En Chee, 2004). In the case of soil erosion control and formation, double counting has been protected against as the service has been defined to include some similar functions of other services while adding unique value that would otherwise be unrepresented if the soil service were defined as an intermediary service. As we try to protect against double counting, we find that these complex connections between services indicate that many valuation assessments undervalue the ecosystem as a whole. As one function becomes degraded, many other services may cease to operate properly. This connective characteristic of ecosystem services strongly suggests that valuation methods may lack the ability to account for the additive effect that ecosystem services have on one another, as ecosystems do not tend to behave in a linear fashion.

V. Habitat and Biodiversity

Habitat protection and biodiversity, sometimes known as habitat refugia, refers to the maintenance of habitats and the diversity of the animal and plant species that live within them.

Diversity is particularly relevant to biological and genetic variability, a characteristic that allows ecosystems to remain healthy and function properly. Similar to soil erosion control and formation, biodiversity is a connected ecosystem service. In the case of habitat maintenance and genetic diversity within plant and animal species, biodiversity is the basis for most other ecosystem services (Schmidt and Batker, 2012; Costanza et al., 1997). The variation of plant species within an ecosystem is crucial to normal functioning processes that allow for water quality control, soil formation, nutrient cycling, and disturbance regulation. Biodiversity is also connected to recreation, allowing for fish populations to thrive in clean water and animals to survive in their habitats for aesthetic or hunting purposes.

Due to the complexity and connectivity of habitat refugia and biodiversity, it is important to describe the significance of the service by looking at both acreage amounts and WTP measures. As it is the basis for most other ecosystem services and contributes to value added for those services, biodiversity has wide value ranges, often with extremely high values on one side of the spectrum. The reason for the uncertainty is the inability of studies to accurately diagnose the extent of the connections between biodiversity and the other ecosystem services and how much biodiversity benefits add to the connected services. The values stated below should not be added to the Big Cottonwood Canyon Watershed total value because they represent the added value that biodiversity contributes to other ecosystem services. Even though biodiversity and habitat services should not be included in the total value of the watershed, it is crucial to understand the value added by biodiversity as some ecosystem services rely on biodiversity for a large share of their total value.

Costanza et al. values biodiversity and habitat refugia at $304 per hectare per year for wetlands, in 1994 dollars (1997). Seidl and Moraes' study values the total contribution of the habitat refugia service at $105.88 per hectare per year in 1994 dollars (2000).

On a local scale, the Cache La Poudre draft study values the habitat and biodiversity service for forests and wetlands. Forests contribute $134 per acre per year, while wetlands provide for only $6 per acre per year (2011). The Cache La Poudre study determines its biodiversity values using the benefits biodiversity adds to the recreation, pollination, and water supply services.

The McKenzie Watershed study provides values for biodiversity in forests, wetlands, scrublands, and riparian buffer zones. Forests account for $1.05 - $543.42 per acre per year, scrublands contribute $0.53 - $538.95 per acre per year, wetlands are valued at $5.82 - $2,241.85 per acre per year for the biodiversity service, and riparian buffer zones are valued at $0.41 - $59.96 per acre per year (2010 dollars) (Schmidt and Batker, 2012). Forest values were obtained using a combination of contingent valuation methods and value added to other services (Dodds W.K. et al., 2008; Kenyon and Nevin, 2001; Wilson, S.J., 2008). Similarly, scrublands, wetlands, and riparian buffer zones were valued using contingent valuation methods, typically using other ecosystem services to value biodiversity, i.e. paying for trout abundance, viewing elk in their natural environment, or pollination provided by species in the region (Dodds, W.K. et al., 2008; Kenyon and Nevin, 2001; Shafer, E.L. et al., 1993; Wilson, S.J., 2008). For riparian buffer zones, specifically, contingent valuation methods for willingness-to-pay were based on conservation and protection of riparian zones based on the water quality, species protection, and soil control services that biodiversity helps to provide (Amigues, J.P. et al., 2002). As with the

Cache La Poudre study, the McKenzie Watershed study looks at connected ecosystem services to value biodiversity habitat protection.

Additionally, biodiversity can be valued using direct contingent valuation and willingness-to-pay methods that have not been applied to acreage values. As quoted in Hurd's summary article, Kotchen and Reiling (2000) found that Maine residents value biodiversity at $32.70 per year per household based on the establishment of a species protection fund. Garber-Yonts, Kerkvliet, and Johnson's study (2004) of Oregon households values biodiversity at $270.40 per year based on conservation programs. Finally, Spash, Urama, Burton, Kenyon, Shannon, and Hill (2009) value the service at $10.83 per year based on biodiversity improvements in an ecosystem located in Scotland, UK (qtd. in Hurd, 2009). Mirroring acreage valuation studies, direct contingent valuation studies tend to focus on what biodiversity adds to other ecosystem services. In these studies, particularly, biodiversity adds value to recreation through protection and conservation programs that add to wildlife viewing opportunities and natural aesthetics for other outdoor recreation activities.

VI. Gas and Climate Regulation

The gas and climate regulation ecosystem service is vital to the health of our planet on local, regional, and global scales. The regulation services provide for carbon dioxide/oxygen balances, while protecting against harmful UV rays and regulating greenhouse gases. The regulation and protection of our atmosphere allows for clean, breathable air, thus promoting human health (Costanza et al., 1997; Schmidt and Batker, 2012).

