

E R R A T A

Technical Report No. 1 (USWB Contract Cwb-10704)

REGRESSION ESTIMATION OF EVENT PROBABILITIES

April 1964

Page 4 - Line 4 - The word "divided" should be "dividing."

Page 6 - Title for Experiment 8 should read "Combination of Selected Predictors from a Network and Single-Station Booleans."

Note: This would also change the title on Page 129.

Page 26 - Line 12 - Insert "City" after Atlantic.

Page 69 - Line 4 - The word "of" should be "by."

- Line 7 (from the bottom) - The word "dependent" should be

AD 602037
U.S. Weather Bureau
Contract Cwb-10704
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April 1964
7411-121

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ABSTRACT

MDA (multiple discriminant analysis) has been found useful in predicting the probability of operationally critical airfield ceiling and visibility conditions. One part of the discriminant procedure requires at the outset a rather lengthy computation by machine to estimate these probabilities. While the operational use of the method takes much less effort, the time needed initially on a large scale computer may be inordinate when many elements, time periods, and geographical locations are being considered. This technical report discusses a prediction technique, REEP (regression estimation of event probabilities), which resulted from attempts to make MDA more efficient. Comparative studies between REEP and MDA are included as well as other experimentations performed using the REEP procedure. Recommendations for future work on the technique are also given.

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1.0 INTRODUCTION

The objective of this task was to develop, in the MDA (multiple discriminant analysis) framework, a method which would produce medium range ceiling and visibility forecasts efficiently. The original plan was to investigate the use of a multivariate statistical procedure called canonical correlation--discriminant analysis being a special case of canonical correlation. By incorporating a feature which screened predictors in canonical correlation, it was expected that more than one predictand could be processed simultaneously with a resulting saving in computer time.

Work on screening canonical correlation was proceeding satisfactorily until it was found that a technique subsequently called REEP (regression estimation of event probabilities) possessed even more desirable computational features. It was later discovered that the REEP technique had appeared in the literature in 1955, Lund [1], (see also Lund [2]). In addition, work related to this approach has been published by Cox [3, 4] and by Warner [5].

This technical report consists of 1) a discussion of the REEP technique, 2) the results of a comparative study between REEP and MDA, 3) the results from a series of experiments investigating various aspects of the REEP procedure, 4) the results from experiments performed to study the effect of modifying the form of the predictor variables by means of Boolean expressions, and 5) discussion and recommendations for future study.

2.0 THE REEP PROCEDURE

Consider the problem of estimating the probability distribution over a set of G mutually exclusive and exhaustive groups where the groups are defined for a specific predictand. The statistical technique of discriminant analysis may be used to estimate probability distributions of this type [6]. The suggested approach for estimating the group probabilities, when the underlying density functions are unknown, is that of Fix and Hodges. This approach requires the computation of "distances" in the discriminant space between a new observation and each observation of the developmental sample. The set of k close neighbors is then used to estimate the group probabilities.

The REEP procedure may be thought of as an alternative to the Fix-Hodges method employed in MDA. Or, more appropriately, it can be viewed as a self-contained statistical prediction method. The following is a description of the REEP procedure:

Perform a series of multiple regressions on G zero-one dependent variables, $Y_1, \dots, Y_G$, where each dependent variable is associated with one of G predictand groups. The independent variables, $X_1, \dots, X_r$, are taken to be the same throughout each of the G regressions. The object of this series of regressions is to obtain the least squares estimate of the A 's in the following equations:

$$E(Y_1 | \underline{X}) = \sum_{s=0}^r A_{1s} X_s$$

$$E(Y_2 | \underline{X}) = \sum_{s=0}^r A_{2s} X_s$$

⋮

$$E(Y_G | \underline{X}) = \sum_{s=0}^r A_{Gs} X_s$$

where $X_0 = 1$

All of the conditional distributions, $f(Y_g | \underline{X})$, $g=1, \dots, G$, are Bernoulli distributions (zero-one) and on a single trial the expectation is equal to the probability that $Y_g = 1$. Thus the regression functions give least squares estimates of the group probabilities, $\hat{P}_g$ ($g=1, \dots, G$).

These estimates possess certain desirable and certain undesirable properties:

Desirable

1) The estimates add to unity, i.e., $\sum_{g=1}^G \hat{P}_g = 1$.

2) The estimates essentially minimize the Brier-Allen $\bar{P}$ score,

$$\text{i.e., } \sum_{i=1}^N \sum_{g=1}^G (Y_{ig} - \hat{P}_{ig})^2.$$

Undesirable

1) The estimates are not bounded by 0 and 1.

An intuitively reasonable approach and the one used to remedy this undesirable property is to renormalize the estimates by: a) setting all negatives equal to zero, b) setting all estimates greater than one equal to one, and c) divided each by the resulting overall sum.

3.0 REEP PREDICTOR SELECTION

A predictor selection procedure has been incorporated into the REEP procedure similar to that used in regression and MDA [6], namely:

Out of a set of P possible predictors $X^{(1)}$ is selected such that in the developmental sample it contributes most significantly with regard to one of the G predictands. That is, out of the G possible F distribution statistics the predictor $X^{(1)}$ has one of these computed statistics larger than any one of the G computed for the remaining $P-1$ predictors.

In a similar manner, a second predictor $X^{(2)}$ is selected from the $P-1$ remaining predictors when considered in conjunction with $X^{(1)}$. Selection continues until r predictors $X^{(1)}, X^{(2)}, \dots, X^{(r)}$ have been chosen; r is determined such that $X^{(r+1)}$ is not satisfactorily significant. The significance criterion has been designed similar to that used in screening regression and MDA (see page 13, reference [6]). Namely, compare the G possible computed F statistics, at any of the r selection stages, with a critical value of F_{α} , where the size α of the test is $\frac{1}{20 [P - (S-1)]}$. The

value S denotes the selection stage number or equivalently the number of predictors thus far selected. Tests must still be performed to confirm its applicability, however.

4.0 EXPERIMENTATION

A number of experiments were performed to test certain aspects of the REEP procedure. The complete list of experiment titles is given below.

	<u>Title</u>	<u>Page</u>
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EXPERIMENT 1. Comparison Between MDA and REEP (Atlantic City Airport)

Purpose

To compare the results of short range ceiling and visibility predictions using the MDA technique and the REEP technique. In the event REEP compares favorably with MDA it might, because of its computational efficiency, be used in place of MDA for forecasting ceiling and visibilities.

Procedure

A test of the REEP technique was made by comparing independent sample predictions of ceiling and visibility using REEP and MDA. Each technique was allowed to select predictors and generate probability forecasts independently. Predictions were made for two stations, Atlantic City Airport, New Jersey and Offutt AFB, Nebraska. (See Experiment 1A for Offutt.)

Predictands

The five operationally significant categories of ceiling and visibility at Atlantic City Airport, New Jersey for the forecast intervals of three and seven hours define the four predictands for which the techniques are compared (see Table 1-1). The specifications for each predictand are given in Table 1-2.

Predictors

Seven meteorological elements at 13 predictor stations (see Figure 1-1) plus the time of day (TOD) and day of year (DOY) variables were transformed into dummy (zero-one) variables (see Tables 1-3 and 1-4). This set of 423 dummy predictors was used as possible predictors for all four predictands.

Data Sample

Standard hourly airways surface observations covering the 10 year period, 1 January 1949 to 31 December 1958, furnished the data for this study. There are 87,672 hours in the 10 years from 1949 through 1958. This is too many to use efficiently; besides not all hours are needed because of the serial correlation present in meteorological variables. The amount of data was reduced by a three-stage process:

- (a) Any variable not observed for a substantial portion of the 87,672 hours was eliminated. A variable was also eliminated if the frequency distribution of its error vector exhibited a bias with regard to hour of day or month of year.
- (b) Those hours were eliminated for which any one of the variables was missing or failed to pass a gross-error check.
- (c) A random selection of the remaining hours was made to select 10,000 cases.

Results

The four sets of predictors selected by MDA and REEP respectively are given in Tables 1-5a to 1-5d as well as the REEP regression equation coefficients for each group of the predictand. Contingency tables (see Tables 1-6a to 1-6d) show the forecast-versus-observed frequencies for persistence, MDA, and REEP. The number of correct forecasts (hits) and the Brier and Allen $\bar{P}$ scores as well as the individual group contributions to the overall $\bar{P}$ score are given below each contingency table. The number of hits and the overall $\bar{P}$ scores are summarized in Table 1-7 by predictand.

Conclusions

See Experiment 1A.

Table 1-i

Definition of Predictand Groups for Atlantic City Municipal Airport

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling < 200 ft
2	200 ft $\leq$ Ceiling < 500 ft
3	500 ft $\leq$ Ceiling < 1000 ft
4	1000 ft $\leq$ Ceiling < 3000 ft
5	3000 ft $\leq$ Ceiling

<u>Group Number</u>	<u>Visibility Intervals</u>
1	0 mi $\leq$ Visibility < 1/2 mi
2	1/2 mi $\leq$ Visibility < 1 mi
3	1 mi $\leq$ Visibility < 2 mi
4	2 mi $\leq$ Visibility < 3 mi
5	3 mi $\leq$ Visibility

Table 1-2

Specification of Predictands
Atlantic City Municipal Airport

Predictand variable	Predictand			
	1	2	3	4
Predictand variable	CIG	CIG	VIS	VIS
Forecast interval--hours (H)	3	7	3	7
Number of Groups (G)	5	5	5	5
Observations in Group 1 (n_1)	100	135	153	167
Observations in Group 2 (n_2)	281	272	125	130
Observations in Group 3 (n_3)	385	420	200	230
Observations in Group 4 (n_4)	660	619	286	283
Observations in Group 5 (n_5)	6530	6510	7192	7146
Total dependent sample size (N)	7956	7956	7956	7956
Number of independent observations in the dependent sample (n)	2652	2652	2652	2652
Total independent sample size (M)	2044	2044	2044	2044
Number of available predictors (P)	423	423	423	423

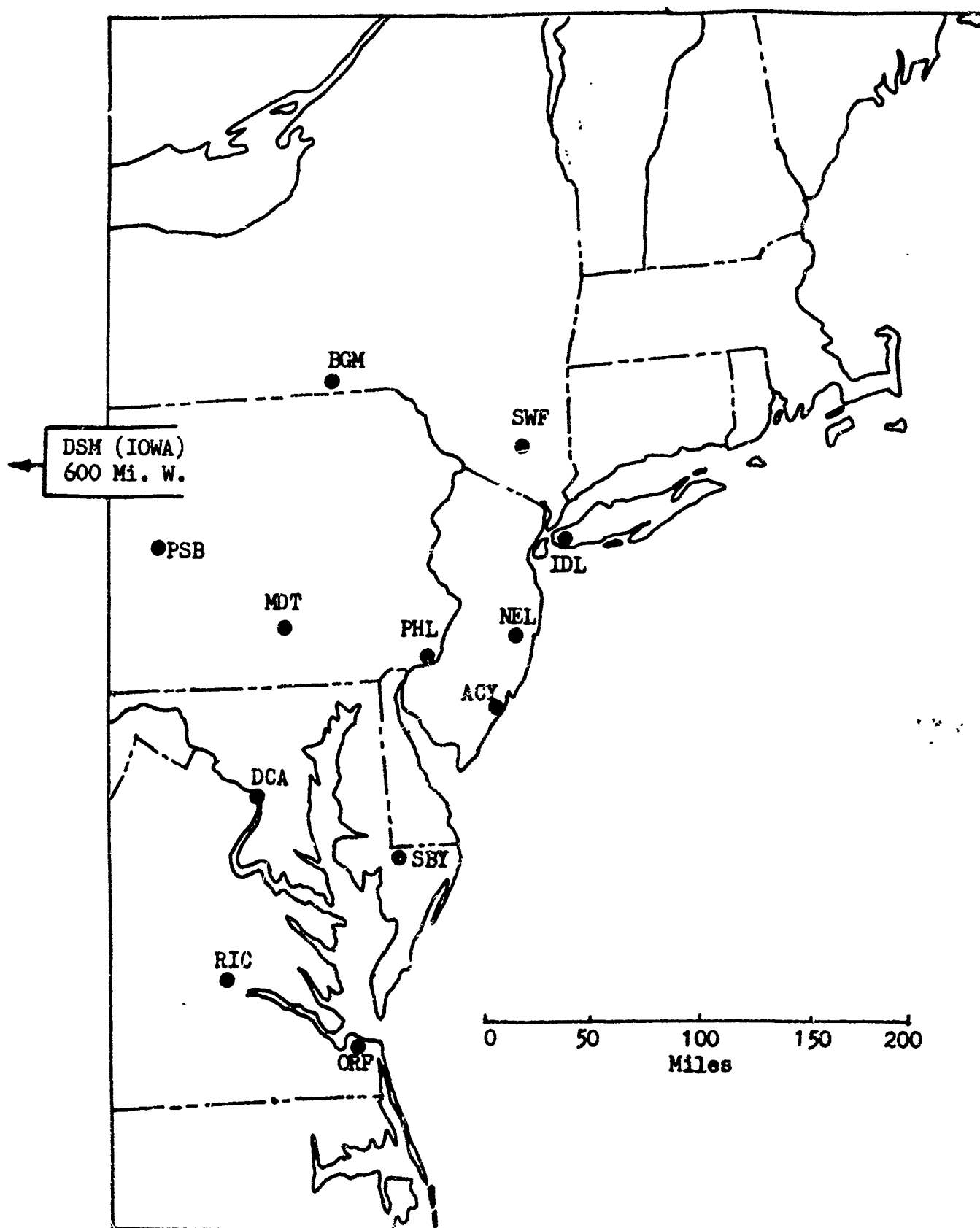


Figure 1-1. Thirteen Station Network for Atlantic City Airport

Table 1-3

Number of Possible Predictors for the
3- and 7-hr Ceiling and Visibility at ACY

Elem.	Station													Total
	ACY	NEL	PHL	SBY	MDT	DCA	ORF	PSB	BGM	SWF	RIC	IDL	DSM	
TOO	5	-	-	-	-	-	-	-	-	-	-	-	-	5
DOY	1	-	-	-	-	-	-	-	-	-	-	-	-	1
CIG	15	5	5	5	5	5	5	5	5	5	5	5	-	70
VIS	15	5	5	5	5	5	5	5	5	5	5	5	-	70
WMD	5	5	5	5	5	5	5	5	5	5	5	5	5	65
RLH	3	3	3	3	3	3	3	3	3	3	3	3	3	39
TCA	2	2	2	2	2	2	2	2	2	2	2	2	2	26
WEA	12	12	12	12	12	12	-	12	12	12	12	12	12	144
SCL	3	-	-	-	-	-	-	-	-	-	-	-	-	3
Total														423

Table 1-4

Specifications and Limits of the Zero-One (Dummy) Variables

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>Time of Day:</u>
TOD	5	1. From 0130 EST to 1330 EST 2. From 0130 EST to 0730 EST 3. From 0730 EST to 1330 EST 4. From 1330 EST to 1930 EST 5. From 1930 EST to 0130 EST
		<u>Day of Year:</u>
DOY	1	1. From 151 (31 May) to 300 (27 Oct)
		<u>Wind:</u>
WND	5	1. Calm to 3 Knots, any direction 2. From 23° to 67°, 3 Knots < Speed 3. From 68° to 202°, 3 Knots < Speed 4. From 203° to 247°, 3 Knots < Speed 5. From 248° to 22°, 3 Knots < Speed
		<u>Relative Humidity:</u>
RLH	3	1. From 75 per cent to 85 per cent 2. From 86 per cent to 93 per cent 3. From 94 per cent to 100 per cent
		<u>Total Cloud Amount:</u>
TCA	2	1. From 5/10 to 9/10 (incl.) 2. More than 9/10
		<u>Ceiling Height, ft:</u>
CIG	5	1. 0 ≤ CIG < 200 2. 200 ≤ CIG < 500 3. 500 ≤ CIG < 1000 4. 1000 ≤ CIG < 3000 5. 3000 ≤ CIG

Table 1-4 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>	
		<u>Ceiling Height*, ft:</u>	
CIG	10	(1)	CIG = 100
		(2)	CIG = 200
		(3)	CIG = 400
		(4)	CIG = 500
		(5)	CIG = 900
		(6)	1500 ≤ CIG < 2000
		(7)	2500 ≤ CIG < 3000
		(8)	3000 ≤ CIG < 5000
		(9)	5000 ≤ CIG < 10,000
		(10)	CIG = Unlimited
		<u>Visibility, mi:</u>	
VIS	5	1.	0 ≤ VIS < 1/2
		2.	1/2 ≤ VIS < 1
		3.	1 ≤ VIS < 2
		4.	2 ≤ VIS < 3
		5.	3 ≤ VIS
		<u>Visibility*, mi:</u>	
VIS	10	(1)	1/4 ≤ VIS < 1/2
		(2)	1/2 ≤ VIS < 3/4
		(3)	3/4 ≤ VIS < 1
		(4)	1 ≤ VIS < 1-1/2
		(5)	1-1/2 ≤ VIS < 2
		(6)	2 ≤ VIS < 3
		(7)	3 ≤ VIS < 4
		(8)	4 ≤ VIS < 5
		(9)	5 ≤ VIS < 6
		(10)	15 ≤ VIS

*Parentheses are used here to help distinguish the two forms of ceiling and visibility dummies.

Table 1-4 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>	
		<u>Weather Element:</u>	<u>Teletype Code:</u>
WEA	12	1. No Weather	
		2. Rain	R-, R, R+
		3. Rain Showers	RW-, RW, RW+
		4. Drizzle or Freezing Drizzle	L-, L, L+ ZL-, ZL, ZL+
		5. Snow	S-, S, S+
		Snow Pellets	SP-, SP, SP+
		Snow Grains	SG-, SG, SG+
		Ice Crystals	IC-, IC, IC+
		6. Snow Showers	SW-, SW, SW+
		Snow Squalls	SQ-, SQ, SQ+
		7. Tornado	Tornado
		Thunderstorm	T, T+
		Squalls	Q-, Q, Q+
		Hail	A-, A, A+
		Hail Pellets	AP-, AP, AP+
		8. Freezing Rain	ZR-, ZR, ZR+
		Sleet	E-, E, E+
		Sleet Showers	EW-, EW, EW+
		9. Fog, Ice Fog	F, IF
		10. Ground Fog	GF
		11. Blowing Snow	BS
		Blowing Sand	BN
		Blowing Dust	BD
		12. Smoke, Haze, Dust	K, H, D
		<u>Sky Condition, Lower:</u>	
SCL	3	1. Sky obscured	X
		2. Thin broken clouds	- ☉
		Thin overcast	- ⊕
		3. Scattered clouds	☉
		Dark scattered clouds	+ ☉

Table 1-5a

Selected Predictors and REEP Equations
Atlantic City 3-hr Ceiling

Predictors Selected by MDA				Predictors Selected by REEP				The Coefficients of the REEP Equations				
Order	Station	Element	Dummy	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅	
1	ACY	CIG	5	ACY	CIG	5	-.006	-.002	-.025	-.218	.251	
2	PHL	CIG	5	ACY	CIG	1	.390	.192	-.025	-.359	-.199	
3	ACY	CIG	4	PHL	CIG	5	.009	-.021	-.067	-.135	.213	
4	ACY	CIG	3	ACY	CIG	2	.049	.318	-.002	-.289	-.076	
5	DCA	CIG	5	ACY	CIG	3	-.000	.067	.188	-.211	-.043	
6	ACY	CIG	1	DCA	CIG	5	.007	-.021	-.051	-.054	.119	
7	SBY	WEA	2	SBY	CIG	5	-.004	-.061	-.036	-.008	.110	
8	NEL	TCA	2	NEL	TCA	2	.005	.004	.014	.050	-.072	
9	SBY	CIG	5	ACY	VIS	5	-.047	.011	-.010	-.003	.049	
10	SBY	CIG	4	DCA	RLH	3	.013	.072	.001	-.052	-.034	
11	SWF	WND	3	NEL	CIG	3	-.009	-.006	.090	-.029	-.046	
12	DCA	RLH	3	ACY	CIG	(1)	-.177	.062	-.073	.048	.140	
13	IDL	WND	2	SBY	CIG	4	-.010	-.078	-.026	.104	.010	
14	ACY	VIS	5	IDL	WND	2	.010	.019	.019	.027	-.075	
15	NEL	WEA	2	SBY	WEA	2	-.009	.078	-.007	.049	-.111	
16	ACY	CIG	(1)	SWF	WND	3	.009	.021	.022	.018	-.071	
17	IDL	CIG	3	SBY	VIS	2	.087	.011	-.037	-.036	-.026	
18				ACY	CIG	(6)	-.010	-.014	-.039	.173	-.110	
19				NEL	WEA	2	-.027	.015	.083	-.048	-.023	
							Additive constant	.042	.089	.185	.429	.256

Table 1-5b

Selected Predictors and REEP Equations
Atlantic City 7-hr Ceiling

Predictors Selected by MDA				Predictors Selected by REEP				The Coefficients of the REEP Equations				
Order	Station	Element	Dummy	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅	
1	PHL	CIG	5	PHL	CIG	5	.002	-.032	-.051	-.087	.168	
2	DCA	CIG	5	DCA	CIG	5	-.003	-.008	-.051	-.073	.135	
3	ACY	CIG	5	ACY	CIG	5	-.015	-.030	-.038	-.061	.144	
4	DCA	WEA	2	PHL	WND	3	.027	.023	.037	.045	-.132	
5	IDL	WND	2	IDL	WND	2	.001	.033	.054	.039	-.127	
6	PHL	WND	3	ACY	TCA	2	.003	.002	.027	.049	-.032	
7	ACY	CIG	4	ACY	SCL	1	.104	-.043	-.041	-.033	.014	
8	MDT	(TCA	2	DCA	WEA	2	-.008	.057	.126	-.036	.139	
9	NEL	WEA	9	ISB	WEA	8	-.023	.253	-.090	-.042	-.099	
10	ACY	TOD	1	NEL	WEA	9	.024	.016	.061	.009	-.110	
11	MDT	WEA	2	ACY	CIG	2	.012	.093	.005	-.145	.035	
12	PHL	WND	2	ACY	TOD	1	-.026	-.018	-.009	.025	.028	
13	SBY	WEA	9	PSB	RIH	3	.007	-.007	.024	.041	-.064	
14	ACY	SCL	1	DCA	CIG	3	-.001	.084	.009	-.049	-.043	
15	PSB	WEA	8	SBY	WEA	9	.013	.047	.014	.031	-.104	
16	RIC	WEA	2	PSB	CIG	1	.007	.092	-.037	-.040	-.021	
17				PHL	WEA	7	-.031	.237	.029	-.063	-.172	
							Additive constant	.076	.137	.223	.533	

Table 1-5c

Selected Predictors and REEP Equations
Atlantic City 3-hr Visibility

Predictors Selected by MDA				Predictors Selected by REEP				The Coefficients of the REEP Equations				
Order	Station	Element	Dummy	Station	Element	Dummy		A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	VIS	5	ACY	VIS	5		-.041	-.023	-.067	-.054	.185
2	ACY	VIS	1	ACY	VIS	1		.274	.038	-.017	-.156	-.139
3	ACY	RLH	3	ACY	RLH	3		.023	.018	.029	.021	-.090
4	ACY	VIS	2	ACY	VIS	2		.113	.178	-.010	-.076	-.204
5	DCA	WEA	9	DCA	WEA	9		.002	.012	.037	.049	-.101
6	SBY	RLH	3	SBY	VIS	5		-.004	-.021	-.030	-.060	.115
7	NEL	WEA	9	NEL	WEA	9		.017	.017	.023	.048	-.106
8	ACY	WEA	1	ACY	WEA	1		-.007	-.005	-.011	-.045	.068
9	PHL	CIG	1	PHL	CIG	1		.183	.018	-.079	-.084	-.039
10	NEL	WEA	2	NEL	WEA	2		-.057	-.015	.024	.033	.016
11	SBY	CIG	1	ORF	RLH	3		.040	.010	.005	.004	-.060
12	ORF	RLH	3	MDT	VIS	2		-.025	.020	.116	-.025	-.086
								Additive constant				
								.052	.051	.109	.165	.623

