BENCHMARKING LAND EVALUATION AND SITE ASSESSMENT MODELS WITH DELPHI EXPERT OPINION PANELS: A CASE STUDY IN LINN COUNTY, OREGON

by

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Abstract: A Delphi Expert Opinion procedure was used for evaluating Land Evaluation and Site Assessment (LESA) ratings in Linn County, Oregon. The Delphi procedure uses an expert panel to answer a set of questions by anonymous responses, controlled feedback in two or three iterations, and a statistical summary of group responses. A panel of 14 local experts rated five diverse sites. Results indicated that the Delphi panel was able to identify site specific factors which were not addressed by the LESA model, indicating that their rating was, for the specific conditions of each site, a reasonable benchmark. Although there were differences between the Delphi panel and LESA ratings, in general the LESA model appears to be correctly ranking sites on a relative scale. Certain improvements to the LESA model were determined by the benchmark evaluation.

INTRODUCTION

In 1981, in response to concerns about potential impacts of programs of the United States government on the conversion of farmland to non-farm uses, the Federal Farmland Protection Policy Act (FPPA) was passed. The FPPA requires federal agencies to identify and take into account the adverse effects of federal programs on farmland protection. Federal agencies are required to consider alternative actions that could lessen adverse effects and to ensure that federal programs, to the extent practicable, are compatible with state, local, and private programs to protect farmland (Steiner, 1987). The final rule implementing the FPPA (Federal Register 49 (130):27716-27727) specified that the criteria to be used for assessing farmland impacts and alternative actions will be based on the Land Evaluation and Site Assessment (LESA) system developed by the Land Use Division of the Soil Conservation Service (SCS).

What is LESA

LESA is a numerical rating system that combines the soil aspects of land evaluation (LE) with the spatial and economic criteria of site assessment (SA). The LE evaluation may be based on one or more of several standard soil-based measures which quantify soil limitations for agricultural use, soil productivity, soil potential for given indicator crops, and the factors that determine important farmlands. Soils are rated and placed in groups ranging from best to worst on a relative scale. The LE component, however, omits important determinants of agricultural productivity value such as farm size and location.

The site assessment (SA) subsystem assesses the quality of a site for agricultural use based on factors other than soils. The factors used in site assessment are generally modified to reflect local planning needs and are typically determined through local committees (DeMers, 1989; Coughlin et. al., 1992a). Point values and weights for site assessment criteria are also most often determined by local groups (Coughlin et. al., 1992a). As designed, the SA portion of the system, allowing local modification, was seen as a great strength. Conversely, local flexibility can lead to inconsistencies and mis-use of the system and may lead to quality control problems.

LE and SA factors for a particular parcel, when totaled, can indicate the quality of a site for farmland activities relative to both the physical and land use contexts of the site (Steiner, 1987; DeMers, 1989). Used in a planning context, the LESA system can place the often complex decisions regarding the conversion of farmland into a technically defensible, quantitative framework.

Before adopting LESA as the tool for implementing the FPPA, the SCS tested the system in 12 counties in 6 states (SCS, 1983; Dunford et. al., 1983; Wright, 1983). Following these tests, the SCS released a handbook to explain the LESA system to federal, state, and local officials and made available assistance in designing LESA systems. The handbook explains the goals of LESA and how to design a system and provides worksheets and lists of site assessment attributes (factors) that local and state governments may incorporate into their own LESA (SCS, 1983). The handbook, however, does not provide guidance in evaluating the performance of a LESA system once it is created.

RESEARCH CONTEXT

In 1991, the Soil Conservation Service funded a research project to inventory the status of LESA systems throughout the United States, evaluate the validity of the ratings, and disseminate the results in publications and in a national LESA conference. The findings would be used to revise criteria and procedures contained in the LESA handbook.

Researchers from Arizona State University, the University of Pennsylvania, and Oregon State University have completed the survey and case study analyses and presented the results at a national LESA conference held in March 1992. The survey completed in 1991 found that there are now at least 145 jurisdictions in 26 states using LESA and 30 jurisdictions in 14 states currently developing a LESA system (Coughlin et. al., 1992a). Given the wide and diverse application of LESA, and the fact that the U.S. Department of Agriculture requires its use by federal agencies and encourages its use by local and state governments, it is important to know how reliable, accurate, and consistent LESA systems are proving to be.

There has been some research on various aspects of LESA, such as factor selection, weighting, and autocorrelation (DeMers, 1987; Bowen et. al., 1990; Ferguson, 1991), consistency of ratings (Van Horn et. al., 1989), and general application (Dunford et. al., 1983; Huddleston et. al., 1987; Stamm et. al., 1987; Tyler et. al., 1987; and Wright, 1983). As a framework for evaluation of LESA models, a five point evaluation process was developed and applied to the Linn County, Oregon LESA system. The process includes evaluation of the extent to which a LESA model focuses on agricultural

productivity potential vs. development potential, autocorrelation of SA criteria, replicability of ratings, data basis for point allocation, and benchmarks for measuring the validity of the ratings. In general, the Linn County LESA model was found to focus on agricultural productivity; the criteria were all measurable, giving consistent ratings by different reviewers; there was a data basis for point allocation; and autocorrelation of the criteria was not a problem. Results of our analyses are presented in other papers (Pease and Sussman, 1992; Coughlin and Daniels, 1992b).

The question remained, however, as to what could be used as a measurement benchmark when evaluating the scientific validity and accuracy of a LESA system. In other words, in evaluating a LESA system's accuracy and reliability in distinguishing land that could be retained in agriculture and land that could be converted to other uses, what does one use for comparison?

RESEARCH PROBLEM

The objective of this research is to develop and test a process to evaluate the accuracy and scientific validity of LESA models. The case study chosen to test the procedure was the LESA model used by Linn County in Oregon's Willamette Valley. A measurement benchmark was established by a panel of local agricultural experts using the Delphi Expert Opinion Method herein referred to as the Delphi Method. As an additional measure of accuracy, and to examine the consistency of neighboring LESA systems, a LESA system from an adjacent county with similar physical and agricultural characteristics was compared to the Linn County system and to ratings of the local

experts. The procedures were also applied to a second case study in Lancaster County, Pennsylvania and are reported in a separate paper (Coughlin, 1992b).

