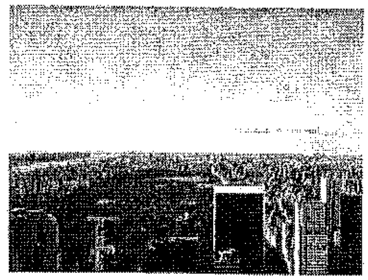
Urban Green Space Design

Introduction

Ancient Greek and Roman planners recognized the importance of centralized gathering spaces within urban areas. Early Greek "agora" and Roman "forums" served as the political, spiritual, and social centers of a city settlement. As trade routes developed through urban settlements, plazas and city squares became central spaces for commerce, religious, and government functions.

Gardens, parks, and other landscaped areas also were incorporated into ancient settlements throughout history. The earliest gardens were designed and maintained for royal or state use and offered limited public access. As settlements continued to grow, reserves were often set aside from development for hunting or agricultural purposes. These spaces were protected as life support systems for the settlement's residents.



Central Park, New York City
Image source: adamjackson1984/ Creative Commons

With the onset of the industrial revolution, cities rapidly expanded to accommodate increasing population pressures. As rural populations shifted into urban centers in search for work and opportunity, people transitioned from being surrounded by vast open fields or forests to city streets, plazas, and skylines. The ensuing rapid growth of infrastructure required to house, transport, feed, and sustain the urban population depleted the natural landscape of cities in favor of industrial production. However, throughout the rapid growth a need was recognized for maintaining open green spaces within the urban environment.

Example Green Space Corridor:
Photo: Dan O'Connor/Creative Commons

The urban *green spaces* we are familiar with today (such as Central Park in New York City) began to be established during the 18^{th} and 19^{th} centuries as places meant to improve the social and physical health of city residents. Today, the term urban *green space* generally refers to preserved natural landscapes or manicured parklands set aside for public use and environmental benefit. Healthy and properly maintained urban *green spaces* make cities more sustainable by providing significant social, environmental, and economic benefits to urban areas

Your team has been tasked with analyzing a proposed urban *green space* development project. The project proposes to develop multiple use corridors linking several neighborhoods to the city's central municipal park and outdoor amphitheater complex. City planners believe the increase in *green space* corridors will help connect city residents to outdoor and cultural opportunities offered within the municipal park.

The city's planning commission retained your team's services to evaluate quantitative sustainability indicators of the social, environmental, and economic benefits of the project. Evaluated social sustainability indicators include green space per capita and green space proximity per capita. Evaluated environmental sustainability indicators include projecting the decrease in runoff and the increase in wildlife habitat in the urban center. An annual worth analysis of the proposed development will serve as the evaluated economic sustainability indicator.

Background Information

Social Sustainability Indicators

Green space per capita (GS_C) is a measure of urban area designated as green space normalized to the city's population. GS_C is defined as:

$$GS_C = \frac{A_{GS}}{P}$$

where, A_{GS} = area of green space within an urban area and P = population of the urban area. While planners heavily debate GS_C requirements, the city planning commission would like to achieve a GS_C requirement of one acre green space per 200 residents.

Green space proximity per capita (GS_P) is a measure of the distance an average city resident travels to access green space. GS_P is a grouped average of travel distances for all residents in the city. GS_P is a measure of accessibility, where shorter proximity distances are a favorable social sustainability indicator.

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The proposed project will develop five green corridors through the city (see Table 1 for corridor length and width details). The city currently has a population of 81,247 residents and 371 acres of green space. The GS_C added based upon the proposed development is determined by summing the area of all individual corridors; remembering that the additional area of each corridor is calculated as the corridor's length times the corridor's width. The GSC is then determined by dividing the total summed area by the city population.

Table 1. Proposed Corridor Data

Corridor	Proposed Length (linear ft)	Proposed Width (ft)
1	6300	21
2	16380	15
3	3696	24
4	520	25
5	8976	17

Additionally, the current GS_P is 2200 ft; the intended development will reduce GS_P to 975 ft. The percent decrease in GS_P due to the project is found by dividing the difference of the two GS_P values by the current GS_P value. Also note that 1 acre is equal to 43,560 square feet.

