ASSESSING VISUAL PREFERENCE FOR AGGREGATE PIT REHABILITATION DESIGNS USING COMPUTER ANIMATED LANDSCAPE MODELS[1]

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Abstract. The most common concern expressed by the public regarding aggregate mining is the negative aesthetic impact the activity has upon the scenic quality of the landscape. It is important that rehabilitation efforts restore scenic quality as well as function to the post-mining landscape. To this end the Management of Abandoned Aggregate Properties (MAAP) Program rehabilitates ten to twenty-fives sites in Ontario annually, based upon the criteria of safety, aesthetic, ecological and economic concerns. This study assesses the public's visual preference for different aggregate property naturalization designs. To investigate this relationship, computer-modeled rehabilitation designs of an aggregate property were developed using landscape modeling software to simulate three-dimensional development over a fifteen year time period. Respondent groups evaluated how natural, rehabilitated, attractive they perceived the simulations to be and assigned a rank order to the eight design strategies from best to worst. Design alternatives are shown to improve the perception of aggregate rehabilitation efforts over the current methods being commonly employed by MAAP.

Additional Key words: gravel pit, reclamation, visual simulation.

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Introduction

Almost seven thousand abandoned pits and quarries, reminders of past aggregate extraction activities, dot the Ontario landscape. These blemishes are serious detractors from the scenic quality of the landscape, and are fodder for public concerns and complaints against the aggregate industry, despite more responsible current rehabilitation practices. The Management of Abandoned Aggregate Properties (MAAP) program rehabilitates 10-25 high priority sites per year depending upon the scale, cost and location of the sites, with a variety of end uses realized such as cropland, pasture, recreation and natural areas. The ultimate goal of the MAAP program is not only the rehabilitation of abandoned pits and quarries, but also the satisfaction of the owners of the abandoned aggregate properties based upon their desired end-use for their land.

To measure the success of the MAAP program a landowner satisfaction survey was completed by Hubregtse (2003). The survey revealed that the majority of participating landowners were quite satisfied with the work done by MAAP, with the only exception being those landowners whose aggregate pits were rehabilitated to natural areas. Natural areas refer to rehabilitation work consisting of grading slopes to a safe and natural profile (3:1 or better), seeding with a specifically-designed herbaceous seed mix and the planting of trees, most commonly 30cm seedlings. Among Hubregtse's (2003) recommendations was that: "MAAP should also reconsider its approach to tree planting. It may be worthwhile to plant larger trees, even if it means providing fewer trees in total. Larger trees may have a better chance of out competing the grass and they will certainly have more of a visual impact both of which may help raise landowner satisfaction" (Hubregtse 2003). Planting larger woody stock involves greater expense and the visual impact of this approach is as of yet untested. For MAAP to seriously consider alternative planting approaches assessing public response to potential alternatives is necessary.

In the early 1990's the Ministry of Natural Resources (MNR) identified over 6800 abandoned aggregate pits and quarries in designated areas across the Province of Ontario. The MAAP Program maintains the abandoned pits database and ranks abandoned pits according to factors including safety, aesthetic, ecological, and economic concerns, with the greatest emphasis being placed upon safety and aesthetics. The MAAP program has a significant opportunity to improve the scenic quality of the landscape through rehabilitating the thousands of abandoned pits in the province and providing the public with a landscape that meets their expectations of scenic quality.

Landscape architects have been trying for decades to introduce new landscape forms and redefine the expectations of a natural landscape. The very term 'landscape' has its roots in landscape painting. The development of a "pictorialized" landscape through the application of picturesque design conventions derived from the landscape paintings of Claude Lorrain, Georgione and Salvatore Rosa. These artists began to shape not only the physical state of the landscape, but also the cultural concept of landscape and nature (Crandell 1992). This cultural concept has come to influence our expectations of what is "natural" in the landscape to the extent that picturesque conventions have come to be associated with perceived ecological quality (Nassauer 1995). Utilizing characteristic pictorial elements in the rehabilitation design of aggregate pits may draw upon the culturally-ingrained preference for this landscape type and make this design approach more favourable to the public.

