AP42 Section 2.5 Open Burning

Related

Title: Source test data from early 1970's

University of California, Riverside and other background information for section

UNIVERSITY OF CALIFORNIA, RIVERSIDE
UCRBL CMP
AUGUST, 1968

CORRELATIONS AND MULTIPLE REGRESSION

PURPOSE

CORRELATIONS

RAW DATA INPUT WILL GIVE AN OUTPUT OF AVERAGES, ADJUSTED SUMS OF SQUARES AND AN UPPER TRIANGULAR MATRIX OF SIMPLE CORRELATION COEFFICIENTS. IF ADJUSTED SUMS OF SQUARES ARE INPUT, AN UPPER TRIANGULAR MATRIX OF CORRELATION COEFFICIENTS WILL BE OUTPUT.

FOLLOWING CALCULATION OF CORRELATION COEFFICIENTS, ONE OR BOTH METHODS OF MULTIPLE REGRESSION MAY BE CALLED.

MULTIPLE REGRESSION DELETION METHOD

SELECTION OF A SUBSET OF INDEPENDENT VARIABLES EACH OF WHICH ACCOUNTS FOR A SIGNIFICANT PORTION OF VARIABLILTY OF THE DEPENDENT VARIABLE. PARTIAL REGRESSION COEFFICIENTS, STANDARD ERRORS, AND PARTIAL CORRELATION COEFFICIENTS ARE CALCULATED.

ALL INDEPENDENT VARIABLES ARE ENTERED INTO THE REGRESSION EQUATION, THE INVERSE OF THE MATRIX OF SUMS OF SQUARES AND CROSS PRODUCTS BEING CALCULATED IN THE PROCESS. THE MULTIPLE CORRELATION COEFFICIENT IS TESTED FOR SIGNIFICANCE ASSUMING ONE DEGREE OF FREEDOM FOR THE MULTIPLE CORRELATION COEFFICIENT AND N-1-K DEGREES OF FREEDOM FOR ERROR, WHERE K IS THE NUMBER OF INDEPENDENT VARIABLES AND N IS THE EFFECTIVE NUMBER OF OBSERVATIONS PER VARIABLE. IF THE TOTAL CONTRIBUTION IS NOT SIGNIFICANT THE PROBLEM IS TERMINATED. OTHERWISE, THE SMALLEST CONTRIBUTOR IN THE SET IS TESTED. IF NOT SIGNIFICANT, THE VARIABLE IS DELETED, THE INVERSE MATRIX AND VECTOR OF SOLUTIONS ARE ADJUSTED, THE TWO MATRICES ARE CONDENSED, AND THE SMALLEST CONTRIBUTOR IS TESTED.

DELETION CONTINUES UNTIL THE SMALLEST CONTRIBUTOR IN A SUBSET IS SIGNIFICANT.

THE CONSTANTS OF THE PREDICTION EQUATION, STANDARD ERRORS, AND PARTIAL CORRELATION COEFFICIENTS FOR THIS SUBSET ARE CALCULATED.

THE ORDER OF VARIABLE DELETION AND THE SQUARE OF EACH MULTIPLE CORRELATION COEFFICIENT IS RECORDED.

ZERO OR NEGATIVE VALUES IN THE MAJOR DIAGONAL OF THE INVERSE MATRIX WILL BE DETECTED.

IN CASE OF SINGULAR MATRIX, INVERSION IS NOT COMPLETE AND OUTPUT WILL SO NOTIFY.

THE ROUTINE FOR OPERATION IN THIS FORM WAS PROVIDED BY DR. JAMES N. BOLES.

MULTIPLE REGRESSION STEPWISE METHOD

A NUMBER OF INTERMEDIATE STEPS ARE COMPUTED. AT EACH STEP ONLY THE VARIABLE WHICH GIVES THE GREATEST INCREASE IN GOODNESS OF FIT IS ADDED. VARIABLES WITH NEGLIGIBLE EFFECTS ARE DROPPED. ONLY VARIABLES WITH SIGNIFICANT EFFECTS WILL BE RETAINED IN THE FINAL EQUATION.

DOUBLE PRECISION FLOATING POINT COMPUTATIONS TRUNCATED TO SEVEN SIGNIFICANT DIGITS.

RESTRICTIONS

1. THE PROGRAM IS WRITTEN FOR CARD INPUT/PRINTER OUTPUT FOR THE IBM 360.

2. INPUT AND OUTPUT ARE IN FORMAT FORM.

3. THERE ARE NO MISSING VALUES.

4. THE NUMBER OF WORDS PER CARD MUST NOT EXCEED THE READ LIST.

5. MAXIMUM NUMBER OF INDEPENDENT VARIABLES IS 34. MAXIMUM NUMBER OF DEPENDENT VARIABLES IS 1.

6. THE NUMBER OF DEGREES OF FREEDOM MUST BE GREATER THAN THE NUMBER OF INDEPENDENT VARIABLES.

7. THE MINIMUM F VALUE IS 1.00 BECAUSE SPECIFIED F VALUE FOR ENTERING A VARIABLE MUST BE AT LEAST AS GREAT AS THAT FOR DROPPING A VARIABLE.

CARD PREPARATION AND INPUT ORDER

1. PARAMETER CARD (6F10.0,4F5.0)

WORD

1. IDENTIFICATION NUMBER.

2. LOT NUMBER.

3. TOTAL NUMBER OF VARIABLES (M).

4. IF AIFORM IS 1., COUNT PER VARIABLE.
IF AIFORM IS 2., DEGREES OF FREEDOM FOR SUM OF SQUARES.

5. AIFORM.

1. IF INPUT CONSISTS OF RAW DATA.
2. IF INPUT CONSISTS OF AVERAGES, ADJUSTED SUMS OF SQUARES AND CROSS PRODUCTS.

6. AIMAIN.

1. IF DATA IS UNCHANGED BY SUBROUTINE.
2. IF DATA IS OPERATED ON BY SUBROUTINE.

7. FORM.
1. IF ENTRY NUMBERS ARE THE SAME AS VARIABLE NUMBERS.
2. IF CARD WITH ORIGINAL VARIABLE NUMBERS FOLLOWS DATA.

8. CODE.
0. IF BOTH REGRESSION METHODS (DELETION AND STEPWISE) ARE DESIRED.
1. IF ONLY DELETION METHOD (752) DESIRED.
2. IF ONLY STEPWISE METHOD (718) DESIRED.

9. TOLERANCE (USUALLY .001).

10. AFMT.

0. IF FORMAT SAME AS PREVIOUS LOT.
1. IF VARIABLE FORMAT CARD PRECEDES DATA.

2. CONTROL CARD WITH OR W/O ALPHAMERIC INFORMATION IN COLS. 2-30.

3. IF AFMT=1., FORMAT CARD INDICATING HOW DATA IS TO BE READ.

4. DATA.

A. IF INPUT IS RAW DATA
   1. PUNCH FIRST ITEM OF EACH VARIABLE, SECOND ITEM OF EACH VARIABLE, ETC., UNTIL LAST ITEM OF EACH VARIABLE IS PUNCHED.
   2. THE F CRITERIA FOR 1 AND N-2, 1 AND N-3,---, 1 AND N-K-1 DEGREES OF FREEDOM WHERE N IS THE EFFECTIVE NUMBER OF OBSERVATIONS AND K IS THE NUMBER OF INDEPENDENT VARIABLES. THE SAME NUMBER OF F VALUES AS INDEPENDENT VARIABLES ARE INCLUDED AT 14F5.0.

B. IF INPUT IS ADJUSTED SUMS OF SQUARES AND CROSS PRODUCTS
   1. PUNCH AVERAGES 1 THROUGH M
   2. PUNCH UPPER TRIANGULAR MATRIX IN THE ORDER SS(1,1),SS(1,2),--SS(1,M),SS(2,2),SS(2,3)---SS(2,M),---SS(M-1,M),SS(M,M), WHERE M IS THE DEPENDENT VARIABLE.
   3. F VALUE FOR DF-1,DF-2,--TO NUMBER OF INDEPENDENT VARIABLES. THE SAME NUMBER OF F VALUES AS INDEPENDENT VARIABLES ARE INCLUDED AT 14F5.0.

5. IF FORM = 2,CARD WITH ORIGINAL VARIABLE NUMBERS OF INDEPENDENT VARIABLES PUNCHED ACCORDING TO FORMAT 14F5.0.

6. BLANK CARD TO TERMINATE JOB.

OUTPUT
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IF BOTH REGRESSION METHODS ARE USED, AN INTERNAL COMBINED LISTING IS MADE OF THE VARIABLES SELECTED BY EACH METHOD. A COMPARISON OF THIS COMBINED LIST IS MADE WITH THE SEPARATE VARIABLE LISTS FOR EACH METHOD. IF THE COMBINED LIST DIFFERS FROM BOTH INDIVIDUAL LISTS, THE PROGRAM WILL PERFORM MULTIPLE REGRESSION ANALYSIS USING DELETION METHOD ON THOSE VARIABLES APPEARING ON COMBINED LIST.

(2)

## Sugar cane fires

| Tot wt | wt trash₁ | wt trash₂ | wt mid cane | wt top cane | moist (wet) trash₁ | (dry) trash₁ | moist (wet) trash₂ | (dry) trash₂ | Rel Hum | Date # | Samp # | wt loss trash | wt loss mid cane | wt loss top cane | partic emiss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66.6 | 13.6 | 4.5 | 35.0 | 13.8 | 15.8 | 18.8 | | | 70. | 1 | 1 | 14.4 | 3.4 | 2.4 | .0413 |
| 10[illegible]8 | 12.3 | 5.0 | 54.8 | 37.8 | 16.6 | 19.8 | | | 64. | 1 | 2 | 12.2 | 5.8 | 7.5 | .0775 |
| 109.3 | 6.0 | 10.0 | 44.0 | 49.3 | 36.5 | 58.0 | 34.5 | 52.5 | 73. | 2 | 3 | 10.3 | 1.3 | 8.3 | .1027 |
| 123.5 | 11.3 | 7.5 | 35.5 | 69.3 | 25.0 | 33.8 | 18.0 | 21.5 | 60. | 3 | 4 | 13.5 | 2.8 | 11.0 | .0663 |
| 72.0 | 5.8 | 6.8 | 23.4 | 36.3 | | | | | 72. | 4 | 5 | 8.3 | 2.0 | 2.8 | .0672 |
| 79.0 | 5.8 | 6.0 | 25.0 | 42.4 | | | 14.0 | 16.3 | 60. | 4 | 6 | 9.0 | 2.8 | 3.0 | .0468 |
| 66.3 | 6.3 | 5.8 | 22.5 | 31.8 | 15.1 | 17.9 | 13.6 | 15.7 | 52. | 5 | 7 | 8.8 | 1.8 | 5.0 | .0475 |
| 79.0 | 4.3 | 4.1 | 31.9 | 38.8 | 16.6 | 20.0 | 18.3 | 22.4 | 40. | 6 | 8 | 7.1 | 1.1 | 6.8 | .0650 |
| 85.8 | 4.5 | 5.5 | 31.5 | 44.3 | 15.0 | 19.5 | 19.6 | 24.4 | 48. | 6 | 9 | 8.5 | 1.3 | 9.3 | .0646 |
| 54.8 | 7.0 | 5.3 | 42.5 | 0 | 22.2 | 28.8 | 20.8 | 27.2 | 62. | 7 | 10 | 11.3 | 2.8 | 0 | .0492 |
| 128.0 | 5.5 | 5.3 | 44.5 | 72.8 | 20.2 | 25.3 | 16.6 | 19.7 | 62. | 7 | 11 | 8.9 | 0.4 | 13.3 | .0896 |
| 73.2 | 3.0 | 5.0 | 44.5 | 20.6 | 20.0 | 25.1 | 21.8 | 27.9 | 25. | 8 | 12 | 6.9 | 2.4 | 2.6 | .0434 |
| 95.2 | 3.4 | 5.8 | 47.1 | 38.9 | 14.4 | 16.9 | 15.8 | 18.7 | 20. | 8 | 13 | 8.1 | 1.0 | 5.3 | .0510 |
| 98.0 | 5.0 | 4.3 | 51.8 | 37.0 | 18.7 | 23.0 | 15.2 | 17.9 | 15. | 8 | 14 | 7.8 | 1.5 | 4.0 | .0433 |
| 96.5 | 3.5 | 6.5 | 42.0 | 44.5 | 14.7 | 17.2 | 16.2 | 19.3 | 29. | 8 | 15 | 8.0 | 2.5 | 4.8 | .0542 |

## Sugar cane trash fires

| tot wt | (wet) moist | (dry) moist | Rel Hum | Date # | Samp # | wt loss | partic emiss |
|---|---|---|---|---|---|---|---|
| 13.0 | 27.0 | 37.0 | 30. | 1 | 1 | 11.6 | .0223 |
| 12.0 | 21.0 | 26.6 | 20. | 1 | 2 | 8.0 | .0354 |
| 6.3 | 20.0 | 25.2 | 34. | 2 | 3 | 6.0 | .0192 |
| [illegible] | 17.0 | 20.2 | 59. | 3 | 4 | 9.0 | .0247 |
| 21.3 | 32.0 | 47.0 | 58. | 4 | 5 | 19.0 | .0988 |
| 13.0 | 14.0 | 16.5 | 69. | 5 | 6 | 11.9 | .0245 |
| 11.0 | 12.8 | 14.7 | 22. | 6 | 7 | 9.8 | .0210 |
| 11.0 | 11.4 | 12.9 | 24. | 6 | 8 | 9.5 | .0186 |
| 11.0 | 8.9 | 9.8 | 22. | 6 | 9 | 9.8 | .0157 |
| 10.4 | 12.3 | 14.0 | 20. | 6 | 10 | 9.0 | .0149 |
| 10.5 | 8.8 | 9.5 | 16. | 7 | 11 | 9.4 | .0345 |
| 10.9 | 8.2 | 8.9 | 18. | 7 | 12 | 10.1 | .0278 |
| 11.8 | 6.6 | 7.1 | 16. | 7 | 13 | 10.4 | .0142 |
| 11.8 | 10.1 | 11.2 | 12. | 7 | 14 | 9.5 | .0239 |
| 9.5 | 16.3 | 19.5 | 11. | 7 | 15 | 9.0 | .0308 |
| 9.5 | 13.0 | 15.0 | 11. | 7 | 16 | 8.8 | .0213 |
| 9.3 | 14.7 | 17.3 | 48. | 8 | 17 | 8.4 | .0221 |

(3)

CORRELATIONS AND MULTIPLE REGRESSION-REVISED A[illegible]1970
SUGAR CANE FIRES - PARTICULATES EMISSION (25 SQ FT)

EXPERIMENT, 10373
LOT 5
PROGRAM CMR

NUMBER OF INDEPENDENT VARIABLES 3 WITH 15 COUNT.

INPUT IS RAW DATA.

| AVERAGE | ENTRY NO. | |
|---|---|---|
| 0.76906650 02 | 1 | wt midt top |
| 0.50133330 02 | 2 | rel humidity |
| 0.99999990 00 | 3 | nbr of frames |
| 0.60639990-01 | 4 | PE |

DEGREES OF FREEDOM FOR SS AND SCP = 14

| ROW | COL | SUM OF SQUARES | VARIANCE OR COVARIANCE | STANDARD DEVIATION | C.V. (PER CENT) |
|---|---|---|---|---|---|
| 1 | 1 | 0.6291314D 04 | 0.4493794E 03 | 0.2119856E 02 | 27.56 |
| 1 | 2 | -0.6645102D 03 | -0.4746501E 02 | | |
| 1 | 3 | 0.6875991D-04 | 0.4911421E-05 | | |
| 2 | 2 | 0.5395736D 04 | 0.3854097E 03 | 0.1963185E 02 | 39.16 |
| 2 | 3 | 0.4482269D-04 | 0.3201621E-05 | | |
| 3 | 3 | 0.8940697D-06 | 0.6386210E-07 | 0.2527095E-03 | 0.03 |
| 1 | 4 | 0.3351138D 01 | 0.2393670E 00 | | |
| 2 | 4 | 0.2473921D 01 | 0.1767086E 00 | | |
| 3 | 4 | 0.5421638D-07 | 0.3872596E-08 | | |
| 4 | 4 | 0.4603156D-02 | 0.3287967E-03 | 0.1813275E-01 | 29.90 |

DEGREES OF FREEDOM FOR CORRELATIONS = 13

| CORRELATIONS | ROW | COL |
|---|---|---|
| 0.1000000D 01 | 1 | 1 |
| -0.1140527D 00 | 1 | 2 |
| 0.9168091D-03 | 1 | 3 |
| 0.6227215D 00 | 1 | 4 |
| 0.1000000D 01 | 2 | 2 |
| 0.6453375D-03 | 2 | 3 |
| 0.4964010D 00 | 2 | 4 |
| 0.1000000D 01 | 3 | 3 |
| 0.8451173D-03 | 3 | 4 |
| 0.1000000D 01 | 4 | 4 |

DELETION METHOD (BL 792)

RSQ FOR 3 VARIABLES IS 0.7139954E 00
ENTRY 3 (VARIABLE 3) IS DELETED.

RSQ FOR 2 VARIABLES IS 0.7139954E 00

| B | S(B) | R(Y1.JK---) | ENTRY | VAR |
|---|---|---|---|---|
| 0.5887474E-03 | 0.1329218E-03 | 0.7877025E 00 | 1 | 1 |
| 0.5310024E-03 | 0.1435296E-03 | 0.7299580E 00 | 2 | 2 |

THE F VALUE FOR THE LOWEST PARTIAL CORR IS 13.69

ERROR DEGREES OF FREEDOM ARE 12

-0.1125954E-01 = THE Y INTERCEPT

PRED. Y = -0.1125954E-01 + 0.5887474E-03(X 1)+ 0.5310024E-03(X 2)

STEPWISE REGRESSION (BL 718)

THE STANDARD DEVIATION OF Y = 0.1813276D-01

| ENTRY | VARIABLE | B | S(B) |
|---|---|---|---|
| 1 | 1 | 0.5887474D-03 | 0.1329218D-03 |
| 2 | 2 | 0.5310026D-03 | 0.1435296D-03 |

WITH MINIMUM F =13.69

STANDARD DEVIATION FROM THE REGRESSION = 0.1047427D-01

THE INTERCEPT = -0.1125953E-01

RSQ = 0.7139954E 00

ERROR DEGREES OF FREEDOM ARE 12

*int mid + top* *rel. hum.*

PREC. Y = -0.1125953E-01 + 0.5887474D-03(X 1)+ 0.5310026D-03(X 2)

OUTPUT IS COMPLETE.

CORRELATIONS AND MULTIPLE REGRESSION-REVISED AUG,1970
SUGAR CANE PARTIC EMISSION VS WT LOSSES

| | |
|---|---|
| EXPERIMENT | 10373 |
| LOT | 1 |
| PROGRAM | CMR |

NUMBER OF INDEPENDENT VARIABLES 4 WITH 15 COUNT.

INPUT IS RAW DATA.

| AVERAGE | ENTRY NO. | |
|---|---|---|
| 0.9539999D 01 | 1 | wt loss trash |
| 0.2193333D 01 | 2 | wt loss mid |
| 0.5739999D 01 | 3 | wt loss top |
| 0.1747333D 02 | 4 | wt loss trash + mid + top |
| 0.6063999D-01 | 5 | PE |

DEGREES OF FREEDOM FOR SS AND SCP = 14

| ROW | COL | SUM OF SQUARES | VARIANCE OR COVARIANCE | STANDARD DEVIATION | C.V. (PER CENT) |
|---|---|---|---|---|---|
| 1 | 1 | 0.7431609D 02 | 0.5308291E 01 | 0.2303972E 01 | 24.15 |
| 1 | 2 | 0.2510402D 02 | 0.1793143E 01 | | |
| 1 | 3 | 0.9066060D 01 | 0.6475757E 00 | | |
| 1 | 4 | 0.1084860D 03 | 0.7749000E 01 | | |
| 2 | 2 | 0.2380933D 02 | 0.1700666E 01 | 0.1304095E 01 | 59.46 |
| 2 | 3 | -0.1816599D 02 | -0.1297570E 01 | | |
| 2 | 4 | 0.3074731D 02 | 0.2196236E 01 | | |
| 3 | 3 | 0.1830360D 03 | 0.1307400E 02 | 0.3615798E 01 | 62.99 |
| 3 | 4 | 0.1739360D 03 | 0.1242400E 02 | | |
| 4 | 4 | 0.3131689D 03 | 0.2236920E 02 | 0.4729609E 01 | 27.07 |
| 1 | 5 | 0.6035648D-01 | 0.4311174E-02 | | |
| 2 | 5 | -0.5035588D-01 | -0.3596848E-02 | | |
| 3 | 5 | 0.6579960D 00 | 0.4699971E-01 | | |
| 4 | 5 | 0.6679962D 00 | 0.4771401E-01 | | |
| 5 | 5 | 0.4603156D-02 | 0.3287967E-03 | 0.1813275E-01 | 29.90 |

DEGREES OF FREEDOM FOR CORRELATIONS = 13

| CORRELATIONS | ROW | COL |
|---|---|---|
| 0.1000000D 01 | 1 | 1 |
| 0.5967991D 00 | 1 | 2 |
| 0.7773362D-01 | 1 | 3 |
| 0.7111201D 00 | 1 | 4 |
| 0.1031941D 00 | 1 | 5 |
| 0.1000000D 01 | 2 | 2 |
| -0.2751801D 00 | 2 | 3 |
| 0.3560772D 00 | 2 | 4 |
| -0.1521068D 00 | 2 | 5 |
| 0.1000000D 01 | 3 | 3 |
| 0.7264936D 00 | 3 | 4 |
| 0.7168481D 00 | 3 | 5 |
| 0.1000000D 01 | 4 | 4 |
| 0.5563612D 00 | 4 | 5 |
| 0.1000000D 01 | 5 | 5 |

DELETION METHOD (BL 7[illegible]

RSQ FOR 4 VARIABLES IS 0.5807922E 00
ENTRY 3 (VARIABLE 3) IS DELETED.

RSQ FOR 3 VARIABLES IS 0.5164821E 00
ENTRY 2 (VARIABLE 2) IS DELETED.

RSQ FOR 2 VARIABLES IS 0.4824524E 00
ENTRY 1 (VARIABLE 1) IS DELETED.

RSQ FOR 1 VARIABLES IS 0.3094260E 00

| B | S(B) | R(Y1.JK---) | ENTRY | VAR |
|---|---|---|---|---|
| 0.2132252E-02 | 0.8836815E-03 | 0.5561701E 00 | 4 | 4 |

THE F VALUE FOR THE LOWEST PARTIAL CORR IS 5.82

ERROR DEGREES OF FREEDOM ARE 13

0.2338245E-01 = THE Y INTERCEPT

PRED. Y = 0.2338245E-01 + 0.2132252E-02(X 4)

STEPWISE REGRESSION (BL 718)

THE STANDARD DEVIATION OF Y = 0.1813276D-01

| ENTRY | VARIABLE | B | S(B) |
|---|---|---|---|
| 3 | 3 | 0.3594899D-02 | 0.9697584D-03 |

WITH MINIMUM F =13.74

STANDARD DEVIATION FROM THE REGRESSION = 0.1311994D-01

THE INTERCEPT = 0.4000527E-01

RSQ = 0.5138711E 00

ERROR DEGREES OF FREEDOM ARE 13

PRED. Y = 0.4000527E-01 + 0.3594899D-02(X 3)

DELETION METHOD (BL 7

RSQ FOR 2 VARIABLES IS 0.5165515E 00
ENTRY 2 (VARIABLE 4) IS DELETED.