The maintenance of the gas and climate regulation ecosystem service is particularly important as a result of climate change and global warming. Protecting an ecosystem service that can help mitigate the human effects of fossil-fuel burning seems necessary. With respect to the

Big Cottonwood Canyon Watershed, gas and climate regulation provided by the natural land may have an almost invisible effect on global climate patterns, but the local effect is crucial to the health of the ecosystems surrounding Salt Lake City and its residents.

Costanza et al. value the global contribution of forests to gas and climate regulation at $144 per hectare per year in 1994 dollars. Additionally, wetlands contribute $133 per hectare per year (1997). On a regional scale, Seidl and Moraes value the gas regulation ecosystem service at a total value of $67.35 per hectare per year in 1994 dollars. Climate regulation totals $44.76 per hectare per year (2000).

On a local scale, Schmidt and Batker's McKenzie Watershed study values the gas and climate regulation service for forests, grasslands, scrublands, urban green space, wetlands, agricultural lands, and riparian buffer zones. For the Big Cottonwood Canyon only forests, scrublands, wetlands, and riparian zones are considered. Forests contribute $10.57 - $253.97 per acre per year to the service (2010 dollars). Scrublands contribute $4.66 - $73.30 to the service, while wetlands contribute $4.85 - $705 per acre per year. Finally, gas and climate regulation is valued at $381.28 per acre per year for riparian buffer zones (2012). Value ranges for the McKenzie study were found using studies that multiply the amount of sequestered carbon dioxide, methane, and other gases by the value of those gases. The value ranges depend on the gases focused on by each study and the accompanying values for those gases (Dodds, W.K. et al., 2008; Mates and Reyes, 2004; Pimental et al., 1997; Wilson, S.J., 2008). Because it is a locally scaled analysis, the McKenzie study's calculated values are much more useful to the Big Cottonwood Canyon study than the regional and global values described above. As valuation studies become more site-specific, particularly for the gas and climate regulation service that is

more influential on a local scale, benefit transfer methods should allow for better estimates of the true values of the service within the study area.

VII. Other Ecosystem Services

Many other services contribute to the health and value of ecosystems. The complexity of natural lands is due to the large variety of services that work with each other to create a functioning ecosystem. Water regulation provides for the regulation of hydrological flows. This includes the provision of natural irrigation, drainage, and channel flow regulation. Nutrient cycling is the storage, cycling, and processing of nutrients. An efficient nutrient cycling system provides for healthy and productive soils. The waste treatment ecosystem service involves both pollution control and detoxification. This service also recovers mobile nutrients or removes excess nutrients when the system is out of balance. The pollination service describes the movement of floral gametes for reproduction. Finally, the cultural ecosystem service provides for non-commercial uses of ecosystems. Artistic, aesthetic, religious, and educational services of functioning ecosystems all contribute to the cultural service (Costanza et al., 1997; Schmidt and Batker, 2012).

Chapter 5
Value of the Big Cottonwood Canyon Watershed

I. Ecosystem Service Values for the Big Cottonwood Canyon Watershed

Analyzing estimates from the studies described above, benefit transfer methods are used to total the values of the services described in the Other Ecosystem Services section based on land type (2012 dollars) (Table 3). These total values are based on previously researched values from studies in which ecosystem service characteristics were similar to those found in the Big Cottonwood Canyon Watershed. For Big Cottonwood Canyon, forested areas contribute $232.99 - $1,484.86 per acre per year to these services. Scrublands contribute $3.32 - $8.14 per acre per year, while wetlands contribute $1,546.86 - $8,035.73 per acre per year. Finally, riparian buffer zones provide services with a value of $489.72 - $922.67 per acre per year.

For each ecosystem service, averaged per acre per year values are calculated based on the contribution made from each land type to the service. The water supply service averages $23.11 - $1,221.54 per acre per year in the canyon. The disturbance regulation service is averaged at $126.95 - $3,090.15 per acre per year, while the soil erosion control and formation service averages $23.86 - $67.24 per acre per year. Gas and climate regulation is averaged at $106.49- $375.03 per acre per year. Finally, the variety of ecosystem services described in the Other Ecosystem Services section are valued at an average of $586.22 - $2,612.85 per acre per year.

Table 3: Ecosystem Service and Land Type Values[1]

Services	Land Types: Forest		Scrubland		Wetlands		Riparian Buffer Zones		Average	
	Low Value	High Value	Low Value	High Value	Low Value	High Value	Low Value	High Value	Low Value	High Value
Water Supply	10.41	49.92	0.00	0.00	10.62	4,552.01	71.42	284.21	23.11	1,221.54
Disturbance Regulation	1.49	5.45	0.00	0.00	460.34	8,232.92	45.96	4,122.23	126.95	3,090.15
Soil Erosion Control and Formation	74.15	159.35	21.18	21.18	0.00	0.00	0.11	88.43	23.86	67.24
Gas and Climate Regulation	11.22	269.52	4.95	77.79	5.15	748.17	404.62	404.62	106.49	375.03
Other (Cultural, Pollination, Waste Treatment, Nutrient Cycling, Water Regulation)	232.99	1,484.86	3.32	8.14	1,546.86	8,035.73	489.72	922.67	568.22	2,612.85
Total	330.26	1,969.10	29.45	107.11	2,022.97	21,568.83	1,011.83	5,822.16		
	Low Value				High Value					
Recreation	21,844,579.07				21,919,093.33					

[1]Values are converted to 2012 using the Bureau of Labor Statistics CPI-U converter. Land type totals are read vertically, ecosystem service averages are read horizontally. All values are U.S. dollars per acre per year. Recreation values are total high and low annual values based on calculations above in the Recreation Service subsection.

