Can a National Job Analysis Serve as a Basis for Individual State Certification Exams? Answers from a National Pesticide Applicator Exam Development Project

Andrew Martin, Curriculum Development Specialist, Purdue Pesticide Programs, Purdue University Cooperative Extension Service, West Lafayette, IN, martinag@purdue.edu

Fred Whitford, Coordinator, Purdue Pesticide Programs, Purdue University Cooperative Extension Service, West Lafayette, IN, fwhitford@purdue.edu

Abstract

This article addresses the extent to which a national pesticide applicator job analysis can legitimately serve as a basis for state-specific pesticide applicator certification examinations. A national right-of-way herbicide applicator job task questionnaire was developed and distributed to a random sample of certified applicators in North Carolina and Colorado. These two states were purposively selected because of different weed species, climate, geography, and state laws. Respondents from both states collectively rated all but one of the constituent job tasks as either very or extremely important. An analysis of response differences between the two states indicated statistically significant item-rank differences between North Carolina and Colorado applicators for several tasks ($p < .05$), but the effect sizes were not meaningful. The results suggest that a national job analysis can serve as a sound basis for individual state certification exams.

Keywords: job analysis, right-of-way herbicide applicator, certification, mixed methods sampling, task inventory questionnaire

Introduction

Purdue Pesticide Programs received a grant from the National Association of State Departments of Agriculture Research Foundation (NASDARF) in 2008 to develop a test blueprint and an item (i.e., question) bank for right-of-way herbicide applicator certification purposes (National Right-of-way Herbicide Applicator Test Plan and Training Syllabus: EPA Cooperative Agreement X8-8323401). The project goal was to furnish state pesticide regulatory agencies with the completed front-end elements of test construction (i.e., content specifications and draft items) to help them revise their right-of-way applicator exams consistent with accepted certification (licensure) test development practices (Richard Herrett, project manager, Pesticide Worker Safety, NASDARF, personal communication, 2008).

Acceptance by state pesticide regulatory agencies of other national certification projects has historically been limited due to a common belief that conditions across states (e.g., geography, climate, pest problems, and state laws) vary so widely that any attempt at a shared approach to test development is doubtful (Leo Reed, manager, Certification and Licensing, Office of Indiana State Chemist, personal communication, 2008). The selection and implementation of this project's job analysis method provided an opportunity to test whether these concerns are valid.

Background

"Job analysis" refers to any systematic method for describing the work activities of jobholders. It permits the identification of knowledge and skills necessary to perform the work. This, in turn, provides descriptive information that can be transformed into a job-related test blueprint (Raymond & Neustel, 2006). Accordingly, job analysis is the appropriate foundation for certification (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 1999).

The task inventory questionnaire was identified as the most appropriate job analysis method for the NASDARF right-of-way herbicide applicator project because it permits sampling of many persons working across a variety of job settings (Raymond, 2001). This is especially important in the context of right-of-way herbicide use where applicators may be treating roadsides, railroads, utility line corridors, pipelines, and other related industrial sites.

Raymond (2001) offers a general description of the task inventory method. This method entails identifying and organizing the tasks (i.e., observable, work-related activities) that define a job. A draft task inventory may be assembled from: a) worker observation, b) worker interviews, c) job literature reviews, or d) facilitated discussions with subject matter experts (SMEs) – typically individuals directly involved with the work.

Tasks are written succinctly to ensure maximum clarity. They are limited to an action verb (what is being done), an object (what is being acted on), and qualifying information. The subject (worker) is assumed (Gael, 1983). For example:

Monitor (action verb) equipment (object) performance during application (qualifying information).

Related task statements are organized under broad duty areas (or job responsibilities). The draft task inventory is transformed into a questionnaire by associating one or more rating schemes with each task. Typically, tasks are written as Likert-type items that address certain attributes, including task frequency, difficulty, or importance. In this case:

Monitor equipment performance during application. 0 1 2 3 4

0= Do not perform, 1= Unimportant, 2= Moderately important, 3= Very important, 4= Extremely important

The resulting task inventory questionnaire, which also generally includes relevant demographic questions, is distributed to a representative sample of jobholders who generate responses that quantify the selected task attributes. A panel of SMEs can then review the data and amend the task inventory by revising, deleting, or adding tasks as necessary (Raymond, 2001).

