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Implications of Lawn Care and Landscape Maintenance Firm Profiles for Adoption of Pest-Management Practices

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ABSTRACT

Firm characteristics and managers' attitudes and opinions about pesticide safety were used to classify lawn care and landscape management firms into four categories and compare them using the logit procedure. Survey data obtained from 223 firms was used in the empirical investigation of the adoption of the IPM techniques. Results showed the need for continued transfer of new technology to independently owned firms, multidisciplinary assessment of IPM methods before their transfer to ascertain the economic viability of proposed methods, public investment in programs training workers in knowledge-based pesticide applications, possible assistance in obtaining capital, and investment in consumer education.

Key Words: *attitudes, cluster analysis, IPM, logit model, management, survey.*

Increased plantings of ornamentals and grasses have created the demand for maintenance services provided by the lawn care and landscape maintenance (LCLM) industry. The LCLM services include the use of chemicals to control unwanted organisms on residential and commercial properties. LCLM firms sell services which must meet the expectations of

their buyers. The appearance of lawns and landscapes plays a vital role in fulfilling a property owner's LCLM demands. A reliable, fast, and cost-effective service can be provided by choosing to use pesticides on a prescribed schedule with additional treatments when necessary. Such an approach assures an LCLM firm of revenues and increases the potential for contract renewals (future revenues), satisfying the goal of profitability. A survey of U.S. professional lawn care and landscape maintenance firms found that the industry spent an estimated \$271 million for pesticides in 1994 (SRI Consulting).

The supplier of LCLM services seldom has control over the selection of plants in the landscape. The lack of homogeneity in a landscape complicates pest-management decisions because various plants may require different treatments (Braman). How LCLM firms arrive at a final insect-control decision can be ad-

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dressed by understanding the firms' goals and objectives and their influence on firms' behavior demonstrated in the actual use of different treatments.

The use of pesticides on residential and commercial properties by the LCLM industry has led to concerns about the health of the public and the environment. To control both lawn/landscape appearance and environmental outcomes, LCLM firms may have to balance the expectations of the customer and the use of chemicals. About 60 percent of consumers surveyed in the Pacific Northwest (Dunlap and Beus) felt that the use of pesticides to protect ornamental plants was not necessary. Alavanja *et al.* reported that 37 percent of commercial applicators indicated exposure to pesticides while Gadon found that despite the use of safety measures, some lawn care and tree service workers were subject to pesticide poisonings. Zahm corroborated the link between dermal exposure and the occurrence of non-Hodgkin's lymphoma among pesticide lawn applicators. Firms may also use alternatives to agrichemicals providing LCLM pest management services. Alternative input management systems in the LCLM industry are, however, less developed and understood than those in commercial production agriculture.

This study generates information needed for policy design including efforts to enhance LCLM firms' knowledge of about the array of pest-management practices which are accessible and can be used by the industry. The purpose of this paper is to explore the linkages between firm objectives and use of pest-management practices. A firm's objectives influence the selection of pest-management practices; therefore, we classify LCLM firms into relatively homogenous groups according to applied practices in order to derive the underlying goals and objectives for firms within each group. Moreover, the study tests hypotheses regarding the impacts on firm classification of 1) firm economic characteristics and 2) LCLM managers' attitudes and opinions regarding the importance of pesticide safety. Classification of LCLM firms is accomplished by applying cluster analysis to survey data. A multinomial logit model is used to test the re-

lationship between firm classification and firm characteristics and managerial attitudes and opinions.

Knowledge about the link between LCLM firm characteristics and pesticide management provides guidance for the development of outreach programs which can effectively transfer outcomes of research projects to their users. Carefully targeted outreach programs are necessary because the industry's goals are not identical with goals of individual firms, and information needs are likely to vary across firm classifications. By accounting for differences in pest-management practices, the targeted information dissemination can close the gap between firms relying mostly on chemicals and firms applying an integrated approach to lawn and landscape maintenance (EPA). The advancement of knowledge across the LCLM industry could involve the industry in consumer education by promoting environmentally sound practices and save the cost of designing regulations and enforcement by encouraging self-regulation.

