T-4300

RESOURCE ALLOCATION AND PARK MAINTENANCE STANDARDS

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T-4300

A thesis submitted to the Faculty and Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science (Mathematics).

Golden, Colorado

Date: Dec 17, 1992

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ABSTRACT

This paper details uses of time per task standards for parks' divisions of US cities. It presents a model to measure people dollars(salary for maintenance personnel) needed to maintain city park areas. The steps to a time per task standard are defined as follows:

1) Science and policy decide preferable work methods. These work methods are the styles of operation for parks. They usually involve a decision to use caretaker or routing styles of task organization.

2) Analysts appraise time value of work. A few cities and professional associations have completed time studies for park maintenance tasks.

3) Managers use results of the above data. This implies compilation of data into a model which allows reports and analysis. The model of this paper is a spreadsheet computation of inventory into personnel dollars.

This analyst spent time with the city and county of Denver parks maintenance workers to assess the situation and gather needed information. She then evaluated the impact of heavy use and high maintenance on time and frequency to perform park maintenance. This information supplemented time per task information available in the literature. At the time of this thesis the parks and budget departments of the city and county of Denver were allocating new park responsibilities according to this spreadsheet measure.

The final product resulting from this thesis is a spreadsheet model of personnel maintenance costs for the city and county of Denver park areas. The users of this model will be the manager in the parks' administration and budget and management financial analyst assigned to parks. The model will aid administration and management in budgeting and operational planning.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

I would like to thank my advisor for his guidance and patience, Robert E.D. Woolsey. I am also grateful to my committee, Ruth Maurer and Bill Astle. All of these people offered their gracious assistance.

Thanks go to the city and county of Denver Parks' division and Budget and Management Office for the resources to complete this thesis. Special mention to Margaret Browne, B.J. Brooks, Bob Grausnick, and Joyce Mendez. I appreciated Joyce's diligence in data gathering, data compiling, and insightful humor.

I lend a special thanks to all the Denver parks' maintenance workers who lent their time, patience, excellent instruction and expertise to an accurate compilation of information. These workers include gardener/florists, maintenance technicians, equipment operators, utility workers, seasonal laborers, operations supervisors, and superintendents. The nine superintendents of Denver parks all deserving special recognition are Ernie Vigil, Kaz Berzins, John Elbeck, Richard Meade, Lyn Tyler, Susan Frye, Dave Acosta, Ron McKenzie, and Jim Kellner. I would also like to acknowledge the workers of the Deputy Manager's office for their assistance, and of special mention is my office mate, Carol Dutcher.

I am indebted and particularly grateful to my family and friends who supported me through the thesis process as if they were family. These friends include the OR guild, an EA group, and the volleyball group of Des Moines, IA. Of special assistance in this project were Meftun Erdogan, Erdem Ince, Halubobya Munkonze, and Ray Bateman. Most importantly, I wish to thank God who has guided me faithfully and bestowed the gifts upon me which have allowed me to complete this thesis.

Chapter 1 RESEARCH PROBLEM

Introduction

In recent years, budgets for cities had not kept pace with inflation and increasing demands for services. This implied individual city departments would have to become more efficient and accountable for their funds, if they wished to minimize loss of dollars. That is, city administration would cut funds for departments unable to account for efficient use of allocated dollars. In particular, parks' departments needed to develop efficient methods of maintenance operations, and parks' administration needed to create measures to justify needed funding. Recent application of industrial practices to maintenance operations in general had yielded use of time standards as a method of accountability,[10][13]. It was time for cities to embrace scientific management practices and, therefore, time for park maintenance divisions to adhere to task time standards.

Tools of accountability available to parks' departments included techniques applied to operations of all industries. Park maintenance workers were acutely aware that times required to perform a task varied greatly. It is conjectured that workers could not accept tight quality control boundaries and approached industrial practices with great trepidation. Wise use and understanding of statistics became paramount. Statistics became a crucial tool in interpretation of task time information because grounds maintenance could vary greatly from day to day. Incorrect interpretation of standards could lead to worker rejection of the standards. Regulation of many factors was outside the control of the workers. Cities needed average times which they could apply to certain work periods, such as two weeks or one year and certain groups of work areas such as park districts or regions.

Cities were often divided into park districts, defined as nonrandom selections of parks. The managers of these districts needed an efficiency measure for work exclusively under their control. Times which technicians derived for the whole city may not have been accurate for these groups of parks. It was impractical to research each park location and establish a standard for it. It would be too costly to establish separate standards even at the district level. Thus the standards established for the whole city would only be accurate with

a random group of park locations. What constituted a random groups of parks? Park professionals believed that each district had its peculiarities. These peculiarities could be so pronounced so as to render the standards irrelevant. Cities needed to be able to adjust standards according to district peculiarities. Factors composing these peculiarities among districts included levels of use and maintenance.

Cities also needed to complete time studies of reasonable use with limited resources and within relatively short time frames. Cities seldom had the planning horizon and management consistency to successfully complete extensive studies.

It was worthwhile to develop time task standard measurements for cities as taxpayers deserved that type of accountability for their dollars. Also, accountable methods of management gave lower level supervisors needed power over their jobs. Giving staff the tools to assist management would allow these supervisors to perform at a higher level of efficiency and control and consequently, a higher level of satisfaction. Having uniform park maintenance and efficient use of city funds would please citizens and enhance civic pride.

This analyst worked with a pool of parks from the city and county of Denver Parks and Recreation Department The goal was to provide a maintenance measure as a tool to aid administration in policy decisions These decisions encompassed allocating dollars, personnel, and equipment. The overall direction was to tighten organization of maintenance procedures.

The purpose of this paper is to provide a maintenance measure of people dollars (salaries of maintenance workers, does not include clerical or managerial costs) needed to maintain city park areas for seasonal cities (cities with snow removal needs) who route tasks within geographical districts. This would be a time per task measure to be a basis for organization and allocation of maintenance resources. This paper will discuss the versatility of organizing a maintenance measure in a spreadsheet model.

Review of Relevant Research and Theory

Recent reviews of professional city literature revealed forecasts of doom and cynical commentaries about the future of American cities. According to Maynard, "Unless something is done, the wide range of problems arising from fiscal difficulties will continue to wreak havoc on American cities...only with responsibility and vision in government that these urban problems can be solved,"[12]. Philadelphia had a budget gap of $300 million for fiscal 1992. Los Angeles predicted a deficit of $180 million,[12]. New York had not experienced such a budget deficit since 1975. At that time other agencies were capable of helping, but that was not true for the 90's,[9].

Citizens were beginning to demand more fiscal responsibility from the cities, including operational accountability, because of these large deficits. According to Brave, "agencies are being held to a constantly spiraling level of accountability,"[4]. Brave believed the key was to "maximize effectiveness while simultaneously minimizing liability." New York was planning to re configure government services due to its financial situation,[9]. Middleton of Public Works magazine stated, "All of us in the industry have been caught between beleaguered cries of the labor force demanding better working conditions, smaller areas of responsibility, and less accountability, and the demands of the taxpayers and budgeting offices for more productivity with the same or smaller resources and better accountability,"[16].

How would cities administer these limited funds and monitor accountability? Administration of funds, which often bled into deciding worker numbers, material proportions and equipment needs, fell under the umbrella of techniques operations researchers referred to as resource allocation. Operations research (OR) and artificial intelligence (AI) personnel have explored a vast variety of approaches to resource allocation problems for years. The following paragraphs detail some of the research work.

Problem formulations varied somewhat in their assumptions, but the typical resource allocation scenario fell into a standard design. It was a set of agencies, each with a set of activities requiring resources,[18]. The differing scenarios and assumptions which

altered the standard format, hence needing special attention, including the activities' or tasks' ability and possibility or compatibility to share resources and to substitute resources. In reference to the park scenario, the park districts could be the agencies each needing to perform maintenance activities such as mowing or sweeping which required resources of workers, equipment, and perishable materials. Sharing resources could apply to one worker performing trash pick-up and mowing tasks simultaneously. A jeep functioning in the same manner as a pick-up would be a substituted resource.

Often OR and AI people formulated resource allocation problems as one objective function with several constraints. The objective function could be production, profit, net present value, a multi-criteria or multi-attribute model, or a host of similar arrangements. The constraints were related to budget and resource limitations and conservation constraints. This format demanded an optimization procedure. Optimization procedures included math programming techniques, heuristic search techniques, and new algorithmic approaches toward finding an optimum,[7]. Both the OR and AI camps approached resource allocation from perspectives other than mere optimization analysis. One of these perspectives was simulation,[6]. The OR analysts and managers also used value measurements such as check lists, scoring formulae, multi-attribute models, and economic models,[1].

The OR and AI optimization techniques fell into two types. One type was to combine various optimization techniques in order to provide decision capability within the procedure of optimization. The other technique was to provide the algorithm leaving difficult decisions of priority or weights to the decision maker. Whichever approach the modeler chose to use, there existed a need for human preferences and difficult decisions at some point in the process.

The broadest and most diverse area of resource allocation detailed in the literature was optimization. Some descriptions of the different optimization techniques researchers used follow below:

1) Both OR and AI people tended to use math programming where appropriate, but few objective functions lent themselves to these algorithms. Where linear, quadratic, or nonlinear programming was appropriate, researchers tended to combine it with spreadsheets or simulations in order to perform some defining calculations to simplify the formulation notation or provide some decision making capability, [14].

2) Researchers approached more complex problems by starting with relaxed problems and LaGrange multipliers or geometric programming,[20].

3) AI camps performed heuristic searches to apply to technological electronic settings,[18].

4) Spatial interaction models combined several other techniques of treatment intensity, proportional flow, and net flow. Proportional flow was most likely to approach the optimum if used repeatedly. It also tended to be robust to random fluctuations in the data,[20].

5) The non smooth optimization with relaxed LaGrange multipliers formulated the objective function with a switching or indicator variable. In essence, it was performing a search to find the best resource for a given activity, and then functioning as a linear program, [7].

6) The Luss-Smith minimax algorithm involved ordering the activities by priority and setting an iterative procedure which selected a subset from the previous set until only one member was left in the subset, [11].

7) Other optimization techniques included queuing theory, Erlang B, bisection search, greedy allocation, knapsack formulation, single-pass algorithm, treatment intensity, convex network optimization, and the ellipsoid method,[7].

Algorithms not strictly in the optimization camp included complete partitioning and complete sharing. These two were actually specific applications of the more general

resource allocation technique,[7]. In complete partitioning the assumption was that the resources were distributed through certain channels, perhaps with limited capacity of the channels. The algorithm attempted to optimize the use of these resources by the activities at the end of the channel. Complete sharing was the opposite. All activities could compete for all resources. The general resource algorithm created a dummy channel. This meant that most of the resources were designated to channels, but some were accessible to any activity. When the dummy channel was completely empty, the general resource algorithm would be complete partitioning. When the dummy channel was completely full, the algorithm was equivalent to complete sharing. There were restrictions to the size of the channel wishing to share with the dummy or general use channel,[7]. Returning again to the park scenario and simplifying the situation to districts needing dollars to perform maintenance, one can see the format for these approaches. The idea is to most efficiently use the resources available. This is almost a goal programming format. The objective is to maximize use of the resources, in the case of park maintenance that would be to maximize beauty. Beauty needs to be delineated by certain priority tasks and priority parks. Complete partitioning would imply there were political reasons for designating the dollars to the districts so the question was how do districts best use those dollars to create a semblance of equity. Complete sharing implied that any maintenance task could grab any dollars from the central pot. A task/park priority would determine priority level and districts would be meaningless in the allocating of resources. The more general approach meant that the administration had some minimum dollar amount or crew size it wanted in each district and any remaining dollars or workers would go into a dummy district, able to be grabbed by competing tasks between different districts. This could become the equivalent of 'floaters' between districts given this situation. The role of priority parks and priority tasks grew more and more prominent. The decision makers' concept of policy issues would influence the modelers' approach toward formulation.

It is the opinion of this analyst that the growing presence of computers, the time consuming aspect of optimization searches, and the ease of visualization of simulation models compelled OR people to use an increasing amount of simulation. This meant creating an environment within the computer which mimicked the critical elements that precipitated resource need; resources had a method for dispersing themselves. Simulation

models personified tasks. The tasks became entities roving through the system in search of resources which were located at nodes. Designers assigned type and amount of resource needed to tasks. They also assigned a decision attribute to each task to predict behaviors when competing for a resource with another task. This could have been a priority or antagonism number. This was much like the way managers fight for their budget and why some managers win bigger pieces of the pie than others. Common formats included election, spawning, auction and bid, barter or exchange, and challenge and share. The names described of these simulation models describe the decision processes of the tasks,[6].

1) Election model: In this model tasks function similar to voters in a general election. The designers designated certain attributes or decision-making criteria to each individual task so that the running of the simulation resulted in certain tasks representing a group of tasks.

2) Spawning: Modelers prepared the task entities to divide into smaller pieces in order to best use available resources in the spawning situation.

3) Auction and bid: Designers programmed available funds and deadline information into entity or task characteristics in this format.

4) Barter: Barter models depict tasks exchanging resources.

5) Challenge and share: This scenario portrays tasks competing for resources when the tasks are present at the same resource location or node. The characteristics of the tasks include antagonism or priority rates,[6].

Once again an abstract model, simulation, caused a problem of needing to assign priorities to parks or maintenance tasks. If one task were to challenge another which one would win continued use of the resource? This did not imply that workers would rove from park to park as needed, although that would be a different possibility, but when the simulation finished and the totals were accumulated, administration would know how

many gardener/florists and other worker type dollars it would allocate to a given district. Further, management would know how many of each worker type it needed. The challenge and share scenario depicted the "diagnose and repair" operational philosophy, also known as "crisis" management. This same scenario would be couched within the complete sharing scenario.

Common Sense approaches to resource allocation included creating a list of priorities and doing the first priority first. Again, as in complete sharing or partitioning, administration could do this for the whole parks' division or by district. As with any industrial problem, this would be couched in the political scenario. Agarwal, Tanniru, and Dacruz created a scheme for combining qualitative and quantitative ranking for an overall rank or priority level,[1]. When figuring allocation of graduate student hours by department Bodin and Brown asked the faculty for areas of high priority concern. After seeing several basic linear programming models highlighting these concerns individually, the faculty committee was willing to agree that recitation ought to be maximized. This reflected the 'idea' that recitation classes made that institution unique. Thus a complex model was not needed and a simple linear objective function with one term and ten constraints filled the bill,[3].

Turning toward particular examples of these techniques this researcher noted that parks were not the primary agency explored in the research. Prime areas explored included high technological industries of communications and electronics and critical industries such as hospitals. This researcher explored a couple of examples from the latter industries as they contained similar concerns with parks' divisions.

In allocating telecommunications for the L.L. Bean company, Quinn and Andrews [17] balanced the cost of resources against the queuing costs of waiting telephone calls and costs for lost orders. For the parks this would mean balancing resource cost against the size of priority task list and loss of public goodwill for keeping a park below standard. Quinn and Andrews minimized total cost. That was the equivalent cost of having resources available to accomplish all tasks, labor costs, time costs for resources to travel and prepare to work on a given site, and opportunity costs of having to do major work

because routine or patchwork maintenance was neglected. The assumptions of Quinn and Andrews, 1) arrivals of priority tasks were Poisson distributed and 2) service time was negative exponentially distributed, were not verifiable in the parks format as politics prohibited accurate labeling and data gathering of anything connected with prioritization.

Researchers with L.L. Bean used profitability, as opposed to productivity as the objective function. This resulted in higher total resource allocation. For the parks this would imply that the parks and recreation department would need to devote a greater portion of its budget to maintenance in order to please the public. That is, public approval was the equivalent of profitability. Another similarity of this problem with the parks' problem was that L.L. Bean needed to build up quickly or down quickly according to seasonal fluctuations. This condition was true for the park districts with climatic seasonal changes,[17].

Although it had become apparent that the parks' departments needed to demonstrate their demand for their piece of the budget, research had focused on more critical departments such as hospitals, police, and public works. Hospital resource allocation had been in particular abundance in recent years. Wilson and Gibberd, [20], used a destination constrained model for their research. They had the three criteria of equity, efficiency, and accessibility. These were much the same concerns of a parks' division. Thus the objective function had three parts, two of which were sums of squares. It, also, included a cost discounting factor. The travel cost from zone to zone for regional hospitals was equivalent to travel cost to certain areas from a district headquarters. The only constraint was to have the district sizes greater than zero and totaling the total capacity. Solving this system required a combination of Euler differentials, decoupling, eigenvalues, and LaGrange multipliers or geometric programming methods,[20].