Purpose and Research Objectives

Typically, task inventory questionnaires are distributed to a sample of field-based respondents big enough to generate data representative of the larger population (Knapp & Knapp, 1995). This entails probability sampling such that theoretically, every person in the population has an equal opportunity of being selected. However, no national sample frame (i.e., list of individuals in the population of interest) exists for right-of-way herbicide applicators.

Although a state sample frame was available from each state pesticide regulatory agency, assembling a national sample frame by combining all 50 state applicator databases was deemed too time-consuming and expensive (Herrett, personal communication, 2008). Instead, a two-state survey was selected as a practical way to simultaneously: a) establish the accuracy of the SME committee's draft task inventory and b) confirm interstate agreement on task importance. This analytical focus on responses from two states, rather than an aggregate national response, also allowed for a close examination of the extent to which the results of a national job analysis can be used as job-related evidence for individual state certification exams.

Methods

Nine industry subject matter experts from around the country were purposively selected to represent: a) roadside, railroad, utility line, and related industrial site interests; b) governmental and private sectors; and c) large and small organizations. They convened in Indianapolis (Indiana), along with nine Cooperative Extension, state lead agency, and federal participants to develop a draft task inventory through a facilitated small-group brainstorming technique known as Developing A CurriculUM (DACUM) (Norton, 1992). The SME committee ultimately identified, organized, and sequenced 52 tasks that all right-of-way herbicide applicators perform.

The draft task inventory generated by the SME committee was converted to a questionnaire by assigning five anchor points (0= Do not perform, 1= Unimportant, 2= Moderately important, 3= Very important, 4= Extremely important) to each task. This permitted respondents to rate task importance in relation to successful job performance. The resulting task inventory questionnaire was then piloted to the nine industry members of the SME committee to assess instrument clarity.

Next, parallel sampling, a mixed methods approach (i.e., qualitative and quantitative techniques), was identified as the best means – given existing financial and structural limitations – to meet the project objectives (Onwuegbuzie & Leech, 2007). Further, parallel sampling permitted analysis of: a) the degree of importance that applicators from two *dissimilar* states assign each task on the inventory and b) whether meaningful response differences exist between those states' applicators.

This sample design entailed the purposive selection of two right-of-way herbicide applicator populations, one in North Carolina and the other in Colorado. These two states were chosen based on presumed differences concerning problem weeds, geography, climate, and state-specific laws. A simple random sample of applicators was drawn from the certified applicator database maintained by each state's pesticide regulatory agency using a random numbers table. Sample size was determined by a power analysis using G*Power, an online program. This analysis was necessary to detect moderate effect sizes between two independent groups with input parameters for a two-tailed test when $\alpha = .05$ and $\beta = .20$ (Buchner, Erdfelder, & Faul, 1997).

The effect size represents a meaningful difference between two samples, determined a priori by the researchers, and is distinct from the concept of statistical significance (Kotrlik, Williams, & Jabor, 2011). It corrects for the temptation to overinterpret findings of statistical significance when real differences are trivial or unimportant (Carver, 1993).

In this case, the magnitude of difference between state responses to a given item, predetermined as moderately meaningful, is equivalent to a probability of .66 (i.e., approximately two times in three) that a randomly sampled individual from one state will rate that item higher than a randomly sampled individual from the other state. To put this effect size in perspective, a value of .50 would mean that the probability of a response from a randomly selected North Carolina applicator being higher than that of a randomly selected Colorado applicator is one in two (i.e., a coin toss, or no effect).

The required minimum sample size calculated to have sufficient power to detect moderate response differences was 47 persons per state. Assuming a response rate of approximately 40 percent, the researchers drew a sample of 114 applicators from North Carolina and 114 applicators from Colorado to ensure that the minimum sample size requirements were met.

A mail survey was conducted according to Dillman (2007) as follows. The persons in both states' samples received a letter explaining that they had been selected to participate in the survey, the nature of the questionnaire, its importance to them, and when to expect its arrival (within the week).

A second letter, accompanying the questionnaire and including completion instructions, followed. A third letter encouraged everyone to complete and return the questionnaire.

