DEVELOPING A BEST PRACTICE FRAMEWORK FOR THE MARYLAND AGRICULTURAL LAND PRESERVATION FOUNDATION:

WHY DON'T CONSERVATION PROFESSIONALS USE OPTIMIZATION?

by

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ABSTRACT

In the state of Maryland, government agencies charged with preserving agricultural land traditionally employ a rank-based selection process that ignores opportunities to acquire low-cost, high-benefit parcels. The potential benefit of applying an optimization method to these selection processes has been established in the literature but not recognized in practice. This study examines the methods currently in use by Maryland's counties in selecting parcels for preservation. It then identifies obstacles to adoption of optimization methods and, using a two-part survey instrument, examines the effect of an educational presentation about optimization on administrators' willingness to adopt it. Administrators put a high value on the fairness and transparency of the selection process. Parcel costs are rarely part of the calculation so funds may be used inefficiently. The survey results indicate that a better understanding of optimization increases willingness to adopt it and decreases predicted difficulties with adoption. Also, administrators in metro areas are more willing to consider optimization methods than those in more rural areas. The study shows that lack of experience with optimization, the initial technical investment required to use it, and a lack of incentive to change selection methods are the main obstacles that influence these decisions.

Chapter 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

Land serves as an important stimulus to overall development of the nation. It is the crucial asset and major input of world agriculture. Farmland preservation programs have received nationwide public support. U.S. citizens are willing to finance programs designed to preserve farmland, open space, and other amenities. Local and state governments approved conservation funding of $7.4 billion in 2000, $1.8 billion in 1999, and $8.3 billion in 1998 (Lynch & Lovell, 2003). According to the Land Trust Alliance in 2008, voters have approved a record $8.4 billion in new funding for conservation that year, despite tough economic times. Not surprisingly, these governments have taken a variety of steps to protect farmland from encroaching urban development. All 50 states have enacted some form of a right-to-farm law and at least 22 states have established protective zoning for agricultural land (Nelson 1998).

Farmland preservation programs became a magnet for economic, ecological and even policy studies in which program effectiveness was the essential theme (Deaton, Norris & Hoehn, 2003; Horowitz and Lynch 2003; Lynch & Duke, 2007; Lynch, 2008). These studies have outlined the theoretical basis for cautioning conservation organizations against directing financial resources to land acquisition without regard to cost, especially if the land that offers the greatest ecological value also tends to cost the most. Optimization, an approach commonly used in operations research, was consequently applied to these conservation efforts. Messer and Allen (2010) examined the selection approach applied by the Delaware Agricultural Land Preservation Foundation's (DALPF's) decade-old farmland protection program. They found that DALPF could have protected an additional 12,000 acres worth approximately $25 million if optimization techniques had been applied when it spent $93 million over the preceding decade. In addition, Baltimore County in Maryland confirms the optimality of this approach. Wally Lippincott, Baltimore County's land preservation administrator, said "After trying for years to balance price with farm quality using rank based methods, we switched to optimization. In the first three years of using optimization, Baltimore County has been able to protect an additional 680 acres for the same amount of funds that would otherwise have been spent. This also translates into a savings of approximately $5.4 million." (Lippincott, personal communication, ____)

Therefore, to help Maryland Agricultural Land Preservation Foundation (MALPF) build a best practice framework for county land protection programs in Maryland, academic research gives the answer of "optimization". (Messer, 2006; Messer & Amundsen, 2009; Messer & Allen, 2010) Apply optimization to their county land selection processes would allow the counties to more efficiently use the funds available and save more of Maryland's productive land. This thesis employs a survey instrument to review the use of benefit factors, cost factors, and the selection process of the's (MALPF's) program. It investigates the degree to which MALPF administrators in Maryland's 23 counties understand optimization techniques and are willing to adopt them.

The aim is to gather information needed to customize optimization techniques for each county and thus to recommend a “best practice framework”—a deployment strategy that will optimize each county’s farm and forest protection program.

1.2 Background

1.2.1 History of MALPF

MALPF was created in 1977 by the Maryland General Assembly to purchase easements on agricultural land that permanently prevent the property from being developed for nonagricultural uses. The foundation’s mission is to “preserve productive farmland and woodland for the continued production of food and fiber for all present and future citizens of the state.”[1] Attention is focused on parcels with the best productive quality, preservation of large blocks of contiguous properties, and increasing incentives to bring critical parcels into the program, which represents the core of the state’s preservation efforts.

MALPF has a 12-member board of trustees and a staff of seven administrators who work closely with local governments. Each county designates an employee as the MALPF county administrator who functions as the primary contact and the bridge between MALPF and the local agricultural community. The responsibilities of the county

[1] MALPF report, page 1

administrator include “monitoring MALPF properties, helping landowners prepare applications and subsequent requests, and advising landowners on MALPF and other programs available to help landowners seeking to preserve their properties.”[2]

In cooperation with other agencies and programs in the state that include Rural Legacy, GreenPrint, and a number of county programs, MALPF and the State of Maryland have permanently preserved more productive farmland than any other state in the country. By the end of 2006, MALPF had purchased conservation easements on 1,933 farms comprising 265,691 acres. In 2007, the foundation managed a public investment of almost $500 million in preserved land valued at more than $1.5 billion at the acquisition costs.[3]

1.2.2 MALPF’s Selection Algorithm

When development rights or easements are purchased, specific selection algorithms are used by decision-makers to determine which properties to preserve. Three selection algorithms are well defined in farmland preservation studies: benefit-target ranking, discount ranking, and optimization (Messer & Allen, 2010). Benefit-target ranking seeks to first acquire the parcel that has greatest benefit as defined by the conservation organization. Once rights to the highest ranked parcel have been purchased,

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[2] MALPF report, page 2.

[3] MALPF report page 1

the organization then seeks to acquire the rights for the parcel with the next highest rank and so forth until all funds available have been exhausted. Discount ranking captures some information about the cost of preservation by ranking the discounts offered by applicants. This method seeks to first purchase the parcel with the largest discount (calculated by the appraised value of the parcel and owner's offering price) and then to work down the list ranked by discount until the budget is exhausted. Optimization seeks to acquire a set of parcels that maximizes total benefit given existing constraints. Different techniques can be used to implement optimization, for example, binary linear programming (BLP) or cost-effectiveness analysis (CEA).

Binary linear programming is an algorithm widely used in operations research. It can assure optimal results under multiple simultaneous constraints. However, it requires complex computation and an intensive investment in explaining how it works to both program staff and the public. Literature search in the database of EconLit finds that cost-effectiveness analysis has been applied traditionally in the fields of health, medicine, and education. It compares the relationship between an activity's cost and outcomes. In farmland preservation, this analysis uses each parcel's benefit-cost ratio to determine which parcels to preserve. It is easy to calculate and to explain but there is no guarantee of optimality.

MALPF uses a combination of benefit-target ranking and discount ranking to select parcels. There are two rounds of selection. In the first round, a county determines its priorities and ranks parcels accordingly using a system that follows the state's guidelines, which emphasize the degree of quality of the property. These ranking systems vary in how they apply benefit factors and weights. For example, some counties incorporate size of the parcel into benefit calculation, others do not. Some counties take soil quality as the most important benefit factors while others only attach a relative low importance.

During the second statewide round, MALPF selects parcels using traditional discount ranking. A discount ratio is determined by dividing the landowner's asking price by the appraised value of the easement, which is calculated as:

Appraised fair market value – Agricultural value = Appraised value

The appraised fair market value is obtained from appraisals conducted by the state and any submitted by the landowner. Agricultural value is the lower of two figures: the average five-year cash rent rate for the county and the amount calculated by land rent based on soil productivity. If the discount ratio is less than 1, the landowner is willing to sell the parcel at a discount. The parcel with the best (lowest) discount ratio ranks first. MALPF makes purchases according to this ranking until the annual budget is exhausted.

1.3 Research Objectives

A significant gap exists between theoretical understanding and actual practice (Prendergast, John, Quinn, Rachel, Lawton, John, 1999). This study not only recognizes and identifies the disconnection between literature in agricultural and resources economics and real world application, but also explores the underlying forces in policy making by evaluating the responses of individual counties in Maryland to enhance their land preservation programs. This thesis asks:

- What is the benefit that the program administrator is seeking? What is the cost of the target parcel?
- What are the current practices of MALPF and the counties? How do the programs select parcels to preserve?
- Does the county's current system meet the administrator's needs? How do the administrators assess the selection process?
- How do the program administrators view optimization? How willing are the programs to adopt optimization?
- What are obstacles to adoption of optimization? How can optimization be customized to improve cost-effectiveness given the counties' priorities in preservation?

Chapter 2

LITERATURE REVIEW

The literature on farmland preservation, and on conservation as a whole, has advocated for cost-efficiency by preservation programs through theory and case studies (Deaton, Norris & Hoehn, 2003; Drechsler, Johst, OHL & Watzold, 2007; Kelsey & Lembeck, 1998). Indeed, great effort has been put into development of theories and techniques to increase the efficiency of conservation programs but these methods are not frequently used by those in charge of conservation planning (Predergast et al, 1999; Lynch, 2008). This chapter begins with the recognition of the gap in theory and in practice, which is one of the motivations for this study, and then reviews the representativeness of benefit factors, which is an important consideration in cost effectiveness study. Following is a discussion of cost factors that identifies issues involved in computing the quantity of farmland that is optimal to balance the social benefit and social cost at the margin. In addition, research on the use of selection algorithms by which optimal and suboptimal results can be obtained mathematically is shown and described.

2.1 Gap between Theory and Practice

Prendergast et al. (1999) recognized the gap between accomplishments in academic research and practical application and discussed it with ecologists, conservationists, and land managers from Europe and the United States. They concluded that the main reason for the low level of adoption of these sophisticated tools was lack of awareness of their existence. Additionally, insufficient funding, lack of understanding about the purpose of the tools, and general antipathy toward what was perceived as a prescriptive approach influenced practitioners' decisions. They called for more communication between theoreticians and practitioners, perhaps through short workshops and internet presentations. Prendergast et al. suggested that theorists should customize the tools to the needs of practical conservationists, who should actively seek scientific information to bridge the gap between the two sides.

2.2 Identification of Benefits of Agricultural Land Preservation

This study seeks to discover benefit factors the conservation professionals used in their programs and examines the efficiency of such benefit calculation concept. Most written work to date has identified and measured the benefits of farmland preservation (Gardner 1977; Kline and Wichelns 1996; Rosenberger 1998; Duke and Hyde 2002). These studies suggest that cost-effective policy design should incorporate reasons to support from the public into the framework and build in an appropriate specification of public demand for nonmarket attributes. Among the four main sources of public support – agriculture, environmental, growth control, and open space – agriculture and environmental concerns play a more important role to satisfy public's preference in preserving farmland (Kline and Wichelns 1996; Duke and Hyde 2002). Protecting water quality or groundwater is especially concerned by the public.

Gardner (1977) identified four benefits of preserving agricultural land: sufficient food and fiber, a viable local agricultural industry, open space and environmental amenities, and more efficient urban development. He analyzed sources of market failure and questioned the basis for agricultural land preservation programs. He argued that agricultural land cannot be viewed as a collective good and cannot deliver relevant externalities to justify interference with the land market. However, Gardner admitted that markets fail to create open space and environmental amenities. In addition, he pointed out that solely using agricultural productivity as the criteria by which to select farmland parcels would not provide optimal quantities of open space and that equity problems might not be explicitly recognized given the absence of discussion.

Kline and Wichelns (1996) recognized that agricultural objectives are the primary focus of preservation programs. However, legislative objectives for the programs also include maintaining the environment, controlling growth, and retaining open space. Motivated by the discrepancy in perspectives, Kline and Wichelns surveyed 515 residents in Rhode Island and established mean ratings of importance for reasons to preserve land from the public side. By examining specific pubic preferences regarding farmland preservation objectives, they sought to incorporate the public's view into policy objectives and thereby improve the social efficiency of these programs. Factor analysis of the ratings revealed that environmental objectives such as protecting groundwater, wildlife habitat, and natural places were rated higher than agrarian goals of providing local food and keeping farming as a way of life. As a result, Kline and Wichelns suggested that purchases of development rights could be more socially efficient if environmental criteria represented by water and wildlife quality were given more consideration while attention to agricultural criteria represented by soil quality and farm productivity were reduced.

Kline and Wichelns (1996) ranked the broad categories of factors in descending order of importance as environmental, aesthetic, agrarian, and anti-growth. Rosenberger (1998) commented on Kline and Wichelns' work and reversed the positions of aesthetic and agrarian interests. Rosenberger argued that expanding program objectives to meet the public's preferences may not necessarily increase efficiency for private programs and that specialization in land preservation may more efficiently produce a specific set of benefits than programs aimed at multiple goals. He suggested that some form of cooperation between public and private programs could improve land preservation by generating a larger pool of resources and public support.

Duke and Hyde (2002) confirmed public support of farmland preservation in the interest of gains from environmental benefit. They measured public demand for various attributes of preservation within four broad categories: agriculture, environmental, growth control, and open space. Within these categories, the eight reasons to preserve land proposed by Kline and Wichelns (1996) were extended to ten qualities. Duke and Hyde then applied the analytic hierarchy process to compare public support for each reason. Results from survey data for the general population of Delaware demonstrated strong public support for the environmental attribute, which is consistent with findings from other studies in this area. However, the survey sample in their research placed the most importance on agricultural attributes and least on open space. Specifically, providing locally grown food, keeping farming as a way of life, and protecting water quality were the top three attributes sought by the public from preserved land. Protecting agriculture as an important industry, preserving natural places, and providing breaks in the built environment received the least support.

2.3 Studying the Costs of Conservation

While the potential benefits of preserved farmland have generated a large body of work, little has been done to examine the cost side. Some of the literature has paid attention to the absence of research. But the concept of cost has generally been used in a broader sense of conservation, mainly the cost of ecological conservation. Therefore, answers to choices of cost factors and their calculation from this study can generate great interests both academically and politically.

Naidoo et al. (2006) divided conservation costs into five categories: acquisition, management, transaction, damage, and opportunity. They discussed a method by which to estimate costs and show efficiency gains by incorporating costs into conservation planning. They pointed out that a cost study also can contribute to an analysis of tradeoffs between obtaining a higher level of a conservation target and the increase in cost necessary to obtain it. Therefore, a cost analysis provides useful information to decision-makers. The study by Naidoo et al. listed three reasons for lack of attention to costs both in practice and in the literature. They considered the prospects for integrating costs into conservation planning and suggested that benefits, costs, and threats should all be taken into consideration when conservation priorities are selected and that frameworks that include dynamics in the level of threat and conservation costs could significantly impact the ultimate conservation portfolio.

Dillman (1984) also recognized that costs have been incompletely considered in farmland preservation. He took the opportunity cost of agricultural land as its real social cost and computed it by the discounted future value of net returns to the land when it is employed in its most productive use. Dillman argued that opportunity cost is a good measure of public cost and that it is real, leading to higher prices in tax bills as well as in goods and services.

Although direct studies of the costs of farmland preservation have been rare, other studies might shed some light on the effect of costs on society for decision-makers indirectly. American Farmland Trust (1999) conducted a cost of community services (COCS) analysis in six U.S. states. The COCS analysis assesses the overall fiscal contribution of current land uses. It compares revenue and expenditure based on existing land use patterns (AFT, 1999). According to their report, the cost of preserving farm, forest, and open land includes expenditures to buy development rights and expenses for public services and works. Public works consist of roads, solid waste systems, equipment rentals, buildings, special paths, drainage utilities, river improvement, and sub-flood control zone districts.

2.4 Research on the Cost-Effectiveness of Farmland Preservation

Studies in identifying and measuring benefit and cost factors ultimately contribute to the selection process to improve the cost-efficiency of preservation programs. Apparently, the selection algorithm employed should be analyzed to secure the most cost-efficient results. Literature in this area emerges mostly from environmental and ecological conservation (Underhill 1994; Pressey et al. 1996; Rodrigues et al. 2000). Therefore, this paper first examines the optimality of the selection algorithm in environmental and ecological conservation, and then moves to the discussion of cost-effectiveness studies in farmland preservation.

2.4.1 Optimality of Selection Algorithms

Underhill (1994) compared reserve selection algorithms that are referred to as "greedy algorithms" to a standard algorithm from operations research. He stated that these greedy algorithms were not optimal as claimed and were in fact suboptimal. Underhill presented a simple counter-example that proved that the greedy algorithm could not assure a minimal number of reserves with a goal of conserving every species. He appealed for closer cooperation between biologists and mathematicians in the development of selection algorithms. He also suggested using techniques from operations research, such as integer programming and multiple-criteria decision-making, in biological conservation.

Pressey et al. (1996) compared optimizing algorithms such as integer linear programming and branch and bound algorithms with heuristic approaches to determine their efficiency and feasibility for conservation planning. They used the term “heuristic” to refer to greedy and rarity algorithms (adopted by Underhill (1994)) and recognized the suboptimality of those algorithms from a mathematical viewpoint. However, they argued that an appropriate heuristic method yields as good or even better solutions than optimizing algorithms because it possesses substantial compensatory advantages. Because optimizing algorithms require intensive computer resources for large regional data sets and have failed to find optimal solutions in complicated cases because of limitations on hardware and/or software, they have not been practical for real-world application.

Although the concerns expressed by Pressey et al. regarding computing speed and the capacity of optimizing algorithms has been greatly reduced and perhaps eliminated today, their hypothesis that good heuristics can be reliable comparative tools still holds. Furthermore, adjustment of the acquisition priorities can influence the optimal result to a large extent. Therefore, the criteria used to assess the utility of various algorithms must be broadened.

2.4.2 Efficiency Analysis in Farmland Preservation

Experts and scholars who study farmland preservation endeavor to design the best framework for various conservation programs and focus on either benefits' attributes or selection mechanisms. Lynch and Musser (2001) built a Farrell efficiency model to determine both technical efficiency and cost-effectiveness for three types of preservation programs in four Maryland counties. They specified four goals in the model: (1) maximize the number of preserved acres; (2) preserve productive farms; (3) preserve farms most threatened by development; and (4) preserve large blocks of land. Lynch and Musser collected data on parcel characteristics to proxy the achievement of these goals and discussed how programs trade off the four objectives. They confirmed that MALPF's purchases of development rights provided greater technical efficiency and cost-effectiveness. Parcel size, percent of prime soil, and percent of crop land were found to affect efficiency measures most. Their work suggests that development threat or proximity to other preserved parcels is not prioritized by preservation programs.

Machado et al. (2006) described a method by which to evaluate sets of farmland parcels—the land evaluation and site assessment or LESA system. They claimed that LESA-type index models consider the full range of socially defined objectives. The primary objectives they identified were maintaining agricultural viability, preserving rural amenities or ecosystems, and directing urban growth. They aggregated the social value of the objectives for each site and then used the overall value as the final benefit score. The cost factor was calculated by the cost of the conservation action—the price of purchasing an agricultural conservation easement and/or the transaction cost of accepting a donated easement. The ratio of the aggregated social value to the predicted easement price was computed and referred to as the “conservation value.” Conservation value identifies the most cost-effective sites. Because this framework requires data that can be obtained by methods similar to traditional ones used by preservation program administrators, it is more likely to be accepted. They concluded that the LESA framework provides a sounder conceptual basis for transforming data into useful information and can bolster the decision-making process.

Messer and Amundsen (2009) promoted the use of cost-effectiveness analysis for land acquisition projects. They defined strategic conservation as “a planning process that seeks to select the highest quality lands given limited financial resources.” They pointed out that traditional conservation ensures the purchase of high quality land by creating prioritization maps and applying rank-based criteria when evaluating the quality of a potential project. However, few states incorporated land costs into the planning framework. Cost-effectiveness analysis, on the other hand, includes costs in the evaluation process. It compares costs and benefits for each potential project, therefore strengthening land conservation efforts and achieving efficiency gains. Based on empirical examples, they concluded that cost-effectiveness analysis results in more successful conservation decisions, especially in times of dramatic budget problems.