Before applying resource allocation models, parks administrations needed to adopt an operational style and organization. Parks managers needed to know the future trends of care of facilities for their districts. For parks' divisions, delicate balances needed to remain in place for any algorithm to make sense. As in the model that balanced cost of having to replace park facilities not properly cared for under routine or patchwork maintenance, "if

you don't increase the agency's annual operating budget proportionately to properly maintain that facility, you must shift funds from other facilities--and those facilities deteriorate from inadequate upkeep,"[19]. Thompson, also, commented that the most important principle in annual maintenance analyses was setting a maintenance standard,[19]. It became apparent before applying any sophisticated resource allocation, the parks' divisions needed to measure their current status and implement effective data gathering strategies. Otherwise, unintended results such as deteriorated facilities would result from inadequate management and planning.

Public works divisions, the brother agencies of parks and recreation departments, listed standards as being central to the planning process. According to Hamilton and Grenke, "Performance standards are the most basic of the system elements. They are used to establish standard crew sizes, equipment, work methods, and production rates, and they provide the basis for planning work and assessing results,"[8]. According to Middleton standards were a priority for public works departments,[16]. Thompson listed standards as the most important principle in annual maintenance analyses,[19].

It is the opinion of this author that many cities avoided standards due to the need to define and quantify such a vast amount of information. Middleton cited standards as being so difficult due to the vast number of possible organizational schemes, "the hypergeometric distribution...illustrates the numerous ways a city can choose to structure its operation compactor trash pick up...

1) crew size...
2) what type of vehicle...
3) where is the collection point...
4) collection frequency...
5) is the collection mode automated or manual...
6) how many hours of the day the crews work,"[16].

Steps for designing standards included defining activities of the department. According to Hamilton and Grenke, "Achieving a higher level of service means doing the

right work,"[8], and defining activities that consider preservation, safety, esthetics, and comfort. Middleton commented, "One of the most confusing things to the general public is what services the public works department provides,"[16]. Directly related to activities was the need for the inventory. An adequate inventory would not only describe routine maintenance, but would predict needed budget for capital maintenance over the maintenance cycles,[7].

Time per task information was a necessary ingredient for standards. However, complicating factors of high maintenance and heavy use introduced a need for adjustment. According to Thompson, maintenance standards were directly related to use,[19]. Time per task evaluations were merely averages so accounting for special considerations such as heavy use or high maintenance involved testing means. With limited data it would be difficult to perform homogeneity of variance tests, but according to Moser and Stevens variance tests were not necessary for the two sample case as the testing procedures were robust to fluctuations in variance,[24]. For more detail on statistics and time per task information one need only turn toward the industrial discoveries of the last century.

Industry began using time standards around the turn of the twentieth century. Frederick W. Taylor pioneered the concept with Frank B. Gilbreth developing the prototype of the modern motion study,[10][13]. Industrial standards involved three steps:

1) Scientific determination of preferable work methods,

2) Appraisal of the time value of work, and

3) Development of practical use of that data,[10][13].

In the 1970's and 80's large cities began to attack the first of these three steps. Cities abandoned the park caretaker format turning to routing patterns. Managers developed specialty crews such as mowing or gardening crews which would travel from park to park performing their tasks. Thus workers would develop skilled and efficient

patterns of operation. The next step was to determine the time value of these tasks. A few sources tackled this monumental project.

The City of Los Angeles Recreation and Parks Department needed to reduce the cost of maintenance to its facilities. It decided to change the caretaker style of facility maintenance to an overall uniform city plan. This change required a system of accountability.

This process took over a decade to complete and validate. It is, also, a procedure Los Angeles continues to use,[22]. Bethel, the original technician for Los Angeles Recreation and Park Department, suggested first dividing the tasks into routine and job order tasks. Then he suggested establishing benchmarks, representative jobs of a general maintenance procedure. Bethel reminded the reader that these benchmark times were applicable to total time only, due to statistical significance of variability. Los Angeles used the method time measurement (MTM) method for determining task time. The MTM method used tables of already established times for certain human movements such as picking up a tool or reaching for equipment. For jobs with no time standard information Los Angeles used median time for the closest benchmark activities. It also detailed travel time and set-up/tear down time for each facility and task.

The LA superintendents determined maintenance task frequency relying on their experience. The MTM technicians then proceeded with the inventory exploring engineering documents with actual facilities. They noted size and type of each item. The technicians then observed operational personnel, analyzed operational procedures, and improved operational methods. The technicians documented the final descriptions as the standards. The technicians also prepared routes. The operations supervisors approved all this information. Bethel suggested adjusting times for certain facility peculiarities, but did not detail how he did this,[2]

The MTM technicians also gathered time information. This information was not debated as it was based on established 'fact,' the MTM tables,[2]. Los Angeles established a uniform maintenance plan at a cost avoidance figure of $7 million. Murray, the current

maintenance technician for the City of LA Recreation and Park, suggested that taking time with lower level supervisors or caretakers would be prudent. LA did have some conflict when workers perceived technicians as arrogant, but relieved the trouble when analysts encouraged workers to express their views and incorporated this information. Murray used a 10% demand factor and a 25% fatigue factor so that the time per acre was intended to be a lower bound,[22].

It appeared that Los Angeles had done an excellent job of defining its maintenance plan and recording accurate time information. It had a 1,000 page manual for any detailed information it may have needed. It also continued to successfully use a system developed several years in the past. This analyst would hold the Los Angeles Park and Recreation system as a system to emulate.

Eagan, MN was, also, a city which has developed standards. Vonderlinden, the Eagan Park and Recreation technician, had made several presentations on the time per task and standard compilation for the city of Eagan. Other park and recreation departments in that area seemed to be suitably impressed. Whereas Eagan also has a manual of its time and task information, Vonderlinden's accomplishment has not yet been published in journals,[23].

Dallas, TX has also worked on park standards. It had divided its land into four classes of appearance. The time task information Dallas acquired was very similar to the National Park Standards,[19].

The public works department of North Vancouver, BC started questioning its methods of street cleaning and grass cutting. It summarized its process in twelve steps. The first step was to define the municipality's expectations, a feat much easier for smaller communities than large cities. It then acquired the city council's authorization for the process and hired a consultant. It introduced all operations staff to the consultant and interviewed operations staff for the list of maintenance activities. It timed the interviews so as to be at a quiet time of the year. It then finished quantifying the inventory of infrastructure. One expected to capture 70-80% of the needed budget the first time a

complete assessment such as this took place. The completed manual went to all permanent maintenance staff. Results included inventory, activities, level of service (appearance), definition of resources, labor, equipment, and material needed. This assessment resulted in record keeping changes. North Vancouver public works department had 285 activities on its maintenance schedule. North Vancouver was able to share computing resources with accounting and payroll creating an efficient system. This, once again, was a feat more easily obtained by smaller communities with directed management than by large cities. The last step critical to North Vancouver was to put someone in charge of communication and update of the maintenance standards,[15].

St. Louis, MO, NYC-Manhattan, and Lakewood, CO have all worked on rating systems for the appearance of parks. St. Louis had a more detailed report to rate parks according to the different features of the parks. It assigned inspectors to different areas of the city which rated the parks on five levels. For example, one of the characteristics under turf care was color of turf: lush, deep green, green, acceptable, poor,[21].

Accountability for maintenance procedures began to be a greater concern for members of the National Recreation and Parks Association (NRPA). Smaller communities, in particular, wanted to develop profession-wide maintenance operations information. They did not have the resources to complete their own studies. They wanted basic maintenance information available including time/task details,[5].

The results of these studies were NRPA Park Maintenance Standards. The standards intended for use in any park district in the United States first detailed several categories of park priorities. It listed seven modes or seven different levels of manicure that could exist in city park systems. It then listed some time task information. It did not detail which method it used to determine the time task information, what type of maintenance organization it assumed, i.e. caretaker vs. routing experts, or which statistic it used, i.e. median, mean, first quartile, etc.

The National Standards would be of use for basic idea of time, but did not provide a great amount of detail in times. For example, 7-gang mowing was average time per open

area mildly rolling. Ride mowing and trim mowing were of similar format. One would need an average time for all 7-gang mowing and an average time for ride and trim mowing around trees, along fence lines, backstops, and sidewalk and curb edges. The average time per medium rolling acre was somewhat irrelevant.

Setting park priorities was a political issue. Fort Collins, CO, a city instrumental in setting the National Park Standards, was able to set two levels of priority,[26]. Lakewood, CO set two levels of priority for ballparks and lakes, only,[25]. Defining these levels of priority beyond two was a political infeasibility. Too many decision makers exist and change yearly to maintain a consistent plan of priorities.

The National Park Standards were helpful because the organizers intended to apply the numbers to any group of park areas in the United States as opposed to Los Angeles, Dallas, and Eagan times which were technically only applicable to Los Angeles, Dallas, and Eagan parks. It was infeasible that every park in the United States was in the pool of parks tested for times in the NRPA study. To Denver's benefit, however, much of the study was done in Boulder and Fort Collins, cities similar in climate to Denver.

Forecasts of city budgets predict an increasing level of shortfalls. City budget offices demand more accountability from their recipient departments. Park divisions fall within this realm of accountability. Whereas many OR and AI optimization techniques exist to best allocate park resources, park departments need to understand their current state of affairs. Several cities have approached park organization through use of time standards. This researcher will approach the situation the city and county of Denver parks presented by organizing time task information into a spreadsheet.

The following chapters detail concerns of the different departments or divisions involved, data gathering, heavy use and high maintenance impact, the spreadsheet model, verification and validation of that model for the city and county of Denver, implementation of standards, and suggestions for further research.

Chapter 2 FORMULATION OF MAINTENANCE STANDARDS FOR CITY PARKS

The exact nature of a standardization problem varies from city to city. The constraints become apparent through discussions with budget departments, parks administration, and operations' management. Creating a method of measuring accountability usually concerns budget departments. Budget departments want their receiving departments to measure maintenance costs so the budget administrators can better assess the department's wisdom of the use of public funds and allocate future funds accordingly. Parks' administrations have a variety of outlooks on the problem which could include reorganization or flexibility of the measure. Operating management wants to include any deviation from the norm and needs assurance of integrity for use of the standard.

Budget department's perspective

Budget departments foresee standards as information necessary for them to allocate funds. Maintenance administrators predict the need for more funds when politics dictates more area for parks' divisions to maintain. Management could argue for more funds using the maintenance standards. Budget departments would then adjust dollar allocation with confidence. Budget departments can plan for city growth as they see the city plan from the perspective of all departments. Knowing the true costs of this growth they can influence city planning so that budget and expectations remain realistic.

From the eyes of park administrators

The scenario for this paper is a parks administration desiring three levels of standards and three levels of maintenance. This involves three different maintenance frequency schedules and a desire to be flexible with those frequencies. Flexibility with frequencies is more complicated than simply adjusting the frequency level. Reducing the frequency of one item increases the frequency of another. For example, reducing the number of times one weeds the shrub beds increases the amount of time spent trim mowing. This paper deals with setting the standards and bounding the frequencies.

Bounding the frequencies prevents an administrator from making a costly mistake by reducing the frequency on one item so as to increase the frequency on another. Thus the bounds become the high and low levels of maintenance frequency standards, and the current level of operation becomes the medium level. Once a city has operated on its standards for some time, exploring the relationships between these variables becomes viable.

Operations' concerns

District differences complicate the set-up of a spreadsheet model of standards along with interactions between maintenance frequency tasks. Operations managers often feel as if they are exerting extra effort for various reasons. This paper considers those reasons into two groups. The first group is heavy use. The turf and facilities of parks undergo excess wear and tear due to lots of foot traffic. In order for facilities with heavy foot traffic to look as the facilities with limited foot traffic, maintenance personnel must either perform extra tasks or take more time and care to perform routine tasks. The second group is high maintenance. This includes anything that causes maintenance to be longer, such as steep slopes for mowing, or to be more frequent, such as drainage problems of low-lying playgrounds. Areas become high maintenance due to natural features, such as hills, or planning design, such as bermed medians.

Appearance as a standard

Setting a standard is a fine beginning, but the managerial concern of accountability remains. If a maintenance organization agrees it will perform a given set of tasks what guarantee is there the organization actually performs those tasks? Assembly line situations have certain quantity and quality attributes they measure to assure performance of tasks. Parks are not exactly assembly line products, and the goal of park engineers is often to create diversity, not to replicate past success. Judging from citizen response to parks and experts' diagnoses for park improvement, appearance is important. Whereas appearance is a subjective measure, within certain criteria, it can approach an objective quality. This analyst proceeds with appearance as the balance measure to the performance of

maintenance tasks. So, in essence, there exist two standards for parks maintenance. One is a "seeing" standard and one is a "doing" standard.

Performance standards

The first stages in setting parks standards are balancing the two standards of appearance and performance. Two questions keep recurring and cycling back and forth; What must maintenance workers do in order to have the parks look as if they are meeting the standard? What will the parks look like if maintenance workers perform standard tasks according to standard frequencies? The maintenance frequency schedule runs parallel to the maintenance inventory. Inventory items include anything upon which workers work. For example, workers trim mow, repair sprinkler heads, and edge the curbline. This means data processing personnel need to track linear feet of curb in order to calculate amount of trim mowing, repairing sprinkler heads, and edging the maintenance workers need to perform. Performing time studies and establishing the inventory lists run hand in hand. For instance, past time studies have shown that asphalt and concrete walks demand differing amounts of time so management must separate the two on the inventory list. Other items often neglected on inventory lists include obstructed areas, such as walks, which need special care such as hand shoveling.

Use and maintenance integrated into the standard

Obtaining the frequency schedule and inventory is a matter of time and effort. Several cities have done this before, as detailed in the literature review. The challenge in determining a fair and accurate measure comes in defining exceptions; it is rare for cities to have equitable districts. For cities that are geographically different, a simple measure based solely in inventory might not be a fair representation for distribution of resources. Some districts might have a greater challenge achieving the visual standards than others. As operations management quickly points out the use and maintenance levels are not trivial when evaluating individual parks. One could not, therefore, conclude that heavy use and high maintenance are irrelevant at the district level. The question remaining in this study was what type of adjustment needed to be made for these heavy use and high maintenance

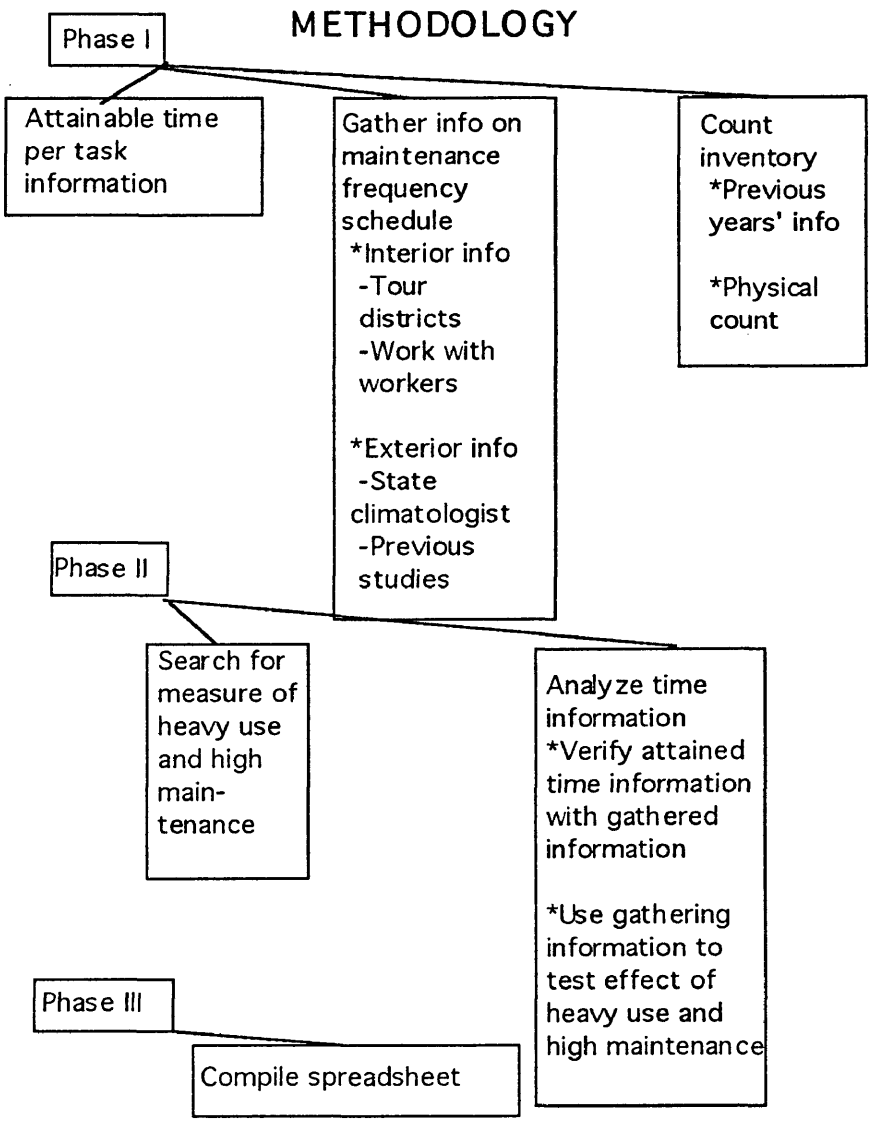
areas and how would one measure an area to see if it were indeed heavy use or high maintenance.