RSQ FOR 1 VARIABLES IS 0.5138713E 00

| B | S(B) | R(Y1.JK---) | ENTRY | VAR |
|---|---|---|---|---|
| 0.3594899E-02 | 0.9697580E-03 | 0.7168481E 00 | 1 | 3 |

THE F VALUE FOR THE LOWEST PARTIAL CORR IS 13.74

ERROR DEGREES OF FREEDOM ARE 13

0.4000527E-01 = THE Y INTERCEPT

PRED. Y = 0.4000527E-01 + 0.3594899E-02(X 3)

OUTPUT IS COMPLETE.

CORRELATIONS AND MULTIPLE REGRESSION-REVISED AUG,1970
SUGAR CANE TRASH FIRES - PARTIC EMISSION (LB/25 SQ FT)

EXPERIMENT 10173
LOT 4
PROGRAM CMR

NUMBER OF INDEPENDENT VARIABLES 7 WITH 17 COUNT.

INPUT IS RAW DATA.

| AVERAGE | ENTRY NO. | |
|---|---|---|
| 0.1131765D 02 | 1 | Total wt (lb/25 sq ft) |
| 0.1494706D 02 | 2 | Moist. Content Wet Basis |
| 0.1837647D 02 | 3 | Moist. Content, Dry Basis |
| 0.2882353D 02 | 4 | Relative Humidity |
| 0.5294117D 01 | 5 | Date Nbr |
| 0.8999999D 01 | 6 | sample Nbr |
| 0.9952940D 01 | 7 | Wt loss (lbs/25 sq ft) |
| 0.2762941D-01 | 8 | Partic Emiss (lbs/25 sq ft) |

DEGREES OF FREEDOM FOR SS AND SCP = 16

| ROW | COL | SUM OF SQUARES | VARIANCE OR COVARIANCE | STANDARD DEVIATION | C.V. (PER CENT) |
|---|---|---|---|---|---|
| 1 | 1 | 0.1455646D 03 | 0.9097787E 01 | 0.3016253E 01 | 26.65 |
| 1 | 2 | 0.1744059D 03 | 0.1090037E 02 | | |
| 1 | 3 | 0.3012870D 03 | 0.1883043E 02 | | |
| 1 | 4 | 0.3328529D 03 | 0.2080330E 02 | | |
| 1 | 5 | -0.1768816D 02 | -0.1105510E 01 | | |
| 1 | 6 | -0.6529986D 02 | -0.4081241E 01 | | |
| 1 | 7 | 0.1244841D 03 | 0.7780257E 01 | | |
| 2 | 2 | 0.7462826D 03 | 0.4664265E 02 | 0.6829542E 01 | 45.69 |
| 2 | 3 | 0.1148899D 04 | 0.7180618E 02 | | |
| 2 | 4 | 0.9510419D 03 | 0.5944011E 02 | | |
| 2 | 5 | -0.1772352D 03 | -0.1107720E 02 | | |
| 2 | 6 | -0.3371999D 03 | -0.2107498E 02 | | |
| 2 | 7 | 0.1461278D 03 | 0.9132988E 01 | | |
| 3 | 3 | 0.1784471D 04 | 0.1115294E 03 | 0.1056075E 02 | 57.47 |
| 3 | 4 | 0.1449330D 04 | 0.9058310E 02 | | |
| 3 | 5 | -0.2635822D 03 | -0.1647388E 02 | | |
| 3 | 6 | -0.5096998D 03 | -0.3185623E 02 | | |
| 3 | 7 | 0.2559514D 03 | 0.1599696E 02 | | |
| 4 | 4 | 0.5408471D 04 | 0.3380293E 03 | 0.1838556E 02 | 63.79 |
| 4 | 5 | -0.2221175D 03 | -0.1388234E 02 | | |
| 4 | 6 | -0.6289997D 03 | -0.3931247E 02 | | |
| 4 | 7 | 0.3399591D 03 | 0.2124744E 02 | | |
| 5 | 5 | 0.8152944D 02 | 0.5095590E 01 | 0.2257340E 01 | 42.64 |
| 5 | 6 | 0.1680000D 03 | 0.1050000E 02 | | |
| 5 | 7 | -0.5464656D 01 | -0.3415409E 00 | | |
| 6 | 6 | 0.4080001D 03 | 0.2550000E 02 | 0.5049752E 01 | 56.11 |
| 6 | 7 | -0.4059991D 02 | -0.2537494E 01 | | |
| 7 | 7 | 0.1152425D 03 | 0.7202653E 01 | 0.2683775E 01 | 26.96 |
| 1 | 8 | 0.7707601D 00 | 0.4817250E-01 | | |
| 2 | 8 | 0.1407686D 01 | 0.8798033E-01 | | |
| 3 | 8 | 0.2323141D 01 | 0.1451963E 00 | | |
| 4 | 8 | 0.2121687D 01 | 0.1326054E 00 | | |
| 5 | 8 | -0.1332468D 00 | -0.8327924E-02 | | |

| | | | | | |
|---|---|---|---|---|---|
| 6 | 8 | -0.339899[illegible] 00 | -0.2124372E-01 | | |
| 7 | 8 | 0.6737833D 00 | 0.4211146E-01 | | |
| 8 | 8 | 0.5995468D-02 | 0.3747167E-03 | 0.1935760E-01 | 70.06 |

DEGREES OF FREEDOM FOR CORRELATIONS = 15

| CORRELATIONS | ROW | COL |
|---|---|---|
| 0.1000000D 01 | 1 | 1 |
| 0.5291534D 00 | 1 | 2 |
| 0.5911501D 00 | 1 | 3 |
| 0.3751347D 00 | 1 | 4 |
| -0.1623669D 00 | 1 | 5 |
| -0.2679503D 00 | 1 | 6 |
| 0.9611249D 00 | 1 | 7 |
| 0.8250491D 00 | 1 | 8 |
| 0.1000000D 01 | 2 | 2 |
| 0.9955785D 00 | 2 | 3 |
| 0.4733809D 00 | 2 | 4 |
| -0.7195239D 00 | 2 | 5 |
| -0.6110908D 00 | 2 | 6 |
| 0.4982818D 00 | 2 | 7 |
| 0.6654916D 00 | 2 | 8 |
| 0.1000000D 01 | 3 | 3 |
| 0.4665253D 00 | 3 | 4 |
| -0.6910416D 00 | 3 | 5 |
| -0.5973511D 00 | 3 | 6 |
| 0.5644125D 00 | 3 | 7 |
| 0.7102467D 00 | 3 | 8 |
| 0.1000000D 01 | 4 | 4 |
| -0.3344939D 00 | 4 | 5 |
| -0.4234314D 00 | 4 | 6 |
| 0.4306091D 00 | 4 | 7 |
| 0.3725912D 00 | 4 | 8 |
| 0.1000000D 01 | 5 | 5 |
| 0.9211324D 00 | 5 | 6 |
| -0.5637666D-01 | 5 | 7 |
| -0.1905847D 00 | 5 | 8 |
| 0.1000000D 01 | 6 | 6 |
| -0.1872357D 00 | 6 | 7 |
| -0.2173246D 00 | 6 | 8 |
| 0.1000000D 01 | 7 | 7 |
| 0.8105923D 00 | 7 | 8 |
| 0.1000000D 01 | 8 | 8 |

```
DELETION METHOD (BL [illegible]2)

RSQ FOR 7 VARIABLE[illegible]S 0.8237326E 00
ENTRY 4 (VARIABLE 4) IS DELETED.

RSQ FOR 6 VARIABLES IS 0.8205681E 00
ENTRY 2 (VARIABLE 2) IS DELETED.

RSQ FOR 5 VARIABLES IS 0.8154506E 00
ENTRY 6 (VARIABLE 6) IS DELETED.

RSQ FOR 4 VARIABLES IS 0.8106967E 00
ENTRY 7 (VARIABLE 7) IS DELETED.

RSQ FOR 3 VARIABLES IS 0.8070934E 00
ENTRY 5 (VARIABLE 5) IS DELETED.

RSQ FOR 2 VARIABLES IS 0.7568187E 00
ENTRY 3 (VARIABLE 3) IS DELETED.

RSQ FOR 1 VARIABLES IS 0.6307057E 00
```

| B | S(B) | R(Y1.JK---) | ENTRY | VAR |
|---|---|---|---|---|
| 0.5294967E-02 | 0.9363398E-03 | 0.8250489E 00 | 1 | 1 |

```
THE F VALUE FOR THE LOWEST PARTIAL CORR IS 31.98

ERROR DEGREES OF FREEDOM ARE 15

-0.3229718E-01 = THE Y INTERCEPT

PRED. Y = -0.3229718E-01 + 0.5294967E-02(X 1)
```

```
STEPWISE REGRESSION  (BE 718)

THE STANDARD DEVIATION OF Y =    0.1935760D-01

ENTRY    VARIABLE             B                  S(B)
    1            1     0.5294969D-02     0.9363397D-03

WITH MINIMUM F =31.98

STANDARD DEVIATION FROM THE REGRESSION =    0.1129695D-01

THE INTERCEPT =   -0.3229718E-01

RSQ =    0.6807059E 00

ERROR DEGREES OF FREEDOM ARE    15

PRED. Y =  -0.3229718E-01 +    0.5294969D-02(X    1)

OUTPUT IS COMPLETE.
```

(4)

# Regression Equation I

PEI←¯.01125953+(.000588747×W)+(.000531003×RH)
PEIA←1742.4×PEI

⍉4 15 ρ PEI,PEIA,W,RH

| PE (lbs/25 sq ft) | PE (lbs/acre) | wt (mid+top cure) lbs/25 sq ft | Rel Hum % |
|---|---|---|---|
| 0.0546415336 | 95.20740814 | 48.8 | 70 |
| 0.0772426342 | 134.5875658 | 92.6 | 64 |
| 0.0824337841 | 143.6326254 | 93.3 | 73 |
| 0.0823013356 | 143.4018471 | 104.8 | 60 |
| 0.0621208819 | 108.2394246 | 59.7 | 72 |
| 0.0602821978 | 105.0357014 | 67.4 | 60 |
| 0.0483215881 | 84.19553511 | 54.3 | 52 |
| 0.0516050029 | 89.91655705 | 70.7 | 40 |
| 0.0588556366 | 102.5500612 | 75.8 | 48 |
| 0.0466844035 | 81.34290466 | 42.5 | 62 |
| 0.0907226791 | 158.0751961 | 117.3 | 62 |
| 0.0403429747 | 70.29359912 | 65.1 | 25 |
| 0.049992772 | 87.10740593 | 86 | 20 |
| 0.0489862486 | 85.35363956 | 88.8 | 15 |
| 0.0550661725 | 95.94729896 | 86.5 | 29 |

MEAN PEI lbs/25 sq ft
0.06063998968

SD PEI
0.01532185043

MEAN PEIA lbs/acre
105.659118

SD PEIA
26.69679219

RSQ←.7139954
DFREG←2
DFDEV←12
FVALUE RSQ
14.97868356

(5)

PEII←.0400053+(.00359490×WLT)
PEIIA←1742.4×PEII

Regression Equation II

⍉3 15 ρ PEII,PEIIA,WLT

| PE (lbs/25 sq ft) | PE (lbs/acre) | wt loss tops (lbs/25 sq ft) |
|---|---|---|
| 0.04863306 | 84.73824374 | 2.4 |
| 0.06696705 | 116.6833879 | 7.5 |
| 0.06984297 | 121.6943909 | 8.3 |
| 0.0795492 | 138.6065261 | 11 |
| 0.05007102 | 87.24374525 | 2.8 |
| 0.05079 | 88.496496 | 3 |
| 0.0579798 | 101.0240035 | 5 |
| 0.06445062 | 112.2987603 | 6.8 |
| 0.07343787 | 127.9581447 | 9.3 |
| 0.0400053 | 69.70523472 | 0 |
| 0.08781747 | 153.0131597 | 13.3 |
| 0.04935204 | 85.9909945 | 2.6 |
| 0.05905827 | 102.9031296 | 5.3 |
| 0.0543849 | 94.76024976 | 4 |
| 0.05726082 | 99.77125277 | 4.8 |

MEAN PEII lbs/25 sq ft
0.060640026

SD PEII
0.01299843463

RSQ←.5138713
DFREG←1
DFDEV←13
FVALUE RSQ
13.74188954

MEAN PEIIA lbs/acre
105.6591813

SD PEIIA
22.6484725

# Regression Equation III

```
PEIII←¯.0322972+(.00529497×TW)
PEIIIA←1742.4×PEIII
```

⍉3 17 ⍴ PEIII,PEIIIA,TW

| PE (lbs/25 sq ft) | PE (lbs/acre) | lbs/25 sq ft Total wt trash |
|---|---|---|
| 3.653741000E¯2 | 6.366278318E1 | 1.300000000E1 |
| 3.124244000E¯2 | 5.443682746E1 | 1.200000000E1 |
| 1.061111000E¯3 | 1.848879806E0 | 6.300000000E0 |
| 2.118199700E¯2 | 3.690751157E1 | 1.010000000E1 |
| 8.048566100E¯2 | 1.402382157E2 | 2.130000000E1 |
| 3.653741000E¯2 | 6.366278318E1 | 1.300000000E1 |
| 2.594747000E¯2 | 4.521087173E1 | 1.100000000E1 |
| 2.594747000E¯2 | 4.521087173E1 | 1.100000000E1 |
| 2.594747000E¯2 | 4.521087173E1 | 1.100000000E1 |
| 2.277048800E¯2 | 3.967529829E1 | 1.040000000E1 |
| 2.329998500E¯2 | 4.059789386E1 | 1.050000000E1 |
| 2.541797300E¯2 | 4.428827616E1 | 1.090000000E1 |
| 3.018344600E¯2 | 5.259163631E1 | 1.180000000E1 |
| 3.018344600E¯2 | 5.259163631E1 | 1.180000000E1 |
| 1.800501500E¯2 | 3.137193814E1 | 9.500000000E0 |
| 1.800501500E¯2 | 3.137193814E1 | 9.500000000E0 |
| 1.694602100E¯2 | 2.952674699E1 | 9.300000000E0 |

MEAN PEIII lbs/25 sq ft
0.02762940165

SD PEIII
0.01597097964

MEAN PEIIIA lbs/acre
48.14146943

SD PEIIIA
27.82783493

```
DFREG←1
DFDEV←15
RSQ←.6807057

FVALUE RSQ
31.9786025
```

Dollar's letter to his cooperators following receipt of the final revision of data calculations from Riverside.

TABLE 1

ESTIMATED ANNUAL PARTICULATE EMISSIONS FROM
SUGAR CANE FIELD BURNING

| State | In Crop 1,000's acres | Harvested 1,000's acres | Burned Estimate 1,000's acres | Emissions Tons |
|---|---|---|---|---|
| State | | | | |
| 1972 | 229.2 | 108.5 | 95 | 4,168 |
| 1973 (Est.) | 226 | 106 | 93 | 4,031 |
| Hawaii | | | | |
| 1972 | 104.6 | 48.0 | 34 | 1,557 |
| 1973 (Est.) | 100 | 46 | 32 | 1,466 |
| Kauai | | | | |
| 1972 | 47.0 | 23.4 | 21 | 962 |
| 1973 (Est.) | 46 | 22 | 20 | 916 |
| Maui | | | | |
| 1972 | 45.5 | 22.7 | 22 | 1,008 |
| 1973 (Est.) | 46 | 23 | 22 | 1,008 |
| Oahu | | | | |
| 1972 | 32.2 | 14.4 | 14 | 641 |
| 1973 (Est.) | 34 | 15 | 14 | 641 |

New predictive eqn

Wt Loss = .8032 + 1.155 Trash − .0430 Mid + .1295 tops

PE $\frac{lbs}{25}$ = .02803 + [illegible]01897 Mid + .00055085 tops

| | lbs/25 ft² | | | | T/A | lbs/25 ft² | | | lbs/A | lbs/T |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J |
| | lbs unused tops | addn loss A×.1295 | old wt loss | New Wt loss B+C | New Wt loss D×.871 | Old PE | addn PE A×.0005516 | New PE F+G | New PE H×1742 | New PE H×2000/D |
| D1 | 22.0 | 2.8 | 20.1 | 22.9 | 20.0 | .0413 | .0121 | .0534 | 93.06 | 4.6 |
| D2 | 7.7 | 1.0 | 25.5 | 26.5 | 23.1 | .0775 | .0042 | .0817 | 142.39 | 6.1 |
| E1 | −6.5 | −.8 | 19.9 | 19.1 | 16.7 | .1027 | −.0035 | .0992 | 172.86 | 10.4 |
| E2 | 19.3 | 2.5 | 27.3 | 29.8 | 26.0 | .0663 | .0106 | .0769 | 134.01 | 5.2 |
| G1 | 11.2 | 1.5 | 13.0 | 14.5 | 12.7 | .0672 | .0062 | .0734 | 127.81 | 10.1 |
| G2 | 22.7 | 2.9 | 14.75 | 17.7 | 15.4 | .0468 | .0125 | .0593 | 103.31 | 6.7 |
| H2 | 8.2 | 1.1 | 15.5 | 16.6 | 14.5 | .0475 | .0045 | .0520 | 90.61 | 6.3 |
| M1 | | | 15.0 | 15.0 | 13.1 | .0650 | | .0650 | 113.23 | 8.7 |
| M2 | | | 19.0 | 19.0 | 16.6 | .0646 | | .0646 | 112.53 | 6.8 |
| N1 | | | 14.0 | 14.0 | 12.2 | .0492 | | .0492 | 85.71 | 7.0 |
| N2 | | | 22.5 | 22.5 | 19.6 | .0896 | | .0892 | 156.08 | 8.0 |
| O-1 | | | 11.9 | 11.9 | 10.4 | .0434 | | .0434 | 75.60 | 7.3 |
| O-2 | | | 14.4 | 14.4 | 12.6 | .0510 | | .0510 | 88.84 | 7.1 |
| P-1 | | | 13.25 | 13.25 | 10.6 | .0433 | | .0433 | 75.43 | 6.5 |
| P-2 | | | 15.25 | 15.25 | 13.3 | .0542 | | .0542 | 94.42 | 7.1 |
| $\Sigma x$ | | | | 272.4 | 236.8 | | | | | |
| $\bar{x}$ | | | | 18.2 | 15.8 | | | .06375 | 111.06 | 7.19 |
| $\Sigma x^2$ | | | | | 4033.54 | | | .06505 | 197398.7 | 811.45 |
| SD | | | | | 4.592 | | | .01707 | 29.74 | 1.588 |
| $S_{\bar{x}} = \frac{SD}{\sqrt{15}}$ | | 15−1=14 DF | | | 1.1856 | | | | 7.6788 | .4100 |
| $t_{.05} \times S_{\bar{x}}$ | $t_{.05} = 2.145$ | | | | 2.543 | | | | 16.471 | .8795 |
| $t_{.01} \times S_{\bar{x}}$ | 2.977 | | | | 3.530 | | | | 22.86 | 1.221 |
| 5% | | | | | $13.3 \le \mu \le 18.3$ | | | | $94.6 \le \mu \le 127.5$ | $6.3 \le \mu \le 8.1$ |
| 1% | | | | | $12.3 \le \mu \le 19.3$ | | | | $88.2 \le \mu \le 133.9$ | $6.0 \le \mu \le$ (8.4) ← |

Regression Program Description

APL\360

```
      )LOAD 500 WS3
SAVED  13.07.11 06/12/72
      DREG

        SIMPLE AND MULTIPLE REGRESSION
        T←V REG X
        ENTERED:24/05/68

   X IS A MATRIX OF OBSERVATIONS, WHERE THE COLUMNS CORRESPOND
TO VARIATES AND THE ROWS TO OBSERVATIONS. V IS A VECTOR OF
POSITIVE INTEGERS. T IS A MATRIX OF 5 COLUMNS. AS AN EXAMPLE
OF THE OUTPUT, LET X HAVE 6 COLUMNS, AND LET V=(3,5,1,4).
THEN T GIVES THE RESULTS OF THE BEST LEAST-SQUARES FIT OF
THE FUNCTION
               X4=A+B×X3+C×X5+D×X1
IN THE FOLLOWING FORMAT:
    ROW1: 4, A, 0, 0, 0
    ROW2: 3, B, ST ERROR OF B, T-VALUE, 0
    ROW3: 5, C, ST ERROR OF C, T-VALUE, 0
    ROW4: 1, D, ST ERROR OF D, T-VALUE, 0
    ROW5: 0, DF FOR REGRESSION, SUM OF SQUARES, MEAN
                               SQUARE, F-VALUE
    ROW6: 0, DF FOR ERROR, SUM OF SQUARES, MEAN SQUARE, 0
    ROW7: 0, DF FOR TOTAL, SUM OF SQUARES, ST ERROR OF ESTIMATE,
                               SQUARE OF MULTIPLE CORR COEFF

    REQUIRES INV.
      ∇REG[⎕]∇
    ∇ T←V REG X;N;U;M;R;Q;S;B
[1]   T←((3+ρV),5)ρ0
[2]   T[ιρV;1]←V[ρV],¯1↓V
[3]   Q←(⍉R)+.×R←U-(ρU)ρM←(+/[1] U←X[;V])÷N←(ρX)[1]
[4]   T[3+ρV;3]←Q[ρV;ρV]
[5]   Q←¯1 0↓Q
[6]   B←(-M+.×B,¯1),B←,(S←INV 0 ¯1↓Q)+.×Q[;ρV]
[7]   T[ιρV;2]←B
[8]   T[1+ρV;3]←(1↓B)+.×Q[;ρV]
[9]   T[(ρV)+ι3;2]←((ρV)-1),(N-ρV),N-1
[10]  T[2+ρV;3]←-/T[(3+ρV),1+ρV;3]
[11]  T[(ρV)+ι2;4]←T[(ρV)+ι2;3]÷T[(ρV)+ι2;2]
[12]  T[1+ι(ρV)-1;3]←(T[2+ρV;4]×+/S×(ι(ρV)-1)∘.=ι(ρV)-1)*0.5
[13]  T[1+ι(ρV)-1;4]←T[1+ι(ρV)-1;2]÷T[1+ι(ρV)-1;3]
[14]  T[3+ρV;4]←T[2+ρV;4]*0.5
[15]  T[1+ρV;5]←T[1+ρV;4]÷T[2+ρV;4]
[16]  T[3+ρV;5]←T[1+ρV;3]÷T[3+ρV;3]
    ∇
```