Preferred landscapes vary somewhat across cultures according to Balling and Falk (1982), however remnants of early human instincts are agreed by many to be the overriding influence on landscape preference. Savanna-type landscapes of the African plains are most highly-preferred as they offer good visual penetration (*prospect*) while also offering opportunities to not be seen if so desired (*refuge*)(Appleton 1996). This preferred landscape is characterized by mature trees with little under-storey and open areas with even, low-level groundcover (Appleton, 1996). There have been numerous visual preference studies conducted on the influence of tree size, species, spatial arrangement, naturalness of vegetation and ecological quality (Brown 1984; Schroeder 1986). Until recently these studies were static. However Orland, Daniel and Vining (2005) are currently collaborating on a self-administered visual preference study entitled "Perception of Future Northern Forests: An Investigation of the Factors Affecting Public Perceptions and Evaluations of Northern Forest Management" through The Imaging Systems Laboratory at the Department of Landscape Architecture at Penn State University. In their simulations type and density of vegetation are modeled as they grow and gradually reforest a former logging area (website: www.imlab. psu.edu./sm1). The use of 3-D simulation in this experiment is relatively simplistic, however it very effectively demonstrates the application of the technology as an evaluative tool and 3-D simulations may allow for a more informed decision-making process.

The feature of computer simulations that is of the most benefit for landscape investigation is the ability to add dynamic motion to a landscape representation to show the evolution of a site over time and the possibility of presenting multiple observer vantage points. In most common applications, either the user's movement is animated to gather experiential data or preference, or elements within the landscape are simulated to gather data about the interaction between the elements and the environment. Computer modeling also allows for superior control of the elements in the represented landscape which facilitates the isolation of the stimuli that are being studied to a much greater extent than previously employed methods of photographic or video simulation (Orland 1994). In this study computer modeling and simulation are used to study visual preference for aggregate pit rehabilitation design.

Problem Context

Naturalization is a lengthy process; given the short history of MAAP's work (seven years), their "natural area" landscapes are in the early stages of development. While natural area establishment can take years, the more well-received rehabilitation projects of cropland or pasture typically reach aesthetic maturity in one or two years following construction. The study attempts to evaluate MAAP's current rehabilitation practices using predictive means of showing the rehabilitated landscape's potential development over time. Alternative design approaches, as suggest by Hubregtse (2003), are also evaluated in the same manner to determine if there is in fact a more preferable design solution possible for these sites. This investigation evaluates alternative tree planting and grading design strategies to learn if there is an increase in visual preference of abandoned aggregate properties that are rehabilitated to "natural areas" over rehabilitation according to MAAP's current practices.

Study Goals

This purpose of this study is to examine the effect of tree planting design and grading on the visual preferences of the respondent group in relation to the rehabilitation of a case study abandoned aggregate property. The study will attempt to answer several questions that have arisen through receiving feedback from landowners about MAAP's work and through research:

1) *Does tree size influence visual preference in potential MAAP rehabilitation designs?* 2) *Can using picturesque design features be used to improve levels of landscape preference for rehabilitation designs? 3) Does perceived naturalness relate to preference ratings? And 4) Does perceived rehabilitation effort relate to visual preference ratings?*

Methods

Site Selection and Analysis

The site examined in this study was one of the sites chosen for rehabilitation by MAAP in the spring 2005 construction season with a naturalized area as the landowner's desired end-use. The case study property (pit) is located just outside of London, Ontario, Canada, a city of approximately 300 000 people. An in-depth site inventory and several site visits were conducted in November of 2004 to create a base map of the site. A laser range finder was used to measure the dimensions of the site and to measure the relationship between the various elements present in the landscape. Digital photographs and videos of the site were taken for use as references in the creation of the schematic base map.