Hypothesis

The hypothesis proposed is that the LESA ratings for Linn County, Oregon are generally reliable, accurate, and consistent. When compared to other methods for rating agricultural suitability (i.e., a panel of experts) the Linn County LESA model will most of the time accurately rate the quality of the soil and site characteristics on a relative scale within the jurisdiction, although research will most likely identify aspects of the LESA system that can be "fine tuned."

Linn County LESA

The Linn County LESA system is used in zoning permit decisions on ownership parcels zoned for exclusive farm use (EFU). The system awards a maximum of 300 points with equal weight given to LE and SA. Land evaluation (LE) is based on soil potential ratings (SPRs). The soil potential ratings measure the net return to soil management for the production of a given crop. For the Linn County LESA, SPR tables were established by arraying the soils from 150 to 0 points based on the highest single rating of four indicator crops.

The two primary criteria for Linn County's site assessment (SA) are conflict with surrounding non-farm parcels and parcel size. Ratings from the Linn County LESA are

used as background information for staff reports to the decision making body. For a detailed description of the Linn County LESA system see Huddleston et. al., 1987.

Lane County LESA

The LESA system developed for Lane County, Oregon was also examined. Lane County lies south and adjacent to Linn County and has similar physical and agricultural characteristics. The Lane County LESA system, which has not yet been implemented, was designed mainly to distinguish between primary and secondary farmland resources. Similar to Linn County, the Lane system awards a maximum of 300 points with equal weight given to LE and SA. There are, however, differences between the two systems in how they determine LE and SA. To determine LE, the Lane County system uses SPRs calculated from the average SPR of four indicator crops, whereas the Linn County system uses the single most profitable crop as the SPR.

The primary SA criteria for the Lane County system are essentially the same as Linn County, but minor refinements were added. The most notable of the refinements is the distribution of points for parcel size. Rather than awarding SA points for parcel size by landform alone as Linn County does, the Lane system partitions the county into production areas based on soil characteristics and agricultural regions and awards points for size based on commercial agriculture in the area of that parcel. Small parcels growing row crops in well drained terrace soils would receive more points then a similar sized parcel growing grass seed on poorly drained terrace soils.

Delphi Expert Opinion Method

The Delphi Method was used by the expert panel to establish benchmark ratings of the parcels. Delphi, developed in the 1950s by the Rand Corporation, is a means of systematically collecting and progressively refining information provided by a group of selected experts (Linstone and Turoff 1975). Delphi is characterized by response anonymity, controlled feedback, and statistical summary of group responses. Anonymity, effected by the use of questionnaires, secret ballots, or on-line computers, reduces the effect of dominant individuals. Controlled feedback, i.e., conducting the exercise in a sequence of rounds between which a summary of the previous round is communicated to the participants, reduces noise and outlying observations. Statistical summary and definition of group response is a way of reducing group pressure for conformity. More importantly, statistical definition of group response assures that the opinion of every member of the group is represented in the final response. For a detailed description of the Delphi Method see Linstone and Turoff, 1975.

Delphi was shown to be an inexpensive and efficient method for gathering information on natural resource and land use data (Pease and Beck, 1984; Nelson, 1984). Research conducted on Delphi in the collection of land use data found that expert opinion was highly correlated (average error of .055) to survey data in the characterization of agricultural marketing and processing as well as in identifying qualitative characteristics such as soil types and field sizes (Pease 1984; Nelson, 1984). Although less accurate in characterizing certain financial aspects of agriculture, Delphi appears to be a reliable method to rate agricultural productivity and suitability of ownership parcels.

METHODS

LESA ratings were evaluated by comparing them to ratings established by a panel of experts. It was assumed that the ratings derived by the panel of experts were the most accurate and therefore could serve as measurement benchmarks. An additional measure was made by comparing Linn County LESA scores to the Lane County LESA system. Accuracy and reliability of the Linn County LESA was determined based on the difference between ratings by the panel and ratings by the LESA system. To carry out the validation, a four step approach was taken.

1) Five ownership parcels in Linn County were selected that are diverse in physical and spatial characteristics. Table 1 gives a description of the sites. Factors considered in the site selection included, but were not limited to, soil type, landform, current agricultural activities, surrounding development, and location within the county.

2) A panel of agricultural experts was shown the five sites during a two-hour field trip, and asked to rate the parcels in terms of "Soil Quality" (LE), "Other Factors" which may affect the ability to conduct agricultural operations (SA), and "Overall" (LESA). The Delphi Method was employed by the panel to establish median ratings.

3) The investigator then completed LESA ratings for the same five ownership parcels using the Linn County LESA system and the Lane County LESA system.

4) Once all the ratings were completed (Delphi, Linn County LESA, and Lane County LESA) a comparison of the results was made. Using the Delphi panel ratings as

the benchmark for accuracy and reliability, and the Lane County LESA as an additional comparison, the accuracy and reliability of the Linn County LESA ratings were analyzed.

Panel Selection

Delphi panelists for the study were selected in consultation with Linn County Agricultural Extension agents and ASCS and SCS personnel. The panel, when completed, consisted of a diverse group of farmers, a Linn County Planning Commissioner, a representative from the Farmers Home Administration, a credit officer from Farm Credit Services, a farmland tax assessor, an agricultural instructor, an Extension Agent, and an Agricultural Stabilization and Conservation Service official, for a total of 14. This group represented a wide range of knowledge on agriculture and land use. Research on the relationship of group size to group error (Dalkey, 1969) found that groups of 10 to 17 were adequate for providing accurate results.

Additional Worksheets

To gain additional information on site assessment and LE to SA ratios, panelists were also asked to complete two worksheets. Following the third iteration of site characteristic ratings for each site, the panelists were asked to note the three most important factors which caused them to rate the parcel as they did, and whether they saw those factors as an advantage or disadvantage to the site. At the conclusion of the

entire rating session another worksheet was used by the panelists to describe how they would weight soil quality to "other factors" in the overall rating. This weighting was done by landform.

RESULTS

The results from this research are reported as follows (1) the Delphi process, (2) comparison of the panel scores to the Linn County LESA scores, (3) comparison of the panel scores to the Lane County LESA scores, and (4) a comparison of all three ratings.