UCR
4/6/73

ORDER REG WTLOSSREG

| | | | | |
|---|---|---|---|---|
| 4 WTLOSS | 0.8031786537 = A | 0 | 0 | 0 |
| 1 Trash (Load) | 1.154674627 = B | 0.417577592 $s_e(B)$ | 2.765173825 = $T_B = \frac{B}{s_e(B)}$ | |
| 2 Mid (Load + Discard) | −0.04302726669 = C | 0.07153892828 $s_e(C)$ | −0.601452492 = $T_C$ | 0 |
| 3 Tops (Load) | 0.1295039539 = D | 0.03626750244 $s_e(D)$ | 3.570798793 = $T_D$ | 0 |
| 0 | 3 DF(regr) | 251.1048033 = SS(regr) | 83.70160111 = MS(regr) | 14.60887709 = F |
| 0 | 11 DF(err) | 63.02453 = SS(err) | 5.729502727 = MS(err) | 0 |
| 0 | 14 DF(total = 15−1) | 314.1293333 = SS(tot) | 2.393637969 = $\sqrt{MS_{err}}$ | 0.7993675747 = $R^2$ → R = .89 |

$F_{(3,11)} = 3.59$ (95%)
$F_{(3,11)} = 6.22$ (99%)

$\frac{lbs}{25 ft^2}$ Wt Loss = .8032 + 1.155 × Trash − 0.0430 Mid + .1295 × Tops

ORDER REG WTLOSSREG

| | | | | | |
|---|---|---|---|---|---|
| PE $\frac{lbs}{25 ft^2}$ | 5.000000000E0 | 2.803214840E¯2 | 0.000000000E0 | 0.000000000E0 | 0.000000000E0 |
| Mid | 2.000000000E0 | 1.897287800E¯4 | 1.914639240E¯4 | 9.909374886E¯1 | 0.000000000E0 |
| Top | 3.000000000E0 | 5.508520487E¯4 | 2.207022222E¯4 | 2.495906218E0 | 0.000000000E0 |
| | 0.000000000E0 | 2.000000000E0 | 1.930669227E¯3 | 9.653346136E¯4 | 4.334545443E0 = F |
| | 0.000000000E0 | 1.200000000E1 | 2.672486773E¯3 | 2.227072311E¯4 | 0.000000000E0 |
| | 0.000000000E0 | 1.400000000E1 | 4.603156000E¯3 | 1.492337067E¯2 | 4.194229409E¯1 = $R^2$ → R = .65 |

$F_{(2,12)} = 3.88$ (95%)
$F_{(2,12)} = 6.93$ (99%)

$\frac{lbs}{25 ft^2}$ PE = .02803 + .0001897 × Mid + .00055085 × Tops

# CANE BURNING - FIELD STUDY

| A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Sample | Stage | Top | Trash Bottom | Total | Top | Cane Middle | Pieces Bottom | Total | Ash lbs. |
| 10/17/72 | B-1 | Before | 3.5 | 8.5 | 12.0 | 31.5 | 74 | 37 | 142.5 | |
| | | After | | | | 47 | 50 | 56 | 153 | 3.54 |
| | B-2 | Before | 5.5 | 6.0 | 11.5 | 37.5 | 125.75 | 43 | 206.25 | |
| | | After | | | | 42 | 55 | 46 | 143 | 1.86 |
| 10/18/72 | C-1 | Before | 8 | 5.25 | 13.25 | 29 | 56 | 74 | 159 | |
| | | After | | | | 51 | 47 | 62 | 160 | 4.98 |
| | C-2 | Before | 5.5 | 13 | 18.5 | 29 | 62 | 74 | 165 | |
| | | After | | | | 54 | 49 | 59 | 162 | 2.88 |
| 11/6/72 | E-1 | Before | 13 | 5 | 18 | 43 | 91 | 59 | 193 | |
| | | After | | | | 60 | 71 | 91 | 222 | 3.8 |
| | E-2 | Before | 12 | 8.5 | 20.5 | 50 | 100 | 40.5 | 190.5 | |
| | | After | | | | 85 | 65 | 50 | 200 | 10.9 |
| 11/8/72 | F-1 | Before | 8.5 | 12.5 | 21 | 41 | 75 | 60 | 176 | |
| | | After | | | | 94 | - | 72 | 166 | 4.6 |
| | F-2 | Before | 8.5 | 7.5 | 16 | 72 | 67 | 71 | 210 | |
| | | After | | | | 76 | 57 | 73 | 206 | 5.5 |
| 11/4/72 | G-1 | Before | 7 | 6.5 | 13.5 | 47.5 | 57.5 | 44.5 | 149.5 | |
| | | After | | | | 53 | 42 | 45 | 140 | 8.3 |
| | G-2 | Before | 8 | 7.75 | 15.75 | 65 | 66.5 | 46 | 177.5 | |
| | | After | | | | 50 | 49 | 54 | 153 | 2.3 |
| 11/15/72 | H-1 | Before | 5.5 | 4 | 9.5 | 47 | 36 | 30 | 113 | |
| | | After | | | | 72 | 51 | 55 | 178 | 3.5 |
| | H-2 | Before | 6.5 | 7 | 13.5 | 40 | 40 | 45 | 125 | |
| | | After | | | | 53 | - | 30 | 83 | 2.5 |
| 12/4/72 | M-1 | Before | 4.25 | 4.5 | 8.75 | 40 | 47.5 | 42 | 129.5 | |
| | | After | | | | 61 | 56 | 36 | 153 | 1.74 |
| | M-2 | Before | 6 | 5 | 11 | 46.5 | 44 | 46 | 136.5 | |
| | | After | | | | 71 | 51 | 39 | 161 | 1.20 |
| 12/5/72 | N-1 | Before | 5.5 | 7.5 | 13 | 43.5 | 43 | 32 | 118.5 | |
| | | After | | | | 57 | - | 52 | 109 | 2.46 |
| | N-2 | Before | 5.5 | 6 | 11.5 | 38 | 45 | 47 | 130 | |
| | | After | | | | 61 | - | 39 | 100 | 1.56 |
| 12/11/72 | O-1 | Before | 4 | 4 | 8 | 24 | 46 | 15 | 85 | |
| | | After | | | | 49 | - | 40 | 89 | 2.2 |
| | O-2 | Before | 6.5 | 4 | 10.5 | 42 | 46 | 23 | 111 | |
| | | After | | | | 50 | - | 51 | 101 | 0.8 |
| 12/12/72 | P-1 | Before | 4.5 | 5.5 | 10 | 39 | 52.5 | 21 | 112.5 | |
| | | After | | | | 37 | - | 65 | 102 | 0.6 |
| | P-2 | Before | 7 | 4 | 11 | 54 | 43.5 | 34.5 | 132 | |
| | | After | | | | 83 | - | 49 | 132 | 1.02 |

SUMMARY 1972 DATA

| | | N | Σx | Σx² | Mean | | SD | |
|---|---|---|---|---|---|---|---|---|
| Trash | Top | 20 | 134.75 | 1021.8125 | 6.7 | | 2.4 | 36% |
| | Bottom | 20 | 132.0 | 997.625 | 6.6 | | 2.6 | 39% |
| | Total | 20 | 266.75 | 3832.1875 | 13.3 | 13.3 | 3.8 | 29% |
| Before Cane & trash | Top | 20 | 859.5 | 39460.25 | 43.0 | | 11.5 | 27% |
| | Middle | 20 | 1218.25 | 84172.5 | 60.9 | | 22.9 | 38% |
| | Bottom | 20 | 884.5 | 44451.75 | 44.2 | | 16.8 | 38% |
| | Total | 20 | 2962.25 | 462188.06 | 148.1 | 148.1 | 35.1 | 24% |
| After Cane & trash | Top | 20 | 1206 | 77120 | 60.3 | | 15.2 | 25% |
| | Middle | 12 | 643 | 35153 | 53.6 | | 8.0 | 15% |
| | Bottom | 20 | 1064 | 60606 | 53.2 | | 14.5 | 27% |
| | Total | 20 | 2913 | 453721 | 145.6 | 145.6 | 39.4 | 27% |
| Ash | | 20 | 66.24 | 346.5292 | 3.3 | 3.3 | 2.6 | 72% |

Difference (13.3+148.1)-(145.6+3.3)= 12.5 lbs./25 ft.²

Burned 7.7% of load 10.9 tons/acre

Trash: Top = 50.5%

Cane pieces: Top = 29% Middle = 41%

Trash as percent total 8.3%

Additional Data Desirable: Leaf materials as percent of top and middle cane pieces.

Subject ________ HAWAII DEVELOPMENT IRRADIATOR
Source ________
Period Covered From ________ To ________ Proj. No.
By ________ Date ________ Page ____ of ____ Pages

II

Revision of Summaries I made after I returned to Riverside. These were sent to Honolulu and form the basis of Dollars letter to his cooperators.

New predictive eqn

Wt Loss = .8032 + 1.155 Trash − .0430 Mid + .1295 tops

PE $\frac{lbs}{25}$ = .02803 + .0001897 Mid + .00055085 tops

| | lbs/25 ft² | | | | T/A | lbs/25 ft² | | | lbs/A | lbs/T |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J |
| | lbs unused tops | addn loss A X .1295 | Old wt loss | New Wt loss B + C | New Wt loss D X .871 | Old PE | addn PE A X .00055085 | New PE F + G | New PE H X 1742 | New PE H X 2000 / D |
| D1 | 22.0 | 2.8 | 20.1 | 22.9 | 20.0 | .0413 | .0121 | .0534 | 93.06 | 4.6 |
| D2 | 7.7 | 1.0 | 25.5 | 26.5 | 23.1 | .0775 | .0042 | .0817 | 142.39 | 6.1 |
| E1 | −6.3 | −.8 | 19.9 | 19.1 | 16.7 | .1027 | −.0035 | .0992 | 172.86 | 10.4 |
| E2 | 19.3 | 2.5 | 27.3 | 29.8 | 26.0 | .0663 | .0106 | .0769 | 134.01 | 5.2 |
| G1 | 11.2 | 1.5 | 13.0 | 14.5 | 12.7 | .0672 | .0062 | .0734 | 127.81 | 10.1 |
| G2 | 22.7 | 2.9 | 14.75 | 17.7 | 15.4 | .0468 | .0125 | .0593 | 103.31 | 6.7 |
| H2 | 8.2 | 1.1 | 15.5 | 16.6 | 14.5 | .0475 | .0045 | .0520 | 90.61 | 6.3 |
| M1 | | | 15.0 | 15.0 | 13.1 | .0650 | | .0650 | 113.23 | 8.7 |
| M2 | | | 19.0 | 19.0 | 16.6 | .0646 | | .0646 | 112.53 | 6.8 |
| N1 | | | 14.0 | 14.0 | 12.2 | .0492 | | .0492 | 85.71 | 7.0 |
| N2 | | | 22.5 | 22.5 | 19.6 | .0896 | | .0892 | 156.08 | 8.0 |
| O-1 | | | 11.9 | 11.9 | 10.4 | .0434 | | .0434 | 75.60 | 7.3 |
| O-2 | | | 14.4 | 14.4 | 12.6 | .0510 | | .0510 | 88.84 | 7.1 |
| P-1 | | | 13.25 | 13.25 | 10.6 | .0433 | | .0433 | 75.43 | 6.5 |
| P-2 | | | 15.25 | 15.25 | 13.3 | .0542 | | .0542 | 94.42 | 7.1 |
| $\Sigma x$ | | | | 272.4 | 236.8 | | | | | |
| $\bar{x}$ | | | | 18.2 | 15.8 | | | .06375 | 111.06 | 7.19 |
| $\Sigma x^2$ | | | | | 4033.54 | | | .06505 | 197398.7 | 811.45 |
| SD | | | | | 4.592 | | | .01707 | 29.74 | 1.588 |
| $S_{\bar{x}} = \frac{SD}{\sqrt{15}}$ | | 15 − 1 = 14 DF | | | 1.1856 | | | | 7.6788 | .4100 |
| $t_{.05} \times S_{\bar{x}}$ | $t_{.05} = 2.145$ | | | | 2.543 | | | | 16.471 | .8795 |
| $t_{.01} \times S_{\bar{x}}$ | | 2.977 | | | 3.530 | | | | 22.86 | 1.221 |
| 5% | | | | $13.3 \le \mu \le 18.3$ | | | | | $94.6 \le \mu \le 127.5$ | $6.3 \le \mu \le 8.1$ |
| 1% | | | | $12.3 \le \mu \le 19.3$ | | | | | $88.2 \le \mu \le 133.9$ | $6.0 \le \mu \le 8.4$ |

UNIVERSITY OF CALIFORNIA, RIVERSIDE

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STATEWIDE AIR POLLUTION RESEARCH CENTER     RIVERSIDE, CALIFORNIA 92502

March 13, 1973

Dear Jim:

It is a bit early in the morning and I am starting this at home--will finish at the office. So pardon again the mistakes in typing but it will get to you faster this way.

Enclosed are copies of the sets of field data that Mel Dollar sent to me and/or brought with him when he was here in December. The first set included the raw data sheets and summary sheets for the six samples (2-25 square foot plots in each sample) B, C, D, E, F, G, and H. The second set included the raw data sheets for the remaining four samples, M, N, O, and P and the summary of all 10 samples or 20 fires.

It took a little time for me to decipher the format so I will try to give you the benefit of what I learned from these sheets.

The first Set

Using B-1 and B-2 as examples, and going first to the raw data sheet. Sample column: Top refers to the top trash when looking at the Trash column and to top cane when looking at the Cane Pieces column. Mid refers to mid cane and there are often two entries because it was necessary to make two packages to keep the weight of packages within reasonable limits. Bottom refers again to both trash and cane as did the Top above. The 1's and 2's refer to first and second sample.

Unburned and Burned columns: The Unburned would be the two samples collected and sent to Riverside, B-1 and B-2, each sample representing 1 fire. In the earlier sampling, bottom cane was sent to us but to keep the weights within the table limits, we did not use the bottom cane. After about sample E, the bottom cane was not shipped to us, although its weight was recorded in Hawaii. Thus for B-1, the trash weights are noted for top and bottom and totaled at 12.0 pounds. The various cane weights are noted and totaled at 142.5 pounds ad I have noted in pencil the total plot weight of 154.5 pounds. The total leaf trash (12 pounds) and the total trash plus cane (154.5 pounds) are then entered on the summary sheet under Leaf Trash "A" and Cane and Leaf Trash "B", respectively, for the Per 25 ft$^2$ columns.

The Burned column would represent the cane weight after the fire on the two plots that were staked out at the same time the two Riverside plots were cut and weighed. ( I am at school now and have changed typewritered). Thus it is evident that on these sheets, there are data from 4 plots---2 sent to Riverside and 2 sampled after the fire. For B-1 after the fire, the cane weights are greater than the material sent to Riverside. This happens in some other plots and accounts for the great variation they show. For B-1 the cane wt. after fire is 153. He then shows the ash weight caught in a pan of 150 square inches. When this is converted to pounds per plot he gets 3.95 pounds. This amount is added to the cane wt. to give 156.95 pounds total material on the plot after the fire. When this amount is subtracted to the total wt. unburned, the value is -2.45 and this is the net disappearance that he puts on the summary sheet. In this particular case, however, he enters -2 on the summary and I believe this is an arithmetic error if my penciled notations are correct. There is also an error in his arithmetic for B-2 because I show a loss of 71.67 but he has entered 72.9. Regardless of these small errors, the explanation I have given above is how he has figured each of the entries on the raw data sheets that are transfered to the summary sheet.

The format shown for B is followed for C and D but changed a little in E, F, G, and H to add columns for <u>Net Burned</u> which is labeled as <u>Net Disappearance</u> on the summary <u>sheet.</u> Also starting with E, the size of <u>the pan for ashes</u> was changed to 133 sq. in. Also. 50 sq ft and Acre columns before & after are not shown.

Back to B for a moment. My penciled notes at the bottom of the sheet is my effort to check his factor of 0.067 for converting grams ashes in the pan to pounds per 25 sq. ft. Thus I get 0.053 instead of his value and calculating B-1 gives me 3.13 pounds instead of 3.95.

Now to E for a moment. You have two sheets for E-- an original and one with my penciled notes. The notes in the upper part of the page just confirm the arithmetic that he shows to obtain <u>Net Burned</u>. For E-1, the 3.8 ashes is added to the 222 burned cane and this sum is subtracted from the total 211 cane and trash sent to Riverside to give a value of -14.8 net burned (which, again is actually a gain). When the total for E-2 (0.1) is added to E-1 (-14.8) his net for the 50 sq ft. is -14.7. This is converted to tons/acre (factor= .435) and the two figures are entered on the summary sheet.

Now to the summary sheet of the first set of data (B thru H). Whereas he has a key to the columns noted at the bottom, I have labeled some columns for my own clarification. For B, the total wt. per 50 square feet is the sum of B-1 and B-2. This should be multiplied by the factor of .435 and when I do this I get slightly different figures as shown roughly in pencil. Then net disappearance is treated on 25, 50 foot and acre basis. Here, for B using his figures the 74.9 should be 72 and the 32.6 would be 30.8. Even though there are these small errors I probably use the figures as shown when doing the computations you suggest in your last letter. It has not arrived yet today so I can't make any forther comments on what you want done.

<u>The second set</u>

The second set of data that he brought with him in December is in two parts---the raw data sheets for M, N, O, and P, and his sumaries of all 20 plots. The format for the raw data is the same as for E through H.

Now for the summaries. I had looked at these before mainly for the purpose of seeing how he did his statistical work at the time I was doing my summaries in January. But now I am looking at them in greater detail to see what I get out of them for the purpose of writing this letter.

So here goes on what appear to be summaries of field data only.

The first page is a summary of the summary that is shown on the second page. I will just note the figures as I see them. 129± 3.7 is from line 2 of second page. 147 ± 30 is from line 5, even though the figures shows 157. The SUM (1469.8) divided by the NUMBER (10) has to be 147. 127 ±34 is from line 11 and the 17 is from line 18. It is this figure of 17 that interestes me the most because it is not too far from our loss of 15 tons per acre as he pointed out in the letter to Erskine Jan. 5. I think when we discussed this on the phone you pointed out that the difference may be due to the absence of mid cane in the Riverside samples.

But back to his 17 tons per acre net disapparence. Up until today I have accepted this figure at face value without going through the calculations to check where the figure came from. Obviously from the figures we see on the second summary page the sum of 344 divided by the number 20 gives 17.2. But I cannot add up any figures that give the 344 Where the other numbers in this column are given in terms of lbs/25 sq ft, I can verify them by adding up the indicated numbers for the 20 entries on the raw data sheets. But if I add up the Net Disappearance in tons per acre from all raw data sheets and /or the summary sheet of the first set (B through H) my sum is 110.6. If I add up the column of Net Disappearance on the basis of 50 sq. ft. I get 316.1 which is closer to 344 but on the wrong basis. — 11.03

Further, unless there is something I do not see, it seems to me that the loss in tons per acre could also be gotten by subtracting the weight after the fire of all plots from the weight before the fire for all plots. But 147 - 127 = 20. Oh, Oh!!!, I just see something as I write this. The 127±34 showing on the first summary page is from line 11 but the labels are different. On the first page, the label is "total wt. cane and ash after burn", whereas on line 10-11 on the second page is labelled "wt. after burn (cane)". It is line 14 of the second page that matches the label on the first page and the value here is 130 (129.8). Now, if we subtract 130 from 147, we get the 17. But I still don't see where the 344 came from and I will have to ask Dollar when I get together with them later this month.

On the third page of the summary, Mel applies the figure of 17 tons/acre to the acres harvtested and then our 7 lbs/ton particulate to come up with the tons of particulate/ per year.

Two figures need verification and/or acceptance. (1) The loss of 17 tons/ per acre from their field data and the 7 pounds of particulate per ton burned from our studies. Next wouldbe the acceptance of the philosophy that it is accurate to express particulate in terms of material burned.

My own point of view at this stage is that the figure of 17 tons burned is not too bad. The concept of basing emissions on the amount burned is certainly reasonable. And I think that our emission factor is within reason. Thus the only alternative is to use the pounds particulate per acre. if we use the figure of 109 and apply it to line 3 of the third page of the summary I get 795 tons per year instead of the 869 Mel shows.

I have rambled on much longer than I intended. If you come up with somethin new on these data Mel sent, let me know. In the mean time I will wait for your last letter with its suggestions and then be in contact with you.

Best regards.

Cordially,

Ells

(1)

~~UNITED STATES GOVERNMENT~~

~~2-Way Memo~~

Subject: Sugar Cane Data

| DATE OF MESSAGE |
|---|
| March 8 1973 |
| DATE OF REPLY |
| |

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To: Dr. Darley
U.C.R.

—FOLD— —FOLD—

USE BRIEF, INFORMAL LANGUAGE

I apologize for using a hand-written message but since I have been so slow in getting my response out, I hope you will understand (and be able to read my "scratchin'").

Since, you are aware of my statistical situation, I won't dwell on the mechanics of the data analysis but limit my comments to the variables being considered.

As I mentioned on the phone, the correlations performed and reported via your letter to Dr Hammerle are of the type I think he had in mind but I am ~~[illegible]~~ fairly confident that some similar analyses of other variables and parameters may be fruitful. I have done some linear regressions ~~[illegible]~~ of two variables at a time and though I am aware that this is of limited meaning and potentially misleading, I think that indications of further analyses are ~~[illegible]~~ identified. First, comments on the Data sent to Hammerle;

1. I question the strong influence of the relative humidity upon the particulate emission, I would expect some effect but not of the same order ~~[illegible]~~ of magnitude as the cane wt. (tail + top). Possibly we would be letting the statistics mislead us.

From: G H Sutherland

OPTIONAL FORM 27
OCTOBER 1962
GSA FPMR (41 CFR) 101

3. TO BE RETAINED BY ORIGINATOR

5027 – 102

UNITED STATES GOVERNMENT

2-Way Memo

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| DATE OF MESSAGE |
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To: Dr Darley

page 2

USE BRIEF, INFORMAL LANGUAGE

2. While it is assumed that there is a constant relationship of whole cane (field simulation) to trash fires, I don't fully understand how useful analysis of the trash ~~[illegible]~~ data can be done. For the time being I have been concentrating on (whole) cane fires only. The equation (III) would however appear to be reasonable.

3. I believe that analysis of conditions or measurements that are possibly indicative of how representative the "burn" samples are to field conditions can be done. For example, is the cane wt. on the table ~~dependent upon~~ related to (a) cane weight in field ("total cane" + bottom cane) (b) % moisture (avg.) (c) relative humidity (d) total wt. loss (e) % loose trash; i.e. $\frac{\text{trash}}{\text{field wt. stems}}$ (including bottom cane) (f) total ashes after fire, and perhaps other items which you might identify.

Also in this same vein; are the total weights of the 25 ft² plots in the field significantly different from the burn table plots? I believe this could be tested in this way simply. It would be a comparison of field totals vs. weight from table (table) cane + bottom cane, I [illegible] think, i.e. are they from the same population?

