Study of Factors Affecting Wildlife Law Enforcement Agent Productivity[1]

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Abstract: The relationships of environmental factors, agent personal background, enforcement methods, and season with enforcement efficiency were analyzed. Three major interactions among independent variables were detected. Analysis of covariance by multiple regression indicated that methods of enforcement were more closely associated with enforcement efficiency than other categories of independent variables. Agent rank was found to be more strongly related to the dependent variable than the single most important environmental attribute (intensity of water recreation).

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Recently we reported (Cowles and Giles 1982) results of development of a decision-aid system (the WILDSTRAT system) which optimizes spatial distribution and movements of wildlife law enforcement agents. Any decision to move personnel between areas requires assumptions regarding the impact of the move on personnel efficiency and effectiveness. Usually it is assumed that a shift of personnel to meet workload will increase the total productivity, and that productivity rates per agent will not be negatively affected. Although overall district game arrests could be predicted from effort measures, Ritter (1975:46) speculated that the reason he could not statistically predict agent game arrests was because "the great diversity in counties which agents work is mainly responsible." This suggests that a workload index-based decision-aid system such as we developed could lead to counter-productive effects in that if agents are moved to optimize their distribution in rela-

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tion to workload, unidentified environmental factors could actually reduce their total productivity or rates of productivity.

Many enforcement professionals have speculated that an agent's productivity is significantly affected by personal background attributes, such as education. Cohen and Chaiken (1972) found that background measures, particularly personal history, can be useful indicators of police officer performance. Other factors such as season or enforcement methods can be surmised as influential.

In order to evaluate the possible effects of administratively directed geographic personnel shifts that may result during application of the WILDSTRAT system, we performed an analysis of the relative strength that environment, agent background, enforcement methods, effort, and season influence agent productivity. A generalized null hypothesis under test was that none of these factors affect agent productivity.

Methods

The Dependent Variable

The nature of work and degree of independence of wildlife law enforcement agents have resulted in a general lack of formal and reliable productivity measurement. Much routine data (e.g., inspection rates, warnings, etc.) or compliance estimators are vulnerable to a host of biases (Cowles et al. 1979). As an index of wildlife law violation rates, arrest data also have limitations (Cowles et al. 1978). However, as productivity (output) measures, arrest data are relatively free of certain biases, and analytical results can be generalized to many regions (as opposed to studying an indicator unique to a single state). In fact, arrest data are one of the few sources that relate directly to apprehension or deterrence functions in enforcement. Thus, for this study we created a measure called a Quality Arrest Score (QAS) where quality was defined as the degree to which different arrests achieve enforcement goals. Once a set of QAS's are developed, arrest efficiency (QAS/enforcement hour) can be determined for each agent. This was accomplished by:

1. Development of a violation seriousness scale for a set of wildlife laws.
2. Collection of arrest data from a sample of wildlife law enforcement agents.
3. Conversion of raw arrest data to QAS's.
4. Computation of each agent's enforcement efficiency where efficiency is defined as total QAS per enforcement hour.

Arrest data and other information were obtained during November 1977 and February, May, and August 1978 from the Division of Enforcement, Virginia Commission of Game and Inland Fisheries. Through a series of questionnaires directed to Division personnel, enforcement goals were weighted according to importance. The purpose of each of 93 laws was associated with a particular goal and each law subjectively evaluated in terms of how seriously violation of the law compromised achievement of the associated goal. Then, a goal-weighted seriousness score was computed for each law by multiplying the law's arithmetic mean (over all respondents) seriousness score by the goal importance of the associated goal (Beattie et al. 1978, Cowles 1979). Arrest data were converted by computer to a monthly enforcement efficiency measure (QAS/enforcement hour) for each agent.

Independent Variables

Environmental Attributes—For Patrol Areas (that area including all counties in which the agent performed enforcement activities, regardless of whether arrests were made) per unit area attribute intensities were computed for each agent, by month, for 20 attributes (Table 1). These computations took into account monthly change in the counties worked by each agent. Attribute intensity was computed as a proportion of the total area in the counties patrolled.

Methods of Enforcement—Agents classified each arrest as being made by 1 of 5 methods: patrol, stakeout, investigation, response to citizen notification, and other. Total QAS by method was computed for each agent each month, yielding TQSP (total QAS by patrol), TQSS (total QAS by stakeout), TQSI (Total QAS by investigation), TQSCN (total QAS by response to citizen notification), and TQSO (total QAS by other methods).