Delphi Process

The median and interquartile range of the panel's scores are displayed in Table 2. Convergence of the interquartile range after two or three rounds was observed in all cases except for Overall rating for site 5 where it remained unchanged from its Round 1 narrow spread. Changes in the median values from Round I to Round II occurred six of 15 times and, where three iterations were conducted, changes from Round II to Round III occurred four of 10 times. Overall, the Delphi Method proved to be an effective tool for gaining group consensus.

Comparison of Linn County LESA and Delphi Ratings

The Linn County LESA ratings were compared to the panel by looking at general numeric differences between the two ratings, testing statistically to see if there was a

significant correlation between the relative ranking of the five sites by the two methods, and by examining the relative weights, as indicated by the panelists, given to LE and SA.

1) General Numeric Differences

General differences between the Delphi panel and Linn County LESA ratings are described by difference (Delphi minus Linn) and percent error (Delphi (A) minus Linn (A_1) divided by Delphi (A) x 100). Results from a comparison of the scores are displayed in Tables 3-5. Comparing the soil ratings (Table 3), it can be seen that the Linn County LESA consistently rated all sites higher than the panel with the exception of site 1 where there was an absolute difference of only .75 points. Excluding site 1, the soil ratings by the panel and the LESA system differed by an average of -21.75 points. The standard error of the average difference was 1.14, indicating that the Delphi panel was quite consistent in their lower rating of the sites as compared to the LESA rating.

It is interesting to note that site 1, where the absolute difference is only .75 points, is the predominant type of landform and agricultural operation (grass seed) found in Linn County. On the other hand, foothill sites such as site 4, which had the largest absolute difference (25 points), are generally perceived as less valuable farmland and may be used for several different types of lower value agricultural activities.

Sites 3 and 5 received 149 of a possible 150 points from the LESA model, indicating they represented the best sites in the county. The Delphi panel awarded 127.5 points to each, which indicates they did not consider the sites the best in the county. Site 3 was a small site (13.3 acres) located in a mixed parcel size area. It was a long, narrow

tract between two homesites and was fallow on the field trip. Site 5, while a large field imbedded in a prime farm area, had a problem familiar to one of the panelists. The tract had an inadequate supply of irrigation water which resulted in only half the tract being irrigated in a given year. Although these factors would be considered SA factors, it may be that the panel penalized the LE portion for some of these factors. These site specific adjustments illustrate the advantage a group of experts has over a general model which cannot compensate for a wide variety of site specific factors.

A comparison of Other Factor ratings (Table 4) shows that, for sites 1 and 4, Linn County LESA ratings are higher than Delphi ratings, while they are lower for sites 2, 3, and 5. The largest difference between the two ratings is for bottomland site 3, where the Delphi panel score was 52.0 points (percent error of 57) higher then LESA. This difference points out discrepancies in the perception of the impact of surrounding non-farm dwellings by the panel and the LESA model.

The Linn County LESA system assumes that low density populations are less likely to object to agricultural practices or cause conflicts. It also assumes that conflicts are likely to occur when non-farm residences are located adjacent to the subject parcel. To quantify the degree of conflict between residential development and agricultural practices, the SA subsystem counts the number of conflicting residences (residences located on parcels smaller than typical farm field size for that landform) within .25 miles and also measures perimeter conflict. For site 3, 18 conflicting residences were located within .25 miles and 44% of the perimeter of the parcel was in conflict. This resulted in a low overall compatibility score of 18 points out of 75 possible and a low score for parcel size,

giving an overall SA of 38 points out of a possible 150 points. In comparison, the SA score by the panel (90 out of 150) makes clear that the experts discounted the potential conflict and smaller parcel size. This is an interesting point in the context that the potential for conflict is an important assumption underlying most farmland protection policies. However, as noted previously, the panelists may have incorporated the small parcel size and surrounding land use in their lower LE rating.

Overall ratings for the sites by the two methods (with the exception of foothill site 4) are rather similar (Table 5). Looking at differences in score by landform, the two terrace sites 1 and 2 were both rated higher by LESA. For bottomland sites 3 and 5 the difference between ratings (Delphi-Linn) ranges from as little as 0.5 points for site 3 and -4.0 points for site 5. Foothill site 4, however, differs from the Delphi panel by 44.0 points reflecting the discrepancy in site 4's ratings for soils and other factors. With the exception of site 4, the Overall scores given by the panel and the LESA system were generally consistent.

2) Relative Ranking

The Linn County LESA system was analyzed to see whether its relative ranking of the five sites was significantly correlated to that of the Delphi panel. Based on the scores given to the parcels by the panel and by LESA, the relative ranking of the sites by Soil Quality, Other Factors, and Overall ratings were determined. Correlation of ranks was calculated using the Spearman Coefficient of Rank Correlation Equation (Ostle and Malone, 1988). However, because of the small number of observations, combined with

ties in ranking, the sample coefficient of correlation may deviate from the "true" coefficient of correlation. Therefore, the calculated coefficients and their associated P values can be seen as only approximate. Additionally, because LESA scores are linearly dependent, a test of the statistical significance of rank correlations of all three factors (soil, other, and overall) would be a redundant test. It was therefore decided to calculate the statistical significance of rank correlation only for Overall ratings (Table 6). A correlation of -1 signifies perfect disagreement and +1 signifies perfect agreement.

Considering the relative rankings of Soil Quality scores Delphi panelists and Linn County LESA ratings ranked bottomland soils (sites 3 and 5) the highest. The Delphi panel ranked foothill site 4 soils the worst, whereas the LESA system ranked terrace site 1 the worst. It should be noted, however, that the LESA relative rank for the foothill site differs from the panel by only a 1 point score difference. Terrace site 1, ranked lowest by LESA, has a poorly drained soil type limited to grass seed production, while site 4 is limited to pasture and other lower per acre value uses. Using Spearman's equation, a rank correlation of the soil ratings was calculated to be .68, showing some evidence of agreement in relative soil rankings.

In the relative ranking of sites by other factor scores, no two sites were ranked exactly the same by the two scoring methods. Using Spearman's equation, the coefficient of rank correlation was calculated to be .60 again showing some evidence of agreement.