From:

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OPTIONAL FORM 27
OCTOBER 1962
GSA FPMR (41 CFR) 101 - 11.6

UNITED STATES GOVERNMENT

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To: Dr. [illegible]

p. 13

USE BRIEF, INFORMAL LANGUAGE

4. Many items (prime measurements independent in themselves) are possibly related to the particulate generated. I think that we should restrict our first look for explanation to the items suspected intuitively or that are obvious initially. On a linear basis [illegible] for example, it would seem that particulate vs total cones wt. would be quite well correlated. This indeed appears to be the case. [illegible] other variables are correlated (r = .71) but it would be more meaningful to use the total weight including "bee bottom" cones. I suspect that we have a non-uniform proportion of weight "not" contributed by the bee bottom cones.

Suggested variables for correlation are:

Total particulate [illegible] as a function of a) total weight on table (optional)
(lb/sample or lb/cone)
or total wt inc. bee bottom cone, b) % combustion (wt loss/[illegible]), c) temperature (position-treated) d) relative humidity, e) % moisture (average) and perhaps other similarly "prime" measurements.

From: Do you see what I am getting at? I may not be explaining properly. If so please let me know.

3. TO BE RETAINED BY ORIGINATOR

5027 – 102

OPTIONAL FORM 27
OCTOBER 1962
GSA FPMR (41 CFR) 101 – 11.6

UNITED STATES GOVERNMENT

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To: Dr. Darley

Page 4

—FOLD— —FOLD—

USE BRIEF, INFORMAL LANGUAGE

5. Total weight loss, Total ashes, or % combustion [illegible] [illegible] (lb [illegible]/ton weight loss) (?) % moisture, relative humidity, and temperature should possibly have an interrelationship identifiable through regression analysis, with total wt. loss or % combustion being the most likely major variables which are acted upon by the others.

6. I am including a table, partially completed, of some of the variables I have mentioned. I do not have the missing bare bottom weights to make the other columns complete. I apologize again for its crude-rough look. Using the bare bottom weights (total) I think such factors as % Burned, % loose trash, and % ashes will tend to remain somewhat constant or at least [illegible] [illegible] to the total [illegible] weight.

From:

3. TO BE RETAINED BY ORIGINATOR

5027-102

OPTIONAL FORM 27
OCTOBER 1962
GSA FPMR (41 CFR) 101-11.6

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To: → Dr. Darley

P1, 5

—FOLD— —FOLD—

USE BRIEF, INFORMAL LANGUAGE

7. I am also including some of the results of my other literary investigations (I was able at [illegible] time) on the other items. They are interesting but one must be aware of drawing too hasty conclusions. I am sending you my only copy of them so I won't be able to refer back – Return [illegible] the paper [illegible] consideration.

8. As far as Hawaii is concerned, I don't know how these analyses will apply. They, in my opinion, will only assist in adjusting from California conditions, if any difference is indeed indicated. Since the major objective, to me at least, is that of how many tons (or lbs) of pollutant are generated per acre of cane burned in the field. The real importance in these analyses are to [illegible] make sure field conditions are accurately simulated. Then if other questions need answers, the specifically designed [illegible] might be employed. Also it [illegible] something that [illegible]

From:

3. TO BE RETAINED BY ORIGINATOR

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OPTIONAL FORM 27
OCTOBER 1962
GSA FPMR (41 CFR) 101 – 11.6

UNITED STATES GOVERNMENT

# 2-Way Memo

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To: → Dr Darley

Page 6

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USE BRIEF, INFORMAL LANGUAGE

the "trash" emissions and the core emissions is identified, this would be helpful in being able to use the trash results for the "alternate disposal" and the "pores" designed by NASA.

9. This area may not make too much sense after I look back over it, but I think that some meaningful relationships exist in the data which can be practically exploited. I am only saying at this point that this is too far out of my background, because it is extremely interesting.

If you wish a formal response to your letter to them I will prepare one. I will be in touch next week, maybe Tuesday or Wednesday to see what your response is.

From:

[illegible]

Jim Sutherland

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OPTIONAL FORM 27
OCTOBER 1962
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JOHN A. BURNS
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STATE OF HAWAII
DEPARTMENT OF AGRICULTURE
1428 SO. KING STREET
HONOLULU, HAWAII 96814

January 4, 1973

Dr. Ellis F. Darley
Plant Pathologist
University of California
Riverside, CA 92502

Dear Ellis:

I've enclosed summary sheets for your review and comment. Some minor errors and missing values were noted:

Pineapple burn 12-19-72 (4)

Particulate 7.2 lbs/ton wt. loss and not 5.3 lbs.

Sugar cane burns 11-8-72 (1) (2) and (3)

Duplicate sets - is one set missing?

Particulate 4.7 and 9.9 dry trash wt. loss rather than 5.7 and 12.6 respectively, if 3.3 lbs. ash is assumed. This would apply on all other sets of data similarly.

When calculating volume of discharge you have multiplied revolutions by 50 - does this value recognize temperature corrections; if so, it would give a good estimate of Btu values.

If I recall correctly, the high volume filters were dried to constant weight in a desiccator before and after the burns. If this is so then the moisture effect should not be important.

Enclosed are the raw data sheets for each field study. This may help you in your interpretations.

Sincerely yours,

[signature]

Alexander M. Dollar, Ph.D.
Supervisor, Hawaii Development Irradiator

AMD:ad

Encl.

[illegible]

TABLE 3 - PINEAPPLE TRASH

Summary:

| | |
|---|---|
| Number of burns | 4 |
| Loading of table | 21.9 ± 6.7 tons/acre |
| Net burned | 15.1 ± 4.4 tons/acre |
| Volume of discharge | 2532 ± 176 $ft.^3$ lb. burned |
| Particulate emissions | 9.2 ± 2.3 lbs./ton net burned |
| | 33823 ± 10011 $ug/m^3$ |
| Burn rate | 0.18 ± .07 $lbs./ft.^2$-min. |

For comparison - field burn rates are in the range 0.4 to 0.8 $lbs./ft.^2$-min.

TABLE 3

SUMMARY - PINEAPPLE TOWER BURNS
U. C. RIVERSIDE

PINEAPPLE TRASH

| Burn Date | | Sample Designation | Load Tons/acre | Burned Tons/acre | Burn Rate lbs./ft.$^2$/min. | Particulate lbs./ton burned | Particulate ug/m$^3$ |
|---|---|---|---|---|---|---|---|
| 10-6 | (1) | - | 27.6 | - | - | - | - |
| 12-19 | (1) | B2 A&B | 16.3 | 11.8 | 0.12 | 12.5 | 41145 |
| 12-19 | (2) | B5 & C3 | 13.1 | 10.9 | 0.12 | 8.5 | 43382 |
| 12-19 | (3) | BB6 | 26.4 | 18.5 | 0.20 | 8.6 | 27957 |
| 12-19 | (4) | BC1 | 26.2 | 19.4 | 0.27 | 7.2 | 22810 |

2.4 Supplemental Reference

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STATEWIDE AIR POLLUTION RESEARCH CENTER RIVERSIDE, CALIFORNIA 92502

copy & filters to Geo Research Dec 1, 1972

Nov. 24, 1972

Dear Mr. Spangler:

I am typing this myself, so please excuse the mispellings and strikeovers. Here are 12 more filters of sugar c ne--- some whole cane and some leaves only. I will not send any more of cane until you have had a chance to look at these to see what differences you may want to have repeat fires on. The next set of filters I will send will be from pineapple trash fires.

Weights on the filters follows:

901126 Whole cane with dry and green leaves

3.42985
3.36980
.06005 = 12.8 pounds per ton of fuel burned

901127 Whole cane

3.36230
3.32350
.03880 = 7.1#/ton

901128--Dry leaves only

3.42330
3.36550
.05780 = 9.3#/ton

901129 Whole cane

3.37045
3.33115
.03930 = 10.5#/ton

901130 Leaves only

3.65300
3.63865
.01435 = 3.8#/ton

901131 Whole cane

3.63785
3.61050
.02735 = 8.0#/ton

901132 Whole cane

NOTE: Filter flow was not siokinetic. Less air than should have been. Factor used would then give a lower yield.

3.67040
3.65780
.01260 = 5.4#/ton

901133 Whole cane

3.63925
3.61150
102775 = 7.9#/ton

901134 Lvs only

3.64700
3.63470
.01230 = 3.8#/ton

901135 Lvs only

3.62485
3.61400
.01085 = 3.4#/ton

901136 Lvs only

3.63520
3.62600
.00920 = 2.9#/ton

901137 Lvs only

3.63640
3.62770
.00870 = 2.9#/ton

Whole cane fires with dry and green leaves continue to give higher yields that dry leaves alone. ilter 901128 is an exception. When the fuel moisture data are worked up we may find that this fuel was of higher moisture content--or it could just be an odd ball, as sometimes happens.

Jime Southerland is coming out about the fourth of Dec. (I think) and you may want to discuss any of your results with him so he can make sug estions while he is here.

Cordially,

Ellis Darley

El is F. Darley

B(a)P IN HI-VOL AIR FILTERS FROM HAWAII

| Filter Number | µg/g particulates |
|---|---|
| 901121 | 135.404 |
| 901122 | 124.623 |
| 901123 | 60.900 |
| 901124 | 35.139 |
| 901125 | 87.417 |
| 901126 | 22.315 |
| 901127 | 41.753 |
| 901128 | 27.336 |
| 901129 | 21.374 |
| 901130 | 32.056 |
| 901131 | 22.669 |
| 901132 | 168.254 |
| 901133 | 181.622 |
| 901134 | 112.195 |
| 901135 | 176.959 |
| 901136 | 76.087 |
| 901137 | 52.874 |

GEOLOGICAL RESOURCES, INC.

[signature]

## TRACE METALS IN HI-VOL AIR FILTERS (ng/m$^3$)

### HAWAII

| Filter Number | Ni | Cr | Be | Cd | Cu |
|---|---|---|---|---|---|
| 901121 | 2,666.4 | tr | 555.5 | 2,888.5 | 5,891.6 |
| 901122 | 1,508.8 | tr | 419.1 | 3,688.2 | 7,525.0 |
| 901123 | 2,584.3 | tr | 592.2 | 3,553.4 | 8,565.4 |
| 901124 | 0 | 0 | 0 | 5,234.2 | 9,682.7 |
| 901125 | 0 | 0 | 0 | 316.1 | 7,183.9 |
| 901126 | 933.2 | 2,205.8 | 339.4 | 1,272.6 | 10,990.4 |
| 901127 | 1,657.7 | 957.8 | 313.1 | 1,031.5 | 6,614.1 |
| 901128 | 2,714.8 | 2,121.0 | 466.6 | 1,484.7 | 9,351.5 |
| 901129 | 2,210.3 | 1,277.0 | 294.7 | 1,080.6 | 6,921.0 |
| 901130 | 1,029.3 | 1,852.7 | 617.6 | 1,749.8 | 10,293.0 |
| 901131 | 2,748.8 | tr | 0 | 1,323.5 | 4,049.1 |
| 901132 | No air volume reported | | | | |
| 901133 | 1,473.5 | 0 | 0 | 1,571.7 | 2,902.4 |
| 901134 | 504.1 | 0 | 251.8 | 1,510.6 | 4,577.6 |
| 901135 | tr | 0 | 294.2 | 1,673.7 | 4,034.4 |
| 901136 | 0 | tr | 356.4 | 1,555.4 | 7,069.9 |
| 901137 | 0 | 0 | 0 | 2,885.2 | 5,528.6 |
| 901138 | 997.1 | 1,150.5 | 0 | 1,188.9 | 11,156.8 |
| 901139 | 2,397.9 | 0 | 162.0 | 2,268.3 | 5,155.1 |
| 901140 | 4,155.8 | 0 | 317.2 | 2,296.6 | 3,852.5 |
| 901141 | 2,390.0 | 975.5 | 292.6 | 1,433.1 | 4,434.1 |
| 901142 | 3,218.6 | 0 | 204.4 | 1,737.0 | 3,599.4 |

# SPECIAL PAPERS FOR SUGAR CANE FIRES

| Filter NO. | Weight before and after collection of particulate and equivalent weight of particulate per ton of fuel burned |
|---|---|
| 901121 whole cane with dry and green lvs | 3.38485 grams<br>3.33655<br>.04830 = 12.3#/ton of dry lvs. |

901122 whole cane with dry and green lvs.

3.41460
3.36485
.04975 = 9.1#/ton of dry leaves

901123 dry leaves only

3.38870
3.37425
.01445 = 5.8# ton dry lvs.

901124 whole cane with dry and green lvs.

3.37350
3.34935
.03415 = 5.6#/ ton dry leaves

901125 whole cane with dry and green leaves

3.38435
3.33905
.04530 = 8.2#/ ton dry leaves.

Mr. Spangler:

Here are the first treated papers you sent us for use on sugar cane fires. When loading our table with whole cane and the dry leaf trash that goes along with it, we are able to weigh only the dry leaves as burnable material. Some of the green leaves do burn and we know we are losing some weight (water?) from the cane itself. But for practical purposes at the moment we are expressing yield of particulate in tems of dry leaves. There is a trend for more particulate to be produced from the whole cane fires. It will be interesting to see if you obtain different kinds and/or amounts of materials from whole cane fires.

Cordially,

Elli Z. Daly

**U.S. ENVIRONMENTAL PROTECTION AGENCY**

**Research Triangle Park, North Carolina 27711**

12-4-80

This is placed in the Backup file for Section 2.4 Refuse Open Burning, AP-42 for reference - future Factor revision

A. MacQueen

2.4 New Additional Reference

Emission Factors

NOTE.—DO NOT USE THIS ROUTE SLIP TO SHOW FORMAL CLEARANCES OR APPROVALS | DATE

TO: ~~Mick~~ | AGENCY | BLDG. | ROOM

~~Tom~~

Here is some info on Factors in Oregon Book

☐ APPROVAL ☐ REVIEW ☐ PER CONVERSATION

☐ SIGNATURE ☐ NOTE AND SEE ME ☐ AS REQUESTED

☐ COMMENT ☐ NOTE AND RETURN ☐ NECESSARY ACTION

☐ FOR YOUR INFORMATION

☐ PREPARE REPLY FOR SIGNATURE OF ____________

REMARKS:

I got this from State of Oregon Air Pollution people.

(Fold here for return)

~~To~~

From Al

PHONE | BUILDING | ROOM

FORM HEW-30 REV. 11/56 **ROUTE SLIP** ☆ GPO : 1969 O—359-816

EMISSION FACTOR REFERENCE SHEET

SOURCE ~~Refuse~~ Slash Burning

| Source Sub-type | Douglas Fir, Hemlock | | | | | |
|---|---|---|---|---|---|---|
| Factor Origin | As noted | | | | | |
| Units | lb / ton fuel [1] | | | | | |
| Aldehydes [2] | 0.01 | | | | | |
| Hydrocarbons [3] | 3.2 | | | | | |
| Other Organics [3] | 13 | | | | | |
| Fine Particulate [3] | ~~5~~ | | | 7 - 12 | 10 | |
| Coarse Particulates | 0 | | | | | |
| $NO_x$ [2] | 2 | | | | | |
| $SO_x$ | — | | | | | |
| CO [3] | 64 | | | | | |
| Other Inorganics | — | | | | | |
| | | | | | | |

Notes:

1. The following densities of slash material per acre consumed [illegible] slash fires have been obtained from various forestry of[illegible]
   a) Old growth Douglas fir and hemlock-spruce clearcuts : 50-75[illegible]
   b) Second growth fir, hemlock, and spruce clearcuts : 15-40 ton/acre
   c) Ponderosa pine partial cut - 2-12 ton/acre
2. Factor from Ref. 1, for open burning of "landscape material"
3. Factor from Ref. 7.

EMISSION FACTOR REFERENCE SHEET

SOURCE Field Burning

| Source Sub-type | All types Stubble and Straw | | | | | |
|---|---|---|---|---|---|---|
| Factor Origin | As noted | | | | | |
| Units | lb/ton [1] | | | | | |
| Aldehydes [2] | 0.01 | | | | | |
| Hydrocarbons [3] | 2.3 | | | | | |
| Other Organics | — | | | | | |
| Fine Particulate [3] | 16 | | | | | |
| Coarse Particulates | 0 | | | | | |
| $NO_x$ [2] | 2 | | | | | |
| $SO_x$ | — | | | | | |
| CO [3] | 101 | | | | | |
| Other Inorganics | — | | | | | |
| | | | | | | |

Notes:

1. Tons of residue per acre (without straw removal) for different s[pecies] are as follows:

   Bent grass - 2.0 tons/acre
   Blue grass - 2.5 "
   Fine fescue - 3.0 "
   Cereal grains - 3.0 "
   Perennial rye grass - 4.0 "
   Annual rye grass - 5.0 "

2. Factor from Ref 1, for open burning of "landscape refuse"

3. Factor from Ref. 8

UNIVERSITY OF CALIFORNIA, RIVERSIDE

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO    SANTA BARBARA • SANTA CRUZ

STATEWIDE AIR POLLUTION RESEARCH CENTER    RIVERSIDE, CALIFORNIA 92502

January 31, 1973

Dr. James R. Hammerle
Chief, National Air Data Branch
and Standards
EPA
Research Triangle Park, NC 27711

Dear Dr. Hammerle:

Following the suggestion you made during your visit January 18, Minn Poe performed the various multiple corrections on the cane and trash fires. Copies of the various printouts are enclosed as follows:

1. UCR Correlations and Multiple Regression Program Description. Minn points out that both the deletion and step wise regression methods were used to derive the predicted equations. How these two methods are reconciled is given on page 3 of the description.

2. Computer listing of the two raw data sheets, one each for cane and trash only. Consecutive numbering was used for date entries and for sample number entries. For the cane fires, if you look at the summary sheets I sent Jim, you may identify dates by numbering consecutively 1 through 8 starting with 10-27. You may identify samples by numbering consecutively 1 through 15 starting with D-1, but deleting H-1. The same system is used for trash only: Dates, 1 through 8, starting with 10-5 and deleting 11-16; samples, 1 through 17, deleting M-3.

3. Computer printout sheets of the three derived equations, I, II and III. The data collected from 15 sugar cane fires and 17 trash fires were analyzed using the above program. The correlation coefficients and the multiple regression equation for particulate emissions (PE) as a function of selected variables were calculated. The simple correlation coefficients, partial correlation coefficients, the square of the multiple correlation coefficients, standard deviations, etc. are listed on the computer printout.

   I--Sugar cane fires testing PE as a function of the several variables observed prior to ignition. These variables are listed at the top of the columns on the raw data listing noted in (2) above. In addition, the total of trash 1 and trash 2, and of mid and top cane was also used. This printout does not include all of the computer work but only those variables (weight of mid cane plus weight of top cane and relative humidity) that had a significant effect on particulate emission. All of the others tested fell by the way. The final prediction equation for PE in pounds per 25 sq.ft. is,

-.0112595 .000588747

PE = -.0~~110~~142 + [.000~~567389~~ x (wt. mid + top cane)]
+ (.0~~0056633~~ x relative humidity)

.000531003

II--Sugar cane fires testing PE as a function of the various weight losses observed after the fire. Only weight loss of top cane was significant. The prediction equation for PE in pounds per 25 sq.ft. is,

.0400053 + (.0035949

PE = .0~~399034~~ + (.00360011 x wt. loss top cane)

III--Trash fires testing PE as a function of the several variables observed before ignition and of weight loss after the fire. The variables are noted at the top of each column on the computer listing of raw data. Only total weight was significant. The prediction equation for PE in pounds per 25 sq.ft. is,

PE = -.0322972 + (.00529497 x total wt.)

4. Summary sheets wherein regression equations I, II and III are applied to the pertinent observed variables of each fire and the predicted values of PE in pounds per 25 sq.ft., and in pounds per acre are given, as well as the mean and standard deviation of these values. The calculated F values based on $R^2$ are also shown.

After you have had an opportunity to review these results I would appreciate your comments. I have indicated to the cooperators in Hawaii that these data were being prepared and that I would send them the results as soon as you had reviewed them and could assist in their interpretation. I hope that this step would help us to know how many more fires and what kind to burn.

Minn tells me that the large $R^2$ indicates the good correlation between PE and the pertinent variables. The high F value indicates the level of significance to be better than 0.5 percent.

For the variables that the program selected, Minn believes that we have sufficient fires, but some of the variables that were dropped may require more fires so as to obtain a wider range of experimental points. Perhaps the variables needing more replicates are moisture (some data points were missing in the current set), weight of trash, and perhaps total weight. She also says that we must have at least as many replicates as there are variables to be examined.

I am not sending copies of this material to Jim and hope that you can share the enclosed with him.

I certainly appreciate your suggestions and assistance. Your visit was very timely.

Cordially,

Ellis F. Darley

Ellis F. Darley
Plant Pathologist

csp

Enclosures

UNITED STATES GOVERNMENT

# 2-Way Memo

Subject: Dr Darley's progress

| DATE OF MESSAGE | 3/18/74 |
|---|---|
| DATE OF REPLY | |

**INSTRUCTIONS**
Use routing symbols whenever possible.
SENDER:
Forward original and one copy.
Conserve space.
RECEIVER:
Reply below the message, keep one copy, return one copy.

To: File 1-F Sugarcane
Ag. Burning
U. of Cal at Riverside

—FOLD— —FOLD—

USE BRIEF, INFORMAL LANGUAGE

Telephone conversation with Dr. Darley on March 19, indicates that he will be submitting his report by April 15. He is taking 6 months (may) sabbatical leave to work with
Bob Martin and Stan Pickford at the
Pacific N.W. Forest and Range Exp. Stn
4507 University Way
Seattle 98105

FTS # to be 206-442-7815 (Pickford)

Alternates 206-442-5329
206-543-6210 {(Martin)

From: J. Southerland

OPTIONAL FORM 27
OCTOBER 1962
GSA FPMR (41 CFR) 101-11.6

5027-102

1. TO BE RETAINED BY ADDRESSEE

SUMMARY STATEMENT

(Privileged Communication)

Application Number: 1 R01 AP00829-01A1

Dual Review:

Review Group: AIR POLLUTION RESEARCH GRANTS ADV. COMM.

Meeting Date: OCTOBER 1969 - AHR

Investigator: DARLEY, ELLIS F

Degree: PHD

Position: PLANT PATHOLOGIST

Organization: UNIVERSITY OF CALIFORNIA

City, State: RIVERSIDE, CALIF

Requested Start Date: 01 01 70

Project Title: AIR POLLUTION FROM FOREST AND AGRICULTURAL BURNING

Recommendation: APPROVAL

Priority Score: 250

Special Note: Executive Secretary's Note; Communication Recommended; Outside Opinion Obtained; Result of Mail Ballot

| PROJECT YEAR | DIRECT COSTS REQUESTED | DIRECT COSTS RECOMMENDED | PREVIOUSLY RECOMMENDED | GRANT PERIOD |
|---|---|---|---|---|
| 01A1 | 89,662 | 37,337 | 04/01/70 - 03/31/73 | |
| 02 | 55,360 | 35,635 | | |
| 03 | 57,444 | 37,719 | | |

RESUME: Certainly the data which the applicant proposes to obtain is worthwhile and should make a valuable contribution to knowledge and should be obtained to provide the needed guidance for possible regulatory decision making. However, phase 1 and 2 do not appear to be realistic at this time. The recommendation is made based upon a greatly reduced budget to allow continuation of the burning tower studies only.