The values in Table 3 place an extremely high value on recreation within the canyon. Compared to the other ecosystem services provided for by the watershed, the recreation service dominates the benefits derived from Big Cottonwood Canyon. This high value range, however, does not represent an overvaluing of the recreation service or an undervaluing of the other services. Instead, it represents the characteristics of Big Cottonwood Canyon and the targeted population surrounding the watershed. As discussed, each service was valued using benefit transfer methods. The recreation service, unlike the other ecosystem services, contained a valuation component that was highly site-specific. Annual Big Cottonwood Canyon non-winter based recreation site visits were used with consumer surplus values to calculate the recreation service's yearly value, while the other services relied completely on similarities in service

characteristics to derive annual values. The high value placed on recreation is therefore likely to be an accurate representation of the benefits received by the Salt Lake City population, as the canyon is known for its close ties to recreation.

II. Annual Value of the Big Cottonwood Canyon Watershed

The Big Cottonwood Canyon Watershed takes up 50 square miles, or approximately 32,000 acres in the Wasatch Range. The land types that make up this area and contribute to the value of ecosystem services consist of forests, scrublands, wetlands, and riparian buffer zones. The size of these areas can be seen in Table 4.

Table 4: Land Cover Figures

Land Cover	**Acreage**
Forest	19,954.00
Scrubland	4,496.82
Wetlands	1,531.89
Riparian Buffer Zone	4.07
Mix Forest and Scrubland	163.65
Developed	685.53
Other	5,619.72
Total	32,455.69

Developed areas do not contribute to ecosystem services, as they have converted the land and degraded the natural capital that is responsible for the proper functioning of these services. While they do not contribute to the ecosystem's value, they should not be counted as negatives. Converted lands have widely varying levels of severity – some are cleared forest areas planted with grass or other vegetation, others have been turned into parking lots, roadways, and other

impervious surfaces. Each form of conversion typically leads to increasing pollution run-off rates, but the specific rate increase requires site-specific assessment. As the exact value of environmental degradation is difficult to quantify for each type of converted land, and this study is focused on value received from natural lands, developed areas will not become negative values that take away from the whole. Instead, their surface area will be left out of the total area calculation, representing lost value. Additionally, other land types are found within Big Cottonwood Canyon (barren land, rock formations), but these areas are not valued because they do not contribute to the services.

Using the total acreage values calculated earlier and the acreage cover of each land type, including the contribution of recreation, results indicate that the Big Cottonwood Canyon Watershed generates $31.69 million to $94.92 million in ecosystem services and natural capital benefits each year (see Table 5). This translates to an average of $976.70 to $2,924.82 per acre per year across the watershed.

Table 5: Annual Value of the Ecosystem Services in the Big Cottonwood Canyon Watershed

Land Cover	Acreage	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Forest	19,954.00	330.26	1,969.10	6,590,009.66	39,291,431.07
Scrubland	4,496.82	29.45	107.11	132,431.37	481,654.46
Wetlands	1,531.89	2,022.97	21,568.83	3,098,974.51	33,041,149.56
Riparian Buffer Zone	4.07	1,011.83	5,822.16	4,114.50	23,675.18
Mix Forest and Scrubland[1]	163.65	179.86	1,038.11	29,433.50	169,887.22
Other	5,619.72	Not Valued	Not Valued	0.00	0.00
Recreation	N/A			21,844,579.07	21,919,093.33
Total	26,150.44			**31,699,542.61**	**94,926,890.82**

[1]Values calculated using the average value of Forest and Scrubland areas.

III. Discount Rates

Benefits from the Big Cottonwood Canyon Watershed, and other ecosystems alike, are not fully realized in one given year. Each year, the watershed offers additional value to the surrounding population. The value derived from the watershed, however, is unlikely to be of the same worth next year, in 10 years, or 20 years down the road. Current dollar values must be discounted to calculate their worth in the future. To do this, discount rates are used, and can cover a range of values. For example, at a 5% discount rate (a fairly standard rate) $100 today is

worth $61.40 in 10 years and only $8.72 in 50 years, whereas a 10% discount rate would value $100 today at a mere 85 cents in the same 50 years. These prices are considered the present value, or the value of current dollars in the future. The lower the discount rate, the more equal future values and current values will be. Applied to an ecosystem, a discount rate of 0% would value the benefits derived from ecosystem services today equally to the benefits gained in the future (Cunningham, Rose, 2009).

What discount rate should be used for environmental services and benefits? Many rates have been considered in the available literature, but most fall within the 2% to 10% range. Again, the lower the rate, the more value realized today from future benefits, suggesting that current and future generations are treated more equitably (Freeman III, A. Myrick, 1993). Some economists recommend using discount rates on a declining scale. Here, the first few years would be discounted at a higher rate, say 4%. The next years would be discounted at 3%, slowly reducing the rate until it reaches 0% for years in the far-distant future (Weitzman, M.L. qtd. in Cunningham, Rose, 2009).