The health of the personnel providing LCLM services, the buyers of the services, and the general public enter into the decision-making process and must be considered to understand and interpret firm behavior. Use of alternative pest-management practices reflects both firm and consumer objectives for reduced environmental impact, while use of only chemical-based pest-management practices may indicate that consumers and firms are not aware of or are unconcerned about impacts of these practices. Classification of LCLM firms into categories which mirror the applied management practices permits the investigation of the links between a firm's characteristics and its choice of pest-management practices.

Data Collection

A survey of landscape maintenance and lawn care firms in the Atlanta, Georgia metro area (AMA) was conducted in 1994. This area was selected because of the high concentration of commercial activity and high population density. The AMA was defined as the Atlanta Statistical Reporting District, which included 20

counties. Mailing lists were collected from professional associations of the LCLM industry: the Professional Lawn Care Association of America, the Metro Atlanta Lawn and Turf Association, the Georgia Green Industry Association, and the Professional Grounds Management Society. County governments in all 20 counties were also contacted to obtain lists of business licenses issued for landscape maintenance and lawn care firms. Compiled lists were based on the county government records using the Standard Industry Code (SIC). However, some inconsistencies were found in the use of SIC codes. Such inconsistencies may have led to omission of some companies relevant to the survey, but the developed list was considered the best available alternative. The population included all residential and commercial LCLM firms, excluding those servicing golf courses and those servicing primarily large utilities and right-of-ways. Golf courses represent a special group of establishments, often using in-house ground maintenance crews.

The survey was sent to 1678 firms, of which 350 returned usable questionnaires. The survey requested information on firm characteristics, services provided, major pest problems, pest-management practices, opinions on the importance of various economic and environmental factors, information sources for agrichemical management, adequacy of information about agrichemicals, and agrichemical applications. In general, the respondents were representative of the population, suggesting little concern about non-response bias. However, there was a slightly higher proportion of larger firms in the sample than in the population. This may have been due to non-response by very small lawn mowing and trimming firms who have little involvement with pest management.

For the empirical analysis, 127 of the 350 LCLM firms were excluded because they do not offer pest-management services. This resulted in an adjusted sample size of 223 firms.

Classification of LCLM Firms

Cluster analysis has been used to classify Nebraska farms based on production practices

(Bernhardt, Allen, and Helmers) and Ontario pork producers based on farm size, structure, and management and production practices (Rosenberg and Turvey). Cluster analysis is a statistical technique useful for distinguishing relatively homogeneous populations within a larger set of observations based on the similarity of attributes of observations. Basically, clustering algorithms use some measure of distance in attribute space to determine how near observational units are to each other. Observations that are near to each other are grouped and then the resulting clusters are checked against other clusters to determine whether further grouping will increase the proportion of the variation in the data explained. The cluster analysis in this paper follows the procedures outlined in Romesburg.

The selection of variables for the cluster analysis was guided by conceptual and empirical considerations. Transferring the approach used to classify farms into categories according to the degree of the sustainability of applied practices, the LCLM firms can be classified given reported use of pest-management practices. Consequently, a set of physical and management practices known to be used by the LCLM industry is the appropriate source of variables to cluster analyze to reflect the efforts of the firm to achieve desired profitability and environmental objectives.

Hubbell *et al.*, showed that pest-management systems used by LCLM firms can be classified along the continuum from conventional methods of pest control to alternative, IPM methods. The scale was based on 18 variables representing chemical applications and information sources identifying five pest-management factors. However, microeconomic firm characteristics were excluded from that analysis. Given the objectives of this study, the clustering procedure used to classify firms into groups is based on their pest-management practices, while the development of the cluster profiles includes both pest-management practices and microeconomic and management characteristics. Firms with similar pest-management practices, reflecting the use of chemicals and alternative pest-management meth-