(The questionnaire booklets were coded to track nonrespondents for follow-up contact.) Nonrespondents received a fourth reminder note and a replacement questionnaire (in case they lost the first copy). A fifth and final letter was mailed to nonrespondents alerting them that the survey was closing and encouraging them to promptly respond. Resulting data were analyzed using Statistical Online Computation Resource (SOCR) (http://www.socr.ucla.edu).

Appropriate statistics for data generated by Likert-type items include medians, frequencies, and nonparametric inferential procedures (Clason & Dormody, 1994). A median is the middle value in a distribution of values arranged from lowest to highest. Frequencies are expressed as counts or percentages. Nonparametric statistics typically do not make any assumptions about distribution of the data.

Statistical significance between item responses from North Carolina and Colorado applicators was assessed by the Mann-Whitney U test (two groups). Corresponding effect sizes were estimated by $\hat{p}_{a>b}$, an unbiased estimator of the probability of superiority (PS), which "…measures the tendency of scores from [one group] to outrank the scores from [another group] across all pairings of the scores of the members of each group" (Grissom & Kim, 2005, p. 106).

Results

A total of 55 individuals from North Carolina and 50 from Colorado (more than the required minimum sample sizes) returned completed, usable questionnaires for an overall response rate of 46 percent.

Nonresponse

Knapp and Knapp (1995) state that job analysis surveys typically yield response rates of 20 percent to 60 percent (25 percent to 35 percent being the norm). While nonresponse does not necessarily imply biased (skewed) results, it does raise the question of whether respondents and nonrespondents differ along important variables relevant to the survey.

Rogelberg and Luong (1998) identified lower education levels and lack of interest in the survey topic as consistent characteristics of nonrespondents. They cautioned researchers to consider whether either of these characteristics might introduce [nonresponse] bias into survey results. In this study, supervisory status was thought to reflect education and interest levels (i.e., supervisors are likely to be better educated and have a greater interest in a job-related questionnaire than nonsupervisors). If this were the case, the survey results might be biased by supervisory status.

However, applicator data maintained by Colorado's pesticide regulatory agency contradicted the assumption that nonsupervisors were less likely to respond than supervisors. The state of Colorado certifies applicators at a qualified supervisor level and a certified operator level (nonsupervisory). The total population of certified right-of-way applicators in Colorado at the time of the survey was 1,156 individuals. This includes 758 qualified supervisors (66 percent of the population) and 398 certified operators (34 percent of the population). There were 30 certified operators in the random sample of 114 applicators (26 percent), while 13 certified operators were among the 50 actual respondents (26 percent). The percentage of certified operators in the random sample was lower than that of the actual population (not surprising for any random sample). But the percentage of certified operators in the random sample and among the actual respondents was the same. Colorado certified operators were, in fact, responding as frequently as the random sample would suggest.

Item Importance

There were 52 items (i.e., task statements associated with a 0 to 4 importance rating) on the task inventory questionnaire. Table 1 indicates that 29 items rated by North Carolina applicators had a median value of 3 and 21 had a median value of 4. Note that two items had a median value of 3.5 (the middle value in the distribution in these two cases fell between 3 and 4). Thirty-two items rated by Colorado applicators had a median of 3 and 19 had a median of 4. One item rated by Colorado applicators had a median of 2 (moderately important). This item was A 12, "Assign job tasks to other crew members." With that single exception, the median item response was 3 or higher (very important to extremely important) for all items as rated by both states' applicators. See Appendix A for all questionnaire items, their response medians, and frequencies.

Table 1. Item median responses[a]

State	**Median response**[b]					
	0	**1**	**2**	**3**	**3.5**	**4**
	Number of items					
NC	0	0	0	29	2	21
CO	0	0	1[c]	32	0	19

[a] There were 52 items on the task inventory questionnaire.
[b] Rating: 0= Do not perform, 1= Unimportant, 2= Moderately important, 3= Very important, 4= Extremely important.
[c] Item A 12: Assign job tasks to other crew members.

Table 2 indicates the number of items that received a rating ≥ 3 (very important to extremely important) by specified percentages of respondents. For example, 18 items were rated 3 or 4 by more than 90 percent of the North Carolina respondents. Another

21 items were rated 3 or 4 by more than 80 percent but less than 90 percent of the North Carolina respondents. Eight items were rated 3 or 4 by more than 70 percent but less than 80 percent of North Carolina respondents, etc. Clearly, most of the 52 items on the questionnaire were rated 3 or 4 by a majority of respondents from both states. Even item A 12 was rated 3 or higher by almost half (47 percent) of the Colorado applicators in the sample.