For this study, benefits from the watershed's ecosystem services will be valued for 50 years in the future, not requiring a declining scale. The 50-year period is fairly arbitrary, except that, at years further out, present values begin to drop steeply, particularly when using a high discount rate. Net present values for the watershed will be calculated at 0% and 10% discount rates to include a range of possible benefits, but a 2% discount rate will be prioritized as this rate falls within the proposed range and has been championed by prominent environmental economists (Freeman III, A. Myrick, 1993).

0% Discount Rate

At a 0% discount rate, the net present value, or asset value, of the Big Cottonwood Canyon watershed can be calculated as benefits in future years are treated equally to current benefits. Applied over a 50-year period, the watershed's asset value is $1.61 billion to $4.84 billion.

10% Discount Rate

Using the same 50-year period, this time with a 10% discount rate, the asset value of the Big Cottonwood Canyon Watershed is $345.99 million to $1.03 billion. The higher discount rate indicates that the value received by residents today declines as we move into the future.

2% Discount Rate

The 2% discount rate was chosen for the primary asset value of the Big Cottonwood Canyon because it provides a realistic case in which values of the ecosystem services decline in future years, but the rate is low enough to create some equitability between the current and future benefits received by Salt Lake City residents. At this discount rate and the same 50-year time period, the asset value of the watershed totals $1.02 billion to $3.07 billion.

Chapter 6
SkiLink and the Watershed

I. What is SkiLink?

SkiLink is a proposed gondola system that would function as a connection between Canyons Resort and Solitude Mountain Resort, two ski resorts located in the Wasatch Range. Canyons Resort is located near Park City, outside of protected watershed areas. Both Solitude Mountain Resort and the proposed site for the gondola connection, however, are located within the Big Cottonwood Canyon Watershed boundary (see Figure 1). With the introduction of SkiLink, skiers and snowboarders would be able to purchase ski passes at either resort, including an additional charge to use the gondola system, and be able to move between the two resorts throughout the day. In effect, SkiLink would create the largest connected ski resort in the country with 6,000 skiable acres, potentially offering Salt Lake City ski resorts an advantage over other ski areas in the United States. Additionally, the interconnection would be the first of its kind in the U.S., modeled after many resorts located in countries abroad, particularly those in Switzerland (*SkiLink and the Big Cottonwood Canyon Watershed*, 2012).

The proposed interconnection would use enclosed gondola cars suspended by cables from towers. The ride between the two mountain resorts would take approximately 11 minutes, offering a unique and novel opportunity to both skiers and snowboarders. The proposed interconnection system is not the first idea of its kind in Utah. Rather, the Government's Task Force first studied a similar system in 1988, suggesting a linked system of five area resorts through the construction of three or four new ski lifts (*SkiLink and the Big Cottonwood Canyon Watershed*, 2012).

The Canyons Resort has offered a study covering the initial economic impact of SkiLink to the area. The ski industry plays a substantial role in Utah's travel and tourism sectors,

reporting approximately 4 million skier and snowboarder visits each year since 2005, ranking below only Colorado (12 million/season) and California (9 million/season) in total skier visits. The completion of SkiLink has been touted as creating a large economic influx for the state. The study projects that immediate impacts would include 75,000 additional annual skier visits to the state. It is estimated that these visits would translate into an extra $50 million for the local economy, $3 million in tax revenues, and the creation of 500 new jobs (Robert Charles Lesser & Co., 2010; *SkiLink and the Big Cottonwood Canyon Watershed*, 2012).

SkiLink would surely add to the skiing experience in Salt Lake City's area resorts, increasing tourism and creating positives effect that would ripple throughout Utah's economy. Similar connected resorts in Europe have had positive and long-lasting economic impacts, a promising sign for Utah if the proposal for SkiLink is passed. While some winter sport enthusiasts do not support SkiLink for its possible impacts on backcountry and Nordic skiing, the gondola system would surely set Utah ski resorts apart from those in other parts of the country, economically benefitting Utah's residents.

II. Environmental Impacts of SkiLink

The proposed SkiLink focus area covers a 30-acre stretch of land connecting Canyons Resort and Solitude Mountain Resort. The actual ground impact of the gondola system would be slightly less than an acre, according to Canyons Resort. Further, towers would be placed carefully to minimize the amount of tree removal. Finally, helicopters would be used to place the towers, requiring no need for road building that would increase the ground impact from construction (*SkiLink and the Big Cottonwood Canyon Watershed*, 2012).

While the direct and indirect economic benefits of SkiLink appear impressive, the environmental impacts of the gondola system must be analyzed before a policy decision can be

made. Cirrus Ecological Solutions, LC undertook a comprehensive study in 2010 to identify the environmental implications of the proposed SkiLink development. Commissioned by Canyons Resort, the study focused on three main categories: special-status plant and animal species, water quality and watershed resources, and visual resources. Of particular importance are the report's findings on water quality and watershed resources; however, each focus area will be covered here.