Table 1. Percent of LCLM Firms Employing Pest-Management Practices

| Management Practice | Classification | Percent of Sample Employing Practice |
|-------------------------------------|--------------------------|--------------------------------------|
| Customer Options: | | |
| IPM option | Alternative | 28 |
| Organic option | Alternative | 15 |
| Predetermined Use of: | | |
| Insecticides | Conventional | 19 |
| Fungicides | Conventional | 24 |
| Herbicides | Conventional | 63 |
| Pesticide Treatment Criteria: | | |
| Predetermined schedule | Conventional | 36 |
| Customer requests | Conventional | 53 |
| Pests or damage present | Alternative/Conventional | 82 |
| Monitoring pest populations | Alternative | 43 |
| Monitoring beneficial insects | Alternative | 11 |
| IPM Practices: | | |
| Scouting | Alternative | 73 |
| Soaps and oils | Alternative | 33 |
| Biological control agents | Alternative | 10 |
| Chemicals only when necessary | Alternative | 85 |
| Identify beneficial insects | Alternative | 21 |
| Insect growth regulators | Alternative | 6 |
| Insect traps | Alternative | 6 |
| Information Sources: | | |
| Commercial sales representatives | Conventional | 68 |
| Peers | Conventional | 38 |
| Trade magazines | Alternative | 58 |
| University or extension specialists | Alternative | 59 |

ods, can be located on a continuum from conventional to IPM approach.

This study models LCLM firms' use of pest-management practices without the explicit effort to identify the relative weights firms place on achieving a specific objective. Rather, the survey instrument was designed to collect data on a number of issues, ranging from the firm's economic profile to types of chemicals used, application methods, pest problems, perception of important issues influencing the operation of the firm, and characteristics of the LCLM manager completing the questionnaire. Therefore, goals are identified and measured indirectly by the responses to questions in the survey.

The observational unit for this analysis is the firm. Attributes are pest-management practices. These attributes are selected because they will

allow LCLM firms to be grouped into clusters which can be used to test hypotheses concerning firm demographic characteristics and the location of firms on the pest-management scale.

Data was collected on 21 pest-management practices. Of these practices, listed in Table 1 with the proportion of the sample adopting each, 13 are subjectively identified as being associated with 'alternative' management. All of the pest-management variables are binary, equal to one if the practice is used and zero if not. Because of the binary nature of the classification variables, it was not necessary to standardize the variables as is generally done in cluster analysis when variables are quantitative.

Cluster analysis requires the calculation of both similarity between observations and clustering of observations based on similarity. This requires the analyst to choose both a similarity

Table 2. Pest-Management Practices: Percent of Cluster Group Employing the Practice

| Management Practice | Cluster Groups | | | | p-Value ^a |
|----------------------------------|---|--|---|--|----------------------|
| | "See and Spray" Managers (44 Firms) | Low Tech, Low Input Managers (70 Firms) | Full Service Managers (22 Firms) | Integrated Pest Managers (87 Firms) | |
| Customer Options: | | | | | |
| IPM option | 18 | 1 | 59 | 47 | .0000 |
| Organic option | 14 | 1 | 45 | 18 | .0000 |
| Predetermined Use of: | | | | | |
| Insecticides | 45 | 4 | 73 | 3 | .0000 |
| Fungicides | 43 | 3 | 95 | 13 | .0000 |
| Herbicides | 50 | 39 | 100 | 80 | .0000 |
| Pesticide Treatment Criteria: | | | | | |
| Pests or damage present | 84 | 67 | 95 | 89 | .0014 |
| Monitoring pest populations | 64 | 7 | 77 | 53 | .0000 |
| Monitoring beneficial insects | 11 | 0 | 50 | 10 | .0000 |
| Customer requests | 77 | 29 | 68 | 56 | .0000 |
| Predetermined schedule | 55 | 20 | 95 | 24 | .0000 |
| IPM Practices: | | | | | |
| Scouting | 86 | 34 | 91 | 93 | .0000 |
| Soaps and oils | 18 | 13 | 68 | 48 | .0000 |
| Biological control agents | 9 | 3 | 14 | 15 | NS |
| Chemicals only when necessary | 73 | 83 | 95 | 90 | .0338 |
| Identify beneficial insects | 9 | 1 | 64 | 31 | .0000 |
| Insect growth regulators | 5 | 1 | 18 | 8 | .0323 |
| Insect traps | 9 | 3 | 5 | 8 | NS |
| Information Sources: | | | | | |
| Commercial sales representatives | 43 | 56 | 91 | 84 | .0000 |
| Trade magazines | 36 | 39 | 86 | 77 | .0000 |
| University/extension specialists | 50 | 39 | 82 | 75 | .0000 |
| Peers | 25 | 9 | 45 | 67 | .0000 |

^a Probability of obtaining the chi-square test statistic for testing independence between cluster membership and the pest management practice. P-values greater than 0.05 are listed as NS.

measure and a clustering algorithm. Based on the binary nature of the classification variables, the binary squared Euclidean distance is used as the measure of similarity. Ward's clustering algorithm was used to cluster analyze the firms (Romesburg). This algorithm minimizes the sum of squared distances between firms within clusters while maximizing the squared distance between clusters. This method provides clusters which are very distinct between each other, with member firms that are very similar to each other.