DESCRIPTION: The applicant requests $204,466 for a 3 year study of pollution from burning. (1) Tests will be conducted in the burning tower and field to evaluate the performance of the burning tower. (2) Samples will be collected in the field during various burn conditions. (3) Materials from the field will be burned in the tower to determine gaseous and particulate emissions.

CRITIQUE: The strength of this proposal is in the fact that a burning tower is available at Riverside. Phase 3, which would be conducted in the tower, has some merit. Considerable data have been collected with agricultural waste products but little is known about the forest materials. The tower has taken money and time to construct and evaluate, so some further use of it appears to be justified.

Phases 1 and 2 do not appear to be realistic at this time. It will not be possible to determine the amount of pollutant given off during the field burning by the proposed method. Qualitative data may be of little real value at this stage of the investigation. The PI's proposal represents an extremely ambitious program which could not be completed within the time and money requested.

Elimination of the field studies from the proposal and concentration on adequate quantification of the "tower" burning studies should provide a more realistic approach to manpower and dollars requested.

(Over)

INVESTIGATORS: Dr. Darley appears overextended in his total program. Research workers expending small percentages of their time on a project are usually under productive unless a competent research assistant is actually responsible for the research work itself. No such research support is indicated.

RESOURCES AND ENVIRONMENT: Good

BUDGET: Should be reduced as indicated under Executive Secretary's Note.

Executive Secretary's Note: Approval has been recommended at a reduced budget. Reviews have indicated that phase 1 and 2 should be deleted at this time. Further, that due to the ambitiousness of the study, only that portion dealing with phase 3 be supported. Consequently, approval has been recommended with the following budget deletions. Justification of equipment needs for 02 and 03 years should be requested.

| | |
|---|---|
| Delete - (1st year) | |
| Spectrometer | $ 22,000 |
| Data acquisition system | 9,100 |
| Laboratory Technician IV | 11,392 |
| Stenographer | 3,333 |
| Travel | 4,000 |
| Other expenses | 2,500 |
| Delete - (years 02 and 03) | |
| Laboratory Technician IV | 11,392 |
| Stenographer | 3,333 |
| Travel | 4,000 |
| Other Expenses | 1,000 |

SECTION I

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

# APPLICATION FOR RESEARCH GRANT

6/19/69

LEAVE BLANK (For PHS Office Use Only)

| TYPE | PROGRAM | NUMBER |
|---|---|---|
| 1 | R01 | AP 00829-01A1 |

| REVIEW GROUP | FORMERLY |
|---|---|
| APC | |
| **COUNCIL (Month, Year)** | **DATE RECEIVED** |
| Nov 69 | 6/19/69 |
| **APPLICANT CODE** | **D CODE** |
| | |

**TO BE COMPLETED BY PRINCIPAL INVESTIGATOR** *(Items 1 through 9 and 17A)*

1. ABBREVIATED TITLE OF RESEARCH PROPOSAL *(Do not exceed 53 typewriter spaces)*

Air Pollution from Forest and Agricultural Burning

2. TYPE OF APPLICATION (Check one)

☐ NEW PROJECT ☐ RENEWAL OF PHS GRANT NO.

☒ REVISION OF PHS APPLICATION NO. AP 00829 ☐ SUPPLEMENT TO PHS GRANT NO.

3. DATES OF ENTIRE PROPOSED PROJECT PERIOD *(This application)*

FROM: January 1, 1970 THROUGH: December 31, 1972

4. TOTAL AMOUNT REQUESTED FOR PERIOD IN ITEM 3

~~$204,466~~ ~~$89,662~~ 110,691

5. AMOUNT REQUESTED FOR FIRST 12-MONTH PERIOD

~~37,337~~ ~~$89,662~~ (RG) ~~$202,466~~ 31,737

6A. NAME OF PRINCIPAL INVESTIGATOR (Last, First, Initial)

DARLEY, Ellis F.

| B. DEGREE | C. SOCIAL SECURITY NO. | D. TELEPHONE DATA Area Code | Telephone Number |
|---|---|---|---|
| Ph.D. | 557-56-8064 | 714 | 787-5140 |

E. TITLE OF POSITION

Plant Pathologist

F. DEPARTMENT, SERVICE, LABORATORY OR EQUIVALENT *(See Instructions)*

Statewide Air Pollution Research Center

G. MAJOR SUBDIVISION *(See Instructions)*

N/A

H. MAILING ADDRESS OF PRINCIPAL INVESTIGATOR *(Street, City, State, Zip Code)*

Statewide Air Pollution Research Center
University of California
Riverside, California 92502

7. IDENTIFY ORGANIZATIONAL COMPONENT RESPONSIBLE FOR CONDUCT OF SCIENTIFIC ASPECTS OF PROJECT

Statewide Air Pollution Research Center

8. ADDRESS WHERE RESEARCH WILL BE CONDUCTED *(if same as Item 6H, check box)* ☒

9. ARE FEDERAL FACILITIES TO BE USED FOR THIS RESEARCH? ☐ NO ☒ YES 5 % OF TIME

**TO BE COMPLETED BY RESPONSIBLE ADMINISTRATIVE AUTHORITY** *(Items 10 through 15 and 17B)*

10. APPLICANT ORGANIZATION *(Name and Address-Street, City, State, Zip Code) (See Instructions)*

Statewide Air Pollution Research Center
University of California
Riverside, California 92502

11. NAME, TITLE AND ADDRESS OF OFFICIAL TO WHOM CHECKS SHOULD BE MAILED

Mr. F. J. Bailey, Accounting Officer
University of California
Riverside, California 92502

12. TYPE OF ORGANIZATION *(Check applicable item)* ☐ INDIVIDUAL

PUBLIC INSTITUTION: ☐ FEDERAL ☒ STATE ☐ LOCAL ☐ OTHER

PRIVATE INSTITUTION: ☐ NONPROFIT, ☐ PROFIT

13. NAME AND TITLE OF OFFICIAL SIGNING FOR APPLICANT ORGANIZATION

Seymour D. Van Gundy
Associate Dean for Research

14. PHS ACCOUNT NUMBER *(Enter if known)*

451480

15. ESTABLISHED PHS INDIRECT COST RATE *(Enter if known)*

44 Shope - 3-13-70
~~45~~ % S&W

16. **TERMS AND CONDITIONS.** The undersigned accept, as to any grant awarded, the obligation to comply with Public Health Service Research Project Grant Regulations in effect at the time of the award (42 CFR, Part 52), the terms and conditions in the Grants for Research Projects Policy Statement, and the undersigned agree to comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), and the Regulation issued pursuant thereto and state that our formally filed Assurance of Compliance with such Regulation (Form HEW-441) applies to this project. The undersigned also certify that they have no commitments or obligations, including those with respect to inventions, inconsistent with compliance with such Regulations, the Manual, and the Act.

17. SIGNATURES *(Use ink. "Per" signatures not acceptable)*

| | | DATE |
|---|---|---|
| A. SIGNATURE OF PERSON NAMED IN ITEM 6A | Ellis F. Darley | 6-11-69 |
| B. SIGNATURE OF PERSON NAMED IN ITEM 13 | Seymour D. Van Gundy | 6-12-69 |

(3) AP 00829 01A1

SECTION 1

NOT FOR PUBLICATION OR PUBLICATION REFERENCE.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

# RESEARCH OBJECTIVES

LEAVE BLANK - (For office use only)
SIE PROJECT NUMBER

ABBREVIATED TITLE OF PROJECT

Air Pollution from Forest and Agricultural Burning

NAME, SOCIAL SECURITY NUMBER, OFFICIAL TITLE AND DEPARTMENT OF ALL PROFESSIONAL PERSONNEL ENGAGED ON PROJECT

| | | |
|---|---|---|
| Darley, Ellis F., | 557-56-8064 | Plant Pathologist, Statewide Air Pollution Research Center, UC Riverside |
| Biswell, Harold H. | 545-70-1631 | Professor, School of Forestry, UC Berkeley |
| Broido, Abraham | 345-16-9207 | Research Associate, Air Poll. Res. Center, Riv. |
| Green, Lisle R. | 529-09-1239 | Project Leader, Fuel-Break, USDA Forest Fire Lab., Riverside |
| Palmer, Thomas Y. | 515-03-6436 | Project Leader, Flambeau, USDA Forest Fire Lab, Riv. |
| Stephens, Edgar R. | 021-22-7438 | Research Chemist III, Air Poll. Res. Center, UC Riverside |

NAME AND ADDRESS OF APPLICANT ORGANIZATION

Statewide Air Pollution Research Center
University of California
Riverside, California 92502

USE THIS SPACE TO MAKE A BROAD STATEMENT OF YOUR RESEARCH OBJECTIVES

The use of prescribed burning of accumulated forest floor fuels in public and private forest land is becoming an increasingly important and widely used factor in reducing fire hazard and maintaining favored plant species. Also, in California considerable amounts of agricultural wastes are burned including brush from watershed and range lands contiguous to forest lands, stubble of various cereal grains and field crops, and prunings from fruit orchards. As more attention is given to all sources of pollution in the national effort to effect clean air standards, it is important to know the relative contributions of such burning. It is therefore the objective of this project to determine the kinds and amounts of gaseous and particulate emissions from this type of burning conducted in field studies and in specialized equipment which simulates open burning situations. Special attention will be given to burning under varying conditions of fuel moisture and loading. Also, methods will be studied for keeping the forest floor debris at the least hazardous level consistent with good ecological practice and a minimum of burning. Where appropriate, results from Grant AP 00568, wherein the chemical process of combustion is being studied with the aim of reducing harmful pollutants, will be applied to the burning situations of the present proposal.

LEAVE BLANK-DO NOT WRITE BELOW THIS LINE

## RESEARCH SUPPORT

List all other research support of the principal investigator, including requests now being considered as well as any proposals which the principal investigator plans to submit to the Public Health Service or other granting agencies, regardless of relevance to this application.

To be included also are current or pending contracts, Fellowship Awards, Research Career Awards, and Training Grants. Include support for this project received from own organization. Amounts shown should reflect total funds awarded or pending over the entire grant periods indicated in the final column.

Use blank continuation pages, if necessary, and follow the same format.

### A. PUBLIC HEALTH SERVICE SUPPORT

| GRANT NUMBER (*If designated*) | TITLE OF PROJECT | PERCENT TIME/EFFORT ON PROJECT | TOTAL AMOUNT | TOTAL PERIOD OF SUPPORT WITH DATES |
|---|---|---|---|---|
| (1) ACTIVE OR APPROVED | | | $ | |
| AP 00272 | Effect of dusts on vegetation | 10 | 191,527 | Sept. 1967<br>Aug. 1970 |
| AP 00568 | Characterization of smoke from cellulosic fuels | 10 | 139,161 | Feb. 1967<br>Jan. 1970 |
| UI 00535 | Noncombustive disposal of solid agricultural wastes | 20 | 200,190 | Feb. 1967<br>Jan. 1970 |

(2) APPLICATIONS PENDING DECISION OR PLANNED

Renewal of AP 00568 - Characterization of smoke from cellulosic fuels

Renewal of UI 00535 - Noncombustive disposal of solid agricultural wastes

### B. ALL OTHER RESEARCH SUPPORT

| SOURCE AND PROJECT NO. (*If designated*) | TITLE OF PROJECT | PERCENT TIME/EFFORT ON PROJECT | TOTAL AMOUNT | TOTAL PERIOD OF SUPPORT WITH DATES |
|---|---|---|---|---|
| (1) ACTIVE OR APPROVED | | | $ | |

(2) APPLICATIONS PENDING DECISION OR PLANNED

AP 00829 01A1

## DETAILED BUDGET FOR FIRST 12-MONTH PERIOD (DIRECT COSTS ONLY)

| FROM | THROUGH |
|---|---|
| January 1, 1970 | December 31, 1970 |

DESCRIPTION (Itemize) — AMOUNT REQUESTED (Omit Cents)

PERSONNEL

| NAME | TITLE OF POSITION | TIME OR EFFORT %/HRS. | SALARY | FRINGE BENEFITS | TOTAL |
|---|---|---|---|---|---|
| E. F. Darley | Plant Pathologist | 10 | None | None | - |
| H. H. Biswell | Prof., Forestry | 15 | " | " | - |
| A. Broido | Research Associate | 5 | " | " | - |
| L. Green | Project Leader | 5 | " | " | - |
| T. Y. Palmer | Res. Meteorologist | 5 | " | " | - |
| E. R. Stephens | Res. Chemist III | 5 | " | " | - |
| | Asst. Res. Chem I S I | 100 | 11,970 | 1,556 | 13,526 |
| | ~~Lab Tech IV~~ | ~~100~~ | ~~10,356~~ | ~~1,036~~ | ~~11,392~~ |
| | Lab Tech II | 100 | 8,520 | 852 | 9,372 |
| | ~~Sr Steno, Step III~~ | ~~50~~ | ~~3,030~~ | ~~303~~ | ~~3,333~~ |
| Richard Benner | Sr Maint Man Step V | 17 | 1,718 | 171 | 1,889 |
| | *Reduction* | *15% =* | *18877* | *2192* | *21069* |
| | | | ~~*22,[illegible]*~~ | ~~*2049*~~ | ~~*24,7[illegible]*~~ |
| | | | ~~35,594~~ | ~~3,918~~ | ~~39,512~~ |

CONSULTANT SERVICES None

EQUIPMENT

| Item | Amount |
|---|---|
| 1 gas chromatograph and recorder | 3,000 |
| ~~1 mass spectrometer~~ | ~~22,000~~ |
| ~~1 data acquisition system~~ | ~~9,100~~ |
| 1 Barnes IT 3 infrared thermometer | 2,700 |
| 1 L&N Azar recorder for thermometer | 1,150 |
| *6,850* | ~~[illegible]~~ |

SUPPLIES

| Item | Amount |
|---|---|
| Calibration gases, glassware, filter paper etc. | 3,000 |

TRAVEL

| | | | |
|---|---|---|---|
| TRAVEL | DOMESTIC | 2 staff conferences<br>trips to field plots | ~~2~~ 500 |
| | FOREIGN | | |

HOSPITALIZATION (Study patients)

OUTPATIENT OR SUBJECT COSTS (Study patients)

ALTERATIONS AND RENOVATIONS

PUBLICATION COSTS — 200

OTHER EXPENSES

| Item | Amount |
|---|---|
| ~~Microchemical analyses of fuels & residues~~ | 2,000 |
| ~~Computer Center charge~~ | ~~1,000~~ |
| ~~1 month rental Bofars real-time scanning camera~~ | ~~1,500~~ |

TOTAL (Enter on Page 1, Item 5) *37,337* → $ ~~89,662~~

## BUDGET ESTIMATES FOR ALL YEARS OF SUPPORT REQUESTED FROM PUBLIC HEALTH SERVICE (DIRECT COSTS ONLY - OMIT CENTS)

| DESCRIPTION | | 1ST PERIOD (SAME AS DETAILED BUDGET) | ADDITIONAL YEARS SUPPORT REQUESTED (This application only) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2ND YEAR | 3RD YEAR | 4TH YEAR | 5TH YEAR | 6TH YEAR | 7TH YEAR |
| PERSONNEL (Salaries, fringe benefits, etc.) | | 24,787 / ~~39,512~~ | 26,935 / ~~41,660~~ | 29,019 / ~~43,744~~ | | | | |
| CONSULTANT SERVICES (Include fees, travel, etc.) | | - | | | | | | |
| EQUIPMENT | | 6,850 / ~~37,950~~ | 3,000 | 3,000 | | | | |
| SUPPLIES | | 3,000 | 3,000 | 3,000 | | | | |
| TRAVEL | DOMESTIC | ~~[illegible]~~,500 | ~~[illegible]~~,500 | ~~[illegible]~~,500 | | | | |
| | FOREIGN | | | | | | | |
| HOSPITALIZATION (Study patients) | | | | | | | | |
| OUTPATIENT OR SUBJECT COSTS (Study patients) | | | | | | | | |
| ALTERATIONS AND RENOVATIONS | | | | | | | | |
| PUBLICATION COSTS | | 200 | 200 | 200 | | | | |
| ALL OTHER EXPENSES | | 2,000 / ~~4,500~~ | 2,000 / ~~3,000~~ | 2,000 / ~~3,000~~ | | | | |
| TOTALS | | 37,337 / ~~89,662~~ | 35,635 / ~~55,360~~ | 37,719 / ~~57,444~~ | | | | |

TOTAL FOR ENTIRE PROPOSED PROJECT PERIOD (Enter on Page 1, Item 4) ⟶ $ 110,691 ~~202,466~~

REMARKS (Justify continuing funds where the need may not be apparent)

Justification for IBM equipment year 01:

| | |
|---|---|
| IBM 1070 Process Communication System | |
| 1071 Terminal Control Model 2 | $5,860 |
| Analog-to-digital converter 1262 | 2,100 |
| Line adapter | 390 |
| 1072 Terminal Multiplexer Model 1 | 390 |
| (2) I/O Switching Modules 4663 | 360 |
| | 9,100 (tax and freight included) |

We believe the purchase of this system is justified for the following reasons:

1. Save considerable time and give results very shortly after fire is conducted.
2. Less cost over a three year period. We estimate that the hand work involved presently is $10.00 per fire. Eight fires per week would cost about $4000 per year.
3. Permit shorter intervals of data acquisition resulting in greater accuracy.

SECTION II - PRIVILEGED COMMUNICATION

AP 00829 01A1

# BIOGRAPHICAL SKETCHES

(Give the following information for EACH key staff member, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

| NAME | TITLE | BIRTHDATE (Mo., Day, Yr.) |
|---|---|---|
| Darley, Ellis F. | Plant Pathologist | Nov. 2, 1915 |
| **PLACE OF BIRTH (City, State, Country)** | **PRESENT NATIONALITY (If non-U.S. citizen, indicate visa status)** | **SEX** |
| Monte Vista, Colorado | US Citizen | ☒ Male ☐ Female |

**EDUCATION (Begin with baccalaureate training and include postdoctoral)**

| INSTITUTION AND LOCATION | DEGREE | YEAR CONFERRED |
|---|---|---|
| Colorado State University, Fort Collins, Colorado | B.S. | 1938 |
| University of Minnesota, St. Paul, Minnesota | Ph.D. | 1945 |

**HONORS**

Guggenheim Fellow, 1963-64
Fulbright Travel Grant, 1963-64
Editorial Board, Air and Water Pollution 63-66, Assoc Ed. Atmos. Environ. 1966-to date

**MAJOR RESEARCH INTEREST**

Identification and effects of air pollutants on plants; atmospheric analysis; agricultural operations as a source of air pollution; fungus root diseases of orchard crops.

**RELATIONSHIP TO PROPOSED PROJECT**

Principal Investigator - Analysis of effluents from burning various plant wastes.

**RESEARCH AND/OR PROFESSIONAL EXPERIENCE** (Start with present position; list ALL experience relevant to project.)

1949 - date Successively Assistant Plant Pathologist, Associate Plant Pathologist and Plant Pathologist, University of California, Riverside

The applicant is presently engaged in research on the effects of industrial pollutant dusts on vegetation. He has spent a number of years on research on the identification of phytotoxicants in photochemical air pollution and of their effects on vegetation. He has recently published results of an investigation on the pollutant contributions of burning of solid agricultural wastes.

## BIOGRAPHICAL SKETCHES

| | | |
|---|---|---|
| Biswell, Harold H. | Professor of Forestry | November 8, 1905 |
| Fayette, Missouri | U. S. Citizen | Male |

### Education

| | | |
|---|---|---|
| Central College, Fayette, Mo. | A.B. | 1930 |
| University of Nebraska, Lincoln, Neb. | M.A. | 1932 |
| University of Nebraska, Lincoln, Neb. | Ph.D. | 1934 |

### Honors

Fulbright Award, 1961-62
Guggenheim Fellow, 2 months in 1961 and 2 months in 1962
Special Award for Outstanding Service from Calif. Wool Growers Assoc., 1964
Distinguished Service Award, Arizona Resources Committee, 1966

### Research Interest

Ecological use of fire for forest land management; range management.

### Relationship to Project

Co-investigator--conduct field studies on burning various forest wastes and on the ecological consequences of such burning.

### Research and/or Professional Experience

1947-date Successively Associate Professor and Professor of Forestry

1940-47 Principal Ecologist, Southeastern Forest Experiment Station, Asheville, N.C.

1934-40 Range Ecologist, Pacific Southwest Forest and Range Experiment Station, Berkeley, California

The applicant is presently engaged in teaching and research in the use of fire in range, wildlife and forest management. For some 28 years he has devoted much of his time to research on the use of fire for improvement of forest lands.

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BIOGRAPHICAL SKETCHES

| | | |
|---|---|---|
| Abraham Broido | Research Associate | 9/12/24 |
| Cherkassi, Russia | U. S. Citizen | Male |

Education

| | | |
|---|---|---|
| University of Chicago, Chicago, Illinois | B.S. | 1943 |
| University of California, Berkeley | Ph.D. | 1950 |

Major Research Interest

Chemistry of fire behavior

Relationship to Proposed Project

Co-investigator

Research and/or Professional Experience

| | |
|---|---|
| 1959-date | Pioneering Research Specialist (physical chemistry) Pacific Southwest Forest & Range Experiment Station, Forest Service, USDA. |
| Currently | Consultant, University of Calif. Inst. of Engineering Research; Research Associate, University of Calif. Dept of Industrial Engineering; Research Associate, University of Calif. Statewide Air Pollution Research Center; Consultant, U.S. Naval Radiological Defense Laboratory. |
| 1964-65 | Guest scientist in Dept. of Organic Chemistry, Hebrew University of Jerusalem, Israel |
| 1956-59 | Chemist, California Forest & Range Exp. Station, Forest Service, USDA |
| 1950-56 | Chemist (radiological), Head, Thermal Radiation Branch (9/51-7/53) U.S. Naval Radiological Defense Laboratory. |
| 1948-50 | Teaching and Research Assistant, College of Chemistry and Radiation Lab. University of Calif., Berkeley |
| 1946-48 | Research Chemist, Clinton Laboratories, Monsanto Chemical Co (later Oak Ridge National Laboratory) |
| 1943-46 | Research Assistant, Research Chemist, Metallurgical Laboratories, University of Chicago (later Argonne National Laboratory) |

BIOGRAPHICAL SKETCHES

| | | |
|---|---|---|
| Green, Lisle R. | Fuel-Break Project Leader | November 18, 1918 |
| Ogden, Utah | U. S. Citizen | Male |

<u>Education</u>

| | | |
|---|---|---|
| Utah State University, Logan, Utah | B.S. | 1941 |
| Utah State University, Logan, Utah | M.S. | 1948 |

<u>Honors</u>

Phi Kappi Phi
Xi Sigma Pi

<u>Major Research Interest</u>

Fuel hazard reduction in brush and mixed conifer types

<u>Relationship to Proposed Project</u>

Co-investigator. Assist in planning, conducting, and evaluating prescribed wildland burns.