Rank correlation appears strongest for the Overall ratings. Both scoring methods rank bottomland site 5 the highest and terrace site 1 the second highest. Using

Spearman's equation, a coefficient of rank correlation of .82 (P = .1007) was calculated. Although not considered statistically significant, considering how small the sample is, it seems likely that larger samples would yield small P values. Overall, it appears that the LESA system and the panel of experts ranked the parcels for soil quality, site characteristics, and overall ratings in a similar way.

A further comparison of the panel and LESA ratings was made using threshold values incorporated into the Linn County LESA system. In 1984, while testing the system on 23 sites in the county, threshold values for good, marginal, and non-agricultural land were determined for each LESA factor, as well as overall score. The thresholds were determined by arraying scores and identifying natural break points (Table 7). Because the panelists did not break their Other Factor scores out by conflict and size a comparison of Other Factor threshold levels cannot be made. However, evaluation of soil ratings found that differences in threshold levels occurred only for site 4 where the panel rated the site as non-agricultural (75 points) compared to marginal (100 points) by the LESA system. There were no differences in threshold levels in the Overall ratings.

3) LE to SA Weights

Worksheets at the end of the rating session were used to investigate the Linn County LESA LE to SA ratio. The Linn County LESA system gives equal weight (50%-50%) to LE and SA in all situations. This differs from the 33% (LE) to 67% (SA) ratio recommended in the LESA Handbook and used by most jurisdictions. The panel of experts were asked to indicate by landform, how they would weight LE and SA points.

In general, the panelists gave more weight to LE in bottomlands, slightly more or equal weight to LE in terrace landforms, and equal or less weight to LE in foothills.

The LE to SA ratios indicated by the panel were applied to the Linn County LE and SA LESA scores and to the Delphi panel scores to examine if it would decrease the gap between the two ratings. Table 8 compares the panel and LESA scores when normalized to the panel's preferred weighting. For bottomland sites 3 and 5, where soil quality is generally high, it was found that increased LE weights increased overall scores and increased the gap between Delphi and LESA. Although the panelists were not asked to weight their scores given to Soil Quality and Other Factors to arrive at the Overall Rating, it is theoretically possible to determine the weights they implicitly used by calculating the ratio between their scores on the three factors. For example, for bottomland site 3, the imputed weights calculated were Soil Quality, 10% and Other Factors, 90%. Although panelists stated they would give more weight to LE it appears that, in rating bottomlands, more weight was given to Other Factors. For bottomland sites, LESA at the 50%-50% ratio was closest to the panel, which is in agreement with actual LESA weighting and the overall Delphi panel score (Table 5).

Giving slightly more weight to LE in terrace sites brought the LESA score and panel score into closer agreement for both sites 1 and 2. The imputed weight for the panel for site 1 was 37% for Soil Quality and 63% for Other Factors. For site 2 the imputed weights were Soil Quality, 32% and Other Factors, 68%. The implicit weights used by the panel were very similar to the 33% to 67% ratio recommended by the LESA Handbook.

Increased SA weight for foothill site 4 decreased the score some, but even at a 33%-66% ratio a minimal change in the LESA score occurs. Because the panel rated all three factors the same, manipulations to weights does not change the score. Also, imputed weights cannot be calculated.

Comparison of Lane County LESA and Delphi Ratings

An additional method of testing the accuracy of the Linn County LESA was to apply a LESA system from an adjacent county to the five sites. If the LESA from an adjacent county (Lane County) was better correlated in terms of score and relative ranking, it could lend insight into weaknesses in the Linn County LESA.

1) General Numeric Differences

A comparison of soil ratings by Delphi and Lane County LESA show absolute differences ranging from -8.25 to -28.5. Similar to the Linn County LESA, the Lane County LESA consistently rated the soils higher than the Delphi panel, in spite of the fact that the Lane LESA uses average SPRs rather than the highest of four indicator crops as the Linn County LESA does. Other Factors ratings by Delphi and Lane County LESA did not vary in a consistent fashion as did the soil ratings. However, the difference in Other Factors ratings for bottomland site 5 was 0. Large differences in overall scores were found between Delphi and Lane County LESA. Similar to the soil ratings, Lane County LESA rated all sites higher than the panel. The Overall scores differed by an

average of -39.5 with the smallest absolute differences found between terrace site 1 and bottomland site 5 (-19.5 and -24.0 points respectively).

2) Relative Ranking

A comparison of the relative ranking of the sites by Delphi and the Lane County LESA was carried out. Using Spearman's equation of rank correlation, a coefficient of .87 was calculated for relative soil rankings, providing some evidence for agreement. The ranking of sites by Other Factors was found to have a coefficient of rank correlation of .60. The rank correlation for Overall scores is almost +1. Spearman's equation yielded a correlation of .97 (p=.054) providing strong evidence for correlation of the relative rankings of the five sites.

COMPARISON OF LINN LESA, LANE LESA, AND DELPHI

A comparison of all three ratings for Soil Quality is displayed in Figure 1. From this figure, it can be seen that, with the exception of site 1 (where Linn LESA and the panel are almost exactly the same), both LESA systems consistently rated soils higher than the panel. Focusing on the difference between the LESA systems, it was found that, although the two systems calculate the SPRs used in LE differently, one using the average and the other using the highest of four indicator crops, the end results varied only by a maximum of 9 points. It should be noted that, when applying the Lane County system to the Linn County sites, some of the site average SPRs were unavailable. For

sites 1 and 2 some average SPRs were estimated by a USDA Soil Conservation Service soil scientist.

Considering that both LESA systems use quantitative, databased SPRs to determine LE, and that both were consistently higher than the ratings of the panel as well as consistent with each other, it appears that there may be limitations to comparing absolute soil ratings with expert opinion. The SPRs for both systems include specific data on crop yields, crop prices, and management practices. Lacking such specific data, absolute differences in panel soil scores would be expected.

Also, the panel of experts was able to adjust its scoring for site specific problems that are not considered by the LESA model. For example, site 5 had a problem with adequate volume of irrigation water, known to the panelists but not accounted for by the LESA model. This most likely caused the LE rating to be lower for the panel than the LESA model. Another possible explanation of the difference in ratings may be that the LESA rating is based on a table of per acre soil potential numbers, which will be the same wherever the soil occurs. The panel may be thinking in terms of the tracts overall relative ranking, which may incorporate factors other than soil quality.