Results of Cluster Analysis

Application of Ward's clustering algorithm resulted in four distinct clusters based on 21 pest-

management practices. Following previous applications of cluster analysis, labels are descriptive and intended to simplify the discussion of the clusters. The four clusters in this analysis are labeled "see and spray" managers; low-tech low-input managers; full-service managers; and integrated pest managers.

Table 2 shows the percent of each cluster group employing the pest-management practices used in clustering the firms. In addition, Table 2 lists the p-values associated with the chi-square tests for independence between the clustering variables and the cluster groups. All but two of the clustering variables were significant, indicating that the group of pest-management practices were useful in delineating clusters.

Cluster groups have been labeled based on the dominant pest-management practices in the cluster. Starting from the leftmost column, cluster groups are ordered from highest reliance on conventional pesticide applications on the left to highest reliance on alternative pest management on the right. The following sections provide more elaborate descriptions of the clusters, tying the cluster characteristics into the goal structure outlined above.

“See and Spray” Managers

These firms are characterized by high reliance on customer requests and observed pest populations for treatment decisions (Table 2). This cluster also has a high proportion of firms using predetermined insecticide and fungicide applications. This group does not utilize sources of information about pest control and most members do not offer either an IPM or organic pest-control option. With the exception of scouting and use of chemicals only when necessary,¹ firms in this cluster do not tend to use IPM practices.

Firms in this cluster are largely independently owned, have mainly residential accounts, have sales less than \$100,000 per year and have low equipment value (Table 3). Characteristics of this cluster suggest that the goal structure of member firms is dominated by the profit objective, and reflects the consumer objective of appearance.

Low-Tech, Low-Input Managers

Firms in the low-tech, low-input cluster have the lowest overall use of predetermined pesticide applications. However, they also have the lowest use of most IPM practices, and only one percent of these firms offers either IPM or organic pest-control options. The primary pesticide treatment criterion for this group is pests or damage present, and only 34 percent

of this group report using scouting, less than half that of any other cluster (Table 2).

Firms in this cluster are largely independently owned, have sales less than \$100,000 per year, and have less experience than any other cluster (Table 3). The primary sub-goals dominating firms in this cluster appear to be profit and health. Given the low sales and low experience of firms in this cluster, the primary factors used to achieve the profit objective are likely to be ease of use and low costs.

Full-Service Managers

This cluster is characterized by a high percentage of firms using almost all of the pest-management practices, both conventional and alternative. This suggests that these firms are customer driven, offering a wide range of services to meet the differing needs of their clients. The firms in this group have the highest percentage offering IPM or organic pest control (Table 2). However, this group also has the highest percentage using predetermined applications of insecticides, fungicides, and herbicides. Likewise, a high percentage of this group uses each of the pesticide treatment criteria and IPM practices, with the exception of insect traps.

Members of this cluster make use of all information sources, with the dominant sources being commercial representatives, trade magazines, and university or extension specialists. This group has the highest percentage of corporate owned or franchise operations, has sales mainly above \$100,000, has high equipment value, has the most experience and the highest level of education of any cluster (Table 3). The dominant objectives for firms in this cluster appear to be profit and environmental protection. Given the provision of both conventional and alternative pest-management service options, it is likely that pest-management practices provided by these firms reflect a derived demand by consumers with goals of environmental quality or health protection, as well as management attitudes concerning environmental protection.

¹ Note that “use of chemicals only when necessary” is determined subjectively by the respondent, rather than based on any objectively determined criterion, such as an economic threshold. Thus a firm may consider that when a customer asks for a spray, it is “necessary” to make an application.