<u>Research and/or Professional Experience</u>

1. Since 1960, as leader of the Fuel-Break Project, Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service, the applicant has been developing techniques for brush-to-grass conversion, or to other acceptable ground cover. He has been studying the use of fire to construct and maintain fuel-break for 4 years in the central Sierra Nevadas; has been involved for 2 years in use of fire and herbicides to eliminate brushfields for timber planting, and helping work out techniques for better use of fire in burning clearcut blocks in the Douglas-fir timber type.

2. Between 1955 and 1960, he taught range management at California State Polytechnic College, San Luis Obispo, California.

3. The applicant worked as a range conservationist at the Forest Service's San Joaquin Experimental Range, Coarsegold, Madera County, between 1948 and 1954. This was a period of development of the rancher control burn program, and he participated in 50 to 60 prescribed burns as observer, firefighter, and representative of the Experimental Range. At the Experimental Range, he worked out a recommended program calling for advance preparation, burning, reseeding, follow-up chemical treatment, and management.

This experience brackets the types of prescribed burning that will be done in this project.

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# BIOGRAPHICAL SKETCHES

| | | |
|---|---|---|
| Palmer, Thomas Y. | Project Leader, Project Flambeau | Sept. 11, 1924 |
| Kiowa, Kansas | U. S. Citizen | Male |

## Education

| | | |
|---|---|---|
| St. Louis University, St. Louis, Missouri | B. S. | 1950 |
| University of Washington, Seattle, Washington | M. S. | 1961 |

## Honors

Associate Fellow AIAA
Post Member AIAA Committee on Atmospheric Environment

## Major Research Interest

Physical mechanisms of mass fires

## Relationship to Proposed Project

Co-investigator. Assist in planning and analysis of prescribed fires.

## Research and/or Professional Experience

1. Since December 1957, leader of Project Flambeau.

2. Since 1956 the applicant has been active in instrumentation, aerosol behavior and intensive convective activity in the atmosphere. From 1962 to 1967 as a Research Specialist with the Boeing Co., he developed hydrodynamic models of convection; studied aerosol behavior and remote sensing techniques. From 1961 to 1962 he was a branch Chief in charge of instrumentation development at Air Force Cambridge Research Laboratories. From 1956 to 1959 he was a Staff Member of Sandia Corporation studying instrumentation and meteorological effects of nuclear weapons. He is holder of patents in remote sensing of atmosphere contaminants and aerosol generating equipment.

3. From 1959 to 1961 he studied and taught Meteorology at the University of Washington.

4. The applicant has worked for 11 years in the fields of convective phenomena, instrumentation and aerosol behavior and diffusion. This experience will be of value in planning methods of sampling fire behavior and dispersion and atmospheric dilution of gaseous and particulate combustion products.

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## Biographical Sketches

| | | |
|---|---|---|
| Stephens, Edgar R. | Research Chemist | August 26, 1924 |
| Detroit, Michigan | U. S. Citizen | Male |

### Education

| | | |
|---|---|---|
| Carnegie Institute of Technology, Pittsburgh, PA | B.S. | 1945 |
| Princeton University, Princeton, New Jersey | M.A. | 1949 |
| Princeton University, Princeton, New Jersey | Ph.D. | 1951 |

### Major Research Interest

Basic studies in photochemistry, atmospheric reactions in air pollution, auto exhaust emissions, spectroscopy

### Relationship to Proposed Project

Co-Investigator

### Research and/or Professional Experience

| | |
|---|---|
| 1963-date | University of California, Riverside, Research Chemist |
| 1959-1963 | University of California, Riverside, Research Associate |
| | Scott Research Labs., Inc., Perkasie, Pennsylvania |
| 1950-1959 | Franklin Inst. Labs., Philadelphia, PA., Senior Staff Chemist |
| 1945-1947 | Shawingan Resins Corporation, Springfield, Massachusetts, Research Chemist |

For the past 10 years his studies have been concerned with the photochemistry of air pollution. He was the first to design, build, and gather data from long path infrared spectroscopy. He was the discoverer of peroxyacyl nitrates in polluted atmospheres which have since been proven to be major components for plant damage and eye irritation. He has also studied and worked out a means by which the age of the photochemical pollution cloud can be determined by comparing reactivities of specific hydrocarbon compounds.

RESEARCH PLAN

A. Introduction and specific aims.

Prescribed fire, the controlled open burning under specified weather and fuel conditions, on forest and agricultural lands has been and is becoming an increasingly important factor as a rapid and relatively inexpensive method of ridding such lands of unwanted plant materials.

In public and private forest lands the objective is to reduce fire hazard and the threat of catastrophic wild fires, maintain favored plant species and, in many cases, effect better recreational use. Prescribed fire has become an integral part of forest management and protection. In the West slash resulting from logging operations is a principal contributor to major wildfires in the forest. Prescribed fire reduces the concentrations of such slash and thereby reduces the fire hazard. At a recent meeting of researchers working on pollution from fires and U.S. Forest Service officials, it was stated that one of the most pressing problems was that of maintaining an acceptable balance between the use of fire and pollution of the atmosphere. Some 2,919,000 acres of forest lands are burned annualy in the U.S. About 9% of this is in the West, the remainder in the East. But because of the heavier loading per acre in the West (80 tons versus 16 tons in the East) about one-third of the total tonnage burned occurs in the West.

On agricultural lands, the objective is to dispose of the plant debris of farming operations as quickly and efficiently as possible. The problem of air pollution from such operations is accentuated because such operations are usually closer to urban areas.

As more attention is given to all sources of air pollution in the national effort to improve air quality, it is important to know the relative contributions of such burning. Of the two operations, the forest is least amenable to alternate methods of disposal; various alternative methods are being studied for some types of agricultural practices. But until the feasibility of such methods is determined and because fire will be used in the interval, perhaps even in conjunction with other methods, more needs to be known about the pollutant contributions of controlled open burning and how pollution might be reduced by modifying burning methods.

Some data have been published recently by the applicant institution showing the yield of several gases which participate in photochemical pollution when agricultural wastes are burned. The tests included fruit tree prunings, grain stubble and various plants from range lands adjacent to public forests. These studies need to be expanded and conducted in greater detail. But we know of no published work on the pollutant effluents from opening burning of undesirable tree species and the accumulated debris under various types of forest cover. Therefore the specific objectives of this project are:

1. In cooperation with fire scientists of the U.S. Forest Service, conduct tests in the "burning tower" at Riverside to further evaluate the similarity of the apparatus with open burning situations. Preliminary observations indicate that the tower simulates open burning, but confirming data are lacking.

2. Conduct prescribed burning tests on experimental plots in various forest types to determine: a) smoke production in relation to burning rate and weight of fuel consumed under varying conditions of weather and fuel moisture, b) alterations in smoke when the fuel has been pretreated with herbicides or various combustion modifying chemicals, and c) follow the subsequent ecological changes in the several forest types in relation to given burning practices.

3. Collect the same forest fuels for tests at Riverside under simulated open burning conditions to determine weight of gaseous and particulate emissions per ton of fuel burned and the effect of fuel loading and moisture on emissions.

4. Expand the present current program of burning various agricultural wastes to determine gaseous and particulate pollutants.

B. Methods of procedure

The project will be carried out in two parts: 1) field studies on the University-owned Whitaker's Forest (adjacent to Sequoia National Park) and on one or more privately owned forest sites, and 2) laboratory studies in Riverside, principally on the campus of the University, and occasionally in the adjacent facilities of the U.S. Forest Service Fire Laboratory.

Field Studies - Most of the prescribed burning will be done on the Whitaker's Forest consisting of some 300 acres situated near Sequoia National Park and owned by the University. Studies have been underway here for some time in an effort to learn how to manage the forest to preserve and enhance the giant redwoods. The following procedures for field burning will be used.

1. Cut understory trees during the summer and fall months, letting them dry before being burned. This will be done because observations have shown that green materials burn with much visible smoke production.

2. Fires will be set under progressively drier conditions and in different fuel types to help determine the weather and fuel conditions necessary for prescribed burning with the least smoke production. On Whitaker's Forest there are five principal fuels: debris produced by giant sequoia, ponderosa pine, white fir, incense-cedar, and bear clover draped with ponderosa pine needles. These fuels have different burnability levels. Probably a dozen or more tests will be made in each fuel type to establish the desired relationship between weather and fuel conditions and fire spread. This work will be done on plots varying in size from 6.6 x 6.6 feet up to 20 acres. Tests will be made each year until satisfactory relationships are established.

3. Two common burning methods will be tested for their smoke production. First, in very heavy fuels, the dead material and small understory trees will be cut, piled, and burned. Second, fire lines will be prepared and fires will be set on the edges of the area to ba burned, letting the fire spread through the fuel under the larger crop trees. Most burning will be done in February, March, April and May when the danger of wildfire is at a low level.

4. Atmospheric samples for particulate and hydrocarbons will be taken during given fires. Whereas it is expected that 50 to 75 fires will be conducted in any one season, perhaps not everyone will be sampled. At the least we would make duplicate samples from each fuel type at high, medium and low fuel moisture conditions. More samples would be taken as conditions permit.

For particulate sampling we would expect to use the Gelman Battery Air Sampler employing a carbon vane pump, 47 mm glass fiber filter in a suitable holder, and a 5-20 CFM flow meter. The maximum sampling rate of this unit may or may not prove to be sufficiently high. Another compact instrument is Gelman's Hurricane Air Sampler which employs a 4 inch filter and air flows up to 225 CFM, but is less portable because it requires standard power sources. The company is looking into the possibility of putting together a unit that is battery operated, using a 4 inch



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filter with air flows of approximately 10 CFM which might be adequate for short sampling periods of 10 to 20 minutes.

With portable equipment as outlined, we would expect to take samples downwind from a given fire making comparisons in weight of particulate collected at given flow rates and time when walking back and forth parallel to the fire line in uniform smoke densities at two or more distances from the fire line. It is possible to determine weight of fuel burned; it may, therefore, be possible to come up with some quantitative data, although they may be quite rough. We already work in close cooperation with NAPCA grantees in Oregon and Washington and would discuss our results with them in order to effect any modifications that might improve the systems.

Gas samples for hydrocarbon analysis will be collected in 300 ml gas sample bottles at the same time particulate samples are taken. By using split air flow lines and suitable stopcocks, the same pump would be used for both systems. If desirable, simultaneous gas samples can be taken at other portions of the fire by drawing the sample through a bottle by means of a hand squeeze bulb. The samples will be transported to Riverside and analyzed on gas chromatographs which distinguish 23 different hydrocarbons, most of them being olefins. Gas chromatographic techniques have been developed at Riverside that permit analyses of hydrocarbons from grab samples in the parts per billion range. The system was recently tested and proven satisfactory with samples taken from a prescribed fire conducted by the U.S. Forest Service Fire Lab. in a brush fuel east of Riverside. While the results are expressed in parts per billion in the sample, it will not be possible to determine yields of hydrocarbon per ton of fuel burned because we will not know total air flow into the fire. We will know the kinds of hydrocarbons and their ratio which can be compared with similar information being taken by our laboratory and other mobile units in the Los Angeles Basin.

5. The rate of buildup in fuels after the initial burning treatment will be determined. This will establish minimum control burning requirements in fire hazard reduction. Needle and debris fall will be sampled and weighed and the rate of increase in understory trees and shrubs will be measured. These studies present the possibility of guiding forest succession toward less hazardous types when fuel manipulation for fire hazard reduction will not be so essential.

6. The use of chippers is an alternative means of reducing fire hazards with low smoke production. The cost of chipping and the effects of chipped material on plant successions will be measured and compared with those of prescribed burning. The contribution of chipped materials to fire hazards, their rate of decay, effect on tree growth, etc. will be studied.

The work crews for the field aspects of the project will be provided from the Miramonte Conservation Camp under agreement between the California Division of Forestry and the School of Forestry and Conservation on the Berkeley campus. Supervision of these crews will be provided by the project and Mr. Benner is listed under Personnel for this purpose.

Whereas most of the field work will be conducted at the Whitaker's forest as indicated above, the Forest Fire Lab often conducts prescribed fires in southern California closer to Riverside. One such fire was held in the mountains east of Riverside on May 26. We successfully sampled this fire for hydrocarbons and would expect to sample more of their fires in the future.

<u>Laboratory Studies</u> - Most of the research at Riverside will be conducted in a burning tower. This is an inverted cone approximately 18 feet high placed over a weighing platform 8 feet in diameter and arranged so that open burning is simulated but

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permitting the effluent to be channeled for adequate sampling. During the burning, air flow and temperature at the sample site are measured continuously. Also, there is continuous recording of CO, $CO_2$ and of total hydrocarbon expressed as carbon. From these data it is possible to calculate yield of CO, $CO_2$ and hydrocarbon in pounds per ton of fuel burned. Grab samples for gas chromatographic analysis of some 23 individual saturated and unsaturated hydrocarbons are taken at specified periods during the fire.

The tower has been modified recently to provide for isokinetic sampling of particulates and for continuous monitoring of oxygen. The particulates are collected on standard sized high volume sampler filter paper and weighed. The sample nozzle is 1/700 of the area of the tower outlet so that calculation of the yield of particulates is quite simple since the flow is isokinetic. Chemical analyses following the standard procedures of the NAPCA laboratories will also be made.

Techniques need to be developed to analyze for aromatics and various oxygenated compounds, which at the present time are not measured. A mass spectrometer to be used in conjunction with a chromatograph is requested for this purpose. Dr. E. R. Stephens, a co-investigator on the project, has had considerable experience with this technique, having used mass spectrometry, time-of-flight spectrometry, and long path infrared spectrometry for the identification, isolation and characterization of the photochemically produced air pollutants, peroxyacyl nitrates. He has also used these techniques with the parent hydrocarbons involved in photochemical reactions. It is expected that whoever fills the position of Assistant Research Chemist will have some knowledge of spectroscopy and that Dr. Stephens will work with him in the use of the mass spectrometer and interpretation of results.

In addition to taking temperature at the sample site, we propose to determine the temperature in the fire. Mr. Palmer, a co-investigator, has had considerable success with the Barnes infrared thermometer in recording flame temperatures in prescribed fires. Smoke does not interfere. At his suggestion we propose to purchase an instrument for this purpose. It has also been suggested that for a one-month period a Bofars real-time scanning camera be leased to further characterize flame temperatures on a number of fuels that could be burned in that period.

BTU determinations of fuels for which standard values are not already known will be made by the Fire Lab using the standard bomb colorimeter. Since we are currently recording the rate of weight loss during the test fires, and know the fuel moisture content, BTU calculations can be made easily.

In cooperation with the fire scientists in the Forest Service Fire Laboratory, a special study will be made to further characterize the "open burning" features of the tower. Some critics have suggested that the tower is more like an incinerator and is actually a forced convection system rather than a free burning system. Preliminary tests of comparing simultaneous fires in the tower and on the ground nearby showed no observable differences. The Forest Service will employ their techniques with radiometry, water cooled anemometers, thermocouples, portable weighing platforms and prefabricated wooden cribs, whose fire behavior is well known, for comparing burning behavior in "tower" and open fires.

Samples of fuels from the Whitaker forest will be brought to Riverside, burned and the effluents measured as noted above. Previous experience has shown that we are able to collect fuels and maintain the moisture during transport to the time they are burned. Fuels at relatively high moisture levels can be collected in sufficient quantities to permit sub-samples to be dried to the desired level at Riverside. Our statistician has advised us that for the objectives of the study, simple duplicates

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are sufficient but that we should have sufficient fuel for a third fire in case there is great variation between the two. Thus in one spring season we would burn duplicates of the five fuels and three moisture levels for a minimum of 30 fires. Since the tower is out-of-doors, burning is regulated somewhat by weather. We confine burning to the morning hours and do not burn when windy or rainy. From 2-4 fires can be conducted in a morning. Thus the maximum number of fires during any week could be from 10-20. Except for the very unusual rainy period this last winter and spring (21 inches when the 64 year average is a little more than 10 inches) we can almost always count on at least two burning days per week. Thus the minimum number of fires would be 4-8. The Whitaker program will run about 16 weeks each year from February through May. With the minimum burning weather at Riverside we would be able to conduct at least 64 and perhaps 128 fires, which is well over the minimum proposed and thus provide for many extra fires if needed, and would permit an examination of different loadings. With 4 burning days per week the possibilities are doubled. Therefore, in addition to the Whitaker fires, we expect to burn fuel samples sent to us from the other two U.S. Forest Service Fire Labs (Macon, Georgia, and Missoula, Montana) in order to compare their controlled environment combustion chamber techniques with ours. This cooperative effort is already underway, for within a few weeks we will receive from Missoula samples of Douglas Fir from plots which have been prepared for burning this summer and fall.

Most agricultural burning takes place in the summer and fall and studies of these fuels would not interfere with the Whitaker program. We have burned several fuels to date but there are others we wish to examine, such as citrus, grape, a more detailed study of rice and barley, and perhaps 5-6 other woody fuels. These can be at the time of year when we can easily expect at least 4 and perhaps 5 burning days per week.

Where appropriate, treatment of the fuels with chemicals used to modify the combustion process will be studied to determine the effect of such treatments on kinds and amounts of effluent. A preliminary test of a commercial fire retardant will be started next week in cooperation with the Fire Lab.

All studies will be conducted in close consultation with the California Air Resources Board, who have displayed a keen interest in our work as they are now faced with the probability of publishing criteria and standards related to emissions from forest and agricultural burning.

Data Analysis - At present, data from continuous recordings of air flow, temperature, CO, $CO_2$ and total carbon are transferred by hand to appropriate forms for each 20 second interval of the fire. A key punch operator then transfers this information to punch cards which are processed by the computer for final calculations. It is proposed therefore to acquire an IBM 1070 Process Communication System which can be mated with our existing computer and will provide for data points to be taken at 1 second intervals. This will save considerable time, would cost less over a three year period (we estimate that the hand work presently involved is $10.00 per fire or at least $4000.00 per year for at least 8 fires/week), permit shorter intervals of data acquisition resulting in greater accuracy, permit examination of results very shortly after the fire is conducted, and eliminate possibility for human error. Validation and editing of data from the acquisition system will be done by modifying the computer program to plot the curves of each set of data. Since we already have a permanent curve being made at each instrument recorder at the time the fire is burning, a comparison of this curve with that of the data acquired by the system can be used for editing purposes.

C. Significance of this research

The results of this project will assist in determining the relative contribution to air pollution from open burning of several types of plant materials. Through cooperation with the U.S. Forest Service and PHS projects in Oregon and Washington, a sufficiently wide variety of fuels will be burned, and results compared with cooperating laboratories, to indicate the range of pollutant contributions throughout the principal areas where open burning is practiced. The need for this type of information becomes more important as the national effort to set regional air quality criteria moves forward.

D. Facilities available.

The laboratories of the Statewide Air Pollution Research Center are available for this project. These include the burning tower with its ancillary equipment and a gas chromatographic laboratory. The Computing Center has an IBM 360/50 which can be mated with the data acquisition system. The University-owned Whitaker Forest, a 320 acre area of redwood and mixed conifers located adjacent to the Sierra National Park, is also available for much of the field work. In addition, the U.S. Forest Service Fire Laboratory at Riverside will be used for a portion of the work.

Major equipment items at the University include CO and $CO_2$ infrared gas analyzers, total carbon analyzer, temperature recorder, air flow recorder, automatic isokinetic particulate sampler, extraction apparatus for high volume filter papers, 3 gas chromatographs, infrared spectrometer (infracord), Mettler analytical balance, and drying ovens.

E. Collaboration

Principal collaboration is with the U.S. Forest Service Fire Laboratory at Riverside. Arrangements have been made with Mr. C. C. Wilson, Chief of the Laboratory, for cooperative efforts. As this laboratory is one of three such installations in the U.S., and all of them work closely together, we are in a unique position of also collaborating with the other two units by exchanging materials and data.

We will also expect to do cooperative work with Dr. Adams, Washington State University, and Dr. Boubel, Oregon State University. These two investigators have NAPCA projects on pollution from burning forest slash. Collaboration between all agencies noted is already underway by virtue of the work conferences on "Air Pollution Aspects of Burning Forest Debris" that were held in 1967 and 1968. These conferences were also attended by NAPCA representatives. Also some 25 grass samples have been burned for Dr. Boubel on another of his projects for purposes of comparing data with his field studies.

SUPPORTING DATA

A. Previous work done in this field

As noted earlier, the applicant institution has already published work on the pollution emissions from the open burning of several types of plant materials. The burning tower was developed for this study. The results showed that hydrocarbon yields were about one-tenth those of auto exhausts based on weight of fuel burned. Relatively little was done on effect of fuel moisture but the results did indicate that increasing moisture increased hydrocarbon yields. At first no effort was made to monitor particulates since the objective was primarily to study emissions related to photochemical pollution. Because smoke is one of the primary effleunts from open burning, the tower has been modified to monitor particulates.

UNIVERSITY OF CALIFORNIA

Date February 27

TO Jim Southerland FROM E. Darley

Subject Enclosures following phone call

For ☐ initial ☐ signature ☐ approval ☐ comments ☐ discussion ☐ information

Please ☐ file ☐ return ☐ draft reply ☐ action ☐ route to

Message Jim Attached are:

1. Missing raw data on fires for E-1, 2 and 3.
2. Dollar s letter to me explaining missing data and his summary of the ~~mmmmmmmmm~~ raw data.
3. My response to Dollar's letter
4. Ed Lui's letter to me conderning future plans.

Ellis

Attachment Memo—Series 249

The various investigators have done considerable work on prescribed burning, the chemistry of the combustion process and on gas analyses by spectroscopy and gas chromatography.

B. Personal Publications

E. F. Darley

Darley, E. F., J. T. Middleton, and M. J. Garber. 1960. Plant damage and eye irritation from ozone-hydrocarbon reactions. J. Agric. and Food Chem. 8: 483-485.

Stephens, E. R., E. F. Darley, O. C. Taylor and W. E. Scott. 1961. Photochemical reaction products in air pollution. Inter. J. Air and Water Pollution 4: 79-100.

Darley, E. F., K. A Kettner and E. R. Stephens. 1963. Analysis of peroxyacyl nitrates by gas chromatography with electron capture detection. Anal. Chem. 35: 589-591.

Darley, E. F., F. R. Burleson, E. H. Mateer, J. T. Middleton, and V. P. Osterli. 1966. Contribution of burning of agricultural wastes to photochemical air pollution. J. Air Poll. Control Assoc. 16: 685-690.

Darley, E. F. 1969. Clean air from a working forest. Proc. 59th Western Forestry Conf., San Francisco, pp. 65-68.

H. H. Biswell

Biswell, H. H. 1957. The use of fire in chaparral for game habitat improvement. Proc. Soc. Amer. For., Syracuse, N. Y., pp. 151-155.

Biswell, H. H. 1959. Prescribed burning and other methods of deer range improvement in ponderosa pine in California. Proc. Soc. Amer. For., San Francisco, Calif., pp. 102-105.

Biswell, H. H. 1963. Research in wildland fire ecology in California. Proc. Second Tall Timbers Fire Ecology Conference, pp. 63-97.

Biswell, H. H. 1968. Forest fire in perspective. Proc. Sixth Tall Timbers Fire Ecology Conference (in press).

A. Broido

Broido, A. 1961. Effect of fire-extinguishing agents on combustion of sucrose. Science 133: 1701-02.