However, examining the relative ranking of sites by the panel and the LESA systems, it can be seen in Figure 1 and in earlier calculations of coefficients of rank correlation that there was general agreement in relative rankings. Overall, there is consistency between the two LESA systems, absolute but consistent differences between the panel and the LESA systems, and agreement in relative ranking for all three.

Figure 2 displays a comparison of Other Factors ratings by the Delphi panel and the two LESA systems. From this figure it can be seen that the correlation between panel scores and SA scores is highly variable. However, with the exception of site 4, the Lane County SA scores are more closely aligned with the panel and, except for site 1, Lane County SA scores are higher than those of the Linn County system. Because SA ratings by panelists were not broken out and weighted by categories, i.e., conflict and size, it is impossible to tell exactly why a parcel received a particular score. However, it appears that refinements in the Lane County LESA are responsible for the closer alignment with the panel ratings.

The Lane County LESA system, developed almost four years after the Linn LESA, puts less emphasis on the conflicts associated with non-resource dwellings in farm areas and refines the evaluation of parcel size to include consideration of not only landform but also the production area within the county. For site 1, a 95.22 acre grass seed field with little surrounding conflict, the two LESA systems rate the "conflict" almost identically. But, in the evaluation of size, because the site was found in a production area of poorly drained soils, the Lane system rated the parcel lower than the Linn system and closer to the panel. Site 2, 13.18 acres of terrace land, was awarded 10 points for size by the Linn County system. In comparison, the Lane system which was closer in absolute rating to the panel, rated the site based on its location in a production area of well drained terrace soils and awarded 45 points for size. Panelists characterized disadvantages of the site in terms of its small size and irregular shape; shape is not considered by either model.

Differing emphasis on conflict and the method for evaluating size appear to cause large differences between the panel and the Linn County system for site 3. Site 3, a 13.36 acre parcel located on bottomland soils, is surrounded by several non-farm parcels. When evaluated for conflict by the Linn County system, a score of 18 out of a possible 70 points was awarded. Additionally, the small size of the parcel was responsible for a size evaluation of 20 out of 75 possible points. Although worksheets by the panelists indicated that the size of the parcel and the surrounding neighbors were a disadvantage of the site, it was penalized to a much lesser degree by the panelists than by the LESA model. A comparison between the two LESA systems shows that Lane County's slightly less emphasis on conflict combined with the refinements in size evaluation bring the panel and the Lane model into much closer agreement than that of Linn County.

As with the other sites, site 5 has closer agreement between the panel and Lane County. The Linn County system emphasis on conflict and its method of size rating results in a lower score as compared to Lane County. Lane County LESA and the panel are in perfect agreement for site 5.

The only exception to the Lane LESA system being closer to the panel is for site 4. In this case, less emphasis on conflict and more value on soils by the Lane model over-rates the parcel compared to the panel. Evaluating panelists' worksheets, the disadvantages of the site were indicated as steep slopes and lack of irrigation, neither of which is addressed directly by the LESA models. As mentioned earlier, it appears that the low scores awarded site 4 by the panel compared to either LESA model are probably

due to the panel's discounting the relative value of foothill sites, useful mostly for pasture, compared to bottomland and terrace cropland found in most of the county.

For Overall ratings (Figure 3) it can be seen that, with the exception of site 4, while the LE and SA parts of LESA may reflect differences between the panel and the Linn County system, the Overall ratings between the two are very closely aligned. In comparison, the Lane LESA consistently over-rates the parcels when compared to a local expert panel.

SUMMARY OF FINDINGS

The Delphi method provides a reasonable benchmark for evaluating LESA ratings. It is best to keep the Delphi procedure simple by focusing on the agricultural productivity of the site in both the LE and SA evaluations. If urbanization potential or suitability is important, it should be evaluated by a separate Delphi procedure. Non-farm development should be considered only to the extent that it impacts agricultural practices.

In this study, because panelists were asked to rate LE, SA, and Overall LESA on a 100 point scale, it was not clear to them that the Overall rating was an additive combination of LE and SA. For this reason, there appears to be little linkage between the parts of the ratings when compared to the whole. This lack of linkage was evident in the differences found in the preferred LE to SA weights indicated by the panelists vs. the imputed weights. To improve the methods used, we suggest that the panel should rate soil quality and site assessment separately on a 100 point scale. LE to SA weights for different landforms or other geographic subareas should be determined by the Delphi

procedure. Overall scores can then be calculated from the LE and SA ratings and the assigned LE to SA weights. A comparison to LESA ratings can then be made by adjusting LESA scores by the weighting for LE and SA as given by the panel. This provides an evaluation of both the LE and SA ratings, the weighting given to each component in the overall LESA rating, and a comparison of Overall ratings.

In addition to these comparisons, the relative ranking of several sites should be compared. Given time and budget limitations, this study compared only five sites. A comparison of 30 or more sites would provide a better basis for relative ranking comparisons.

It was found that the ratings given by the Delphi panel were logical and specific to site conditions. Certain problems or limitations which affected the panel's rating of a specific site were not recognized by the general LESA model. This result, of course, is expected of any generalized rating system which is intended to be relatively simple to administer and easy to understand. It does, however, validate the more accurate ratings of the panel.

In counties with diverse farming activities, the use of agricultural subareas helps to fine-tune the parcel size ratings. In spite of widespread assumptions about the negative effects of non-farm homesites on farming operations, the expert panel discounted the conflict potential even beyond the conservative ratings of the LESA models. In Lane County, potential conflict was linked with parcel size, causing fewer points to be deducted for conflicting residences around larger parcels. Nevertheless, the

Delphi finding would indicate that penalties for conflict should be reduced for both Linn and Lane County systems.

Parcel size, while a significant variable in relative ranking, also needs to be re-examined. In areas of prime soils, even small parcels (10-20 acres) appear to have more value than assigned in the LESA models. While the Lane County LESA model did include refinements to place more value on small parcels in areas of productive soils, the point distribution needs to be re-examined.