Table 3. Cluster Group Characteristics^a

| Survey Variables | Means of Variables by Cluster Group | | | | |
|--|-------------------------------------|--------------------------|------------------------------|-----------------------|--------------------------|
| | Combined Sample | “See and Spray” Managers | Low Tech, Low Input Managers | Full Service Managers | Integrated Pest Managers |
| <i>Binary variables:^b</i> | | | | | |
| Independently owned firm | 82 | 94 | 90 | 67 | 75 |
| Corporate owned or franchise | 18 | 6 | 10 | 33 | 25 |
| Sales <\$100,000 | 51 | 65 | 67 | 27 | 38 |
| Sales >\$100,000 | 49 | 35 | 33 | 73 | 62 |
| Equipment value <\$25,000 | 45 | 62 | 55 | 40 | 32 |
| Equipment value >\$25,000 | 55 | 38 | 45 | 60 | 68 |
| Provide services to inner metro counties | 88 | 76 | 84 | 100 | 95 |
| Provide services to suburban counties | 46 | 44 | 43 | 53 | 47 |
| Provide services to fringe counties | 65 | 62 | 55 | 93 | 67 |
| <i>Continuous variables:</i> | | | | | |
| Percent residential sites | 67 | 76 | 65 | 72 | 64 |
| Percent commercial sites | 33 | 24 | 35 | 28 | 36 |
| Years in business | 8.11 | 8.82 | 7.18 | 11.00 | 7.79 |
| Years of education | 12.08 | 11.44 | 11.86 | 13.40 | 12.26 |
| Age | 37.79 | 37.29 | 37.80 | 37.93 | 38.99 |
| <i>Categorical variables:^c</i> | | | | | |
| Importance of impact of applied chemicals on water quality | 4.31 | 4.44 | 4.10 | 3.93 | 4.47 |
| Importance of safety of pesticides to the public | 4.63 | 4.56 | 4.55 | 4.53 | 4.73 |
| Importance of pesticide exposure to non-target organisms | 4.35 | 4.47 | 4.10 | 4.67 | 4.40 |
| Importance of resistance to pesticides | 4.23 | 4.32 | 4.04 | 4.47 | 4.26 |

^a Because of missing data on economic characteristics and opinions, cluster characteristics are based on sample sizes of 34, 49, 15, and 73 for the clusters from left to right, respectively.

^b Binary variable, percent of sample with characteristic is listed instead of the mean.

^c Variable measured on an importance scale ranging from 1 = Not important to 5 = Very important.

Integrated Pest Managers

This group has a high percentage of firms offering IPM or organic pest control. In addition, they have a low percentage using predetermined insecticide or fungicide applications. This group has a relatively high proportion using most of the IPM practices, with the exception of insect growth regulators and insect traps (Table 2). Firms in this cluster use all sources of information, including the highest use of peer information of any cluster. Firms in this cluster are largely independently owned, have sales greater than \$100,000 and have high equipment value (Table 3). Firms in this cluster are the most likely to have goal structures heavily influenced by environmental and health objectives.

With the exception of the low tech, low input managers, all clusters had a high percentage of firms using predetermined applications of herbicides. This may reflect the less-developed state of weed IPM. Firms may have few alternatives to prophylactic herbicide applications. All clusters had a large percentage of firms reporting that they use chemicals only when necessary, even when a large percentage also reported using predetermined applications. This may reflect an underlying attitude that some predetermined pesticide applications are necessary to ensure adequate pest control.

Relationships between Cluster Membership and Characteristics of Firms and Managers

Classification of LCLM firms into four relatively homogenous groups based on pest control methods provides a basis for evaluating the current status of the LCLM industry with regard to adoption of desired practices. From a policy standpoint and because of the need to broaden the acceptance and use of more environmentally appropriate methods, it is helpful to identify those firm or manager characteristics which are correlated with membership in each of the four clusters identified in the previous section.

A firm's human and physical capital is likely to influence the selection of methods used

in providing LCLM services, and it is expected that IPM methods are management intensive and require additional, specialized information (Hall and Duncan). Factors such as the experience, age, and educational attainment of the firm operator, as well as the value of equipment, indicate the firm's accumulated capital. The types of customers served and the geographical focus of the firm help identify the relative importance of particular practices to a firm because of the nature of services provided; i.e., residential customers in densely populated areas may have different demands from commercial customers or residential customers in sparsely populated areas. The ability to offer alternative services can be influenced by the firm's revenues; 'alternative' practices may imply higher risk associated with the undefined market size or the inability to guarantee expected results. Generally, the larger the revenue, the greater will be the ability and willingness to offer alternative services. In addition, firm ownership can affect the ability to offer alternative services. Corporate-owned firms or franchise operations may have better access to research on alternative practices than independently owned firms, lessening the need for costly investments in developing expertise in providing quality alternative LCLM services.