Table 1-5d

Selected Predictors and REEP Equations
Atlantic City 7-hr Visibility

Predictors Selected by MDA						Predictors Selected by REEP						The Coefficients of the REEP Equations				
Order	Station	Element	Dummy	Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅				
1	ACY	WEA	9	1	ACY	WEA	9	.052	.020	.050	.005	-.128				
2	PHL	CIG	5	2	DCA	VIS	5	-.040	-.032	-.034	-.067	.173				
3	ACY	TOD	1	3	ACY	TOD	1	-.037	-.019	-.026	-.027	.109				
4	DCA	VIS	5	4	PHL	WEA	1	-.015	-.004	-.020	-.018	.055				
5	DCA	WEA	2	5	PHL	CIG	5	.010	-.019	-.036	-.026	.071				
6	NEL	WEA	1	6	IDL	VIS	3	.087	-.004	-.038	.012	-.058				
7	ACY	VIS	5	7	PHL	WND	3	.018	.020	.021	.012	-.070				
8	PHL	WND	5	8	ACY	VIS	2	.069	.099	-.015	-.037	-.115				
9				9	DCA	WEA	2	-.022	-.016	.062	.076	-.101				
10				10	NEL	WEA	1	-.011	-.009	-.010	-.026	.055				
			</													

Table 1-6a

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, MDA, and REEP

3-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	21	8	4	0	5	38
	2	13	33	25	10	9	90
	3	2	14	50	21	21	108
	4	1	8	21	68	70	168
	5	7	10	27	66	1530	1640
	Total	44	73	127	165	1635	2044

Hits = 1702 $\bar{P} = 0.2385$

$\bar{P}_g$ 0.0156 0.0284 0.0462 0.0636 0.0847

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
MDA	1	13	5	2	0	4	24
	2	14	29	24	6	1	74
	3	1	13	41	15	6	76
	4	3	14	24	53	36	130
	5	13	12	36	91	1588	1740
	Total	44	73	127	165	1635	2044

Hits = 1724 $\bar{P} = 0.2135$

$\bar{P}_g$ 0.0161 0.0279 0.0424 0.0601 0.0669

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP	1	6	4	1	0	1	12
	2	19	34	25	8	4	90
	3	0	11	42	14	5	72
	4	1	6	19	41	20	87
	5	18	18	40	102	1605	1783
	Total	44	73	127	165	1635	2044

Hits = 1728 $\bar{P} = 0.2135$

$\bar{P}_g$ 0.0163 0.0277 0.0423 0.0605 0.0666

Table 1-6b

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, MDA, and REEP
7-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	8	12	8	4	6	38
	2	12	22	19	19	18	90
	3	7	9	38	26	28	108
	4	2	12	33	37	84	168
	5	12	24	49	72	1483	1640
	Total	41	79	147	158	1619	2044
Hits = 1588 $\bar{P} = 0.2899$							
$\bar{P}_g$ 0.0183 0.0342 0.0598 0.0671 0.1105							

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
MDA	1	0	0	0	0	0	0
	2	6	9	10	4	0	29
	3	9	29	42	15	12	107
	4	2	5	9	13	12	41
	5	24	36	86	126	1595	1867
	Total	41	79	147	158	1619	2044
Hits = 1659 $\bar{P} = 0.2589$							
$\bar{P}_g$ 0.0181 0.0321 0.0539 0.0653 0.0894							

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP	1	0	0	0	0	0	0
	2	3	9	9	1	2	24
	3	7	19	34	12	9	81
	4	8	7	22	20	6	63
	5	23	44	82	125	1602	1876
	Total	41	79	147	158	1619	2044
Hits = 1665 $\bar{P} = 0.2600$							
$\bar{P}_g$ 0.0180 0.0323 0.0540 0.0666 0.0891							

Table 1-6c

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, MDA, and REEP

3-hr Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	17	10	7	1	6	41
	2	4	8	9	1	16	38
	3	4	11	21	11	31	78
	4	3	6	13	23	45	90
	5	14	11	28	57	1687	1797
	Total	42	46	78	93	1785	2044

Hits = 1756 $\bar{P} = 0.1910$

$\bar{P}_g$ 0.0170 0.0200 0.0334 0.0413 0.0793

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
MDA	1	16	10	6	1	5	38
	2	2	4	3	0	5	14
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	24	32	69	92	1775	1992
	Total	42	46	78	93	1785	2044

Hits = 1795 $\bar{P} = 0.1795$

$\bar{P}_g$ 0.0173 0.0201 0.0329 0.0391 0.0701

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP	1	13	9	5	1	4	32
	2	2	5	4	0	9	20
	3	0	2	0	0	0	2
	4	0	0	3	4	0	7
	5	27	30	66	88	1772	1983
	Total	42	46	78	93	1785	2044

Hits = 1794 $\bar{P} = 0.1800$

$\bar{P}_g$ 0.0169 0.0199 0.0331 0.0395 0.0707

Table 1-6d

Contingency Tables Showing Predictand-Versus-Actual Groups
for Persistence, MDA, and REEP

7-hr Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	6	4	6	7	18	41
	2	3	3	4	4	24	38
	3	4	8	17	9	40	78
	4	7	2	15	11	55	90
	5	23	21	48	68	1637	1797
	Total	43	38	90	99	1774	2044

Hits = 1574 $\bar{P} = 0.2270$

$\bar{P}_g$ 0.0201 0.0180 0.0405 0.0455 0.1029

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
MDA	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	43	38	90	99	1774	2044
	Total	43	38	90	99	1774	2044

Hits = 1774 $\bar{P} = 0.2120$

$\bar{P}_g$ 0.0191 0.0178 0.0391 0.0448 0.0912

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP	1	0	0	1	0	1	2
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	43	38	89	99	1773	2042
	Total	43	38	90	99	1774	2044

Hits = 1773 $\bar{P} = 0.2150$

$\bar{P}_g$ 0.0196 0.0178 0.0394 0.0446 0.0936

Table 1-7

Comparison Between Persistence, MDA, and REEP

(Independent Sample - 2044 Observations)

Atlantic City, Ceiling 3 Hours in Advance

Hits	Persistence	1702
	MDA	1724
	REEP	1728*

$\bar{P}$ Score	Persistence	.2385
	MDA	.2135*
	REEP	.2135*

Atlantic City, Ceiling 7 Hours in Advance

Hits	Persistence	1588
	MDA	1659
	REEP	1665*

$\bar{P}$ Score	Persistence	.2899
	MDA	.2589*
	REEP	.2600

Atlantic City, Visibility 3 Hours in Advance

Hits	Persistence	1756
	MDA	1795*
	REEP	1794

$\bar{P}$ Score	Persistence	.1910
	MDA	.1795*
	REEP	.1800

Atlantic City, Visibility 7 Hours in Advance

Hits	Persistence	1674
	MDA	1774*
	REEP	1773

$\bar{P}$ Score	Persistence	.2270
	MDA	.2120*
	REEP	.2150

Asterisks are used to denote superiority.

EXPERIMENT 1A. Comparison Between MDA and REEP (Offutt AFB, Nebraska)

The Purpose and the Procedure are the same as those in Experiment No. 1.

Predictands

Visibility at Offutt AFB was divided into four and ceiling into five operationally significant categories (see Table 1A-1) for the following four predictands: CIG + 3 hours, CIG + 7 hours, VIS + 3 hours, and VIS + 7 hours. The specifications of the predictands are tabulated in Table 1A-2.

Predictors

As in Experiment 1, seven meteorological elements at the 13 predictor stations constituted the Offutt AFB network (see Figure 1A-1), plus the time of day and day of year variables. These were then transformed into 423 dummy variables (see Tables 1A-3 and 1A-4).

Data Sample

A data sample containing 10,000 observations was selected at random from the ten year period, 1 January 1949 to 31 December 1958. The developmental sample from the first eight years contained 7668 observations, and the verification sample from the last two years contained 2332 observations.

Results

The four sets of predictors selected by MDA and REEP are shown in Tables 1A-5a to 1A-5d in addition to the REEP regression coefficients for each group of the predictand. The contingency tables (see Tables 1A-6a to 1A-6d) give the forecast-versus-observed frequencies for

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persistence, MDA, and REEP. The number of hits, the $\bar{P}$ scores, and the individual group contributions to the $\bar{P}$ score are also shown. Table 1A-7 summarizes the number of correct forecasts and the overall $\bar{P}$ scores.

Conclusions

1) In the Atlantic City experiment (Experiment 1) the selected predictors for REEP and MDA are both alike in numbers and in kind. However, in the Offutt experiment (Experiment 1A) this is not the case. There are many more predictors selected as significant in REEP. This is due to two adjustable factors introduced into the REEP computer program for the Offutt experiment but not for the Atlantic experiment.

The first of these is that in REEP each group can be assigned its own effective degrees of freedom determinable from a runs test, whereas MDA must use an average number (from previous studies determined empirically to be at about one-third the developmental sample size or roughly crediting only one observation a day as independent). Most of these additional selected predictors explain a significant amount of variability in the low ceiling and visibility categories.

Another adjustable factor is that of minimum frequency in the number of observations for a possible predictor (in our terminology "bit count"). In order for a predictor to be selected it must have been observed at least a minimum number of times in the developmental sample. This is an adjustable input parameter to the

program*. A more detailed discussion on its effects is given in a subsequent experiment. Suffice it to say that for larger values it selects more stable predictors with a tendency toward predictor selection to favor higher ceiling and visibility categories. An additional effect is that for larger values it would select fewer predictors thus offsetting some of the effects due to the degrees of freedom factor.

2) A summary of the results shows MDA with ten asterisks in its favor while REEP has eight. In almost every instance where an individual $\bar{P}$ score or the number of hits differ this difference is very small. We conclude that for all practical purposes MDA and REEP produce comparable results.

*The present MDA program now has this as an input parameter. At the time of the Atlantic City and Offutt comparisons it was not available.

Table 1A-1

Definition of Predictand Groups for Offutt AFB, Nebraska

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling < 300 ft
2	300 ft $\leq$ Ceiling < 1000 ft
3	1000 ft $\leq$ Ceiling < 1500 ft
4	1500 ft $\leq$ Ceiling < 5000 ft
5	5000 ft $\leq$ Ceiling

<u>Group Number</u>	<u>Visibility Intervals</u>
1	0 mi $\leq$ Visibility < 1 mi
2	1 mi $\leq$ Visibility < 3 mi
3	3 mi $\leq$ Visibility < 5 mi
4	5 mi $\leq$ Visibility

Table 1A-2

Specification of Predictands - Offutt AFB, Nebraska

		Predictand			
		1	2	3	4
Predictand variable		CIG	CIG	VIS	VIS
Forecast interval--hours (H)		3	7	3	7
Number of Groups (G)		5	5	4	4
Observations in Group 1 (n_1)		49	63	94	106
Observations in Group 2 (n_2)		373	379	212	213
Observations in Group 3 (n_3)		236	259	250	223
Observations in Group 4 (n_4)		959	920	7112	7126
Observations in Group 5 (n_5)		6051	6047	-	-
Total dependent sample size (N)		7668	7668	7668	7668
Number of independent observations in the dependent sample (n)		2256	2256	2256	2256
Degrees of Freedom for each group n_g ($g=1, \dots, G$)	Group 1	5400	5400	5500	5500
	Group 2	4600	4600	5800	5800
	Group 3	5800	5800	6300	6300
	Group 4	5200	5200	4400	4400
	Group 5	3500	3500	-	-
Total independent sample size (M)		2332	2332	2332	2332
Number of available predictors (P)		423	423	423	423

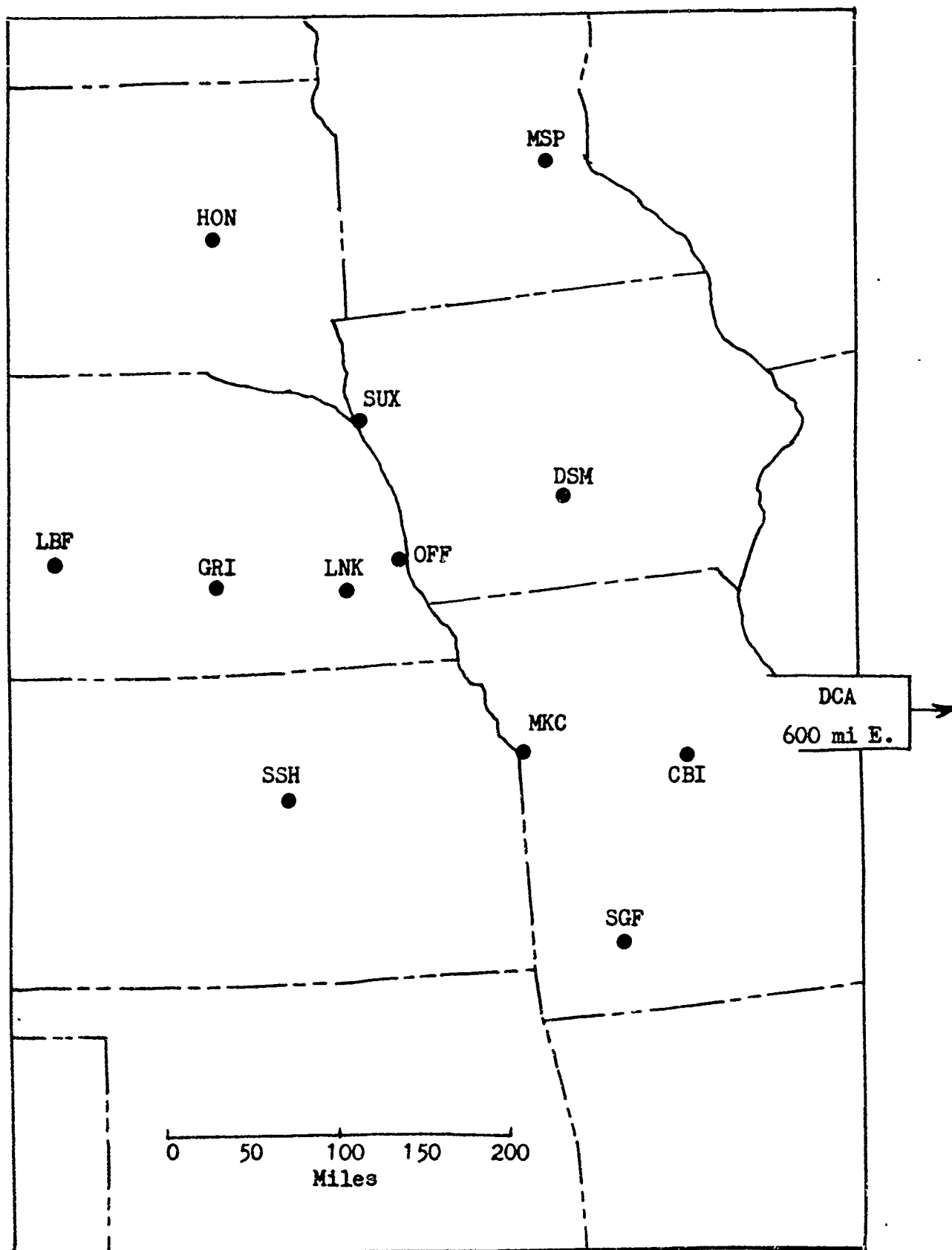


Figure 1A-1. Thirteen Station Network for Offutt AFB, Nebraska

Table 1A-3

Number of Possible Predictors for the
3- and 7-hr Ceiling and Visibility at OFF

Elem.	Station													Total
	OFF	GRI	SUX	DSM	MKC	SSH	LBF	HON	MSP	LNK	CBI	SGF	DCA	
TOD	5	-	-	-	-	-	-	-	-	-	-	-	-	5
DOY	1	-	-	-	-	-	-	-	-	-	-	-	-	1
CIG	15	5	5	5	5	5	5	5	5	5	5	5	-	70
VIS	14	4	4	4	4	4	4	4	4	4	4	4	-	58
WND	5	5	5	5	5	5	5	5	5	5	5	5	5	65
RLH	3	3	3	3	3	3	3	3	3	3	3	3	3	39
TCA	2	2	2	2	2	2	2	2	2	2	2	2	2	26
WEA	12	12	12	12	12	12	12	12	12	12	12	12	12	156
SCL	3	-	-	-	-	-	-	-	-	-	-	-	-	<u>3</u>
Total														423

Table 1A-4
Specifications and Limits of the Zero-One (Dummy) Variables for
Offutt AFB, Nebraska

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
<u>Time of Day:</u>		
TOD	5	(Same as for ACY - see Table 1-4)
<u>Day of Year:</u>		
DOY	1	(Same as for ACY - see Table 1-4)
<u>Wind:</u>		
WND	5	(Same as for ACY - see Table 1-4)
<u>Relative Humidity:</u>		
RLH	3	(Same as for ACY - see Table 1-4)
<u>Total Cloud Amount:</u>		
TCA	2	(Same as for ACY - see Table 1-4)
<u>Ceiling Height, ft:</u>		
CIG	5	1. 0 ≤ CIG < 300
		2. 300 ≤ CIG < 1000
		3. 1000 ≤ CIG < 1500
		4. 1500 ≤ CIG < 5000
		5. 5000 ≤ CIG
<u>Ceiling Height*, ft:</u>		
CIG	10	(1) CIG = 100
		(2) CIG = 200
		(3) CIG = 400
		(4) CIG = 500
		(5) CIG = 900

*Parentheses are used here to help distinguish the two forms of ceiling and visibility dummies.

Table 1A-4 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>Ceiling Height*, ft:</u>
		(6) 1500 ≤ CIG < 2000
		(7) 2500 ≤ CIG < 3000
		(8) 3000 ≤ CIG < 5000
		(9) 5000 ≤ CIG < 10,000
		(10) CIG = Unlimited
		<u>Visibility, mi:</u>
VIS	4	1. 0 ≤ VIS < 1
		2. 1 ≤ VIS < 3
		3. 3 ≤ VIS < 5
		4. 5 ≤ VIS
		<u>Visibility*, mi:</u>
VIS	10	(1) 1/4 ≤ VIS < 1/2
		(2) 1/2 ≤ VIS < 3/4
		(3) 3/4 ≤ VIS < 1
		(4) 1 ≤ VIS < 1-1/2
		(5) 1-1/2 ≤ VIS < 2
		(6) 2 ≤ VIS < 3
		(7) 3 ≤ VIS < 4
		(8) 4 ≤ VIS < 5
		(9) 5 ≤ VIS < 6
		(10) 15 ≤ VIS
		<u>Weather Element:</u>
WEA	12	(Same as for ACY - see Table 1-4)
		<u>Sky Condition, Lower:</u>
SCL	3	(Same as for ACY - see Table 1-4)

*Parentheses are used here to help distinguish the two forms of ceiling and visibility dummies.

Table 1A-5a

Selected Predictors and REEP Equations
Offutt AFB, Nebraska 3-hr Ceiling

Predictors Selected by MDA			The Coefficients of the REEP Equations					
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	OFF	CIG	5	-.413	-.123	.045	.135	.356
2	OFF	CIG	4	-.388	.192	.090	.060	.047
3	OFF	CIG	1	-.260	.145	.055	-.092	.153
4	SUX	CIG	5	-.018	-.090	.059	.106	-.057
5	LNK	CIG	5	-.003	-.118	-.057	-.054	.231
6	OFF	CIG	2	-.270	.260	.095	-.077	-.008
7	SUX	CIG	4	.021	.024	.009	-.018	-.036
8	GRI	CIG	5	-.273	.105	.237	-.005	-.065
9	LNK	CIG	1	-.262	.144	.088	.044	-.014
10	LNK	CIG	2	-.421	-.065	.198	.260	.028
11	DSM	WEA	4	-.416	-.141	.046	.455	.056
12	GRI	CIG	4	-.006	-.056	-.025	-.056	.143
13	LNK	CIG	5	.002	-.103	-.037	.100	.038
14	LNK	CIG	2	.030	.009	-.049	.043	-.033
15	LNK	CIG	3	-.008	-.098	.121	.004	-.019
16	DSM	WEA	5	.008	-.091	.073	.057	-.047
17	OFF	CIG	4	.000	.015	.016	.041	-.072
18	SSH	CIG	1	-.001	-.004	-.006	.065	-.055
19	DSM	CIG	4	-.006	-.068	-.027	.065	.035
20		WEA	2	-.016	.094	.019	-.018	-.079
21	SGF	CIG	1	-.010	.091	-.049	-.065	.033
22	DSM	CIG	2	-.011	.052	.018	-.013	-.045
23	DSM	WEA	9	.029	.004	.009	-.026	-.016
24	GRI	VIS	1	.038	-.002	.057	-.089	-.004
25	HON	WEA	9	.019	-.032	.064	-.040	-.011
26	OFF	CIG	(6)	-.000	.026	.065	-.057	-.033
27	LBF	CIG	5	.003	-.005	.015	-.056	.043
28	DSM	WEA	2	-.030	.046	-.011	.008	-.013
29	OFF	CIG	(8)	.003	.012	-.001	-.102	.087
30	SSH	WEA	9	.004	.061	-.018	-.027	-.020
Additive Constant:				.671	.247	-.107	.082	.107

Table 1A-5b

Selected Predictors and REEP Equations
Offutt AFB, Nebraska 7-hr Ceiling

Predictors Selected by MDA				Predictors Selected by REEP				The Coefficients of the REEP Equations				
Order	Station	Element	Dummy	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅	
1	LNK	CIG	5	LNK	CIG	5	.013	-.021	-.036	-.045	.090	
2	SUX	CIG	5	SUX	CIG	5	-.021	-.123	-.037	.030	.152	
3	LNK	WEA	9	OFF	CIG	2	-.025	.090	.034	-.065	-.034	
4	GRI	CIG	5	GRI	CIG	5	-.136	.097	-.078	-.103	.219	
5	SUX	CIG	4	DSM	WEA	9	.023	.024	-.016	-.007	-.025	
6	OFF	CIG	1	GRI	CIG	2	-.135	.199	-.034	-.037	.006	
7	HON	TCA	2	OFF	SCL	1	.081	-.022	-.045	-.013	-.001	
8	DSM	FLH	3	HON	TCA	2	-.001	.006	.012	.047	-.063	
9	GRI	CIG	4	LNK	WEA	9	.050	.079	-.063	-.090	.025	
10	OFF	TCA	2	SSH	CIG	2	-.020	.106	-.014	-.014	-.058	
11	GRI	CIG	1	SUX	CIG	4	-.019	-.100	-.013	.110	.021	
12	SSH	CIG	2	DSM	WEA	5	-.015	-.048	-.001	.165	-.102	
13	CBI	WEA	9	CBI	WEA	9	.039	-.019	.029	-.021	-.028	
14	OFF	CIG	2	OFF	TCA	2	.004	.004	.017	.070	-.095	
15	HON	CIG	5	GRI	VIS	1	.012	.092	.008	-.113	.001	
16	OFF	TOD	3	MSP	CIG	2	.039	-.002	.006	-.000	-.043	
17	DSM	WEA	5	GRI	CIG	4	-.138	.081	-.079	.058	.077	
18				GRI	CIG	3	-.142	.096	.007	-.009	.048	
19				HON	CIG	5	-.003	-.006	-.009	-.074	.092	
20				MKG	CIG	4	-.001	-.013	-.003	.072	-.055	
21				OFF	TOD	3	-.009	-.032	-.010	.020	.031	
22				DSM	VIS	2	.034	-.018	-.036	.023	-.003	
23				LNK	WEA	2	.002	.112	-.029	-.016	-.069	
24				SUX	CIG	3	-.014	-.010	.077	.047	-.100	
25				LEF	CIG	5	.001	-.014	-.010	-.059	.082	
26				MKG	WEA	9	.035	.003	.015	-.037	-.015	
27				DSM	WND	3	.001	.029	-.002	.007	-.034	
28				OFF	CIG	3	-.024	.009	.062	-.007	-.040	

Table 1A-5b - Continued

Predictors Selected by MDA				Predictors Selected by REEP				The Coefficients of the REEP Equations				
Order	Station	Element	Dummy	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅	
29	CBI	WEA	1	WEA			.003	-.041	-.000	.013	.024	
30	LNK	VIS	3	VIS			-.040	-.005	.058	.050	-.063	
31	OFF	VIS	3	VIS			.067	.014	.003	.012	-.097	
32	OFF	VIS	(8)	VIS			-.062	.003	.004	.003	.053	
33	MSP	WEA	1	WEA			.004	-.004	.006	-.050	.044	
34	GRI	VIS	2	VIS			.002	.095	-.012	-.079	-.005	
35	DSM	RLH	3	RLH			.009	.055	.022	-.014	-.072	
36	CBI	CIG	1	CIG			-.044	.002	-.008	.003	.047	
Additive Constant:							.141	.111	.166	.295	.288	