Table 2. Items rated $\geq$ 3 by percentage of respondents[a]

State	Percentage of respondents					
	< 50%	**> 50 ≤ 60%**	**> 60 ≤ 70%**	**> 70 ≤ 80%**	**> 80 ≤ 90%**	**> 90%**
	Number of items rated ≥ 3 (Very important to Extremely important)					
NC	0	2	3	8	21	18
CO	1[b]	3	7	8	18	15

[a] Rating: 0= Do not perform, 1= Unimportant, 2= Moderately important, 3= Very important, 4= Extremely important.
[b] Item A 12: Assign job tasks to other crew members (47%).

Tables 1 and 2 strongly suggest that all of the job tasks drafted by the SME committee to define the job of right-of-way herbicide applicator are important to job performance. There were no compelling reasons based on these results to amend the task inventory.

Item response differences

Responses to each of the 52 items on the job task questionnaire were analyzed to determine whether applicators from North Carolina and Colorado rated them differently. Table 3 displays the results for only those items that had effect sizes greater than 0.60. See Appendix B for item-rank differences between North Carolina and Colorado respondents for all items.

An example of how to read Table 3 follows. Fifty-five applicators from North Carolina (n_{NC}) and 49 from Colorado (n_{CO}) responded to questionnaire item A 4, "Access telephone call list." Responses were rank-ordered, summed, and mean ranks calculated for both states (MR_{NC} and MR_{CO}). The mean rank for North Carolina is larger than the mean rank for Colorado on item A 4. This indicates that applicators from North Carolina collectively rated that item higher than applicators from Colorado. The Mann-Whitney U statistic is the number of times that ratings from North Carolina applicators are higher than the ratings from Colorado applicators with which they are paired. Distribution of the U statistic approaches normal when the sample size is greater than 20, so its corresponding z statistic is provided to simplify interpretation. Critical values for the z statistic (two-tailed) are 1.96 ($p= .05$) and 2.576 ($p= .01$). This signifies that the response differences between North Carolina and Colorado applicators are statistically significant at $p< .05$ for item A 4 (i.e., the probability that these results occurred by chance is .033).

The effect size represents the U statistic divided by all possible pair ratings, or $U/n_{NC} \times n_{CO}$. In this case, the effect size of 0.621 means that the response to item A 4 by a randomly selected applicator from North Carolina has a probability of being higher than that of an applicator randomly selected from Colorado 62 times out of 100. The researchers' threshold for a moderately important effect is a probability of .66. While the response difference between the two samples is statistically significant, the effect size, by definition, is not even moderately important.

Table 3. Item-rank differences with effect sizes > 0.60 between North Carolina and Colorado respondents

Questionnaire item	n_{NC}[a]	n_{CO}[a]	MR_{NC}	MR_{CO}	Mann-Whitney U_{NC}	z	P (2-tailed)	$\hat{P}_{NC>CO}$
A 4. Access telephone call list	55	49	58.44	45.84	1,674.0	-2.126	.033[b]	.621
A 5. Locate water source	55	49	60.03	44.05	1,761.5	-2.696	.007[c]	.654
A 6. Identify herbicide product mix site	55	49	57.37	46.08	1,613.0	-1.915	.055	.610
A 11. Participate in onsite safety briefing	54	49	59.58	43.64	1,732.5	-2.704	.007[c]	.655
A 12. Assign job tasks to other crew members	54	49	57.99	45.40	1,646.5	-2.136	.033[b]	.622
E 5. Label service containers	54	50	58.02	46.35	1,648.5	-1.942	.053	.610
F 2. Document application information	55	50	47.68	58.85	1,082.5	1.877	.061	.394

[a] The sample (n) may be less than the total because not every respondent rated every item.
[b] $p < .05$.
[c] $p < .01$.

The results for item A 12, "Assign job tasks to other crew members," closely resemble those for A 4. Data interpretation is the same.

State response differences to items A 5, "Locate water source," and A 11, "Participate in onsite safety briefing," are statistically significant at $P < .01$. Responses to these items by North Carolina applicators are, again, collectively higher than those from Colorado applicators. Nonetheless, the effect sizes, while close, still do not exceed the threshold for moderately important.