A benchmark evaluation using a local expert panel in a systematic procedure is an important part of a LESA validation procedure. When used in conjunction with other evaluation criteria, it can lend great insight into an effort to improve the scientific basis for LESA ratings of resource lands.

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Table 1. **Description of Study Sites**

Linn County LESA Study Sites			
SITE #	SIZE (in acres)	LANDFORM	CURRENT USE
1	95.22	Terrace	grass seed
2	13.18	Terrace	residence/grazing
3	13.36	Bottomland	fallow
4	49.20	Foothill	grazing/timber
5	65.43	Bottomland	row crops

Table 2
Linn County Delphi Panel Scores, By Round

	Soil Quality			Other Factors			Overall		
	Round 1	Round 2	Round 3	Round 1	Round 2	Round 3	Round 1	Round 2	Round 3
Site 1									
Upper Quartile	72	70	68	83	80	78	80	75	74
Median	65	65.5	66.5	76	76	75	71	71	71.5
Lower Quartile	62	65	65	65	69	69	66	69	70
Site 2									
Upper Quartile	75	70	68	60	52	50	60	55	55
Median	65	65	65	47.5	47.5	45	52.5	50	50
Lower Quartile	50	55	58	40	45	44	44	40	40
Site 3									
Upper Quartile	86	86	85	80	75	72	73	70	70
Median	85	85	85	65	60	60	66	65	62.5
Lower Quartile	80	80	80	40	50	50	55	60	60
Site 4									
Upper Quartile	60	55	--	60	52	52	55	55	--
Median	50	50	--	51	50	50	50	50	--
Lower Quartile	50	50	--	45	46	46	48	50	--
Site 5									
Upper Quartile	90	90	--	85	80	--	85	85	--
Median	84.5	85	--	80	80	--	80	80	--
Lower Quartile	75	80	--	70	75	--	79	79	--

Table 3. **Analysis of "Soil Quality Ratings." Delphi Panel Ratings vs. Linn County LESA System Ratings.**

SITE NUMBER	SIZE (in acres)	LANDFORM	DELPHI RATING* (A)	LESA RATING** (A_1)	DIFFERENCE Delphi-LESA	% ERROR $A-A_1/A \times 100$
1	95.22	Terrace	99.75	99.0	+ 0.75	0.75%
2	13.18	Terrace	97.50	117.0	-19.50	20%
3	13.36	Bottomland	127.50	149.0	-21.50	16%
4	49.20	Foothill	75.0	100.0	-25.0	33%
5	65.43	Bottomland	127.50	149.0	-21.50	16%

* The Delphi rating is the **median** "Soil Quality Rating" given by the 14 panelists. Delphi Ratings were multiplied by 1.5 to fit the Linn County LESA system (150 points possible).

** The LESA rating is the Soil Potential Rating using the Linn County LESA system.

Note: Sites 1-3 had three iterations; Sites 4-5 had two iterations.

Table 4. **Analysis of "Other Factor" Ratings. Delphi Panel Ratings vs. Linn County LESA System Ratings.**

SITE NUMBER	SIZE (in acres)	LANDFORM	DELPHI RATING* (A)	LESA RATING** (A_1)	Difference Delphi-LESA	% ERROR $A-A_1/A \times 100$
1	95.22	Terrace	112.50	136.0	-23.50	20%
2	13.18	Terrace	67.50	42.0	+25.50	37%
3	13.36	Bottomland	90.0	38.0	+52.0	57%
4	49.20	Foothill	75.0	94.0	-19.0	25%
5	65.43	Bottomland	120.0	95.0	+25.0	20%

* The Delphi rating is the **median** "Other Factor Rating" given by the 14 panelists. Panelists were asked to rate the parcels for OTHER FACTORS that affect the ability to conduct agricultural operations. Delphi scores were multiplied by 1.5 to fit the scale of the Linn County LESA system (150 points possible).

** The LESA rating is the score given for Site Assessment using the Linn County LESA system (SA).

Note: Sites 1-4 had three iterations; Site 5 had two iterations.

Table 5. **Analysis of "Overall Ratings." Delphi Panel Ratings vs. Linn County LESA System Ratings.**

SITE NUMBER	SIZE (in acres)	LANDFORM	DELPHI RATING* (A)	LESA RATING** (A_1)	DIFFERENCE Delphi-LESA	% ERROR $A-A_1/A \times 100$
1	95.22	Terrace	214.50	235.0	-20.50	9%
2	13.18	Terrace	150.0	159.0	- 9.0	6%
3	13.36	Bottomland	187.50	187.0	+ 0.5	0.2%
4	49.20	Foothill	150.0	194.0	-44.0	29%
5	65.43	Bottomland	240.0	244.0	- 4.0	1%

* The Delphi rating is the **median** "Overall Rating" given by the 14 panelists. The Delphi ratings have been multiplied by 3 to fit the scale of the Linn County LESA system (300 points possible).

** The LESA rating is the Overall Score a parcel received using the Linn County LESA system.

Note: Sites 1-3 had three iterations; Sites 4-5 had two iterations.

Table 6. **Relative Rank of Sites by Delphi Panel and Linn County LESA**

Overall Ratings			
SITE #	DELPHI RELATIVE RANK	LESA RELATIVE RANK	DIFFERENCE IN RANK
1	2	2	0
2	4*	5	1
3	3	4	-1
4	4*	3	1
5	1	1	0

Coefficient of rank correlation =.82 (p= .1007)

* signifies a tie in ranking.

Table 7. **Linn County LESA Threshold Levels**

Thresholds				
THRESHOLD LEVELS	SOILS	CONFLICT	SIZE	TOTAL
Good	>80	>52	>45	>200
Marginal	50-79	18-51	10-44	100-200
Non-Ag.	<50	<18	<10	<100

Table 8. **Comparison of Delphi and LESA OVERALL scores when normalized to the LE to SA ratio indicated by the panel.**

Results Weighted by Landform			
SITE #	DELPHI	LESA	DIFFERENCE Delphi-LESA
1	210	228	-18
2	171	174	-3
3	236	243	-7
4	150	190	-40
5	251	271	-20

Terrace Sites #1 and #2 the preferred LE to SA Ratio was 60% to 40%

Bottomland Sites #3 and #5 the preferred LE to SA ratio was 75% to 25%

Foothill Site #4 the preferred LE to SA ratio was 40% to 60%

Figure 1.