Table 1A-5c
Selected Predictors and REEP Equations
Offutt AFB, Nebraska 3-hr Visibility

Predictors Selected by MDA					Predictors Selected by REEP					The Coefficients of the REEP Equations			
Order	Station	Element	Dummy		Station	Element	Dummy		A ₁	A ₂	A ₃	A ₄	
1	OFF	VIS	4		OFF	VIS	4		.005	-.096	-.228	.319	
2	OFF	CIG	1		OFF	VIS	1		.235	.014	-.178	-.071	
3	GRI	VIS	4		LNK	WEA	1		-.011	-.016	-.035	.062	
4	SUX	VIS	4		SUX	VIS	4		-.004	-.075	-.041	.120	
5	OFF	VIS	3		GRI	VIS	4		-.015	-.048	-.011	.074	
6	SSH	CIG	1		OFF	VIS	2		.045	.149	-.163	-.032	
7	LNK	WEA	1		OFF	VIS	(9)		-.013	.019	.126	-.132	
8	LNK	VIS	1		GRI	VIS	1		.093	-.069	.034	-.058	
9	OFF	VIS	1		MKC	WEA	9		.016	.039	.025	-.080	
10	SSH	WEA	8		OFF	SCL	1		.119	-.135	-.003	.018	
11	OFF	VIS	(9)		LNK	VIS	2		-.023	.098	-.019	-.056	
12	CBI	WEA	9		OFF	WEA	9		.056	-.007	-.033	-.016	
13	OFF	VIS	(2)		OFF	CIG	2		-.054	.032	-.003	.025	
14	DSM	CIG	1		SUX	WEA	9		.052	.001	.015	-.067	
15	GRI	WEA	5		CRI	WEA	5		.029	.067	.042	-.138	
16	OFF	VIS	(3)		SUX	WEA	2		-.060	-.003	.002	.060	
17	OFF	VIS	(1)		CBI	WEA	2		.043	.021	-.000	-.064	
18	LNK	WEA	9		LNK	CIG	2		-.020	.014	.076	-.070	
19	GRI	VIS	1		OFF	WEA	5		-.046	-.014	-.007	.067	
20					SSH	RLH	3		.031	.029	-.013	-.048	
21					OFF	TOD	3		-.009	-.009	-.011	.029	
22					MSP	WEA	9		.009	.018	.031	-.059	
23					LNK	WEA	2		.017	-.052	.081	-.046	
24					LNK	RLH	3		-.006	.045	.001	-.040	
25					DSM	VIS	2		.042	-.048	-.013	.019	
26					LEF	VIS	3		-.007	.067	-.028	-.032	
27					DSM	WEA	5		-.035	.025	.021	-.011	
28					SGF	CIG	1		.021	.064	-.057	-.028	
29					OFF	RLH	2		.002	.005	.027	-.034	
Additive Constant:									.026	.235	.322	.417	

Table 1A-5d

Selected Predictors and REEP Equations
Offutt AFB, Nebraska 7-hr Visibility

Order	Predictors Selected by MDA			Predictors Selected by REEP			The Coefficient of the REEP Equations			
	Station	Element	Dummy	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄
1	OFF	VIS	4	OFF	VIS	4	-.036	-.034	-.044	.114
2	GRI	VIS	4	GRI	VIS	4	-.070	-.083	-.009	.163
3	SUX	WEA	1	SUX	WEA	1	-.001	-.047	-.034	.082
4	DSM	WEA	9	DSM	WEA	9	.052	.012	.018	-.081
5	LNK	VIS	1	OFF	SCL	1	.086	-.025	-.067	.006
6	LBF	WEA	5	LBF	WEA	5	.042	.068	.002	-.113
7	SSH	CIG	1	SUX	WEA	9	.010	.082	.028	-.121
8	SUX	WEA	9	GRI	VIS	3	-.081	-.019	.014	.085
9	SSH	RLH	2	MKC	WEA	9	.041	-.031	.015	-.025
10				LNK	TCA	2	-.007	-.001	.026	-.019
11				MSP	CIG	2	.044	-.010	-.013	-.021
12				SGF	VIS	4	.009	-.040	-.007	.038
13				OFF	TOD	3	-.009	-.016	-.018	.043
14				LNK	CIG	2	-.037	.066	.022	-.051
15				SSH	RLH	3	.040	.050	-.035	-.056
16				SSH	RLH	2	.004	.029	.024	-.057
17				DSM	WEA	2	-.048	-.029	.001	.076
18				SUX	VIS	2	.036	-.016	.073	-.093
19				SUX	RLH	3	.024	-.050	-.013	.038
20				DSM	WEA	12	.016	.033	.040	-.089
21				LNK	WEA	2	-.040	.001	.007	-.039
22				LBF	CIG	2	-.018	.043	.017	-.042
23				LNK	WND	5	-.013	-.011	-.005	.030
24				CBI	VIS	2	.039	.010	-.021	-.028
Additive Constant:							.104	.212	.106	.577

Table 1A-6a

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, MDA, and REEP

OFF 3-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	9	6	0	0	3	18
	2	4	64	22	19	8	117
	3	3	20	18	21	8	70
	4	0	21	16	199	119	355
	5	1	11	16	122	1622	1772
	Total	17	122	72	361	1760	2332
Hits = 1912 $\bar{P} = .2664$							
	$\bar{P}_g$	.0053	.0338	.0270	.1000	.1003	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
MDA	1	9	7	0	0	3	19
	2	5	75	32	21	7	140
	3	0	7	7	7	2	23
	4	0	22	15	183	70	290
	5	3	11	18	150	1678	1860
	Total	17	122	72	361	1760	2332
Hits = 1952 $\bar{P} = .2369$							
	$\bar{P}_g$	.0054	.0310	.0271	.0888	.0845	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP	1	6	5	0	0	2	13
	2	5	74	30	22	5	136
	3	0	6	5	3	1	15
	4	0	23	16	177	62	278
	5	6	14	21	159	1690	1890
	Total	17	122	72	361	1760	2332
Hits = 1952 $\bar{P} = .2368$							
	$\bar{P}_g$	.0057	.0304	.0265	.0897	.0845	

Table 1A-6b

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, MDA, and REEP

OFF 7-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	4	7	0	2	5	18
	2	3	45	20	28	21	117
	3	3	16	10	20	21	70
	4	0	26	21	134	174	355
	5	6	23	25	170	1548	1772
	Total	16	117	76	354	1769	2332
Hits = 1741 $\bar{P} = .3319$							
	$\bar{P}_g$	.0065	.0392	.0301	.1185	.1376	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
MDA	1	1	2	0	0	1	4
	2	7	57	28	41	20	153
	3	1	0	1	1	1	4
	4	0	27	17	94	53	191
	5	7	31	30	218	1694	1980
	Total	16	117	76	354	1769	2332
Hits = 1847 $\bar{P} = .2906$							
	$\bar{P}_g$	.0065	.0369	.0298	.1090	.1084	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP	1	1	0	0	1	2	4
	2	6	50	19	28	11	114
	3	0	2	1	0	0	3
	4	1	29	20	82	44	176
	5	8	36	36	243	1712	2035
	Total	16	117	76	354	1769	2332
Hits = 1846 $\bar{P} = .2890$							
	$\bar{P}_g$	.0069	.0352	.0285	.1095	.1089	

Table 1A-6c

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, MDA, and REEP

OFF 3-hr Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>				<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
PERSISTENCE	1	24	11	7	6	48
	2	12	18	16	17	63
	3	4	14	18	32	68
	4	6	20	39	2088	2153
	Total	46	63	80	2143	2332
Hits = 2148 $\bar{P} = .1093$						
	$\bar{P}_g$	.0140	.0227	.0300	.0425	

	<u>Group</u>	<u>Actual</u>				<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
MDA	1	13	5	3	3	24
	2	15	23	14	8	60
	3	3	7	6	8	24
	4	15	28	57	2124	2224
	Total	46	63	80	2143	2332
Hits = 2166 $\bar{P} = .0996$						
	$\bar{P}_g$	.0138	.0214	.0286	.0358	

	<u>Group</u>	<u>Actual</u>				<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
REEP	1	17	9	5	3	34
	2	9	17	11	4	41
	3	2	5	7	6	20
	4	18	32	57	2130	2237
	Total	46	63	80	2143	2332
Hits = 2171 $\bar{P} = .1007$						
	$\bar{P}_g$	.0141	.0216	.0287	.0363	

Table 1A-6d

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, MDA, and REEP

OFF 7-hr Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>				<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
PERSISTENCE	1	14	8	5	21	48
	2	8	8	13	34	63
	3	6	9	17	36	68
	4	20	40	60	2033	2153
	Total	48	65	95	2124	2332
Hits = 2072 $\bar{P} = .1504$						
	$\bar{P}_g$	.0183	.0261	.0374	.0686	

	<u>Group</u>	<u>Actual</u>				<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
MDA	1	5	3	4	3	15
	2	6	5	9	9	29
	3	0	0	0	0	0
	4	37	57	82	2112	2288
	Total	48	65	95	2124	2332
Hits = 2122 $\bar{P} = .1411$						
	$\bar{P}_g$	.0184	.0256	.0372	.0600	

	<u>Group</u>	<u>Actual</u>				<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
REEP	1	2	1	1	5	9
	2	7	4	5	4	20
	3	0	0	0	0	0
	4	39	60	89	2115	2303
	Total	48	65	95	2124	2332
Hits = 2121 $\bar{P} = .1402$						
	$\bar{P}_g$	.0181	.0255	.0368	.0598	

Table 1A-7

Comparison Between Persistence, MDA, and REEP

(Independent Sample - 2332 Observations)

Offutt AFB, Ceiling 3 Hours in Advance

Hits	Persistence	1912
	MDA	1952*
	REEP	1952*
$\bar{P}$ Score	Persistence	.2664
	MDA	.2369
	REEP	.2368*

Offutt AFB, Ceiling 7 Hours in Advance

Hits	Persistence	1741
	MDA	1847*
	REEP	1846
$\bar{P}$ Score	Persistence	.3319
	MDA	.2906
	REEP	.2890*

Offutt AFB, Visibility 3 Hours in Advance

Hits	Persistence	2148
	MDA	2166
	REEP	2171*
$\bar{P}$ Score	Persistence	.1093
	MDA	.0996*
	REEP	.1007

Offutt AFB, Visibility 7 Hours in Advance

Hits	Persistence	2072
	MDA	2122*
	REEP	2121
$\bar{P}$ Score	Persistence	.1504
	MDA	.1411
	REEP	.1402*

Asterisks are used to denote superiority.

Purpose

A test to compare the results obtained when the predictor variables are in raw dummy form to those obtained when the predictor dummies are in cumulative form.

Predictands

Predictands used in this experiment were the Atlantic City ceilings for periods of 2, 5, and 7 hours in advance. These three predictands were divided into five intervals according to the operationally significant categories of ceiling, as shown in Table 2-1. Specifications for each predictand are shown in Table 2-2.

Predictors

Seven meteorological elements at ten predictor stations (see Figure 2-1) plus the time of day (TOD) and day of year (DOY) variables were transformed into dummy variables by dividing each predictor element into a number of intervals or categories (Table 2-3).

Data Sample

The data used for this experiment is the same as was used for Experiment No. 1, consisting of 10,000 observations selected randomly from the ten-year period from 1 January 1949 to 31 December 1958. The developmental sample consists of 7956 observations from the first eight years and the verification or independent sample contains 2044 observations from the last two years.

The set of 450 standard form dummy predictors are shown in Table 2-3. Table 2-4 tabulates the cumulative dummy predictors. Table 2-5 gives the specifications and limits of the dummy variables when used in the standard form and Table 2-6 gives similar information when the predictors are in the cumulative dummy form. Predictions using REEP were made for Atlantic City ceiling at 2, 5, and 7 hours in advance using the standard dummies and the cumulative dummies separately.

Results

The dummy predictors selected by REEP are shown in Tables 2-7a to 2-7f, as well as the REEP regression equation coefficients for each group of the predictand. Results of the forecasts using the two sets of predictors are shown in the contingency tables (Tables 2-8a to 2-8c) for the independent sample. Also shown are the results using persistence. The number of correct forecasts (hits), the Brier and Allen $\bar{P}$ scores, and the individual group contributions to the overall $\bar{P}$ score are given below each contingency table. The number of hits and overall $\bar{P}$ scores are summarized in Table 2-9.

Conclusions

From these limited results there does not appear to be any reason to prefer one form of dummy variables over the other.

Definition of Predictand Groups for Atlantic City Municipal Airport

Group Number

1	$0 \text{ ft} \leq \text{Ceiling} < 200 \text{ ft}$
2	$200 \text{ ft} \leq \text{Ceiling} < 500 \text{ ft}$
3	$500 \text{ ft} \leq \text{Ceiling} < 1000 \text{ ft}$
4	$1000 \text{ ft} \leq \text{Ceiling} < 3000 \text{ ft}$
5	$3000 \text{ ft} \leq \text{Ceiling}$

Table 2-2

Specification of Predictands
Atlantic City Municipal Airport

	Predictand		
	1	2	3
Predictand variable	CIG	CIG	CIG
Forecast interval--hours (H)	2	5	7
Number of Groups (G)	5	5	5
Observations in Group 1 (n_1)	116	128	135
Observations in Group 2 (n_2)	263	259	272
Observations in Group 3 (n_3)	395	426	420
Observations in Group 4 (n_4)	656	631	619
Observations in Group 5 (n_5)	6526	6512	6510
Total dependent sample size (N)	7956	7956	7956
Number of independent observations in the dependent sample (n)	2652	2652	2652
Total independent sample size (M)	2044	2044	2044
Number of available predictors (P)	378	378	378

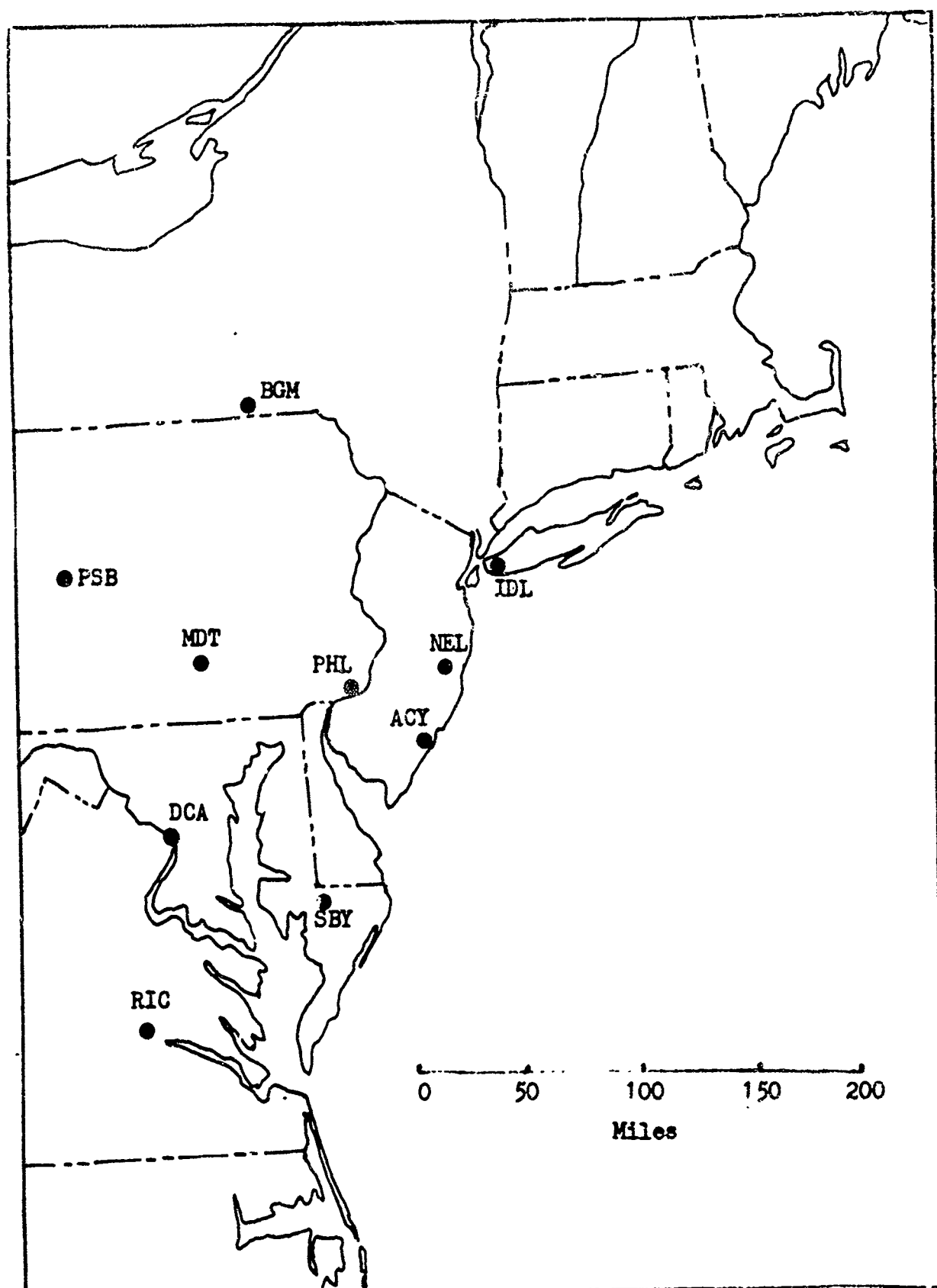


Figure 2-1. Ten Station Network for Atlantic City Municipal Airport

Table 2-3

Number of Possible Predictors When Used in Standard Form

Elem.	Station										Total
	ACY	NEL	PHL	SBY	MDT	DCA	PSE	BGM	RIC	IDL	
TOD	1	-	-	-	-	-	-	-	-	-	1
DOY	1	-	-	-	-	-	-	-	-	-	1
CIG	24	5	5	5	5	5	5	5	5	5	69
VIS	24	5	5	5	5	5	5	5	5	5	69
UWC	5	5	5	5	5	5	5	5	5	5	50
VWC	5	5	5	5	5	5	5	5	5	5	50
RLH	5	5	5	5	5	5	5	5	5	5	50
TCA	4	4	4	4	4	4	4	4	4	4	40
WEA	12	12	12	12	12	12	12	12	12	12	<u>120</u>
Total											450

Table 2-4

Number of Possible Predictors When Used in Cumulative Form

<u>Elem.</u>	<u>Station</u>										<u>Total</u>
	<u>ACY</u>	<u>NEL</u>	<u>PHL</u>	<u>SBY</u>	<u>MDT</u>	<u>DCA</u>	<u>PSB</u>	<u>BGM</u>	<u>RIC</u>	<u>IDL</u>	
TOD	1	-	-	-	-	-	-	-	-	-	1
DOY	1	-	-	-	-	-	-	-	-	-	1
CIG	22	4	4	4	4	4	4	4	4	4	58
VIS	22	4	4	4	4	4	4	4	4	4	58
UWC	4	4	4	4	4	4	4	4	4	4	40
VWC	4	4	4	4	4	4	4	4	4	4	40
RLH	4	4	4	4	4	4	4	4	4	4	40
TCA	3	3	3	3	3	3	3	3	3	3	30
WEA	11	11	11	11	11	11	11	11	11	11	<u>110</u>
Total											378

Table 2-5

Specifications and Limits of the Zero-One (Dummy) Variables
Used in the Standard Dummy Form

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>Time of Day:</u>
TOD	1	1. 0130 EST to 1330 EST
		<u>Day of Year:</u>
DOY	1	1. From 151 (31 May) to 300 (27 Oct)
		<u>Ceiling Height, ft:</u>
CIG*	5	1. $0 \leq \text{CIG} < 200$
		2. $200 \leq \text{CIG} < 500$
		3. $500 \leq \text{CIG} < 1000$
		4. $1000 \leq \text{CIG} < 3000$
		5. $3000 \leq \text{CIG}$
	19	(1) CIG = 0
		(2) CIG = 100
		(3) CIG = 200
		(4) CIG = 300
		(5) CIG = 400
		(6) CIG = 500
		(7) CIG = 600
		(8) CIG = 700
		(9) CIG = 800
		(10) CIG = 900
		(11) $1000 \leq \text{CIG} < 1500$
		(12) $1500 \leq \text{CIG} < 2000$
		(13) $2000 \leq \text{CIG} < 2500$
		(14) $2500 \leq \text{CIG} < 3000$
		(15) $3000 \leq \text{CIG} < 5000$
		(16) $5000 \leq \text{CIG} < 10,000$

*The predictand station (ACY) has ceiling and visibility dummied in two ways. Parentheses are used to identify the second set of dummies.

Table 2-5 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>Ceiling Height, ft:</u>
		(17) $10,000 \leq \text{CIG} < 20,000$
		(18) $20,000 \leq \text{CIG} < \text{Unlimited}$
		(19) $\text{CIG} = \text{Unlimited}$
		<u>Visibility, mi:</u>
VIS*	5	1. $0 \leq \text{VIS} < 1/2$
		2. $1/2 \leq \text{VIS} < 1$
		3. $1 \leq \text{VIS} < 2$
		4. $2 \leq \text{VIS} < 3$
		5. $3 \leq \text{VIS}$
	19	(1) $0 \leq \text{VIS} < 1/16$
		(2) $1/16 \leq \text{VIS} < 1/8$
		(3) $1/8 \leq \text{VIS} < 1/4$
		(4) $1/4 \leq \text{VIS} < 1/2$
		(5) $1/2 \leq \text{VIS} < 3/4$
		(6) $3/4 \leq \text{VIS} < 1$
		(7) $1 \leq \text{VIS} < 1-1/2$
		(8) $1-1/2 \leq \text{VIS} < 2$
		(9) $2 \leq \text{VIS} < 3$
		(10) $3 \leq \text{VIS} < 4$
		(11) $4 \leq \text{VIS} < 5$
		(12) $5 \leq \text{VIS} < 6$
		(13) $6 \leq \text{VIS} < 7$
		(14) $7 \leq \text{VIS} < 8$
		(15) $8 \leq \text{VIS} < 9$
		(16) $9 \leq \text{VIS} < 10$
		(17) $10 \leq \text{VIS} < 11$

*The predictand station (ACY) has ceiling and visibility dummies in two ways. Parentheses are used to identify the second set of dummies.