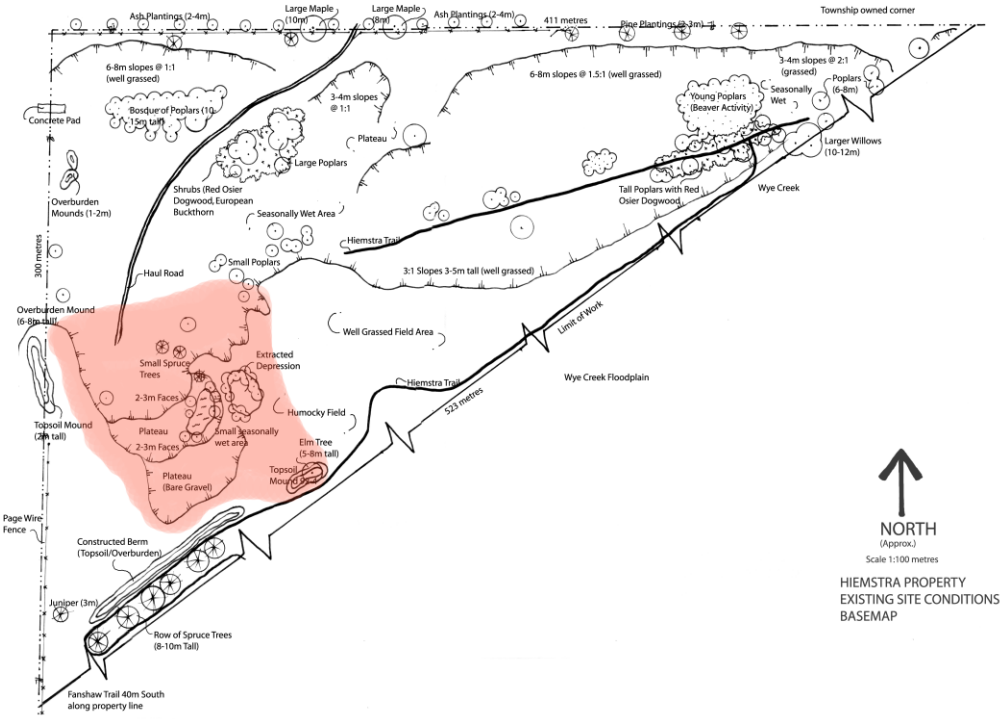


Figure 1. Base Map of an abandoned aggregate property – approximately 6 hectares in area. Field notes by author (2004 conditions). Study area indicated by shading.

The site is of ecological importance as it falls within the Wye Creek watershed, at the edge of a provincially-significant wetland known as the Fanshawe Wetland Complex and Conservation Area. The site is being rehabilitated in the spring of 2005 by MAAP program. The site is

approximately 6 hectares in size (14.8 acres) and triangular in shape. Extraction on the property ceased over thirty years ago, leaving the site to naturally regenerate which was partially successful. While the majority of the site has regenerated quite successfully, steep pit faces still remain in the South-west portion of the pit along with hummocky terrain, overburden mounds and bare gravel and rock areas which will be the area rehabilitated by MAAP and the area studied in this study. This area is approximately one and a half hectares in size (3.7 acres) (Fig. 2).

Figure 2. Existing study site conditions viewed from the haul road at the base of the northerly slope

Visual Preference Study

A visual preference study was created using a series of computer-animated landscape scenes of potential rehabilitation designs and a paper survey consisting of a series of Likert-type scale ratings, a series of open-ended questions and an overall ranking of the designs. A computer-generated base landscape model was created using Vue 4 Professional software package (list publisher name) and readily-available computer hardware, from site measurements and a digital elevation model of the site. From the base landscape model, eight virtual designs were animated for preference testing. Two observer vantage points, eye-level (Fig. 3) and oblique (Fig. 4), were used to visualize the designs thereby offering multiple perspectives on the designs as they developed over a fifteen year period.

Design “A” MAAP seedling	Design “E” MAAP sapling
Design “B” Landform seedling	Design “F” Landform sapling
Design “C” Pits and mounds seedling	Design “G” Pits and mounds sapling
Design “D” Picturesque seedling	Design “H” Picturesque sapling

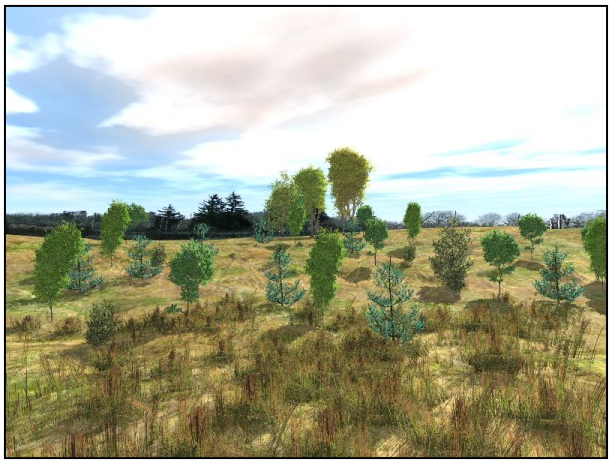


Figure 3. Pits and mounds landform grading with seedling design shown from eye-level. Eye-level perspective

Figure 4. Pits and mounds landform grading with seedling design shown from oblique angle. Oblique perspective

Designs

The design approaches tested in this study were inspired by research and several of themhave been used by MAAP in recent design work. In these designs the spatial distribution of the trees is dependent upon the landform design similar to the constraints of MAAP's typical procedures. In this study four design strategies are tested, with two tree sizes and shown from the two vantage points. The designs tested are:

MAAP Design: MAAP's typical design is a very functional solution to the problems posed by an abandoned gravel pit. The pit faces are graded to a 3:1 slope or less when possible. The slopes are contour-graded to match the surround landforms so as to make the rehabilitated landscape blend in with the context of the site. Trees are planted on the graded slopes in a loose grid-like distribution with regular spacing. The tree species are distributed evenly across the slope without specific location.