The role of priority parks

The remaining issue, again not a frivolous detail, for city park districts is priority parks. There are going to be some areas which maintenance maintains at a higher level for various reasons. How could one measure those and what time concessions does one make for higher level parks? In this case administration agreed that separating the parks into urban parks and community parks per planning intent was safe and accurate. Thus inventory information needs to be separated into two parts, urban park totals and community park totals. Due to the limited size of districts separating information into many priorities may inhibit the accuracy of the average. Each priority park grouping demands a different set of inventory because the frequency increases of some of the maintenance activities. The time per task information is an average time per unit of inventory. Thus if the inventory is not a cumulative of a significant number of different park areas, theoretically a random group of park areas, the average time many not represent the actual time to perform maintenance on those park areas. The intent of using averages is that administration will group enough different parks together so that the average of those parks is close to the overall average. The conclusion is to avoid too many levels of priority parks.

Chapter 3 DATA GATHERING

The order of collecting information for the city and county of Denver follows on this page. Note that several items were gathered simultaneously.



Inventory and Maintenance Schedule

This analyst gathered inventory and maintenance frequency schedule lists simultaneously. Measuring inventory is a formidable task. Inventory is never stagnant when counting living things and their condition. Inventory is also very large when counting park assets of a large city. This author spent time working with the crews to discover pertinent inventory items and activities on the frequency schedule. The object of the study was the city and county of Denver parks. The routing organization was specialization of worker types into crews except where prohibitive, usually due to quick coupler irrigation systems. This analyst incorporated information from parks maintenance literature into the initial inventory and maintenance frequency schedule lists, especially when establishing upper and lower bounds of frequency. The current level of frequency was an average from parks maintenance management and supervisors. In addition to the inventory items workers and experience made apparent, this researcher included frequency information and inventory suggestions from other sources which had completed park time per task studies. This analyst combined the information into a Lotus 123 spreadsheet.

Actually measuring inventory proved to be a task too vast to complete in its entirety. Park maintenance management gathered what it could for its districts in limited time. Defining park inventory to parks management is an ongoing task. It is not necessarily obvious to them how the information is relevant. They do not always see inventory as driving people hours needed to keep a park up to appearance standards. They do not realize that the number of workers they will receive the next year depends on the inventory from the previous year.

Maintained acres and flower bed detail, titles of some inventory items, were available for all the parks. The administration felt that this information was accurate because planning departments had used it in the past. There were various other items available for various other parks, but no other items available for the whole system. For items unobtainable, this analyst computed an average per maintained acre. Sidewalk length

and curbline regressed fairly well against maintained acres. Whereas averages wash out district differences, it is not always cost effective to count every inventory item. In this case, this analyst used an average shrub square footage as opposed to hiring surveyors or hiring individuals to approximate shapes and measure circumferences. Parks administration compiled inventory information into a Q & A database. Remember there are several inventory lists to track, one for each priority level. For the city and county of Denver this meant two lists.

Time per Task Information

Time per task information is available from several sources including the National Recreation and Park Association (NRPA) handbook and cities who have completed formal time studies. Whereas time study information is valuable, few cities have the long range planning, funding, or administrative vision to complete these studies. Using the information available provides a good initial estimate for total dollars and people needed. Maintenance managers, experts on high profile tasks such as mowing, can quote times for several of their park areas. This is a good check to see if other time information is in the ballpark. This author spent time working with crews and observing crews in the city and county of Denver, CO. It is this information along with the expert estimates that is the basis for testing assumptions of heavy use and high maintenance detailed later.

As is common in occupations with varied funding and nonrepetitive work patterns, the parks' division of the city and county of Denver has a time accountability system. As is also common to these occupations, the time accountability system is good for rough approximations, but not a detail of individual task information. The sorted data consisted of sums per year for four out of nine districts. This implied the need for assumptions including number of times per year workers performed a given task and correctness of coding the tasks. This was the first time the city and county of Denver had run a summary of the time accountability data. For this reason some bugs in the process were still to be worked out.]

After gathering the information, this analyst proceeded to quantify heavy use and high maintenance impact in order to structure the spreadsheet. The details follow in the next chapters.

Chapter 4 DEFINING DISTRICTS WITH EXCEPTIONAL CIRCUMSTANCES

Appearance Ratings

The first measurement one wants for a standard is the accountability measure. That is, some inspector needs to determine appropriate appearance. Although there is no totally quantifiable way to do this, a listing of high profile characteristics with corresponding rating information approximates a standard measure.

Use Ratings

Heavy use is difficult for cities to measure as there are so many sources of use. Athletics, picnics, homeless, and drive-by abuse all constitute heavy use. Permitting information, if available, is invaluable. This model settles on number of people per maintained acre in the park districts and number of recreation centers or major attractions within the districts as a measure of heavy use areas. Recall from Chapter 2 that this model divides the parks into two priority levels, a community park and an urban park level. Number of people per acre addressed the community parks, but an accurate measure of urban parks and medians had yet to be produced. Once parks' maintenance personnel establish a standard, a possible measure could be number of trash barrel equivalents. This could measure both urban and community park use. An example of a trash barrel equivalent would be the sum total of the following items:

1) Number of trash barrels times 1.

2) Number of trash dumpsters times 7.

3) Number of round cement containers times .75.

4) Number of square cement containers time .5.

Maintenance workers would need to calculate equivalent volume of any trash receptacle to a trash barrel. Whereas any number of levels of use are possible, this model endorsed three levels, low, medium, and high.

Park exceptions of this model include not only use, but also high maintenance.

Maintenance Ratings

High maintenance is vague and diverse in definition. The only measure which approximates the intent of high maintenance is a superintendent's rate. This analyst based the rate on the following criteria:

1) mowing obstacles,
2) drainage,
3) road, trail, sidewalk base,
4) structure, shelter,
5) shrub and rock garden weed prevention,
6) curbs and enclosures,
7) soil top cover preparation,
8) playground,
9) playground structures, and
10) steeply sloping areas.
11) irrigation system

Under a three level maintenance format, low (requires little time), medium, and high (requires a significant amount of extra time), medians are medium maintenance unless there are other problems, in which case they become high maintenance. The superintendents establish maintenance level by park so analysts need to develop a district rate such as average rating per maintained acre within each district.

Once use and maintenance become measurable one need attack the political question of whether or not the city will endorse priority parks.

Priority Parks

Establishing certain parks or areas as priority puts the administration at risk of harsh citizen response. Once citizens notice the parks in their neighborhood receives less attention than parks in the other neighborhoods, they file complaints. Soon citizens begin to vie for attention for their neighborhood parks. Parks administration needs to be able to support its reasoning for establishing areas as top priority or it will spend its time forever reordering its priorities. This study assigns priorities for maintenance purposes correlate with the priorities assigned for planning purposes. Maintenance follows the planning division's lead in this case. For the city and county of Denver this meant following the 1986 Masterplan. This masterplan categorized parks as community parks or urban areas. For the maintenance standards urban areas became priority one parks and community areas became priority two parks. See appendix J.

Use, maintenance, and priority were now measurable. So one can identify a park area as heavy use, high maintenance, or top priority. What impact do these levels have on people dollars?

Chapter 5 RESULTS OF IMPACT ON MAINTENANCE TIME AND FREQUENCY FOR HEAVY USE AND HIGH MAINTENANCE AREAS.

Increased maintenance frequency items related to use are trash pick-up, emptying barrels into dumpsters, fertilizing, patching sod, and overseeding. Increased maintenance frequency items due to high maintenance activity include rescheduling mowing, setting out cones, shaving the curbline, mowing slower, overseeding, fertilizing, and edging flower beds. This analyst compared statistical means of the time study results and time estimate results for the activities of mowing and trash pick-up. The null hypothesis in this situation was that the mean time to accomplish an activity in any use or maintenance level park was the same regardless of park level. The alternative hypothesis was that at least one mean time was different.

Turning attention to the informal time studies one notices 7-gang mowing was significantly different for use level 2 parks. See appendix D. There was no significant difference due to maintenance level. Individual parks yielded some significant differences for two parks. This difference could be due to heavy use as use level measurement is not a tried and tested measurement and potentially inaccurate. Decision makers may have miscoded a heavy use park as low use and visa versa because the measure was not completely accepted and validated at the time of this study. These errors could mask differences that do exist between use levels or could make differences appear that do not actually exist. One of these parks was on a steep slope and field personnel expected it to be higher for high maintenance areas. Ride mowing only yielded different statistical means when comparing different parks. The steeply sloping park again was significantly higher in statistical mean time to mow per acre. Trim mowing showed no significant differences.

Trash pick-up was greater in a few small parks, but due to scanty data for individual parks, this was not a significant result. Perhaps there are certain areas which attract trash and are more concentrated in small parks.

Verification of results from informal studies would involve field worker estimates. Results from testing the field estimate means yielded no significant differences in any of the types of mowing or trash pick-up. Thus this analyst made no conclusions as to differences in time for mowing or trash pick-up. The researcher could not reject the hypothesis of equal mean times for performing these tasks.

The next section details the extra work required for heavy use and high maintenance areas. Those things labeled below as not available are not available because workers could not quantify what was needed. The zero entries reflect the results of the hypothesis testing. That is, although maintenance personnel experts believed that these activities caused extra time, the data gathered over the summer did not reflect this. The city and county of Denver was not currently operating in a fashion such that all the parks looked as if the standards were maintained. That is, according to maintenance supervisors, some parks suffered in appearance due to unaddressed heavy use or high maintenance needs. They never had the funds to pick these parks up to the appearance standard and had not had the opportunity to know how much extra work was needed in those area.

The following table depicts the use and maintenance generated activity followed by the expected hours per 100 acres per year for heavy use or high maintenance areas. The expected hours are the extra frequency generated per year multiplied by the standard time per hour from the spreadsheet. The contributions to heavy use and high maintenance are:

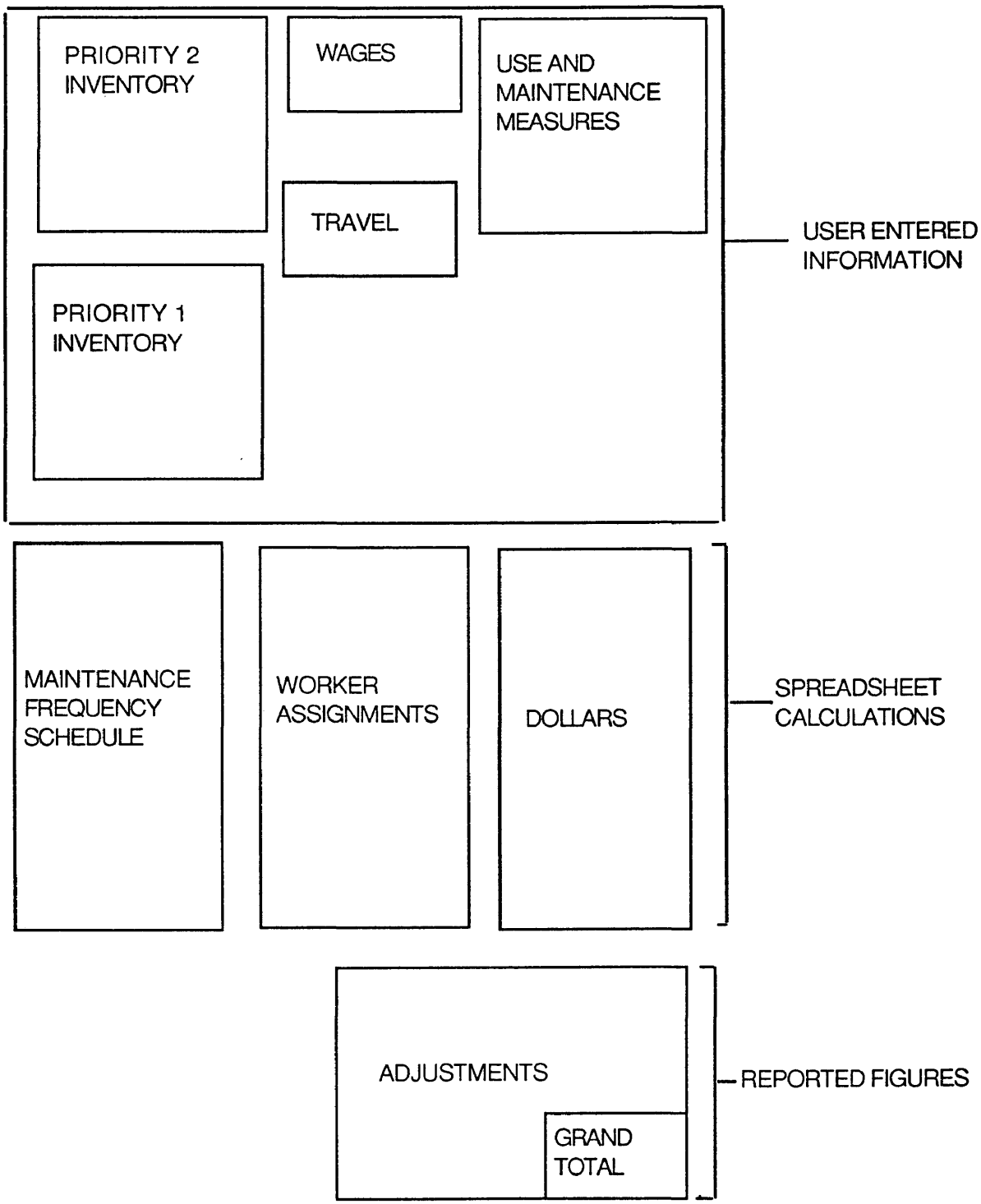
USE:	HOURS/100 ACRES/YR
Increased trash pick-up	0
Empty barrels into dumpsters (daily)	47.5
Fertilize (one time)	59
Patch sod	NA
Overseed (one time)	89
Total	195.5

MAINTENANCE:	HOURS/100ACRES/YR
Reschedule mowing	NA
Set out cones	NA
Shave curbline (every five years)	2.2
Mow slower	0
Overseed (one time)	89
Fertilize (one time)	59
Edge flower beds (1.5 times ave)	1.5
Total	150.2

Field workers verified that the unavailable times were relatively small. These total times are just short of 1% of the time needed to maintain 100 average acres of Denver parkland. The extra time needed for heavy use and high maintenance districts became a 1% increase in total hours.

This author has detailed all the information needed and quantified the special circumstances needed to complete the model. The next chapter details the spreadsheet model.

FORMAT OF THE SPREADSHEET



Chapter 6 THE SPREADSHEET MODEL OF PERSONNEL AND MAINTENANCE COSTS FOR THE CITY AND COUNTY OF DENVER

The top portion of the spreadsheet consists of use entered information. Inventory and maintenance schedule are the skeleton for the spreadsheet. The time per task information correlates with each maintenance frequency item. This analyst based bottom line percent increases for heavy use and high maintenance on entered measurement information.

Information Needed for the Spreadsheet

Information individual districts need to feed into the spreadsheet includes the community and urban inventory, or an inventory for each park priority level. They must also enter the average hourly dollar rate per worker type. Transportation information needed includes percent of parks within 1.4, 2.7, 4.0, and 6.7 miles, arbitrarily chosen concentric circles, a weight of number of parks per average number of parks in a section, and average time to greenhouse and headquarters. The purpose for entering this transportation information is that equity in transportation time is not often in the criteria for determining district boundaries. Dividing the districts into sections provides some reprieve for districts with a large percentage of parkland a long distance from the headquarters or district shop. Accounting for the number of parks assigns time credit to districts who must travel several times during the day due to small parks all requiring attention. If transportation time were not included in the standard calculation some districts would not be able to keep their parks up to the appearance standards because workers would devote too much time designated as task time to travel time. Oftentimes an objective for districted cities is to create equity among the districts. The spreadsheet needs district codes as some activities are district specific and the spreadsheet 'if' statements need a cell reference. Lastly, data analysts need to enter use and maintenance level for district or parks of interest. One could enter all land as medium use and maintenance if one did not want to consider differences in use and maintenance level.