Broido, A., and F. J. Kilzer. 1963. A critique of the present state of knowledge of the mechanism of cellulose pyrolysis. Fire Research Abstracts and Reviews 5: 157-161.

Kilzer, F. J., and A. Broido. 1965. Speculations on the nature of cellulose pyrolysis. Pyrodynamics 2: 151-163.

Broido, A. 1966. Thermogravimetric and differential thermal analysis of potassium bicarbonate contaminated cellulose.

UNIVERSITY OF CALIFORNIA, RIVERSIDE

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STATEWIDE AIR POLLUTION RESEARCH CENTER | RIVERSIDE, CALIFORNIA 92502

June 22, 1973

Dear Mel:

Minn just finished the analyses of the pineppple fires for me. To save time, I will again type this myself so as to get it in the mail this afternoon---so please pardon the errors.

Between May 4 and 29 we ran 20 pine trash fires at times when the humidity was generally above 50 percent. But always because . . fuels and/or other conditions were not comparable, analyses were done on only 14 of the fires. The results are shown on the attached table and the analyses of the various factors for the variables listed are shown on the accompanying sheets, one variable to each sheet.

To the table. The fires were burned on an inclined plane (49percent slope)-- head fires from the bottom, back fires from the top. The fuel was arranged in a 4' x 4' pattern at a basic air-dry loading of 16 pounds. This gave a bed of 10" to 12" deep. Thus the fires at the low moisture content on a dry weight basis were burned at what ever the air dry content was and then those at the medium and high levels had the appropriate amount of water added to 16 pounds of fuel contained in a large plastic bag and allowed to come to equilibrium for about 18 hours.

Sprayed + mixed

Head and back fires on the same line of the table were burned on the same day---sometimes the head fire first and sometimes the back fire first (the RH gives the clue to order of burning ) Thus for analyses there were two fires each at the low moisture, 3 each at the medium and, two each at the high. One pair at the low and high (*) were not included in the analyses because the trash was heavily covered with red soil and the emissions were different. This red soil stuff was from the first shipment sent to us last winter.

Two more head fires (1/, 2/) were sort of mistakes but I have included them so you can see what the worst possible situation might be. In both of them the moisture was more than I wanted and they were hard to ignite. In (1/) I had neglected to put in the bottom screen so that there was poor ventilation under the fuel. In (2/), burned the same day, I put the screen in but the humidity had dropped so drastically that it is difficult to say what part the screen or the humidity had in the lower emissions.

Minn did a two-way analysis of variance and Duncan's Multiple Range Test of Mean Differences, to show the significance (or lack of same) for head and back fires and moisture for 5 variables. R.H. was not considered---all we tried to do here was burn at humidities that might approach those found in Hawaii during the burning season.

Within either the 5 percent, 1 percent, or o.1 percent level she has indicated significance with the letter system wherein different letters indicate significance and same letters do not. I won't try to go into a discussion of this because you can see them for yourself. But in general, high moisture back fires are not too much worse than low moisture head fires for particulate. Wet head fires get to be pretty bad. Thus if the grower's have the choice and could burn against the wind they should produce the minimum of pollution but it will take longer and the material should be uniform in density as possible so as to assure that the fire will carry.

One feature that is not present in these fires that was in the earlier four fires we burned las t winter, is that the stumps were dry and burned up almost completely in the May fires. Had they been present at the moisture level as collected in Hawaii, I believe that the particulate loading would have been higher. Another way of saying this is that adding moisture to the fuels may not be the same thing as having wet stumps in the system.

I want to get this in the afternoon mail so will stop here.

Best regards.

Cordially,

Ell

cc: Jim Southerland
Don Hendricks

P.S. I have enclosed enough copies of the data so that you can give them to DOH and the Pineapple people.

P.P.S. On Minn's sheets, she has always listed means in decending order of value so that head, back, and lo, med and hi are not always in the same order from sheet to sheet.

| | HEAD FIRES | | | | | | | BACK FIRES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Moisture | | Rate of burn | | Emissions, lbs per ton wt. loss | | | Moisture | | Rate of burn | | Emissions, lbs per ton wt. loss | | |
| | Fuel | R.H. | ft./min | av. lb/min | CO | HC | Part. | Fuel | R.H. | ft./min | av. lb/min | CO | HC | Part |
| Low | 8.8 | 42 | 2.7 | 3.7 | 108.7 | 4.3 | 6.3 | 8.1 | 32 | 0.9 | 2.7 | 113.9 | 3.2 | 6.2 |
| | 10.4 | 52 | 3.0 | 3.4 | 102.1 | 4.9 | 6.4 | 10.4 | 65 | 1.1 | 2.3 | 100.9 | 4.2 | 6.6 |
| | * 10.8 | 85 | 2.0 | 3.6 | 78.0 | 5.7 | 7.0 | 12.3 | 66 | 0.8 | 2.1 | 78.2 | 4.9 | 7.0 |
| Medium | 16.7 | 68 | 1.8 | 3.1 | 121.8 | 6.6 | 8.7 | 15.6 | 77 | 0.5 | 1.7 | 112.9 | 4.6 | 6.5 |
| | 18.4 | 68 | 1.3 | 2.8 | 91.0 | 5.7 | 8.1 | 17.9 | 59 | 0.5 | 1.5 | 103.1 | 5.3 | 7.4 |
| | 15.7 | 51 | 1.6 | 3.2 | 87.4 | 5.4 | 8.8 | 16.1 | 37 | 0.5 | 1.6 | 121.5 | 8.2 | 9.2 |
| High | 25.0 | 84 | 1.0 | 1.9 | 131.9 | 11.7 | 28.4 | 25.0 | 65 | 0.4 | 1.4 | 110.7 | 6.6 | 8.2 |
| | 28.3 | 82 | 0.8 | 2.0 | 127.8 | 12.8 | 21.7 | 23.8 | 60 | 0.4 | 1.1 | 122.7 | 7.8 | 9.9 |
| | * 26.9 | 74 | 1.1 | 2.5 | 99.3 | 8.4 | 10.5 | 28.3 | 60 | 0.5 | 1.3 | 146.0 | 7.2 | 9.0 |
| | 1/ 30.6 | 40 | 0.6 | 1.3 | 166.0 | 26.4 | 45.0 | (head fires only) | | | | | | |
| | 2/ 30.7 | 24 | 0.8 | 1.6 | 126.0 | 17.2 | 28.5 | | | | | | | |

* Fuel dusted heavily with red soil. Data not included in analyses

1/ Same fuel as those analysed but at a higher moistube than intended and screen was left off of table by mistake

2/ Same as 1/ but screen used. However, humidity dropped drastically. Neither of these two fires used in analyses.

PINEAPPLE TRASH

Factors 1) Head vs Back
2) Moisture Lo - Med - Hi

Variables

B Rate of Burn (ft/min)

| | | means | |
|---|---|---|---|
| 1) | Head | 1.7429 | NOT SIG |
| | Back | 0.8571 | |

| 2) Moist | means | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Lo | 1.925 | a | a | a |
| Hi | 1.075 | b | b | b |
| Med | 1.033 | b | b | b |

3) Moist × (Head/Back)

| | means | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Head Lo | 2.85 | a | a | a |
| Head Med | 1.5667 | b | b | b |
| Back Hi | 1.25 | bc | bc | bc |
| Back Lo | 1.0 | c | bcd | bc |
| Head Hi | 0.9 | c | cd | bc |
| Back Med | 0.5 | d | d | c |

C Ave lbs loss/min

1) Head/Back

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Head | 2.871 | a | a | a |
| Back | 1.757 | b | b | b |

2) Moist

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Lo | 3.025 | a | a | a |
| Med | 2.317 | b | b | ab |
| Hi | 1.600 | c | c | b |

3) Moist x (Head/Back)

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Head Lo | 3.55 | a | a | a |
| Head Med | 3.03 | b | ab | a |
| Back Lo | 2.50 | c | bc | ab |
| Head Hi | 1.95 | d | c | bc |
| Back Med | 1.60 | de | cd | bc |
| Back Hi | 1.25 | e | d | c |

D CO lbs/T NOT SIG

1) Back 112.2
   Head 110.1

2) Moist

   Hi 123.3
   Lo 106.4
   Med 106.3

3) Moist x (Head/Back)

   Head Hi 129.85
   Back Hi 116.7
   Back Med 112.5
   Back Lo 107.4
   Head Med 105.4
   Head Lo 100.1

E HC (lbs/Ton)

1)

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Head | 7.343 | a | a | a |
| Back | 5.7000 | b | a | a |

2) Moisture

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Hi | 9.725 | a | a | a |
| Med | 5.967 | b | b | ab |
| Lo | 4.150 | c | b | b |

3) Moist x (Head/Back)

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Head Hi | 12.25 | a | a | a |
| Back Hi | 7.20 | b | b | ab |
| Back Med | 6.03 | bc | b | ab |
| Head Med | 5.9 | bc | b | b |
| Head Lo | 4.6 | bc | b | b |
| Back Lo | 3.1 | c | b | b |

F Particulates

| | | | 5% | 1% | 0.1% |
|---|---|---|---|---|---|
| 1) | Head | 12.11 | a | a | a |
| | Back | 7.71 | b | b | b |

2) Moisture

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Hi | 16.15 | a | a | a |
| Med | 8.12 | b | b | b |
| Lo | 6.38 | c | b | b |

3) Moist x (Head/Back)

| | | 5% | 1% | 0.1% |
|---|---|---|---|---|
| Head Hi | 23.25 | a | a | a |
| Back Hi | 9.05 | b | b | b |
| Head Med | 8.53 | bc | b | b |
| Back Med | 7.9 | bc | b | b |
| Back Lo | 6.4 | bc | b | b |
| Head Lo | 6.35 | c | b | b |

Encl 1

State of Hawaii
Department of Agriculture
Honolulu, Hawaii

January 5, 1973

MEMORANDUM

To: Frederick C. Erskine, DOA
Richard Marland, OEQC
Henri Minette, DOH
Doak Cox, UH-EC
Ed Lui, HSPA
Ron Terry, MP

Subject: Data Summaries from U. C. Riverside Burning Tower Studies

Ellis Darley had completed 17 tower burns for cane trash, 20 for restructured cane matrix and 4 for pineapple trash. Data on particulate matter is complete while analyses of CO, $CO_2$ and hydrocarbons are incomplete. Data available has been summarized for sugar cane trash (Table 1), cane including trash (Table 2) and pineapple (Table 3).

Sugar Cane Burn Studies:

Sugar cane field studies on Oahu, 20 individual sets of data, indicate leaf trash averages 13 tons per acre, 9 percent of the total weight of cane and trash. In the tower studies of cane plus trash the weight of leaf trash averaged 11 tons per acre, 14 percent of the total weight of cane and trash. The quantity burned, i.e., net disappearance, in field studies was 17 tons per acre or 12 percent of the initial load as compared to 15 tons per acre or 20 percent of the initial load in tower studies.

Sugar Cane Emission Values:

These results of field and tower studies agree reasonably well for a range of platform loadings. Emission values for normal loading of the test platform averaged 7.1 ± 2.0 lbs. per net ton burned.

Pineapple Burn Studies:

Field studies on Oahu indicate 36-39 percent of the total trash disappears during a burn. Earlier studies reported by the Pineapple Growers indicated about 70 percent disappearance. Field loads range from 25-54 tons per acre. The net disappearance values for the 1972 field studies were 9 tons per acre and for tower studies 4.4 tons per acre. The values for the tower studies were for a table load of 6.7 tons per acre which is about one-half the normal field load.

Pineapple Trash Emission Values:

Emission values for four tower burns 9.2 ± 2.3 pounds per net ton burned. These values while preliminary are reasonable estimates when considered in parallel with the sugar cane values.

## SUMMARY ANALYSIS OF U. C. RIVERSIDE TOWER BURNS

### TABLE 1 - SUGAR CANE TRASH ONLY

Summary:

| | |
|---|---|
| Number of burns | 16 |
| Loading of table | 8.9 ± 1.5 tons/acre |
| Net burned | 7.9 ± 2.2 tons/acre |
| Volume of discharge | 1999 ± 281 $ft.^3$/lb. burned |
| Particulate emissions | 5.0 ± 1.5 lbs./ton net burned |
| | 16517 ± 3364 $ug/m^3$ |
| Burn rate | 0.19 ± 0.03 lbs./$ft.^2$-min. |

### TABLE 2 - SUGAR CANE AND TRASH COMBINED

Summary:

| | |
|---|---|
| Number of burns | 20 |
| Loading of table | 76.7 ± 18.0 tons/acre |
| Trash portion | 10.8 ± 4.1 tons/acre |
| Net burned | 15.0 ± 4.2 tons/acre |
| Volume of discharge | 1170 ± 607 $ft.^3$/lb. burned |
| Particulate emission | 7.1 ± 2.0 lbs./ton burned |
| | 46312 ± 11053 $ug/m^3$ |
| Burn rate | 0.36 ± 0.12 lbs./$ft.^2$-min. |

TABLE 1

SUMMARY - SUGAR CANE TOWER BURNS
U. C. RIVERSIDE

TRASH BURNS - 1972

| Burn Date | | Sample Designation | Loading Tons/acre | Burned Tons/acre | Burn Rate lbs./ft.$^2$ min. | Air ft.$^3$/lb. | Particulates lbs./ton burned loss | Particulates ug/m$^3$ | Particulates lbs/acre |
|---|---|---|---|---|---|---|---|---|---|
| 10.5 | (1) | A-2 | 8.8 | 7.8 | 0.24 | | 3.8 | | 30.4 |
| | (2) | A-2 | 8.2 | 6.1 | 0.08 | | 8.0 | | 48.2 |
| 10.6 | (1) | A-1 | 4.2 | 4.0 | 0.13 | | 6.4 | | 26.2 |
| 10.24 | (1) | B-3 | 8.8 | 7.8 | 0.17 | 2233 | 5.5 | 19627 | 43.0 |
| 11-8 | (2) | E-3 | 18.5* | 16.5* | 0.14 | 1555 | 10.4 | 53715* | 172.0* |
| 11-15 | (2) | G-3 | 11.3 | 10.4 | 0.23 | 1777 | 4.1 | 18631 | 43.0 |
| 11-16 | (2) | H-3 | - | - | 0.18 | - | - | - | - |
| 11-22 | (1) | J-1 | 9.6 | 8.5 | 0.19 | 2210 | 4.3 | 15624 | 37.0 |
| | (2) | D-3 | 9.6 | 8.3 | 0.21 | 2253 | 3.9 | 13883 | 32.0 |
| | (3) | F-3 | 9.6 | 8.5 | 0.23 | 1723 | 3.2 | 15041 | 27.0 |
| | (4) | I-2 | 8.9 | 7.7 | 0.20 | 2256 | 3.3 | 11726 | 26.0 |
| 11-30 | (1) | J-1 | 9.1 | 8.2 | 0.21 | | 7.3 | | 60.0 |
| | (2) | J-2 | 9.5 | 8.8 | 0.24 | | 5.5 | | 48.0 |
| | (3) | F-M | 10.0 | 9.0 | 0.23 | | 2.7 | | 24.0 |
| | (4) | F-M | 10.2 | 8.3 | 0.10 | | 5.0 | | 42.0 |
| | (5) | K-1 | 8.3 | 7.9 | 0.14 | | 6.8 | | 54.0 |
| | (6) | K-2 | 8.3 | 7.7 | 0.10 | | 4.8 | | 37.0 |
| 12-5 | (2) | M-3 | 8.0 | 7.2 | 0.16 | 1982 | 5.3 | 21090 | 38.0 |

*Omitted from data summary - double load

TABLE 2

SUMMARY - SUGAR CANE TOWER BURNS
U. C. RIVERSIDE

CANE/TRASH BURNS - 1972

| Burn Date | | Sample Designation | Load Tons/ acre Total | Trash | Burned Tons/ acre | Burn Rate $lbs/ft.^2$ min. | Air $ft.^3$/ lb. | Particulate lbs/ton burned | Particulate ug/ $m^3$ |
|---|---|---|---|---|---|---|---|---|---|
| 10-19 | (1) | B-1 | 99.4 | - | 10.3 | 0.16 | | 11.0 | |
| 10-20 | (1) | B-2 | 86.0 | 8.7 | 11.3 | - | | 6.2 | |
| 10-23 | (1) | C-1 | 57.5 | 11.8 | 18.3 | 0.36 | 1376 | 7.9 | 45124 |
| | (2) | C-2 | 71.3 | 15.7 | 21.8 | 0.55 | 1038 | 6.8 | 52602 |
| 10-27 | (1) | D-1 | 58.0 | 15.8 | 17.5 | 0.38 | 889 | 4.1 | 37080 |
| | (2) | D-2 | 95.6 | 15.0 | 22.2 | 0.39 | 947 | 6.1 | 51439 |
| 11-8 | (1) | E-1 | 95.2 | 13.9 | 17.2 | 0.45 | 1301 | 10.4 | 64261 |
| 11-9 | (1) | F-2 | 104.0 | 16.3 | 23.7 | 0.42 | 939 | 4.9 | 41521 |
| 11-15 | (1) | G-1(G-2) | 62.7 | 13.9 | 11.3 | 0.19 | 1696 | 10.3 | 48697 |
| | (3) | G-2 | 68.8 | 16.3 | 12.8 | 0.25 | 1447 | 6.3 | 35122 |
| 11-16 | (1) | H-1 | 59.9 | 10.4 | 11.8 | 0.26 | | 3.2 | |
| | (3) | H-2 | 57.7 | 10.2 | 13.5 | 0.35 | 1406 | 6.1 | 34385 |
| 12-5 | (1) | M-1 | 68.8 | 7.4 | 13.1 | 0.37 | 1877 | 8.7 | 36766 |
| | (3) | M-2 | 74.7 | 8.7 | 16.6 | 0.64 | 1045 | 6.7 | 52143 |
| 12-7 | (1) | N-1 (no tops) | 47.7 | 10.7 | 12.2 | - | 1593 | 7.0 | 35376 |
| | (2) | N-2 (2xtops) | 111.5 | 9.4 | 19.6 | - | 947 | 8.0 | 67536* |
| 12-14 | (1) | O-1 | 63.7 | 7.0 | 10.3 | 0.30 | | 7.3 | |
| | (2) | O-2 | 82.9 | 7.9 | 12.5 | 0.31 | | 7.1 | |
| | (3) | P-1 | 85.4 | 8.0 | 11.5 | 0.34 | | 6.5 | |
| | (4) | P-2 | 84.1 | 8.7 | 13.3 | 0.40 | | 7.1 | |

*Double top cane

Encl 2

State of Hawaii
Department of Agriculture
Honolulu, Hawaii

April 12, 1973

MEMORANDUM

TO: Frederick C. Erskine
Doak Cox, UH-EC
Ellis Darley, UC
Ed Lui, HSPA
Richard Marland, OEQC
Henry Minette, DOH
Ron Terry, MP

SUBJECT: Particulate Emissions and Net Fuel Values - Sugar Cane

Tower studies are essentially complete. Results have been reviewed by HSPA, Departments of Health and Agriculture, EPA Region IX, and U.C. Riverside.

Field net fuel loss values are representative of actual field conditions. Tower net fuel loss values are for reconstructed fire matrices in which the fuel may differ significantly in moisture content and physical structure from field conditions.

Variations between field and tower values should have no significant effect on particulate emission values, except on the highside. The vertical flow of heat from combustion, lower moisture in the fuel, and proximity of the cane tops to the fire zone all increase the net fuel values obtained in tower studies.

By adopting the upper 99 percent confidence limit for particulate emission values from the tower studies the factor for particulate emissions will include virtually all possible values which could be expected on repeated study.

Net fuel loss values as determined from field studies represent three cane varieties, two culture methods, two growing zones, and normal field wind velocities.

Net particulate emissions per acre are calculated by multiplying the mean net fuel loss value for field studies by the particulate emission factor.

Recommended Factors

Particulate Emission Values (Tower values)

Mean (N=15) = 7.19 pounds per ton net fuel loss
Mean + 99% confidence limit ($^{t}01$) = 8.4 pounds per ton
Coefficient of variation (SD/mean) = 22%

Particulate emission value recommended for control strategy

8.4 pounds per ton net fuel loss

Net Fuel Loss Values (Field studies)

Mean (N=20) = 10.9 tons per acre
Coefficient of variation (SD/mean) = 28%
(Note: Compares favorably with 29% for tower studies)

Net fuel loss value recommended for control strategy

10.9 tons net fuel loss per acre burned

Why not use high side of figures

Net Particulate Emissions Per Acre

91.6 pounds (8.4 x 10.9) particulate emissions per acre burned

Particulate emissions for each County have been estimated (Table 1) on the basis of acreage harvested. Virtually all acreage on Kauai, Maui, and Oahu are burned. In contrast, an average of less than 70 percent of the acreage harvested on Hawaii can be burned due to persistent rainfall in growing areas.

Changing crop acres, cultural and harvesting practices also affect estimates of particulate emissions. Future revisions of emission estimates will decrease as newer practices are introduced.

Alexander M. Dollar, Ph.D.
Hawaii Development Irradiator

UNIVERSITY OF CALIFORNIA, RIVERSIDE

Encl 3

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STATEWIDE AIR POLLUTION RESEARCH CENTER RIVERSIDE, CALIFORNIA 92502

January 5, 1973

Mel Dollar
Don Hendricks
Ed Lui
Jim Southerland

Gentlemen:

Enclosed are three groups of documents related to the burning of sugar cane beginning October 19 and going through the last burns that we did on December 14.

1. The raw data sheets for cane fire and for trash only fires.
2. Summary of pertinent data from the raw data sheets for cane and trash fires and the amount of ash left from each class of fires.
3. The calculations that I made to determine standard deviations for the several columns listed on the summary sheets. For calculating these I used the statistical method that Mel used in the summaries that were sent from OSC field data. Since I am not a statistician I put down all the figures so that you could check the work in case you wished.

Following the visit of Ed Lui, Lou Herschler, Jim Southerland and Don Hendricks December 13 - 15, I rearranged the raw data sheets so as to put the information in more logical form. Following the visit of Mel Dollar on December 27 I decided to go ahead and make up the summaries and send them along with the raw data sheets. My original intention was just to send you the raw data sheets so that you could be looking at the information while I was drawing up some of the summaries. Thus, I have spent the last several days between Christmas and New Years doing this and it is in a rough form. Please accept my apologies for having it in such a rough form but I believe it is better to send it this way so that you can have a look at the information as quickly as possible.

RAW DATA SHEETS

First of all I will explain the raw data sheets so that you will understand the various entries. The sheets are arranged chronologically by date of burn. If there is more than one fire on a given date the fires are then numbered 1, 2, 3, 4, etc.

Cane fires. -- To explain these sheets please look at the 10/27/72 cane fire designated as D-1.