Environmental Sustainability Indicators

Green corridors not only facilitate access to natural landscapes for urban residents, but also act as wildlife habitat. Green corridor projects expand access to wildlife habitat by expanding the amount of green space within urban settings. Green corridors also serve as physical connectors and link larger habitat spaces together. Unmaintained landscape within a green space area is a favorable indicator of environmental sustainability. City planners designate that 41% of the proposed green corridor area be unmaintained land to allow minimal disturbance of wildlife populating the corridor.

Another important indicator of sustainability of green space development is the resulting decrease in stormwater runoff due to the development. Urban spaces with a lot of paved areas generate higher amounts of runoff per unit area than green spaces.

Runoff during a rainfall event is generated when the rate of precipitation is greater than the infiltration capacity of the soil receiving the precipitation. Precipitation falling onto an asphalt parking lot does not infiltrate into the ground. Instead, the intercepted water remains on the surface of the parking lot and is directed to a stormwater conveyance system by grading the parking lot to shed water. The generated runoff carries contaminants present on the surface of the parking lot (heavy metals from brake pads and petroleum residues from leaking engines as examples) into the stormwater conveyance system—potentially contaminating the receiving stream.

Green spaces, on the other hand, contain little impervious (paved) areas. Rainfall falling on a green space infiltrates where it falls, generating reduced runoff. While there are multiple methods to estimate runoff volumes, the Social Conservation Service (SCS) Runoff Method is a simplified, empirically based method used to estimate runoff volume. The SCS Equation used to calculate the volume of runoff is:

$$V = A_s \cdot \left(\frac{[P - 0.2(S)]^2}{P + 0.8(S)} \right) \left(\frac{1 \text{ ft}}{12 \, in} \right)$$

where V = runoff volume (ft^3)

A_s = surface area receiving rainfall (ft^2);

P = Rainfall (inches) and

S = maximum retention after runoff begins (inches).

S is calculated using curve numbers (CN), which describe the relationship between the type and condition of a land use and expected runoff. The equation used to calculate S is:

$$S = \frac{1000}{CN} - 10$$

Curve numbers are tabulated for different types of land cover on the basis of soil hydrologic groups and the land use's condition. Decreased runoff volumes are a desirable environmental measure.

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A soil analysis determined that Group B soils are the underlying hydrologic soil group within the development. The soil analysis also provided the following curve numbers for land use covering group B soils:

$CN_{concrete} = 98$

$CN_{gravel} = 85$ and

$CN_{dirt} = 82$.

The SCS equation is used to compare runoff volumes from different types of surfaces. During the comparison analysis, P and A are kept constant and CN is varied. By changing the CN and keeping the other terms constant, the difference in runoff volume due to the change in surface type can be determined.

Economic Sustainability Indicators

Annual worth (AW) analysis is an economic evaluation tool used as an indicator of fiscal sustainability of a proposed project. AW analysis examines the financial viability of a proposed project by predicting the overall annual worth (as a cost or revenue) from projected cash flows. AW analysis includes the impact of compounding interest rates on the time value of money within the project.

When an AW analysis is conducted, the initial costs incurred at the start of a project are distributed over each year of the projects lifetime (annualized) according to the formula:

$$A_P = P \left[\frac{i}{1 - (1 + i)^{-n}} \right]$$

Where

A_p = initial investment amount turned into an annualized cost ($)

P = principal cost of initial investment ($)

i = interest rate for a given compounding period (%/100)

n = number of compounding periods (years)

At an annual interest rate of 8% for a project that has a 20-year lifespan, the formula for A_P reduces down to:

$$A_P = P \cdot (0.10185)$$

Any one-time future costs or revenues are also distributed over each year of the project's lifetime (annualized) during AW analysis according to the formula:

$$A_F = F \left[\frac{1}{(1 + i)^{m}} \right] \cdot \left[\frac{i}{1 - (1 + i)^{-n}} \right]$$

Where

A_F = future investment or revenue amount turned into an annualized amount ($)