Management attitudes and opinions may be important in determining whether a firm will offer alternative methods of pest control and reflect the goals underlying the firm's behavior. Variables reflecting the relative importance of environmental and health issues surrounding pesticide use are examined to account for the relevance of the environmental and health objectives of the LCLM firm.

A multinomial logit model was estimated to explore the relationship between pest management cluster membership and firm characteristics. The multinomial logit model estimates the probability that a firm will be classified into a given group as a function of firm and manager characteristics. The form of the multinomial logit probabilities are:

$$(1) \quad p_{jk} = \frac{e^{\beta_j - X_k}}{\sum_{i=1}^4 e^{\beta_i - X_k}} \quad \begin{matrix} j = 1, \dots, 4; \\ k = 1, \dots, N. \end{matrix}$$

Table 4. Results of Multinomial Logit Estimation^{a,b,c}

| | Cluster | | |
|---|------------------------------------|-----------------------------|--------------------------------|
| | Low Tech, Low Input Managers | Full Service Managers | Integrated Pest Managers |
| Constant | 2.94 (2.12) | -3.93 (3.82) | 3.01 (2.21) |
| Independently owned firm | -1.15 (1.02) | -2.17 (1.15) | -2.27 (0.96) |
| Sales <\$100,000 | 0.47 (0.68) | -2.61 (1.31) | -0.78 (0.62) |
| Equipment value <\$25,000 | -0.66 (0.62) | 1.31 (1.35) | -1.16 (0.60) |
| Provide services to fringe counties | -0.34 (0.53) | 3.36 (1.47) | -0.15 (0.52) |
| Years in business | -0.03 (0.03) | 0.00 (0.03) | -0.07 (0.03) |
| Years of education | -0.02 (0.05) | 0.17 (0.09) | 0.00 (0.05) |
| Importance of the impact of applied chemicals on water quality ^d | -0.60 (-0.38) | -0.99 (0.55) | -0.29 (0.39) |
| Importance of safety of pesticides to the public ^d | 1.45 (0.58) | -1.62 (1.17) | 1.49 (0.60) |
| Importance of pesticide exposure to non-target organisms ^d | -1.06 (0.47) | 1.59 (0.97) | -0.89 (0.48) |
| McFadden R-square | 0.19 | | |

^a Coefficients for "See and Spray Managers" cluster normalized to zero.

^b Standard errors are in parentheses.

^c This table reports coefficients only for those variables for which at least one coefficient was significant. Complete results are available from the authors.

^d Importance variables measured on a scale from 1 = not important to 5 = very important.

In equation (1), p_{jk} is the probability that firm k will be a member of cluster j , β_j is the coefficient vector corresponding to the j th cluster, and X_k is the vector of explanatory variables for the k th firm. As discussed above, firm characteristics included are firm ownership; sales; equipment value; customer base; and owner experience, age, and education. In addition, four attitudinal variables measuring the importance of water quality, public safety, non-target organism safety, and pesticide resistance to firm managers were included in the model specifications.

Results of the multinomial logit estimation are presented in Table 4. Overall, the model correctly classified 59 percent of the firms. However, the percentage of correctly classified firms varies by cluster, with 40 percent correct predictions for the full-service managers cluster,

43 percent for the low-tech, low-input managers cluster, 47 percent for the "see and spray" managers cluster, and 79 percent for the integrated pest managers cluster.

The multinomial logit estimation procedure requires that the coefficient vector for one of the clusters be normalized to zero for model identification. The omitted cluster, the "see and spray" managers, serves as a benchmark for comparisons with the remaining clusters. Relative to the "see and spray" managers cluster, firm characteristics had no significant impact on the probability of a firm being classified as a low-tech, low-input manager (Table 4). Independently owned firms and firms with low sales had a significantly lower probability of being classified as full-service managers. Firms providing services to counties on the fringe of the Atlanta metro area had a signif-

icantly higher probability of being classified as full-service managers. In addition, higher education increased the probability of being classified as a full-service manager.