III. Water Quality and Watershed Resources

The SkiLink project proposal falls within the Big Cottonwood Canyon Watershed boundary, requiring thorough analysis of the water quality and watershed resources impacts. Under the Salt Lake City Watershed Management Plan (1999), water quality is the first priority and multiple use of the watershed is second. The goal of the plan is to maintain healthy, stable environmental conditions with minimal pollution sources. The plan goes so far as to say that existing or potential sources of water quality pollution will be eliminated if the effects are too damaging. With respect to the potential construction of SkiLink, Salt Lake City is primarily concerned with water quality issues, and not water availability, an important distinction (Cirrus Ecological Solutions, LC, 2010).

Salt Lake City has monitored water quality in Big Cottonwood Canyon since the opening of Brighton Ski Resort in 1936 and Solitude Mountain Resort in 1956. Water quality has remained stable throughout this time and conforms to standards detailed in the 1972 Clean Water Act. Moreover, water quality within the canyon has even showed some improvement during the study period, although these results are by no means attributed to the opening of the ski resorts (Cirrus Ecological Solutions, LC, 2010). In fact, it is likely that improvements in water quality have occurred due to the implementation of federal laws and regulations that require high water

quality levels. Even as annual skier visits have increased, water quality has continued to improve, which should be attributed to the application and maintenance of best management practices (BMPs) by ski resorts and other developed areas, as stated in the Clean Water Act and other federal statutes.

Finally, the proposed site for the SkiLink gondola system contains soils that are not easily eroded, meaning BMPs used in other ski resort areas should effectively limit soil erosion and the associated water quality impacts in Big Cottonwood Creek. Riparian zones could be easily protected from the development through the implementation of the standard setback requirements. In conclusion, the study believes surface waters and groundwater should not be adversely impacted due to the construction and use of the proposed SkiLink development plan, as the water quality and watershed resource issues are similar to those typically encountered in other Wasatch area ski projects (Cirrus Ecological Solutions, LC, 2010).

IV. Additional Considerations

a. Transportation

Transportation in and out of Big Cottonwood Canyon and the other Salt Lake City area canyons represents a major environmental issue. Vehicle use contributes to a variety of environmental concerns, particularly air pollution. As a response to the increased use of canyon roads, Envision Utah, the Utah Department of Transportation, the Wasatch Front Regional Council, and the Utah Transit Authority have implemented increased transit and carpool access to Big Cottonwood Canyon. While these advancements have been largely successful, transportation is a constant threat and must be battled continually (InterPlan, 2010).

According to a study funded by Canyons Resort and completed by the transportation planning group, InterPlan, SkiLink could offer major benefits in the form of reduced vehicle use.

As the demand for winter sports continues to grow as population increases, the short-term and long-term benefits of the gondola system are of great importance. It has been hypothesized that, with SkiLink, tourists and residents alike will not have to drive from canyon to canyon to ski at different resorts. Instead, skiers and snowboarders could use the gondola system to travel between canyons. With the reduced need to drive to multiple ski resorts, the project is estimated to eliminate approximately 1 million miles of driving annually. This translates to the removal of 1 million pounds of greenhouse gas emissions due to the reduction of nearly 18,000 cars in Big Cottonwood Canyon each year, including a 10% reduction of cars during peak driving times (InterPlan, 2010; *SkiLink and the Big Cottonwood Canyon Watershed*, 2012).

b. Special-Status Species

According to the Endangered Species Act of 1973, special-status species that are listed as threatened or endangered must be protected. Additionally, the Migratory Bird Treaty Act protects raptor species in areas under consideration for development. As required by the federal statutes, significant alteration of the development proposal is necessary if special-status species are threatened by the proposal (Cirrus Ecological Solutions, LC, 2010).

As stated in the environmental impact study done by Cirrus Ecological Solutions, LC, no listed threatened or endangered plant species were found in the area. Additionally, no sensitive plant species or watch-list plant species were found in the area. With respect to listed animal species, none would be threatened by the development and habitat areas would be minimally affected by the slight fragmentation associated with the development of the SkiLink gondola system (2010).

c. Visual Resources

The visual impairment that would be caused by the construction of the SkiLink gondola system has been termed a “red flag” issue by Cirrus Ecological Solutions, LC. This designation does not arise from the importance of the visual impact, however. As claimed in the study, the possibility of visual impacts lacks importance, due to the lack of environmental damage. In conclusion, the study concludes that the visual resource issue is minor and should warrant little consideration in the final decision for SkiLink (Cirrus Ecological Solutions, LC, 2010).

V. SkiLink: A Cost-Benefit Analysis

SkiLink offers Utah ski resorts a unique opportunity to increase annual skier visits and gain the economic benefits associated with more skiers. Significantly, this can be done without adding to the skiable acres of the resorts, according to the proposal. The interconnection would mimic many European resorts, offering skiers and snowboarders the chance to ski diverse terrain in a time-efficient manner. This analysis of SkiLink is isolated, however, and other development consequences that may follow SkiLink cannot be fully analyzed at this point.

Using the values reported earlier in Table 5 and isolating the economic value of forested areas (gondola proposal site located in a forested area), SkiLink would reduce the total value of the Big Cottonwood Canyon Watershed by $9,907.80 to $59,073 per year, if the entire 30 acres were subject to development. Discounted at 2%, the net present value, or asset value lost from the construction of SkiLink (using the same 50-year period discussed earlier) is $321,246.60 to $1.9 million. While these values are likely to be overestimates since they have been calculated using the full 30-acre stretch of land, they represent a substantial loss in benefits. If the actual ground impact was less than an acre, as stated by the Canyons Resort study, the losses would be much smaller, but not insignificant.