Table 2-5 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>Visibility, mi:</u>
		(18) $11 \leq \text{VIS} < 15$
		(19) $15 \leq \text{VIS}$
		<u>"U" Wind Component (East-West Comp.):</u>
UWC	5	1. $\text{UWC} \leq -15$
		2. $-15 < \text{UWC} \leq -5$
		3. $-5 < \text{UWC} \leq 5$
		4. $5 < \text{UWC} \leq 15$
		5. $15 < \text{UWC}$
		<u>"V" Wind Component (North-South Comp.):</u>
VWC	5	1. $\text{VWC} \leq -15$
		2. $-15 < \text{VWC} \leq -5$
		3. $-5 < \text{VWC} \leq 5$
		4. $5 < \text{VWC} \leq 15$
		5. $15 < \text{VWC}$
		<u>Relative Humidity, per cent:</u>
RLH	5	1. $\text{RLH} \leq 50$
		2. $50 < \text{RLH} \leq 75$
		3. $75 < \text{RLH} \leq 90$
		4. $90 < \text{RLH} \leq 99$
		5. $99 < \text{RLH}$
		<u>Total Cloud Amount:</u>
TCA	4	1. $\text{TCA} < 1/10$
		2. $1/10 \leq \text{TCA} \leq 5/10$
		3. $5/10 < \text{TCA} \leq 9/10$
		4. $9/10 < \text{TCA}$

Table 2-5 - Continued

<u>Meteorological Element</u>	<u>Number of Dumrales</u>	<u>Limits of Each Category</u>	<u>Teletype Code:</u>
WEA	12	<u>Weather Element:</u>	
		1. No Weather	
		2. Rain	R-, R, R+
		3. Rain Showers	RW-, RW, RW+
		4. Drizzle or Freezing Drizzle	L-, L, L+ ZL-, ZL, ZL+
		5. Snow Snow Pellets Snow Grains Ice Crystals	S-, S, S+ SP-, SP, SP+ SG-, SG, SG+ IC-, IC, IC+
		6. Snow Showers Snow Squalls	SW-, SW, SW+ SQ-, SQ, SQ+
		7. Tornado Thunderstorm Squalls Hail Hail Pellets	Tornado T, T+ Q-, Q, Q+ A-, A, A+ AP-, AP, AP+
		8. Freezing Rain Sleet Sleet Showers	ZR-, ZR, ZR+ E-, E, E+ EW-, EW, EW+
		9. Fog, Ice Fog	F, IF
		10. Ground Fog	GF
		11. Blowing Snow Blowing Sand Blowing Dust	BS BN BD
		12. Smoke, Haze, Dust	K, H, D

Table 2-6

Specifications and Limits of the Zero-One (Dummy) Variables
Used in the Cumulative Dummy Form

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>Time of Day</u>
TOD	1	1. 0130 EST to 1330 EST
		<u>Day of Year</u>
DOY	1	1. From 151 (31 May) to 300 (27 Oct)
		<u>Ceiling Height, ft:</u>
CIG*	4	1. CIG < 200 2. CIG < 500 3. CIG < 1000 4. CIG < 3000
	18	(1) CIG = 0 (2) CIG ≤ 100 (3) CIG ≤ 200 (4) CIG ≤ 300 (5) CIG ≤ 400 (6) CIG ≤ 500 (7) CIG ≤ 600 (8) CIG ≤ 700 (9) CIG ≤ 800 (10) CIG ≤ 900 (11) CIG < 1500 (12) CIG < 2000 (13) CIG < 2500 (14) CIG < 3000 (15) CIG < 5000

*The predictand station (ACY) has ceiling and visibility dummied in two ways. Parentheses are used to identify the second set of dummies.

Table 2-6 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>Ceiling Height, ft:</u>
		(16) CIG < 10,000
		(17) CIG < 20,000
		(18) CIG < Unlimited
		<u>Visibility, mi:</u>
VIS*	4	1. VIS < 1/2
		2. VIS < 1
		3. VIS < 2
		4. VIS < 3
	18	(1) VIS < 1/16
		(2) VIS < 1/8
		(3) VIS < 1/4
		(4) VIS < 1/2
		(5) VIS < 3/4
		(6) VIS < 1
		(7) VIS < 1-1/2
		(8) VIS < 2
		(9) VIS < 3
		(10) VIS < 4
		(11) VIS < 5
		(12) VIS < 6
		(13) VIS < 7
		(14) VIS < 8
		(15) VIS < 9
		(16) VIS < 10
		(17) VIS < 11
		(18) VIS < 15

*The predictand station (ACY) has ceiling and visibility dummied in two ways. Parentheses are used to identify the second set of dummies.

Table 2-6 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>
		<u>"U" Wind Component (East-West Comp.):</u>
UWC	4	1. UWC $\leq$ -15 2. UWC $\leq$ - 5 3. UWC $\leq$ 5 4. UWC $\leq$ 15
		<u>"V" Wind Component (North-South Comp.):</u>
VWC	4	1. VWC $\leq$ -15 2. VWC $\leq$ - 5 3. VWC $\leq$ 5 4. VWC $\leq$ 15
		<u>Relative Humidity, per cent:</u>
RLH	4	1. RLH $\leq$ 50 2. RLH $\leq$ 75 3. RLH $\leq$ 90 4. RLH $\leq$ 99
		<u>Total Cloud Amount:</u>
TCA	3	1. TCA $<$ 1/10 2. TCA $\leq$ 5/10 3. TCA $\leq$ 9/10

Table 2-6 - Continued

<u>Meteorological Element</u>	<u>Number of Dummies</u>	<u>Limits of Each Category</u>	<u>Teletype Code</u>
WEA	11	<u>Weather Element:</u> 1. No Weather 2. Rain 3. Rain, Rain Showers 4. Rain, Rain Showers Freezing Rain, Sleet Sleet Showers 5. Drizzle Freezing Drizzle 6. Snow Snow Pellets Snow Grains Ice Crystals 7. Snow Snow Pellets Snow Grains Ice Crystals Snow Showers Snow Squalls 8. Tornado Thunderstorm Squalls Hail Hail Pellets 9. Fog, Ice Fog 10. Fog, Ice Fog Ground Fog 11. Smoke, Haze, Dust	(See Table 2-5)

Table 2-7a

Selected Predictors and REEP Equations
ACY 2-hr Ceiling - Standard Dummies*

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy*	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	5	-.006	.013	-.016	-.349	.358
2	ACY	CIG	1	.294	.267	-.089	-.415	-.057
3	ACY	CIG	2	.027	.402	.001	-.395	-.035
4	PHL	CIG	5	.012	-.026	-.071	-.112	.198
5	ACY	CIG	3	.002	.081	.283	-.347	-.019
6	SBY	CIG	5	.000	-.069	-.053	.001	.121
7	NEL	TCA	4	.000	.001	.010	.044	-.055
8	ACY	CIG	(1)	.240	-.147	-.001	.008	-.100
9	NEL	CIG	3	-.064	-.050	.092	.044	-.022
10	ACY	VIS	5	-.036	-.011	-.023	.030	.041
11	DCA	CIG	2	.095	-.004	-.088	.029	-.032
12	NEL	CIG	4	-.058	-.048	-.024	.144	-.013
13	NEL	CIG	5	-.063	-.038	-.036	.063	.074
14	DCA	CIG	5	.006	-.015	-.024	-.039	.071
15	BGM	WEA	8	.146	-.104	-.056	-.024	.038
16	PHL	WEA	2	-.023	.063	.046	-.003	-.083
17	DCA	VIS	1	.148	-.072	-.051	-.022	-.003
18	SBY	CIG	4	-.007	-.068	-.058	.108	.025
19	PHL	UWC	2	-.000	.021	.016	.026	-.064
20	ACY	VIS	(5)	.103	-.035	-.011	-.055	-.002
Additive Constant:				.089	.143	.221	.413	.134

*Refer to Table 2-5.

Table 2-7b

Selected Predictors and REEP Equations
ACY 2-hr Ceiling - Cumulative Dummies*

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy*	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	4	.009	-.012	-.005	.301	-.292
2	ACY	CIG	1	.232	-.109	-.072	-.036	-.015
3	ACY	CIG	2	.036	.313	-.272	-.051	-.026
4	PHL	CIG	4	-.011	.024	.073	.125	-.211
5	ACY	CIG	3	.010	.083	.269	-.401	.038
6	SBY	CIG	4	-.008	.001	-.006	.111	-.098
7	ACY	VIS	(5)	.098	-.104	-.003	.024	-.015
8	NEL	TCA	3	-.002	.001	-.008	-.053	.063
9	DCA	CIG	2	.103	-.033	-.074	.006	-.002
10	ACY	CIG	(1)	.208	-.129	.008	.009	-.097
11	NEL	CIG	3	-.000	-.007	.117	-.067	-.044
12	IDL	UWC	2	.009	.009	.028	.014	-.059
13	SBY	CIG	3	.000	.069	.075	-.115	-.029
14	ACY	CIG	(12)	-.002	-.006	.038	.127	-.157
15	ACY	RLH	4	.009	-.064	-.001	.060	-.003
16	DCA	CIG	4	-.007	.017	.023	.042	-.076
17	NEL	CIG	2	.057	.057	-.079	-.037	.002
18	SBY	VIS	2	.056	.017	-.075	.002	-.001
19	PHL	WEA	4	-.006	.032	.035	.017	-.078
Additive Constant:				-.006	.061	.007	.001	.937

*Refer to Table 2-6.

Table 2-7c

Selected Predictors and REEP Equations
ACY 5-hr Ceiling - Standard Dummies*

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy*	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACI	CIG	5	-.003	-.002	-.006	-.154	.166
2	DCA	CIG	5	-.026	-.107	-.032	.018	.147
3	PHL	CIG	5	.001	-.024	-.045	-.070	.139
4	ACY	CIG	1	.183	.078	.092	-.229	-.124
5	PHL	UWC	2	-.000	.044	.043	.032	-.119
6	ACY	CIG	2	.045	.168	.048	-.266	.005
7	MDT	TCA	4	-.003	.013	.016	.052	-.078
8	SBY	CIG	5	-.004	.010	-.031	-.075	.100
9	DCA	CIG	4	-.028	-.102	.011	.105	.014
10	MDT	WEA	2	-.011	.042	.101	-.027	-.105
11	ACY	TOD	1	-.027	-.014	.002	.032	.007
12	ACY	CIG	3	.008	.055	.108	-.143	-.028
13	ACY	VIS	5	-.050	.017	-.005	-.018	.056
14	IDL	CIG	5	-.012	-.009	-.030	-.035	.086
15	SBY	WEA	9	.002	.068	.046	-.022	-.094
16	IDL	UWC	2	.005	.008	.040	.026	-.080
Additive Constant:				.111	.117	.143	.330	.298

*Refer to Table 2-5.

Table 2-7d

Selected Predictors and REEP Equations
ACY 5-hr Ceiling - Cumulative Dummies*

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy*	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	(13)	.002	.004	.021	.156	-.182
2	DCA	CIG	4	-.002	.004	.040	.089	-.131
3	PHL	CIG	4	.000	.025	.044	.075	-.144
4	ACY	CIG	(3)	.122	-.110	.010	.003	-.025
5	PHL	UWC	2	-.000	.040	.051	.029	-.120
6	ACY	CIG	2	.024	.137	-.049	-.109	-.004
7	MDT	TCA	3	.004	-.014	-.015	-.051	.075
8	SBY	CIG	4	.005	-.012	.027	.079	-.100
9	IDL	RLH	2	-.012	-.004	-.020	-.034	.070
10	DCA	CIG	3	.026	.105	-.009	-.103	-.019
11	MDT	WEA	2	-.012	.038	.095	-.032	-.089
12	ACY	TOD	1	-.026	-.014	.003	.032	.005
13	ACY	CIG	3	.010	.053	.102	-.148	-.018
14	SBY	WEA	9	.001	.068	.044	-.026	-.087
15	IDL	UWC	2	.006	.013	.037	.025	-.081
16	ACY	VIS	4	.045	-.013	.002	.011	-.044
Additive Constant:				.022	.018	.024	.074	.862

*Refer to Table 2-6.

Table 2-7e

Selected Predictors and REEP Equations
ACY 7-hr Ceiling - Standard Dummies*

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy*	A ₁	A ₂	A ₃	A ₄	A ₅
1	PHL	CIG	5	.004	-.035	-.046	-.078	.155
2	DCA	CIG	5	-.010	-.012	-.040	-.061	.122
3	ACY	CIG	5	-.017	-.030	-.042	-.076	.165
4	PHL	UWC	2	.003	.025	.057	.042	-.132
5	MDT	TCA	4	-.001	.013	.020	.051	-.084
6	DCA	WEA	2	-.003	.056	.125	-.038	-.139
7	ACY	VIS	5	-.044	-.001	.007	.020	.019
8	PSB	WEA	8	-.020	.248	-.095	-.047	-.086
9	ACY	TOD	1	-.028	-.019	-.009	.024	.031
10	RIC	RLH	4	-.005	.014	.032	.040	-.081
11	NEL	WEA	9	.018	.019	.062	.013	-.112
12	IDL	UWC	2	.011	.017	.035	.020	-.082
13	ACY	CIG	2	.025	.101	.003	-.132	.003
14	ACY	CIG	(1)	.155	-.010	-.015	.006	-.135
15	DCA	CIG	3	-.004	.093	.007	-.051	-.045
16	NEL	UWC	4	-.005	-.010	-.011	-.028	.054
Additive Constant:				.087	.087	.124	.212	.491

*Refer to Table 2-5.

Table 2-7f

Selected Predictors and REEP Equations
ACY 7-hr Ceiling = Cumulative Dummies*

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy*	A ₁	A ₂	A ₃	A ₄	A ₅
1	PHL	CIG	4	-.004	.025	.047	.082	-.151
2	DCA	CIG	4	.001	-.002	.039	.084	-.123
3	ACY	CIG	(13)	.008	.018	.014	.097	-.137
4	PHL	UWC	2	.007	.033	.063	.032	-.135
5	MDT	TCA	3	-.000	-.010	-.014	-.049	.073
6	ACY	VIS	2	.091	-.040	-.052	.032	-.030
7	DCA	WEA	4	-.017	.022	.094	-.020	-.079
8	IDL	RLH	2	-.008	.000	-.017	-.040	.066
9	DCA	CIG	3	.016	.098	.004	-.093	-.025
10	ACY	TOD	1	-.027	-.018	-.004	.027	.023
11	NEL	UWC	3	.006	.008	.012	.030	-.057
12	SBY	WEA	9	.010	.044	.019	.039	-.113
13	ACY	CIG	(9)	.037	.064	.072	-.134	-.038
14	IDL	UWC	2	.011	.017	.030	.020	-.078
15	PHL	WEA	4	-.000	.056	.029	-.027	-.057
Additive Constant:				.021	.011	.021	.069	.878

*Refer to Table 2-6.

Table 2-8a

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, REEP with Standard Dummies,
and REEP with Cumulative Dummies

2-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	26	4	3	0	5	38
	2	8	48	22	6	6	90
	3	4	10	57	24	13	108
	4	2	4	24	72	66	168
	5	4	9	16	55	1556	1640
	Total	44	75	122	157	1646	2044

Hits = 1759 $\bar{P} = .2063$

$\bar{P}_g$.0128 .0241 .0407 .0590 .0696

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Standard Dummies	1	19	2	2	0	4	27
	2	11	46	21	5	2	85
	3	3	8	52	21	10	94
	4	2	4	21	58	31	116
	5	9	15	26	73	1599	1722
	Total	44	75	122	157	1646	2044

Hits = 1774 $\bar{P} = .1878$

$\bar{P}_g$.0138 .0237 .0369 .0558 .0575

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Cumulative Dummies	1	25	3	3	0	4	35
	2	6	46	21	5	2	80
	3	3	8	52	19	10	92
	4	1	4	24	56	26	111
	5	9	14	22	77	1604	1726
	Total	44	75	122	157	1646	2044

Hits = 1783 $\bar{P} = .1884$

$\bar{P}_g$.0134 .0236 .0367 .0571 .0576

Table 2-8b

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, REEP with Standard Dummies,
and REEP with Cumulative Dummies

5-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	11	11	6	2	8	38
	2	7	34	18	15	16	90
	3	3	13	38	28	26	108
	4	2	11	29	47	79	168
	5	9	15	31	82	1503	1640
	Total	32	84	122	174	1632	2044

Hits = 1633 $\bar{P} = .2689$

$\bar{P}_g$.0138 .0326 .0489 .0723 .1013

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Standard Dummies	1	1	1	1	0	0	3
	2	3	24	7	6	2	42
	3	7	20	32	17	8	84
	4	0	10	24	23	11	68
	5	21	29	58	128	1611	1847
	Total	32	84	122	174	1632	2044

Hits = 1691 $\bar{P} = .2375$

$\bar{P}_g$.0136 .0310 .0460 .0687 .0782

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Cumulative Dummies	1	0	0	0	1	0	1
	2	1	19	8	4	3	35
	3	9	23	31	17	5	85
	4	0	9	21	18	9	57
	5	22	33	62	134	1615	1866
	Total	32	84	122	174	1632	2044

Hits = 1683 $\bar{P} = .2367$

$\bar{P}_g$.0137 .0310 .0459 .0685 .0776

Table 2-8c

Contingency Tables Showing Predicted-Versus-Actual Groups
for Persistence, REEP with Standard Dummies,
and REEP with Cumulative Dummies

7-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
PERSISTENCE	1	8	12	8	4	6	38
	2	12	22	19	19	18	90
	3	7	9	38	26	28	108
	4	2	12	33	37	84	168
	5	12	24	49	72	1483	1640
	Total	41	79	147	158	1619	2044
Hits = 1588 $\bar{P} = .2899$							
	$\bar{P}_g$	.0183	.0342	.0598	.0671	.1105	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Standard Dummies	1	0	1	0	0	0	1
	2	1	8	5	0	3	17
	3	9	22	32	9	7	79
	4	7	6	18	12	5	48
	5	24	42	92	137	1604	1899
	Total	41	79	147	158	1619	2044
Hits = 1656 $\bar{P} = .2617$							
	$\bar{P}_g$	.0184	.0322	.0547	.0668	.0896	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Cumulative Dummies	1	0	0	0	0	0	0
	2	5	9	6	1	0	21
	3	7	19	28	10	4	68
	4	4	7	21	10	9	51
	5	25	44	92	137	1606	1904
	Total	41	79	147	158	1619	2044
Hits = 1653 $\bar{P} = .2621$							
	$\bar{P}_g$	.0182	.0323	.0556	.0674	.0885	

Table 2-9

Comparison Between Persistence, REEP with Standard Dummies, and REEP
with Cumulative Dummies for the Independent Sample (2044 Observations)

<u>2-hr Ceiling</u>		
Hits	Persistence	1759
	Standard	1774
	Cumulative	1783*
$\bar{P}$ Score	Persistence	.2063
	Standard	.1878*
	Cumulative	.1884
<u>5-hr Ceiling</u>		
Hits	Persistence	1633
	Standard	1691*
	Cumulative	1683
$\bar{P}$ Score	Persistence	.2689
	Standard	.2375
	Cumulative	.2367*
<u>7-hr Ceiling</u>		
Hits	Persistence	1588
	Standard	1656*
	Cumulative	1653
$\bar{P}$ Score	Persistence	.2899
	Standard	.2617*
	Cumulative	.2621

Asterisks are used to denote superiority.

EXPERIMENT 3. Nullifying the Effect of High Ceilings in Predictor Selection.

Purpose

To determine the effect on the forecast of assuming a zero degree of freedom for category 5 of the ceiling predictand.

Procedure

Forecasts were made for ceiling at Atlantic City 3 hours and 7 hours in advance. The degrees of freedom specified for categories 1 through 4 of the ceiling predictand was specified as 2652, the number normally used for the Atlantic City developmental sample size of 7956, or one-third of the total developmental sample. The degrees of freedom for category 5 of the ceiling predictand was specified as zero. This in effect eliminated the possibility of having category 5 affect the selection of any predictor.

Data Sample

The ten years of data from 1 January 1949 to 31 December 1958, consisting of 10,000 observations selected at random was used in this experiment. The developmental sample consisted of 7956 observations from the first eight years and the verification or dependent sample of 2044 was from the last two years of the data sample.

Predictands

The ceiling at time intervals of 3 and 7 hours in advance were the predictands for this experiment. The operationally significant categories for which the forecasts were made are shown in Table 3-1. The specifications are shown in Table 3-2.

Predictors

The set of 423 dummy predictors used in Experiment No. 1 for the 13-station Atlantic City network was used for this experiment (see Figure 1-1 and Tables 1-3 and 1-4).

Results

The predictors selected by REEP for each of the predictands are given in Tables 3-3a and 3-3b, as well as the coefficients in the REEP regression equation for each group of the predictand. Contingency tables showing the forecast-versus-observed frequencies for REEP with zero degree of freedom in category 5 and for persistence are shown in Tables 3-4a and 3-4b. The number of correct forecasts (hits), the Brier and Allen $\bar{P}$ scores, and the individual group contributions to the overall $\bar{P}$ score are shown.

Table 3-5 summarizes the hits and $\bar{P}$ scores and compares them with the results using the regular degree of freedom for all categories of the predictand as determined by Experiment No. 1.

Conclusions

The results in this experiment are the same or slightly worse than those using the regular degrees of freedom, both with regard to $\bar{P}$ score and hits as well as with regard to better predicting the low categories. It is therefore concluded that modifying the degrees of freedom within the higher categories does not appreciably change the results from those obtained using the regular degrees of freedom. The lack of success in this effort to force the selection of predictors which contribute to improving the forecasts of low ceiling conditions suggests that the regular selection method is performing this function satisfactorily.

Table 3-1

Definition of Predictand Groups for Atlantic City Municipal Airport

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling < 200 ft
2	200 ft $\leq$ Ceiling < 500 ft
3	500 ft $\leq$ Ceiling < 1000 ft
4	1000 ft $\leq$ Ceiling < 3000 ft
5	3000 ft $\leq$ Ceiling

Table 3-2

Specification of Predictands
Atlantic City Municipal Airport

Predictand variable	Predictand	
	1	2
Predictand variable	CIG	CIG
Forecast interval--hours (H)	3	7
Number of Groups (G)	5	5
Observations in Group 1 (n_1)	100	135
Observations in Group 2 (n_2)	281	272
Observations in Group 3 (n_3)	385	420
Observations in Group 4 (n_4)	660	619
Observations in Group 5 (n_5)	6530	6510
Total dependent sample size (N)	7956	7956
Number of independent observations in the dependent sample (n)		
Group 1	2652	2652
Group 2	2652	2652
Group 3	2652	2652
Group 4	2652	2652
Group 5	0	0
Total independent sample size (M)	2044	2044
Number of available predictors (P)	423	423

Table 3-3a

Selected Predictors and KEEP Equations
Atlantic City 3-hr Ceiling Forecast

(Zero Degrees Freedom, Category 5)

Predictors Selected				Coefficients of the <u>KEEP</u> Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	2	.057	.329	.025	-.075	-.336
2	ACY	CIG	1	.396	.202	.001	-.146	-.453
3	ACY	CIG	4	.008	.016	.027	.199	-.250
4	ACY	CIG	3	.007	.082	.214	-.013	-.291
5	PHL	CIG	5	.008	-.036	-.082	-.143	.253
6	DCA	RLH	3	.012	.079	.017	-.033	-.075
7	SBY	CIG	4	-.009	-.079	-.033	.089	.032
8	SBY	WEA	2	-.009	.084	-.002	.053	-.124
9	NEL	CIG	3	-.008	-.010	.098	.008	-.088
10	ACY	VIS	5	-.047	.013	-.006	-.001	.041
11	ACY	CIG	(1)	-.176	.064	-.069	.049	.132
12	NEL	WEA	2	-.025	.021	.087	-.046	-.036
13	ACY	TCA	2	.004	-.008	.016	.054	-.066
14	SBY	CIG	5	-.004	-.071	-.052	-.023	.150
15	SBY	VIS	2	.085	.007	-.037	-.031	-.024
16	ACY	CIG	(6)	-.009	-.012	-.041	.164	-.102
17	NEL	CIG	4	-.003	-.017	.012	.082	-.074
Additive Constant:				.045	.094	.141	.180	.539

Table 3-3b

**Selected Predictors and REEP Equations
Atlantic City 7-hr Ceiling Forecast**

(Zero Degrees Freedom, Category 5)

Predictors Selected				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	PHL	CIG	5	-.009	-.048	-.060	-.079	.195
2	DCA	WEA	2	-.003	.055	.126	-.041	-.136
3	ACY	SCL	1	.112	-.025	-.016	.006	-.077
4	ACY	CIG	2	.017	.103	.019	-.124	-.016
5	SBY	CIG	5	-.010	-.000	-.036	-.077	.123
6	DCA	CIG	3	.005	.102	.055	.025	-.187
7	PHL	TCA	2	-.003	.013	.023	.055	-.087
8	PSB	WEA	8	-.024	.243	-.065	-.030	-.105
9	ACY	TOD	1	-.026	-.019	-.009	.024	.030
10	NEL	WND	2	-.005	.038	.064	.025	-.122
11	NEL	WEA	9	.028	.021	.071	.015	-.135
12	DCA	CIG	4	.000	.012	.047	.085	-.145
13	PSB	CIG	1	.014	.098	-.017	-.023	-.072
14	BGM	RLH	3	-.004	-.028	.008	.065	-.041
15	PHL	WND	3	.029	.022	.037	.042	-.130
16	IDL	CIG	3	.010	.072	-.004	-.015	-.063
Additive Constant:				.037	.056	.097	.157	.654

Table 3-4a

Contingency Tables Showing Predictand-Versus-Actual Groups
for Persistence and REEP Forecast With
Zero Degree of Freedom in Category 5

3-hr Ceiling (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Persistence	1	21	8	4	0	5	38
	2	13	33	25	10	9	90
	3	2	14	50	21	21	108
	4	1	8	21	68	70	168
	5	7	10	27	66	1530	1640
	Total	44	73	127	165	1635	2044
Hits = 1702 $\bar{P} = .2385$							
P_g .0156 .0284 .0462 .0636 .0847							

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP With Zero Degree of Freedom In Category 5	1	7	4	1	0	1	13
	2	18	34	24	8	7	91
	3	0	10	40	15	7	72
	4	1	7	19	42	18	87
	5	18	18	43	100	1602	1781
	Total	44	73	127	165	1635	2044
Hits = 1725 $\bar{P} = .2131$							
P_g .0163 .0275 .0429 .0591 .0673							

Table 3-4b

Contingency Tables Showing Predictand-Versus-Actual Groups
for Persistence and REEP Forecast with
Zero Degree of Freedom in Category 5

7-hr Ceiling (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Persistence	1	8	12	8	4	6	38
	2	12	22	19	19	18	90
	3	7	9	38	26	28	108
	4	2	12	33	37	84	168
	5	12	24	49	72	1483	1640
	Total	41	79	147	158	1619	2044
		Hits = 1588 $\bar{P} = .2899$					
		P_g	.0183	.0342	.0598	.0671	.1105

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP With Zero Degree of Freedom in Category 5	1	0	0	0	0	0	0
	2	3	11	12	3	4	33
	3	5	18	28	10	6	67
	4	5	5	21	13	8	52
	5	28	45	86	132	1601	1892
	Total	41	79	147	158	1619	2044
		Hits = 1653 $\bar{P} = .2638$					
		P_g	.0181	.0325	.0546	.0667	.0920

Table 3-5

Comparison Between Persistence, REEP with Zero Degrees of Freedom in Category 5, REEP with the Regular Degrees of Freedom in All Categories (See Experiment No. 1)

Atlantic City - Independent Sample

Ceiling: 3-hr Forecast

Hits	Persistence	1702
	REEP - Zero degrees freedom in Category 5	1725
	REEP - Regular degrees freedom in all categories	1728*
$\bar{P}$ Score	Persistence	.2385
	REEP - Zero degrees freedom in Category 5	.2131*
	REEP - Regular degrees freedom in all categories	.2135

Ceiling: 7-hr Forecast

Hits	Persistence	1588
	REEP - Zero degrees freedom in Category 5	1653
	REEP - Regular degrees freedom in all categories	1665*
$\bar{P}$ Score	Persistence	.2899
	REEP - Zero degrees freedom in Category 5	.2638
	REEP - Regular degrees freedom in all categories	.2600*

*Asterisks are used to denote superiority.