Effect sizes for items A 6, "Identify herbicide product mix site," E 5, "Label service containers," and F 2, "Document application information," are barely above 0.60. They are not statistically significant at $p < .05$. Note that for item F 2, responses by Colorado applicators were collectively higher than those from North Carolina. (The effect size in this case is obtained by subtracting $\hat{p}_{NC>CO}$ from 1, or 1.000 - .394 = .606.)

Discussion

North Carolina and Colorado right-of-way herbicide applicators who responded to a task inventory questionnaire confirmed that the task inventory developed by a national SME committee accurately defined the job of a right-of-way applicator.

Item response differences between North Carolina and Colorado also indicated that even two such diverse states are remarkably similar in how right-of-way herbicide applicators conduct their work. Effect sizes for seven items only approached, and never exceeded, the threshold for moderate differences. Further, of the seven items that had effect sizes close to the moderate threshold, only four were statistically significant at $p < .05$. A conservative interpretation is that there are four items on the questionnaire with real response differences between North Carolina and Colorado applicators. The magnitude of those differences, however, is not enough to suggest that they are meaningful.

The results of this study indicate that a national job analysis can serve as a basis for individual state certification examinations. Responses to a job task questionnaire by applicators from two states, who may view their tasks very differently (given diverse job settings and situations), were highly consistent.

The authors concede that the job analysis results do not address state-specific variables, such as weed species, geography, climate, and laws. However, this lack of specificity in no way limits the use of a national job analysis as a basis for individual state certification exams. For example, an important task performed by all right-of-way herbicide applicators is “Identify target vegetation.” Therefore, test development specialists should include items on their state’s exams that require test takers to identify common weeds. Responsibility lies with the test development specialists to work with SMEs to determine which weed species are common within their own state.

Similarly, differences in geography and climate might be addressed by how states write items for the task “Determine vegetation management method.” And different state laws will likely be reflected in state-specific items regarding such tasks as “Notify public about application.” It is the concept of “task” that is central to certification test development. Once tasks are identified, state-specific differences are addressed during development of the test blueprint and subsequent item writing.

Presumed differences about how a job is performed in different areas of the country should not prevent any state from adopting a national job analysis. In an environment of diminished resources and given the need to simultaneously protect the public welfare and treat test takers fairly, national job analyses offer state pesticide regulatory agencies a sound, economical foundation on which to develop job-related certification tests.

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Appendix A. Item response medians and frequencies

Questionnaire item	State	n[a]	Median response	Item response frequency[b]				
				0	1	2	3	4
Duty A. Organize work plan								
A 1 Review job specifications	NC CO	55 49	3 3	2 1	0 0	2 9	31 23	20 16
A 2 Locate work site	NC CO	55 49	3 3	0 1	0 0	3 5	25 20	27 23
A 3 Select application equipment/tools	NC CO	55 49	3 3	1 2	0 0	0 6	30 21	24 20
A 4 Access telephone call list	NC CO	55 49	3 3	2 3	0 2	7 12	24 20	22 12
A 5 Locate water source	NC CO	55 49	3 3	2 2	0 4	10 16	17 15	26 12
A 6 Identify herbicide product mix site	NC CO	54 49	3 3	2 1	0 2	6 12	22 20	24 14
A 7 Select PPE for job	NC CO	55 49	4 4	1 1	0 0	1 5	19 18	34 25
A 8 Clean PPE	NC CO	55 49	4 3	1 2	0 1	5 6	16 19	33 21
A 9 Replace worn PPE	NC CO	55 48	4 3	1 1	0 0	3 2	17 23	34 22
A 10 Test communication equipment	NC CO	52 49	3 3	2 5	1 4	16 15	25 17	8 8
A 11 Participate in onsite safety briefing	NC CO	54 49	3 3	4 3	0 3	3 14	23 17	24 12
A 12 Assign job tasks to other crew members	NC CO	54 49	3 2	6 8	1 1	9 17	27 18	11 5