Standing alone, the impact area of SkiLink represents a small portion of the 50 square mile watershed. We must, however, also take into account additional development that may result from SkiLink. As it is connected to an existing ski resort, a logical step is to study the ecosystem service losses resulting from the land conversion required to create the resorts, and the possible expansion of ski areas to accommodate additional skiers and snowboarders. Both Brighton Ski Resort and Solitude Mountain Resort already represent a sizeable coverage area that has been converted from natural land to ski runs, parking lots, and resort lodging.

Opened in 1936, Brighton covers 1,050 skiable acres. This converted land area represents a loss of $13.83 million to $82.49 million in ecosystem services to date (using a 2% discount rate and annual acreage value of forested areas). Solitude, opened in 1956 and including 1,200 skiable acres, represents an ecosystem services loss of $13.67 million to $81.53 million. Totaled, these two resorts contribute to a loss of $27.51 million to $164.02 million in ecosystem services to date. These values illustrate significant human welfare losses, surpassing the annual ecosystem value of the Big Cottonwood Canyon Watershed that ranges from $31.69 million to $94.92 million. While the $50 million in initial economic benefits from SkiLink and the added welfare from reductions in greenhouse gas emissions are sizable, we must tread carefully when deciding on development in natural areas due to the fragile connectivity of the ecosystem services.

One final and important consideration is the added pressure SkiLink may put on the canyon for future housing development. Developments near other resorts in different Salt Lake City canyons have been moving forward. For example, Snowbird Ski & Summer Resort in Little Cottonwood Canyon is hoping to expand with a new subdivision, and that resort is receiving opposing arguments similar to those waged against SkiLink (Gorrell, Mike, 2012). The development precedent represents a major argument against SkiLink.

As previously noted, it is difficult to pin down the tipping point associated with nonlinear ecosystem collapse. If SkiLink creates a prolonged influx of skiers to the area, as the proposal believes it will, pressures to expand ski resorts and increase lodging amenities would likely follow. These added developments, if allowed, might ultimately spell disaster for the watershed. It is important to note that the same valuation methods used to analyze the SkiLink proposal could be implemented on future development options to decide if their added economic benefits trump the ecological losses. Considered in isolation, SkiLink does not represent severe environmental damage, but it sets a dangerous precedent for canyon development.

To reach a final conclusion on SkiLink, a more comprehensive environmental study on the impacts accompanying the development's implementation should be a priority. This study should not only include the localized effects of the gondola system, but must also include the consequences faced by the total watershed area. The main concern should not be the marginal losses along the 30-acre tract of land; rather, it should focus on whether or not SkiLink's construction and precedent pushes the canyon too close to a threshold that may cause widespread ecosystem service failure. The methodology presented in this paper can assist in that evaluation and potentially be used to establish mitigation measures, such as an impact fee that could be applied to mitigating actions. Until a more thorough and neutral environmental review has been completed, and the feasibility of various mitigation measures considered, SkiLink should be delayed.

Chapter 7
Conclusion

SkiLink offers Salt Lake City a unique example of how environmental valuation studies can be a useful tool for policy and development proposal decision-making processes. After a detailed economic valuation, the annual ecosystem value of the watershed totals $31.69 million to $94.92 million. The direct environmental losses incurred from the SkiLink site seem to be minimal, but the precedent set by the development could prove to be adverse to the Big Cottonwood Canyon Watershed. For this reason, further environmental reviews are necessary.

To calculate the values used to inform the SkiLink decision, many studies were considered that focused on single habitat types in specific survey areas. For example, the contributions of restored riparian areas in the western United States were valued. While these habitat-specific studies are useful, few studies have valued the economic contribution of all land types within a study area. The Big Cottonwood Canyon Watershed study is a prime example of an all-encompassing case study. Not only does it give the entire ecosystem a value, it can be used to inform decision-makers on current and future development proposals. The value ranges calculated can be used for both small-scale and large-scale proposals within the ecosystem. Moreover, a complete ecosystem study allows decision-makers to estimate regional benefits stemming from ecosystem services, whereas habitat-specific studies are generally confined to local-scale analysis.

Extending from the Big Cottonwood Canyon Watershed case study, environmental economics has many important implications for further studies. While some weaknesses are apparent, including wide value ranges, time costs, and varying methodologies, the advantages of economic valuation are substantial. Benefit transfer methods allow researchers to cut down on time and expenses while still obtaining accurate results. More importantly, valuation methods

allow for more accurate and educated policy decisions. Future decisions can now compare the economic influxes, typically displayed in terms of dollars and jobs created, to the environmental consequences of increased development and use. The by-products of growth have historically been described using abstract and vague terminology, depreciating their worth in major policy decisions. As environmental economics continues to be refined, ecosystems will be better detailed using dollar values, allowing for more accurate comparisons that hopefully result in decisions that maximize benefits for the population of the study area. While no concrete solution was presented for SkiLink, this case study has shown the constructive results that stem from environmental valuation practices.