Similarly, Horowitz and Lynch (2003) recommended comparing benefits and costs. They framed farmland preservation programs in Maryland as one of three types: bidding, “menu-based,” and bargaining. They examined MALPF’s programs to determine whether the program selects the “right” parcels. MALPF used a selection algorithm that ranked the ratio of the easement's value to the farmer's bid. In the analysis, the land's development value and the farmer's desire to continue farming were identified as the essential characteristics for decision-making in farmland preservation. Because the easement value captures information from both characteristics, it was taken as the gauge of the parcel's benefit. The farmer's bid was viewed as the cost of the parcel. Horowitz and Lynch concluded that, by introducing both the easements' values and the farmers' bids into the selection process, MALPF had preserved larger parcels with a lower price per acre than menu-based programs and that the selection process had performed relatively more efficiently than others. Meanwhile, the competition among farmers to bid could reduce the cost of the easements. MALPF's discount selection process increased competition among landowners and therefore contributed to the efficiency of the program. This study did not take attributes such as environmental and open space into consideration. Rather, only the market attribute was calculated in the efficiency formula.

More complex and comprehensive calculation of preservation benefits was conducted by Messer and Allen (2008). They distinguished three selection algorithms: benefit-targeting, the DALPF algorithm,[4] and optimization. The benefits were determined by the LESA score and a Core GI[5] score. An analytic hierarchy process was applied to obtain weights on the LESA and Core GI scores and then the aggregated conservation

[4] DALPF selects parcels based on a discounting system. The parcel with the greatest discount will be purchased first, the second greatest next.

[5] The Conservation Fund defines "core green infrastructure" (Core GI) as "an interconnected network of natural areas, green spaces, and working landscapes that protect natural ecological processes and support wildlife."

benefit was derived by combining those three values. The number of parcels preserved also served as a criterion for the benefit comparison. The purchase price was taken as the only cost factor. The study demonstrated that optimization using binary linear programming preserves more parcels of land, thus producing more conservation benefits than either the DALPF algorithm or benefit-targeting given the same budget. Messer's (2006) study in Maryland further assured the cost-effectiveness of the optimization algorithm. In that study, benefit-targeting and optimization were compared for a case in the Catoctin Mountains of Maryland. He first suggested including development risk in the analysis because adding values based on threat of development can impact the conservation values significantly under both benefit-targeting and optimization. Messer then concluded that benefit-targeting, viewed as a type of "greedy" algorithm in ecological conservation, can lead to highly inefficient results while optimization generates in a higher level of conservation benefit at the same level of purchase cost.

In summary, literature has proved the optimality of optimizing algorithms such as integer programming both mathematically and empirically (Underhill, 1994; Messer & Allen, 2010). However, a real application of such algorithms is in question. Machado et al's "conservation value" is merely heuristic, although it sounds acceptable. Therefore, whether the optimal algorithms are adopted or will be adopted, how conservation professionals view "optimality" in their daily work, how they distinguish heuristic algorithms from optimal ones, are the questions that should be answered by further research. Motivated by the lack of literature on this issue, this study tries to make some effort in filling the blank in optimal algorithm's real-world application.

Chapter 3

RESEARCH APPROACH

In this chapter, the research approach is described step by step, including the survey construction, the pre-test of the survey, the revision process, the administration of the survey and the follow-up procedure. Overall, response rate of the survey is 100%. More than 30 responses are received by March, 2010. (See Table 3.4 for details.)

3.1 Survey Instrument

Borrowed the idea of optimization from operations research, this study uses the term "Optimization" later in the survey as a selection approach in farmland preservation. It is defined as a process "to provide a high level of aggregated benefits at the best possible price." (See Appendix A) Two specific optimization techniques are brought up. One is called binary linear programming[6], which is the assured optimal algorithm as in literature. The other is names as cost-effectiveness analysis, which resembles the calculation of "conservation value" (Machado et al, 2006). The main objectives of the survey are:

1. Identify preservation program selection criteria in each county and how these benefit factors are measured.

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[6] Binary linear programming is one kind of integer programming. Its decision variable(s) are binary and the constraint equation(s) is/are linear.

2. Identify the methods used by programs in each county to measure the easement cost and how those costs are incorporated into the selection process.
3. Identify the selection techniques used by the county programs to assess the performance of selections made and the criteria used.
4. Identify administrator's willingness to adopt optimization as a selection process and compare the feasibility of two optimization techniques.
5. Identify obstacles to adopting optimization and the severity of the obstacles.

Target participants in the survey are the program administrators in Maryland counties. Since there are 23 counties (see Figure 3.1), 23 survey subjects are expected. Two survey instruments were used—a pre-survey and a post-survey (See Appendix A). The pre-survey was conducted before educational material about optimization was presented. The post-survey was conducted after discussions with the administrators about optimization techniques, the results of its application in Baltimore County, and other related issues.

The pre-survey contains five parts. The first part collects background information, including personal information and the program's historical performance. Personal information consists of the participant's name, years of employment in current position, and degree of professional knowledge. It serves to confirm that targeted participants are surveyed and thus that the results obtained from them are valid. The second part uses open questions to determine the program's beneficial factors and how they are measured. Individual programs that make up the county's conservation efforts are distinguished so the selection criteria and calculation system are not only specific to that county and but are customized by program. The third part seeks to answer questions about the cost formulation used. Participants are asked to identify the method the county uses to determine the cost of an easement and how it is factored into the selection process. In the following part, the selection process is investigated. The algorithms are described and participants can choose the method or methods they employ from the listed choices. Then they can evaluate their current selection process in terms of the program's goals. The final part assesses the current selection techniques and overall efficiency for each distinct county program.

The post-survey contains six parts. The first part collects the participant's name and the county's name. It helps to match the results from the post-survey with those from the pre-survey, making paired comparisons and tests feasible. In the second part, the importance of the criteria for applying a selection technique is valued. The criteria are identical to the ones used in the fifth part of the pre-survey when the current selection technique is assessed. The third part of the post-survey investigates the participant's understanding and willingness to adopt an optimization process for the preservation programs. The fourth and fifth parts discuss two optimization techniques—binary linear programming and cost-effectiveness analysis, respectively. Identical formatting is applied in each part. Knowledge of each technique, its predicted ability according to the criteria set out in the second part of the post-survey, and willingness to adopt the process are measured on a scale of one to five. The questionnaire ends with two open questions and acknowledgement of their participation. The first open question gathers additional thoughts from program administrators about the selection process currently used and the optimization selection process. The second asks for comments and suggestions about the survey.

3.2 Survey Pre-test

On August 20, 2009, the survey instruments (both the pre-survey and post-survey questionnaires) were pre-tested by a critical review panel. The panel was given the following tasks:

- Confirm the most appropriate method to define selection criteria and its calculation mechanism.
- Review the terms that county administrators could use to describe easement costs and select the best terms to provide a clear and understandable definition.
- Modify survey questions specifically related to county and state government contexts.
- Review the survey language and administration to ensure that it met current standards for academic research.

Several revisions were made after the August meeting. First, based on MALPF officials' opinions and county representative experience, we changed the comparison list of preservation programs. The final program choices were MALPF, the County program, the Rural Legacy program, the Maryland Environmental Trust (MET) program, and Program Open Space. In case counties had additional special programs, “Other” was presented as a final option. Second, questions on benefit factors, cost factors, and the selection process were customized for programs within a county. In other words, participants were asked to explain the benefits, cost factors, and selection algorithm they used for each specific program in the county. Third, the criteria for evaluating the programs’ current selection process were reduced from fifteen to six. This change was related to concerns about the length of the questionnaires, readability, and ease of completion. The previous list contained 15 items, some of which were derived from the literature on public preference. The revised list included only six items that were derived from MALPF’s program guide. In addition, we added one question about price caps, which have been used by many counties at the request of MALPF officials. This question queried the advantages and disadvantages of this method in the eyes of the county administrators. It also revealed the demand for the “price cap[7]” method and barriers to adopting it.

3.3 Survey Procedure and Response

3.3.1 Administration of the Survey

[7] Price cap is the up-limit of the price that a county sets to purchase an easement.

On November 19, 2009, MALPF held an annual conference at Annapolis for all county administrators. Representatives from 12 counties attended the meeting. Another five county representatives used the video conference software to participate. Pre-surveys and materials for the optimization presentation were prepared for each seat before the meeting. After several county reports, the pre-survey was conducted. Twenty-three pre-survey questionnaires were collected: 18 from administrators and staff members of the 12 counties at the meeting, one from a county using video conference software, one from a MALPF board member, and three from MALPF staff members. (See Table3.1.)

After the pre-survey data were collected, Dr. Kent Messer, University of Delaware, gave an educational presentation on optimization. He explained how the approach performs, how to implement it, and what had been achieved after its application. He also compared two optimization techniques this study defines: binary linear programming (BLP) and cost-effectiveness analysis (CEA). After his speech, Wally Lippincott and Robert Hirsch, MALPF county administrator and GIS analyst from Baltimore County, Maryland, gave a presentation on improved results generated in Baltimore County after applying cost-effectiveness analysis to its county preservation program. The post-survey was then conducted and 21 responses were received: 17 from county representatives at the meeting, one from a user via the video conference, and three from MALPF staff members. (See Table3.2.)

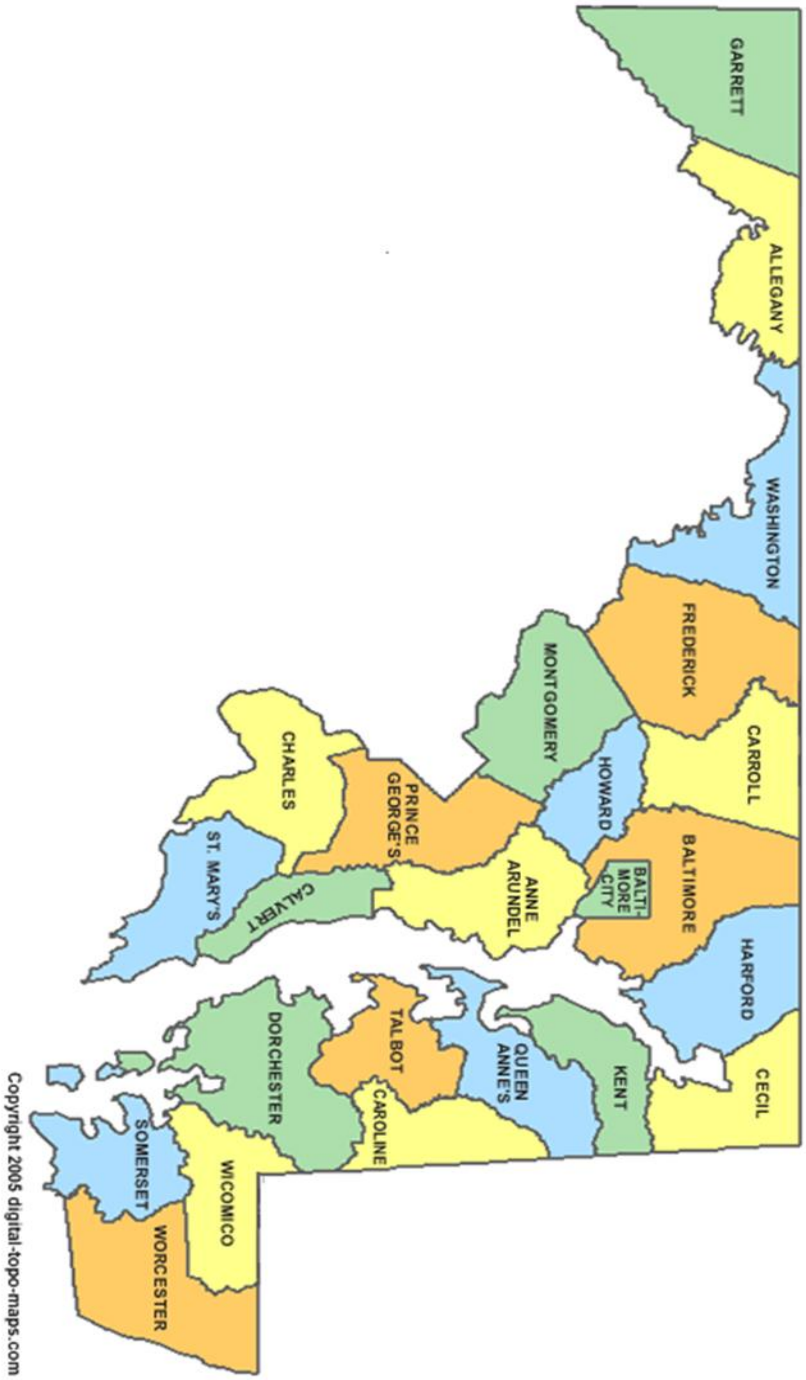
3.3.2 Follow-up for Non-responses

Based on the concept of Dillman's (1978) total design survey method, emails were sent to four participants who used the video conference but did not respond to the survey as a reminder on December 7. Six other county administrators who could not participate in the November 19 meeting and the survey also received emails that introduced the MALPF project and explained the purpose of the survey, how to participate in it, and how to obtain help. Written letters were sent to these ten county administrators immediately after the email with a printed pre-survey and a prepaid return envelope enclosed. Two weeks later, a DVD and post-survey were mailed to the six county administrators who did not attend the November 19 meeting. On the DVD was a Powerpoint file with Dr. Messer's narration, providing them with the same presentation he made at the meeting. The administrators were asked to watch the DVD first and then to complete the questionnaire. Emails with the post-survey and the Powerpoint presentation attached were also sent to those target subjects. To the four county administrators who used the video conference, both an email and a hard copy of the post-survey were sent. These mentioned the availability of the DVD and expressed our willingness to provide them with the disk on their request.

Prior to January 7, 2010, we received a completed pre-survey from one county and a completed post-survey from another county. Telephone calls were made to county administrators who had not completed one or both of the surveys. If not connected, a message is left, asking for their help to complete the surveys. On January 20, we called the remaining five county administrators who had not sent back the surveys. We sought to help them with the survey questions if necessary and ensure that they had all of the materials needed to answer the questions. On January 25, another round of emails and phone calls was made. Only four counties remained listed on the follow-up list on that date. Two confirmed that they received all of the materials and agreed to mail back the questionnaires soon. One county asked for copies of the surveys while another county expressed concern about available hours to complete them.

On February 12, 2010, responses from only two counties were still missing. Considering that both counties were having difficulty finishing the surveys, we abridged the two questionnaires into one for those counties and kept only the key questions that collected data for comprehensive conclusions (see Appendix B). These abridged surveys were emailed and mailed to the two counties with a return envelope enclosed. These last two counties returned their surveys by March 10, 2010. (Summary of the follow-up procedure can be found in Table 3.3.)

Figure 3.1: Maryland County Map[8]



[8] Image is retrieved from http://www.digital-topo-maps.com/county-map/maryland.shtml. Permission to use this image is provided in Appendix C.

Table 3.1: Responses to the pre-survey at the November 19, 2009, meeting

	County			**MALPF**			**Total**
	Admin	**Staff**	**Total**	**Staff**	**Board**	**Total**	
At the meeting	12	6	18	3	1	4	**22**
Through video conference	0	1	1	-	-	-	**1**
Total	12	7	19	3	1	4	**23**

Table 3.2: Responses to the post-survey at the November 19, 2009, meeting

	County			MALPF			Total
	Admin	Staff	Total	Staff	Board	Total	
At the meeting	11	6	17	3	0	3	**20**
Through video conference	0	1	1	-	-	-	**1**
Total	11	7	18	3	0	3	**21**

Table 3.3: Number of counties that responded to the survey between November 19, 2009, and March 10, 2010

<table>
<tr><th rowspan="2">Date</th><th rowspan="2">Event</th><th colspan="3">Survey response*</th></tr>
<tr><td>Pre-survey</td><td>Post-survey</td><td>Response rate</td></tr>
<tr><td>November 2009</td><td>MALPF meeting</td><td>12</td><td>11</td><td>52.17%</td></tr>
<tr><td rowspan="2">December 2009</td><td>Initial reminder</td><td rowspan="2">15</td><td rowspan="2">14</td><td rowspan="2">65.22%</td></tr>
<tr><td>Duplicate packets</td></tr>
<tr><td rowspan="3">January 2010</td><td>Initial phone calls</td><td rowspan="3">21</td><td rowspan="3">21</td><td rowspan="3">91.30%</td></tr>
<tr><td>Second round calls</td></tr>
<tr><td>Follow-up reminder</td></tr>
<tr><td>Feb.–Mar., 2010</td><td>Revised survey</td><td>23</td><td>23</td><td>100.00%</td></tr>
</table>

* The survey response counts only the number of counties that responded to the survey.

Table 3.4: Overall responses to the pre-survey

	County			**MALPF**			**Total**
	Admin	**Staff**	**Total**	**Staff**	**Board**	**Total**	
Complete	19	8	27	3	1*	4	**31**
Abridged	2	0	2	-	-	-	**2**
Total	21	8	29	3	1*	4	**33***

* No response was received from board members on the post-survey so the total number of responses for the post-survey is 32.

Chapter 4

DESCRIPTIVE AND SURVEY RESULTS

Having described the manner in which the survey tool was administered with all of the counties in Maryland, this chapter presents the results from the survey: a description of the data set, the histogram and box plot from the data analysis, and a table comparing the criteria for assessing specific selection techniques. The five criteria were knowledge, fairness, transparency, cost-effectiveness, and ease of administration.

4.1 Descriptive Results from the Pre-survey

4.1.1 County Information

The first eight questions in the pre-survey collected personal information about the participants. It was used to distinguish the target subjects and verify their professional ability to validate the continued analysis. Following are the names of the variables:

- years-for-county: number of years the survey participant worked for the county.
- years-for-job: number of years the survey participant worked at the current position.
- know-MALPF: knowledge about MALPF’s program.
- know-county: knowledge about the county’s program.

County administrators were asked to fill in the blanks the number of years they worked in the county or at the current position. Their knowledge of MALPF's program and county program was measured on a scale of one to five with one standing for not knowledgeable, three for somewhat knowledgeable, and five for expert. Two and four meant the degree between. All 33 responses provided answers to these questions. The average working experience of participants is 11.85 years. When MALPF's staff members are excluded from the sample, the average working experience of the county participants is 11.91 years. Participants have spent an average of 8.31 years in the current job position. The know-MALPF and know-county variables measured how much participants knew about the two types of programs. The results show that all 29 county representatives obtained an average score of 4.02 for MALPF's program and 4.43 for their county programs (see Table 4.1). It can be concluded that the surveyed participants have a high level of knowledge in the field of land preservation and therefore represent the understanding and opinions of preservation program administrators in general. And that the problems they reveal are representative in practice and worthy of study and theoretical research.

4.1.2 Identifying Benefit Factors

Question ten in the pre-survey asked participants to list the three to five most important benefit factors that their programs use in the selection process. We used the data from 23 senior representatives of counties. (Unless stated otherwise, data from these

23 observations are used in the rest of the chapter.) These participants included 21 program administrators who were the original targets of the survey and two senior county staff members who were representatives of their administrators.

Nineteen counties listed soil quality as one of the most important benefit factors that their programs aim to obtain. Eighteen counties considered location-related factors when selecting parcels. Eleven counties listed parcel size and ten stated an interest in development-related issues. Other benefit factors were mentioned by one or two counties (see Table 4.2 for detailed information). In conclusion, soil quality is the benefit factor measured by almost all of the counties surveyed. Location of the parcel and its size are also widely considered. Almost half of the counties consider development pressure as another influential element. Concern about agricultural land, environmental benefits, and economic viability also draw some attention.