Line by Line Information

One line of the spreadsheet consists of the inventory item, the activity workers perform upon that item, such as volleyball court, rototill, and the corresponding detail. This designer divided each line into two parts for the two levels of priority park areas. The time per task information follows each activity. This researcher adjusted time for mowing to reflect time per maintained acre. It was more appropriate to pursue a mowing equipment ratio than to calculate turf acres assigned to 7-gang, turf acres assigned to riding mowers and linear feet assigned to trim mowers. Equipment proportions resulted in one 7-gang, three riding, and three trim mowers.

The next spreadsheet cell references inventory counts and measures from the top "information needed" portion of the spreadsheet. The spreadsheet totals the time needed to perform that task for a year (or appropriate period of evaluation). The modeler provided an option to place on weight on each activity to allow for future amendments to the present conceptual model. For instance, one could allot maintenance allowances for certain activities only.

The next segment of line by line information assigns worker types per task. The number of each worker type is entered beneath the titles "gardener/florist," "maintenance technician," etc.

This author delegated tasks to worker types based on concept and season. Permanent workers are to supervise and perform more technical tasks. The deputy manager in charge of parks for the city and county of Denver designates permanent employees as supervisors. In the minds of park maintenance managers permanent employees should not be performing routine work unless there is no other choice, as happens before and after the seasonal labor force is available. For instance, weeding a flower bed would require one gardener for overall supervision, one utility worker for subcrew supervision and six seasonal laborers. This designer assigned permanent workers

to routine labor for tasks which managers expect workers to perform when seasonal laborers are unavailable. The spreadsheet then assigns time and dollars to worker types accordingly. Each line has a total for that activity so administration can equate relative importance to relative dollars and bestow appropriate changes.

For example, data analysts will enter information on the top section of the spreadsheet. Call the entered information items; $i_1, i_2, \ldots, i_{100}$. Consider grass or turf. The descriptive inventory title is 'grass.' Activities performed on grass include, 'spray 2-4-D,' 'aerate,' 'trim mow,' and others. This spreadsheet includes 16 activities related to grass that the city and county of Denver would like to perform. Following the activity description are the priority parks, 'community' (low priority) and 'urban' (high priority). Thus there are 32 lines of 'grass' information. Call them $l_1, l_2, \ldots l_{32}$. Each line will yield a total dollar figure for that activity in that priority park area. Let

g_i = number of gardener/florists needed to perform the activity listed in line i

m_i=number of maintenance technicians needed to perform the activity listed in line i

e_i = number of equipment operators needed to perform the activity listed in line i

u_i = number of utility workers needed to perform the activity listed in line i

s_i = number of seasonal laborers needed to perform the activity listed in line i

x_i = total time per activity needed to perform the activity listed in line i

hg_i = gardener/florist hours needed to perform the activity listed in line i

hm_i = maintenance technician hours needed to perform the activity listed in line i

he_i = equipment operator hours needed to perform the activity listed in line i

hu_i = utility worker hours needed to perform the activity listed in line i

hs_i = seasonal laborer hours needed to perform the activity listed in line i

t_i = total number of workers needed to perform the activity listed in line i

ppl $'s = total number of salary and benefit dollars dedicated to performance of activity listed in line i

Therefore,

x_i=Number of times per period city performs an activity times hours per inventory unit

For the three specific line items listed above, times per maintained acres are 0.17, 2.415, and 0.75 hours respectively, the yearly frequencies for the city and county of Denver are 1, .5, and 14. The total times for these activities are:

$x_1 = 1 \times 0.17 = 0.17$
$x_2 = 0.5 \times 2.416 = 1.208$
$x_3 = 14 \times 0.75 = 10.5$

The assignment of workers, assigned according to the criteria listed earlier, resulted in:

One utility worker for spraying 2-4-D.

One equipment operator for aerating.

One utility worker and four seasonal laborers for trim mowing.

The other lines follow in like fashion.

Thus, for these three specified lines, the total number of workers is:

$t_i = g_i + m_i + e_i + u_i + s_i$
$t_1 = 1 + 0 + 0 + 0 + 0 = 1$
$t_2 = 0 + 0 + 1 + 0 + 0 = 1$
$t_3 = 0 + 0 + 0 + 1 + 4 = 5$

Administration needs hours per worker type for each line item, for validation and amending purposes. Hours per worker type is also needed to calculate dollars per activity, one of the figures of major interest to superintendents. The inventory units cell references inventory quantity or measurement numbers from the input section of the spreadsheet. Call the entered inventory information $i_1, i_2, \ldots, i_{60}$. Let i_{21} = number of maintained acres, which for this case is 85 acres. The hours per worker type for this example are:

$hg_i = (g_i/t_i) \times x_i \times i_{21}$ $hg_1 = (0/1) \times 0.17 \times 85 = 0.0$

$hm_i = (m_i/t_i) \times x_i \times i_{21}$ $hm_1 = (0/1) \times 0.17 \times 85 = 0.0$

$he_i = (e_i/t_i) \times x_i \times i_{21}$ $he_1 = (0/1) \times 0.17 \times 85 = 0.0$

$hu_i = (u_i/t_i) \times x_i \times i_{21}$ $hu_1 = (1/1) \times 0.17 \times 85 = 14.45$

$hs_i = (s_i/t_i) \times x_i \times i_{21}$ $hs_1 = (0/1) \times 0.17 \times 85 = 0.0$

$hg_2 = (0/1) \times 2.416 \times 85 = 0.0$ $hg_3 = (0/1) \times 0.75 \times 85 = 0.0$

$hm_2 = (0/1) \times 2.416 \times 85 = 0.0$ $hm_3 = (0/1) \times 0.75 \times 85 = 0.0$

$he_2 = (1/1) \times 2.416 \times 85 = 102.68$ $he_3 = (0/1) \times 0.75 \times 85 = 0.0$

$hu_2 = (0/1) \times 2.416 \times 85 = 0.0$ $hu_3 = (1/5) \times 0.75 \times 85 = 178.50$

$hs_2 = (0/1) \times 2.416 \times 85 = 0.0$ $hs_3 = (4/5) \times 0.75 \times 85 = 714.00$

Also entered as initial information is dollars per hour per worker type. Let dollars per hour be the variables, $i_{61}, i_{62}, \ldots, i_{65}$ referring to gardener/florists ($11.00), maintenance technicians ($13.00), equipment operators ($13.00), utility workers ($9.50), and seasonal laborers ($6.10) respectively. Thus the final entry on the line, total people dollars per activity, becomes:

$$\text{ppl \$'s} = hg_i \times i_{61} + hm_i \times i_{62} + he_i \times i_{63} + hu_i \times i_{64} + hs_i \times i_{65}$$

l_1 :

$$\text{ppl \$'s} = hg_1 \times \$11.00 + hm_1 \times \$13.00 + he_1 \times \$13.00 + hu_1 \times \$9.50 + hs_1 \times \$6.10 = \$137.275$$

l_2 :

$$\text{ppl \$'s} = hg_2 \times \$11.00 + hm_2 \times \$13.00 + he_2 \times \$13.00 + hu_2 \times \$9.50 + hs_2 \times \$6.10 = \$1334.940$$

l_3 :

$$\text{ppl \$'s} = hg_3 \times \$11.00 + hm_3 \times \$13.00 + he_3 \times \$13.00 + hu_3 \times \$9.50 + hs_3 \times \$6.10 = \$6051.150$$

This completes the spreadsheet information per line. The bottom information,m grand total and adjustments usually of interest to administrative personnel, is detailed in the next section.

Totals

The information on totals begins with number of maintenance hours. Number of maintenance hours is 85% of the number of worker hours. A worker coming to city standards will spend some time on training, safety, and vacation. This consumes 15% of the worker's job time. This analyst based number of workers on 6 hours of on-task time. The one-half hour break, preparation, and tear down time are considered standard deviations from task time for an eight hour day. The model then adds transportation time approximations. The potential 1% credit for use and maintenance levels appears after transportation credits. Following credit for use and maintenance is the credit for number of parks. The credit for number of parks is due to lack of resources to measure set-up, tear-down and transportation time per park. The time accountability system revealed that adding an extra park to a large park (15 acres and larger) resulted in 0.45% increase in average time. This means that a park district of forty locations takes 20% longer than a single park of equal inventory. The last cell reveals total number of people dollars (money for salaries and benefits of maintenance workers, this does not include superintendents, operations supervisors, foremen, cleric or staff expenses), the district needs per year (or period of evaluation). This is the number of interest to higher level management, budget offices, architectural planning divisions, and other related agencies.

To examine these totals in greater detail, consider the last five lines of the spreadsheet. Call them l_{600} l_{601} ...l_{604}. The first of these lines, l_{600}, is the total dollars needed before including use and maintenance issues. Use and maintenance levels are user entered information. Let i_{77},i_{78}, and i_{79} be the number of acres at the three different use levels in ascending order, the higher subscript indicating a use level requiring more maintenance work to look to the same appearance standard as the average park. Let i_{80},i_{81}, and i_{82} be the number of acres at the three different maintenance levels following the same pattern as the use level subscripts. Let i_{60} be the inventory item indicating number of parks in park area or responsibility being evaluated. Beneath the column title 'ppl $'s' will appear the rows:

l_{601}	$i_{77} \times .99 + i_{78} \times 1.00 + i_{77} \times 1.01$	Use credit
l_{602}	$i_{80} \times .99 + i_{81} \times 1.00 + i_{82} \times 1.01$	Maintenance credit
l_{603}	$1.0045^{i_{60}}$	Number of parks-set-up/tear down & transportation credit
l_{604}	$l_{600} \times l_{601} \times l_{602} \times l_{603}$	Grand total

This concludes the calculations required for the spreadsheet. The next chapter details some of the verification stages of the spreadsheet code and information evaluated for the spreadsheet as applied to the city and county of Denver.

Chapter 7 VERIFICATION

This process needed verification of the spreadsheet formulae and verification of data entered into software programs. One can achieve verification through testing various scenarios and searching for reasonable results. For example, isolate one park of Denver and assume that volunteers would do the weeding. Enter the inventory for that one park, isolate the maintenance frequency activities and test how much money the volunteers would save the system. This analyst compared the results of this run with volunteer coordinator estimates. This resulted in re-evaluating weeding time.

Four out of nine districts had compiled inventory information. Entering the inventory totals for those four districts revealed gardener totals somewhat high and total dollar totals originally high. Evaluating the line by line information revealed trash pick-up was incredibly high. This provided the opportunity to check coding, frequency, and time assumptions. Analysts suspected shrub bed estimates to be too high yielding large estimates for number of gardeners needed. The final three products included dollars needed for one hundred average acres of Denver parkland at each of the maintenance frequency levels.

This analyst performed statistical test of the effect of heavy use and high maintenance using informal time study data. The time estimates from the field experts were to support or refute these results. Due to small sample sizes no effect of heavy use and high maintenance could be accepted. Transfer of data verification was verified through proof reading due to small sample sizes.

Continuation of Data Gathering

Parks maintenance management needs to update inventory yearly. Planning divisions constantly change facilities resulting in need for more workers or lower

appearance standards for maintenance. This could disrupt the standardization process as resource allocation would again become unequal.

Administration will improve the time accountability system. Streamlining coding according to worker type and further defining codes are works in progress.

The city and county of Denver is just beginning its trek to standard operating procedures. The administration of the parks' division had agreed to 25% completion of standardization with budget and management. Part of that 25% was completed inventory and compiling time accountability information for four out of nine districts. The deputy manager's office will compile the information for the remaining five districts within the next two years in an effort to complete the standardization process. Another part of that 25% is evaluating whether or not the assumption to date properly mirror reality. The procedure is as following in chapter 8.

Chapter 8 VALIDATION

Several points in this problem solving process (see appendix I) needed validation. The attained time per task information should not be accepted as appropriate for Denver or any particular location with question. Fortunately several organizations have performed time studies or gathered together information including the city of Los Angeles Recreation and Park, and the National Recreation and Park Association. This analyst looked for time similarities among the literature and also compared observed time and time from the time accountability system with time from other studies. The time per task information from informal time studies and field worker estimates verified times from other studies.

Superintendents and the director of infrastructure management approved the maintenance frequency schedule. This section of the spreadsheet is also a compilation of results from several other studies so the cross study check was available. A couple of maintenance frequency schedule items were out of kilter in the first run through. This analyst made frequency and time adjustments at this point. Defining a task is difficult. Even picking up garbage can be confusing. There are basically two types of garbage pick-up. One is a basic turf pick-up to allow the mowers to do their job, the other is a thorough trash pick-up. Polishing these definitions polished the final product.

Workers began to gather inventory information again by searching for previous study information. This information was of some benefit, but because inventory is stochastic, constantly changing, a count of actual inventory was needed. Superintendents performed the inventory count where possible and used estimates whenever an actual count was infeasible and estimates were reasonable. The remainder of the inventory was an average against maintained acres. Attempts were made to verify maintained acres with the city real estate survey information, but due to the opposing nature of accounting styles this proved infeasible within the allotted time. Inventory was not validated directly in this case, but weighed as a reflection of the totals. Looking at times per unit also revealed gross inaccuracies of inconsistencies. For example time per acre to ride mow had no consistency acre using estimated bluegrass "tree covered" acres. This analyst chose to use maintained

acres for a mowing time inventory base because the time accountability data was much more consistent under this assumption. Technicians will need to develop an adequate measure of turf acres. The current compromise is to adjust the times according to the time accountability system per maintained acre as the variance was less doing this than using superintendents' guesses of turf acres and time from other studies.

Assuming the maintained acres to be accurate implied testing the average per acres figures. Average shrub bed square feet did not regress well, and shrub bed activity totals were high. Administration will need to better account for that total in the future. Using times per maintained acre decreases accuracy in the same way averages do. This increases the variability.

The superintendents evaluated measure for heavy use and high maintenance according to their intuition. Heavy use was acceptable if permitting information could be included. At the completion of this study the high maintenance measure had not been calculated. The superintendents' evaluation of the condition of their parks was the basis for this measure so they would likely approve it. The measurements for heavy use and high maintenance need to be tested in time. The consequence for mislabeling a district as low use or maintenance is relatively low; that is a 2% maximum error, because the results in the statistical testing of means yielded a 1% increase for high maintenance areas. Permitting information needs to be incorporated into the use factor. Measurements are more psychological or political than the actual quantitative results. The validation is a comfortableness of the major players of decision processes.

The spreadsheet has been applied to the city and county of Denver . Denver now faces the formidable task of adhering to its standards.

Chapter 9 IMPLEMENTATION

Implementation for these standards involves both the budget and management office and parks' administration. Whereas both of these departments have similar concerns the implementation plans differ somewhat in perspective.

The Budget and Management Office

The budget and management office (BMO) plans to implement the standards as planned parkland develops. This will begin in 1993. The spreadsheet model will aid budget and management in dividing the budget. The maintenance analyst will enter the final inventory information into the spreadsheet and the spreadsheet will put out estimated maintenance costs. Thus BMO will know how much to increase the general parks budget.

The budget and management office, also, intends to evaluate the impact of streetscapes and medians on maintenance. This could influence the planning of the city and delegating the responsibility of median maintenance. That is, maybe the parks' division is not the ideal source to perform median maintenance.

Goals for the future include evaluating district inequalities and developing district budgets. Budget and management is primarily concerned with keeping its recipient departments accountable. The goal for 1992 was for the parks' division to be 25% complete with the standardization process. BMO intends for the parks' division to constantly increase this percent of completion. One of the ways to completely standardize Denver will be to complete the inventory and time accountability information for the remaining five districts.

Planning will soon begin for the 1994 fiscal year. Budget and management will look at the numbers from the spreadsheet model and potentially make adjustments. BMO can evaluate the accuracy of its current budget allocation to general parks.

Parks' Division

The parks administration hopes to influence BMO in its budgeting decisions. Administration and operating staff feel confident that appearance expectations from the city and county administration exceed what is possible with the current budget.

Before implementing the standard parks administration should evenly allocate future responsibilities to the districts. Denver has a significant amount of parkland being developed. Administration will look to spreadsheet totals for the districts to decide which districts will incorporate the new parkland.

In January 1993, the parks' division will begin to decentralize the budget. Administration will slowly allocate a larger and larger percent of the budget to district control as training of district managers approaches completion. Administration will designate proportions of the budget based on proportions discovered with the spreadsheet model.