Works Cited

Allen, J., Cunningham, M., Greenwood, A., Rosenthal, L. “The Value of California Wetlands: An Analysis of their Economic Benefits.” *Campaign to Save California Wetlands*. Oakland, California. (1992).

Amigues, Jean-Pierre, Catherine Boulatoff, Brigitte Desaigues, Caroline Gauthier, and John E. Keith. "The Benefits and Costs of Riparian Analysis Habitat Preservation: A Willingness to Accept/Willingness to Pay Contingent Valuation Approach." *Ecological Economics* 43 (2002): 17-31.

Bingham, Gail, Richard Bishop, Michael Brody, Daniel Bromley, Edwin Clark, William Cooper, Robert Costanza, Thomas Hale, Gregory Hayden, Stephen Kellert, Richard Norgaard, Bryan Norton, John Payne, Clifford Russell, and Glenn Suter. "Issues in Ecosystem Valuation: Improving Information for Decision Making." *Ecological Economics* 14 (1995): 73-90.

Bishop, K. “Assessing the Benefits of Community Forests: An Evaluation of the Recreational Use Benefits of Two Urban Fringe Woodlands.” *Journal of Environmental Planning and Management*. 35 (1992). 63-76.

Bockstael, N., R. Costanza, I. Strand, W. Boynton, K. Bell, and L. Wainger. "Ecological Economic Modeling and Valuation of Ecosystems." *Ecological Economics* 14 (1995): 143-59.

Boxall, Peter C., Bonita L. McFarlane, and Michael Gartrell. "An Aggregate Travel Cost Approach to Valuing Forest Recreation at Managed Sites." *The Forestry Chronicle* 72.6 (1996): 615-21.

Boyd, James, and Spencer Banzhaf. "What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units." *Ecological Economics* 63 (2007): 616-26.

Brighton: The Tradition Continues Since 1936. Web. 5 Nov. 2012. <http://www.brightonresort.com/>.

Cirrus Ecological Solutions, LC. *Preliminary Environmental Review: Canyons-Solitude SkiLink*. Cirrus Ecological Solutions, LC, 2010.

Costanza, R., d’Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., et al., 1997. “The Value of the World’s Ecosystem Services and Natural Capital.” *Nature* 387, 253–260.

Cunninghum, Rose. “Discount Rates for Environmental Benefits Occurring in the Far-Distant Future.” Independent Economic Advisors, 2009.

de Groot, Rudolf S. "Environmental Functions as a Unifying Concept for Ecology and Economics." *The Environmentalist* 7.2 (1987): 105-09.

Dodds, Walter K., Kymberly C. Wilson, Ryan L. Rehmeier, G. Layne Knight, Shelly Wiggam, Jeffrey A. Falke, Harmony J. Dalgleish, and Katie N. Bertrand. "Comparing Ecosystem Goods and Services Provided by Restored and Native Lands." *BioScience* 58.9 (2008): 837-45.

Doss, Cheryl R., and Steven J. Taff. "The Influence of Wetland Type and Wetland Proximity on Residential Property Values." *Western Agricultural Economics Association* 21.1 (1996): 120-29.

Ecosystem Services and the Cache La Poudre: A Case Study of the Economic Value of Western Watersheds. Working paper. 2011.

Emerton, L., and B. Kekulandala. “Muthurajawela Marsh, Sri Lanka: Safeguarding Wetland Protected Areas in Cities.” World Conservation Union, 2003.

Emerton, Lucy, and Elroy Bos. “Value: Counting Ecosystems as Water Infrastructure.” International Union for Conservation of Nature and Natural Resources, 2004.

Freeman, A. Myrick, III. "Summary." *The Measurement of Environmental and Resource Values*. Washington, DC: Resources for the Future, 1993. 216-17.

Garber-Yontz, Brian, Joe Kerkvliet, and Rebecca Johnson. “Public Values for Biodiversity Conservation Policies in the Oregon Coast Range.” *Forest Science* 501 (1): (2004) 589-602.

Gorrell, Mike. "Snowbird Subdivision Plan Scales First Hurdle." *The Salt Lake Tribune*. 14 Nov. 2012. Web. 14 Nov. 2012. <http://www.sltrib.com/sltrib/politics/55277454-90/acres-canyon-canyons-county.html.csp>.

Holl, Karen D., and Richard B. Howarth. "Paying for Restoration." *Restoration Ecology* 8.3 (2000): 260-67.

Hurd, Josh. “Economic Benefits of Watershed Restoration.” *The Political Economy of Watershed Restoration Series*. Missoula, MT: Wildlands CPR. (2009).

InterPlan. “Initial Study for Feasibility Analysis of Traffic Benefits and Impacts of a Ski Lift Between Canyons and Solitude Ski Areas.” Rep. no. 100247. Midvale: InterPlan Transportation Planning, 2010.

Kenyon, Wendy, and Ceara Nevin. "The Use of Economic and Participatory Approaches to Assess Forest Development: A Case Study in the Ettrick Valley." *Forest Policy and Economics* 3 (2001): 69-80.

Kotchen, M. J., and S. D. Reiling. “Environmental Attitudes, Motivations, and Contingent Valuation of Nonuse Values: A Case Study Involving Endangered Species.” *Ecological Economics*. 32 (2000):93-107.