Duty B. Manage herbicide products								
B 1 Obtain herbicide product	NC CO	55 49	3 3	6 1	0 0	3 7	32 22	14 19
B 2 Secure herbicide product during transportation	NC CO	55 49	4 4	3 0	0 1	6 4	15 19	31 25
B 3 Manage empty product containers	NC CO	55 49	3 3	2 0	0 1	5 5	22 20	26 23
B 4 Clean application equipment	NC CO	55 49	4 3	1 1	0 0	7 6	19 20	28 22
B 5 Store products securely	NC CO	55 49	4 4	1 0	0 0	4 3	17 15	33 31
B 6 Respond to product spills promptly	NC CO	55 49	4 4	1 0	0 0	1 1	8 9	45 39

[a] The sample (n) may be less than the total because not every respondent rated every item.
[b] 0= Do not perform, 1= Unimportant, 2= Moderately important, 3= Very important, 4= Extremely important.

Questionnaire item	State	n[a]	Median response	Item response frequency[b]				
				0	1	2	3	4
Duty C. Manage target vegetation								
C 1 Evaluate previous treatment	NC CO	55 50	3 3	1 0	0 0	12 8	34 29	8 13
C 2 Calculate area of treatment site	NC CO	55 50	3 3	2 1	0 0	7 11	27 27	19 11
C 3 Identify target vegetation	NC CO	55 50	3 4	1 1	0 0	6 2	22 17	26 30
C 4 Determine vegetation management method	NC CO	53 50	3 3	1 3	0 1	5 5	30 19	17 22
C 5 Select appropriate product mix	NC CO	55 50	4 4	1 1	0 0	1 1	16 15	37 33
C 6 Calibrate application equipment	NC CO	55 50	4 4	3 0	1 0	2 1	17 19	32 30
C 7 Calculate product mix rate	NC CO	54 50	4 4	1 0	0 0	1 1	15 12	37 37
C 8 Prepare product mix	NC CO	54 50	4 4	1 0	0 0	0 3	22 20	31 27
C 9 Apply product mix to treatment site	NC CO	55 50	4 4	1 0	0 0	1 2	19 17	34 31
Duty D. Protect nontarget areas								
D 1 Transfer sensitive site information to work plan	NC CO	55 50	3 3	8 4	0 2	8 8	23 22	16 14
D 2 Recognize conditions conducive to volatility	NC CO	54 50	3.5 4	0 1	0 0	6 4	21 18	27 27
D 3 Select management techniques to minimize environmental impact	NC CO	55 49	4 4	1 1	0 0	7 4	16 15	31 29
D 4 Manage spray drift	NC CO	55 50	4 4	1 0	1 0	2 3	11 11	40 36
D 5 Prevent herbicide runoff	NC CO	55 50	4 4	1 0	0 0	3 3	7 9	44 38
D 6 Identify sensitive areas during application	NC CO	55 50	4 4	0 1	1 0	4 1	19 15	31 33

[a] The sample (n) may be less than the total because not every respondent rated every item.
[b] 0= Do not perform, 1= Unimportant, 2= Moderately important, 3= Very important, 4= Extremely important.

Questionnaire item	State	n[a]	Median response	Item response frequency[b]				
				0	1	2	3	4
Duty E. Maintain application equipment								
E 1	NC	54	3	2	0	7	25	20
Conduct truck inspection	CO	50	3	2	0	6	28	14
E 2	NC	54	3.5	1	0	3	23	27
Inspect spray equipment for proper working order	CO	50	4	0	0	2	19	29
E 3	NC	53	4	1	1	3	20	28
Inventory on-board safety supplies	CO	50	3	0	0	6	27	17
E 4	NC	54	4	2	1	3	17	31
Carry government- and company-required documents	CO	50	4	1	0	1	21	27
E 5	NC	54	4	2	0	5	19	28
Label service containers	CO	50	3	1	1	8	25	15
E 6	NC	53	3	1	0	3	28	21
Monitor equipment performance during application	CO	50	3	1	0	5	27	17
E 7	NC	53	3	1	0	6	26	20
Perform in-field adjustments/repairs	CO	50	3	1	0	9	20	20

Duty F. Record work activities daily								
F 1	NC	55	3	7	0	9	25	14
Record environmental conditions	CO	50	3	1	0	7	26	16
F 2	NC	55	3	3	0	7	23	22
Document application information	CO	50	4	0	0	4	17	29
F 3	NC	55	3	6	1	4	20	24
Explain unusual incidents/observations	CO	50	3	1	2	14	18	15