In May, 1993, superintendents will decide which of the maintenance frequency activities are most important to them. The standardization process will begin with a few activities at a time. These few activities the superintendents identify will be the ones which workers will perform according to the frequency listed on the spreadsheet model. Currently each district decides what frequency is best for its district. Since these numbers are not identical it will be a difficult adjustment for maintenance personnel.

Ultimately, the current management of parks wishes to complete a privatization and redistricting study. This study would include several options ranging from totally privatizing the parks maintenance to reforming the districts based on different criteria to changing nothing. The standard will provide the base for contracting with private firms. It provides a point of cost comparison. The spreadsheet model contains all work information so few variables are left for redistricting comparisons. One of these variables would be transportation.

Further detailing of how to use this model for such purposes follows in Chapter 10.

Chapter 10 POTENTIAL USES OF SPREADSHEET STANDARDIZATION MODEL: IMPLICATIONS OF A MAINTENANCE MEASURE

Once administration has a maintenance measure available it can measure maintenance costs. It can use this measure to allocate budgets or resources. It now has a picture of the present against which to base decisions such as new equipment or new processes. In fact, the data analyst can put the time and frequency assumptions into the spreadsheet for new equipment or processes information. The spreadsheet measure of maintenance costs is a quick picture representation for scenarios.

Decentralizing the Budget

Once administration has decided the groupings of parks for managerial responsibility it can use the spreadsheet to figure people dollars needed by each of those groupings. That is, once administration divides managerial responsibility the model puts out personnel costs. The data analyst can obtain the inventory information for each of these park groupings from a database. The analysts need then only enter inventory information into the spreadsheet. The spreadsheet will then total maintenance personnel costs. If transportation and equipment costs are unavailable administration still has a ratio of one park grouping needed people dollars to the total needed people dollars to use as a guide for dividing the total budget.

Increasing the General Parks' Budget

Administration now has a total for personnel dollars needed to maintain its parks. It has a history of material and equipment costs. Parks can present these costs as justification for more funding. It can approach the shortfall of funds by presenting different appearance adjustment scenarios. It could sacrifice a park or facility or bring down the general appearance standard.

Regulate Growth of Park Maintenance Areas

A spreadsheet maintenance measure quickly measures cost for different scenarios. Administration could use it as an aid for planning actual project costs. Given a plan for inventory of a new facility or park area, the data analyst may enter the designed information getting a yearly maintenance cost which financial analysts could then incorporate into their cash flow analysis. Generally speaking, construction costs account for 15% of total project costs. Maintenance administrators often underestimate the actual cost of maintenance. See Appendix F.

Increase Superintendent Managerial Control

Superintendents now have average times to complete activities district wide. They have a better idea of what portion of the week they need to dedicate for a crew, such as shrub bed weeding. Thus they can schedule other activities for these crews. Superintendents also have expected average times and time accountability systems to look at worker efficiency. They have a way of tracking which workers may need more training.

The most managerial use for standards is to uphold them. A manager need only look at expected time for an activity and actual time. This will give the manager an idea of how on target that manager's workers and parks are. It is also a way of identifying areas that are hard to maintain and form alternative strategies to limit the amount of grief in these areas. Individual workers should come at least close to the standard after a several week total. If they do not, the manager has the responsibility to see these workers receive proper training.

Cost Benefit Analyses

Of particular interest to the maintenance workers in city organizations is adequate equipment. The spreadsheet model provides a quick evaluation of dollars saved using different equipment. The analyst can replace the new time for the new equipment and compare maintenance dollars saved. Financial analysts can then compare capital costs and performance and repair costs to evaluate the wisdom of purchasing new equipment. It could be the basis for calculating break-even points for equipment retirement. See appendix G.

Entering Privatization Studies

In the 1980's and 1990's cities have explored privatization of most aspects of operation. Parks are no exception. The maintenance measure provides an upper bound and conditions for a contract. This maintenance measure provides the listing and dollars for activity . Adding an appropriate percentage for equipment and materials will give maximum possible dollars for a private contract. The appearance standard provides a measure of accountability. Again a maximum payment would be the total of the line items subcontracted.

Subcontracting

Cities whose philosophy it is to maximize use of people resources could pursue contracts for routine tasks such a shrub bed weeding based on task performance. Thus the city could entice private agencies, who would appreciate the challenge, to complete those tasks.

Impact for Lower-level Supervisors

A maintenance measure exists as much for maintenance workers as for supervisors. Providing a measure can be an aid to planning for lower level supervisors. Some of the more interesting results of this measure are isolated circumstances. That is, a spreadsheet model of standard time per task details can aid supervisors in planning for isolated circumstances.

For example, look at the gardener. The gardener's responsibility includes planting flowers, usually within a given time frame, such as four weeks. The natural tendency of the gardener is to plant as much as possible as quickly as possible. Entering all work the gardener will need to accomplish into a spreadsheet as the frequency totals one can iterate appropriate weekly total flower beds to plant. The data analyst needs to enter the maintenance frequencies which apply to the given circumstance. Maintenance frequency time period and inventory time period must correspond. Thus for isolated conditions most of the frequencies will be zero as they do not apply to a specific instance such as a gardener planting flowers. The purpose for this example is to calculate inventory. This involves rerouting the cell containing inventory information to four new cells for each of the four weeks. The goal of iterating through each of these four weeks is to know the average square feet of flower beds the gardener would need to plant under those conditions. Enter the first week inventory information as a guess and increase or decrease this number until the bottom worker row totals to the appropriate number of workers. The variable

changes. Instead of fixing everything but total number of workers, fix total number of workers and let inventory vary.

The results for a gardener with three seasonal workers were to plant 23,000 square feet of beds the first week, 22,000 the second week, 13,000 the third week and 8,000 the fourth week. Note this indicates a paced approach with fewer flowers planted the second week than the first. This is due to the assumed circumstance that gardeners must weed flower beds within two weeks of planting.

Data analysts can perform similar analyses for other permanent workers such as plumbers. This spreadsheet measure is especially good for approximating averages within constraints such as time, number of workers, or inventory associated with work a worker needs to finish; it is a way to seek a reasonable estimate for one variable while fixing the others. See appendix C.

Adjusting to Budget Shortfalls or Surpluses

When difficult decisions arise as where to add or cut maintenance, a spreadsheet model provides immediate evaluation of alternatives. For instance, a parks' division may anticipate a 2% budget decrease. The data analyst can adjust frequencies within their bounds suggesting several options. The maintenance supervisors can then predict the resulting change in appearance. The next year can run smoothly avoiding last minute halt of operations due to underestimated expected return and needing to retrieve budget shortfalls.

Allocating Materials

One of the more mundane and yet useful aspects of the model is use of the skeletal information. Often resource managers seek certain products wherever available. They want the largest amount of resource they can get for a given amount of money. The chore then becomes dividing that resource equitably. With a spreadsheet model available one need only look at the use of that resource and divide it proportionately. For example,

suppose fertilizer is a luxury item. The resource manager buys as much as the budget will allow. The maintenance frequency schedule dictates administration wished to have 1/2 of the ballfields and 1/4 of bluegrass turf acres fertilized. The resource manager need give a district an amount of fertilizer in proportion to number of ballfields and bluegrass turf acres. That is, if the city parks must suffer from insufficient fertilization, all parks and all districts should suffer equally.

Chapter 11 SUGGESTIONS FOR FURTHER RESEARCH WITHIN THE ASSUMPTIONS OF THIS MODEL

Further Exploration into Impact of Heavy Use and High Maintenance

The use and maintenance information of this model is a beginning toward exploring a new horizon. It is not adequate as a conclusion about the effect of heavy use and high maintenance on park appearance and standard performance. The obvious way to obtain this information is with detailed time studies. Fix appearance; make appearance level of the parks constant. That is, the goal is equal appearance. It would be best to begin with an area in which there are no priority parks. Maintenance workers tend to judge themselves on citizen feedback, and citizen complaint tends to increase when citizens can easily compare a city park of higher manicure to their community park. A separate study might constitute establishing different levels of priority and monitoring citizen feedback, assuming citizens are the customer. This would help establish the effect of having priority parks.

Time Studies

Time analysts can gather extensive information while performing their study. Initial information could include a detailed description of inventory and equipment. Inclusion of this information allows for exploration of unexpected results. For instance, perhaps having a cab on a riding mower increases or decreases task performance time. Also included in the time study would be date, time of day, park, district, and worker. This gives the analyst the opportunity to explore several factors and develop some conclusions. Field workers perceive weeding and cultivating of flower beds to be an exponential type of distribution. It takes much longer to weed after the first planting and little time to weed once the weather becomes warm and dry and the flowers shade the ground. Winter flowers seem to demand very little weeding. Time studies would yield data against which to base this assumption. The analysts could estimate flower bed weeding distribution with

a higher degree of confidence. In my opinion mowing seems to have a symmetric Beta pattern throughout the day. Mowing in the morning is time consuming due to wet grass and longer in the afternoon due to increased number of park users. Operations' supervisors tend to schedule mowing to give as much slack as possible at the end of the week to prepare for weather or equipment breakdowns without regard to the distribution of mowing time. Perhaps there is a better way of taking advantage of the high point of the day and a more efficient method of scheduling that still permits weather disturbances. Also, the analysts would need to incorporate this distribution information when comparing means for a task performed at different use and maintenance level park areas.

Analysts could look at individual park information. They could regress certain factors. It appears that a regression of available resources (some combination of equipment and worker quality) against use and maintenance level would be helpful in predicting impact of heavy use and high maintenance on average time per task. Perhaps managers send their best workers and best machinery to the hardest parks. Thus the average time to perform a task at a high maintenance level park underestimates the effect of that park on consuming district resources.

There may be differences in average time per task due to temperature. The informal studies for this model indicated activities in July tend to be longer. Results from time studies could aid in scheduling or routing, knowing which subtleties are significant.

Relationships Between Variables

There are endless relationships to explore between the entries in the maintenance frequency schedule. A sensitivity analysis would be helpful. How far can one cut back on the frequency of weeding before the extra time to do an individual weeding exceeds the time to increase the frequency per year by one? Knowing the weeding distribution may prove helpful here. The same exploration would prove helpful for weeding shrub beds versus trim mowing. Diligently weeding shrub beds minimizes trim mowing. In fact, there may be no trim mowing depending on the edging and chemical weed treatment

patterns. The question would be what is the price of labor to pursue such a pattern. Where is the break-even point?

A spreadsheet model is very useful. The goal in establishing standards is to make maintenance more efficient and effective. Consequently, workers would feel greater pride and power in their work and accomplishments. The danger of establishing standards is to create a new branch of staff needed to keep information current and accurate without operating workers receiving benefit. Inventory information currently needed is voluminous. It involves analysts identifying what maintenance work is done to what inventory and further categorizing those inventory times by detail. This is because some activities, such as sweeping cement or asphalt walkways, take a different time per unit to complete based on material composing that inventory item.

A useful but basic study would involve gathering information from cities who have completed accurate inventories for their parkland and facilities and regressing different inventory items against each other. In this study for the city and county of Denver the analyst used maintained acres as a base for estimating number of square feet of deciduous and evergreen shrubs. She also used maintained acres to estimated linear feet of curbline in isolated instances. The shrub and maintained acres figures available correlated with a coefficient of determination between 20 and 40%. This is a relationship hardly worth using, but the only possibility in this case. Trash barrel equivalents resulted in a similar relationship. Trash barrel equivalents, however, may be an indicator of use as much as size of park. Linear feet of cement walkways correlated with maintained acres yielded a coefficient of determination of nearly 99%. If there exists other inventory items that consistently correlate or are directly related to the size of the park, administration could drop those inventory items from the list of updated inventory each year. The spreadsheet could simply estimate those items through a cell reference. Again, as with heavy use and high maintenance information, one needs to be careful that district peculiarities do not exist, or meticulously detail the exceptions. For example, one district in the city and county of Denver consists largely of medians which do not have walkways. Due to the city and county of Denver parks' division timeline for compiling inventory information,

information from this district was not available at the time of evaluation of correlation between walkways and acreage.

Chapter 12 SUGGESTIONS FOR STANDARDIZATION OF PARKS

Why Divide Park Responsibilities into Districts?

The parks administration needs to answer several questions before it pursues time studies. For cities who district, it becomes apparent there must be a reason. It is important for maintenance managers to explore that reason. Often parks' divisions district according to planning criteria such as demographics and natural land forms. These criteria usually have little to do with maintenance demands. Maintenance administration needs to explore possible district options. As mentioned earlier, a district criterion could be transportation. As with simulation models of resource allocation this could either be to minimize total transportation or to divide districts such that transportation is equitable. This latter method would eliminate the need for transportation concessions in the spreadsheet model.

Other options for districting include function. Traditionally cities operated in the caretaker mode so that equipment needed for a park was at that park. Cities then began to district as a means of dividing or consolidating management responsibility. When routing became vogue, cities often did not look at their districting patterns and simply routed within previous district boundaries. Another option would be to district by function. Cities could have one 'district' or one area of managerial responsibility as medians, one as local parks, and one as regional areas. Another view would be to divide responsibility according to facility or equipment. Thus there would be a rototilling crew which would traverse the whole city rototilling playgrounds and volleyball courts. Again administration needs to decide what it wishes to minimize and data analysts need to incorporate total costs to get accurate alternative pictures.

Operating Style

Parks administration also needs to decide upon a style of operation. The most obvious of those styles is routing versus caretaking. Most cities operate using some combination of the two. A city needs to identify why it uses caretakers if the primary mode is routing and visa versa. A mixture of styles presents a more complicated plan.

For instance, the city and county of Denver uses caretakers in parks with quick coupler sprinkler systems. This implies that those workers will perform other tasks between changing heads, such as pruning tree suckers or cultivating trees.

Equipment

Good equipment is vital. It is important for administration to designate appropriate equipment. Analysts constantly evaluate make and model of equipment. Also needed is evaluation for appropriate type of equipment. Cities on a slow development plan may need a weed mower, but developed cities may no longer have this need. Medians often demand a push mower and larger push mowers may pay off for this task.

Another useful tidbit of policy is the purpose of equipment. What are the criteria for determining which district receives which equipment? For example, what is the purpose of a pick-up? Is transportation of workers a valid argument for needing this piece of equipment?

Planning Horizon

Setting standards is directly related to the realistic planning horizon. For example, recent trends in planning medians include planting dense shrub beds so as to minimize weed pulling and mowing. If the budget does not provide for plant material replacement, however, the intent of this plan is lost. Medians inevitably suffer plant loss due to abuse, vandalism, or natural causes. Once the plant is gone it exposes bare earth and weeds begin to flourish. Either the appearance will suffer or workers will need to spend more and more frequent time pulling weeds. An area planned as low maintenance becomes high maintenance due to lack of foresight in planning.

CONCLUSION

Citizens wish to see their dollars wisely invested into city infrastructure. Labor forces wish to minimize the inevitable crunch between budget and political limitations and citizen demands. Creating a maintenance standard provides a way to measure citizen expectations and budget realities.

The model presented in this thesis represents the revolutionary change for the city and county of Denver. Several political battles having been fought with best guesses and approximations in the past, will be fought using actual expect impact. Administration will use the model to evaluate different scenarios.

The model this paper presents is a collection of data into a total maintenance measure. It represents a fuzzy yet quantitative picture of Denver parks which will come into focus as Denver implements and perfects its standard. The maintenance dollars needed to balance heavy use and high maintenance areas remains a question although the results of this study show these costs to be relatively small. This analyst intends the model to measure average need for the district and not to dictate need for each individual park. The measure is to aid management, not to replace it. The accountability for the performance standard lies in an appearance rating.

Uses for a maintenance measure include administrative, managerial, and supervisory perspectives. Administration has a measure to guide budget, perishable resource, and personnel allocation. It also has a measure to regulate work flow through helping to regulate growth of parkland area and privatization or subcontracting options. Management has a guide to its effectiveness and an aid in scheduling. Lower level supervisors also have a guide for short term scheduling.

Further studies can increase accuracy of a spreadsheet model. Those factors which may not be randomly distributed such as heavy use or high maintenance need further specification. Time per task information is a continually growing and changing pool of

data. The spreadsheet can detail any relationships between maintenance frequency or inventory items.

Cities planning to implement standards need to evaluate their current organization and operation schemes. Included in this evaluation are purposes for districting or not districting and routing, caretaking or other operational formats. Once administration is satisfied with the current mode of operations it can have analysts quantify that information and compile it into a spreadsheet. Once information is accessible in a spreadsheet technicians can explore scenarios and sensitivities.