4.1.3 Incorporating Cost Information

Question 14 asked participants to check the factors they use in calculating the cost of an easement for various types of preservation programs. (The variables for easement cost factors in pre-survey question 14 are presented in Table 4.3.) Five programs were listed on the survey: the MALPF program, the county program, the Rural Legacy program, the Maryland Environmental Trust program, and Program Open Space. Participants could specify a program in the line of “Other” if their counties worked with additional programs that were not listed. MALPF's program adopts diversified methods for calculating the easement value. Asking price, seller's discount, a calculated easement value, and the appraised value all help to determine the ultimate easement cost. The county program also takes multiple factors into account. Appraised value, asking price, and a calculated easement value are the three major factors. Rural Legacy's program uses a price cap and a calculated easement value most. Only four counties have Maryland Environmental Trust programs and two of those do not know what factors are used for easement cost calculations. Most of the counties do not have Program Open Space and know little about it. Four counties operate programs other than the listed five. (Details can be found in Table 4.4 and Figures 4.1 through 4.3.)

Question 15 investigates the actual usage of cost information in various types of preservation programs. Participants were asked how cost factors are incorporated into the selection process. (The variables for cost usage in pre-survey question 15 are listed in Table 4.5.) Nearly half of the counties do not include cost information in the selection process and do not use it to determine the priority for MALPF programs. Cost only signals the balance of the available funds. More than a quarter of the counties do not think easement cost is applicable in their MALPF programs. Similarly, the county and Rural Legacy programs usually do not take the easement cost into consideration when parcels are selected and Maryland Environmental Trust and Program Open Space make little use of cost information. (Details are presented in Table 4.6 and Figures 4.4 through 4.6.) Only one county uses cost as part of a benefit calculation in its MALPF program. Baltimore County uses cost information in its optimization process both for MALPF and its county program. Another county claims to use cost information in optimization process for its Rural Legacy program. In the MALPF, county, and Rural Legacy programs, administrators noted that they use easement costs in other ways but they did not specify how.

4.1.4 Identifying the Selection Process

Question 16 investigated the selection process and identified the techniques used in each program. Selection algorithms and general guidelines could both be applied to determine which parcel to purchase. (The variables for selection techniques in pre-survey question 16 are shown in Table 4.7.) The MALPF program values the parcels with the greatest benefit most. Therefore, 16 counties rank the parcels based on a benefit score. The county program uses benefit ranking and board recommendations to select parcels. The Rural Legacy program selects parcels based on flexible standards that incorporate the benefit score, benefit-cost ratio, board recommendations, political advice, and other criteria. Again, the criteria used by Maryland Environmental Trust and Program Open Space were mostly unknown to the administrators. In addition, 43% of the responding administrators do not view the standard selection process as applicable while 20% of the programs use benefit ranking to determine selection priorities. (Details can be found in Table 4.8 and Figures 4.7 through 4.9.)

Questions 17 through 22 asked participants to evaluate the performance of the current selection process using given criteria. (The variables for the evaluation criteria can be found in Figure 4.10.) Results show that their current selection processes have done best protecting soil and large blocks of contiguous land. On a scale of one to five, protecting soil receives a score of 4.10 and protecting large blocks of land receives 4.05. The selection processes have some ability to maximize the number of agricultural acres (score of 3.6) and the quality of open space (score of 3.06). But the existing processes do poorly in acquiring the best deals and increasing incentives to remain in farming. Administrators give scores of only 2.76 and 2.95, respectively, to those two criteria. Figure 4.10 uses the box plot to show the results with regard to the six evaluation criteria.

Questions 23 through 28 asked participants to assess various techniques used in their current selection processes according to a set of given criteria. (The variables for the evaluation criteria can be found in Figure 4.11.) Of the 23 senior county representatives who participated, 21 responded to these questions. A mean score of 4.10 on knowledge of the techniques demonstrates that these administrators are well versed in how to use them. Senior representatives think that their current techniques are fair and transparent. They give fairness a score of 4.05 and transparency a score of 4.0. They do not, however, find the techniques easy to administer, giving a score of 3.74. And the techniques used do only moderately well in terms of cost-effectiveness with a score of 3.16 (see Figure 4.11).

4.2 Descriptive Results from the Post-survey

4.2.1 Importance of the Selection Criteria

Questions three through eight measured how important various attributes of the selection process are to the administrators. (Descriptions of the variables can be found in Figure 4.12.) The importance of each attribute is measured on a scale of one to five with one standing for not important, three for somewhat important, five for very important, and two and four between. Statistical results from responses by the 23 senior representatives show that fairness of the selection process is valued most. It generates a mean score of 4.65. Transparency, scoring 4.48, is also very important. Knowledge of the selection process, including understanding of the selection techniques used, rates a score of 4.26. Ease of administration of the process and the cost-effectiveness of the resulting selections were only moderately important, generating scores of 3.87 and 4.17 respectively. (See Figure 4.12.)

4.2.2 Optimization

Questions nine and ten compared administrators' understanding of a selection process using optimization techniques before and after the educational presentation by Dr. Messer and experience-sharing presentation by Wally Lippincott and Robert Hirsch. These questions quantify the effects of short seminars as a means of communication between an academic and practitioners. Twenty-one of the 23 senior representatives answered these questions. There was a significant increase in understanding of optimization methods after the educational presentation. The mean score for optimization knowledge, a measure of the administrators' confidence in their understanding of the program, before the presentation is 2.43. After the two presentations, this score rose to 3.70. (See Figure 4.13.)

Question 11 evaluated a general willingness to adopt optimization while Questions 21 and 22 provided further information on their willingness when some additional resources are offered. In Question 21, access to user-friendly software to help with optimization is offered. In Question 22, both access to and training for such software are offered. General willingness to adopt optimization gave a score of 3.0, meaning they are somewhat willing. When access to the optimization software tool was offered, willingness rose to 3.30, a 10% increase and significantly different from the previous one at 1% level. When both access and training were offered, willingness increased to 3.5, a 16.7% increase and also significantly different from general mean of 3.0 at 1% level. Therefore, survey results show that participants are more willing to accept optimization when additional resources are available (see Figure 4.14).

Questions 12 through 20 described potential obstacles to adopting optimization as the selection process. (Descriptions of the variables can be found in Figure 4.15.) The survey listed eight obstacles and asked participants to assess the difficulty each one presented on a scale of one to five. One stood for not difficult at all, three stood for somewhat difficult, and five stood for very difficult. Two and four signified a level of difficulty between the adjacent two numbers. All eight obstacles received a mean score of about 3, suggesting that challenges to incorporating an optimization process do limit its use. No one obstacle was dominant (see Figure 4.15).

4.2.3 Binary Linear Programming

Questions 23 and 24 compared the administrators' knowledge of binary linear programming before and after Dr. Messer and Baltimore's presentations. Twenty-one participants answered the two questions. The average score of their prior knowledge was only 2, falling between "Not at all" and "Somewhat." After the presentation, their knowledge level averaged a score of 3, "Somewhat" (see Figure 4.16). So, while the increase in understanding was significant, binary linear programming was still difficult to understand for most participants.

Questions 25 through 30 of the post-survey used the same criteria as pre-survey questions 23 through 28 and were designed to assess administrators' views of binary linear programming as a selection technique. The variable names were identical to the pre-survey ones (shown in Figure 4.11). Participants from 20 counties answered the questions. Per their responses, binary linear programming is viewed as cost-effective and fair. Cost-effectiveness scored highest of the five attributes. However, participants do not feel knowledgeable about this technique (score of 2.26). Therefore, they do not consider it to be easy to administer or transparent to explain (see Figure 4.17).

4.2.4 Cost-Effectiveness Analysis

Questions 32 and 33 identified the participants' knowledge regarding another optimization technique, cost-effectiveness analysis, before and after the presentation. Participants were not familiar with this technique before the presentations so their understanding improved. The score of their knowledge level rose from 2.43 to 3.48, an increase of 33.8% (see Figure 4.18).

Questions 34 through 39 used the same five criteria for assessing binary linear programming to evaluate cost-effectiveness analysis. Twenty county representatives evaluated this tool. For these participants, the cost-effectiveness analysis was viewed as yielding efficient results (score of 3.78). Although not thoroughly knowledgeable about this tool, they scored it fairly high in terms of fairness, transparency, and ease of administration (see Figure 4.19).

4.3 Statistical Comparison

In both the pre-survey and the post-survey, six criteria were given to assess a specific selection technique: knowledge, fairness, transparency, cost-effectiveness, ease of administration, and "Other." None of the participants provided additional criteria in the "Other" line. Therefore, only five criteria are used by the participants. This section compares the three selection techniques—current techniques, binary linear programming, and cost-effectiveness analysis—according to those five criteria. The importance of the criteria is also surveyed.

Of the 23 participants who completed surveys, 21 assessed their current techniques, 20 assessed linear programming and cost-effectiveness analysis, and all rated the importance of the five criteria. Fairness and transparency rank at the top in terms of importance, followed by knowledge of the application. Cost-effectiveness is less important and ease of administration is the least concern. Pair-wise t-tests show that fairness (score of 4.65) and transparency (score of 4.17) are not significantly different from each other but both are significantly different from the other three at a 5% significance level. With regard to current techniques, participants feel that they are knowledgeable about them (score of 4.10) and that the techniques are fair (score of 4.05) and transparent (score of 4.00). These scores are not significantly different from one another but vary significantly from scores for the other two techniques at a 10% level of significance. The ease of administration score is highest for participants' current techniques (3.74), most likely because they are less familiar with the other two. Cost-effectiveness scored only 3.16, the lowest rating in this section for current techniques. It is also lower than cost-effectiveness score that cost-effectiveness analysis receives (3.78). However, pair-wise t-tests show that it is not significantly different from the average score that binary linear programming receives (3.56).

Hence, one can conclude that participants admit that their current selection techniques are less cost-effective than cost-effectiveness analysis, but as better as binary linear programming in terms of cost-effectiveness. They view the cost-effectiveness analysis as fiscally more efficient than binary linear programming, which is not correct according to the properties of the two techniques. There are a couple of explanations for the misunderstanding. First, participants have a least knowledge about binary linear programming. They have limited knowledge of the two techniques and do not fully understand the algorithms underlying them. Second, the name “cost-effectiveness analysis” may influence perceptions of the optimality of the technique itself, thus leading to a misinterpretation of the power of the selection algorithm. It also seems like they find the cost-effectiveness analysis intuitively easier to understand. Because they feel like they understand it better, they may view it as more successful. Table 4.9 records the mean scores for each technique.

Table 4.1: Average number of years working and mean score of knowledge level

	Number of observations	years-for-county	years-for-job	know-MALPF	know-county
Senior Rep.	**23**	**14** (9.11)	**9.59** (6.53)	**4.11** (0.521)	**4.54** (0.722)
County Rep.	**29**	**11.91** (9.12)	**8.31** (6.37)	**4.02** (0.543)	**4.43** (0.678)
All Responses	**33**	**11.85** (9.05)	**8.75** (6.83)	**4.02** (0.566)	**4.33** (0.899)

Note: Numbers in () are the standard errors.

Table 4.2: Benefit factors listed from results in question 10 of the pre-survey

	Benefit Factors				
County	Soil	Location	Size	Development	Others
Allegany	-	-	-	-	-
Anne Arundel	Soil quality			Development potential	Resource protection
Baltimore	Soil quality	Contiguous			Price
Calvert	Soil quality	Location	Size		Site index
Caroline	Soil quality	Easement adjacency	Area of preservation		
Carroll	Soil quality	Adjacency to other protected land	Size	Development right	Streams, sensitive space, woodland
Cecil		Adjacent preserved properties			Owner, operator
Charles	Soil quality	Contiguity to other preservation	Size	Development potential	Amount of land devoted to agricultural use
Dorchester	Soil quality	Proximity to other preserved land			Consistency of preserved land
Frederick	Soil quality	Contiguousness	Size	Development	
Garrett	Soil quality	Proximity to other preserved land	Size		
Harford			Size	Development potential	Capital income; LESA score; types
Howard (continued)	Soil quality	Adjacency	Size		

Table 4.2: Benefit factors listed from results in question 10 of the pre-survey (continued)

	Benefit Factors				
County	Soil	Location	Size	Development	Others
Kent	Soil quality	Contiguity to other protected land	Size		
Montgomery	-	-	-	-	-
Prince George's	Soil quality			Development pressure	Open space, environmental
Queen Anne's	Soil quality	Contiguousness to preserved lands	Size	Development threat	PPA
Somerset	Soil quality	Priority area			% of property in ag production; Stewardship
St. Mary's	Soil quality	Contiguous	Size		
Talbot	Soil quality	Contiguous preservation			BMP
Washington	Soil quality	Proximity to other preserved land		Lots developed since acquired / total development rights	Economic Viability: intensity of operation & water availability Agricultural Misc.: active role on farm, BMP's capital intensity and long-term chances
Wicomico	Soil quality	Preserved lands		Development pressure	
Worcester	Soil quality	Adjacency to other protected land		Development right to extinguish	

Table 4.3: Variable names in pre-survey question 14

Variable	Description of Variable
Asking price	The price farm owners offer in the application
Seller discount	Discount farm owners offer in the application
Calculated easement value	Value calculated by special scoring systems
Price cap	Maximum price a county is able to pay for one parcel
Appraised value	Value calculated by the easement value formula
Others	Other factors not list above
Don’t know	Factors that are unknown
N/A	Program does not exist

Table 4.4: Number of responses that indicates easement cost factors considered and/or calculated

	Asking Price	Seller Discount	CEV	Price Cap	Appraised value	Others	Don’t know	N/A
MALPF	14	8	10	2	15	1	0	1
County	2	2	7	2	5	3	0	8
Rural Legacy	1	2	11	6	5	4	1	4
MET	0	0	0	0	1	1	2	16
Open Space	1	0	1	0	3	0	7	11
Other	0	0	3	0	1	1	0	17

Table 4.5: Variable names in pre-survey question 15

Variable	Description of Variable
Not included	Cost is not explicitly included except to determine whether funds are still available
Part of benefit	Cost is considered as part of the parcel benefit scoring
Used in OP	Cost is used in an optimization process
Used in B/C ratio	Cost is used to calculate benefit-cost ratio
Other	Other usage not list above
Don’t know	Cost usage is unknown
N/A	The program does not exist

Table 4.6: Number of responses that indicates easement cost usage in different programs

	Not included	Part of benefit	Used in OP	Used in B/C ratio	Other	Don't know	N/A
MALPF	10	1	1	0	3	0	6
County	6	0	1	0	1	0	13
Rural Legacy	8	0	1	0	2	3	7
MET	0	0	0	0	0	5	15
Open Space	1	0	0	0	1	7	12
Other	2	0	0	0	0	0	19
Sum	**27**	**1**	**3**	**0**	**7**	**15**	**72**

Table 4.7: Variable names in pre-survey question 16

Variable	Description of Variable
Highest benefit	Parcels with the highest benefit scores are selected first until the budget is exhausted
Highest B/C ratio	Parcels with the highest benefit-cost ratios are selected first until the budget is exhausted
Board recommend	Parcels are selected based on advisory board recommendations
Political advice	Parcels are selected based on political considerations
BLP	Parcels are selected based on their benefits and costs using binary linear programming
Not used	No official selection system is used
Other	Other method not list above
Don't know	Selection method is unknown
N/A	The program does not exist

Table 4.8: Number of responses that indicates different techniques used in the selection process

	Highest benefit	Highest B/C ratio	Board recommendations	Political advice	BLP	Not used	Other	Don't know	N/A
MALPF	16	4	6	1	0	0	2	0	1
County	8	2	5	2	0	1	1	0	8
Rural Legacy	5	2	3	3	0	0	6	0	4
MET	0	0	0	0	0	0	1	5	15
Open Space	0	0	0	0	0	0	0	8	14
Other	1	0	0	0	0	0	0	0	20
Sum	**30**	**8**	**14**	**6**	**0**	**1**	**10**	**13**	**62**

Table 4.9: Assessment of preservation selection techniques from senior representatives

	Knowledge	Fairness	Transparency	Cost-effectiveness	Ease of administration
Current technique	**4.10***[,b,c] (0.62)	**4.05***[,b,c] (0.74)	**4.00***[,b,c] (0.92)	3.16[c] (0.96)	3.74[b,c] (0.81)
BLP	2.26[a,c] (1.19)	3.11[a] (0.83)	2.67[a] (0.97)	**3.56*** (0.70)	2.78[a,c] (0.94)
CEA	2.63[a,b] (1.16)	3.33[a] (0.84)	3.11[a] (1.08)	**3.78*[,a]** (0.73)	3.17[a,b] (0.92)
Importance of criteria	4.26 (0.62)	**4.65**** (0.65)	**4.48**** (0.79)	4.17 (0.65)	3.87 (0.76)

Note:

1. Numbers in bold are the highest score in the corresponding row.

2. * and ** denote number(s) significantly different from the rest in the corresponding row at the 10% and 5% levels respectively.

3. a denotes number significantly different from that with current technique at 5% level.

4. b denotes number significantly different from that with BLP at 5% level.

3. c denotes number significantly different from that with CEA at 5% level.

Figure 4.1: Easement cost factors considered and/or calculated by MALPF's program

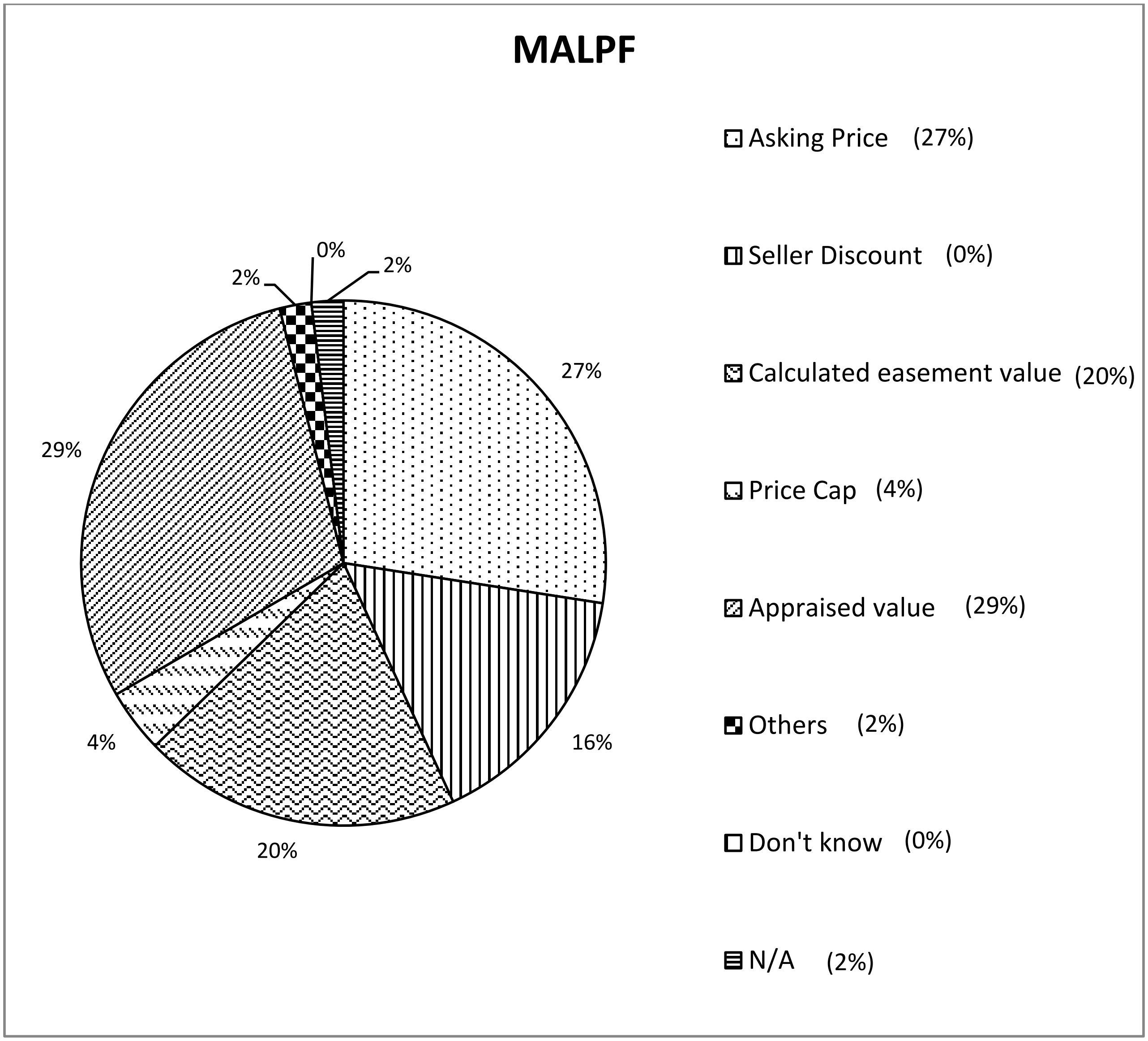


Figure 4.2: Easement cost factors considered and/or calculated by the county's program