Effort—Agents provided the number of hours spent in enforcement activities during each study period, exclusive of other activities. The variable was identified as TOTHRS.

Season—As a classification variable representing seasonal influences, each

Table 1. Variable names and explanations for environmental attributes quantified as a Patrol Area intensity.

Variable	Explanation
1. TOTRP	Total trapping license sales
2. HUACCI	Total hunting accidents investigated
3. TOTAC	Total county area
4. ACTRTWA	Area of native and stockable trout water
5. AVSPTK	Average legal spring turkey harvest
6. AVFATK	Average legal fall turkey harvest
7. AVBRHV	Average legal bear harvest
8. AVDEHV	Average legal deer harvest
9. TOTHU	Total human population
10. TOTFA	Total farms
11. ACCPL	Area of cropland
12. ACHVCPL	Area of harvestable cropland
13. COMMERF	Area of commercial forest
14. OAK	Area of commercial oak forest
15. TRTSTK	Number of trout stocked
16. STKTRP	Number of trout stocking trips
17. TOWAREC	Index of existing and proposed water recreation sites and boat ramps
18. GMNGT	Index of amount of state game management lands
19. TOREFU	Index of state, federal game management and wildlife refuge lands
20. TOTOTHR	Total enforcement hours worked by other agents

Table 2. Variable names and explanations of personal background measures quantified on a per agent basis.

Variable	Explanation
1. AGEAPP	Age at application
2. LENRES	Length of residency at application
3. MILIYRS	Length of active military service
4. LOFLEX	Indication of preferred location, yes or no
5. JOFLEX	Accept temporary work, yes or no
6. TRAFLEX	Accept frequent travel, yes or no
7. FLEXINDX	Sum of responses to variables 4–6
8. DIS	Presence of chronic disease, yes or no
9. SIGHT	Sight disorder, yes or no
10. SPE	Speech disorder, yes or no
11. HEAR	Hearing disorder, yes or no
12. BLIM	Disorder of body or limb, yes or no
13. CON	Convicted of law violation, yes or no
14. FIRED	Ever fired, yes or no
15. EDUC	Maximum educational attainment at application, one of 14 codes, less than high school to advanced degrees (or vocational), by category
16. EXPERDIV	Number of unique full-time positions held for more than 9 months
17. YRSEXP	Total years previous work experience in full-time positions
18. PREVENF	Years of previous full-time law enforcement experience, including military police
19. DIFFPOS	Number of different positions, regardless of uniqueness, held 9 months or more
20. FISH	Hold fishing license, yes or no
21. HUNT	Hold hunting license, yes or no
22. RANK	Rank as of July 1978; 5 classifications, R1–R5
23. AGEHIRE	Age at employment
24. MOSERV	Length of service to July 1978

observation (QAS/enforcement hour per agent) was assigned a code M1 (fall, November), M2 (winter, February), M3 (spring, May) or M4 (summer, August).

Personal Background—Following each participating agent's authorization, we reviewed employment application forms submitted by each agent prior to employment and recorded information on each of 24 personal background characteristics (Table 2). State radio numbers were used to align each observation of enforcement efficiency with personal background data in later analyses.

Data Analysis

The OSIRIS (Institute of Social Research 1973) Automatic Interaction Detection (AID, version 3) algorithm was used to identify potential interactions among independent variables. Stepwise multiple regression models were built to screen all variables measured on an interval scale (metric variables) as well as interactions previously detected. Then, variables entering stepwise models (i.e., those with sufficient strength in explaining variance in the dependent variable) were analyzed as covariates in models which included discrete (classification) variables. Analysis of covariance was accomplished by multiple regression procedures as provided by the Statistical Analysis System (Barr et al. 1976).

It was necessary to use the AID because we would have otherwise had to evaluate all possible (a very large number) interactions and test them in saturated models. AID eliminated the need to build and test such unwieldy regression models. Since the AID algorithm is designed for analysis of classification level data only, we converted all interval scale measures to classification data during the AID analysis. Specific operational parameters used in the AID and stepwise multiple regression are described further in Cowles (1979).

Results

The Dependent Variable

Observations of arrest productivity were obtained voluntarily from 110, 117, 112, and 117 agents for the periods of November, February, May, and August, respectively. This represented an overall response rate of 79%. Although it is a high rate when compared to other survey research response rates, it is representative of the commitment of participating personnel to the project.