The spreadsheet model defined in this thesis has already had preliminary utilization by B.J. Brooks, deputy manager of the parks' division of the city and county of Denver. The potential further uses have been documented above. It is anticipated that this model will receive further utilization by the parks' division in the next annual budgetary processes for this municipality.

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Appendix A

INFORMAL TIME STUDY INFORMATION

INFORMAL TIME STUDY INFORMATION

This is a summary of information attained while working with and observing maintenance operations in the city and county of Denver Parks and Recreation Department during the summer of 1992. The time is morning (m) or afternoon (a) or both (b). The date is month and day. The use and maintenance are the estimated use and maintenance levels of the park area by maintenance administration. The inventory is an abbreviation of inventory item which was the subject of the maintenance task. The activity is what the worker did to the item. The park is the park location and time/unit is the length of time per inventory unit. required to complete that task.

Time	Date	Use	Main	Inventory	Activity	Park	Time
m	625	1	1	Amph	Sweep	Confl	.5000
m	625	1	1	Step	Sweep	Confl	.0167
a	628	3	1	Macres	Pick-up	Sl Lake	.1080
a	630	3	1	Macres	" "	Skyline	.1340
a	630	2	2	Macres	" "	Martinez	.0467
m	705	3	1	Amph	Power scr	Civic C	.1633
m	705	3	1	Fl bed	Edge	Civic C	.0008
m	705	3	1	Macres	Pick-up	MacInt	.6410
a	707	2	3	Fl bed	Cultivate	Ruby H	.0053
m	707	3	1	Str trim	Wall & fen	Civic C	.0007
a	708	2	3	Turf	7-gang mo	Ruby H	.5533
a	709	2	3	Turf	Ride mow	" "	2.1000
b	612	3	2	shrub,tree	trim mow	City	.5000
b	602	1	3	Curbline	Spr irr m	Monoco	1.0000(ac)
a	527	1	1	Fl bed	Plant	Sunken	.0068
m	616	3	1	Fl bed	Cult & Fert	Wash P	.0015
a	616	3	1	Fl bed	Weed	" "	.0100
m	618	1	2	Turf	Ride mow	Bezoff	.3000
m	715	1	1	Turf	7-gang mo	Hallack	.1666
m	715	1	1	Turf	" "	" "	.1882
m	715	1	1	" "	" "	51st & Z.	1460
m	715	1	1	" "	" "	" "	.1162
m	715	2	1	" "	Ride mow	Columbus	1.6970
m	715	2	1	Turf	" "	Rocky Mtn	.4518
m	715	2	1	" "	" "	" "	.6974
m	715	2	1	" "	Trim mow	" "	.9900
m	715	1	2	RR	Clean	Chaffee	.1333
a	716	1	2	Turf	Ride mow	Bromwell	.7250
a	716	1	2	Sculpture	Paint	Univ Isl	.0011

a	716	1	2	" "	" "	" "	.0028
a	716	3	1	Turf	Ride mow	Cheesman	2.0000

Time	Date	Use	Main	Inventory	Activity	Park	Time
m	720	3	2	Macres	Pick-up	City	.2581
m	720	3	2	Macres	" "	" "	.1383
a	721	1	2	Fl bed	Weed	Yosemite	.0019
a	721	1	2	Fl bed	Sweep	" "	.0025
a	721	1	2	Turf	Trim mow	Hamp H g	1.0580
a	721	1	2	Vand ac	Remove tr	Babi Yar	1.0500
a	722	3	1	Turf	Trim mow	Wash P	.3443
a	722	3	1	" "	Ride mow	Wash P	.7716
a	722	3	1	Fl bed	Hoe	" "	.0009
a	722	3	1	Turf	7-gang mo	" "	.1046
a	722	3	1	Turf	Trim mow	Wash P	.5356
m	728	1	2	Fl bed	Pull pans	Forest	.0040
m	728	1	2	" "	Weed & cul"	"	.0040
m	728	1	2	Turf	Ride mow	" "	.6273
m	728	1	2	" "	Trim mow	" "	1.3310
m	728	1	2	" "	" "	" "	1.5730
a	728	9	9	9	Sharpen hoMC		.0111
a	728	1	2	Schrub	Weed	Alameda	.0008
m	730	1	2	Undev	Weed mowUnion & G		.2949
m	730	1	2	Playgr	Rototill	" "	1.0000
m	730	2	2	Irracre	Replace h	Bear cr.	2500/hd
a	730	1	3	Turf	7-gang mo	Havard G	.1018
a	730	1	3	Turf	Ride mow	" "	.3700
a	730	1	2	Macres	Pick-up	Union & G	.0694
a	730	1	2	Macres	" "	Garland & S	.0732
m	610	3	1	" "	Reg pump	" "	.7500
m	604	1	2	Irracres	Check	Alameda	.2000/sec
m	720	3	2	Turf	7-gang mo	City	.1184
m	720	2	1	Macres	Pick-up	25th & CA	.5000
m	720	2	1	Turf	Ride mow	" "	1.5000
m	720	2	1	Irracres	Check	28th & CA.	6600/ac
m	720	2	1	Macres	Pick-up	28th & CA	1.0000
m	720	2	1	Turf	Ride mow	" "	.8333
m	720	2	2	Turf	7-gang mo	Curtis.	3548
m	720	2	2	Turf	Ride mow	" "	.3815
m	720	3	2	QC acres	Insert hd	City	.6230
a	720	3	2	Turf	7-gang	City	.1014
a	720	3	2	Turf	Ride mow	City	.2880
a	720	3	2	Turf	Trim mow	City	4.6420
a	720	3	2	Turf	Ride mow	City	.5376
a	720	3	2	RR	Check	City	.1111

Appendix B

TIME ESTIMATES FROM FIELD MANAGEMENT AND WORKERS

TIME ESTIMATES FROM FIELD MANAGEMENT AND WORKERS

This table depicts times from the heads of superintendents and other permanent maintenance workers. The district is an abbreviation for Denver park districts. The 'use' and 'maint' values are use and maintenance levels. A use or maintenance level of '9' indicates that use or maintenance did not apply for that activity. The inventory is the item to which the activity is done. The activity is the activity the maintenance workers would perform. The park is the park and the time is the time per unit. Park entries of 'dist' imply that time applied to the whole district.

Dist	Use	Maint	Inventory	Activity	Park	Time
E	2	2	Macres	Pick-up	Curtis	.4301
MC	1	2	Clocks	Turn off	MC	2.0000
MC	1	2	QC acres	QC water	Crest	.4534
E	3	2	Amph	Power Sc	Civic C	6.0000
E	2	2	Barberry	Trim	Police S	.0068/sqft
W	2	3	Turf	7-gang mo	Ruby H	.4133
W	2	3	Fl beds	Edge	Ruby H	.0027
W	2	3	Snaps	Deadhead	" "	.0002
W	2	3	Flbd clocks	Check	" "	2.0000
C	2	2	Turf	7-gang mo	Congress	.2000
C	1	2	" "	" "	7th Prkw	1.0360
C	1	2	" "	Rotary	" "	1.3813
C	2	2	Curb & Side	Edge	Park Ave	2.5000
C	2	2	Dist off	Repair hd	" "	15 hrs
C	1	1	Turf	Ride mow	Brest & CO	1.0390
C	1	2	" "	" "	Cherry, Ala	1.9394
C	1	2	" "	Rotary	" "	1.9394
C	3	2	" "	Ride mow	Broadway	.8332
C	1	2	" "	" "	Gr-Humph	.2500
C	2	2	" "	" "	Dist Att	.2500
C	1	2	" "	" "	Auraria	1.6393
E	3	2	RR	Clean	City	.2500
E	3	2	Shoreline	Spr maint	City	16.6667
E	3	2	Amph	Power Sc	Civic C	12.0000
S	3	2	Pavilion	Relamp	Wash P	12.0000
S	3	2	Playgr-H	Sweep Ch	" "	2.0000
S	3	2	" "	Wood prese	" "	90.0000
SE	2	2	Turf	7-gang mo	Princet	3.3333
SW	9	9	" "	" "	Dist	.3319
SW	9	9	Irr	Repair &	Dist	.4267

MB	9	9	Nursery	setup/tear Nurs	30.0000
MB	9	9	" "	Plant tree " "	.2500

Dist	Use	Maint	Inventory	Activity	Park	Time
MC	9	9	Clocks	Turn off	Dist	9.0000
NW	3	2	Turf	7-gang mo	Sl Lake	.3000
NW	1	1	" "	" "	Hallack	.2700
NW	2	2	" "	Ride mow	Insp Pr	.2056
NW	2	1	Macres	Pick-up	Rocky Mtn	.0470
NW	2	1	Turf	Ride mow	" "	.1750
NW	2	1	Turf	" "	Berkeley	.2877
NW	2	1	Macres	Pick-up	Chaffee	.3333
NW	3	2	Macres	" "	Sloan(mon)	.2107
C	1	2	Sculpture	Paint	Univ Isl	.0107
SE	9	9	Fl beds	Deadhead	Dist	1/3 weed
SW	9	9	Playgr	Weed	dist	30.0000
SW	3	2	Spr sys	Check	Bear cr.	.2632
SW	1	3	Turf	HP mow	Harvey	.3371
SW	1	3	Turf	HP mow	Harv Gul	.6060
SW	1	2	" "	" "	Bear Val	.3571
SW	1	1	" "	" "	Bates & Ho	.6250
SW	9	9	Irracres	Turn off dr	Dist	60.0000

Appendix C

RESULTS FOR SUPERVISOR SCENARIOS

GARDENER/FLORIST

IMPACT FOR LOWER LEVEL SUPERVISORS

The spreadsheet information is available for supervisors to aid them in planning various tasks. The spreadsheet does well in time-constrained situations. A common situation for parks' division is flower planting. There is usually one day when flowers become available for planting and one day when city administration would like to see all the beds planted. Often times this planning horizon is limited. The examples of instructions for the gardener/florist and maintenance technician follow:

The standards are available to you should you wish to use them . If you would like some assistance in planning crews and time estimates the standards could be of use. State the problem and Deputy Manager Brooks' office can assist you in finding average times to do tasks.

For example, I am a gardener. My operations supervisor has granted me the help of three seasonal workers to plant flowers. My flower beds need to be weeded and cultivated within two weeks of planting. I need to fertilize all beds within three weeks of planting. All beds need to be watered three times per week after planting. After transportation time to the green house and parks I anticipate six hour a day to plant and week. How many beds can I plant each of four weeks?

The results from using the spreadsheet model for Denver standards are as follows:

Week	Square feet of flowers to plant
1	23,000
2	22,000
3	13,000
4	8,000
Total	66,000

If your operations supervisor expects you to plant much more than 66,000 square feet you need to talk to him about getting more help.

The data analyst needs to enter the maintenance frequencies which apply to the given circumstance. Thus for isolated conditions most of the frequencies will be zero as they do not apply to a specific instance such as a gardener planting flowers. The purpose for this example is to calculate inventory. This involves rerouting the cell containing inventory information to four new cells for each of the four weeks. The goal of iterating through each of these four weeks is to know the average square feet of flower beds the gardener would need to plant under those conditions. Enter the first week inventory information as a guess and increase or decrease this number until the bottom worker row totals to the appropriate number of workers. The variable changes. Instead of fixing everything but total number of workers, fix total number of workers and let inventory vary.

Another situation may be that the gardeners have 52,000 square feet of flowers that they must get planted within four weeks. They need to weed and cultivate within two weeks of planting and needs to water three times per week and fertilize within three weeks of planting. How much help do they need?

According to the spreadsheet model for maintenance standards for Denver one gardener needs two helpers with the planting schedule:

Week	Square feet of flowers
1	18,000
2	5,000
3	15,000
4	14,000
Total	52,000

The spreadsheet details of the situation are as follows. The analyst assigns the activities the gardener plans to do with the weekly frequency. The analyst would use weekly frequency as opposed to total frequency as the desired information is weekly

totals. The analyst sets all impertinent activity frequencies to zero. The pertinent secion of the maintenance frequency schedule and the total workers and square footage of flower beds to be planted follow. Note that the model abbreviates worker types as follows:

Gardener/florist = Gardener
Maintenance Technician = MainT
Equipment Operator = Equip O
Utility Worker = Utility W
Seasonal Laborer = Seasonal

Activity	Park Priority Type	Number of times	Time (hrs)/unit (sqr ft)
flower beds-plant	community	1	0.0050
	urban	1	0.0050
flower beds-till cultivate	community	1	0.0008
	urban	1	0.0008
flower beds-edge & realign	community	0	0.0024
	urban	0	0.0024
flower beds- weed	community	1	0.0010
	urban	1	0.0010
flower beds water	community	3	0.0001
	urban	3	0.0001
flower beds- fertilize	community	1	0.0010
	urban	1	0.0010
flower beds insect and disease control	community	0	0.0007
	urban	0	0.0007
flower beds- remove dead flowers	community	0	0.0066
	urban	0	0.0066

Gardener	MainT	Equip O	Utility W	Seasonal
0.9601	0.0000	0.0000	0.0493	1.9798

week #	# Sqr Ft.
w1	18000
w2	5000
w3	15000
w4	14000
total	52000

Iterating to as close to one gardener as possible yields the result of one gardener and two seasonals.

Activity	Park Priority Type	Number of times	(hrs)/unit (sqr ft)
flower beds-plant	community	1	0.0050
	urban	1	0.0050
flower beds-till cultivate	community	1	0.0008
	urban	1	0.0008
flower beds-edge & realign	community	0	0.0024
	urban	0	0.0024
flower beds- weed	community	1	0.0010
	urban	1	0.0010
flower beds water	community	3	0.0001
	urban	3	0.0001
flower beds- fertilize	community	1	0.0010
	urban	1	0.0010
flower beds insect and	community	0	0.0007
	urban	0	0.0007
flower beds- remove dead	community	0	0.0066
	urban	0	0.0066

Gardener	MainT	Equip O	Utility W	Seasonal	Week #	# Sqr Ft.
					w1	23000
					w2	22000
					w3	13000
1.3181	0.0000	0.0000	0.0964	2.6821	w4	8000
					total	66000

Iterating as close as possible to three workers yielded the inventory result of 66,000 square feet of flower beds to be planted.

MAINTENANCE TECHNICIAN

The maintenance standards exist to aid you in planning. If you are curious as to the average time to do some activity, state the problem and ask Deputy Manager Brooks' office to run numbers on the spreadsheet.

For example, I am a maintenance technician. I need to quickly finish Spring maintenance on the parkway for a parade. I am also responsible to see that the parkway is manually watered three time per week. This is five miles of irrigation. How much help do I need? I expect to have seven hours to work on site after discounting transportation time.

The results from the spreadsheet model for maintenance standards for Denver parks predicts you need three assistants with an extra half-time person who is experienced or has expertise in plumbing.

Appendix D

Testing of Means for Mowing time and Trash pick-up

Testing of Means for Mowing time and Trash pick-up

This test was performed on the Minitab software package. The null hypothesis of the test was that the means of all levels of use and all levels of maintenance were the same. The alternative hypothesis would be that at least one of the mean times was different. The package computed 95% confidence intervals for the means to illustrate the overlap. Thus the analysis of variance follows:

ANALYSIS OF VARIANCE ON C27

SOURCE	DF	SS	MS	F	p
C22	2	0.16998	0.08499	23.91	0.001
ERROR	7	0.02489	0.00356		
TOTAL	9	0.19486			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	---------+---------+---------+-------
1	5	0.14376	0.03543	(----*---)
2	2	0.45405	0.14036	(-----*------)
3	3	0.10813	0.00903	(----*-----)

---------+---------+---------+-------

POOLED STDEV = 0.05963 0.15 0.30 0.45

Note that there appears to be a difference in use level 2 park areas for 7-gang mowing as the level of significance is 0.05 and the p-value is .001.

Bonferroni simultaneous 95% confidence intervals (based on a t-statistic of .9916 with n-3 degrees of freedom:

Use level:	Interval:
1	(.03290, .25462)
2	(.01486, .89324)
3	(.07868, .13519)

ANALYSIS OF VARIANCE ON C27

SOURCE	DF	SS	MS	F	p
C23	2	0.0480	0.0240	1.14	0.372
ERROR	7	0.1468	0.0210		
TOTAL	9	0.1949			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	-+---------+---------+---------+-----
1	5	0.1443	0.0346	(---------*---------)
2	3	0.1915	0.1416	(-----------*----------)
3	2	0.3276	0.3193	(--------------*---------------)
				-+---------+---------+---------+-----
POOLED STDEV =		0.1448		0.00 0.16 0.32 0.48

Note there appears to be no difference for the average time to mow a bluegrass acre with a 7-gang tractor because the level of significance is 0.05 and the p-value is .372.