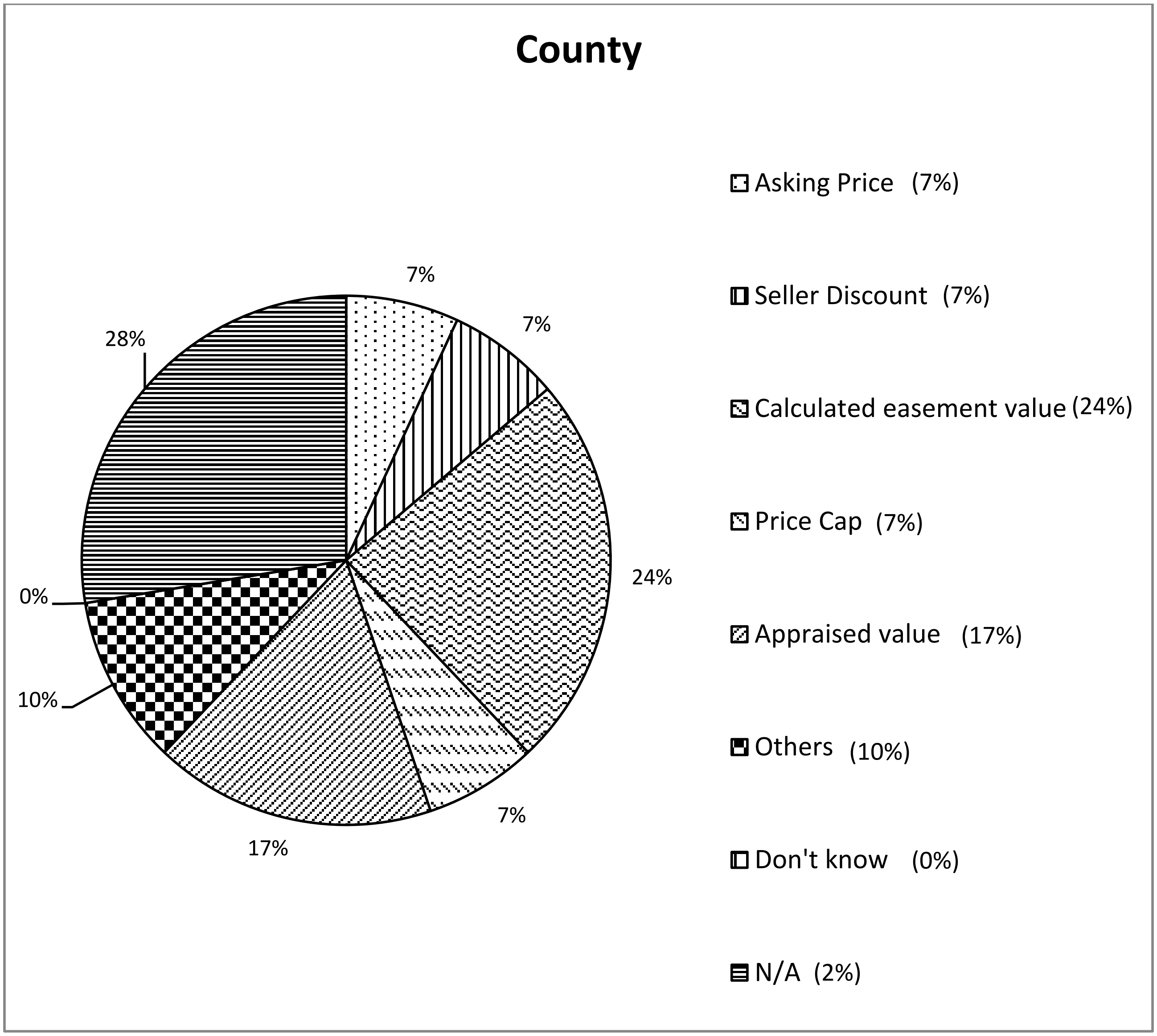


Figure 4.3: Easement cost factors considered and/or calculated by the Rural Legacy program