Goal weights, violation seriousness scaling, and QAS determination for each of 93 possible wildlife law violations resulted in a QAS range of 0.0–14.346. A total of 3,902 arrests were each assigned a score within this range. Assignment of QAS 0.0 occurred infrequently (0.8%) and included cases such as "Driving with suspended license" which had limited applicability to wildlife agency goals. Other examples of QAS scorings were "Fishing on Sunday in certain counties" (3.154), "Fishing after legal hours" (6.224), "Buy fur without permit" (9.275), "Hunting during closed season" (12.465), and "Deposit litter or trash" (14.346). For November data, in only 52 cases (3.5%) was investigator judgment used to resolve when an exact match was not possible but when an approximation existed (2.7%) or when no match (0.8%) between an arrest and scaled violation could be found. In all other cases a computer assisted direct match between the listed case and the scaled violation could be made. Degree of investigator decisions on QAS assignment was similar for other months.

A significant correlation ($r = 0.99$, $P < 0.001$) existed between numbers of arrests and QAS scores for each agent. Thus, statistically, numbers of arrests could be substituted for QAS's. We chose, however, to continue the analysis of enforcement efficiency in terms of QAS measures since their theoretical value is superior, as argued above. Although unimodal, the distribution of QAS's was skewed positively as compared to a standard normal distribution. It has been shown (Scheffe 1959:346) that the type of tests planned (F tests) are not sensitive to skewness. Also, comparison of standardized regression coefficients (indicate the slope and direction of a relationship between two variables) or partial mean squares (a portion of the variability in the dependent variable explained by an independent variable) can provide assessments of the importance of potential factors without heavy reliance on normal theory. Therefore, we did not transform the data to achieve "normality."

Independent Variables

Applications for employment were released by 104 (72%) of the agents. Missing data was found on 67 of the applications, primarily for variables LOFLEX, JOFLEX, TRAFLEX, FISH and HUNT (Table 2). AGEAPP, MOSERV, and RANK were known for all personnel. Data on work experience, health, military experience, and education were obtained from all applications. The occurrence of non-respondents to release requests reduced sample sizes in later analyses (below).

Due to an omission on the Summons Data Sheets for November and February, we only knew the counties where arrests were made and were not able to compute Patrol Area environmental attribute intensity directly. Instead, based on predictive equations derived from May and August data, we estimated each agent's fall and winter Patrol Area attribute intensity. This was done by using fall and winter Arrest Area attribute intensities to predict Patrol Area intensities for the same months. Since the two types of Areas were, by definition, very similar (and often the same in practice) the multiple correlation coefficients (R^2) for the equations were high (7 of 20 > 0.80; all but 1 > 0.50). Thus, we believe any error imparted to our independent measures of environmental attributes in fall and winter was slight and the gain of maximizing sample size compensated for error increase.

Patrol, stakeout, investigation, citizen notification, and other methods accounted for 68.3, 10.6, 5.6, 12.4, and 2.8 mean percent of total QAS, respectively. A total of 8 observations reported no enforcement effort and were excluded from AID and regression analyses since a dependent variable did not exist for them.

Automatic Interaction Detection

Potential interactions among independent variables detected by screening all major categories were restricted to effort and methods variables, and included TQSP*TOTHRS, TQSP*TQSCN, and TQSP*TQSCN*TOTHRS. In the first case, the interaction means that efficiency (QAS/hr) of agents with a high TQSP is affected differently by effort (TOTHRS) than those with a lower TQSP. Similarly, change in QAS by response to citizen notification will have a different effect on efficiency for agents who make lower QAS by patrol compared to those making higher QAS by patrol. Weak interactions were detected involving HUACCI, TOTRP, and COMMERF environmental measures but these were not evident in simultaneous tests with the methods variables. Personal background variables did not interact with others. Thus, we entered 3 major interactions as unique variables in regression models and assessed their relative strength as well.

Stepwise Multiple Regression Analyses

We first screened all independent candidate variables in restricted categories; e.g., all environmental attributes only. Then, variables that were strong enough to enter the restricted models were analyzed together. Consequently, TQSP, TQSI,

Table 3. Regression parameters, standard errors, and significance levels attained in model of enforcement efficiency as determined by ridge regression.