Bonferroni simultaneous 95% confidence intervals (based on a t-statistic of.9916 with n-3 degrees of freedom:

Maintenance level	Interval
1	(.03606, .25258)
2	(.00000, .63340)
3	(.00000, 1.32664)

ANALYSIS OF VARIANCE ON C37

SOURCE	DF	SS	MS	F	p
C32	2	0.172	0.086	0.20	0.825
ERROR	12	5.255	0.438		
TOTAL	14	5.427			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	---------+---------+---------+-------
1	5	0.7440	0.5614	(------------*------------)
2	6	0.9940	0.6726	(-----------*-----------)
3	4	0.8993	0.7599	(-------------*-------------)
				---------+---------+---------+-------
POOLED STDEV =		0.6618		0.50 1.00 1.50

There is no difference due to use for the average time to mow a bluegrass acre with a riding mower because the p-value is large.

Bonferroni simultaneous 95% confidence intervals (based on a t-statistic of .9916 with n-3 degrees of freedom:

Use level:	Interval:
1	(.00000, 2.20476)
2	(.00000, 2.74410)
3	(.00000, 2.87656)

ANALYSIS OF VARIANCE ON C37

SOURCE	DF	SS	MS	F	p
C33	2	0.777	0.388	1.00	0.396
ERROR	12	4.650	0.387		
TOTAL	14	5.427			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	--------+---------+---------+--------
1	6	1.0424	0.5850	(--------*---------)
2	7	0.6510	0.4903	(--------*-------)
3	2	1.2350	1.2233	(---------------*---------------)
				--------+---------+---------+--------
POOLED STDEV =		0.6225		0.60 1.20 1.80

There is no significance between different maintenance level park areas for average time to ride mow because the level of significance is 0.05 and the p-value is large.

Bonferroni simultaneous 95% confidence intervals (based on a t-statistic of .9916 with n-3 degrees of freedom:

Maintenance level	Interval
1	(.00000, 2.56452)
2	(.00000, 1.92677)
3	(.00000, 4.41724)

ANALYSIS OF VARIANCE ON C57

SOURCE	DF	SS	MS	F	p
C52	2	0.244	0.122	0.46	0.646
ERROR	9	2.391	0.266		
TOTAL	11	2.635			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	---+---------+---------+---------+---
1	2	0.0713	0.0027	(----------*----------)
2	3	0.5156	0.4768	(----------*----------)
3	7	0.3859	0.5681	(------*-------)
				---+---------+---------+---------+---
POOLED STDEV =		0.5154		-0.60 0.00 0.60 1.20

There is no significant difference for the average time to pick-up trash because the level of significance is 0.05 and the p-value is large.

Bonferroni simultaneous 95% confidence intervals (based on t-statistic .9916 with n-3 degrees of freedom:

Use level:	Interval:
1	(.061669, .08093)
2	(.00000, 2.21631)
3	(.00000, 2.39511)

ANALYSIS OF VARIANCE ON C57

SOURCE	DF	SS	MS	F	p
C53	1	0.855	0.855	4.80	0.053
ERROR	10	1.780	0.178		
TOTAL	11	2.635			

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

LEVEL	N	MEAN	STDEV	------+---------+---------+---------+
1	5	0.6817	0.6583	(---------*---------)
2	7	0.1403	0.0876	(--------*-------)
				------+---------+---------+---------+
POOLED STDEV =		0.4219		0.00 0.40 0.80 1.20

There is no significant difference for time to pick up trash based on maintenance level although the p-value is very close to the level of significance, 0.05.

Bonferroni simultaneous 95% confidence intervals (based on t-statistic .9875 with n-3 degrees of freedom:

Maintenance level	Interval
1	(.00000, 2.976157)
2	(.00000, .44882)

Analysis of Variance for 7-gang mowing using a general linear model:

Factor	Levels	Values
use1	3	1 2 3
maint1	3	1 2 3

Analysis of Variance for time1

Source	DF	Seq SS	Adj SS	Adj MS	F	P
use1	2	0.169979	0.130058	0.065029	19.37	0.004
maint1	2	0.008097	0.008097	0.004048	1.21	0.374
Error	5	0.016790	0.016790	0.003358		
Total	9	0.194865				

Note there appears to be some difference in mean time to 7-gang mow an acre of bluegrass as the P-value is small and the level of significance is 0.05. There is no significant difference due to maintenance level as the P-value is large.

Unusual Observations for time1

Obs.	time1	Fit	Stdev. Fit	Residual	St.Resid
1	0.553300	0.499353	0.051488	0.053947	2.03R
6	0.104600	0.158547	0.051488	-0.053947	-2.03R
7	0.101800	0.155747	0.051488	-0.053947	-2.03R
9	0.354800	0.408747	0.051488	-0.053947	-2.03R

R denotes an obs. with a large st. resid.

Analysis of variance for ride mowing using the general linear model:

Factor	Levels	Values
use2	3	1 2 3
maint2	3	1 2 3

Analysis of Variance for time2

Source	DF	Seq SS	Adj SS	Adj MS	F	P
use2	2	0.1715	0.0166	0.0083	0.02	0.982
maint2	2	0.6219	0.6219	0.3110	0.67	0.533
Error	10	4.6332	4.6332	0.4633		
Total	14	5.4266				

Note the P-values for use and maintenance levels are large indicating that the mean time to ride mow an acre of bluegrass remains the same despite use or maintenance level..

Unusual Observations for time2

Obs.	time2	Fit	Stdev.Fit	Residual	St.Resid
1	2.10000	1.24418	0.54605	0.85582	2.11R
10	0.37000	1.22582	0.54605	-0.85582	-2.11R

R denotes an obs. with a large st. resid.

Analysis of variance for picking up trash using the general linear model.

Factor	Levels	Values
use4	3	1 2 3
maint4	2	1 2

Analysis of Variance for time4

Source	DF	Seq SS	Adj SS	Adj MS	F	P
use4	2	0.2436	0.0134	0.0067	0.03	0.970
maint4	1	0.6249	0.6249	0.6249	2.83	0.131
Error	8	1.7663	1.7663	0.2208		
Total	11	2.6348				

The P-values for use and maintenance are larger than 0.05, the level of significance indicating, the average time to pick up trash per maintained acre does not vary according to use or maintenance level.

Unusual Observations for time4

Obs.	time4	Fit	Stdev.Fit	Residual	St.Resid
4	1.66670	0.67868	0.24863	0.98802	2.48R

R denotes an obs. with a large st. resid.

Appendix E

Results of Regressing Against Maintained Acres

Results of Regressing Against Maintained Acres

The following tests were performed using the Minitab software package. The purpose of doing the regression was to determine how accurate estimates against maintained acres were for inventory purposes. The regressions follow:

Evergreen shrub square feet vs. maintained acres:
The regression equation is
eversh = - 299 + 408 macres

Predictor	Coef	Stdev	t-ratio	p
Constant	-299.1	526.9	-0.57	0.591
macres	408.0	190.3	2.14	0.076

s = 938.9 R-sq = 43.4% R-sq(adj) = 33.9%

Analysis of Variance

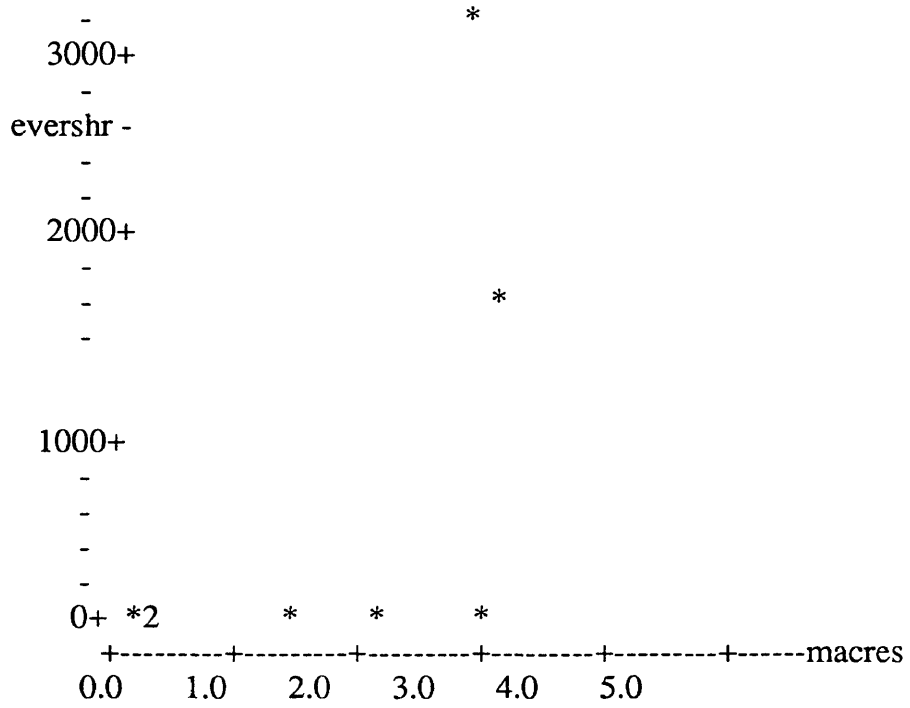
SOURCE	DF	SS	MS	F	p
Regression	1	4052166	4052166	4.60	0.076
Error	6	5289631	881605		
Total	7	9341797			

Unusual Observations

Obs.	macres	eversh	Fit	Stdev.Fit	Residual	St.Resid
4	4.20	3125	1415	512	1710	2.17R

R denotes an obs. with a large st. resid.

Maintained acres vs. Evergreen Shrub Square Feet



Thus, according to the linear fit, average square feet of evergreen shrub per maintained acres is not a good estimator. The coefficient of determination is only 43%, indicating no correlation for fixed quantities such as maintained acres and shrub beds.

Deciduous shrub square feet vs. maintained acres:
The regression equation is
decshr = 152 - 17.4 acres

Predictor	Coef	Stdev	t-ratio	p
Constant	152.3	137.1	1.11	0.303
acres	-17.35	41.24	-0.42	0.687

s = 217.3 R-sq = 2.5% R-sq(adj) = 0.0%

Analysis of Variance

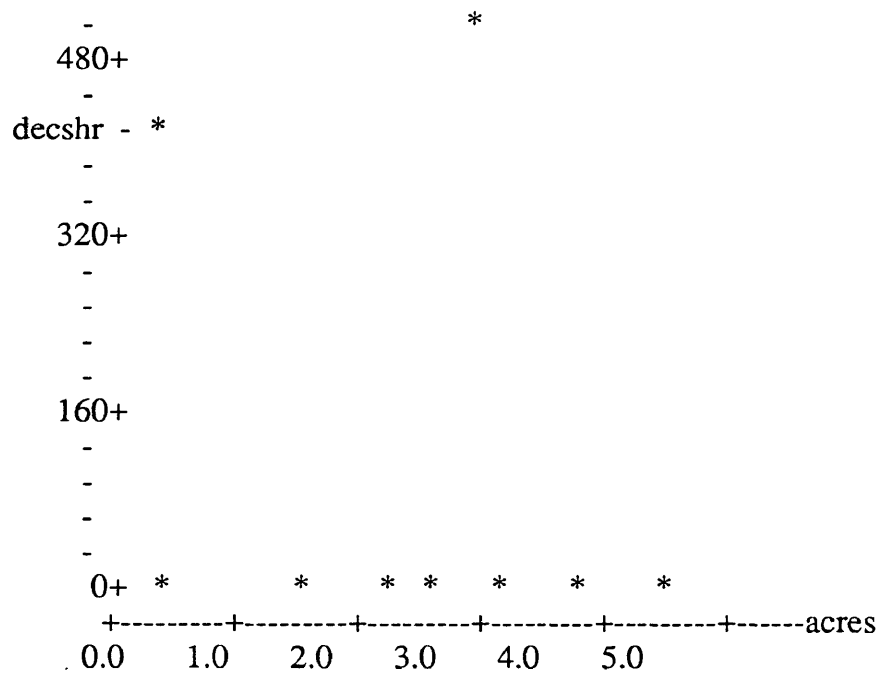
SOURCE	DF	SS	MS	F	p
Regression	1	8359	8359	0.18	0.687
Error	7	330441	47206		
Total	8	338800			

Unusual Observations

Obs.	acres	decshr	Fit	Stdev.Fit	Residual	St.Resid
5	4.20	500.0	79.4	92.1	420.6	2.14R

R denotes an obs. with a large st. resid.

Maintained Acres vs. Deciduous Shrub Square Footage



According to the linear fit average square feet of deciduous shrubs per maintained acre is an irrelevent estimator of deciduous shrubs. The available data is limited, however. As evidenced by the graph, too few areas with deciduous shrubs were actually witnessed. Most of the observations are from park areas with no deciduous shrubs.

Curbline in linear feet vs. maintained acres:
The regression equation is
curb = 235 + 326 macres2

Predictor	Coef	Stdev	t-ratio	p
Constant	234.9	210.6	1.12	0.283
macres2	326.25	61.63	5.29	0.000

s = 529.8 R-sq = 66.7% R-sq(adj) = 64.3%

Analysis of Variance

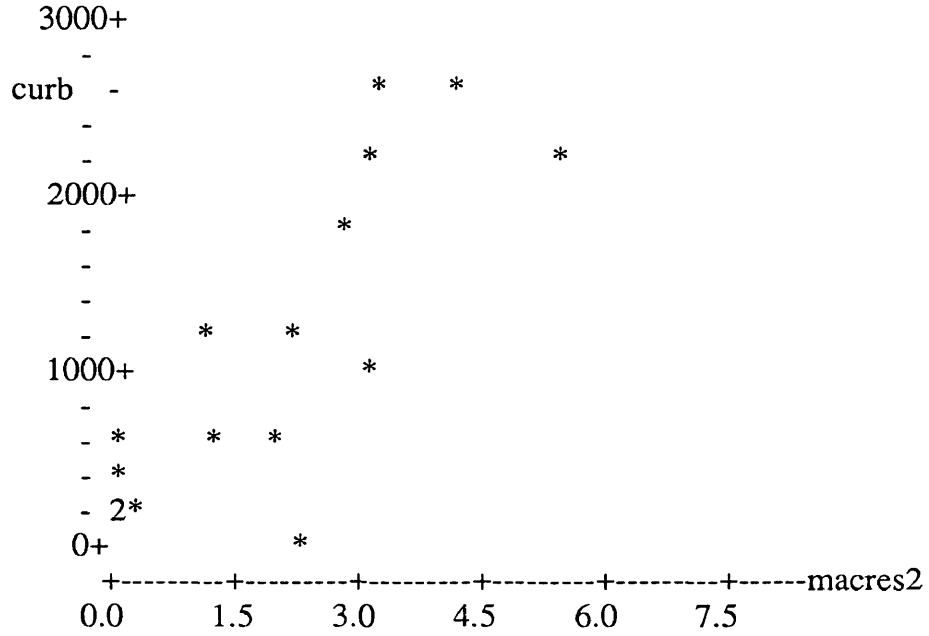
SOURCE	DF	SS	MS	F	p
Regression	1	7865781	7865781	28.02	0.000
Error	14	3929477	280677		
Total	15	11795258			

Unusual Observations

Obs.	macres2	curb	Fit	Stdev.Fit	Residual	St.Resid
5	7.70	2250	2747	338	-497	-1.22 X
6	3.00	0	1214	134	-1214	-2.37R

R denotes an obs. with a large st. resid.
X denotes an obs. whose X value gives it large influence.

Maintained acres vs. curbline



The available information indicates that average linear feet of curb per maintained acre is a precarious yet acceptable way to estimate linear feet or miles of curbline. The coefficient of determination, 66%, indicates a correlation between curbline and maintained acres. This is a precarious relationship because for something as fixed as shrub square footage and maintained acres one would look for coefficients of determination closer to 80 or 90 %.