Duty G. Promote public relations								
G 1	NC	55	3	0	1	8	28	17
Maintain professional appearance	CO	50	3	1	0	13	24	12
G 2	NC	55	3	6	0	9	25	15
Explain job to customer’s employees	CO	50	3	5	0	10	20	15
G 3	NC	55	3	10	1	15	18	11
Notify public about application	CO	49	3	3	0	14	17	15
G 4	NC	54	3	4	0	14	24	12
Promote appearance of right-of-way	CO	49	3	3	2	14	18	12
G 5	NC	55	4	2	0	4	16	33
Respond courteously to public employees	CO	50	3	0	0	7	20	23

Duty H. Pursue professional development								
H 1	NC	55	4	0	0	2	18	35
Fulfill state pesticide certification requirements	CO	50	4	1	0	2	13	34
H 2	NC	55	3	0	1	10	21	23
Attend educational seminars	CO	50	3	1	0	6	23	20
H 3	NC	55	3	0	1	16	27	11
Read professional materials	CO	50	3	1	1	10	24	14
H 4	NC	55	3	6	1	18	20	10
Participate in professional mentoring	CO	50	3	3	3	11	25	8

[a] The sample (n) may be less than the total because not every respondent rated every item.
[b] 0= Do not perform, 1= Unimportant, 2= Moderately important, 3= Very important, 4= Extremely important.

Appendix B. Item-rank differences between North Carolina and Colorado respondents

Questionnaire item	n_{NC}[a]	n_{CO}[a]	MR_{NC}	MR_{CO}	Mann-Whitney U_{NC}	z	P(2-tailed)	$\hat{P}_{NC>CO}$
Duty A. Organize work plan								
A 1. Review job specifications	55	49	55.24	49.42	1,498.5	-0.983	.325	.556
A 2. Locate work site	55	49	53.87	50.96	1,423.0	-0.492	.623	.528
A 3. Select application equipment/tools	55	49	54.96	49.55	1,492.0	-0.941	.347	.554
A 4. Access telephone call list	55	49	58.44	45.84	1,674.0	-2.126	.033[b]	.621
A 5. Locate water source	55	49	60.03	44.05	1,761.5	-2.696	.007[c]	.654
A 6. Identify herbicide product mix site	55	49	57.37	46.08	1,613.0	-1.915	.055	.610
A 7. Select PPE for job	55	49	55.8	48.77	1,530.0	-1.188	.235	.568
A 8. Clean PPE	55	49	57.0	47.39	1,597.5	-1.628	.104	.593
A 9. Replace worn PPE	55	48	55.47	48.02	1,511.0	-1.263	.207	.527
A 10. Test communication equipment	52	49	54.66	47.11	1,464.5	-1.294	.196	.575
A 11. Participate in onsite safety briefing	54	49	59.58	43.64	1,732.5	-2.704	.007[c]	.655
A 12. Assign job tasks to other crew members	54	49	57.99	45.40	1,646.5	-2.136	.033[b]	.622
Duty B. Manage herbicide products								
B 1. Obtain herbicide product	55	49	49.41	55.97	1,177.5	1.107	.268	.437
B 2. Secure herbicide product during transport	55	49	52.85	52.10	1,367.0	-0.127	.899	.507
B 3. Manage empty product containers	55	49	52.44	52.56	1,344.5	0.020	.984	.498
B 4. Clean application equipment	55	49	53.74	51.11	1,415.5	-0.443	.658	.525
B 5. Store products securely	55	49	51.45	53.67	1,290.0	0.374	.708	.479
B 6. Respond to product spills promptly	55	49	52.95	52.0	1,372.0	-0.160	.873	.509

[a] The sample (n) may be less than the total because not every respondent rated every item.
[b] $p < .05$.
[c] $p < .01$.