F = future cost or revenue occurring at a specific year ($)

i = Interest rate for a given compounding period (% value/100)

m = the project year the one time future cost or revenue occurs

n = project lifetime (years)

At an annual interest rate of 8% for a project that has a 20-year lifespan, the formula for A_F reduces down to:

$$A_F = F \left[\frac{1}{(1.08)^{m}} \right] \cdot (0.10185)$$

Estimated annual operating costs (AOC), projected annual revenues, and converted initial and future amounts are summed to determine the total annual worth (AW) of the project.

$$AW = \sum AOC + A_P + A_F$$

Questions

1. The GS_C added due to the proposed project on a square foot per capita basis is closest to:

   a. 14

   b. 22

   c. 1

   d. 8

   e. 199

2. If the proposed corridor project is developed, what additional minimum amount of green space would need to be developed in the future to meet the GS_C requirement of 1 acre for every 200 residents?

   a. 21 acres

   b. 6 acres

   c. 40 acres

   d. 100 acres

   e. 392 acres

3. The percent decrease of GS_P due to the proposed project is closest to:

   a. 15%

   b. 57%

   c. 82%

   d. 63%

   e. 44%

Work it Out

4. Using the data found in Table 1 and the planned percent of the new development that will be unmaintained landscape, the total acreage of undeveloped habitat area based upon the proposed development is:

a. 6.0

b. 22.7

c. 14.5

d. 12.8

e. 2.7

5. If one section of the development replaces a 300 ft segment of a 4 ft wide concrete sidewalk with a gravel path, the anticipated decrease in runoff volume for a 1 inch precipitation event is approximately:

a. 5 ft^3

b. 30 ft^3

c. 250 ft^3

d. 60 ft^3

e. 120 ft^3

6. By examining the SCS runoff volume equation, a relationship between CN and runoff volume can be inferred. If the CN decreases, the runoff volume will:

a. increase only if precipitation increases

b. decrease only if precipitation increases

c. increase regardless of precipitation

d. decrease regardless of precipitation

e. not change

Work it Out

7. The city engineers estimated the total construction costs for the proposed project to be $5 million. If the project has a 20-year service lifespan (the amount of time the project will be used and maintained), and an annual interest rate of 8% compounded yearly is assumed, the annualized cost of the construction portion over the 20-year timeframe is closest to:

   a. $500,000

   b. $250,000

   c. $750,000

   d. $100,000

   e. $1,000,000

3. The city engineers also plan a one-time cost to completely re-gravel the entire corridor during year 10 of the project's anticipated lifetime. The engineers estimated the cost of the re-gravelling effort 10 years from now to be $750,000. If the project has a lifespan of 20 years, and an annual interest rate of 8% compounded yearly is assumed, the annualized cost of the future re-gravelling effort is approximately:

   a. $10,000

   b. $20,000

   c. $90,000

   d. $75,000

   e. $35,000

Work it Out

9. The city planning commission received a bid from a construction firm that estimated the initial cost of the gravel path installation to be $1.5 million U.S. dollars. The bid also included a re-gravelling cost of $700,000 in year 10. The company also included a cost estimate for a gravel path maintenance cost of $50,000 per year and a routine inspection cost of $5,000 per year. Based upon these cost projections, if the project has a lifespan of 20 years, and an annual interest rate of 8% compounded yearly is assumed, the approximate annual worth of the project is:

   a. $182,000/yr
   b. $94,000/yr
   c. $590,000/yr
   d. $241,000/yr
   e. $72,000/yr

10. The city planning commission received a second bid with an annual worth projection of $138,000 per year. If the project is developed, the city expects $60,000 per year of revenues from increased amphitheater sales and $27,000 per year revenue from increased festival-related sales. The city also expects to generate increased revenue from property taxes, as property values surrounding green spaces increase. How much annual tax revenue must the project generate each year to pay for itself?

   a. $160,000
   b. $60,000
   c. $72,000
   d. $51,000
   e. $80,000

Work it Out

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Answers - High School Activity

1. D
2. A
3. B
4. A
5. D
6. D
7. A
8. E
9. D
10. D