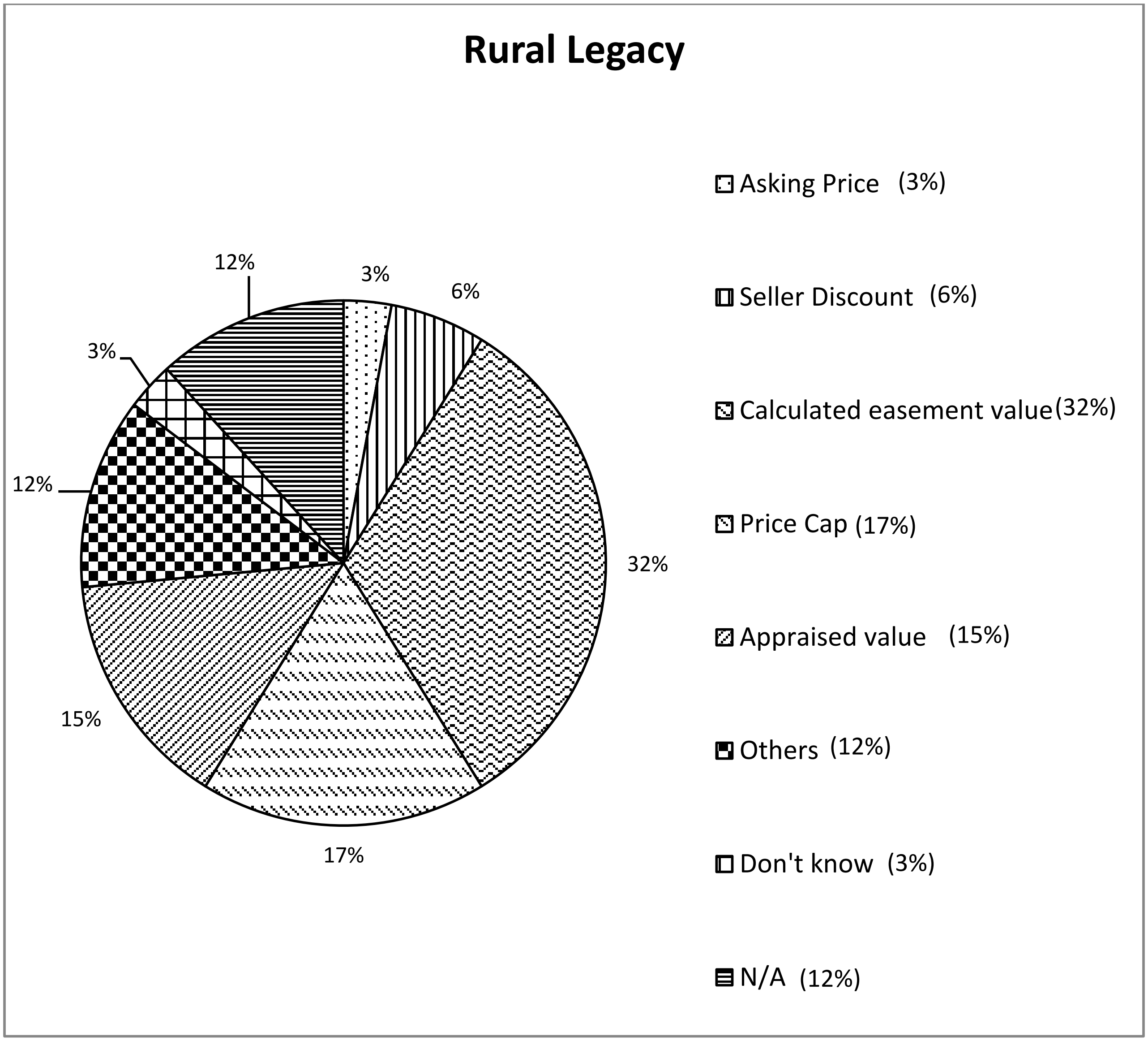


Figure 4.4: Use of easement cost in MALPF's program

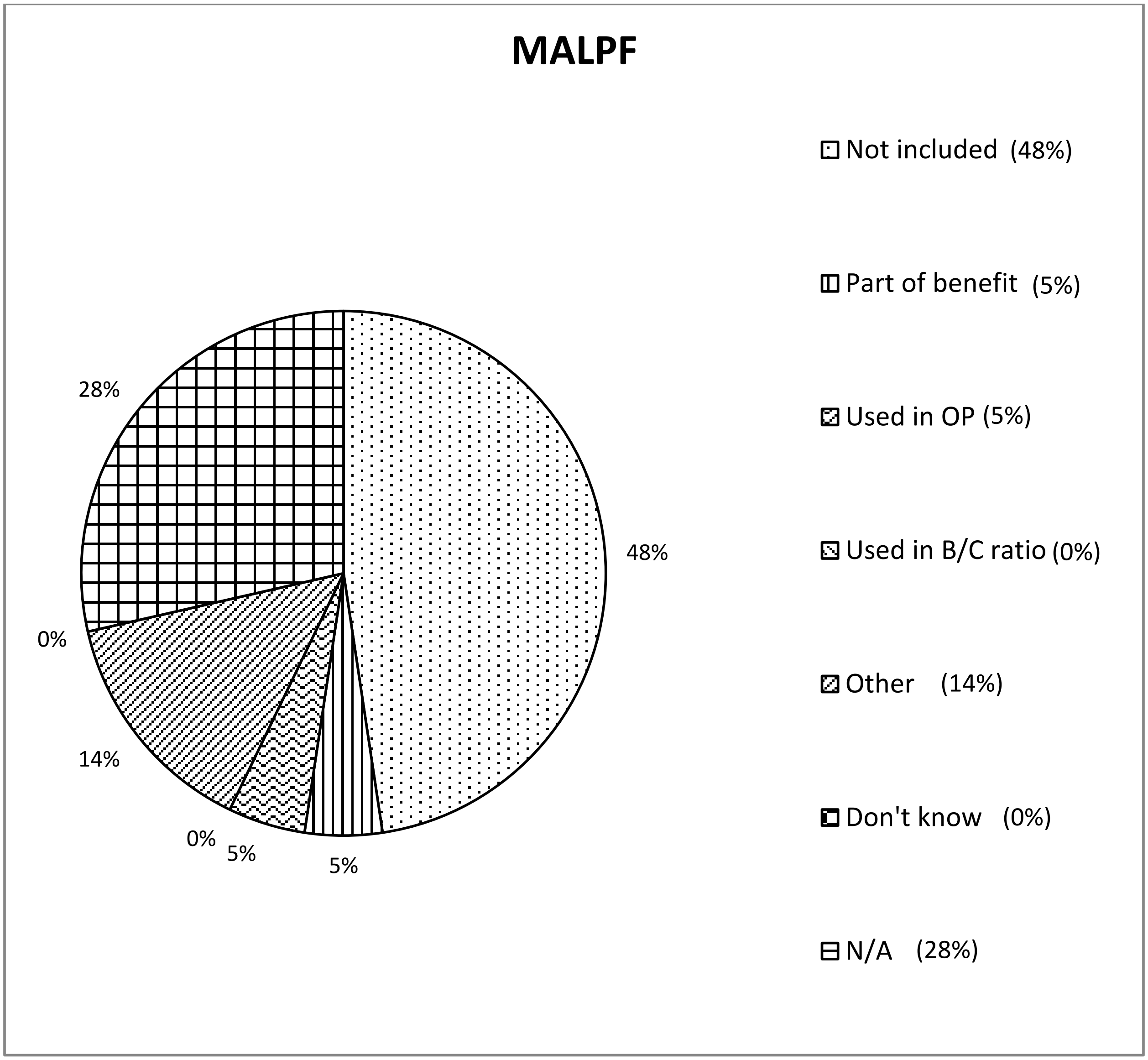


Figure 4.5: Use of easement cost in the county's program

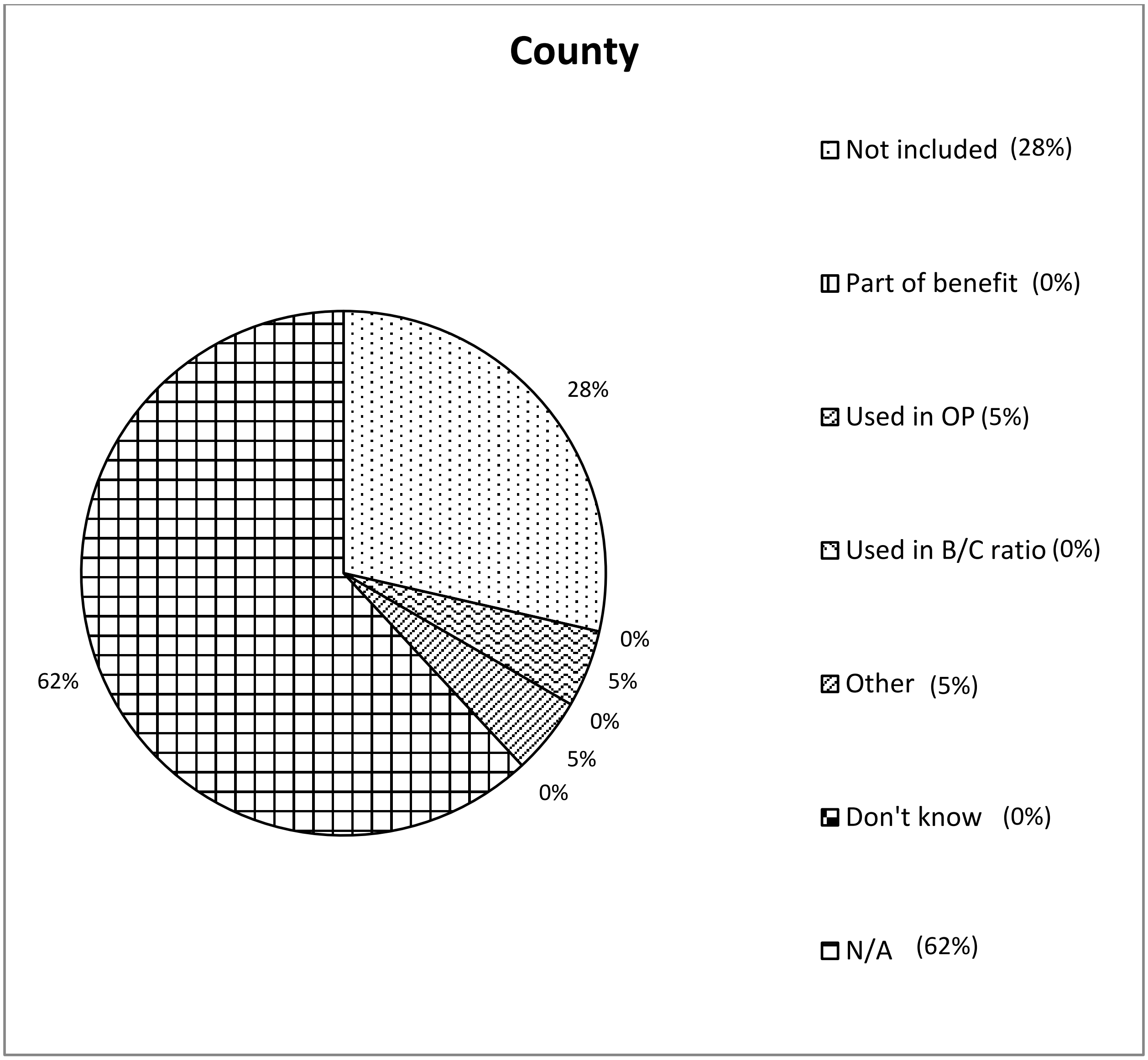


Figure 4.6: Use of easement cost in the Rural Legacy program

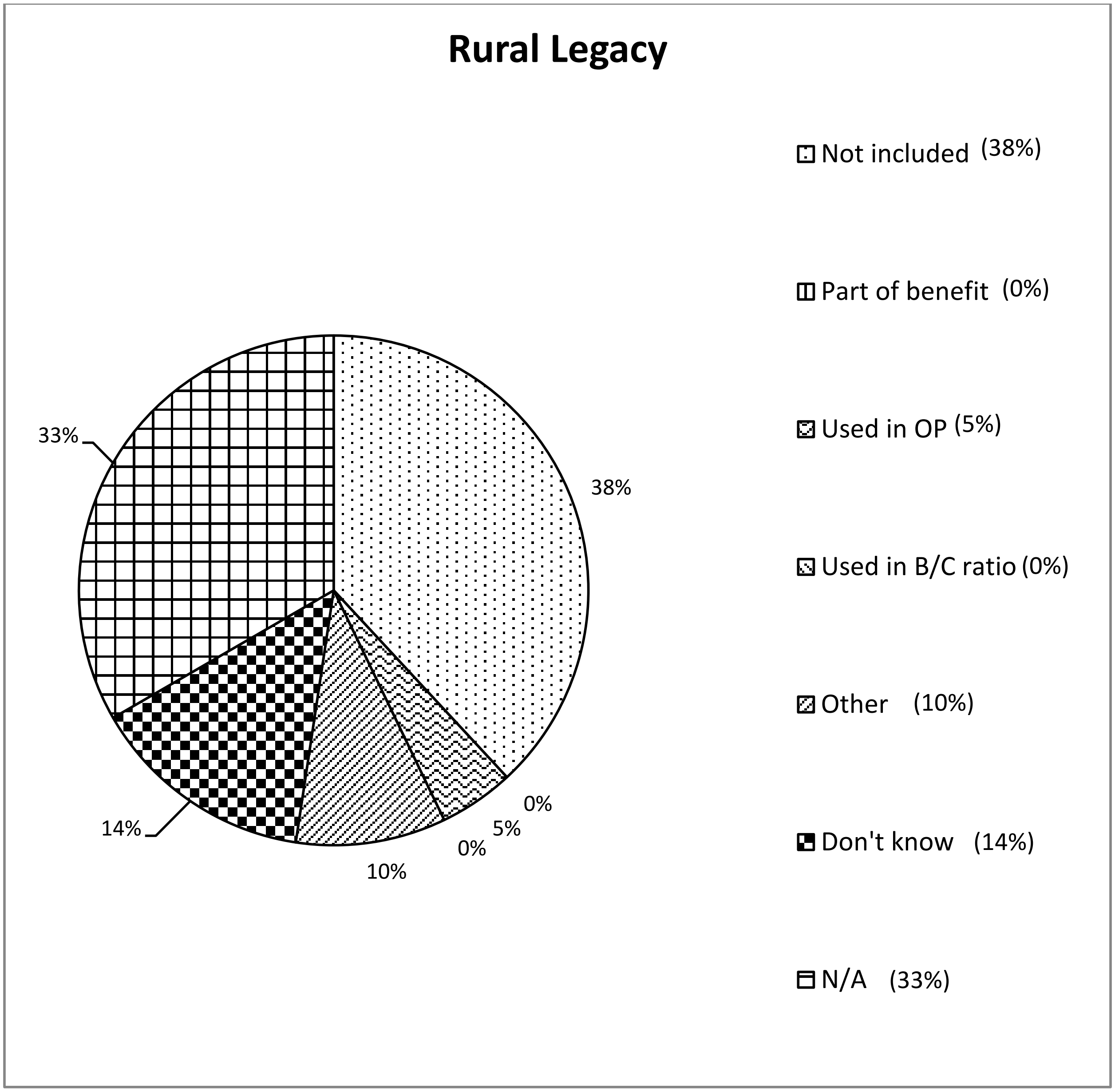


Figure 4.7: Use of selection process techniques for MALPF's program

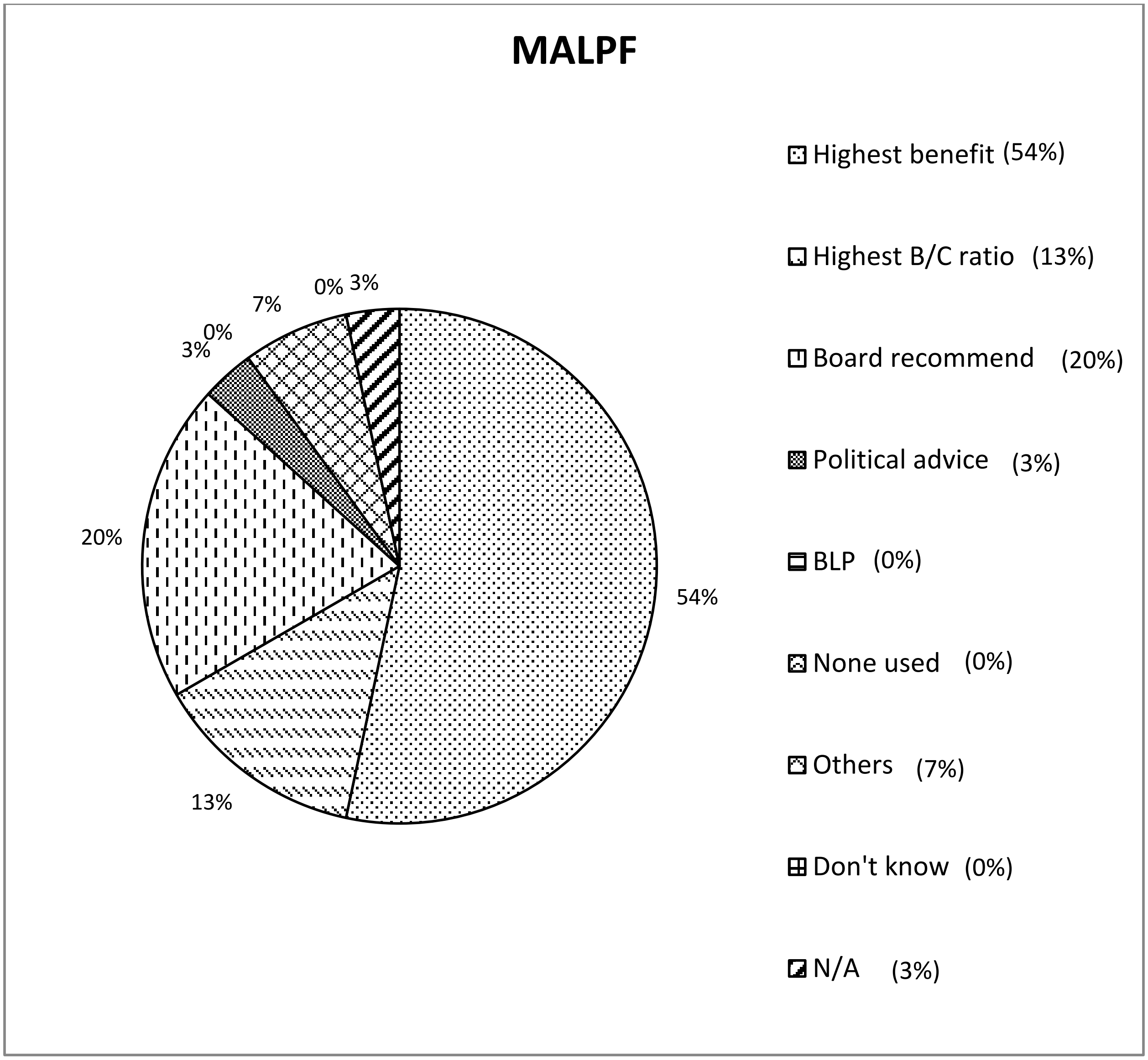


Figure 4.8: Use of selection process techniques by the county program

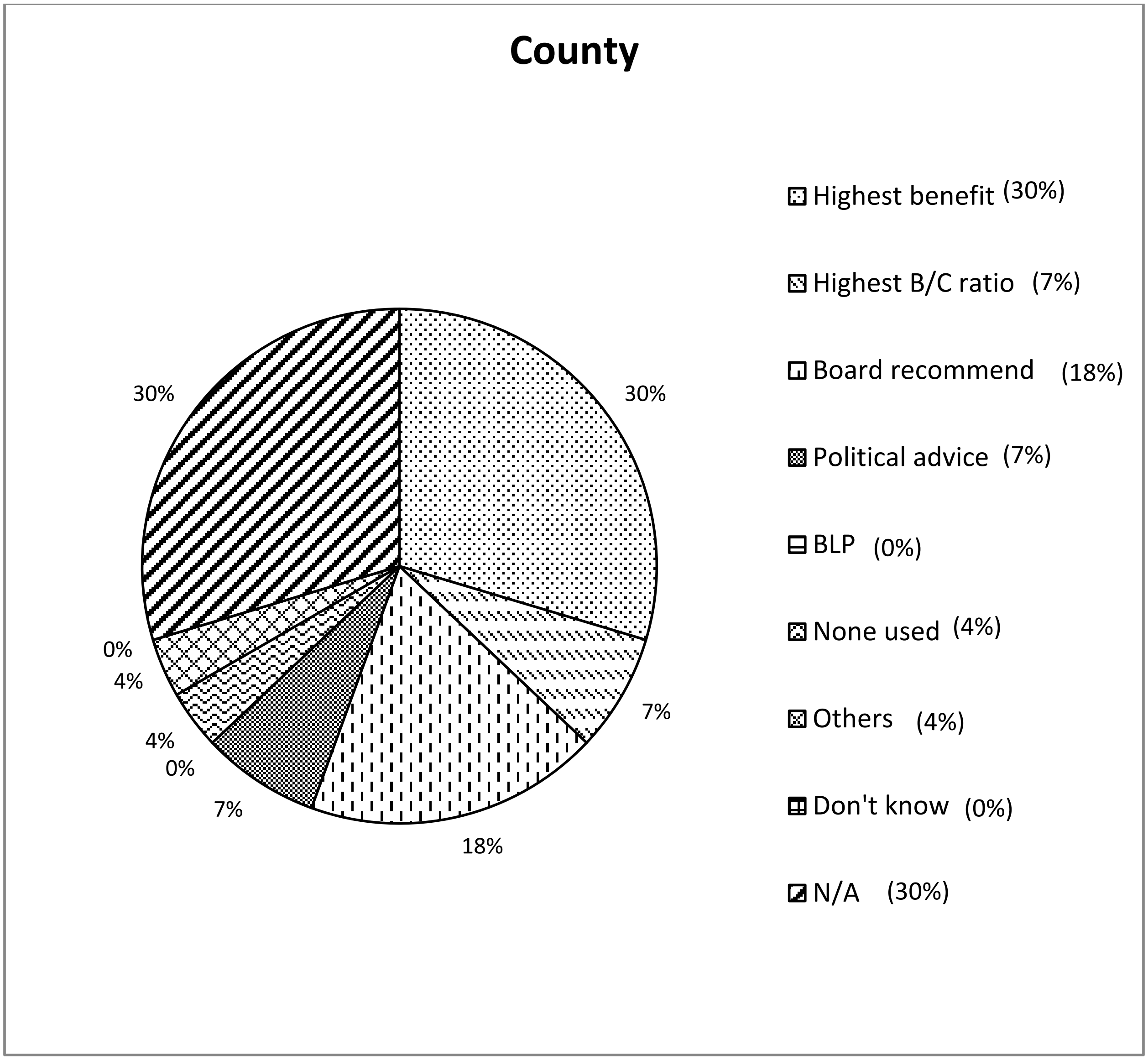


Figure 4.9: Use of selection process techniques for the Rural Legacy program

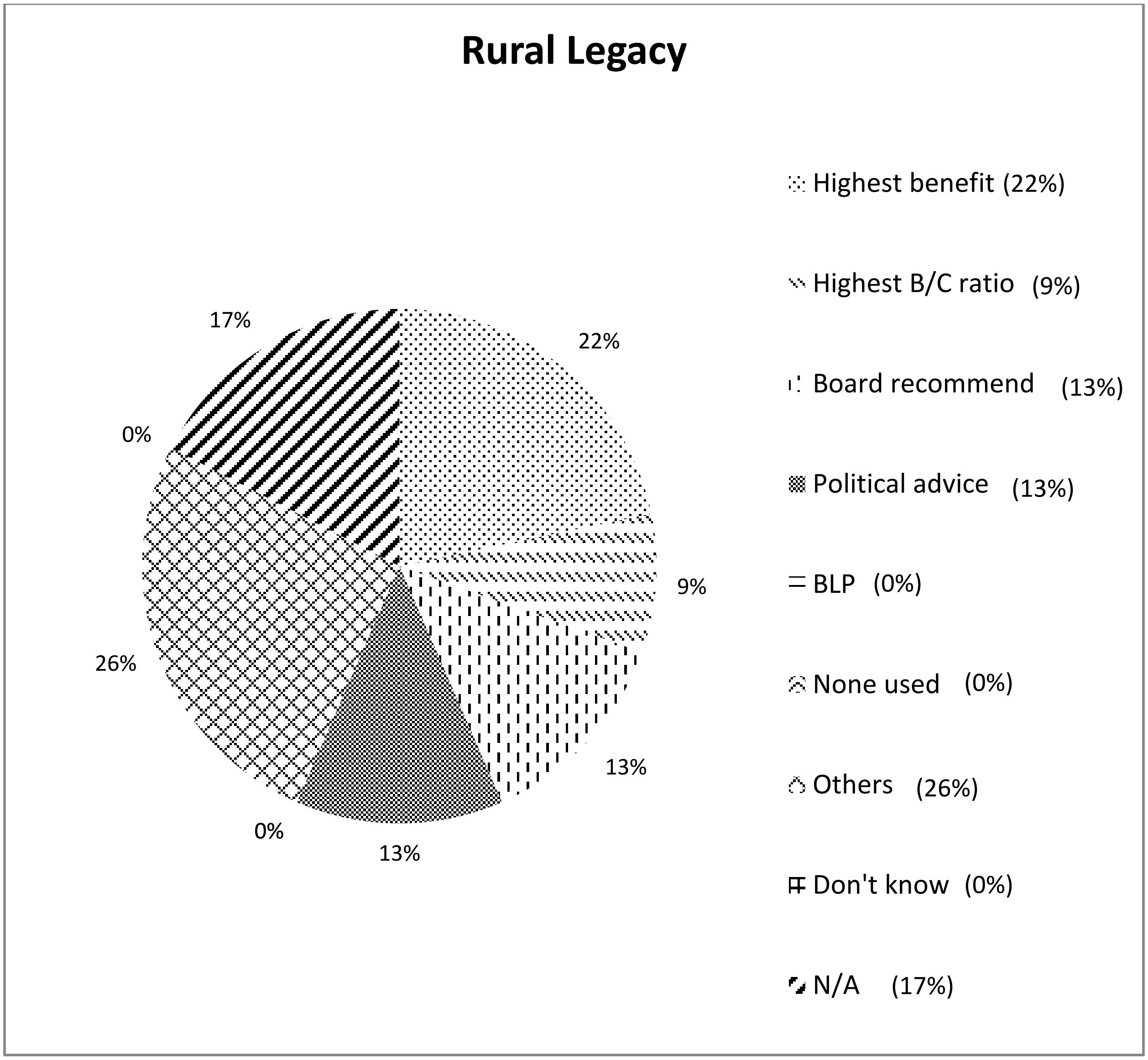
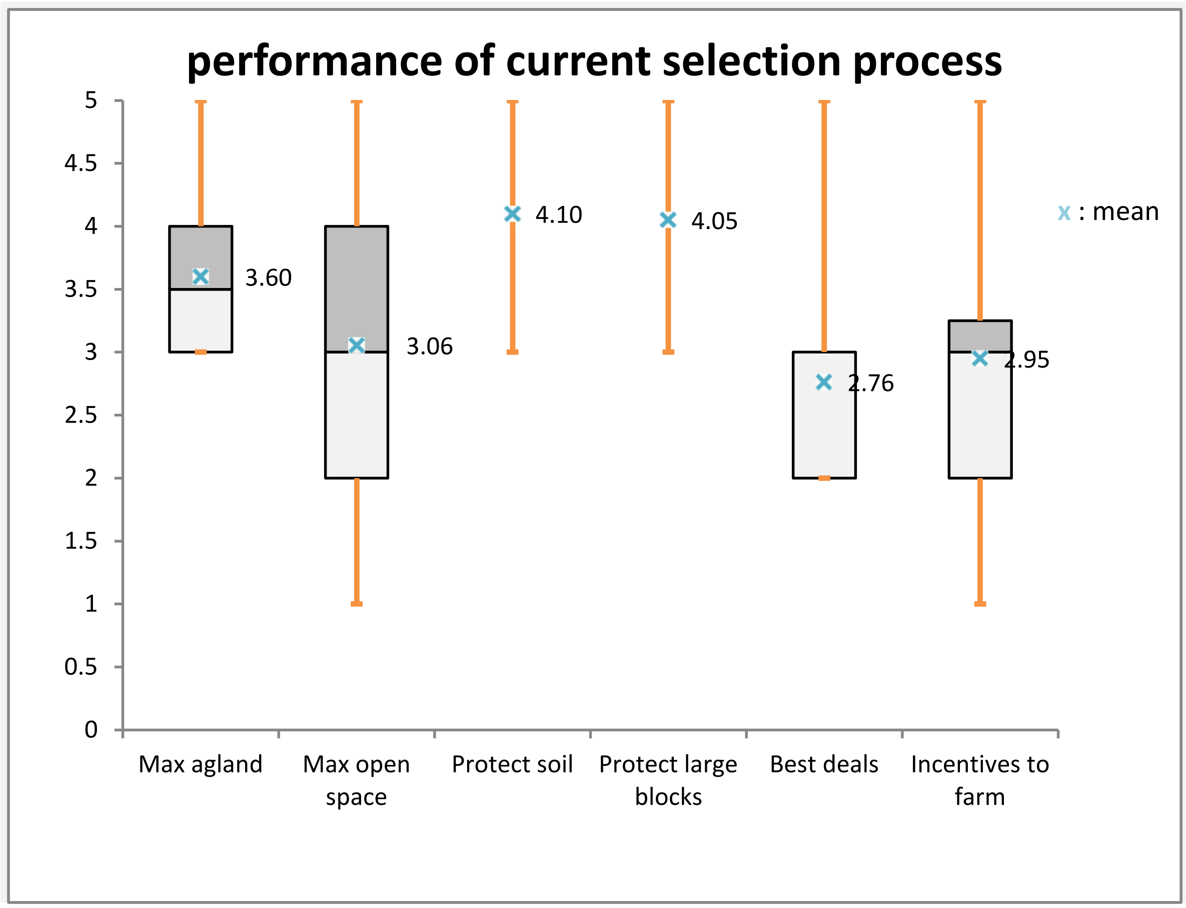


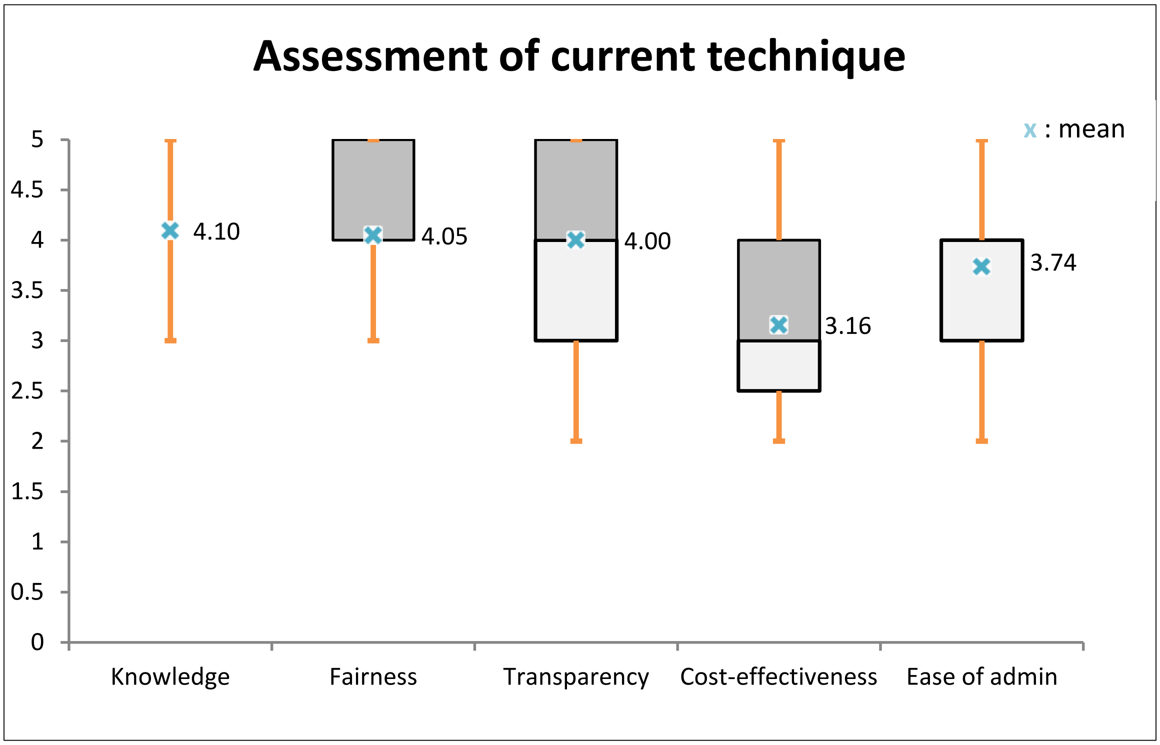
Figure 4.10: Assessments of the performance of current selection processes



* Variable description:

Max agland	Maximize the number of agricultural acres protected.
Max open space	Maximize the open space quality of acres protected.
Protect soil	Protect the best agricultural land in terms of soil.
Protect large blocks	Preserve large blocks of contiguous agricultural land.
Best deals	Acquire the best deals on agricultural land.
Incentives to farm	Increase incentives for participants to remain in farming.

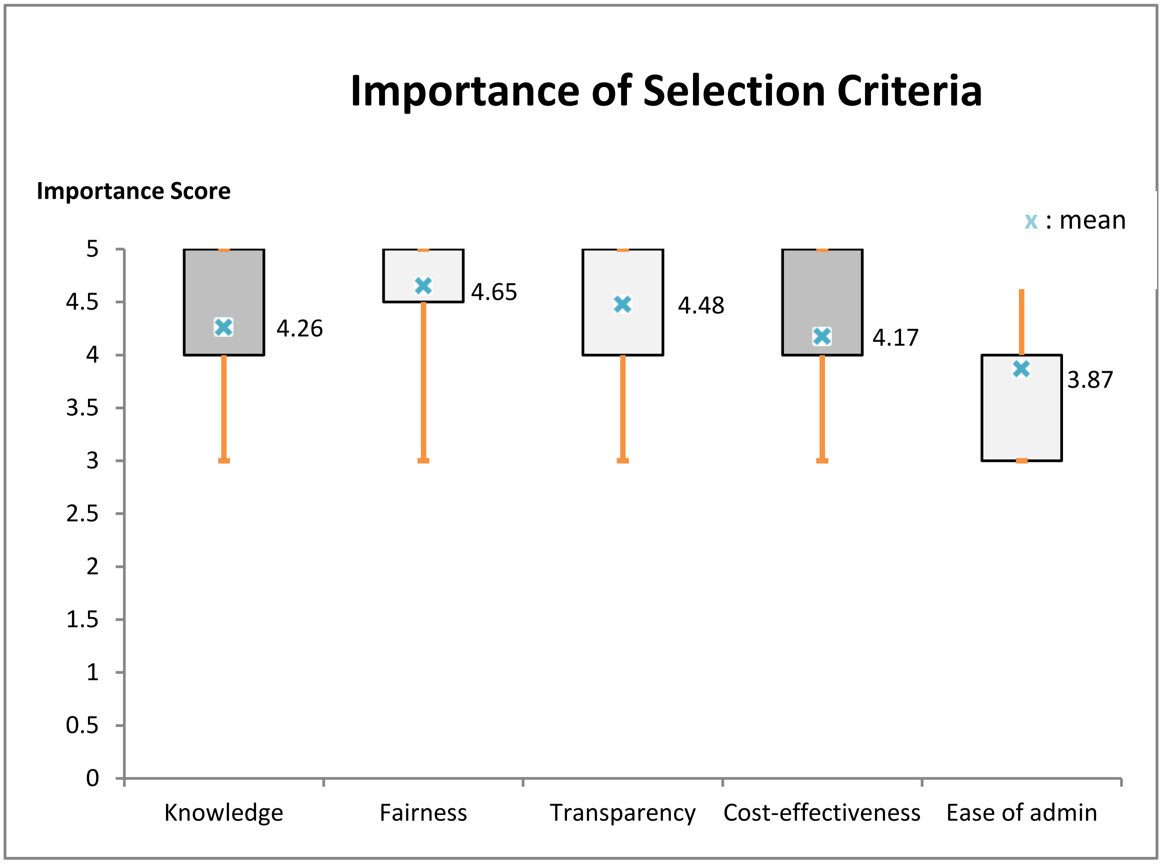
Figure 4.11: Assessment of various techniques used in current selection processes



* Variable Description:

Knowledge	Knowledge of staff on how to use this technique.
Fairness	Fairness to applicants.
Transparency	Transparency denotes ease of explanation to the public, advisory boards, potential applicants, etc.
Cost-effectiveness	Cost-effectiveness of the selection process
Ease of admin	Ease of administration.
Others	Other criteria not list above.