EXPERIMENT 4. Ceiling Prediction Using Persistence with One and Two Hour Lagged Persistence.

Purpose

A test on the predictability of persistence when time variations in persistence are made available.

Predictands

Predictands chosen for this experiment were ceilings at 1, 2, and 3 hours in advance. The operationally significant categories for which the forecasts were made are shown in Table 4-1. The specifications for the predictands are shown in Table 4-2.

Predictors

All the possible combinations of the five categories of ceiling for Atlantic City at the three time periods: 1) time of observation, 2) time of observation minus one hour, and 3) time of observation minus two hours, were used in combinations of logical "ANDS" and logical "ORS" to form 400 predictors. These 400 predictors plus the 15 ceiling dummies for the three different time periods gave a total of 415 predictors, made up only of ceiling dummies for only one station--Atlantic City. The intervals for the five categories of ceiling used as predictors are the same as those for the predictands shown in Table 4-1.

Data Sample

Standard hourly airways surface observations covering the ten year period, 1 January 1949 to 31 December 1958, furnished the data for this study. The developmental sample of 7956 observations is a random selection from the first eight years and the verification sample of 2044 observations is a random selection from the last two years. Note: This sample is not the same as in previous experiments because lagged predictors were involved.

Results

The predictors selected by REEP for each of the three predictands are given in Tables 4-3a to 4-3c. Also shown are the REEP regression equation coefficients for each group of the predictand.

Contingency tables showing the forecast-versus-observed frequencies for each of the three forecasts, and comparing the results using REEP to the results using persistence (without lags) is shown in Tables 4-4a to 4-4c. The number of correct forecasts (hits) and the Brier and Allen $\bar{P}$ scores as well as the individual group contributions to the overall $\bar{P}$ score are shown below each contingency table. The number of hits and the overall $\bar{P}$ scores are summarized in Table 4-5.

Conclusions

The 415 possible predictors exhaust the ways in which persistence with lags could improve the forecast. Contrary to common belief the results of this experiment show there is little improvement over persistence when lagged persistence is made available for selection.

Table 4-1

Definition of Predictand Groups for Atlantic City Municipal Airport

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling < 200 ft
2	200 ft $\leq$ Ceiling < 500 ft
3	500 ft $\leq$ Ceiling < 1000 ft
4	1000 ft $\leq$ Ceiling < 3000 ft
5	3000 ft $\leq$ Ceiling

Table 4-2

Specifications of Predictands
Atlantic City Municipal Airport

	Predictand		
	1	2	3
Predictand variable	CIG	CIG	CIG
Forecast interval--hours (H)	1	2	3
Number of Groups (G)	5	5	5
Observations in Group 1 (n_1)	125	128	133
Observations in Group 2 (n_2)	273	259	272
Observations in Group 3 (n_3)	403	426	418
Observations in Group 4 (n_4)	655	631	620
Observations in Group 5 (n_5)	6500	6512	6513
Total dependent sample size (N)	7956	7956	7956
Number of independent observations in the dependent sample (n)	2652	2652	2652
Total independent sample size (M)	2044	2044	2044
Number of available predictors (P)	415	415	415

Table 4-3a

Selected Predictors and REEP Equations
Atlantic City 1-hr Ceiling Forecast (Experiment 4)

Predictor Selected (see note)			Predictor Ceiling Category at time:			Coefficients of the REEP Equations				
Order	Sta.	Elem.	t_0	t_{-1}	t_{-2}	A_1	A_2	A_3	A_4	A_5
1	ACY	CIG	5			.005	-.011	-.084	-.544	.634
2	ACY	CIG	1			.767	.120	-.073	-.630	-.184
3	ACY	CIG	2			.124	.526	.049	-.588	-.110
4	ACY	CIG	3			.009	.115	.460	-.478	-.106
5	ACY	CIG		*	5	-.005	-.008	-.013	-.094	.120
6	ACY	CIG	2	*	2	-.235	.352	-.154	.010	.027
7	ACY	CIG		3	*	-.125	.156	.025	-.047	-.009
8	ACY	CIG	2		*	.186	-.165	.065	-.031	-.054
9	ACY	CIG	2		+	-.008	-.012	.086	-.017	-.049
Additive Constant:						.003	.021	.102	.657	.217

Note: t_0 means at time of observation.

t_{-1} means one hour before time of observation.

t_{-2} means two hours before time of observation.

* means logical "AND"

+ means logical "OR"

See Table 4-1 for limits of each category (group).

Table 4-3b

Selected Predictors and REEP Equations
Atlantic City 2-hr Ceiling Forecast (Experiment 4)

<u>Predictor Selected (see note)</u>			<u>Predictor Ceiling Category at time:</u>				<u>Coefficients of the REEP Equations</u>					
<u>Order</u>	<u>Sta.</u>	<u>Elem.</u>	<u>t₀</u>	<u>t₋₁</u>			<u>t₋₂</u>	<u>A₁</u>	<u>A₂</u>	<u>A₃</u>	<u>A₄</u>	<u>A₅</u>
1	ACY	CIG	5					.001	-.024	-.071	-.380	.475
2	ACY	CIG	1					.545	.189	-.110	-.471	-.153
3	ACY	CIG	2					.117	.349	.168	-.411	-.223
4	ACY	CIG	3					.045	.013	.321	-.238	-.141
5	ACY	CIG			5	*	5	-.006	-.016	-.032	-.138	.192
6	ACY	CIG	1	*	1	*	2	.334	-.058	-.099	-.051	-.127
7	ACY	CIG	5	*	2			.339	-.134	-.037	-.074	-.094
8	ACY	CIG	3	+	2			-.013	.118	-.011	-.036	-.008
9	ACY	CIG	4	*	5	*	2	-.008	-.044	.185	-.356	.223
10	ACY	CIG	1	+	3	+	1	-.021	-.042	.097	-.019	-.015
Additive Constant:								.008	.044	.111	.542	.295

Note: t_0 means at time of observation

t_{-1} means one hour before time of observation

t_{-2} means two hours before time of observation

* means logical "AND"

+ means logical "OR"

See Table 4-1 for limits of each category (group).

Table 4-3c

Selected Predictors and REEP Equations
Atlantic City 3-hr Ceiling Forecast (Experiment 4)

<u>Predictor Selected (see note)</u>			Predictor Ceiling Category at time:			Coefficients of the REEP Equations				
<u>Order</u>	<u>Sta.</u>	<u>Elem.</u>	<u>t₀</u>	<u>t₋₁</u>	<u>t₋₂</u>	<u>A₁</u>	<u>A₂</u>	<u>A₃</u>	<u>A₄</u>	<u>A₅</u>
1	ACY	CIG	5			.004	-.018	-.074	-.285	.374
2	ACY	CIG	1			.389	.173	-.006	-.338	-.217
3	ACY	CIG	2			.111	.346	.167	-.320	-.304
4	ACY	CIG	3			.008	.105	.308	-.203	-.219
5	ACY	CIG		5	* 5	-.016	-.032	-.049	-.099	.196
6	ACY	CIG	2		* 1	-.033	-.246	.045	.186	.048
7	ACY	CIG		1	* 2	.175	.026	-.082	-.066	-.054
Additive Constant:						.016	.056	.132	.415	.381

Note: t₀ means at time of observation

t₋₁ means one hour before time of observation

t₋₂ means two hours before time of observation

* means logical "AND"

+ means logical "OR"

See Table 4-1 for limits of each category (group).

Table 4-4a

Contingency Tables Showing Predictand-Versus-Actual Groups
for Persistence and REEP Forecast Using Persistence with One
and Two-Hour Lagged Persistence of Ceiling

Atlantic City 1-hr Ceiling (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Persistence	1	32	7	2	0	3	44
	2	2	51	14	2	4	73
	3	1	15	80	22	9	127
	4	0	2	15	113	35	165
	5	3	5	8	33	1586	1635
	Total	38	80	119	170	1637	2044

Hits = 1862 $\bar{P} = .1469$

P_g .0073 .0204 .0316 .0433 .0442

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP With Lagged Persistence	1	32	7	2	0	3	44
	2	2	51	14	2	4	73
	3	1	15	80	22	9	127
	4	0	2	15	113	35	165
	5	3	5	8	33	1586	1635
	Total	38	80	119	170	1637	2044

Hits = 1862 $\bar{P} = .1458$

P_g .0075 .0207 .0318 .0427 .0432

Table 4-4b

Contingency Tables Showing Predictand-Versus-Actual Groups
for Persistence and REEP Forecast Using Persistence With One
and Two-Hour Lagged Persistence of Ceiling

Atlantic City 2-hr Ceiling (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Persistence	1	24	12	4	1	3	44
	2	2	41	18	4	8	73
	3	2	24	57	33	11	127
	4	1	0	21	89	54	165
	5	3	7	22	47	1556	1635
	Total	32	84	122	174	1632	2044

Hits = 1767 $\bar{P} = .2016$

P_g .0095 .0267 .0436 .0571 .0647

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP With Lagged Persistence	1	24	12	4	1	3	44
	2	2	32	13	3	5	55
	3	2	33	62	34	14	145
	4	1	0	14	70	41	126
	5	3	7	29	66	1569	1674
	Total	32	84	122	174	1632	2044

Hits = 1757 $\bar{P} = .2009$

P_g .0102 .0267 .0429 .0572 .0639

Table 4-4c

Contingency Tables Showing Predictand-Versus-Actual Groups
for Persistence and REEP Forecast Using Persistence With One
and Two-Hour Lagged Persistence of Ceiling

Atlantic City 3-hr Ceiling (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Persistence	1	20	13	5	1	5	44
	2	6	31	20	5	11	73
	3	4	26	53	32	12	127
	4	1	2	28	64	70	165
	5	5	11	32	61	1526	1635
	Total	36	83	138	163	1624	2044

Hits = 1694 $\bar{P} = .2392$

P_g .0130 .0301 .0514 .0626 .0822

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP With Lagged Persistence	1	20	13	5	1	5	44
	2	5	26	16	5	11	63
	3	5	31	57	32	12	137
	4	1	2	22	53	56	134
	5	5	11	38	72	1540	1666
	Total	36	83	138	163	1624	2044

Hits = 1696 $\bar{P} = .2375$

P_g .0132 .0306 .0512 .0623 .0802

Table 4-5

Comparison Between Persistence and REEP
with Lagged Persistence of Ceiling

Ceiling: 1-hr Forecast

Hits	Persistence	1862
	REEP with Lagged	
	Persistence of Ceiling	1862
$\bar{P}$ Score	Persistence	.1469
	REEP with Lagged	
	Persistence of Ceiling	.1458*

Ceiling: 2-hr Forecast

Hits	Persistence	1767*
	REEP with Lagged	
	Persistence of Ceiling	1757
$\bar{P}$ Score	Persistence	.2016
	REEP with Lagged	
	Persistence of Ceiling	.2009*

Ceiling: 3-hr Forecast

Hits	Persistence	1694
	REEP with Lagged	
	Persistence of Ceiling	1696*
$\bar{P}$ Score	Persistence	.2392
	REEP with Lagged	
	Persistence of Ceiling	.2375*

Asterisks are used to denote superiority.

EXPERIMENT 5. Multiple Predictands Processed Simultaneously.

Purpose

To investigate the selection of predictors for more than one predictand at a time in an attempt to reduce the number of analysis runs ordinarily required.

Procedure

Four REEP selection runs were performed using the following pairs of predictands as the predictand:

- 1) Ceiling plus 3 hours and visibility plus 3 hours
- 2) Ceiling plus 3 hours and ceiling plus 7 hours
- 3) Visibility plus 3 hours and visibility plus 7 hours
- 4) Ceiling plus 7 hours and visibility plus 7 hours

Predictors consisted of dummy (zero-one) variables of seven meteorological elements from a thirteen-station network (see Figure 1-1). The predictors selected from those runs were compared with those selected when the predictands were run singly. This comparison is shown in Table 5-1. The predictors selected when the predictands were run singly are indicated by an x under the appropriate ceiling or visibility predictand.

Predictands

The five operationally significant categories of ceiling and visibility for the predictands are shown in Table 5-2. The specifications of the predictands are listed in Table 5-3.

Predictors

The 423 predictors used in this experiment are the same as those used in Experiment No. 1 (see Tables 1-3 and 1-4).

Data Sample

Standard hourly airways surface observations covering the ten year period, 1 January 1949 to 31 December 1958, constituted the data used in this study. The developmental sample of 7956 observations is a random selection from the first eight years and the verification sample of 2044 observations is a random selection from the last two years.

Results

Contingency tables (Tables 5-4a and 5-4b) were formed to show the forecast-versus-observed frequencies for the 3-hr predictions of ceiling and visibility using the predictors selected by REEP when the predictand was a single predictand and also when the predictand was a pair of predictands. The number of correct forecasts (hits) and the Brier and Allen $\bar{P}$ scores as well as the individual group contributions to the overall $\bar{P}$ score are given below each contingency table.

Conclusions

There is sufficient redundancy in the predictands such that selection of predictors may be made on more than one predictand at a time. This applies even though they differ with regard to meteorological element or with regard to time leads. These conclusions were drawn from the fact that the predictors selected, when the predictands were processed singly, are all essentially among those selected when they are considered jointly. The one direct comparison for which results on independent data were obtained (Ceiling 3 hrs and Visibility 3 hrs) confirms this surmise.

Table 5-1

Predictors Selected When the Predictand is a Set

(Columns at left of each list show those predictors also selected when selection was run singly for the indicated predictand.)

CIG-3, VIS-3			CIG-3, CIG-7			VIS-3, VIS-7			CIG-7, VIS-7		
CIG VIS			CIG VIS			VIS VIS			CIG VIS		
3	7	Predictors	3	7	Predictors	3	7	Predictors	3	7	Predictors
X	X	ACY CIG-5	X	X	ACY CIG-5	X	X	ACY VIS-5	X	X	PHL CIG-5
X	X	ACY VIS-5	X	X	ACY CIG-1	X	X	ACY VIS-1	X	X	DCA CIG-5
X	X	PHL CIG-5	X	X	PHL CIG-5	X	X	ACY RLH-3	X	X	ACY CIG-5
X	X	ACY CIG-1	X	X	ACY CIG-2	X	X	ACY VIS-2	X	X	PHL WND-3
X	X	ACY CIG-2	X	X	DCA CIG-5	X	X	PHL CIG-5	X	X	DCA VIS-5
X	X	DCA CIG-5	X	X	ACY CIG-3	X	X	ACY TOD(02-13)	X	X	ACY TOD(02-13)
X	X	ACY CIG-3	X	X	PHL WND-3	X	X	DCA VIS-5	X	X	IDL WND-2
X	X	ACY VIS-1	X	X	IDL WND-2	X	X	SBY RLH-3	X	X	ACY WEA-1
X	X	SBY RLH-3	X	X	NEL TCA-2	X	X	PHL WEA-1	X	X	DCA WEA-2
X	X	ACY VIS-2	X	X	SBY CIG-5	X	X	PHL CIG-1	X	X	ACY SCL-1
X	X	NEL TCA-2	X	X	DCA WEA-2	X	X	NEL WEA-9	X	X	MDT TCA-2
X	X	SBY CIG-5	X	X	ACY VIS-5	X	X	NEL WND-3	X	X	PSB WEA-8
X	X	ACY WEA-1	X	X	PSB WEA-8	X	X	DCA WEA-2	X	X	ACY CIG-2
X	X	DCA RLH-3	X	X	SBY CIG-4	X	X	SBY VIS-5	X	X	NEL WEA-9
X	X	NEL CIG-3	X	X	ACY TOD(02-13)	X	X	MDT VIS-2	X	X	SBY WEA-9
X	X	NEL WEA-9	X	X	ACY CIG(1)	X	X	IDL VIS-3	X	X	IDL VIS-3
X	X	SBY WEA-2	X	X	NEL CIG-3	X	X	ORF RLH-3	X	X	PHL WND-2
X	X	PHL CIG-1	X	X	PSB RLH-3	X	X	NEL WEA-12	X	X	NEL WEA-12
X	X	SWF WND-3	X	X	SBY VIS-2	X	X				
X	X	ACY CIG(1)	X	X	DCA RLH-3	X	X				
X	X	IDL WND-2	X	X	NEL WEA-2	X	X				
X	X	ACY CIG(6)	X	X	ACY CIG(6)	X	X				
X	X	SBY CIG-4	X	X	SBY CIG-4	X	X				
X	X	ORF RLH-3	X	X	ORF RLH-3	X	X				
X	X	NEL WEA-2	X	X	NEL WEA-2	X	X				
X	X	MDT VIS-2	X	X	MDT VIS-2	X	X				

Table 5-2

Definition of Predictand Groups for Atlantic City Municipal Airport

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling < 200 ft
2	200 ft $\leq$ Ceiling < 500 ft
3	500 ft $\leq$ Ceiling < 1000 ft
4	1000 ft $\leq$ Ceiling < 3000 ft
5	3000 ft $\leq$ Ceiling

<u>Group Number</u>	<u>Visibility Intervals</u>
1	0 mi < Visibility < 1/2 mi
2	1/2 mi < Visibility < 1 mi
3	1 mi < Visibility < 2 mi
4	2 mi < Visibility < 3 mi
5	3 mi < Visibility

Table 5-3

Specification of Predictands
Atlantic City Municipal Airport

Predictand variable	Predictand	
	1	2
	CIG	VIS
Forecast interval--hours (H)	3	3
Number of Groups (G)	5	5
Observations in Group 1 (n_1)	100	153
Observations in Group 2 (n_2)	281	125
Observations in Group 3 (n_3)	385	200
Observations in Group 4 (n_4)	660	286
Observations in Group 5 (n_5)	6530	7192
Total dependent sample size (N)	7956	7956
Number of independent observations in the dependent sample (n)	2652	2652
Total independent sample size (M)	2044	2044
Number of available predictors (P)	423	423

Table 5-4a

Contingency Tables Showing Predicted-Versus-Actual Groups
Using Predictors Selected when the Predictand was a Single
Predictand and Using Predictors Selected when the Predictand
was a Pair of Predictands

Atlantic City 3-hr Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Using Predictors Selected When Predictand was Single	1	6	4	1	0	1	12
	2	19	34	25	8	4	90
	3	0	11	42	14	5	72
	4	1	6	19	41	20	87
	5	18	18	40	102	1605	1783
	Total	44	73	127	165	1635	2044

Hits = 1728 $\bar{P} = .2135$

P_g .0163 .0277 .0423 .0605 .0666

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Using Predictors Selected When Predictand was a Pair	1	6	3	1	0	2	12
	2	19	35	25	8	4	91
	3	0	13	40	14	5	72
	4	1	7	19	41	22	90
	5	18	15	42	102	1602	1779
	Total	44	73	127	165	1635	2044

Hits = 1724 $\bar{P} = .2133$

P_g .0165 .0279 .0421 .0605 .0663

Table 5-4b

Contingency Tables Showing Predicted-Versus-Actual Groups
Using Predictors Selected when the Predictand was a Single
Predictand and Using Predictors Selected when the Predictand
was a Pair of Predictands

Atlantic City 3-hr Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Using Predictors Selected When Predictand was Single	1	13	9	5	1	4	32
	2	2	5	4	0	9	20
	3	0	2	0	0	0	2
	4	0	0	3	4	0	7
	5	27	30	66	88	1772	1983
	Total	42	46	78	93	1785	2044

Hits = 1794 $\bar{P} = .1800$

P_g .0169 .0199 .0331 .0395 .0707

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
Using Predictors Selected When Predictand was a Pair	1	10	7	4	0	3	24
	2	3	4	4	0	6	17
	3	0	3	0	0	0	3
	4	0	0	0	2	1	3
	5	29	32	70	91	1775	1997
	Total	42	46	78	93	1785	2044

Hits = 1791 $\bar{P} = .1803$

P_g .0167 .0199 .0334 .0395 .0708

EXPERIMENT 6. Effect of Restricting Selection to Predictors with Certain Minimum Occurrence Frequencies.

Purpose

This experiment was conducted to determine in a general way if there was any optimum limit to the number of occurrences to be permitted in a predictor before REEP would be allowed to include that predictor among those selected.

Procedure

Forecasts were made for 3-hr and 7-hr ceiling and visibility at Atlantic City Airport. Three different minimum number of occurrences of the predictors were specified in the separate runs, except for ceiling three hours in advance, which was tested for only two. The number of occurrences of the predictors specified were 10, 50, and 100. In the first case any predictor must have occurred at least ten times before it could be considered by REEP for selection, and similarly for the cases of 50 and 100. The forecasts made using the predictors selected by REEP in each case were then compared to determine the most favorable minimum occurrence frequency, comparing the $\bar{P}$ score and the number of correct forecasts in each case.

Data Sample

The developmental sample of 7956 observations is a random selection of hourly surface observations from the eight year period from 1 January 1949 to 31 December 1956. The verification sample of 2044 observations is a random selection from the two year period from 1 January 1957 to 31 December 1958. Observations are included in this sample for the 13 stations comprising this Atlantic City Airport network (Figure 1-1).

Predictands

Table 6-1 shows the five operationally significant categories of ceiling and visibility for the predictands used in this experiment. The specifications of the predictands are shown in Table 6-2.

Predictors

The 423 original dummy predictors used in this experiment are the same as those used in Experiment No. 1 (see Tables 1-3 and 1-4). The predictors with number of occurrences less than 100 are listed in Table 6-3. There are 90 such dummy predictors out of a total of 423. The number of observations in the developmental sample, as noted previously, is 7956.