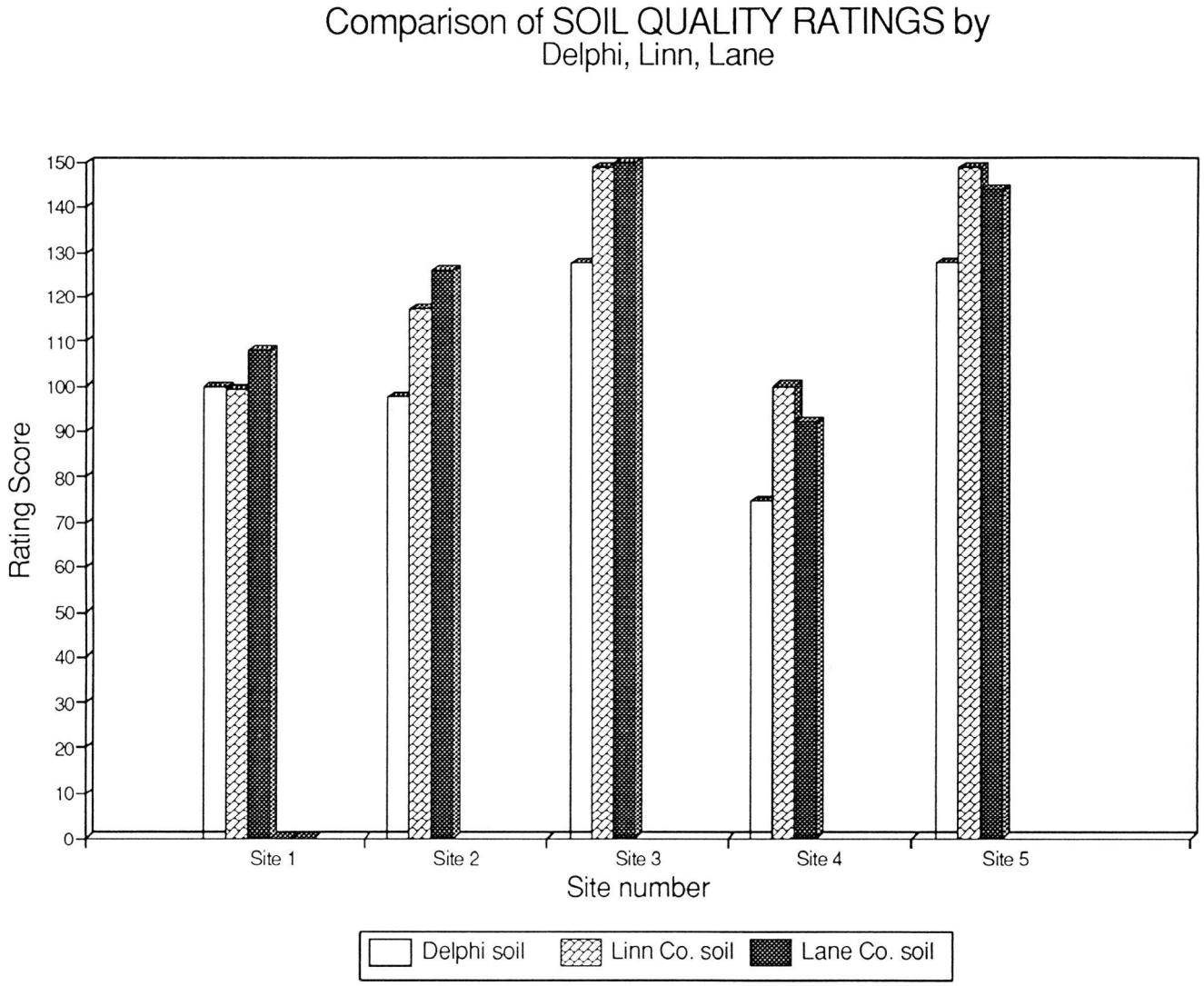

Comparison of SOIL QUALITY RATINGS by
Delphi, Linn, Lane
Rating Score
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Site 1
Site 2
Site 3
Site 4
Site 5
Site number
Delphi soil
Linn Co. soil
Lane Co. soil

Figure 2.