Figure 4.12: Box plot of average score for importance of criteria used to assess the selection process



* Variable Description:

Knowledge	Knowledge of staff on how to use the selection process.
Fairness	Fairness to applicants.
Transparency	Ease of explanation to the public, advisory boards, potential applicants, etc.
Cost-effectiveness	Cost-effectiveness of the selection process.
Ease of admin	Ease of administration.
Others	Other criteria not list above.

Figure 4.13: Education effect on knowledge of optimization

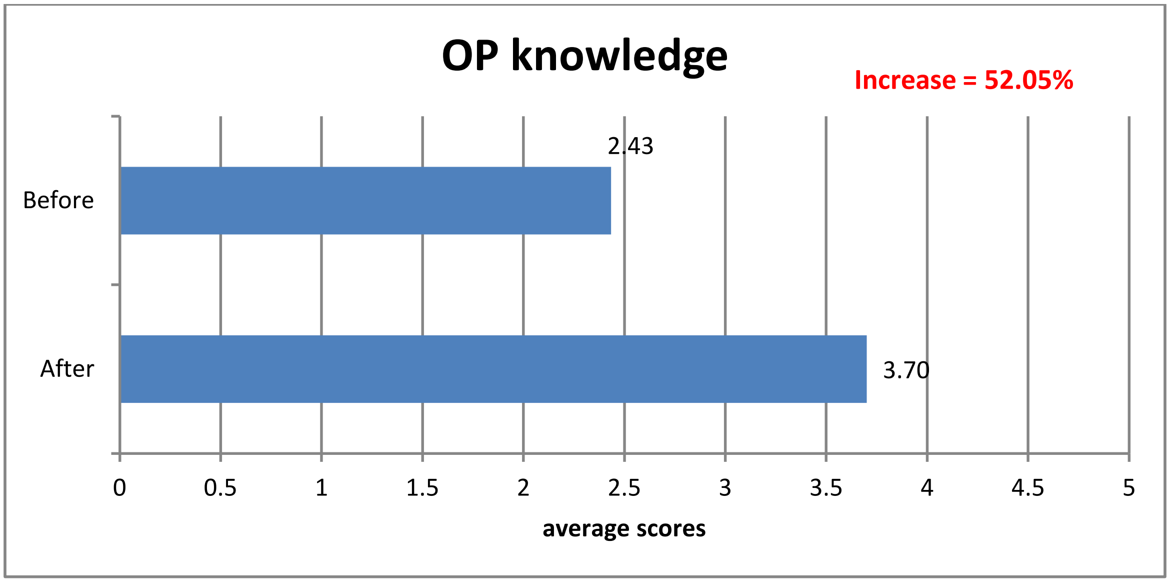


Figure 4.14: Willingness to adopt optimization under different scenarios

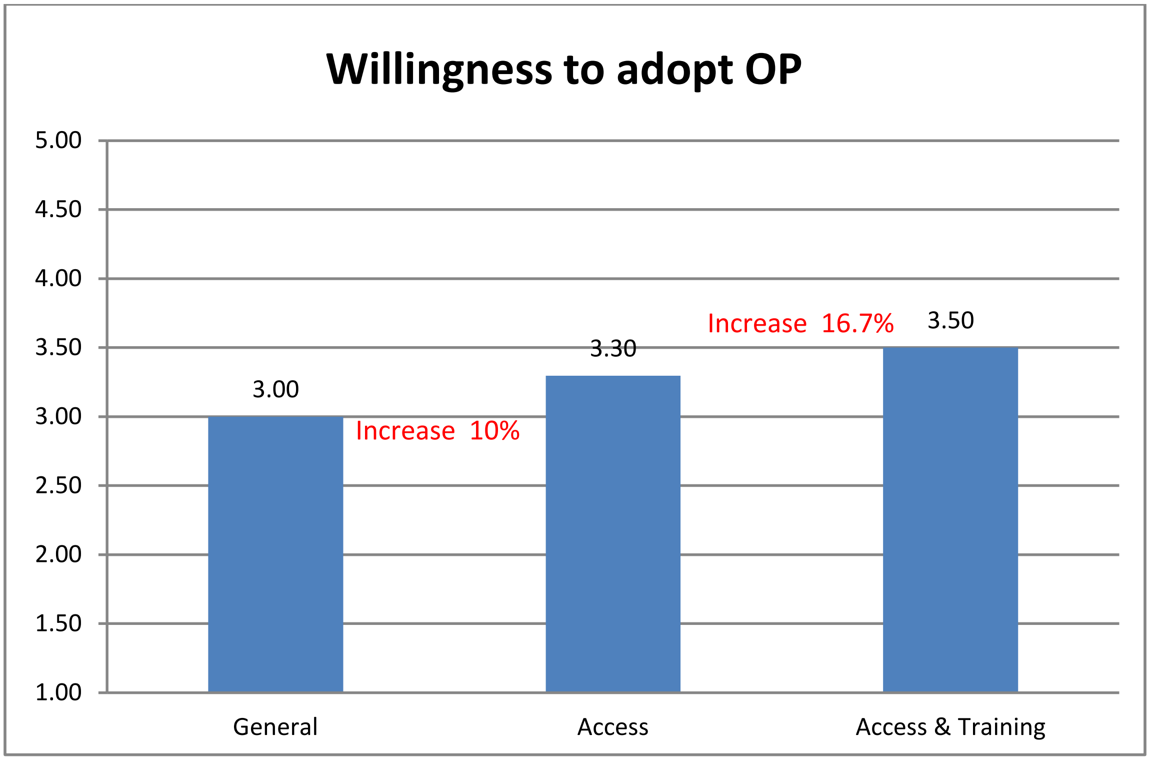
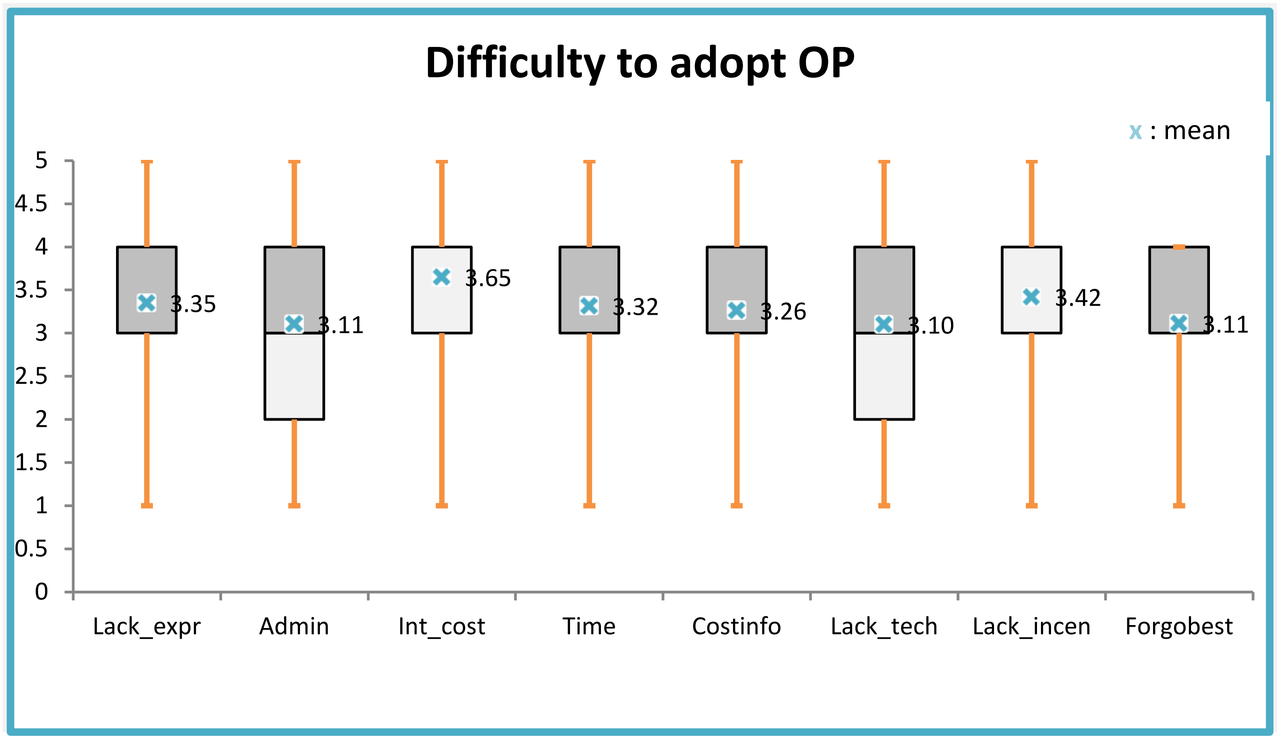


Figure 4.15: Obstacles to adopting optimization



* Variable Description:

Lack_expr Lack of previous experience.

Admin Administration of the process.

Int_cost Initial technical cost.

Time Time to implement the process.

Costinfo Need for cost information at the time of selection.

Lack_tech Lack of availability of technical resources.

Lack_incen Lack of incentives to justify a change in process.

Forgobest Possibly forgoing the “best” land regardless of cost.

Other Other obstacles not listed above.

Figure 4.16: Education effect on knowledge of binary linear programming

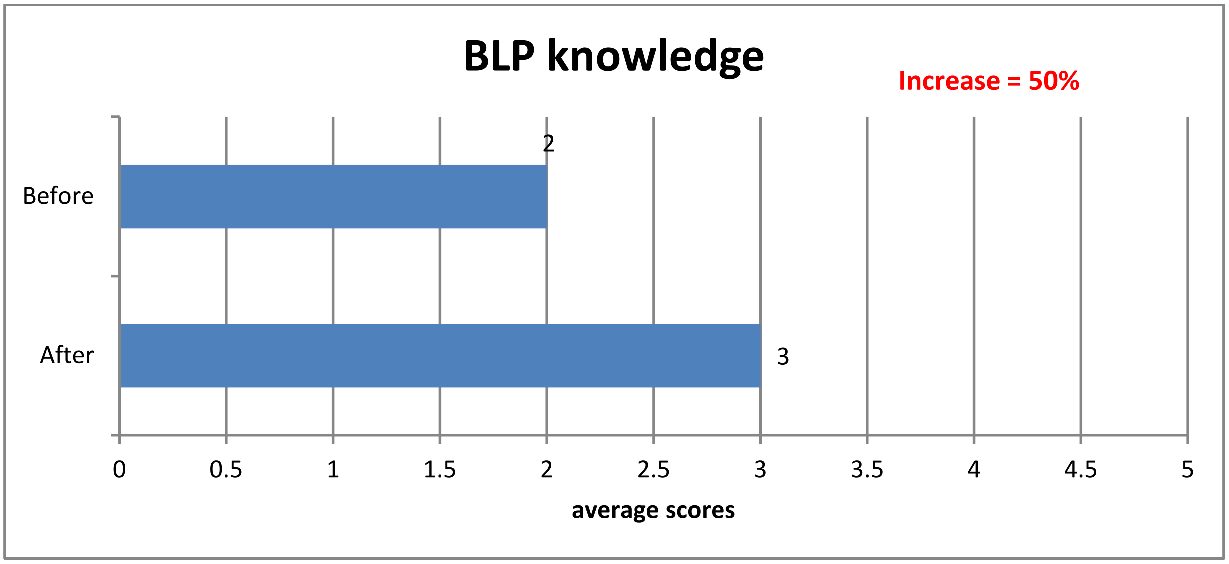


Figure 4.17: Assessments of Binary Linear Programming as a selection technique

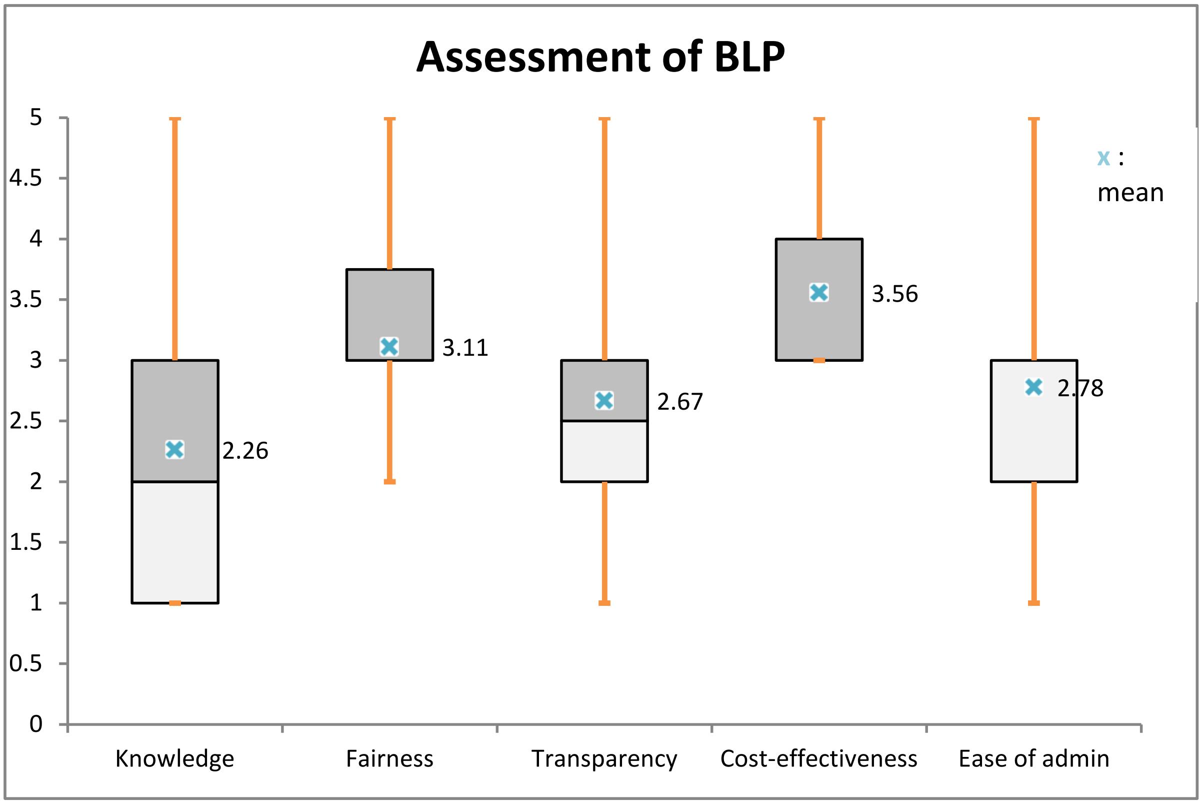


Figure 4.18: Education effect on knowledge of cost-effectiveness analysis

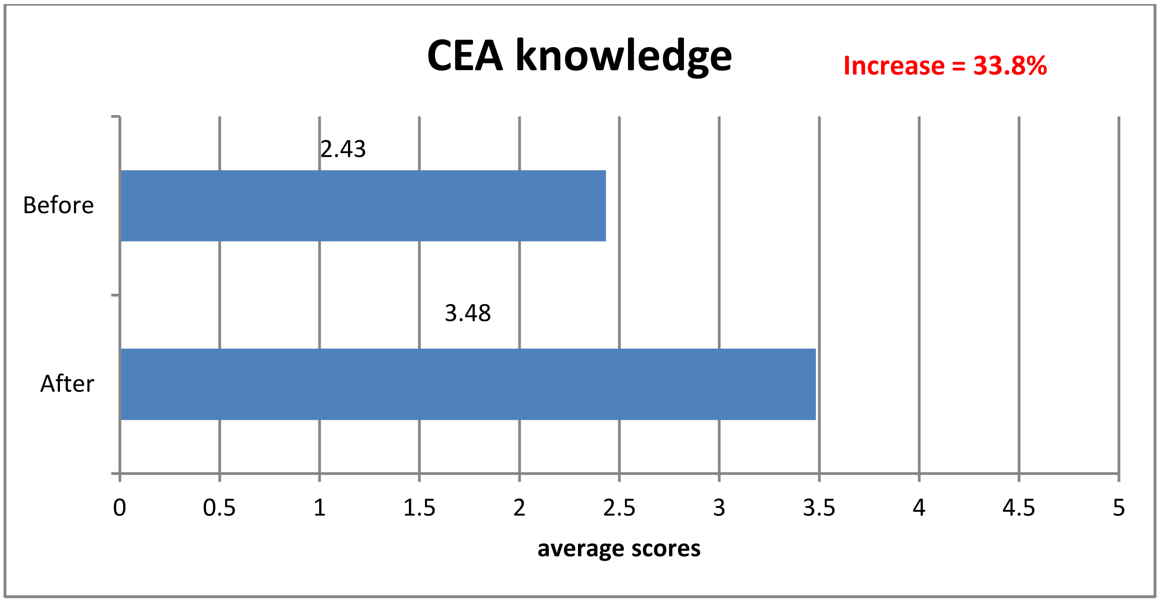
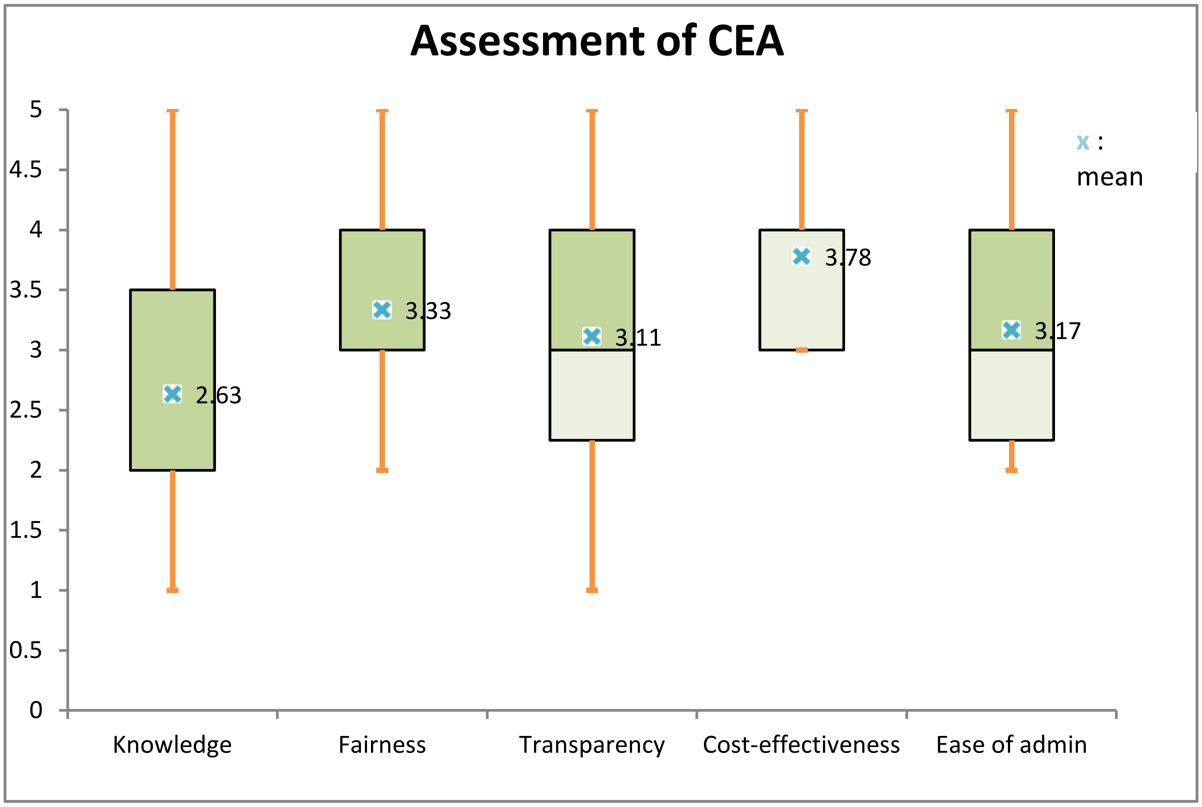


Figure 4.19: Assessment of cost-effectiveness analysis as a selection technique



Chapter 5

STATISTICAL ANALYSIS

This chapter explores the answer to the main question posed in this thesis: Why is optimization rarely adopted by conservation professionals? Using data collected from the survey, along with data from Maryland State Data Center, an ordered Probit model is applied to analyze the relationships between willingness to adopt optimization and the regressors. Another linear regression is then produced to describe how professionals assess the difficulty presented by potential obstacles differently. This chapter provides a description of the data set, the coefficients of the ordered Probit model and linear regression, and interpretation of the parameters and their meaning.