Results

Contingency tables (Tables 6-4a to 6-4d) were formed to show the forecast-versus-observed frequencies for the 3-hr and 7-hr predictions of ceiling and visibility using the predictors selected by REEP when the conditions of 10, 50, and 100 occurrence minimum were applied to the selection procedure. The number of correct forecasts (hits) and the Brier and Allen $\bar{P}$ scores as well as the individual group contributions to the overall $\bar{P}$ score are given below each contingency table. The number of hits and the overall $\bar{P}$ scores are summarized in Table 6-5.

Conclusions

The results suggest that, when selection is restricted to predictors with a larger number of occurrences, the predictors are as good or better than those when restricted by fewer number of occurrences. In addition, there is no apparent deterioration in the ability to forecast low conditions by this restriction.

Table 6-1

Definition of Predictand Groups for Atlantic City Municipal Airport

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling $<$ 200 ft
2	200 ft $\leq$ Ceiling $<$ 500 ft
3	500 ft $\leq$ Ceiling $<$ 1000 ft
4	1000 ft $\leq$ Ceiling $<$ 3000 ft
5	3000 ft $\leq$ Ceiling

<u>Group Number</u>	<u>Visibility Intervals</u>
1	0 mi $\leq$ Visibility $<$ 1/2 mi
2	1/2 mi $\leq$ Visibility $<$ 1 mi
3	1 mi $\leq$ Visibility $<$ 2 mi
4	2 mi $\leq$ Visibility $<$ 3 mi
5	3 mi $\leq$ Visibility

Table 6-2

Specification of Predictands
Atlantic City Municipal Airport

Predictand variable	Predictand			
	1	2	3	4
	CIG	CIG	VIS	VIS
Forecast interval--hours (H)	3	7	3	7
Number of Groups (G)	5	5	5	5
Observations in Group 1 (n_1)	100	135	153	167
Observations in Group 2 (n_2)	281	272	125	130
Observations in Group 3 (n_3)	385	420	200	230
Observations in Group 4 (n_4)	660	619	286	283
Observations in Group 5 (n_5)	6530	6510	7192	7146
Total dependent sample size (N)	7956	7956	7956	7956
Number of independent observations in the dependent sample (n)				
Group 1	5500	5500	5500	5500
Group 2	5500	5500	5500	5500
Group 3	5500	5500	5500	5500
Group 4	5500	5500	5500	5500
Group 5	3000	3000	3000	3000
Total independent sample size (M)	2044	2044	2044	2044
Number of available predictors (P)	(423)	(423)	(423)	(423)
10 Occurrence Criteria	403	403	403	403
50 Occurrence Criteria	371	371	371	371
100 Occurrence Criteria	333	333	333	333

Table 6-3

Predictors in Developmental Sample (7956 Observations)
with Number of Occurrences Less Than 100

Predictors in dummy (zero-one) form

<u>Predictor</u>	<u>Number of Occurrences</u>	<u>Predictor</u>	<u>Number of Occurrences</u>	<u>Predictor</u>	<u>Number of Occurrences</u>
NEL WEA 5	46	ACY CIG (1)	53	BGM VIS 2	97
NEL WEA 6	11	ACY CIG (2)	64	BGM WEA 4	84
NEL WEA 7	43	ACY CIG (3)	98	BGM WEA 7	58
NEL WEA 8	2	ACY CIG (4)	62	BGM WEA 8	37
NEL WEA 11	5	ACY VIS (1)	46	BGM WEA 11	52
		ACY VIS (2)	52		
PHL CIG 1	42	ACY VIS (3)	63	SWF CIG 1	81
PHL VIS 1	68	ACY VIS (5)	99	SWF WEA 6	21
PHL VIS 2	59	ACY WEA 5	42	SWF WEA 7	56
PHL WEA 4	41	ACY WEA 6	3	SWF WEA 8	26
PHL WEA 5	46	ACY WEA 7	36	SWF WEA 11	8
PHL WEA 6	7	ACY WEA 8	3		
PHL WEA 7	25	ACY WEA 11	5	RIC CIG 1	74
PHL WEA 8	5			RIC VIS 1	91
PHL WEA 11	1	DCA CIG 1	19	RIC VIS 2	66
		DCA CIG 2	81	RIC WEA 5	38
SBY CIG 1	71	DCA VIS 1	29	RIC WEA 6	5
SBY VIS 2	91	DCA VIS 2	16	RIC WEA 7	52
SBY WEA 5	36	DCA WEA 4	77	RIC WEA 8	8
SBY WEA 6	3	DCA WEA 5	45	RIC WEA 11	0
SBY WEA 7	60	DCA WEA 6	7		
SBY WEA 8	5	DCA WEA 7	50	IDL CIG 1	76
SBY WEA 11	1	DCA WEA 8	11	IDL VIS 1	90
		DCA WEA 11	0	IDL VIS 2	69
MDT CIG 1	51			IDL WEA 5	64
MDT CIG 2	90	ORF CIG 1	47	IDL WEA 6	11
MDT VIS 1	74	ORF VIS 1	67	IDL WEA 7	37
MDT WEA 4	72	ORF VIS 2	41	IDL WEA 8	9
MDT WEA 5	80			IDL WEA 11	6
MDT WEA 6	17	PSB WEA 7	67		
MDT WEA 7	28	PSB WEA 8	43	DSM WEA 4	99
MDT WEA 8	13	PSB WEA 11	45	DSM WEA 6	40
MDT WEA 11	2			DSM WEA 8	23
				DSM WEA 10	70
				DSM WEA 11	24

Table 6-4a

Contingency Tables Showing Predicted-Versus-Actual Groups
When Selection of Predictors is Limited to Those With A
Specified Minimum Occurrence Frequency

Atlantic City 3-hour Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 10-Occurrence Minimum	1	5	4	2	0	2	13
	2	19	33	23	6	3	84
	3	1	11	39	12	9	72
	4	0	7	22	43	21	93
	5	19	18	41	104	1600	1782
	Total	44	73	127	165	1635	2044

Hits = 1720 $\bar{P} = .2131$

P_g .0165 .0278 .0433 .0592 .0663

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 50-Occurrence Minimum	1						
	2		(Prediction not made for				
	3						
	4		3-hr Ceiling)				
	5						
	Total						

Hits = $\bar{P} =$

P_g

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 100-Occurrence Minimum	1	10	5	2	0	3	20
	2	18	30	25	6	2	81
	3	0	13	41	12	8	74
	4	0	7	20	46	18	91
	5	16	18	39	101	1604	1778
	Total	44	73	127	165	1635	2044

Hits = 1731 $\bar{P} = .2110$

P_g .0161 .0272 .0429 .0592 .0656

Table 6-4b

Contingency Tables Showing Predicted-Versus-Actual Groups
When Selection of Predictors is Limited to Those With A
Specified Minimum Occurrence Frequency

Atlantic City 7-hour Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 10-Occurrence Minimum	1	0	0	0	0	0	0
	2	9	17	7	3	2	38
	3	3	15	32	10	6	66
	4	5	8	19	16	7	55
	5	24	39	89	129	160	418
	Total	41	79	147	158	161	444

Hits = 1669 $\bar{P} = .2567$

P_g .0177 .0325 .0539 .0658 .0868

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 50-Occurrence Minimum	1	0	0	0	0	0	0
	2	7	17	8	3	3	38
	3	6	16	34	11	7	74
	4	5	6	18	13	8	50
	5	23	40	87	131	160	441
	Total	41	79	147	158	161	444

Hits = 1665 $\bar{P} = .2567$

P_g .0177 .0325 .0540 .0660 .0866

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 100-Occurrence Minimum	1	0	0	0	0	0	0
	2	9	16	10	5	2	42
	3	5	16	33	10	6	70
	4	5	5	19	16	6	51
	5	22	42	85	127	160	444
	Total	41	79	147	158	161	444

Hits = 1670 $\bar{P} = .2572$

P_g .0178 .0326 .0538 .0662 .0868

Table 6-4c

Contingency Tables Showing Predicted-Versus-Actual Groups
When Selection of Predictors is Limited to Those With A
Specified Minimum Occurrence Frequency

Atlantic City 3-hour Visibility (Independent Sample)

	Group	Actual					Total
		1	2	3	4	5	
REEP with Selection of Predictors Limited to 10-Occurrence Minimum	1	11	6	3	0	5	25
	2	3	6	7	0	5	21
	3	1	3	0	0	3	7
	4	0	0	0	6	1	7
	5	27	31	68	87	1771	1984
	Total	42	46	78	93	1785	2044

Hits = 1794 $\bar{P} = .1799$

P_g .0166 .0197 .0328 .0393 .0715

	Group	Actual					Total
		1	2	3	4	5	
REEP with Selection of Predictors Limited to 50-Occurrence Minimum	1	11	8	5	0	3	27
	2	1	4	5	0	6	16
	3	1	3	0	0	1	5
	4	1	0	1	6	1	9
	5	28	31	67	87	1774	1987
	Total	42	46	78	93	1785	2044

Hits = 1795 $\bar{P} = .1793$

P_g .0168 .0199 .0327 .0392 .0707

	Group	Actual					Total
		1	2	3	4	5	
REEP with Selection of Predictors Limited to 100-Occurrence Minimum	1	19	11	7	0	6	43
	2	1	4	1	0	7	13
	3	0	1	0	0	0	1
	4	1	0	0	6	0	7
	5	21	30	70	87	1772	1980
	Total	42	46	78	93	1785	2044

Hits = 1801 $\bar{P} = .1799$

P_g .0169 .0201 .0332 .0393 .0705

Table 6-4d

Contingency Tables Showing Predicted-Versus-Actual Groups
When Selection of Predictors is Limited to Those With A
Specified Minimum Occurrence Frequency

Atlantic City 7-hour Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 10-Occurrence Minimum	1	0	0	0	1	1	2
	2	1	0	0	0	0	1
	3	1	0	0	0	0	1
	4	0	0	0	0	0	0
	5	41	38	90	98	1773	2040
	Total	43	38	90	99	1774	2044

Hits = 1773 $\bar{P} = .2161$

P_g .0195 .0181 .0404 .0447 .0934

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 50-Occurrence Minimum	1	0	0	0	1	1	2
	2	1	0	0	0	0	1
	3	1	0	0	0	0	1
	4	0	0	0	0	0	0
	5	41	38	90	98	1773	2040
	Total	43	38	90	99	1774	2044

Hits = 1773 $\bar{P} = .2162$

P_g .0195 .0180 .0404 .0447 .0935

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP with Selection of Predictors Limited to 100-Occurrence Minimum	1	0	0	1	0	1	2
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	43	38	89	99	1773	2042
	Total	43	38	90	99	1774	2044

Hits = 1773 $\bar{P} = .2144$

P_g .0193 .0180 .0401 .0447 .0923

Table 6-5

Comparison Between Predictions Made When Selection of Predictors is Limited to a Minimum Occurrence Frequency of 10, 50, and 100.

ACY Ceiling - 3-hr Forecast

Hits	10 Occurrence Minimum	1720
	50 Occurrence Minimum	--
	100 Occurrence Minimum	1731*
$\bar{P}$ Score	10 Occurrence Minimum	.2131
	50 Occurrence Minimum	--
	100 Occurrence Minimum	.2110*

ACY Ceiling - 7-hr Forecast

Hits	10 Occurrence Minimum	1669
	50 Occurrence Minimum	1665
	100 Occurrence Minimum	1670*
$\bar{P}$ Score	10 Occurrence Minimum	.2567*
	50 Occurrence Minimum	.2567*
	100 Occurrence Minimum	.2572

ACY Visibility - 3-hr Forecast

Hits	10 Occurrence Minimum	1794
	50 Occurrence Minimum	1795
	100 Occurrence Minimum	1801*
$\bar{P}$ Score	10 Occurrence Minimum	.1799
	50 Occurrence Minimum	.1793*
	100 Occurrence Minimum	.1799

ACY Visibility - 7-hr Forecast

Hits	10 Occurrence Minimum	1773
	50 Occurrence Minimum	1773
	100 Occurrence Minimum	1773
$\bar{P}$ Score	10 Occurrence Minimum	.2161
	50 Occurrence Minimum	.2162
	100 Occurrence Minimum	.2144*

Asterisks are used to denote superiority.

EXPERIMENT 7. Single-Station Predictors: Raw Dummies and Boolean Combinations.

Purpose

To investigate the accuracy of forecasts using only single-station predictors. In the event the accuracy is sufficiently competitive, a generalized operator might be developed where spacial analyses of network parameters would not be required.

Procedure

From the 423 predictors used in the Atlantic City network of 13 stations (see Table 1-3), the 55 predictors for only Atlantic City predictors (not including TOD and DOY) were extracted. Selections and predictions were first made for ACY ceiling and visibility for three and seven hours using the 55 dummy predictors alone.

Next, those dummy predictors with 400 or more occurrences were then formed into all possible combinations of pairs joined by a logical "AND" including the combination of each predictor with itself. An exception to this procedure was made in figuring the number of occurrences under the Weather Element heading. In this case the weather dummies from 2 to 8 (precipitation) were grouped together to represent a precipitation predictor. Combining the dummy predictors in this way resulted in the formation of 467 new predictors. Selections and predictions were again made for ACY ceiling and visibility at three and seven hours in advance using the 467 Boolean-paired predictors. The results were compared with those from the prediction runs with the raw dummy predictors, as well as with the results using all the network predictors (Experiment No. 1).

Predictands

The predictands, as used in the earlier experiments, are subdivided into five operationally significant intervals of ceiling and visibility as shown in Table 7-1. The specifications of the predictands are shown in Tables 7-2a and 7-2b.

Predictors

As noted previously the predictors used in this experiment were extracted from the 423 predictors used in the Atlantic City network of 13 stations. The 55 dummy predictors used in the first prediction runs are shown in Table 7-3 together with the number of occurrences of each in the developmental sample of 7956 observations. Table 7-3 also lists the specifications and limits of the dummy variables. Those predictors with 400 occurrences or more, plus the time of day (TOD) and day of year (DOY), were formed into all possible pairs joined by a logical "AND" resulting in 467 Boolean-paired predictors.

Data Sample

As in the earlier experiments the 10,000 observations used in this experiment were randomly selected from the ten year period 1 January 1949 to 31 December 1958. The developmental sample has 7956 observations from the first eight years of the ten year period, and the verification sample has 2044 observations from the last two years.

Results

The four sets of predictors selected by REEP, using the 55 predictors for ACY are listed in Tables 7-4a to 7-4d. The predictors selected using the 467 Boolean-paired predictors are shown in Tables 7-5a to 7-5d. Also shown in each of these tables are coefficients in the REEP

regression equation for each group of the predictand. Contingency tables (Tables 7-6a to 7-6d) show the forecast-versus-observed frequencies for the 3-hr and 7-hr predictions of ceiling and visibility using the 55 dummy predictors for ACY listed in Table 7-3 and also using the 467 Boolean combination of predictors previously described. The number of correct forecasts (hits) and the Brier and Allen $\bar{P}$ scores as well as the individual group contributions to the overall $\bar{P}$ score are given below each contingency table. Tables 7-7a and 7-7b summarize the hits and $\bar{P}$ scores for this experiment. In addition, these tables show how the results of this experiment compare with those of Experiment No. 1, in which all the dummy predictors for the 13 station Atlantic City network were used, and with the results of a straight persistence forecast.

Conclusions

- 1) The single-station raw dummy predictors give results which are better than persistence.
- 2) The single-station Boolean predictors are as good or better than the raw predictors except for the $\bar{P}$ score in predicting 3-hr ceiling. Low conditions are forecast more often and more accurately with Boolean predictors.
- 3) Although the selected network predictors are quite a bit better than either single-station set of predictors, the Boolean set is consistently better than the network in predicting visibility.
- 4) The results are sufficiently encouraging to suggest that more work be done. In addition, it seems worth attempting to combine the set of network and Boolean predictors in a separate experiment (see Experiment No. 8).

Table 7-1

Definition of Predictand Groups for Atlantic City Municipal Airport

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling < 200 ft
2	200 ft $\leq$ Ceiling < 500 ft
3	500 ft $\leq$ Ceiling < 1000 ft
4	1000 ft $\leq$ Ceiling < 3000 ft
5	3000 ft $\leq$ Ceiling

<u>Group Number</u>	<u>Visibility Intervals</u>
1	0 mi $\leq$ Visibility < 1/2 mi
2	1/2 mi $\leq$ Visibility < 1 mi
3	1 mi $\leq$ Visibility < 2 mi
4	2 mi $\leq$ Visibility < 3 mi
5	3 mi $\leq$ Visibility

Table 7-2a

Specification of Predictands - Atlantic City Municipal Airport

(As used in prediction runs using raw predictors)

	Predictand			
	1	2	3	4
Predictand variable	CIG	CIG	VIS	VIS
Forecast interval--hours (H)	3	7	3	7
Number of Groups (G)	5	5	5	5
Observations in Group 1 (n_1)	100	135	153	167
Observations in Group 2 (n_2)	281	272	125	130
Observations in Group 3 (n_3)	385	420	200	230
Observations in Group 4 (n_4)	660	619	286	283
Observations in Group 5 (n_5)	6530	6510	7192	7146
Total dependent sample size (N)	7956	7956	7956	7956
Number of independent observations in the dependent sample (n)	7956	7956	7956	7956
Total independent sample size (M)	2044	2044	2044	2044
Number of available predictors (P)	55	55	55	55

Table 7-2b

Specification of Predictands - Atlantic City Municipal Airport

(As used in prediction runs using Boolean predictors)

	Predictand			
	1	2	3	4
Predictand variable	CIG	CIG	VIS	VIS
Forecast interval--hours (H)	3	7	3	7
Number of Groups (G)	5	5	5	5
Observations in Group 1 (n_1)	100	135	153	167
Observations in Group 2 (n_2)	281	272	125	130
Observations in Group 3 (n_3)	385	420	200	230
Observations in Group 4 (n_4)	660	619	286	283
Observations in Group 5 (n_5)	6530	6510	7192	7146
Total dependent sample size (N)	7956	7956	7956	7956
Number of independent observations in the dependent sample (n)	2652	2652	2652	2652
Total independent sample size (M)	2044	2044	2044	2044
Number of available predictors (P)	467	467	467	467

Table 7-2b

Specification of Predictands - Atlantic City Municipal Airport

(As used in prediction runs using Boolean predictors)

	Predictand			
	1	2	3	4
Predictand variable	CIG	CIG	VIS	VIS
Forecast interval--hours (H)	3	7	3	7
Number of Groups (G)	5	5	5	5
Observations in Group 1 (n_1)	100	135	153	167
Observations in Group 2 (n_2)	281	272	125	130
Observations in Group 3 (n_3)	385	420	200	230
Observations in Group 4 (n_4)	660	619	286	283
Observations in Group 5 (n_5)	6530	6510	7192	7146
Total dependent sample size (N)	7956	7956	7956	7956
Number of independent observations in the dependent sample (n)	2652	2652	2652	2652
Total independent sample size (M)	2044	2044	2044	2044
Number of available predictors (P)	467	467	467	467

Table 7-3

Predictors Available for Single-Station Predictions
Using Dummy Predictors for the Forecast Station (ACY)

<u>Element</u>	<u>No. of Dummies</u>	<u>Dummy No.</u>	<u>Specifications and Limits</u>	<u>Number of Occurrences</u>
			<u>Ceiling Height*, ft:</u>	
CIG	5	1.	$0 \leq \text{CIG} < 200$	109
		2.	$200 \leq \text{CIG} < 500$	263
		3.	$500 \leq \text{CIG} < 1000$	410
		4.	$1000 \leq \text{CIG} < 3000$	661
		5.	$3000 \leq \text{CIG}$	6513
	10	(1)	$\text{CIG} = 100$	53
		(2)	$\text{CIG} = 200$	64
		(3)	$\text{CIG} = 400$	98
		(4)	$\text{CIG} = 500$	108
		(5)	$\text{CIG} = 900$	62
		(6)	$1500 \leq \text{CIG} < 2000$	146
		(7)	$2500 \leq \text{CIG} < 3000$	123
		(8)	$3000 \leq \text{CIG} < 5000$	596
		(9)	$5000 \leq \text{CIG} < 10,000$	722
		(10)	$\text{CIG} = \text{Unlimited}$	4039
			<u>Visibility*, mi:</u>	
VIS	5	1.	$0 \leq \text{VIS} < 1/2$	139
		2.	$1/2 \leq \text{VIS} < 1$	115
		3.	$1 \leq \text{VIS} < 2$	213
		4.	$2 \leq \text{VIS} < 3$	274
		5.	$3 \leq \text{VIS}$	7215
	10	(1)	$1/4 \leq \text{VIS} < 1/2$	46
		(2)	$1/2 \leq \text{VIS} < 3/4$	52
		(3)	$3/4 \leq \text{VIS} < 1$	63
		(4)	$1 \leq \text{VIS} < 1-1/2$	114
		(5)	$1-1/2 \leq \text{VIS} < 2$	99

*Parentheses () used to help distinguish the two forms of dummies.

Table 7-3 - Continued

<u>Element</u>	<u>No. of Dummies</u>	<u>Dummy No.</u>	<u>Specifications and Limits</u>	<u>Number of Occurrences</u>
			<u>Visibility*. mi:</u>	
		(6)	2 ≤ VIS < 3	274
		(7)	3 ≤ VIS < 4	334
		(8)	4 ≤ VIS < 5	282
		(9)	5 ≤ VIS < 6	370
		(10)	15 ≤ VIS	1575
			<u>Wind:</u>	
WND	5	1.	Calm to 3 Knots, any direction	723
		2.	23° to 67°, 3 Knots < Speed	854
		3.	68° to 202°, 3 Knots < Speed	1727
		4.	203° to 247°, 3 Knots < Speed	1656
		5.	248° to 22°, 3 Knots < Speed	2976
			<u>Relative Humidity:</u>	
RLH	3	1.	75 per cent to 85 per cent	1387
		2.	86 per cent to 93 per cent	1418
		3.	94 per cent to 100 per cent	1262
			<u>Total Cloud Amount:</u>	
TCA	2	1.	5/10 to 9/10 (incl.)	2026
		2.	More than 9/10	2633
			<u>Weather Element**:</u>	
WEA	12	1.	No Weather	5721
		2.	Rain	395
		3.	Rain Showers	144
		4.	Drizzle	106
		5.	Snow	42
		6.	Snow Showers	3
		7.	Thunderstorm, Hail	36

* Parentheses () used to help distinguish the two forms of dummies.