Landform Design: Landform grading and planting emulates the natural topography and distribution of vegetation that results from erosion. The slope profile in this strategy is characterized by a series of concave and convex undulations. Trees are planted in the convex areas concentrated near the toe of the slope. This strategy provides the trees with a greater moisture level and increase slope stability by minimizing the mass on the slope.(Schor and Gray 1995)

Pits and Mounds Design: Pits and mounds is an approach that is being developed and applied by Mathis Natvik (2003, http://www.nanps.org/feature/pitsandmounds.html). This strategy emulates the effects of a catastrophic wind event on a mature forest wherein large trees are toppled over ripping up the root ball creating a depression that exposes sub-soils and ephemeral pools of water. Overtime the decaying tree creates a mound of rich soil at the edge of the pit creating a micro topography that offers microclimatic benefits for a variety of tree species. In this design earthmoving equipment is used to simulate the pits and mounds landscape creating a series of depressions approximately one metre (3.3 feet) deep and two to four metres

(6.6 – 13.1 feet) in diameter. Mounds are created through depositing soil in piles of approximately one metre (3.3 feet) in height. Trees are planted according to their moisture preferences with the spruce and silver maple planted in the pits and the red oak and red pine are planted on the upland areas.

Picturesque Design: The picturesque design strategy is inspired the formulaic landscape paintings of Claude Lorrain, Georgione and Salvatore Rosa (Crandell 1992). Just as in the paintings in this design the landscape is divided into topographic bands to create an increased sense of perspective. To heighten this effect the trees are planted in clusters on the topographic bands.

Pre-test

A pre-test of the research instrument was conducted on a class of 15 graduate landscape architecture students. The subjects were shown the simulations and asked to rate the designs using a seven-point Likert-type scale based upon the degree to which the participants perceived the simulations to be natural, rehabilitated and attractive. The subjects were also asked to provide answers to open-ended questions indicating what they "liked" and "disliked" about each simulation. Finally the respondents ranked the eight designs from best to worst. The completed surveys were compiled and the data were entered into tables for data analysis.

Results

Data were initially visualized as a series of histograms (Fig. 5). The MAAP seedling design received the lowest ranking of all the designs tested having received 8 of the lowest ranks but only 2 of the highest. The design that received the highest overall ranking was the pits and mounds sapling design. Six of the fifteen respondents gave the pits and mounds sapling design first-place ranking with two second-place rankings. Analysis of the histograms suggested a potential preference for the sapling over seedling designs overall that required further investigation. To investigate the potential trend all seedling design rankings were compared to all sapling rankings (Fig. 6). The seedling designs showed that the majority of the rankings for these designs were in the lower half of the ranking scale. Conversely the sapling designs showed that the majority of the rankings were in the higher half of the ranking scale. To further understand the rankings given by the subjects a correlational analysis was conducted between the overall rankings and how natural, rehabilitated and attractive the subjects perceived the designs to be Spearman's rank correlation was used to investigate the relationships.

The first test revealed a correlation between how natural the scene was rated to be and the ranking scores (Fig. 7). A correlation was found between naturalness and ranking ($r = 0.5202$, $p<0.0001$). In general the more natural the design was perceived to be, the more highly it was ranked, though the relationship is not particularly strong. The correlation between the degree to which the designs were perceived to be rehabilitated and their ranking was also examined. Results indicated a weak correlation ($r=0.2345$, $p=0.0099$) (Fig. 8). This characteristic did not play as much of a role in influencing the respondents rankings. Finally, a correlation between attractiveness and ranking was also found ($r=0.5568$, $p<0.0001$) which indicated that rankings were also based on perceived attractiveness (Fig. 9).