5.1 Description of the Data Set

5.1.1 Data Set of the Ordered Probit Model

The ordered Probit model analyzes factors that potentially influence a program administrator's decision to adopt optimization as a selection approach. The data set is comprised of 27 observations from administrators and senior staff members from every county in Maryland except Baltimore County. Included are 22 senior representatives, one from each of 22 counties, and five other county staff representatives. Baltimore County is excluded from the analysis because it had already adopted optimization in its MALPF and county programs.

The dependent variable WILLING represents the willingness of administrators to adopt optimization as the selection process for agricultural land preservations in the future and was collected from question 11 in the post-survey. WILLING is measured on a scale of one to five.

Dependent Variable: WILLING

= 1 if the respondent is not willing to adopt optimization at all

= 2 if the respondent is slightly willing to adopt optimization

= 3 if the respondent is somewhat willing to adopt optimization

= 4 if the respondent is willing to adopt optimization

= 5 if the respondent is very willing to adopt optimization

The regressors in the ordered Probit model are OPKNOW, LACK_EXPR, ADMIN, INT_COST, LACK_INCEN, PCT_PRESV, and RURALITY. Five of these independent variables are measured on a scale of one to five by the survey. OPKNOW is rated by responses to question 10 of the post-survey. It describes the respondents' level of knowledge and understanding of the optimization method after Dr. Messer's presentation.

Independent Variable: OPKNOW

= 1 if the respondent does not understand optimization at all

= 2 if the respondent understands optimization a little

= 3 if the respondent understands optimization somewhat

= 4 if the respondent understands optimization well

= 5 if the respondent understands optimization very well

LACK_EXPR, ADMIN, INT_COST, and LACK_INCEN represent data gathered by questions 12, 13, 14, and 18 in the post-survey. These factors describe potential obstacles to adopting optimization as the selection process. LACK_EXPR is lack of previous experience in applying optimization. ADMIN is the administrative requirements of the process. INT_COST is the initial technical cost for staff training and software. LACK_INC is a lack of incentive to justify a change in process. Respondents rated the difficulties presented by these obstacles on a scale of one to five.

Independent Variable: LACK_EXPR, ADMIN, INT_COST, LACK_INCEN

= 1 if the respondent views the obstacle as not difficult at all

= 2 if the respondent views the obstacle as slightly difficult

= 3 if the respondent views the obstacle as somewhat difficult

= 4 if the respondent views the obstacle as difficult

= 5 if the respondent views the obstacle as very difficult

PCT_PRESV is the percentage of total agricultural land that was preserved by individual counties from 2002 through 2007. The amount of farmland preserved comes from MALPF's 2002–2007 annual report. Information on the total number of acres of land in farms in Maryland in 2007 is from the 2007 Census of Agriculture collected by the U.S. Department of Agriculture's (USDA's) National Agricultural Statistics Service.

PCT_PRESV = Acres of Preserved Agricultural land ÷ Acres of Total Agricultural land

RURALITY measures the rurality of each county using data derived from urban influence codes (UIC) formulated by USDA's Economic Research Service (ERS).[9] It is one of three widely accepted rural classification systems. Based on the concepts of central place theory in regional economics, these codes were developed to account for factors such as population size, urbanization, and access to larger economies (Parker, 2007). The 2003 urban influence codes categorize counties as "metro" (metropolitan) and "nonmetro." Metro counties are then divided into two groups by the size of the metro area. Nonmetro counties are located outside of the boundaries of metro areas and are further subdivided into two types: micropolitan areas, which are defined as centered on

[9] The urban influence coding structure does not reflect a continuous decline in urban influence. Therefore, RURALITY cannot be used to explain the relationship between urban influence and program administrators' willingness to adopt optimization. Rather, the relationship provides a legitimate assumption that adjacency to metro areas brings a strong development threat to agricultural lands and breeds motivation among administrators to improve their selection techniques and processes.

urban clusters of 10,000 or more persons, and all remaining "noncore" counties. Micropolitan counties fall into one of three groups that are defined by adjacency to urban areas while noncore counties are divided into seven groups based on their adjacency to metro or micro areas and whether they have their "own town" of at least 2,500 residents (Cromartie, 2007). (See Table 5.1.).

5.1.2 Data Set of Linear Regression

The linear regression describes differences in the degree of difficulty that obstacles to adopting optimization present to respondents. These results analyze possible influences on program administrators' opinions regarding barriers to adoption. The data set contains 24 valid observations. Baltimore County is again excluded from the analysis because of prior adoption. The dependent variable of the regressions, MDIFF, which is the mean score of the eight obstacle variables, is generated from questions 12 through 19 of the post-survey (see Table 4.5). The degree of obstruction from the eight factors was measured on a scale of one to five. Therefore, the mean falls within the same range. The greater the mean, the more difficulty respondents predicted in adopting optimization.

The regressors are OPKNOW_NONE, OPKNOW_LITTLE, OPKNOW_SOME, OPKNOW_GOOD, and OPKNOW_EXCT. The independent variables are binary variables taking a value of either zero or one. They distinguish the level of knowledge and understanding of optimization expressed by the respondents. Therefore, this regression is called the knowledge model. It summarizes the relationship between the mean of the obstacle difficulty level and the knowledge level.

Independent Variable:

OPKNOW_NONE: the observation has no knowledge about optimization

= 1, if OPKNOW = 1
= 0, otherwise

OPKNOW_LITTLE: the observation has very little knowledge about optimization

= 1, if OPKNOW = 2

= 0, otherwise

OPKNOW_SOME: the observation has some knowledge about optimization

= 1, if OPKNOW = 3

= 0, otherwise

OPKNOW_GOOD: the observation has good knowledge about optimization

= 1, if OPKNOW = 4

= 0, otherwise

OPKNOW_EXCT: the observation has excellent knowledge about optimization

= 1, if OPKNOW =5

= 0, otherwise

5.2 Ordered Probit Model

5.2.1 Model Specification

An ordered Probit model is used with the survey data to estimate relationships between an ordinal dependent variable and a set of regressors. The ordinal variable is WILLING, which is categorical and ordered and indicates the respondents' willingness to adopt optimization from low to high. In the ordered Probit model, an underlying score is estimated as a linear function of the regressors and a set of cut points. The probability of observing outcome *k* corresponds to the probability that the estimated linear function plus residuals is within the range of the cut points estimated for the outcome.

$$P(willingness = 1 \mid X) = P\,(Xi'\beta+\xi i \leq U_1 \mid X) = \Phi\,(U_1 - Xi'\beta)$$

$$P(willingness = 2 \mid X) = P\,(U_1 < Xi'\beta+\xi i \leq U_2 \mid X) = \Phi\,(U_2 - Xi'\beta) - \Phi\,(U_1 - Xi'\beta)$$

$$P(willingness = 3 \mid X) = P\,(U_2 < Xi'\beta+\xi i \leq U_3 \mid X) = \Phi\,(U_3 - Xi'\beta) - \Phi\,(U_2 - Xi'\beta)$$

$$P(willingness = 4 \mid X) = P\,(U_3 < Xi'\beta+\xi i \leq U_4 \mid X) = \Phi\,(U_4 - Xi'\beta) - \Phi\,(U_3 - Xi'\beta)$$

$$P(willingness = 5 \mid X) = P\,(Xi'\beta+\xi i > U_4 \mid X) = 1 - \Phi\,(U_4 - Xi'\beta)$$

In other words, we assume that each observation has an underlying real willingness that takes a value of U. The probability that observation *i* has a willingness of 1 equals the probability that his or her real willingness, U, is no bigger than U_1. The probability that observation *i* has a willingness of 2 equals the probability that his or her real willingness, U, is between U_1 and U_2.

5.2.2 Model Results

STATA software is used to conduct the analysis. The actual values of the coefficients are irrelevant except that larger values are assumed to correspond to "higher" outcomes. A positive sign on the coefficients represents a positive influence on the dependent variable. Table 5.2 displays the regression results from the equations previously described. Six of the seven explanatory variables are significant at the 95% level. The survey's parameter estimators of OPKNOW and ADMIN are significantly positive. The positive OPKNOW coefficient is 2.31, indicating that the more knowledge the respondent has about optimization, the more willing he or she is to adopt it. The positive ADMIN coefficient is 2.79, indicating that willingness increases when more difficulties are predicted in administration of the optimization process. This may imply that program administrators' assumptions about the superiority of a method are in direct proportion to the method's perceived sophistication. It may also imply that the administrative process is not the major concern in determining whether a new method shall be adopted. Participants may assume that optimization can ultimately simplify the whole administration process once people have abundant experience with it. Baltimore County's story validates that assumption. Robert Hirsch said "Optimization has proven easier to administer and run than our old methods. During our rank-based days, we performed extra administrative and mathematical work in order to solicit discounts and award extra LESA points for discounting. With optimization, this is no longer required." In addition, a WALD test shows that the coefficient of ADMIN is not statistically different from that of OPKNOW at the 10% significance level (see Table 5.3). Therefore, both variables have essentially the same influence on willingness.

Three survey parameter estimators—LACK_EXPR, INT_COST, and LACK_INCEN—have a negative sign. These estimators represent obstacles to use of optimization. The LACK_EXPR coefficient is -1.88, showing that the less experience a county has with optimization, the less willing it is to adopt it. The INT_COST coefficient is -2.66, indicating that the initial technical cost is a considerable obstacle to adoption. Both limited budgets and a prediction of high technical costs discourage administrators from using optimization. The LACK_INCEN coefficient is -2.85. The more unwilling a county is to change the status quo, the less willing it is to adopt a new approach. The three coefficients are not statistically significantly different from one another. Therefore, lack of experience, the initial technical cost, and a lack of incentive to change have about the same effect on the decision.

The PCT_PRESV coefficient is significantly positive, meaning that the greater the percentage of agricultural land that the county has preserved, the more willing it is to adopt optimization. Counties with greater percentages of preserved agricultural land may have larger budgets or more experienced employees, which would provide them with more resources both financially and technically. Such counties may also have more incentive to develop better practices, further improving their effectiveness. Their administrators may place a high value on techniques in the preservation process and be more open to embracing new ideas and approaches. The absolute value of the coefficient is not comparable to those of the previously discussed parameters because this variable is not a categorical value obtained from the survey but is a very small contiguous percentage number instead.

The RURALITY estimator takes a negative sign and a value of -0.33, which is not significant at the 10% level but is significant at the 15% level. Our sample was comprised of only 22 observations. As a result, the negative coefficient can be viewed as significant. It reflects the strong development pressures that can arise from high population densities and access to larger economies that are centers of information, communication, trade, and finance. These pressures are a major concern for preservation program administrators. Therefore, the more urban a county is or the closer it is to an urbanized area, the more willing program administrators are to use a highly cost-effective approach to preserve agricultural lands.

5.3 Knowledge Model

5.3.1 Model Specification

The dependent variable in the knowledge model is the mean of the eight obstacle variables. The independent variables are binary. Therefore, the knowledge model can use a linear regression without a constant to estimate the population mean for the overall difficulty level at each knowledge level. The knowledge model can be expressed as follows:

(1) $MDIFF = \beta 1 * OPKNOW\_NONE + \beta 2 * OPKNOW\_LITTLE + \beta 3 * OPKNOW\_SOME + \beta 4 * OPKNOW\_GOOD + \beta 5 * OPKNOW\_EXCT$

OPKNOW_NONE has only one value, zero. Hence, it is omitted from the regression estimation.

5.3.2 Model Results

STATA software is used to conduct the analysis. After the parameter estimation is complete, a WALD test is formulated to test the true value of these parameters. By restricting one parameter to being equal to another, we can compare differences in knowledge levels. Table 5.5 provides the regression results. Table 5.6 provides the WALD test results. All respondents had at least some knowledge about optimization after the presentation; therefore, OPKNOW_NONE is zero for all observations and omitted from the regression. The remaining four parameters are significant at the 99% level. According to the WALD test, they are significantly different from each other at the 95% level. The coefficients of OPKNOW_LITTLE, OPKNOW_SOME, OPKNOW_GOOD, and OPKNOW_EXCT are 1.88, 1.18, 0.81, and 0.4, respectively, with a steady decrease in order. This result illustrates that an administrator who feels knowledgeable about the approach will predict less difficulty in adopting it. It suggests that increasing administrators' understanding of the approach dispels their doubts about using it. Consequently, education can promote adoption of optimization in practice.

Table 5.1: 2003 Urban influence codes

Code	2003 Urban Influence Codes
1	Large—in a metro area with at least 1 million residents or more
2	Small—in a metro area with fewer than 1 million residents
3	Micropolitan area adjacent to a large metro area
4	Noncore adjacent to a large metro area
5	Micropolitan area adjacent to a small metro area
6	Noncore adjacent to a small metro area with town of at least 2,500 residents
7	Noncore adjacent to a small metro area and does not contain a town of at least 2,500 residents
8	Micropolitan area not adjacent to a metro area
9	Noncore adjacent to micro area and contains a town of at least 2,500 residents
10	Noncore adjacent to micro area and does not contain a town of at least 2,500 residents
11	Noncore not adjacent to a metro/micro area and contains a town of 2,500 or more residents
12	Noncore not adjacent to a metro/micro area and does not contain a town of at least 2,500 residents

Table 5.2: Ordered Probit regression

			Number of ob.	=	22	
			LR chi2(7)	=	37.25	
			Prob > chi2	=	0.0000	
Log likelihood = -11.422877			Pseudo R2	=	0.6199	

WILLING	Coef.	Std.	z	P>|z|	[95% Conf.	Interval]
OPKNOW	2.317214	0.980028	2.36	0.018	0.396394	4.238035
LACK_EXPR	-1.88336	0.857706	-2.2	0.028	-3.56444	-0.20229
ADMIN	2.791324	1.123973	2.48	0.013	0.588379	4.99427
INT_COST	-2.66958	1.057707	-2.52	0.012	-4.74265	-0.59652
LACK_INCEN	-2.85349	1.014945	-2.81	0.005	-4.84275	-0.86424
PCT_PRESV	241.2943	93.11752	2.59	0.010	58.7873	423.8013
RURALITY	-0.32926	0.227968	-1.44	0.149	-0.77607	0.117552
/cut1	-7.62639	4.474297			-16.3959	1.143075
/cut2	-4.6518	4.208904			-12.9011	3.597503
/cut3	1.353044	4.027364			-6.54045	9.246533
/cut4	3.04914	4.001569			-4.79379	10.89207

Table 5.3: WALD test of ordered Probit model

P(Willingness=k) = Φ ($U_{k-1} < U \leq U_k$)

U = β1 * OPKNOW + β2 * LACK_EXPR + β3 * ADMIN + β4 * INT_COST + β5 * LACK_INCEN + β6 * PCT_PRESV + β7 * RURALITY

Null Hypothesis	**Test Statistics**		
	Chi^2 (n)	**n**	**Prob > Chi^2**
B1 = β3	0.63	1	0.4284
β2 = β4	1.69	1	0.1939
β2 = β5	2.01	1	0.1566
B4 = β5	0.08	1	0.7800
β2 = β4 = β5	2.50	2	0.2870

Table 5.4: 2003 urban influence codes for Maryland Counties

County Name	2003 Urban Influence Code*	2000 Population	Persons per Square Mile in 2000
Allegany	2	74,930	176.13
Anne Arundel	1	489,656	1,177.23
Baltimore	1	754,292	1,260.12
Calvert	1	74,563	346.52
Caroline	4	29,772	93.00
Carroll	1	150,897	335.98
Cecil	1	85,951	246.89
Charles	1	120,546	261.49
Dorchester	5	30,674	55.02
Frederick	1	195,277	294.59
Garrett	7	29,846	46.06
Harford	1	218,590	496.40
Howard	1	247,842	983.35
Kent	4	19,197	68.70
Montgomery	1	873,341	1,762.49
Prince George’s	1	801,515	1,651.14
Queen Anne’s	1	40,563	108.98
St. Mary’s	3	86,211	238.65
Somerset	2	24,747	75.63
Talbot	3	33,812	125.63
Washington	2	131,923	287.96
Wicomico	2	84,644	224.42
Worcester	5	46,543	98.35

Table 5.5: Knowledge model

Number of ob. = 24
F(4, 20) = 217.79
Prob > F = 0.0000
R-squared = 0.9776
Adj. R-squared = 0.9731
Root MSE = .54838

MDIFF	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
OPKNOW_LITTLE	1.875	0.274188	6.84	0	1.303054	2.446946
OPKNOW_SOME	1.184028	0.0527675	22.44	0	1.073957	1.294099
OPKNOW_GOOD	0.8125	0.04847	16.76	0	0.7113933	0.9136067
OPKNOW_EXCT	0.4	0.063321	6.32	0	0.2679147	0.5320853

Table 5.6: WALD test of knowledge model

MDIFF = $\beta1$ * OPKNOW_NONE + $\beta2$ * OPKNOW_LITTLE + $\beta3$ * OPKNOW_SOME + $\beta4$ * OPKNOW_GOOD + $\beta5$ * OPKNOW_EXCT

Null Hypothesis	**Test Statistics**	
	F (1, 20)	**Prob > F**
$\beta2 = \beta3$	6.12	0.0224
$\beta2 = \beta4$	14.56	0.0011
$\beta2 = \beta5$	27.47	0.0000
$B3 = \beta4$	26.89	0.0000
$B3 = \beta5$	90.48	0.0000
$B4 = \beta5$	26.76	0.0000

Chapter 6

SUMMARY AND CONCLUSION

This last chapter summarizes major conclusions from the survey and the two regressions. It discusses the best practice framework for MALPF to cost-effectively preserve agricultural lands. It also outlines the limitations of the study. Suggestions for future research are given at the end.

6.1 Survey Conclusions

Descriptive statistics revisit the current usage of benefit factors, cost factors, selection algorithms in each county as well as their perception to the new selection approach – optimization. Since county difference is targeted, survey data from the 23 senior representatives is used to conduct the analysis. The 23 senior representatives include 21 MALPF's county administrators and 2 senior staff, one from each of 23 counties.