** See Table 1-4 for a complete list of Weather Elements.

Table 7-3 - Continued

<u>Element</u>	<u>No. of Dummies</u>	<u>Dummy No.</u>	<u>Specifications and Limits</u>	<u>Number of Occurrences</u>
<u>Weather Elements**:</u>				
		8.	Freezing Rain, Sleet	3
		9.	Fog	689
		10.	Ground Fog	439
		11.	Blowing Snow, Blowing Sand	5
		12.	Smoke, Haze, Dust	816
<u>Sky Condition, Lower:</u>				
SCL	3	1.	Sky obscured	209
		2.	Thin broken clouds Thin overcast	380
		3.	Scattered clouds Dark scattered clouds	2267

**See Table 1-4 for a complete list of Weather Elements.

Table 7-4a

Selected Predictors and REEP Equations Using
Single-Station Predictors in Raw Dummy Form

Atlantic City 3-hr Ceiling

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	5	-.001	-.020	-.106	-.360	.487
2	ACY	CIG	1	.365	.278	.022	-.477	-.188
3	ACY	CIG	2	.035	.331	.017	-.301	-.082
4	ACY	CIG	3	-.006	.090	.175	-.208	-.052
5	ACY	TCA	2	.002	-.005	.023	.050	-.070
6	ACY	WEA	2	-.025	.083	.063	.018	-.140
7	ACY	VIS	5	-.061	.026	.041	-.040	.035
8	ACY	WND	5	-.006	-.026	-.032	-.022	.086
9	ACY	CIG	(1)	-.187	.050	-.106	.079	.164
10	ACY	CIG	(7)	.004	.012	-.086	-.129	.200
11	ACY	WND	4	-.007	-.028	-.033	-.013	.081
12	ACY	VIS	(1)	.099	-.024	.001	.040	-.116
13	ACY	WEA	9	.004	.055	-.001	.001	-.059
14	ACY	VIS	(4)	-.055	-.025	.161	-.049	-.032
15	ACY	WEA	7	-.014	-.035	-.077	-.180	.306
16	ACY	CIG	(8)	.001	-.002	.014	.082	-.095
17	ACY	VIS	4	-.038	.018	.028	-.026	.018
18	ACY	RLH	2	.005	.013	.026	.038	-.082
19	ACY	CIG	(6)	-.008	-.016	-.076	.142	-.042
20	ACY	WND	1	.006	-.021	-.042	-.014	.071
21	ACY	RLH	3	.013	.028	.038	.002	-.082
22	ACY	RLH	1	-.001	-.001	.011	.039	-.049
23	ACY	CIG	(4)	.004	-.004	.109	-.109	-.001
24	ACY	CIG	(5)	.001	-.100	-.018	.041	.075
25	ACY	WEA	4	-.006	.009	.082	.028	-.112
26	ACY	SCL	3	.000	.001	.008	.019	-.028
27	ACY	VIS	2	.035	.022	.097	-.066	-.088
28	ACY	SCL	1	.002	-.073	-.036	.042	.065
29	ACY	CIG	(2)	.012	.084	-.054	-.042	-.000
30	ACY	CIG	(9)	-.001	.001	-.002	.035	-.032
Additive Constant:				.066	.014	.083	.409	.428

Table 7-4b

Selected Predictors and REEP Equations Using
Single-Station Predictors in Raw Dummy Form

Atlantic City 7-hr Ceiling

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	5	-.010	-.110	-.137	-.079	.336
2	ACY	TCA	2	.000	.011	.037	.060	-.108
3	ACY	WND	5	-.025	-.047	-.052	-.039	.163
4	ACY	WND	4	-.022	-.044	-.053	-.035	.155
5	ACY	RLH	3	.010	-.000	.046	.086	-.142
6	ACY	CIG	2	.006	.090	-.016	-.090	.011
7	ACY	SCL	1	.047	-.074	-.057	-.019	.103
8	ACY	RLH	2	.009	.018	.033	.050	-.110
9	ACY	WEA	2	.001	.079	.075	-.037	-.117
10	ACY	WND	1	-.011	-.032	-.047	-.021	.111
11	ACY	CIG	4	-.008	-.048	-.088	.060	.085
12	ACY	RLH	1	.007	.008	.019	.032	-.066
13	ACY	WEA	9	.025	.004	.010	-.000	-.039
14	ACY	VIS	(3)	.054	.008	.090	-.135	-.017
15	ACY	WEA	4	.046	.044	.070	-.016	-.143
16	ACY	CIG	(8)	.004	.005	.012	.039	-.060
17	ACY	WEA	7	.010	.002	-.130	-.109	.228
18	ACY	CIG	1	.127	.035	-.004	.025	-.184
19	ACY	CIG	(1)	-.122	-.010	.042	-.094	.184
20	ACY	VIS	2	.039	.047	-.099	.119	-.106
21	ACY	VIS	4	.029	.014	.007	-.045	-.005
22	ACY	CIG	(5)	-.048	-.079	-.033	.116	.044
23	ACY	CIG	(7)	.026	-.073	-.005	-.034	.086
24	ACY	CIG	(6)	.011	-.063	-.020	.070	.002
25	ACY	WEA	3	-.001	-.020	.063	.019	-.061

Additive Constant: .029 .146 .174 .115 .536

Table 7-4c

Selected Predictors and REEP Equations Using
Single-Station Predictors in Raw Dummy Form

Atlantic City 3-hr Visibility

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	VIS	5	-.025	-.014	-.067	-.098	.204
2	ACY	VIS	1	.285	.041	-.087	-.150	-.089
3	ACY	RLH	3	.034	.026	.040	.035	-.134
4	ACY	VIS	2	.156	.189	-.016	-.084	-.245
5	ACY	WEA	1	-.036	.002	.006	-.040	.069
6	ACY	WEA	9	.000	.018	.042	.047	-.106
7	ACY	RLH	2	.011	.006	.018	.027	-.062
8	ACY	CIG	1	.217	.017	.119	.041	-.395
9	ACY	CIG	(1)	-.138	-.056	-.086	-.065	.344
10	ACY	WEA	2	-.062	-.013	.032	.026	.017
11	ACY	WEA	5	-.060	.088	.154	-.077	-.135
12	ACY	CIG	(2)	-.027	-.007	.119	.036	-.122
13	ACY	VIS	3	.053	.041	-.053	-.005	-.036
14	ACY	SCL	1	-.071	.030	-.031	-.026	.098
15	ACY	VIS	(1)	-.052	.022	.140	-.062	-.048
16	ACY	VIS	(8)	-.012	.017	.005	.055	-.064
17	ACY	WEA	4	-.056	.025	.067	.006	-.044
18	ACY	WEA	7	-.081	-.010	-.058	-.036	.184
19	ACY	WND	5	-.005	-.010	-.007	-.014	.038
20	ACY	WND	4	-.004	-.010	-.016	-.005	.035
21	ACY	VIS	(4)	.030	-.017	.082	-.103	.008
22	ACY	WEA	12	-.029	.006	.018	-.014	.019
23	ACY	CIG	3	-.029	-.012	.011	.018	.012
Additive Constant:				.064	.021	.069	.149	.697

Table 7-4d

Selected Predictors and REEP Equations Using
Single-Station Predictors in Raw Dummy Form

Atlantic City 7-hr Visibility

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	WEA	9	.012	.001	.044	.009	-.066
2	ACY	WEA	1	-.011	-.002	-.011	-.028	.052
3	ACY	WND	5	-.013	-.020	-.018	-.027	.078
4	ACY	WND	4	-.003	-.017	-.015	-.020	.055
5	ACY	CIG	2	.014	.037	.053	.011	-.115
6	ACY	VIS	5	-.048	-.011	.002	.011	.046
7	ACY	RLH	2	.014	.012	.022	.021	-.069
8	ACY	CIG	3	.005	.004	.046	.007	-.062
9	ACY	VIS	2	-.029	.092	-.041	-.010	-.012
10	ACY	TCA	2	-.009	.001	.014	.022	-.028
11	ACY	CIG	1	.121	-.070	.072	.063	-.186
12	ACY	CIG	(1)	-.128	-.023	-.040	.065	.126
13	ACY	VIS	(3)	.129	-.020	.080	-.036	-.153
14	ACY	SCL	1	.019	.068	-.054	-.032	-.002
15	ACY	WND	3	.021	.000	.000	-.003	-.018
16	ACY	WEA	4	.005	.051	-.006	.008	-.058
17	ACY	RLH	3	.015	.005	.010	.010	-.040
18	ACY	WEA	5	-.055	.046	.034	-.010	-.014
19	ACY	WEA	2	-.016	.000	.030	.038	-.052
Additive Constant:				.069	.031	.026	.045	.829

Table 7-5a

Selected Predictors and REEP Equations Using
Single-Station Predictors in Boolean Pairs

Atlantic City 3-hr Ceiling

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	5	.063	-.029	-.064	-.287	.318
2	ACY	CIG	1	.414	.215	.009	-.378	-.260
3	ACY	CIG	2	.068	.304	.039	-.260	-.151
4	ACY	CIG	3	.005	.059	.221	-.209	-.076
5	and ACY	TOD 1930E-0130E						
	ACY	WEA	9	.171	.010	-.103	-.082	.004
6	ACY	TCA	2	-.005	-.021	-.010	.063	-.027
7	and ACY	WEA	2-8					
	ACY	WEA	9	-.039	.108	.045	-.046	-.068
8	and ACY	WND	2					
	ACY	TCA	2	.014	.059	.085	.038	-.196
9	and ACY	WND	3					
	ACY	TCA	2	.015	.055	.069	-.007	-.132
10	and ACY	CIG	5					
	ACY	VIS	5	-.067	-.021	-.048	-.048	.184
11	ACY	CIG	(1)	-.197	.040	-.058	.075	.139
12	ACY	WEA	2	-.010	.079	.039	.028	-.136
13	ACY	CIG	(7)	.006	.010	-.073	-.171	.227
14	and ACY	CIG	(8)					
	ACY	TCA	2	.001	.004	.024	.103	-.132
15	and ACY	TOD 0730E-1330E						
	ACY	CIG	4	-.007	-.061	-.035	.150	-.047
16	and ACY	WEA	2-8					
	ACY	DOY	151-300	-.004	-.090	.076	-.016	.035
Additive Constant:				.005	.054	.116	.353	.472

Table 7-5b

Selected Predictors and REEP Equations Using
Single-Station Predictors in Boolean Pairs

Atlantic City 7-hr Ceiling

Order	Selected Predictors			Coefficients of the REEP Equations				
	Station	Element	Dummy	$-A_1$	A_2	A_3	A_4	A_5
1	ACY	CIG	5	-.005	-.049	-.069	-.129	.252
2	ACY	TCA	2	.025	.076	.123	.113	-.336
3	and	ACY	TOD 1930E-0130E	.175	.024	-.031	-.095	-.074
		ACY	WEA 9					
4	and	ACY	WND 5	-.037	-.104	-.109	-.063	.313
		ACY	TCA 2					
5	and	ACY	WND 4	-.034	-.092	-.115	-.050	.292
		ACY	TCA 2					
6		ACY	RLH 3	.023	.054	.006	.045	-.128
7		ACY	CIG 2	-.006	.105	.007	-.089	-.016
8		ACY	RLH 2	.009	.023	.034	.030	-.095
9		ACY	WEA 2	-.005	.064	.044	-.018	-.085
10	and	ACY	TOD 1330E-1930E	.104	-.002	-.077	-.053	.027
		ACY	WEA 9					
11	and	ACY	WND 1	-.008	-.063	-.094	-.018	.183
		ACY	TCA 2					
12	and	ACY	WND 3	.020	.014	.028	.050	-.113
		ACY	TCA 1					
13	and	ACY	DOY 151-300	-.015	-.069	.100	.021	-.037
		ACY	RLH 3					
14	and	ACY	WEA 2-8	-.007	.025	.132	-.059	-.091
		ACY	WEA 9					
15		ACY	SCL 1	.072	-.026	-.012	-.026	-.007
16	and	ACY	TOD 0130E-0730E	-.015	-.015	-.023	.071	-.017
		ACY	DOY 151-300					
Additive Constant				.008	.051	.069	.140	.732

Table 7-5c

Selected Predictors and REEP Equations Using
Single-Station Predictors in Boolean Pairs

Atlantic City 3-hr Visibility

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	VIS	5	-.039	-.029	-.076	-.082	.227
2	ACY	VIS	1	.290	.042	-.008	-.134	-.190
3	ACY	RLH	3	.042	.036	.054	.056	-.187
4	ACY	VIS	2	.114	.179	-.007	-.062	-.224
5	and ACY	CIG WEA	5 1	-.002	-.008	-.013	-.042	.064
6	and ACY	TOD 1930E-0130E WEA	9	.133	.064	.044	-.006	-.236
7	and ACY	TOD 1930E-0130E WEA	10	.121	-.008	.012	-.038	-.087
8	ACY	RLH	2	.007	.005	.019	.033	-.065
9	and ACY	WND RLH	4 3	-.013	-.037	-.081	-.016	.147
10	and ACY	WEA RLH	2-8 2	-.068	-.017	.028	.008	.048
11	and ACY	WEA TOD 0130E-0730E	2-8	.011	.003	.053	.087	-.153
Additive Constant:				.041	.038	.090	.126	.706

Table 7-5d

Selected Predictors and REEP Equations Using
Single-Station Predictors in Boolean Pairs

Atlantic City 7-hr Visibility

Order	Selected Predictors				Coefficients of the REEP Equations				
	Station	Element	Dummy		A ₁	A ₂	A ₃	A ₄	A ₅
1	and	ACY ACY	CIG VIS	5 5	-.027	-.022	-.057	-.043	.148
2	and	ACY ACY	TOD 1930E-0130E RLH	3 3	.092	.021	.053	.040	-.205
3	and	ACY ACY	TCA WEA	2 9	.059	.044	.059	.040	-.201
4	and	ACY ACY	TOD 1930E-0130E RLH	2 2	.026	.020	.045	.052	-.143
5	and	ACY ACY	TOD 1330E-1930E WEA	12 12	.043	.028	.037	.042	-.150
6		ACY	WHD	5	-.018	-.019	-.018	-.028	.083
7		ACY	WHD	4	-.013	-.017	-.017	-.020	.067
8		ACY	VIS	2	.067	.095	-.030	-.042	-.090
9	and	ACY ACY	TOD 0130E-0730E WEA	9 9	-.068	-.055	-.028	-.017	.167
10	and	ACY ACY	CIG VIS	4 5	-.026	-.020	-.039	-.026	.111
Additive Constant:					.042	.040	.077	.077	.765

Table 7-6a

Contingency Tables Showing Predicted-Versus-Actual Groups When
Single Station Predictors are in Raw Dummy Form and When
Single Station Predictors are in Boolean Form

Atlantic City 3-hour Ceiling (Independent Sample)

REEP Single
Station Predictors in
Raw Dummy Form

<u>Group</u>	<u>Actual</u>					<u>Total</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
1	9	4	2	0	3	18
2	20	36	27	10	10	103
3	1	11	45	14	12	83
4	1	9	20	47	28	105
5	13	13	33	94	1582	1735
Total	44	73	127	165	1635	2044

Hits = 1719 $\bar{P} = .2246$

P_g .0163 .0275 .0440 .0613 .0755

REEP Single
Station Predictors in
Boolean Form (Pairs)

<u>Group</u>	<u>Actual</u>					<u>Total</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
1	12	3	1	0	1	17
2	19	38	27	10	10	104
3	0	9	42	10	6	67
4	1	7	16	40	29	93
5	12	16	41	105	1589	1763
Total	44	73	127	165	1635	2044

Hits = 1721 $\bar{P} = .2275$

P_g .0158 .0277 .0442 .0626 .0772

Table 7-6b

Contingency Tables Showing Predicted-Versus-Actual Groups When
Single Station Predictors are in Raw Dummy Form and When
Single Station Predictors are in Boolean Form

Atlantic City 7-hour Ceiling (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Single Station Predictors in Raw Dummy Form	1	0	0	1	1	0	2
	2	3	9	9	5	4	30
	3	8	11	24	12	8	63
	4	2	5	5	3	4	19
	5	28	54	108	137	1603	1930
	Total	41	79	147	158	1619	2044

Hits = 1639 $\bar{P} = .2678$

P_g .0187 .0336 .0564 .0658 .0932

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Single Station Predictors in Boolean Form (Pairs)	1	2	1	0	2	3	8
	2	6	11	9	5	3	34
	3	6	12	26	9	5	58
	4	4	7	13	8	6	38
	5	23	48	99	134	1602	1906
	Total	41	79	147	158	1619	2044

Hits = 1649 $\bar{P} = .2676$

P_g .0184 .0326 .0567 .0660 .0939

Table 7-6c

Contingency Tables Showing Predicted-Versus-Actual Groups When
Single Station Predictors are in Raw Dummy Form and When
Single Station Predictors are in Boolean Form

Atlantic City 3-hour Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Single Station Predictors in Raw Dummy Form	1	8	6	3	0	3	20
	2	0	2	6	0	5	13
	3	1	3	0	0	0	4
	4	0	0	0	0	0	0
	5	33	35	69	93	1777	2007
	Total	42	46	78	93	1785	2044

Hits = 1787 $\bar{P} = .1796$

P_g .0167 .0197 .0326 .0392 .0713

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Single Station Predictors in Boolean Form (Pairs)	1	16	9	7	1	4	37
	2	0	1	0	0	3	4
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	26	36	71	92	1778	2003
	Total	42	46	78	93	1785	2044

Hits = 1795 $\bar{P} = .1788$

P_g .0165 .0201 .0327 .0389 .0705

Table 7-6d

Contingency Tables Showing Predicted-Versus-Actual Groups When
Single Station Predictors are in Raw Dummy Form and When
Single Station Predictors are in Boolean Form

Atlantic City 7-hour Visibility (Independent Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Single Station Predictors in Raw Dummy Form	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	43	38	90	99	1774	2044
	Total	43	38	90	99	1774	2044

Hits = 1774 $\bar{P} = .2170$

P_g .0200 .0180 .0401 .0444 .0945

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Single Station Predictors in Boolean Form (Pairs)	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	43	38	90	99	1774	2044
	Total	43	38	90	99	1774	2044

Hits = 1774 $\bar{P} = .2140$

P_g .0196 .0178 .0398 .0443 .0924

Table 7-7a

Comparison Between REEP Forecasts Using Single-Station Predictors in Raw Dummy Form, Single-Station Predictors in Boolean Pairs, All the Dummy Predictors from the 13-Station Network*, and Persistence*.

ACY Ceiling, 3-hr Forecast (Independent Sample)

Hits	Single-Station Dummies	1719
	Single-Station Boolean Pairs	1721
	Network Dummies	1728**
	Persistence	1702
$\bar{P}$ Score	Single-Station Dummies	.2246
	Single-Station Boolean Pairs	.2275
	Network Dummies	.2135**
	Persistence	.2385

ACY Ceiling, 7-hr Forecast (Independent Sample)

Hits	Single-Station Dummies	1639
	Single-Station Boolean Pairs	1649
	Network Dummies	1665**
	Persistence	1588
$\bar{P}$ Score	Single-Station Dummies	.2678
	Single-Station Boolean Pairs	.2676
	Network Dummies	.2600**
	Persistence	.2899

*See Experiment No. 1.

**Asterisks are used to denote superiority.

Table 7-7b

Comparison Between REEP Forecasts Using Single-Station Predictors in Raw Dummy Form, Single-Station Predictors in Boolean Pairs, All the Dummy Predictors from the 13-Station Network*, and Persistence*.

ACY Visibility, 3-hr Forecast (Independent Sample)

Hits	Single-Station Dummies	1787
	Single-Station Boolean Pairs	1795**
	Network Dummies	1794
	Persistence	1756
$\bar{P}$ Score	Single-Station Dummies	.1796
	Single-Station Boolean Pairs	.1788**
	Network Dummies	.1800
	Persistence	.1910

ACY Visibility, 7-hr Forecast (Independent Sample)

Hits	Single-Station Dummies	1774**
	Single-Station Boolean Pairs	1774**
	Network Dummies	1773
	Persistence	1674
$\bar{P}$ Score	Single-Station Dummies	.2170
	Single-Station Boolean Pairs	.2140**
	Network Dummies	.2150
	Persistence	.2270

*See Experiment No. 1.

**Asterisks are used to denote superiority.

EXPERIMENT 8. Combination of Selected Predictors from Network and Single-Station Boolean.

Purpose

To determine the extent of the improvement in the forecast when using the combined predictors selected by two separate methods.

Procedure

The 58 predictors selected by REEP in the four selection runs (CIG + 3 hrs, CIG + 7 hrs, VIS + 3 hrs, VIS + 7 hrs) using all the dummy predictors of the 13-station Atlantic City network (see Experiment No. 1) were combined with the 53 single-station predictors selected using the Boolean-paired predictors of the forecast station (see Experiment No. 7). Eliminating the duplication of predictors selected in these two ways resulted in 78 predictors, which were used in this experiment (Table 8-3). Four prediction runs were made and the results compared with the results using the network predictors (Experiment No. 1) and the Boolean-paired predictors (Experiment No. 7).

Predictands

As before, the predictands are divided into five operationally significant intervals of ceiling and visibility (Table 8-1). The specifications of the predictands are listed in Table 8-2.

Predictors

The 78 predictors used in this experiment are shown in Table 8-3, with the number of occurrences of each in the developmental sample of 7956 observations also shown. The specifications and limits of the dummy variables are as previously indicated in Table 1-4.

Data Sample

The data sample consists of 10,000 observations selected at random from the ten-year period, 1 January 1949 to 31 December 1958. The developmental sample consists of 7956 observations from the first eight years of the data sample and the verification sample consists of 2044 observations from the last two years of the ten-year period.

Results

The predictors selected by REEP for the four selection runs are shown in Tables 8-4a to 8-4d. The REEP regression equation coefficients for each group of the predictand is also shown. Contingency tables (Tables 8-5a to 8-5d) show the forecast-versus-observed frequencies for the 3-hour and 7-hour predictions of ceiling and visibility using the combined predictors as previously described. The number of correct forecasts (hits), the Brier and Allen $\bar{P}$ scores, and the individual group contributions to the overall $\bar{P}$ score are given. The comparison of the hits and the $\bar{P}$ scores achieved by these combined predictors with the hits and $\bar{P}$ scores of the network predictors alone, and the Boolean-paired single station predictors alone, is shown in Table 8-6.

Conclusions

The results of this combined study are a decided improvement over either the network or the single station Boolean predictors taken separately. This suggests that Boolean predictors generated between network variables might even improve upon the results obtained in the present combination.