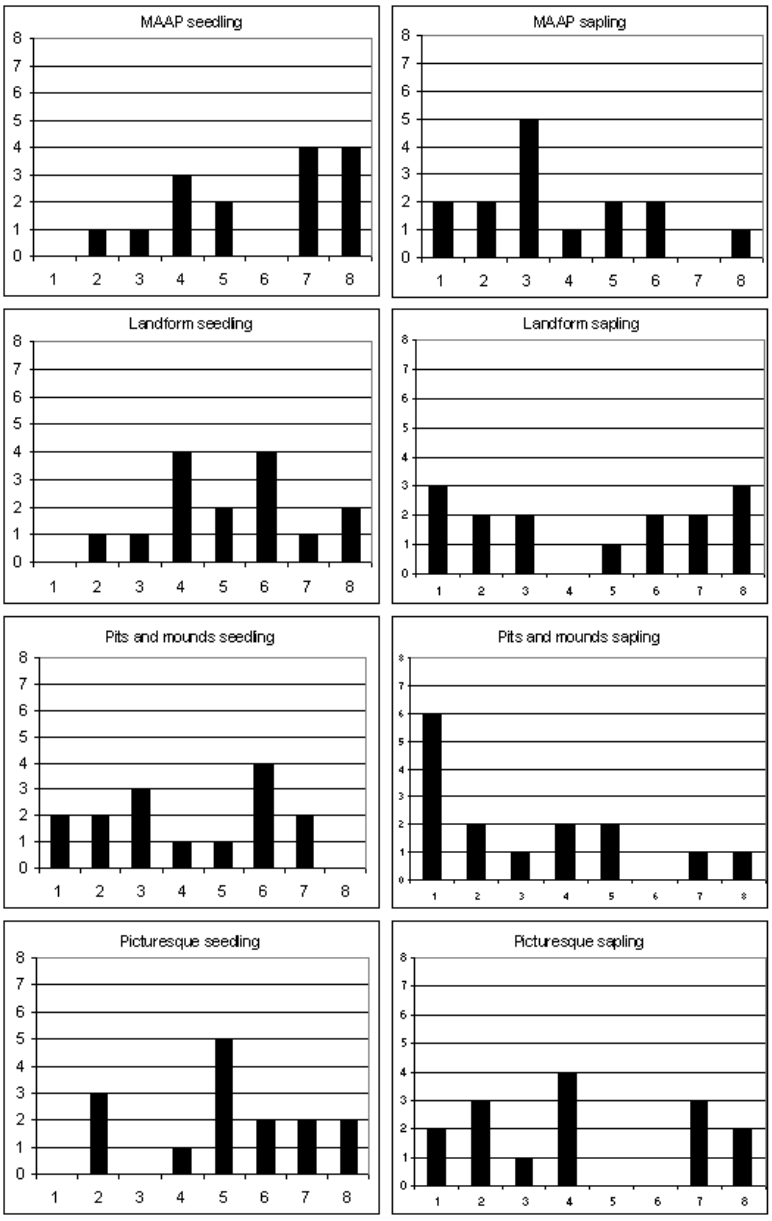


Figure 5 Histograms showing frequency of overall rankings for each design, X axis show ranking from best to worst, Y axis shows number of responses

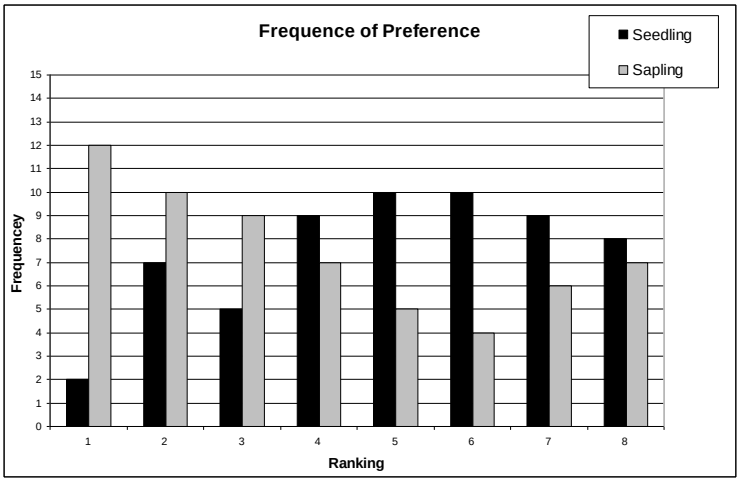
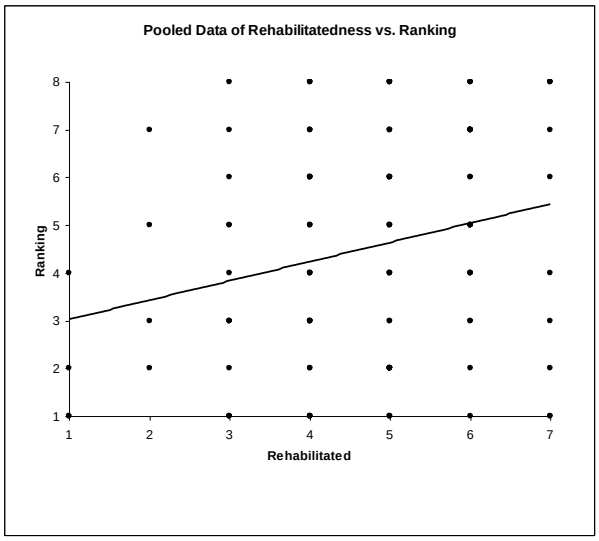