Independent ownership and low equipment value decreased the probability of being classified as an integrated pest manager. Younger firms had a higher probability of being classified as integrated pest managers.

Three of the four attitudinal variables had significant impacts on cluster membership (Table 4). Importance of resistance to pesticides had no significant impact on cluster membership. Firms indicating a higher importance rating for the impact of pesticides on water quality were less likely to be classified as full-service managers. Firms indicating a higher importance rating for the safety of pesticides to the public were more likely to be low-tech, low-input managers or integrated pest managers. However, firms indicating a higher importance rating for pesticide exposure to non-target organisms were less likely to be classified as low-tech, low-input managers or integrated pest managers.

Results regarding firm and manager characteristics suggest that large, corporate-owned or franchise LCLM firms are more likely to be members of clusters that offer IPM and organic pest control methods. This may be due to the ability of corporations to engage in research programs or absorb risk associated with adopting new techniques better than independent operations. Firm size, as measured by the value of sales, may reflect a greater customer base that can support alternative pest-control programs. Equipment value has a positive impact on membership in the integrated pest managers cluster, suggesting that firms may have to make capital investments to be able to offer alternative pest-management options to clients.

Results suggest that the influence of attitudinal variables was generally consistent with the classification of firms. The importance of water quality, public safety, and impacts on non-target organisms reflects the goals of LCLM firms and was included in the model specification without any implied relative rankings in terms of importance in decision-

making. As expected, firms that indicated safety of pesticides to the public is important have a higher probability of being in a cluster with low use of pesticides, i.e. low-tech, low-input managers and integrated pest management.

Implications

With the continuing growth in both the demand for LCLM services and the accompanying growth in pesticide use by LCLM firms, public policy may address alternative LCLM pest-control methods. As a part of public policy, the development of research and extension programs to increase the availability of alternative LCLM services is necessary. The effectiveness of such programs will be improved by identifying segments of the LCLM industry currently providing alternative pest-control methods and those relying on conventional pesticide-based pest management.

Our goals for this analysis were (1) to develop a classification of LCLM firms based on the employment of chemical and non-chemical pest-management practices and reflecting underlying goals of firms and consumers, (2) to explore the effects of firm economic and demographic characteristics on firm classification, and (3) to determine whether firm opinions about the importance of pesticide safety had impacts on firm classification. Using a cluster analysis with 21 clustering variables, we identified four distinct groups of firms, ranging from highly conventional chemical intensive firms to alternative, management-intensive firms. Multinomial logit analysis revealed that firm ownership, size, equipment value, and years in business, as well as the age and education of the owner/manager, were all significant determinants of cluster membership. Several implications stem from the results of this analysis. Their importance is supported by other observations based on survey results and developments in research on alternative pest-management practices.

Independent operators require assistance in adopting less chemical-dependent practices. In the Atlanta metropolitan area, these firms represent the largest portion of LCLM firms

and outreach programs can, therefore, focus on helping many firms to quickly broaden their expertise and the array of services offered to customers beyond the currently used chemical pest management. For some firms, this step would allow for transition to a full-service company and possibly increase the value of service sales above the \$100,000 identified as the threshold level by the model. Full-service firms tend to be the largest in terms of sales value and are more likely to reach a wider segment of the population than any other class. These firms provide IPM and organic options, but also provide traditional, chemical-intensive pest-management options.

Continuous update of pest management methods used by firms is highly desirable to offset the knowledge gap between recent entrants and established firms. Age of firms matters in the adoption of IPM practices. Recent entrants were more likely to be classified as IPM users than firms which have been in business for a number of years. This result is consistent with expectations that the decision to enter an industry or service sector is influenced by the availability of new technologies offering higher returns than the existing methods. It is also conceivable that recent entrants were exposed to the benefits of new technologies and the shortcomings of traditional techniques during their education, reinforcing the use of new approaches to pest management. However, the age of the respondent was not a significant influence on pest management classification, while more educated managers tended to work for firms classified as "full-service." An alternative explanation is that firms were able to stay in business longer because their use of chemicals guaranteed the economic viability of the firm. The influence of education, on the other hand, seems to be related in this study to the need for management skills encompassing various tasks and not limited to the use of a single pest management practice.