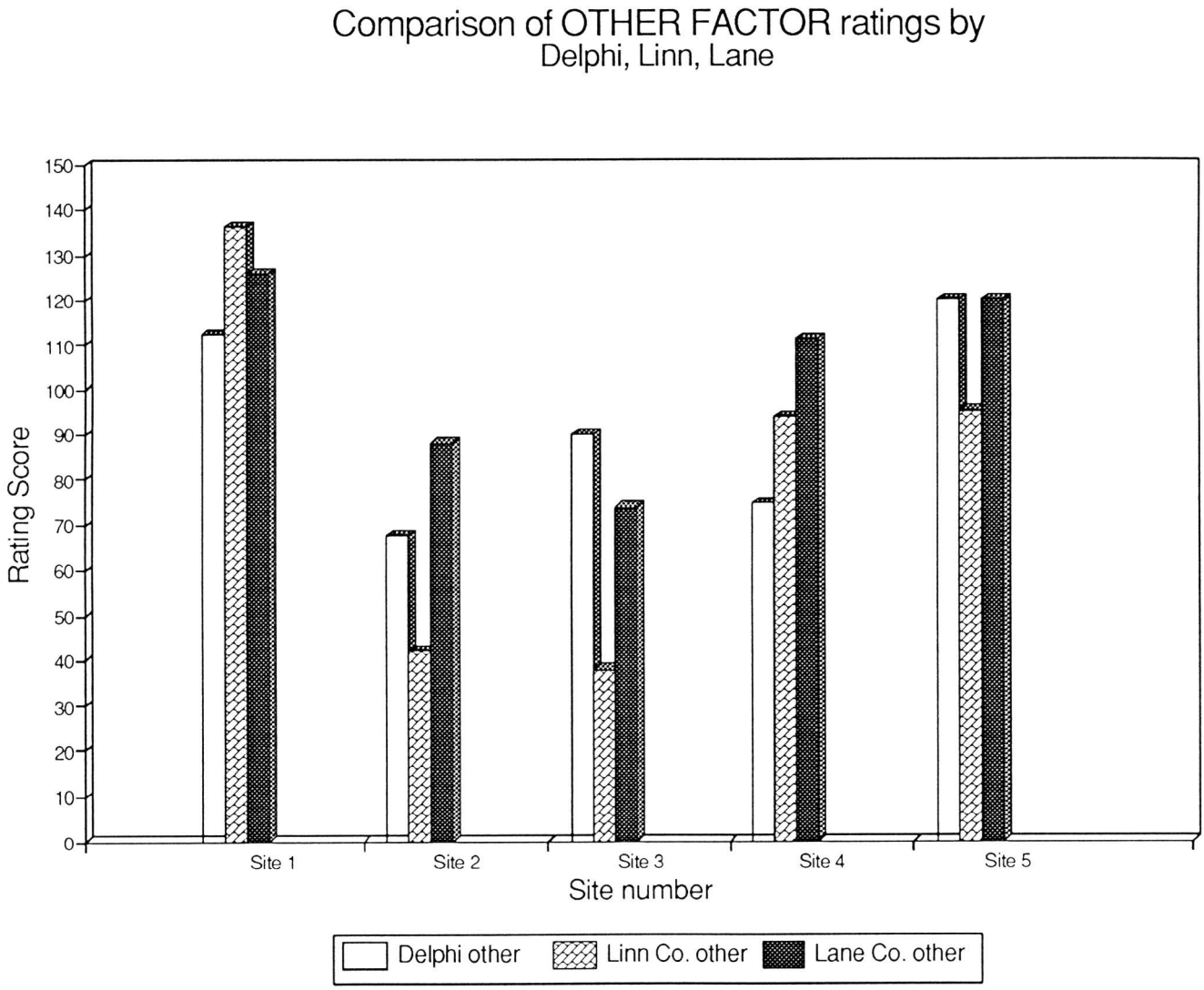
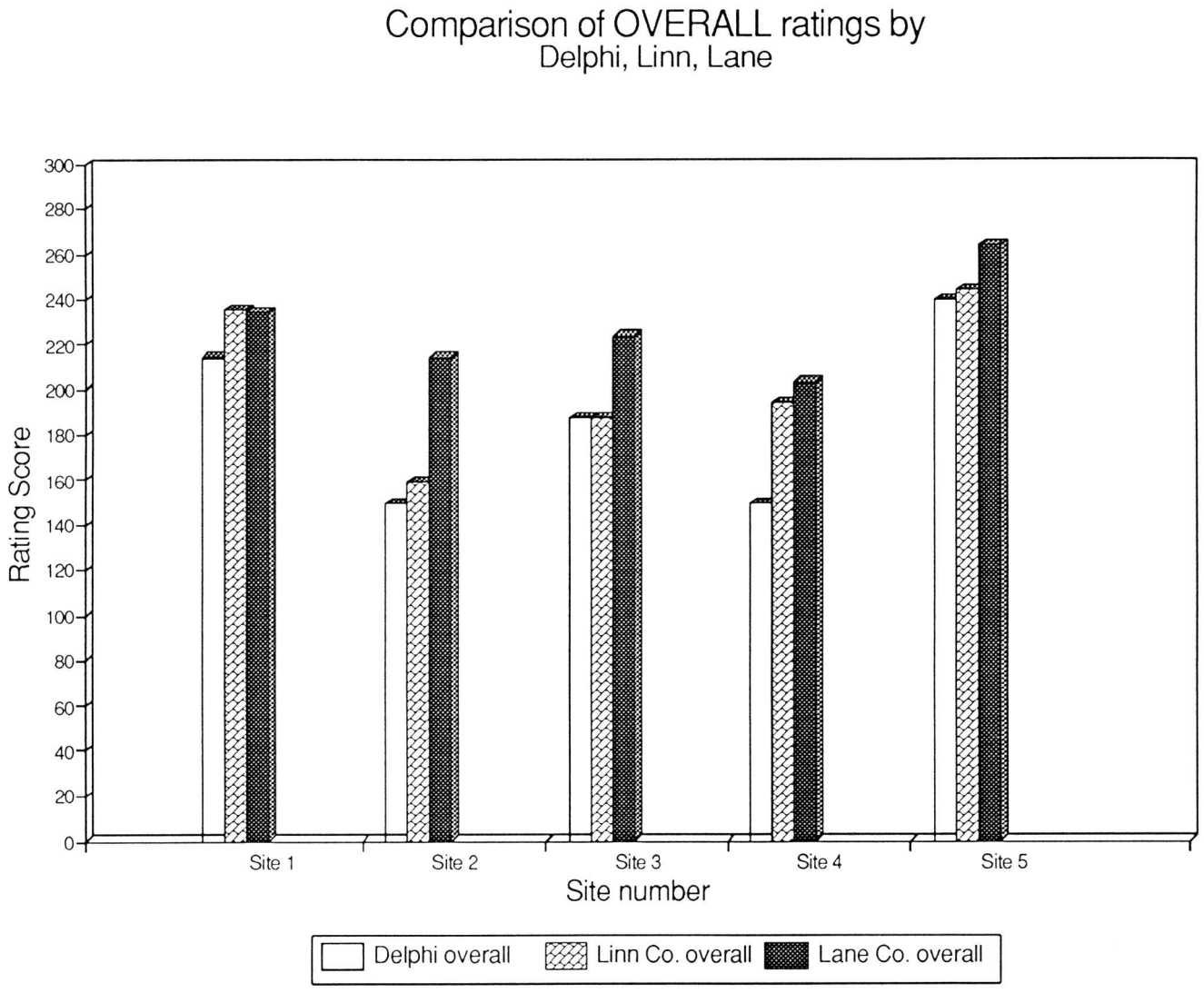

Comparison of OTHER FACTOR ratings by
Delphi, Linn, Lane
Rating Score
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Site 1
Site 2
Site 3
Site 4
Site 5
Site number
Delphi other
Linn Co. other
Lane Co. other

Figure 3.


Comparison of OVERALL ratings by
Delphi, Linn, Lane
Rating Score
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Site 1
Site 2
Site 3
Site 4
Site 5
Site number
Delphi overall
Linn Co. overall
Lane Co. overall