According to the descriptive statistics from the pre-survey, respondents in the study have a profound level of knowledge and experience with agricultural land preservation. The survey results identify levels of performance and procedures used by Maryland's current programs. The one fact universally used to measure the benefits of a parcel under consideration for protection is soil quality. The parcel's size and the development pressure to which it is subject are the next two most often used benefit factors included in decision-making. Environmental factors are not taken into consideration in most of the counties, which contradicts prior research on the public's preference (Kline & Wichelns, 1996; Duke & Hyde, 2002). The public attaches great importance to environmental benefits when preserving agricultural land. However, this study shows that professionals are more interested in agriculture benefits such as soil quality, or development threat issues.

Meanwhile, a cost analysis is seldom used. Cost is typically viewed as the asking price of the parcel or the amount required to purchase the development rights. Acquisition and transaction costs are easy to calculate and comparable in practice, which helps to explain why professionals take them as the easement's cost. However, even when cost is calculated, it is not generally included as a criterion in the selection process. More than half (57.6%) of the programs in Maryland's 23 counties do not consider a cost analysis as applicable; 21.6% use the easement cost solely to determine the availability of funding. A small number of the respondents, 12%, did not know whether they use cost information in the selection process. Because so little attention is paid to costs, most counties use a simple but biased formula when they calculate the cost at all. It is not surprising, then, that program administrators do not attend to the cost until they come up against a budget restraint. Given their priorities in current selection processes, administrators are confident that they are successfully protecting high-quality soils, large blocks of land, and agricultural uses. Nevertheless, they acknowledge that the programs may not be as cost-effective as they could be.

According to the descriptive statistics from the post-survey, cost-effectiveness is not the top selection criterion. Therefore, although optimization can improve the overall efficiency and effectiveness of the parcels selected by maximizing their combined benefits and/or minimizing the cost of achieving the preservation goal, it may not appeal to conservation professionals in practice until they understand what this operations research tool has to offer. The administrators' willingness to adopt optimization increases when their knowledge of it grows. Prendergast et al. (1999) suggested that lack of awareness is the main reason for low levels of adoption of advanced conservation techniques and that communication between theoreticians and practitioners by way of workshops could help bridge the gap. This study demonstrates that an administrator's level of knowledge increases significantly after an educational presentation on optimization. That knowledge does, however, remain limited. A comparison of the two optimization techniques, binary linear programming and cost-effectiveness analysis, indicates that conservation professionals generally do not have enough expertise to understand their relative advantages. The respondents highly value fairness and transparency and do not pay much attention to the ease of administration.

Both in order probit mode and knowledge model, a second sample population was employed to complete the analysis. This sample is comprised of 27 observations, including 22 senior representatives, one from each of 22 counties, and five other county staff representatives. Baltimore County is excluded from the analysis because it had already adopted optimization in its MALPF and county programs. As a result, some county would have more than one observation to account for their willingness. However, instead of modeling each county's willingness, our model explores individual's willingness and potential forces to influence their personal decision making. Therefore, all 27 observations shall be viewed as one sample, representing the community of conservation professionals in Maryland counties, where optimization has not been adopted yet.

The ordered Probit model shed further light on improvements we can make in an effort to build a best practice framework using optimization. The primary survey results demonstrate that a better understanding of optimization increases willingness to adopt it. In addition, the required initial investment in technical resources has prevented program administrators from using this new approach. If there is no perceptible incentive to alter the current system, they surely will not be willing to put optimization to use. Administrators who have been the most successful in protecting land in terms of the percentage of farmland available are most willing to adopt more advanced approaches. Similarly, metro areas that are experiencing particularly strong development pressures are more willing than nonmetro areas to step up their efforts by adopting "sophisticated" but cost-effective preservation techniques. The knowledge model indicates that administrators' predictions about obstacles to adoption are related to how much they know about the new approach. The more people know about optimization, the less difficulty they perceive.

In conclusion, to build a best practice framework for MALPF, education on optimization and/or training on the optimization decision tool must first be provided to program administrators and employees. Training should address the importance of a cost analysis and the value of being able to customize benefit factors in the analysis. Familiarity with the optimization tool will relieve concerns about implementing it, increase the incentive to reform existing processes, and increase willingness to employ a new tool. To customize optimization for Maryland's counties, the percentage of preserved land and geographic context should be used in the analyses. Optimization can be applied to counties in metro areas with greater percentages of preserved agricultural lands first. Since those counties are facing the greatest development pressure, relief of that pressure should be incorporated into the benefit calculation. These counties' experience with optimization could then be passed on first to counties in micropolitan areas and then to those in noncore areas. In terms of which optimization technique to use, a cost-effectiveness analysis seems to be a better starting point than binary linear programming because people feel more confident with the cost-effectiveness analysis, viewing it as easier and more straight-forward to understand.

6.2 Limitations of the Study

Several limitations of this study should be mentioned. First, the survey questions on potential obstacles to adoption of optimization may not have fully represented actual barriers faced by county administrators. The administrators admit that the listed obstacles have some influence but none was fundamentally critical to the final decision. Only three county administrators mentioned obstacles other than the ones presented and they did not disclose the nature of those obstacles. It is possible that some county administrators encounter difficulties that were not listed but did not identify that fact in the survey.

Second, since our survey subjects were targeted, the model is based on a small sample. To design the best possible model, several versions were pretested. Tested ordered Probit models either included all of the obstacle variables or used different combinations of the regressors. Our final choice omitted some obstacle variables because their coefficients were not significant in the test model. One could argue that the regressors in the ordered Probit model could be varied according to observers' perceptions. As a result, there could be different explanations for why counties fail to adopt an optimization approach.

Third, our model considers obstacles that prevent programs from adopting optimization. It also includes some historical and geographic factors that can be easily obtained. However, it does not discuss what may motivate conservation professionals to actively adopt the new approach. This other side of the story, the reasons why counties do adopt optimization, could provide valuable insight into this question. Reasons for adopting may not correspond to predicted obstacles to adoption. In other words, why people refuse to adopt optimization may not be the same as why people do adopt the approach.

6.3 Suggestion for Future Research

Given the sparse number of studies on cost-effectiveness in land conservation, future research could be aimed at identifying and measuring preservation costs to help county officials incorporate a cost analysis into their selection processes.

Future study could also be dedicated to identifying the forces that motivate people's willingness to adopt optimization. In our model, the geographic variable RURALITY demonstrates some influence on the decision-making process. A close examination of regional differences might reveal the forces driving that reform. In addition, an index derived from the urban influence codes could replace the original value for RURALITY so that urban influences could be modeled and applied as a way to customize optimization in each county.

Moreover, decision-makers' knowledge of an approach or technique has proven to be key to adopting the approach or technique. Communication between academic researchers and administrators certainly bridges the gap of understanding. Therefore, identification of the most effective communication channels begs for further experiment and study.

Appendix A

SURVEY QUESTIONNAIRE

PRE-SURVEY

1. Your name:____

2. Maryland county and/or your organization:____

3. How many years have you worked for this county/organization?________________________________

4. Your current job title:____

5. How many years have you been employed in this position?____________________________________

6. How many people in your county/organization work on agricultural preservation programs?

a. Full-time employees _____________________________
b. Part-time employees _____________________________
c. Volunteers _____________________________

7. How knowledgeable are you regarding the **Maryland Agricultural Land Preservation Foundation's** (MALPF) agricultural preservation program? (Circle one)

Not Knowledgeable		*Somewhat Knowledgeable*		*Expert*
1	2	3	4	5

8. How knowledgeable are you regarding your **County/Organization's** agricultural preservation program? (Circle one)

Not Knowledgeable		*Somewhat Knowledgeable*		*Expert*
1	2	3	4	5

9. In your county, *approximately* what percentage of agricultural land, measured by acreage, has been protected by the following sources over the past five years? (Total should sum to 100%)

a. Maryland Agricultural Lands Preservation Foundation	%
b. Your county's agricultural preservation program	%
c. Rural Legacy Program	%
d. Maryland Environmental Trust (MET) Program	%
e. Program Open Space	%
f. Other ________________	%
Total:	100 %

10. List, *in order of importance*, the 3 to 5 **most important benefit factors** (such as, soil quality, acres, biodiversity value, or development potential) in your county/organization's selection process.

Indicate how each benefit is measured (such as, GIS mapping, Land Evaluation and Site Assessment (LESA), or site visits).

Benefit Factor	***How Measured***
1.	
2.	
3.	
4.	
5.	

11. Who determines the benefit factors and weights for your county/organization's selection process? (Circle ALL that apply)

a. County program staff
b. County advisory board
c. MALPF guidelines
d. County guidelines
e. Other____
f. Don't know

12. If your county/organization has a LESA system to help determine the benefit score for any preservation program, please describe how this LESA system is used.

Program	***How LESA system is used***
1. MALPF program	
2. County Program	
3. Rural Legacy Program	
4. MET Program	
5. Program Open Space	
6. Other	

13. Do any of your preservation programs use **price caps** to determine the easement cost? (Circle one)

Yes No Unsure

If you answered "Yes", please describe what advantages and disadvantages your county has experienced with price caps:

Advantages ***Disadvantages***

If you answered "No", please complete one of the following:

We are planning to use price caps because:

We are *not* planning to use price caps because:

14. For each program in the table below, which of the following methods determines the easement cost in your county? (Please check all that apply for each program.)

Program / Method	MALPF	County	Rural Legacy	MET	Program Open Space	Other ___
Asking price	□	□	□	□	□	□
Seller discount	□	□	□	□	□	□
Calculated easement value	□	□	□	□	□	□
Price caps	□	□	□	□	□	□
Appraised value	□	□	□	□	□	□
Other________________	□	□	□	□	□	□
Don't know	□	□	□	□	□	□
Not applicable	□	□	□	□	□	□

15. For each program in the table below, how are easement costs factored into your county/organization's selection process? (Please check all that apply for each program.)

Program	MALP F	County	Rural Legacy	MET	Progra m Open Space	Other ___
Not explicitly included, except to determine whether funds are still available in the budget	□	□	□	□	□	□
Considered as part of the parcel benefit scoring	□	□	□	□	□	□
Used in an optimization process	□	□	□	□	□	□
Used in calculation of benefit-cost ratios	□	□	□	□	□	□
Other__________________	□	□	□	□	□	□
Don't know	□	□	□	□	□	□
Not applicable	□	□	□	□	□	□

16. For each program in the table below, how are the parcels selected for agricultural preservation in your county/organization? (Please check all that apply for each program.)

Program / Method	MALPF	County	Rural Legacy	MET	Program Open Space	Other ____
Parcels with the highest benefit scores are selected first until the budget is exhausted	□	□	□	□	□	□
Parcels with the highest benefit-cost ratios are selected first until the budget is exhausted	□	□	□	□	□	□
Parcels are selected based on advisory board recommendations	□	□	□	□	□	□
Parcels are selected based on political considerations	□	□	□	□	□	□
Parcels are selected based on their benefits and costs using binary linear programming	□	□	□	□	□	□
No official selection system is used	□	□	□	□	□	□
Other	□	□	□	□	□	□
Don't know	□	□	□	□	□	□
Not applicable	□	□	□	□	□	□

Assess the **ability** of your county/organization's **current selection processes** for agricultural land preservation according to the following criteria:	**Poor**		**Fair**		**Excellent**
17. Maximize the number of agricultural acres protected	1	2	3	4	5
18. Maximize the open space quality of acres protected	1	2	3	4	5
19. Protect the best agricultural land in terms of soil	1	2	3	4	5
20. Preserve large blocks of contiguous agricultural land	1	2	3	4	5
21. Acquire the best deals on agricultural land	1	2	3	4	5
22. Increase incentives for participants to remain in farming	1	2	3	4	5

Assess the technique used for your county/organization's **current selection processes** for agricultural land preservation according to the following criteria:	**Poor**	**Fair**	**Excellent**		
23. Knowledge of staff on how to use this technique	1	2	3	4	5
24. Fairness to applicants	1	2	3	4	5
25. Transparency (i.e. ease of explanation to public, advisory board, or potential applicants)	1	2	3	4	5
26. Cost-effectiveness	1	2	3	4	5
27. Ease of administration	1	2	3	4	5
28. Other	1	2	3	4	5

Please rate the following programs according to their **efficiency** in preserving agricultural land:	**Low**	**Medium**	**High**		
29. MALPF Program	1	2	3	4	5
30. County Program	1	2	3	4	5
31. Rural Legacy Program	1	2	3	4	5
32. MET Program	1	2	3	4	5
33. Program Open Space	1	2	3	4	5
34. Other program ___________________________________	1	2	3	4	5

POST-SURVEY

1. Your name:____

2. Maryland county and/or your organization:_________________

Please rate the following criteria for an agricultural preservation selection process in terms of importance:	**Low**		**Medium**		**High**
3. Knowledge of staff on how to use the selection process	1	2	3	4	5
4. Fairness to applicants	1	2	3	4	5
5. Transparency (i.e. ease of explanation to public, advisory board, potential applicants, etc.)	1	2	3	4	5
6. Cost-effectiveness	1	2	3	4	5
7. Ease of administration	1	2	3	4	5
8. Other	1	2	3	4	5

Optimization is a process of including both benefit information and acquisition costs to identify parcels that provide a high level of aggregate benefits at the best possible price ('getting the most bang for the buck').

9. How well did you understand optimization **before today**?

Not at all		*Somewhat*		*Very well*
1	2	3	4	5

10. How well do you understand optimization **now**?

Not at all		*Somewhat*		*Very well*
1	2	3	4	5

11. How willing do you think your county/organization would be to adopt **optimization** as the selection process for agricultural land preservation in the future?

Not at all		*Somewhat*		*Very well*
1	2	3	4	5

Assess the **difficulty** of the following potential obstacles for adopting **optimization** as the selection process in your county/organization's agricultural preservation program:	**Not**		**Somewhat**		**Very**
12. Lack of previous experience	1	2	3	4	5
13. Administration of the process	1	2	3	4	5
14. Initial technical costs (staff training, software, etc.)	1	2	3	4	5
15. Time to implement the process	1	2	3	4	5
16. Need for cost information at the time of selection	1	2	3	4	5
17. Lack of availability of technical resources	1	2	3	4	5
18. Lack of incentives to justify a change in processes	1	2	3	4	5
19. Possibly forgoing the 'best' land regardless of cost	1	2	3	4	5
20. Other	1	2	3	4	5

21. If your county was given **access** to user-friendly software to help with optimization, how willing do you think your county/organization would be to adopt this selection process in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

22. If your county was given **access to and training for** user-friendly software to help with optimization, how willing do you think your county/organization would be to adopt this selection process in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

Binary Linear Programming is an **optimization technique** that seeks to use mathematical programming software to identify the set of acquisitions that maximizes the total possible benefits given a variety of constraints (i.e. budget constraints, staff constraints, minimum acreage goals, etc.).

23. How well did you understand optimization using binary linear programming **before today**?

Not at all		*Somewhat*		*Very well*
1	2	3	4	5

24. How well do you understand optimization using binary linear programming **now**?

Not at all		*Somewhat*		*Very well*
1	2	3	4	5

Assess **binary linear programming** as a technique in the selection process to preserve agricultural land in your county/organization according to the following criteria:	**Poor**	**Fair**	**Excellent**		
25. Knowledge of staff on how to use this technique	1	2	3	4	5
26. Fairness to applicants	1	2	3	4	5
27. Transparency (i.e. ease of explanation to public, advisory board, potential applicants, etc.)	1	2	3	4	5
28. Cost-effectiveness	1	2	3	4	5
29. Ease of administration	1	2	3	4	5
30. Other	1	2	3	4	5

31. How willing do you think your county/organization would be to adopt **binary linear programming** in the selection process for agricultural land preservation in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

Cost-Effectiveness Analysis is an **optimization technique** that assesses a parcel's conservation value by taking the ratio of benefits divided by costs, and then acquiring the parcels with the highest benefit-cost ratios until the acquisition funds are exhausted.

32. How well did you understand optimization using cost-effectiveness analysis **before today**?

Not at all		*Somewhat*		*Very well*
1	2	3	4	5

33. How well do you understand optimization using cost-effectiveness analysis **now**?

Not at all		*Somewhat*		*Very well*
1	2	3	4	5

Assess **cost-effectiveness analysis** as a technique in the selection process to preserve agricultural land in your county/organization according to the following criteria:	**Poor**	**Fair**	**Excellent**		
34. Knowledge of staff on how to use this technique	1	2	3	4	5
35. Fairness to applicants	1	2	3	4	5
36. Transparency (i.e. ease of explanation to public, advisory board, potential applicants, etc.)	1	2	3	4	5
37. Cost-effectiveness	1	2	3	4	5
38. Ease of administration	1	2	3	4	5
39. Other	1	2	3	4	5

40. How willing do you think your county/organization would be to adopt optimization using **cost-effectiveness analysis** in the selection process for agricultural land preservation in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

41. Are there any other thoughts you would like to share with us concerning your county/organization's current selection process, or the optimization selection process?

42. Do you have any comments or suggestions about this survey?

Thank you very much for your participation.

If you have any further questions or suggestions, please don't hesitate to contact us:

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Appendix B

REVISED SURVEY

<u>REVISED-SURVEY</u>

1. Your name:____

2. Maryland county and/or your organization:____

3. How many years have you worked for this county/organization?________________________________

4. Your current job title:____

5. How many years have you been employed in this position?____________________________________

6. How many people in your county/organization work on agricultural preservation programs?

a. Full-time employees _____________________________

b. Part-time employees _____________________________

c. Volunteers _____________________________

7. How knowledgeable are you regarding the **Maryland Agricultural Land Preservation Foundation's** (MALPF) agricultural preservation program? (Circle one)

Not Knowledgeable		*Somewhat Knowledgeable*		*Expert*
1	2	3	4	5

8. How knowledgeable are you regarding your **County/Organization's** agricultural preservation program? (Circle one)

Not Knowledgeable		*Somewhat Knowledgeable*		*Expert*
1	2	3	4	5

Please rate the following criteria for an agricultural preservation selection process in terms of importance:	Low	Medium	High		
9. Knowledge of staff on how to use the selection process	1	2	3	4	5
10. Fairness to applicants	1	2	3	4	5
11. Transparency (i.e. ease of explanation to public, advisory board, potential applicants, etc.)	1	2	3	4	5
12. Cost-effectiveness	1	2	3	4	5
13. Ease of administration	1	2	3	4	5

14. How willing do you think your county/organization would be to adopt **optimization** as the selection process for agricultural land preservation in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

15. If your county was given **access** to user-friendly software to help with optimization, how willing do you think your county/organization would be to adopt this selection process in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

16. If your county was given **access to and training for** user-friendly software to help with optimization, how willing do you think your county/organization would be to adopt this selection process in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

17. How willing do you think your county/organization would be to adopt optimization using **cost-effectiveness analysis** in the selection process for agricultural land preservation in the future?

Not at all		*Somewhat*		*Very willing*
1	2	3	4	5

Appendix C

PROOF OF IMAGE USING PERMISSION

from **Hobart King** <hobart@digital-topo-maps.com>
to Yu Chen <yuchen@udel.edu>
date Wed, Jul 28, 2010 at 10:00 AM
subject Re: Image use permission

Dear Yu Chen,

You have permission to use the map in your thesis.

Good luck with your work.

Hobart King
Digital-Topo-Maps.com

On Wed, Jul 28, 2010 at 9:59 AM, Yu Chen <yuchen@udel.edu> wrote:

> Dear Sir/Madame,
>
> I'm a Master Graduate at the University of Delaware. I'm doing a thesis on the farmland preservation in Maryland and need a map of Maryland counties. I found a perfect one at your website. It says that I can use it in my website, but I will use it in my thesis and later my school will print it out and put it in the library. Therefore, may I have your permission to include this picture in my paper? Here is the link to this image:
>
> http://www.digital-topo-maps.com/county-map/maryland.shtml
>
> It will still have your copyright stamp in the picture and I will give citation to the original website. Thank you very much.
>
> Best,
> Yu Chen

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