Figure 6 All of the seedling designs vs all of the sapling designs



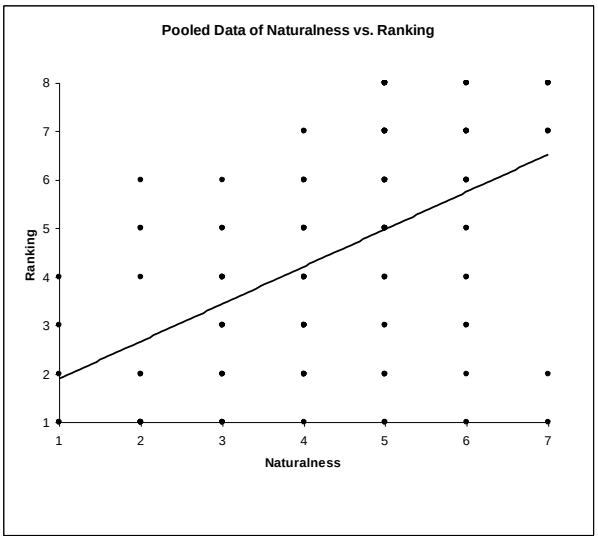


Figure 7 Natu Figure 8 Rehabilitated vs

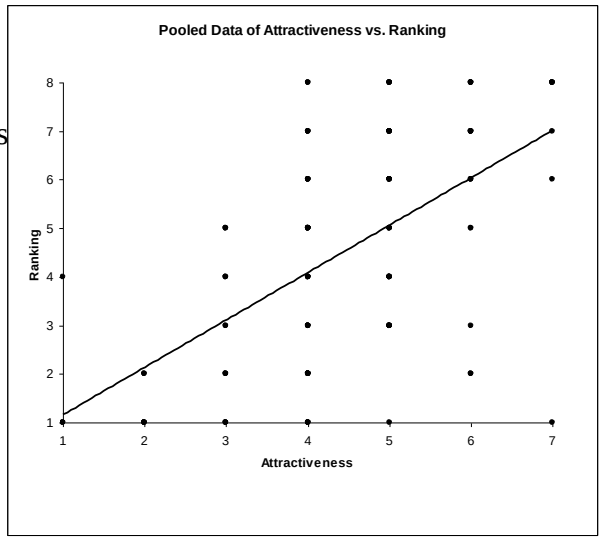


Figure 9 Attractiveness vs. Ranking

Discussion

The pre-test data indicate that tree size influences visual preference. Sapling designs were preferred over seedling designs despite the reduced number of trees in the sapling designs; a finding that supports Hubregtse's recommendation (2003) to use larger size trees in initial plantings. While it was thought that the addition of picturesque design features would increase the preference for those alternatives, there was no increased preference shown for the picturesque designs (Figure 5). The attractiveness and naturalness of the alternatives have significant influences on the ranking given to the designs. Evidence of rehabilitation has little influence on the ranking of the alternatives overall which was surprising as it was thought that an obvious effort to reclaim the land would be well-received by the subjects.

Preliminary Conclusions

Analysis of the pre-test data suggests that MAAP may be able to increase the aesthetic appeal of their natural area projects by planting saplings using the pits and mounds design approach or using their current spatial distribution of trees with saplings as these two designs were shown to be the two most-preferred approaches in the pre-test.

Future research will utilize the final version of the survey based upon the feedback and results of the pretest, which will be administered to at the Parks Research Forum Ontario (PRFO) conference at the University of Guelph on May 6, 2005. A second respondent group consisting of members of the Greater London Kinsmen society will also be surveyed and the responses compared to those of the PRFO conference group. The results of the testing of these two groups will be analyzed and the completed study will be presented at the ASMR conference.

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