Questionnaire item	n_{NC}[a]	n_{CO}[a]	MR_{NC}	MR_{CO}	Mann-Whitney U_{NC}	z	p (2-tailed)	$\hat{p}_{NC>CO}$
Duty C. Manage target vegetation								
C 1. Evaluate previous treatment	55	50	49.11	57.28	1,161.0	1.376	.170	.422
C 2. Calculate area of treatment site	55	50	56.74	48.89	1,580.5	-1.319	.187	.573
C 3. Identify target vegetation	55	50	49.37	56.99	1,175.5	1.280	.201	.427
C 4. Determine vegetation management method	53	50	50.62	53.46	1,252.0	0.482	.630	.472
C 5. Select appropriate product mix	55	50	53.34	52.63	1,393.5	-0.119	.906	.507
C 6. Calibrate application equipment	55	50	51.63	54.51	1,299.5	0.484	.628	.473
C 7. Calculate product mix rate	54	50	51.04	54.08	1,271.0	0.514	.607	.471
C 8. Prepare product mix	54	50	53.75	51.15	1,417.5	-0.439	.661	.525
C 9. Apply product mix to treatment site	55	50	52.97	53.03	1,373.5	0.01	.992	.499
Duty D. Protect nontarget areas								
D 1. Transfer sensitive site information to work plan	55	50	52.71	53.32	1,359.0	0.103	.918	.494
D 2. Recognize conditions conducive to volatility	54	50	51.53	53.55	1,297.5	0.342	.733	.481
D 3. Select management techniques to minimize environmental impact	55	49	51.47	53.69	1,291.0	0.368	.713	.479
D 4. Manage spray drift	55	50	53.03	52.97	1,376.5	-0.010	.992	.500
D 5. Prevent herbicide runoff	55	50	53.84	52.08	1,421.0	-0.295	.768	.517
D 6. Identify sensitive areas during application	55	50	50.29	55.98	1,226.0	-0.956	.339	.446

[a] The sample (n) may be less than the total because not every respondent rated every item.

Questionnaire item	n_{NC}[a]	n_{CO}[a]	MR_{NC}	MR_{CO}	Mann-Whitney U_{NC}	z	P(2-tailed)	$\hat{P}_{NC>CO}$
Duty E. Maintain application equipment								
E 1. Conduct truck inspection	54	50	54.30	50.56	1,447.0	-0.631	.528	.536
E 2. Inspect spray equipment for proper working order	54	50	50.20	54.96	1,226.0	0.807	.420	.454
E 3. Inventory on-board safety supplies	53	49	56.45	47.28	1,561.0	-1.557	.119	.589
E 4. Carry government- and company-required documents	54	50	52.51	52.49	1,350.5	-0.003	.997	.500
E 5. Label service containers	54	50	58.02	46.53	1,648.5	-1.942	.052	.610
E 6. Monitor equipment performance during application	53	50	54.63	49.93	1,428.5	-0.683	.495	.540
E 7. Perform in-field adjustments/repairs	53	50	52.54	51.43	1,353.5	-0.188	.851	.511
Duty F. Record work activities daily								
F 1. Record environmental conditions	55	50	49.04	57.36	1,157.0	1.399	.162	.421
F 2. Document application information	55	50	47.68	58.85	1,082.5	1.877	.061	.394
F 3. Explain unusual incidents/observations	55	50	56.82	48.80	1,585.0	-1.347	.178	.576
Duty G. Promote public relations								
G 1. Maintain professional appearance	55	50	56.42	49.4	1,563.0	-1.206	.228	.568
G 2. Explain job to customer's employees	55	50	52.86	53.15	1,367.5	0.048	.962	.497
G 3. Notify public about application	55	49	47.70	57.89	1,083.5	1.719	.086	.402
G 4. Promote appearance of right-of-way	54	49	52.72	51.20	1,362.0	-0.258	.797	.515
G 5. Respond courteously to public employees	55	50	56.30	49.37	1,556.5	-1.165	.244	.566

[a] The sample (n) may be less than the total because not every respondent rated every item.

Questionnaire item	n_{NC}[a]	n_{CO}[a]	MR_{NC}	MR_{CO}	**Mann-Whitney** U_{NC}	**z**	**P(2-tailed)**	$\hat{P}_{NC>CO}$
Duty H. Pursue professional development								
H 1. Fulfill state pesticide certification requirements	55	50	52.18	53.90	1,330.0	0.289	.773	.484
H 2. Attend educational seminars	55	50	52.54	53.51	1,349.5	0.164	.870	.491
H 3. Read professional materials	55	50	50.44	55.81	1,234.5	0.901	.184	.449
H 4. Participate in professional mentoring	55	50	51.10	55.09	1,270.5	0.670	.503	.462

[a] The sample (n) may be less than the total because not every respondent rated every item.