Table 8-1

Definition of Predictand Groups for Atlantic City Municipal Airport

<u>Group Number</u>	<u>Ceiling Intervals</u>
1	0 ft $\leq$ Ceiling < 200 ft
2	200 ft $\leq$ Ceiling < 500 ft
3	500 ft $\leq$ Ceiling < 1000 ft
4	1000 ft $\leq$ Ceiling < 3000 ft
5	3000 ft $\leq$ Ceiling

<u>Group Number</u>	<u>Visibility Intervals</u>
1	0 mi $\leq$ Visibility < 1/2 mi
2	1/2 mi $\leq$ Visibility < 1 mi
3	1 mi $\leq$ Visibility < 2 mi
4	2 mi $\leq$ Visibility < 3 mi
5	3 mi $\leq$ Visibility

Table 8-2

Specification of Predictands - Atlantic City Municipal Airport

	Predictand			
	1	2	3	4
Predictand variable	CIG	CIG	VIS	VIS
Forecast interval--hours (H)	3	7	3	7
Number of Groups (G)	5	5	5	5
Observations in Group 1 (n_1)	100	135	153	167
Observations in Group 2 (n_2)	281	272	125	130
Observations in Group 3 (n_3)	385	420	200	230
Observations in Group 4 (n_4)	660	619	286	283
Observations in Group 5 (n_5)	6530	6510	7192	7146
Total dependent sample size (N)	7956	7956	7956	7956
Number of independent observations in the dependent sample (n)	2652	2652	2652	2652
Total independent sample size (M)	2044	2044	2044	2044
Number of available predictors (P)	78	78	78	78

Table 8-3

The 78 Dummy Predictors Used in Experiment 8

(See Table 1-4 for limits and specifications of each dummy)

<u>Predictor Number</u>	<u>Station</u>	<u>Element</u>	<u>Dummy</u>	<u>Number of Occurrences</u>
1	ACY	TOD	1	3994
2	NEL	CIG	3	411
3	NEL	TCA	2	2671
4	NEL	WEA	1	5042
5	NEL	WEA	2	423
6	NEL	WEA	9	845
7	PHL	CIG	1	42
8	PHL	CIG	5	6726
9	PHL	WND	3	1192
10	PHL	WEA	1	4760
11	PHL	WEA	7	25
12	SBY	CIG	4	654
13	SBY	CIG	5	6678
14	SBY	VIS	2	91
15	SBY	VIS	5	7438
16	SBY	WEA	2	319
17	SBY	WEA	9	751
18	MDT	VIS	2	107
19	ACY	CIG	1	109
20	ACY	CIG	2	263
21	ACY	CIG	3	410
22	ACY	CIG	4	661
23	ACY	CIG	5	6513
24	ACY	CIG	(1)	53
25	ACY	CIG	(6)	146
26	ACY	VIS	1	139
27	ACY	VIS	2	115
28	ACY	VIS	3	213
29	ACY	VIS	4	274
30	ACY	VIS	5	7215
31	ACY	RLH	3	1262
32	ACY	SCL	1	209
33	ACY	TCA	2	2633
34	ACY	WEA	1	5721
35	ACY	WEA	9	689
36	DCA	CIG	3	283
37	DCA	CIG	5	6943
38	DCA	VIS	5	7568
39	DCA	RLH	3	526
40	DCA	WEA	2	423

Table 8-3 - Continued

<u>Predictor Number</u>	<u>Station</u>	<u>Element</u>	<u>Dummy</u>	<u>Number of Occurrences</u>
41	DCA	WEA	9	512
42	ORF	RLH	3	791
43	PSB	CIG	1	206
44	PSB	RLH	3	1595
45	PSB	WEA	8	43
46	SWF	WND	3	1007
47	IDL	VIS	3	174
48	IDL	WND	2	1025
49	ACY	CIG	(7)	123
50	ACY	WND	4	1676
51	ACY	WND	5	2976
52	ACY	RLH	2	1418
53	ACY	WEA	2	395
54	and ACY	TOD	1	841
	ACY	DOY	1	
55	and ACY	TOD	2	258
	ACY	WEA	9	
56	and ACY	TOD	3	243
	ACY	CIG	4	
57	and ACY	TOD	4	118
	ACY	WEA	9	
58	and ACY	TOD	4	290
	ACY	WEA	12	
59	and ACY	TOD	5	505
	ACY	RLH	2	
60	and ACY	TOD	5	425
	ACY	RLH	3	
61	and ACY	TOD	5	160
	ACY	WEA	9	
62	and ACY	TOD	5	105
	ACY	WEA	10	
63	and ACY	DOY	1	578
	ACY	RLH	3	
64	and ACY	CIG	3	383
	ACY	TCA	2	
65	and ACY	CIG	5	6264
	ACY	VIS	5	
66	and ACY	CIG	5	5277
	ACY	WEA	1	

Table 8-3 - Continued

<u>Predictor Number</u>	<u>Station</u>	<u>Element</u>	<u>Dummy</u>	<u>Number of Occurrences</u>
67	and ACY ACY	CIG TCA	(8) 2	332
68	and ACY ACY	WND TCA	1 2	233
69	and ACY ACY	WND TCA	2 2	496
70	and ACY ACY	WND TCA	3 1	538
71	and ACY ACY	WND TCA	3 2	754
72	and ACY ACY	WND RLH	4 3	236
73	and ACY ACY	WND TCA	4 2	492
74	and ACY ACY	WND TCA	5 2	658
75	and ACY ACY	WEA TOD	(1-8) 2	182
76	and ACY ACY	WEA DOY	(1-8) 1	215
77	and ACY ACY	WEA RLH	(1-8) 3	424
78	and ACY ACY	WEA WEA	(1-8) 9	273

Table 8-4a

Selected Predictors and REEP Equations

(Combined Network and Single Station Boolean Predictors)

Atlantic City 3-hr Ceiling

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	CIG	5	.044	-.014	-.008	-.168	.146
2	ACY	CIG	1	.264	.215	.003	-.295	-.188
3	PHL	CIG	5	.008	-.021	-.066	-.129	.208
4	ACY	CIG	2	.062	.262	.009	-.216	-.118
5	and ACY	TOD	5	.164	.015	-.082	-.057	-.040
	ACY	WEA	9					
6	and ACY	CIG	3	.006	.038	.188	-.157	-.075
	ACY	TCA	2					
7	DCA	CIG	5	.004	-.021	-.050	-.050	.117
8	SBY	CIG	5	-.014	-.057	-.034	-.006	.110
9	NEL	TCA	2	.003	.007	.010	.042	-.062
10	and ACY	CIG	5	-.053	-.008	-.035	-.020	.115
	ACY	VIS	5					
11	DCA	RLH	3	.011	.067	.000	-.048	-.030
12	NEL	CIG	3	-.008	-.010	.085	-.023	-.044
13	and ACY	WEA	(1-8)	-.038	.099	-.003	-.051	-.007
	ACY	WEA	9					
14	IDL	WND	2	.009	.018	.016	.030	-.074
15	SBY	CIG	4	-.016	-.073	-.026	.098	.017
16	SWF	WND	3	.007	.023	.021	.019	-.071
17	ACY	CIG	(6)	-.007	-.016	-.041	.171	-.108
18	SBY	WEA	2	-.006	.070	-.009	.054	-.109
19	NEL	WEA	2	-.018	.003	.072	-.037	-.020
20	ACY	CIG	2	-.004	-.073	.075	-.009	.012
21	and ACY	CIG	(8)	.002	-.015	.002	.087	-.077
	ACY	TCA	2					
22	ACY	VIS	1	.069	-.052	-.063	.035	.011
23	and ACY	TOD	3	-.003	-.046	-.031	.115	-.036
	ACY	CIG	4					
<u>Additive Constant:</u>				.009	.116	.190	.381	.305

Table 8-4b

Selected Predictors and REEP Equations

(Combined Network and Single Station Boolean Predictors)

Atlantic City 7-hr Ceiling

Order	Selected Predictors			Coefficients of the REEP Equations				
	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	PHL	CIG	5	.003	-.038	-.045	-.084	.164
2	DCA	CIG	5	-.001	-.001	-.040	-.074	.116
3	and	ACY	TOD	.174	.033	-.006	-.100	-.101
		ACY	WEA					
4	ACY	TCA	2	-.007	-.020	.000	.052	-.026
5	IDL	WND	2	-.002	.022	.040	.035	-.096
6	PHL	WND	3	.023	.012	.025	.044	-.104
7	ACY	CIG	5	-.006	-.022	-.029	-.070	.127
8	DCA	WEA	2	-.016	.052	.117	-.026	-.127
9	NEL	WEA	9	.014	.019	.056	.011	-.100
10	and	ACY	WND	.020	.067	.093	.012	-.192
		ACY	TCA					
11	and	ACY	WND	.025	.063	.055	-.000	-.142
		ACY	TCA					
12	and	ACY	TOD	.104	.017	-.029	-.076	-.017
		ACY	WEA					
13	and	ACY	TOD	-.017	-.022	-.032	.066	.006
		ACY	DOY					
14	and	ACY	DOY	-.005	-.038	.082	.029	-.068
		ACY	RLH					
15	DCA	CIG	3	.000	.088	-.003	-.053	-.032
16	ACY	CIG	2	-.008	.087	-.002	-.127	.051
17	ACY	SCL	1	.073	-.041	-.037	-.022	.027
18	SBY	WEA	9	.011	.046	.002	.030	-.088
19	PSB	RLH	3	.011	.004	.019	.022	-.056
20	and	ACY	WEA (1-8)	-.014	.010	.106	-.035	-.067
		ACY	TOD					
21	PSB	CIG	1	.002	.076	-.037	-.025	-.016
<u>Additive Constant:</u>				.007	.064	.111	.237	.581

Table 8-4c

Selected Predictors and REEP Equations

(Combined Network and Single Station Boolean Predictors)

Atlantic City 3-hr Visibility

Selected Predictors				Coefficients of the REEP Equations				
Order	Station	Element	Dummy	A ₁	A ₂	A ₃	A ₄	A ₅
1	ACY	VIS	5	-.034	-.017	-.056	-.053	.161
2	ACY	VIS	1	.229	.037	-.023	-.158	-.085
3	ACY	RLH	3	.027	.027	.036	.023	-.114
4	ACY	VIS	2	.089	.173	-.019	-.077	-.166
5	DCA	WEA	9	.009	.010	.029	.047	-.095
6	SBY	VIS	5	-.001	-.020	-.026	-.060	.107
7	and ACY	TOD	5	.122	.066	.043	-.019	-.212
	ACY	WEA	9					
8	and ACY	TOD	5	.131	-.001	.028	-.030	-.127
	ACY	WEA	10					
9	NEL	WEA	9	.008	.011	.020	.052	-.091
10	and ACY	WEA	(1-8)	-.068	-.023	.015	-.009	.085
	ACY	RLH	3					
11	ACY	WEA	1	-.001	-.003	-.008	-.045	.056
12	MDT	VIS	2	-.019	.021	.119	-.027	-.095
13	ORF	RLH	3	.035	.009	.004	.005	-.053
14	and ACY	WND	4	-.005	-.031	-.072	.003	.104
	ACY	RLH	3					
15	ACY	CIG	1	.102	-.008	.001	-.017	-.078
16	and ACY	WEA	(1-8)	.006	.006	.053	.078	-.143
	ACY	TOD	2					
17	and ACY	TOD	4	.028	.048	.042	.023	-.141
	ACY	WEA	9					
<u>Additive Constant:</u>				.034	.042	.093	.164	.667

Table 8-4d

Selected Predictors and REEP Equations

(Combined Network and Single Station Boolean Predictors)

Atlantic City 7-hr Visibility

Order	Selected Predictors				Coefficients of the REEP Equations				
	Station	Element	Dummy		A ₁	A ₂	A ₃	A ₄	A ₅
1	and ACY	CIG	5		-.010	-.005	-.019	-.012	.046
	ACY	VIS	5						
2	and ACY	TOD	5		.083	.017	.046	.035	-.180
	ACY	RLH	3						
3		DCA	VIS	5	-.040	-.033	-.035	-.071	.179
4		ACY	TOD	1	-.019	-.009	-.011	-.013	.052
5		PHL	WEA	1	-.009	-.004	-.018	-.022	.054
6		ACY	WEA	9	.063	.030	.058	.022	-.173
7		DCA	WEA	2	-.026	-.018	.062	.078	-.096
8		IDL	VIS	3	.085	-.003	-.037	.017	-.062
9		PHL	WND	3	.013	.020	.020	.013	-.067
10		ACY	VIS	2	.061	.087	-.023	-.036	-.089
11	and ACY	TOD	2		-.070	-.054	-.033	-.011	.168
	ACY	WEA	9						
12	and ACY	TOD	5		.017	.016	.036	.042	-.111
	ACY	RLH	2						
13	and ACY	TOD	4		.028	.024	.032	.034	-.118
	ACY	WEA	12						
14		ACY	CIG	2	-.001	.061	.019	-.020	-.059
15	and ACY	WND	2		-.003	.019	.035	.034	-.086
	ACY	TCA	2						
<u>Additive Constant:</u>					.069	.049	.076	.117	.689

Table 8-5a

Contingency Tables Showing Predicted-Versus-Actual Groups for
(1) Combined Predictors Selected from Network and Single-Station
Boolean, (2) Network Alone, and (3) Single-Station Boolean Alone

Atlantic City 3-hr Ceiling (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Combined Predictors	1	14	1	2	0	3	20
	2	14	35	25	7	2	83
	3	0	10	40	14	6	70
	4	0	6	19	44	21	90
	5	16	21	41	100	1603	1781
	Total	44	73	127	165	1635	2044
Hits = 1736 $\bar{P} = .2114$							
P_g		.0155	.0276	.0422	.0600	.0660	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Network Predictors (See Experiment No. 1)	1	6	4	1	0	1	12
	2	19	34	25	8	4	90
	3	0	11	42	14	5	72
	4	1	6	19	41	20	87
	5	18	18	40	102	1605	1783
	Total	44	73	127	165	1635	2044
Hits = 1728 $\bar{P} = .2135$							
P_g		.0163	.0277	.0423	.0605	.0666	

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Single-Station Boolean Predictors (See Experiment No. 7)	1	12	3	1	0	1	17
	2	19	38	27	10	10	104
	3	0	9	42	10	6	67
	4	1	7	16	40	29	93
	5	12	16	41	105	1589	1763
	Total	44	73	127	165	1635	2044
Hits = 1721 $\bar{P} = .2275$							
P_g		.0158	.0277	.0442	.0626	.0772	

Table 8-5b

Contingency Tables Showing Predicted-Versus-Actual Groups for
(1) Combined Predictors Selected from Network and Single-Station
Boolean, (2) Network Alone, and (3) Single-Station Boolean Alone

Atlantic City 7-hr Ceiling (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Combined Predictors	1	0	2	1	2	1	6
	2	7	12	6	0	2	27
	3	2	18	39	14	9	82
	4	5	4	14	13	4	40
	5	27	43	87	129	1603	1889
	Total	41	79	147	158	1619	2044
Hits = 1667 $\bar{P} = .2576$							
P_g .0184 .0320 .0531 .0661 .0879							

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Network Predictors (See Experiment No. 1)	1	0	0	0	0	0	0
	2	3	9	9	1	2	24
	3	7	19	34	12	9	81
	4	8	7	22	20	6	63
	5	23	44	82	125	1602	1876
	Total	41	79	147	158	1619	2044
Hits = 1665 $\bar{P} = .2600$							
P_g .0180 .0323 .0540 .0666 .0891							

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Single-Station Boolean Predictors (See Experiment No. 7)	1	2	1	0	2	3	8
	2	6	11	9	5	3	34
	3	6	12	26	9	5	58
	4	4	7	13	8	6	38
	5	23	48	99	134	1602	1906
	Total	41	79	147	158	1619	2044
Hits = 1649 $\bar{P} = .2676$							
P_g .0184 .0326 .0561 .0660 .0939							

Table 8-5c

Contingency Tables Showing Predicted-Versus-Actual Groups for
(1) Combined Predictors Selected from Network and Single-Station
Boolean, (2) Network Alone, and (3) Single-Station Boolean Alone

Atlantic City 3-hr Visibility (Verification Sample)

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Combined Predictors	1	16	9	3	0	2	30
	2	2	2	3	0	5	12
	3	0	3	0	1	1	5
	4	0	1	4	3	0	8
	5	24	31	68	89	1777	1989
	Total	42	46	78	93	1785	2044

Hits = 1798 $\bar{P} = .1772$

P_g .0162 .0200 .0330 .0389 .0690

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Network Predictors (See Experiment No. 1)	1	13	9	5	1	4	32
	2	2	5	4	0	9	20
	3	0	2	0	0	0	2
	4	0	0	3	4	0	7
	5	27	30	66	88	1772	1983
	Total	42	46	78	93	1785	2044

Hits = 1794 $\bar{P} = .1800$

P_g .0169 .0199 .0331 .0395 .0707

	<u>Group</u>	<u>Actual</u>					<u>Total</u>
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
REEP Using Single-Station Boolean Predictors (See Experiment No. 7)	1	16	9	7	1	4	37
	2	0	1	0	0	3	4
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	26	36	71	92	1778	2003
	Total	42	46	78	93	1785	2044

Hits = 1795 $\bar{P} = .1788$

P_g .0165 .0201 .0327 .0389 .0705

Table 8-5d

Contingency Tables Showing Predicted-Versus-Actual Groups for
(1) Combined Predictors Selected from Network and Single-Station
Boolean, (2) Network Alone, and (3) Single-Station Boolean Alone

Atlantic City 7-hr Visibility (Verification Sample)

		Actual					
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>Total</u>
REEP Using Combined Predictors	1	1	0	1	1	1	4
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	42	38	89	98	1773	2040
Total		43	38	90	99	1774	2044
		Hits = 1774 $\bar{P} = .2141$					
P_g		.0193	.0179	.0397	.0447	.0924	

		Actual					
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>Total</u>
REEP Using Network Predictors (See Experiment No. 1)	1	0	0	1	0	1	2
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	43	38	89	99	1773	2042
Total		43	38	90	99	1774	2044
		Hits = 1773 $\bar{P} = .2150$					
P_g		.0196	.0178	.0394	.0446	.0936	

		Actual					
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>Total</u>
REEP Using Single-Station Boolean Predictors (See Experiment No. 7)	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	43	38	90	99	1774	2044
Total		43	38	90	99	1774	2044
		Hits = 1774 $\bar{P} = .2140$					
P_g		.0196	.0178	.0398	.0443	.0924	

Table 8-6

Comparison Between (1) Combined Predictors Selected from Network and Single-Station Boolean, (2) Network Predictors Alone*, and (3) Single-Station Boolean Predictors Alone**.

(Verification Sample)

ACY Ceiling, 3-hour Forecast

Hits	Combined Predictors	1736#
	Network Predictors	1728
	Single-Station Predictors	1721
$\bar{P}$ Score	Combined Predictors	.2114#
	Network Predictors	.2135
	Single-Station Predictors	.2275

ACY Ceiling, 7-hour Forecast

Hits	Combined Predictors	1667#
	Network Predictors	1665
	Single-Station Predictors	1649
$\bar{P}$ Score	Combined Predictors	.2576#
	Network Predictors	.2600
	Single-Station Predictors	.2676

ACY Visibility, 3-hour Forecast

Hits	Combined Predictors	1798#
	Network Predictors	1794
	Single-Station Predictors	1795
$\bar{P}$ Score	Combined Predictors	.1772#
	Network Predictors	.1800
	Single-Station Predictors	.1788

ACY Visibility, 7-hour Forecast

Hits	Combined Predictors	1774#
	Network Predictors	1773
	Single-Station Predictors	1774#
$\bar{P}$ Score	Combined Predictors	.2141
	Network Predictors	.2150
	Single-Station Predictors	.2140#

*See Experiment No. 1.

**See Experiment No. 7.

#Denotes superiority.

5.0 DISCUSSION

The REEP procedure has the following features to recommend its use over MDA:

Feature 1: The series of G regressions in REEP need not be restricted to mutually exclusive or exhaustive events as in MDA. Thus, any combination of conditions may be done simultaneously. For example, the following series of predictand elements might be considered in a single REEP analysis, where $G = 15$.

Y_1 = equal to unity if $0 \text{ ft} \leq \text{ceiling} < 200 \text{ ft}$

Y_2 = equal to unity if $200 \text{ ft} \leq \text{ceiling} < 500 \text{ ft}$

Y_3 = equal to unity if $500 \text{ ft} \leq \text{ceiling} < 1000 \text{ ft}$

Y_4 = equal to unity if $1000 \text{ ft} \leq \text{ceiling} < 1500 \text{ ft}$

Y_5 = equal to unity if $1500 \text{ ft} \leq \text{ceiling}$

Y_6 = equal to unity if $0 \text{ mi} \leq \text{visibility} < 1/2 \text{ mi}$

Y_7 = equal to unity if $1/2 \text{ mi} \leq \text{visibility} < 1 \text{ mi}$

Y_8 = equal to unity if $1 \text{ mi} \leq \text{visibility} < 2 \text{ mi}$

Y_9 = equal to unity if $2 \text{ mi} \leq \text{visibility} < 3 \text{ mi}$

Y_{10} = equal to unity if $3 \text{ mi} \leq \text{visibility}$

Y_{11} = equal to unity if $\begin{array}{l} 0 \text{ ft} \leq \text{ceiling} < 200 \text{ ft} \\ \text{or} \\ 0 \text{ mi} \leq \text{visibility} < 1/2 \text{ mi} \end{array}$

Y_{12} = equal to unity if $\begin{array}{l} 200 \text{ ft} \leq \text{ceiling} < 500 \text{ ft} \\ \text{or} \\ 1/2 \text{ mi} \leq \text{visibility} < 1 \text{ mi} \end{array}$

Y_{13} = equal to unity if $\begin{array}{l} 500 \text{ ft} \leq \text{ceiling} < 1000 \text{ ft} \\ \text{or} \\ 1 \text{ mi} \leq \text{visibility} < 2 \text{ mi} \end{array}$

Y_{14} = equal to unity if $1000 \text{ ft} \leq \text{ceiling} < 1500 \text{ ft}$
or
 $2 \text{ mi} \leq \text{visibility} < 3 \text{ mi}$

Y_{15} = equal to unity if $1500 \text{ ft} \leq \text{ceiling}$
or
 $3 \text{ mi} \leq \text{visibility}$

This feature has been made use of in Experiment 5.

Feature 2: Predictor selection in REEP is not biased by the group frequencies as is the case in MDA predictor selection. This is because each predictand variable (e.g., $Y_1, Y_2, \dots, Y_G$) is considered separately and distinctly during selection. Most importantly, at the time of termination of selection, the significance test says there is no predictor able to provide a significant contribution to any one of the G predictand variables. For example, if the series of predictand variables is the usual five ceiling categories then predictors able to discriminate category 1 (ceiling $< 100 \text{ ft}$) are being considered on an equal basis with those able to discriminate category 5 (ceiling $\geq 1500 \text{ ft}$). Another important feature in REEP selection is that the effective degrees of freedom, after account is taken of serial correlation, may be determined for each predictand variable separately and distinctly. For example, high ceiling conditions have a very high serial correlation (low effective degrees of freedom for nearly consecutive observations) whereas low ceiling conditions have a low serial correlation (high

effective degrees of freedom for consecutive observations). The facility to avoid the use of an average, as is unfortunately required in MDA, aids somewhat in selecting predictors having discriminatory information regarding the low conditions.

Feature 3: The mode of calculation in the REEP procedure has an additive structure in place of the multiplicative structure in MDA. That is, for both development and operational use REEP needs only the logical and arithmetic operations of addition which are faster relative to the arithmetic operations of multiplication required in the distance neighborhood portion of MDA. This has a decided effect on the speed with which both the statistical development and operational forecasting may be performed using the two techniques. The factor is in favor of REEP over MDA by about four to one (confirmed) in development and by 300 to one (estimated) in making operational forecasts.

Feature 4: It appears that REEP permits physical and synoptic interpretation of the selected predictors and the effect each has on the probability of the event being forecast. For example, in Experiment 1 (Table 1-5c) it can be seen that if the 9th predictor is a one (condition PHL ceiling < 200 ft is being observed) then .183 is added to the probability that the visibility condition three hours hence will be < 1/2 mile, whereas the other visibility categories add or subtract the following probability amounts: .018, -.079, -.084, and

-.039. However, the danger still exists for misinterpretation as a result of intercorrelation among predictors.

Feature 5: In operational forecasting, the REEP procedure can deal more efficiently than MDA with the problem of missing data or with previously unobserved weather combinations. The reason for this is that the output from REEP is a set of IBM cards containing a series of regression equations and a matrix and vector of crossproducts. If the value of a predictor variable is unavailable for making an operational forecast, a new equation omitting the missing predictor value may be generated from the output information. This operation takes very little time on a computer even when more than one predictor value is missing. MDA on the other hand has to have a matrix diagonalization performed to account for the missing predictor or predictors. In addition, discriminant functions must be calculated for the entire developmental sample of data. In REEP there is obviously no difficulty in making a prediction when the combination of predictors is not observed in the developmental sample. However, in MDA the output (on magnetic tape) is a table within which all predictor combinations observed in the developmental sample are given with the corresponding probability forecasts. When a new combination of events arises probabilities must be determined using distance neighborhood. The frequency of occurrence is about one out of every ten operational forecasts. This requirement is very

time consuming making it much less efficient than REEP
in those instances.

6.0 FUTURE WORK

The most profitable single item for future effort is the modification of the prediction model so as to introduce some form of nonlinear capability. A suitable approach to this problem has already been suggested by J. G. Bryan¹. The model consists of a linear exponential function which restricts the probability estimates to the interval (0,1). An additional feature of this model is that it uses the present REEP selection method to obtain a set of selected predictors and the REEP procedure to form a first estimate of the required coefficients. It therefore does not require an extended developmental period before it can be tested.

Another area for possible future work is a study of the selection criterion employed by REEP. The MDA criterion has been the subject of extensive research. Several possible alternatives are available and some have been looked into but none have been subjected to a fair comparison with the present method.

A combination of MDA and REEP to form a somewhat different forecast system should also be considered. This consists of applying the REEP method to the points enclosed in the Fix-Hodges neighborhood used by MDA. The purpose of this approach would be to replace the relative frequencies, now used as probabilities within the neighborhood, by the REEP estimates. While a detailed discussion of this method cannot be included here, it can be reported that this has been done for some selected cases with results which are quite encouraging.

¹ Bryan, J. G., 1963: Parametric estimation of probabilities in multiple group classification. Unpublished manuscript. The Travelers Research Center, Inc., 13 pp.

The matter of transforming continuous predictors to dummy predictors needs further investigation. Considerations include: means for introducing as much synoptic and/or dynamic information as possible into the dummies; experimentation with different logical combinations of the dummies; the effect of suppressing the within class variance of the continuous predictors which is an integral part of the dummifying process; and the forcing of a complete set of dummies onto the selection program whenever one of the sets is selected.

In the area of application of the technique many experiments remain to be carried out to determine its characteristics on different predictands and different data. The possibility of selecting a single set of predictors applicable to several predictands distributed either in space or in time has not been thoroughly explored. Several more parameters remain to be tested for both prediction and specification. Attempts to make predictions of continuous variables by increasing the number of predictand groups is also worth investigating. In summary, a great deal of work remains to be done in the application area.

7.0 ACKNOWLEDGEMENTS

Development of the REEP procedure was substantially aided by the efforts of Mr. Thomas G. Johnson. Programming of REEP for the IBM-7090 was performed by Mr. Johnson, Miss Edna L. Sorenson, and Miss Katherine Fogarty. Mr. Karl A. Abrahamson assisted in the preparation of the report. The manuscript was typed by Mrs. Edward Miller. The author is grateful to all of these individuals.

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