Linear feet of sidewalk vs. maintained acres:
The regression equation is
WALK = 734 + 203 ACRES

Predictor	Coef	Stdev	t-ratio	p
Constant	734.2	343.7	2.14	0.061
C8	203.476	4.235	48.05	0.000

s = 1076 R-sq = 99.6% R-sq(adj) = 99.6%

Analysis of Variance

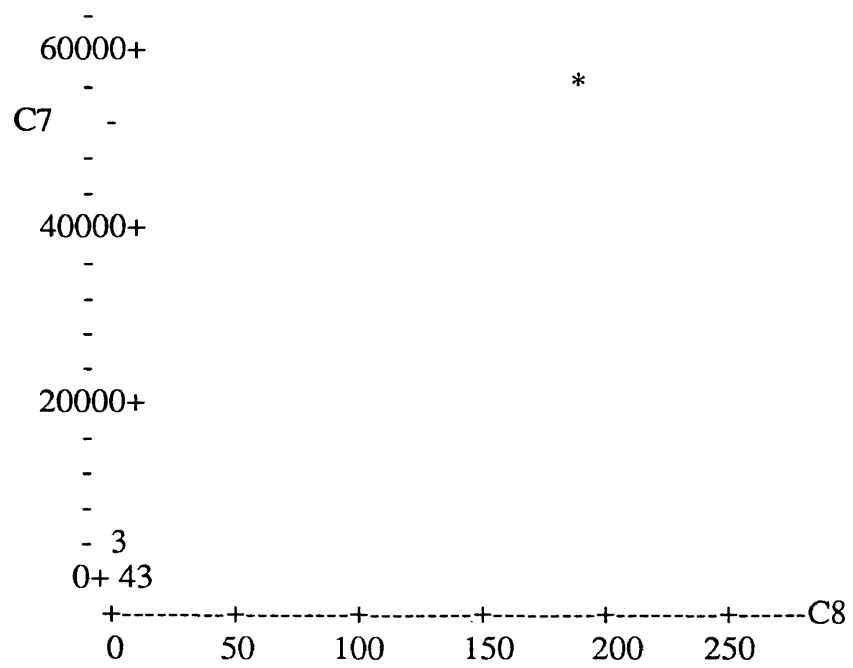
SOURCE	DF	SS	MS	F	p
Regression	1	2674748160	2674748160	2308.51	0.000
Error	9	10427807	1158645		
Total	10	2685176064			

Unusual Observations

Obs.	C8	C7	Fit	Stdev.Fit	Residual	St.Resid
11	269	55440	55469	1076	-29	-1.27 X

X denotes an obs. whose X value gives it large influence.

Maintained acres vs. Linear Feet of Sidewalk



From available data average feet of sidewalk per maintained acre is an excellent estimator for linear feet of sidewalk. The coefficient of determination, 99%, is a very high. Under ordinary circumstances one would be very comfortable with this correlation. Note that this is available information. Information from districts with medians as a large percent of parkland was not available.

Appendix F

Regulating Park Growth

REGULATE GROWTH OF PARK MAINTENANCE AREAS

Managers can use this spreadsheet as a guide to predict yearly maintenance costs for new park areas. The architects would give the inventory information to the maintenance analyst who would then enter that information into the spreadsheet. The managers of maintenance then have a yearly maintenance cost to enter into a discounted cash flow analysis. If the resulting discounted cash flow analysis was too high the planners would need to reduce construction costs or change the plan so as to plan for lower maintenance. For example, a picturesque sidewalk ambling through the woods may be an obstructed sidewalk, i.e. it must be hand shoveled, so one option for the planners to reduce cost would be to design a sidewalk that could be machine plowed. Following are a couple of examples. The inventory information entered into the spreadsheet is listed first, followed by the total costs and workers. The spreadsheet abbreviations for worker types are as follows:

Gardener/florist = Gardener
Maintenance Technician = Main T
Equipment Operator = Equip O
Utility Workers = Utility W
Seasonal Laborer = Seasonal

Community park

	Number	Measure
amphitheatre a-tot	1	
bridges-a-total FO	1	0.1
flood parks	1	
flower beds-zz(tot	1	100
grass -bluegrass turf		1.5
irrigation-manual(ACRES)		1.5

	Gardener	Main T	Equip O	Utility	W Seasonal	Ppl $'
transport < 1.4	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport < 2.7	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport < 4.0	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport < 6.7	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport greenhou	0.0000				0.0000	$0.000
transport headquar			0.0000			$0.000
Total transport cr	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
Workers	0.0083	0.0161	0.0061	0.0528	0.0592	$1,938.409
Credit for high us	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Credit for extra m	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Credit for nmbr of	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Workers	0.0083	0.0161	0.0061	0.0528	0.0592	$1,938.409

The dollars required to maintain the area is $1,938.409 per year.

Urban park inventory:	Number	Measure
amphitheatre-total	1	
bridges	1	0.1
buildings	1	
ditches	1	
drinking fountains	1	
flood parks	1	
flower beds-zz(tot)	5	3000
fountains	1	
grass -bluegrass turf		150
grass-natural (weed mower)		10
grass-undev (weed mow)		10
irrigation (auto)		100
irrigation-manual		25
irrigation-quick coupler		25
picnic table	15	
playgrounds-other-	1	
shrub beds-deciduous		150
shrub beds-evergreen		200
shrub beds-shaped (barberry, he		10
sidewalks or cemen		12
sidewalks-other cement areas		10
sports-ball courts	1	
sports-ballfields	1	
sports-bleachers	2	
sports-croquet or	1	

transport < 1.4	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport < 2.7	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport < 4.0	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport < 6.7	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
transport greenhou	0.0000			0.0000		$0.000
transport headquar			0.0000			$0.000
Total transport cr	0.0000	0.0000	0.0000	0.0000	0.0000	$0.000
Workers	0.3964	0.4218	0.7581	3.1320	5.8042	$132,379.443
Credit for high us	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Credit for extra m	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Credit for nmbr of	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total workers	0.3964	0.4218	0.7581	3.1320	5.8042	$132,379.443

The yearly maintenance costs for the above inventory is $132,379.443. If this figure is too high for the budget the plan for the park must change. If this figure is not too high for the budget in the discounted cast flow analysis managers could plan a more elaborate park.

Appendix G

Cost Benefit Analysis

COST BENEFIT ANALYSIS

There are many purchases managers consider. Managers must also set priorities and work within their budgets. Perhaps workers are interested in purchasing new 7-gang mowers. It is conjectured that the new machines will work twice the speed of the old machines and management is comfortable with this assessment. Looking at the line items of the spreadsheet can yield a quick and useful figure. Below are two line items. Parks' maintenance personnel use 7-gang mowers for one purpose only, to mow bluegrass. The first line is the total for the inventory of this manager's responsibility. The second line is the total with the adjusted time.

Inventory	Activity	Park Type	Time/unit	Total personnel dollars
grass-mow	7-gang	community	.2000	$7,410.000
		urban	.2000	$741.000
grass-mow	7-gang	community	.1000	$3,705.000
		urban	.1000	$370.500

This is a relatively simple case because 7-gang mowers are used only in one activity. The manager could save 7410-3705 or 3705 dollars in personnel costs in community parks and 370.5 dollars in urban parks for a total savings of 4075.5 dollars in personnel costs. The manager could then give this figure to a financial analyst who could evaluate the savings of purchasing new equipment in a discounted cash flow analysis. These managers can apply this same method to any machinery used in any number of maintenance tasks.

Appendix H

Terms

Terms:

Maintenance: Maintenance includes all activities pertaining to keeping 'outdoor' facilities in 'new' condition. It generally requires less than one year of planning for individual activities and no special 'large' equipment. The exception for large equipment would be trash compactors and tree spades. This definition does not include maintenance of formal ballfields and swimming pools, or technical fountain and restroom maintenance.

People dollars: This refers to money which goes toward salaries for all field workers except managers. This does not include staff workers.

City park areas: These include any area of land with its 'outdoor' facilities that a city assigns as park responsibility. This includes parks, medians, and agricultural ditches.

Seasonal: Cities with a period of considerably higher maintenance activity encompass seasonal cities.

Route tasks: Specialists who travel throughout the district performing a small variety of tasks compose the routed crew. For example, a worker may travel from park to park doing only riding mowing.

Geographic districts: Any segregation of park maintenance workers and managerial responsibility due to physical location of the park areas. Districts are contiguous. Districts do not overlap.

Inventory items: This inventory refers to any quantifiable park characteristics or facilities.

Maintenance frequency schedule: The schedule is intended or average number of times per year workers perform a given task. Frequencies which are fractional number of times per year such as picnic bench paint 1/3 may imply that workers paint one third of those inventory items or workers paint each picnic table once every three years.

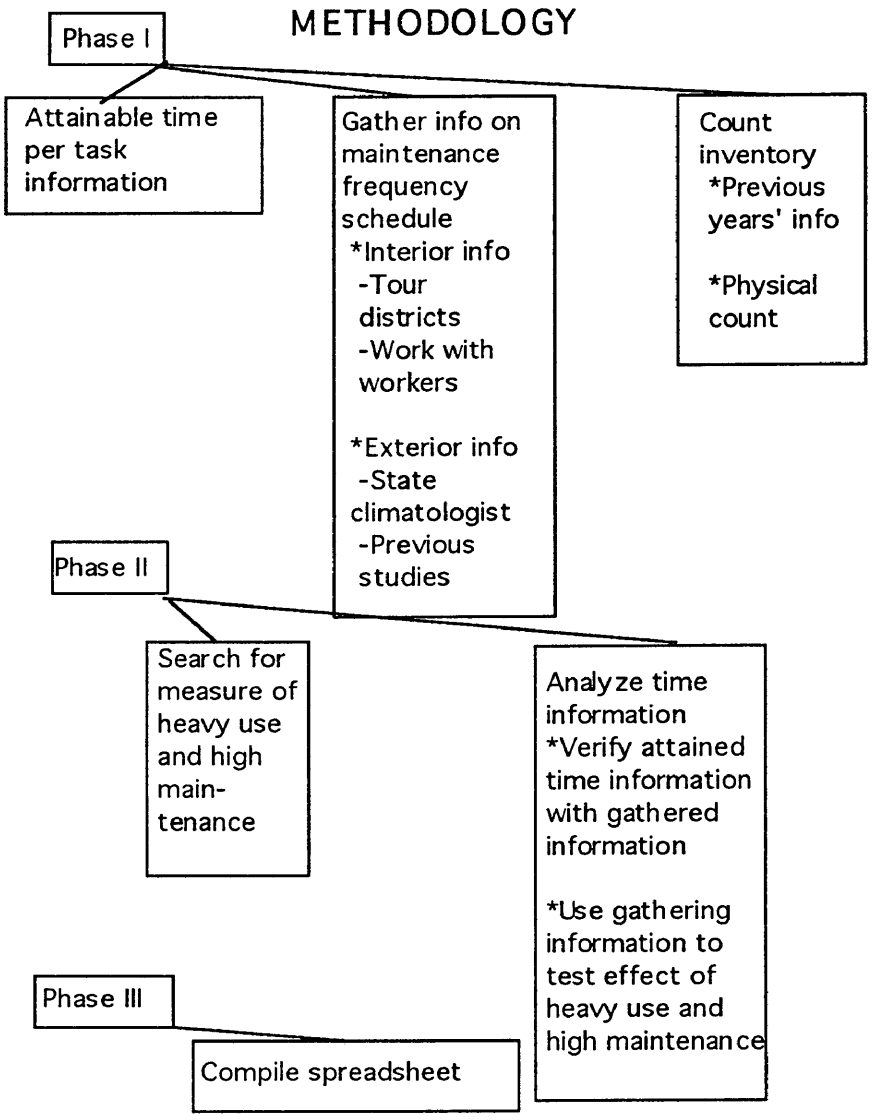
Transportation: This is time from the district office or shop to park locations and back to the office or shop.

Set-up/tear down: Time required before task actually begins or after worker completes task. This could be loading or unloading a mower from a trailer.

Heavy use: Park areas with a lot of people traffic constitute heavy use areas. This would include both athletic and nonathletic activity.

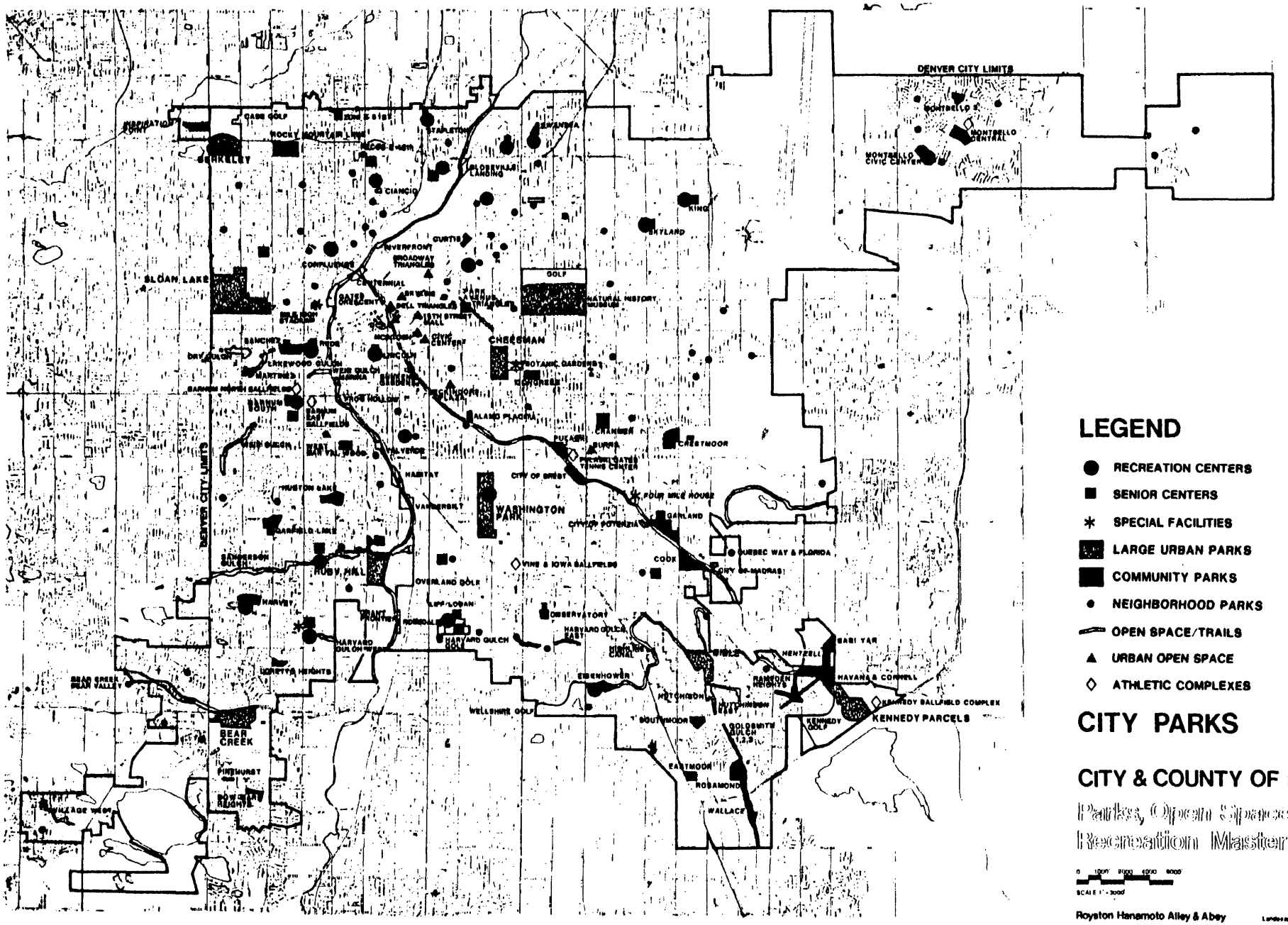
High maintenance: Any park features which make a maintenance task more difficult or repetitive than usual could categorize a park as high maintenance. This is usually due to planning or natural land forms. For instance, managers would consider areas with poor drainage or steep slopes as high maintenance areas.

Appendix I
Flow of Problem Solving Process


METHODOLOGY
Phase I
Attainable time per task information
Gather info on maintenance frequency schedule
*Interior info
-Tour districts
-Work with workers
*Exterior info
-State climatologist
-Previous studies
Count inventory
*Previous years' info
*Physical count
Phase II
Search for measure of heavy use and high main-tenance
Analyze time information
*Verify attained time information with gathered information
*Use gathering information to test effect of heavy use and high maintenance
Phase III
Compile spreadsheet

Appendix J

Map of the city and county of Denver park areas


DENVER CITY LIMITS
SLOAN LAKE
BERKELEY
CHEESMAN
WASHINGTON PARK
BEAR CREEK
KENNEDY PARCELS
LEGEND
RECREATION CENTERS
SENIOR CENTERS
SPECIAL FACILITIES
LARGE URBAN PARKS
COMMUNITY PARKS
NEIGHBORHOOD PARKS
OPEN SPACE/TRAILS
URBAN OPEN SPACE
ATHLETIC COMPLEXES
CITY PARKS
CITY & COUNTY OF DENVE
Parks, Open Space, &
Recreation Master Plan
NORTH
Royston Hanamoto Alley & Abey