Independent variable	Regression parameter	Standard error	Level attained
TQSP	1.607	0.061	0.0001
TQSI	0.380	0.016	0.0001
TQSP*TOTHRS	−0.839	0.070	0.0001
TQSCN	0.335	0.047	0.0001
TQSS	0.176	0.029	0.0001
TOTHRS	−0.132	0.029	0.0001
TQSO	0.058	0.016	0.0003
TQSCN*TOTHRS	−0.152	0.050	0.0023
TOWAREC	0.046	0.016	0.0036
R1	0.283	0.121	0.0122
R2	0.243	0.119	0.0257
R3	0.237	0.126	0.0328
FIRED	−0.157	0.086	0.0624
TQSP*TQSS	0.049	0.030	0.0646
MOSERV	0.032	0.019	0.0727

Intercept = −0.259, R^2 = 0.934, k = 0.24035

TQSCN, TOTHRS, TQSS, TQSO, TOWAREC, AVDEHV, TOTAC, AVBRHV, TOTRP, HUACCI, COMMERF, ACCPL, MOSERV, EXPERDIV, and DIFFPOS were identified as metric candidates for analysis of covariance. HUACCI, ACCPL, and DIFFPOS were dropped from future tests due to their multicollinearity (correlation) with other variables. In summary, all methods, 7 environmental attributes, 2 personal background measures, and 3 interactions were selected as metric candidates for entry with discrete variables (e.g., season, rank) in analysis of covariance.

Table 3 shows the final results of all regressions, as adjusted by ridge regression (Hoerl and Kennard 1970) to offset any remaining multicollinearity. The interpretation of Table 3 is straight forward—the larger the regression parameter (standard partials), the greater the influence of the variable on enforcement efficiency. A negative sign means that as the independent variable inceased, efficiency decreased and a positive sign indicates both variables changed in the same direction. All regression parameters shown were significant at $P < 0.073$, most (TQSP − R3, Table 3) were significant at $P < 0.033$. The variables shown explained 93% of the variance in enforcement efficiency. Methods (especially patrol and investigation) and an interaction of patrol and effort explained 83% of the total variance, as determined by examination of partial mean squares (not shown).

These results show that methods of enforcement (as they affect total QAS by method), especially patrol, are more closely associated with enforcement efficiency than are other major categories of independent variables studied herein. Environmental attributes of patrol areas tended to have a stronger relationship with enforcement efficiency than personal background variables in preliminary analyses, but final analysis of covariance showed rank of potentially more influence than the single most important environmental attribute, an index of total water recreation

(TOTWAREC). These findings generally fail to support Ritter's (1975:46) hypothesis that the diversity of working conditions in Virginia counties may explain differences in agent productivity. Our results reduce the degree to which Cohen and Chaiken's (1972:15) findings appear applicable to wildlife law enforcement agents as well.

Conclusions

The results suggest that most environmental factors as they relate to the enforcement efficiency measure herein are relatively unimportant, especially as compared to the influence of enforcement methods. Therefore, shifting personnel among counties to meet temporary prescriptions of workload should not be expected to lead to adverse effects on productivity (excluding possible negative aspects of permanent shifts which may be incurred and for which we made no analysis). This conclusion reduces concern for the assumption of workload deployment models that effectiveness and efficiency of individual agents are unaffected by short term geographic shifts.

Also of interest was the finding that rank was the strongest personal background characteristic influencing efficiency. Much conjecture abounds regarding whether agents with higher education are as qualified for wildlife law enforcement work as those lacking it. These results produced no evidence that educational attainment prior to employment has a strong relationship to enforcement efficiency. The stronger relationship was shown for other personal background variables, such as rank or length of service.

Since the relationships of efficiency with enforcement methods variables were positive, it can be concluded that efficiency will increase as productivity by an enforcement method is increased, and more so in the case of the patrol method. This finding may seem self-evident. However, it should be recalled that a valid hypothesis predicating this research was that total QAS by any method and efficiency were both random variables and therefore there was no reason to expect any specific association. The wildlife law enforcement agent who would choose that method by which he might have the greatest opportunity for modifying his overall efficiency (as defined herein) would be wise to select patrol. The relationship of stakeout with overall efficiency (Table 3) was less than patrol, investigation, or response to citizen notification. This finding is of relevance considering that the proportion of total effort devoted to stakeout may be disproportionately large in certain seasons.

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