Kulshreshtha, S. N., Gillies, J.A., 1993. “Economic-Evaluation of Aesthetic Amenities – A Case-Study of River View.” *Water Resources Bulletin* 29, 257-266.

Loomis, John. “Updated Outdoor Recreation Use Values on National Forests and Other Public Lands.” United States Department of Agriculture, 2005.

Loomis, John, and Pam Kaval. “Updated Outdoor Recreation Use Values with Emphasis on National Park Recreation.” Fort Collins: Department of Agricultural and Resource Economics, Colorado State University, 2003.

Mates, William J., and Jorge L. Reyes. “The Economic Value of New Jersey State Parks and Forests.” New Jersey Department of Environmental Protection, Division of Science, Research, & Technology, 2004.

Pimentel, David, Christa Wilson, Christine McCullum, Rachel Huang, Paulette Dwen, Jessica Flack, Quynh Tran, Tamara Saltman, and Barbara Cliff. "Economic and Environmental Benefits of Biodiversity." *BioScience* 47.11 (1997): 747-57.

Poor, P. Joan, Keri L. Pessagno, and Robert W. Paul. "Exploring the Hedonic Value of Ambient Water Quality: A Local Watershed-Based Study." *Ecological Economics* 60 (2007): 797-806.

Postel, Sandra L., and Barton H. Thompson, Jr. "Watershed Protection: Capturing the Benefits of Nature’s Water Supply Services." *Natural Resources Forum* 29 (2005): 98-108.

Qiu, Zeyuan, Tony Prato, and Gerry Boehrn. "Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed." *Journal of the American Water Resources Association* (2006): 1583-596.

Robert Charles Lesser & Co. “Initial Economic Impact Analysis of Proposed Ski Interconnect Between The Canyons Resort and Solitude Mountain Resort, Utah.” Canyons Resort, 2010.

Roberts, Martha G., and Dan Grossman. “Healthy Rivers, Healthy Economy: Enhancing Instream Flows Will Benefit Colorado's Environment and Economy.” Rustic: Environmental Defense, 2008.

Salt Lake City Department of Public Utilities. *Salt Lake City Watershed Management Plan*. 1999.

Salt Lake City Department of Public Utilities. *The Wasatch Front Watershed*.

Salt Lake County Engineering Division. *Big Cottonwood Creek Guide*. Salt Lake City: Salt Lake County Stormwater Coalition, 2003.

Schmidt, Rowan, and David Batker. "Nature's Value in the McKenzie Watershed: A Rapid Ecosystem Service Valuation." Tacoma: Earth Economics, 2012.

Seidl, Andrew F., and Andre S. Moraes. "Global Valuation of Ecosystem Services: Application to the Pantanal Da Nhecolandia, Brazil." *Ecological Economics* 33 (2000): 1-6.

Seyam, I. M., A. Y. Hoekstra, G. S. Ngabirano, and H.H. G. Savenije. "The Value of Freshwater Wetlands in the Zambezi Basin." *International Institute for Infrastructural, Hydraulic and Environmental Engineering* (2001).

Shafer, Elwood L., Robert Carline, Richard W. Guldin, and H. Ken Cordell. "Economic Amenity Values of Wildlife: Six Case Studies in Pennsylvania." *Environmental Management* 17.5 (1993): 669-82.

SkiLink and the Big Cottonwood Canyon Watershed. 2012.

Solitude Mountain Resort. Web. 5 Nov. 2012. <http://www.skisolitude.com/>.

Spash, C.L., K. Urama, R. Burton, W. Kenyon, P. Shannon, and G. Hill. "Motives Behind Willingness to Pay for Improving Biodiversity in a Water Ecosystem: Economics, Ethics and Social Psychology." *Ecological Economics* 68 (4) (2009): 955-964.

Wackernagel, Mathis, Larry Onisto, Patricia Bello, Alejandro C. Linares, Ina S. Falfan, Jesus M. Garcia, Ana I. Guerrero, and Guadalupe S. Guerrero. "National Natural Capital Accounting with the Ecological Footprint Concept." *Ecological Economics* 29 (1999): 375-90.

Wasatch Canyons Tomorrow. 2010.

Weitzman, M.L. (2001) "Gamma Discounting," *American Economic Review* 91(1), 260-271.

Wilson, Sara J. "Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services." Gibsons: David Suzuki Foundation, 2008.

Woodward, Richard T., and Yong-Suhk Wui. "The Economic Value of Wetland Services: A Meta-Analysis." *Ecological Economics* 37 (2001): 257-70.

Young, Robert A. "Applied Methods of Valuation of Water as Environmental Public Goods." *Determining the Economic Value of Water: Concepts and Methods*. Washington, DC: Resources for the Future, 2005. 118-57.

Yung En Chee. "An Ecological Perspective on the Valuation of Ecosystem Services." *Biological Conservation* 120 (2004): 549-65.

Zavaleta, Erika. "The Economic Value of Controlling an Invasive Shrub." *AMBIO: A Journal of the Human Environment* 29.8 (2000): 462-67.

Zhou, X., Al-Kaisi, M., Helmers, M.J. "Cost Effectiveness of Conservation Practices in Controlling Water Erosion in Iowa." Soil & Tillage Research 106, 71-78. (2009).