Multidisciplinary assessment of new IPM methods before their transfer will ensure economic viability of firms. The emphasis on the economic viability of the firm and the relatively limited importance of education regard-

ing the use of IPM practices suggests that with the exception of firms already applying IPM others need to be informed about them. Linking decreased dependence on chemicals to practical evidence of cost effectiveness of such an approach is a necessary component of outreach programs. Because outreach is based on research results, scientists developing and testing alternative approaches must measure their effectiveness in economic terms. Multidisciplinary teams which include agricultural economists will develop IPM techniques with proven cost-effectiveness which can lead to the faster adoption of tested methods. Economic performance of LCLM firms will remain important and will determine the degree of the industry's confidence in new techniques.

Public investment in improvement of LCLM workers will encourage knowledge-based reduced pesticide application. LCLM firms are serious about the exposure of the public or non-target organisms to pesticides. This awareness had so far resulted in a significant number of firms choosing to use low-input or IPM approaches. These approaches, although both leading to lower chemical use, represent very different attitudes. It appears that low-input firms show great risk aversion regarding consequences of pesticide application, whereas IPM firms deliberately choose to apply alternative techniques. Low-input firms may be particularly interested in learning sound IPM practices so as to recognize new market opportunities for additional services. Public investment in human capital development in the LCLM industry can provide benefits to the whole population.

Expanding human capital will involve LCLM firms in the process of lowering the use of pesticides, a goal pursued by government agencies. Knowledge of reduced application rates and changing patterns of chemical applications can readily be applied because it does not require a wholesale abandonment of current pest-management methods. Furthermore, by working with the LCLM industry organizations, the government may encourage effective and rapid dissemination of new tech-

niques, self-regulation, and industry-led consumer education.

Assistance in obtaining physical capital will accelerate adoption of IPM techniques. To accelerate the adoption of alternative pesticide-management techniques a firm may require investment in physical capital. Given independent ownership, limited sales value, and low equipment value, many LCLM firms may have little opportunity to commit resources to additional purchase of pest-management equipment. These firms may need financial assistance in purchasing or leasing equipment. Incentive programs in the form of subsidies or cost-sharing programs, successfully applied to soil conservation and timber management, may be necessary to increase adoption of IPM by existing firms. Such approach received international support regarding reduction of pesticide use by farmers (OECD). Additional research identifying barriers to IPM adoption and how to effectively encourage adoption of alternative practices by LCLM firms is warranted.

Consumers need to be educated about benefits of alternative treatments. Increased use of IPM methods creates the potential to lower use of chemicals, but the final outcome depends on local growing conditions and consumer demand. In the southeastern United States, the long growing season, coupled with high relative temperatures and humidity, presents a challenge for LCLM service providers. Furthermore, because the evaluation of service quality is highly subjective and dependent on customer perception of lawn or landscape appearance, education of the public about the broader benefits of the IPM approach is needed. Over 50 percent of LCLM firms use customer requests as a criterion for making chemical treatment decisions, indicating that there is a good opportunity for reducing LCLM chemical use through consumer education about IPM and organic pest-control alternatives. Also, education of consumers regarding the limited benefits of predetermined chemical applications may enhance the demand for IPM based services. The specific content of the message aimed at the public and the medium for communicating it may be selected by

LCLM firms in cooperation with researchers and extension specialists and may vary from region to region, emphasizing specific climatic or ecological conditions. In addition to requesting chemical treatments, LCLM service consumers can also reduce the off-site impacts of lawn chemical use through proper management of lawn clippings, i.e., on-site composting or mulching. This may help to prevent large-scale leaching of chemicals from municipal waste sites.

Future studies may address the relation between adoption of the IPM approach and profitability in the LCLM industry. An especially important set of empirical questions concerns the way IPM alters profitability and how providing IPM affects the market share of LCLM firms. If there is a public demand for IPM services, then firms may be able to increase profits or market share by offering IPM. Also important is the determination of the extent to which changing public attitudes and perceptions of lawn and landscape appearance and health can lead to substitution of biological for chemical pest controls. Public education on the benefits of an IPM approach may increase consumer demand for IPM and thus encourage LCLM firms to supply IPM services. The acceptance by firms and consumers of the explicit costs associated with changing pest-control methods and the implicit costs in the form of altered landscape appearance will in part determine the speed of IPM adoption in the LCLM industry.

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