Starting at the top left corner of the sheet is fire No. 1, the date, and time of day. At first we did not note the time so all I can tell you for this fire is that we burned in the morning; in later fires the hour is noted. Comp notes whether we ran the fire response data through the computer at the time the fire was burning. For all of the cane fires we did not use the computer because difficulties in loading did not permit the precise timing required to coordinate ignition and start of computer polling. Chr stands for chromatograph. HC is the hydrocarbon peak and T is the temperature peak and indicates whether or not we did or did not take the sample. If you look through all of these sheets you will note that I show a No in most cases. However, in some fires we do have the chromatographic data but I have not indicated all of these instances. The fuel is labeled Cane with the designation D-1 as given to us by OSC. The type of fire is indicated as F which stands for flat. H and B stand for Head and Back fire but with all cane every fire will be flat. The rack indication of 36 inches refers to the fact that we were using the rack and the screen holding the tops in the vertical position was 36 inches above the table. Only in fires O and P do we have a second screen; details of these fires are given later. The weather on this date was not recorded but in later fires we tried to note something about weather conditions. Immediately below the weather we note the relative humidity with the dry and wet bulb. All of the sheets whether cane or trash will have this same general arrangement of heading.

As you will recall from your visit here, we load the bottom trash first, followed by the midcane, the top trash and the tops. What I am showing here in the extreme left column is the accumulated scale readings as these four classes of fuel are put on the table. Thus with D-1 the bottom trash weighed 13 lbs. 10 oz. After we put on the midcane the accumulated weight was 48 lbs. 10 oz. and so on with the top trash and tops. The next column to the right gives the weight of each fuel class before ignition. Thus the bottom trash weighed 13 lbs. 10 oz. The midcane is the difference between bottom trash and accumulated weight after midcane was added and in this case is 35 lbs. 0 oz. The top trash of 4 lbs. 8 oz. is the difference between the accumulated figures for top trash and midcane and so on to the tops. The next column to the right gives the total of all trash which is the sum of the first and third entries for plant weight before fire; in this case the total is 18 lbs. 2 oz. Moving to the right again we show the moisture content of the bottom and top trash. However, in this particular case I did not take a sample of top trash. Moisture values for each fuel class is given on both the wet and dry basis.

In summary to this point and looking at the columns from left to right on fuel category loading, we have all the information up to the time of ignition.

The fire is ignited and during the burning we take two pieces of information. I have put these at the bottom of the sheet so as not to clutter up the calculation I want to conduct later when we are indicating losses. These pieces of information show fire speed and indicated weight at two particular points; (1) at the time the fire has moved the five feet from one side of the rack to the other, and (2) the time when the fire went out.

Now go back up to the entry End Fire. This shows the indicated weight and the elapsed time since ignition. The fire is ended when the levels of hydrocarbon, CO and $CO_2$ on the recorders in the instrument building have returned essentially to the background level before ignition. The weight noted here was 46 lbs. 8 oz. and the time was 9 min. At this point I want to indicate significance of the numbered and lettered lines. After the end of the fire we want to know the total weight loss during the fire. This is obtained by subtracting line 2 from line 1 and entering the value on line 3 which in this case is 20 lbs. 2 oz.

When the fire is over you will recall that we unload the scale in reverse order to that in which it was loaded. This is done in order to determine the amount of midcane and top material that was burned during the fire. Therefore, move down the sheet in the left hand column which I still label as Scale. Starting with taking the tops off, the scale reads 35 lbs. and 6 oz. as shown on line 4. Then when we take off the midcane the residual on the scale is 3 lbs. 12 oz. and when we take off all the ashes we just record that line as 0.

Moving over to the next column we want to know the plant weight after the fire just as we wanted to know the plant weight before the fire. Therefore, the tops after the fire weighed 11 lbs. 2 oz. and this is determined by subtracting line 4 from line 2. To determine the weight of the midcane after the fire we subtract the line 5 from line 4 and this gives 31 lbs. 10 oz. We subtract line 6 from line 5 and that will give us the total weight of ashes. The double * means that we assume that the ashes from the top and the midcane make negligible contribution to the final ash. As pointed out later in this discussion this assumption may be wrong but for the purpose of this sheet I have done as indicated.

With the plant weights before and after the fire, it is possible to calculate losses in various ways. This is what is shown in the next three columns to the right under the heading Loss. The three categories of loss are the weight in pounds and ounces of the individual type, the weight percent, and the percent of the total loss. In making these calculations, I use lines (a) and (b) and the column labeled (c). The label (c) may be a bit confusing because it refers to all three lines under Wt. after fire. In other words, I use the first line of (c) for the tops, the second line of (c) for the midcane and the third line of (c) for the trash. Thus, under weight loss for tops I subtract (c) of 11 lbs. 2 oz. from (b) to get 2 lbs. 6 oz. For midcane, subtract (c) of 31 lbs. 10 oz. from (a) to give 3 lbs. 6 oz. and for trash subtract (c) of 3 lbs. 12 oz. from (z) to give 14 lbs. 6 oz. For the weight percent loss for each category the figures in the Wt. column are divided by (b), (a), and (z), respectively. Similarly, for the percent that each category contributes to the total loss, the figures in the Wt. column are divided by line 3. For example, the weight loss of tops of 2 lbs. 6 oz. is divided by line 3 of 20 lbs. 2 oz. to give 12 percent.

Down to this far on the data sheet we have been dealing only with what is happening on the table, namely, putting the fuel on the table, burning it, taking it off and recording the difference in weight to obtain the losses.

The rest of the sheet has to do with what happened to the filter that was inserted in the modified high volume sample up near the top of the stack. The first line on the left indicates the filter number. All of these large numbers in the 900,000 series are those filters that were sent to us from North Carolina. These have been specially treated so that analysis can be made for benzo a pyrene. All of these have been returned to North Carolina and Jim is having them analyzed. Other filter numbers that are in the 100 and 200 series are our own filters and are available for whatever analysis we wish to make other than weight. The only thing that shows on the raw data sheet in the analysis for weight in particulate collected on the filter.

The weight is shown on the left side of the sheet. The first figure is the weight of the filter after collecting the particulate. The next figure is the weight of the filter before and the difference is shown as total grams in the sample. This is multiplied by a constant of 1.71. The constant is arrived at by dividing 776 by 454 grams per pound. 776 is the ratio of our sampling volume to the total volume of the stack during the fire since our sampling technique is isokinetic. The result is labeled pounds in the stack as if we had been able to sample and collect all of the particulate going out of the stack. This figure is then multiplied by 1752 which represents that portion of an acre represented by the 25 square feet sampled by OSC. This was done at Jim Southerland's suggestion to come up with a figure of pounds of particulate per acre assuming that our 25 square feet simulates an acre in the field. This final figure in pounds per acre has a dark arrow directed to it just to call attention to one of the major items that you might want to take off the raw data sheet. Then if you look over to the right side of the sheet we are talking about the particulates per ton of fuel by three different methods. The first calculation is done by the total weight loss, the second by trash loading and the third by trash weight loss to get some comparison with the trash fires. I realize that these last two items (by trash loading and by trash weight loss) may or may not have any significance. The main feature that was decided upon when you fellows were here in December was the particulate by total weight loss and that is why I am showing the figure first. The method is to make a proportion of the total pounds particulate in the stack related to total weight loss in the fire to what the total particulates would have been if there would have been 2000 pounds weight loss. In this instance we move the figure of pounds in the stack to be the numerator on the left side of the equation (in this case rounded off to the 4th place at .0413). This is multiplied by 2000 ( = 82.6) and the figures written above the numerator. For the first equation 82.6 is divided by the total weight loss at line 3 to give 4.1 lbs. per ton of weight loss. Then the numerator of 82.6 is moved to each one of the other equations and divided by the appropriate figure for trash loading (z) and for trash weight loss (z-c). These figures also have a dark arrow going to them so as to call the reader's attention to a major result item in which he would be interested. This completes the explanation of the cane data sheet.

Trash fires.-- Look at the first sheet dated 10/5 and designated A-2. The heading is essentially the same as for fires except that I have added the percent slope to those fires that are either head or back fires. In other words, for F, H, or B (flat, head and back) the percent slope applies to a head fire or a back fire. Again I show the weight of the trash put on and the moisture percent both on a wet and dry basis. The weight of residue at the end of the fire and the time since ignition are shown next. This is followed by total weight loss and percent loss. When we get down to the filter the details are the same as for cane fires except that for calculating particulate in pounds per ton, there are only two categories: by total weight loss and by total trash load.

SUMMARIES

There are three summary sheets: for cane fires, for trash fires, and one combined summary of ashes from cane and trash fires.

Cane fires.-- Look again at the cane fire for 10/27 designated as D-1 which I can use as an example for orienting the columns on the cane summary sheet. The first four columns on the summary sheet are taken from the heading of the raw data sheet. The moisture content figure is the average of the bottom and top trash figure on the dry weight basis to the nearest whole percent. Since moisture was taken only on bottom trash for this fire, moisture is entered at 19 percent.

The next 8 columns have to do with the loss data. The first column list is the pounds per 25 square feet which is the same as item on line 3 from the raw data sheet (20.1 lbs.). I should have mentioned earlier that in transfering figures I converted ounces to the nearest 0.1 pounds. The next column (Tot %) is not represented on the raw data sheet and is something I calculated as I was preparing this summary and is merely the percentage derived by dividing line 3 by line 1 (20.1/66.6 = 30%). The next three sets of paired columns are the various losses of trash, midcane, and tops, respectively. Within each fuel class the pair of columns lists weight percent loss on the left and the percent of total loss to the right. For example, for D-1 the figures are taken directly from the losses on the raw data sheets and are: 80 and 72 for trash; 10 and 17 for midcane; and 18 and 12 for tops.

The next 4 columns to the right have to do with particulate emissions and are the figures associated with the 4 dark arrows on the data sheet. The first column is pounds per acre and the next three are pounds per ton by the three categories on the right side of the data sheet. The entries in each column are averaged and the standard deviation given at the bottom of each column. Examination of loss data shows that the total loss in pounds per 25 square feet is a little over 17 with a standard deviation of 4.8. This equates to 15.1 tons per acre with a standard deviation of 4.2. This is about 2 lbs. less than the value that Mel recently worked out; his field data notes a net disappearance of 17 tons per acre. I think its rather encouraging that the figures are this close. This represents about a 20% loss as shown by the second column under losses. Whereas it has often been stated that most of the weight loss in the field was due to the trash, it is evident from these figures that the tops also contribute a significant amount to the total loss. A little more than half of the total weight loss is in the trash, but the Riverside figures show that about 35% plus or minus 13% is lost by the tops and a relatively smaller amount is lost by the midcane, as would be expected. Most of the loss that is shown in midcane apparently is due to the leaves on the midcane as shown by the detailed study that will be mentioned later in samples O and P. The greatest variation is in the midcane and tops and this is to be expected because of variations in amount of leafy material and variable dryness of the tops. The standard deviation in the other mean values is not unreasonable.

With particulates the greatest variation was in the pounds per acre which has a mean of 109 and a deviation of 31.5. The low value was 70 and the high value was a 179. This figure should be probably used with caution and if possible we should try to refine it and examine carefully how it was obtained. As far as pounds per ton are concerned on total weight loss we come up with a figure of 7.3 with a standard deviation of 1.7 which is not too bad. At this point I am not sure of the real meaning of the pounds per ton on a trash weight loss or trash load basis and only list the values for the present.

Next, look at the trash only figures and go back to the raw data sheet dated 10/5 for the sample A-2. A summary sheet again has the first four columns taken from the heading of the raw data sheet. The fifth column is the total loss in the fire by percent. The last three columns have to do with particulate emissions, and are the figures associated with the three dark arrows on the left and right sides of the sheet. Again, the entries are averaged with the standard deviations shown at the bottom of each column. In addition I showed just the means for all entries compared to flat fires only, head fires only, and back fires only. When comparing these data with the cane fires, it appears the trash losses in trash fires is higher than trash losses in a cane fire. This discrepancy is probably due to the fact that mid and top cane do in fact contribute to the ashes and our assumption that they do not is wrong.

Particulate emission on a pounds per acre basis from trash fires alone are considerably lower than from a cane fire, the values being 48 and 109, respectively. Further, the variation in the trash fires on a percentage basis is quite a bit higher. This may be due to the very high emissions in one fire, namely E-3 on the date of 11/8. On the pages that I submitted showing the calculation methods I have made the comparison additionally by eliminating E-3, as perhaps being a real odd ball fire. When this is done on the pounds per acre basis we see that the 48 ± 32 drops to 40 ± 11 which is somewhat more reasonable. The only possible explanation that I can see at the moment for the relatively high emission rate in E-3 is that this fire was run at a relatively high humidity and at the highest moisture content of any of the fires. Since this is only one instance it would not be fair to say at this time that the high emissions of E-3 was due totally to the high moisture content.

When comparing particulates in pounds per ton on a total weight loss basis for trash alone and cane the values are 5.3 $\pm$ 2.0 and 7.3 $\pm$ 1.7. Since the standard deviations overlap it appears that there is no real difference in the two fuels and that the main additional problem from whole cane is the production of Hawaiian snow. Very little snow comes from our trash fires.

A little bit earlier I made a comparison between field data and Riverside data on the point of net disappearance or loss in terms of tons per acre. You recall the figures being roughly 17 tons in the field and 15 tons in Riverside. Another point of comparison using the figures that Mel supplied just recently would be that of looking at the ash residue in terms of pounds per 25 square feet. The figures that he supplied from field were a mean of 3.3 with a standard deviation of 2.6. I have attempted to make a similar comparison with the Riverside data and this is shown in the data summary sheet labeled "Leafload vs. Ashes" on the basis of trash fires only and top and bottom trash in cane fires, looking just at the trash loading to see what happened. Of course this does not take into account the leaves that were on the midcane or in the tops. In trash fires, using all entries where the load averaged 10.8 lbs $\pm$ 1.7, the ashes averaged 1.3 $\pm$ 0.7. We can also look at trash fires and make comparisons between the same samples, i.e., where we burn leaves alone in the same shipment in which we receive cane (shipments D, E, G, H, and M). The loading was 11.3 $\pm$ 2.0 and the ashes were 1.4 $\pm$ 0.6, both items being slightly higher than when using all entries. If we look at the cane we see that the top and bottom trash load is slightly higher (12 lbs.) and ash yield is 2.7 lbs. which more nearly approaches the figure that Mel has in the field. Obviously, some of the ash is coming from the midcane and tops. When we look at fires again that can be compared from the same sample we can see that a loading of 13.3 of bottom and top trash gave us ashes of 3.5 lbs. which is very close to what Mel had except that our standard deviation is a little less.

MODIFIED FIRES

Some modifications were made in fires O-1, O-2, P-1, P-2. A major change was an attempt to raise the tops farther above the fire zone. This was accomplished by having a second screen higher up in the air to try to hold the leaves vertical. Actually, whereas we were able to get the leaves and the stalks away from the fire, we were not able to make the top leaves stand vertical. This was due to the fact that the tops were bent back to make the package to ship to Riverside. In every fire, even though we got the cane tops farther away from the fire zone, the top leaves always laid horizontal on the screen to form sort of a canopy.

I tried to indicate the upper most node for purposes of describing the distance of the cane from the fire bed. In fire O-1 the upper node ranged 7" to 20" above the rail of the rack. Whereas, by gradually raising the height of the two screens, the nodes raised from 50" to 60" above the rail in fire P-2. But in every case it was practically impossible to prevent the folding green leaves from forming a horizontal canopy on the upper screen. Even with these changes there did not appear to be a significant effect of raising the green tops on the amount of particulate produced. The values ranged from 6.5 to 7.1, but there was no clear indication that the particulate became less as the tops got farther away from the fire bed. When we first discussed this problem with Ed and Lou, it was believed that as the tops got farther from the fire we should get less particulates but from these four fires there is no clear indication of this. The amount of percent weight loss from within the tops did seem to be slightly less when the tops were higher. But here again with only a few examples this is not a clear cut case.

Another thing we did in these four fires was to get individual weight losses on all of the different kinds of cane. That is, within the midcane we separated out those that had leaves from those who were bare. Within the tops we separated the dry leafy cane from the green tops. In each one of those selected we placed a metal tag in the cane weighed (grams) before and after the fire. These data are shown on the four sheets that accompany the last four raw data sheets of 0-1, 0-2, P-1 and P-2. The bare midcane lost a little weight, averaging about 2%. Those midcanes with some leaves lost a little bit more and this averaged somewhere around 4 - 5%. When these were combined, that is the leafy midcane with the bare midcane, the loss ranged from 2.4 to 3.4%. There is not always agreement between this method of measuring weight loss on midcane and the mass scale method used on the fire table itself. Fires 0-2 and P-1 agreed fairly well, but 0-1 and P-2 did not agree too well, being off of a factor of about 2. Nevertheless it is safe to say that midcane loss is a relatively small portion of the total loss of burning a complete field of cane. The loss in dry leafy tops ranged from about 6 - 7% whereas the green tops ranged from about 11 - 23%

indicating that top leaves do burn and contribute a significant amount to the total loss of a cane fire. Unless you have other thoughts on these methods, I think it is ok to use scale weights to derive losses of cane and tops.

This has been a long letter, but I wanted to be sure that you had all the information so you could make you own examination of the data.

Hydrocarbon, CO and $CO_2$ emissions are yet to be evaluated and I will send that information as soon as possible.

Cordially,

Ellis

Ellis F. Darley
Plant Pathologist

EFD/vls
Attachments

Fire No. 1  Date: 10-19-72  Time 1145  Comp NC  Chr. HC 114 T

Fuel Cane  Desig. B-1 Fd 029  Type: F X, H , B

Weight on:  Rack NO RACK  Weather

R.H. 62 %

Dry 65
Wet 58

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bot. tr. | ? | ? | | 16.0 W |
| Mid cane | ? | (a) ? | | 18.6 D |
| Top tr. | ? | ? | (z) ? | 13.9 W |
| Tops | (1) 114-2 | (b) ? | | 16.0 D |
| End Fire | (2) 102-4 | 10 min | | |
| Tot. loss | (3) 11-14 | | | |

load 24" high without rack.

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) | (2-4) | (b-c) | (÷b) | (÷3) |
| Mid cane | (5) | (4-5) | (a-c) | (÷a) | (÷3) |
| Trash | (6) | (5-6) ** | (z-c) | (÷z) | (÷3) |

Filter No. 180

Weights; particulate

After- 3.04015

Before- 3.00195

.03820 gr. in sample

x 1.71

.065322 #in stack

x 1742

114 # per Acre

Particulate, # per ton

by total wt loss:

$$(3) \frac{130.6 \quad 06533}{11.9} = \frac{X}{2000} = 11.0$$

by trash loading:

(z) = X

by trash wt loss:**

(z-c) = X

Fire speed and wt loss:

5' in min sec at #

Flame out 2 min 20 sec at 104-8 #

Not on PRINTOUT

**assumes ashes from tops and mid cane make negligible contribution to final ash

SUGAR CANE FIRES

Fire No. 1 Date 10-20-72 Time AM Group No Chr. HC ___ T ___

Fuel Cane Desig. B-2 Type: F X, H ___, B ___

Fd 029

Weight on: Rack 36 " Weather Raining lightly

Fire with wet trash.

R.H. ___ %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture | |
|---|---|---|---|---|---|
| | | | | | Dry ___ Wet ___ |
| Bots tr. | 5-0 | 5-0 | | 21.2 W / 27.0 D | |
| Mid cane | 58-8 | (a) 53-8 | | | |
| Top tr. | 63-8 | 5-0 | (z) 10.0 | 21.0 W / 26.5 D | |
| Tops | (1) 98-12 | (b) 35-4 | | | |

End Fire (2) 85-12 9 min

Tot. loss (3) 13-0

Data not taken

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | % | % of total loss |
|---|---|---|---|---|---|
| Tops | (4) | ~~(2-4)~~ | (b-c) | (÷b) | (÷3) |
| Mid cane | (5) | (4-5) | ~~(a-c)~~ | (÷a) | (÷3) |
| Trash | (6) | ~~(5-6)~~ ** | (z-c) | (÷z) | ~~(÷3)~~ |

15.2% total wt loss

Filter No. 181

Weights; particulate

After- 3.20380

Before- 3.18015

.02365 gr. in sample

x 1.71

.040442 #in stack

x 1742

70 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0404}{13.0} = \frac{X}{2000} \quad X = 6.2$$

(80.8)

by trash loading:

$$(z)\ \frac{80.8}{10.0} = 8.1$$

by trash wt loss:**

~~(z-c)~~

Fire speed and wt loss:

5' in ___ min ___ sec at ___ #

Flame out 2 min 30 sec at ___ #

No wt tape

Not on Printout

**assumes ashes from tops and mid cane make negligible contribution to final ash

SUGAR CANE FIRES

Fire No. 1 Date: 10-23-72 Time AM Comp No Chr. HC No T

Fuel Cane Desig. C-1 Type: F X, H, B

Fd 343

Weight on: Rack 36 " Weather ——

R.H. 45 %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bots tr. | 8-4 | 8-4 | | 16.2 W / 19.1 D |
| Mid cane | 38-4 | (a) 30-0 | | |
| Top tr. | 43-8 | 5-4 | (z) 13-8 | 13.7 W / 16.4 D |
| Tops | (1) 66-0 | (b) 22-8 | | |

Dry 71

Wet 58

15.5
16.0
2/35.5 | 17.75
15.
14.5

End Fire (2) 45-0 10 min

Tot. loss (3) 21-0

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) —— | (2-4) Data not taken | (b-c) | (÷b) | (÷3) |
| Mid cane | (5) —— | (4-5) | (a-c) | (÷a) | (÷3) |
| Trash | (6) —— | (5-6) ** | (z-c) | (÷z) | (÷3) |

Filter No. 901121

578
50
289 ÷ 776 = 37.2 cft

Weights; particulate

After- 3.38481

Before- 3.33455

.04830 gr. in sample

x 1.71

.082593 #in stack

x 1742

144 # per Acre

Particulate, # per ton

by total wt loss:

(3) 165.2 .0826 / 21.0 = X / 2000 = 7.9

by trash loading:

(z) 165.2 / 13.5 = 12.2

by trash wt loss:**

(z-c) =

Fire speed and wt loss:

5' in —— min —— sec at —— #

Flame out 2 min 0 sec at 48-0#

Not on PRINT OUT

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 2 Date 10-23-72 Time AR Comp 110 Chr. HC ___ T ___ (HC: 116)

Fuel cane Desig. C-2 (FC 043) Type: F X, H ___, B ___

Weight on: Rack 36 " Weather ———

R.H. 29 %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bot. tr. | 8-0 | 8-0 | | 12.2 W / 13.8 D |
| Mid cane | 50-0 | (a) 42-0 | | |
| Top tr. | 60-0 | 10-0 | (z) 18-0 | 13.1 W / 15.1 D |
| Tops | (1) 81-8 | (b) 21-8 | | |

Dry 77
Wet 58

13.8
15.1
28.9

End Fire (2) 56-8 10 min

Tot. loss (3) 25-0

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | % of total loss |
|---|---|---|---|---|---|
| Tops | (4) — | (2-4) ___ | (b-c) ___ | (÷b) ___ | (÷3) ___ |
| Mid cane | (5) — | (4-5) ___ | (a-c) ___ | (÷a) ___ | (÷3) ___ |
| Trash | (6) — | (5-6) ___ ** | (z-c) ___ | (÷z) ___ | (÷3) ___ |

Data not taken

Filter No. 901122

519 / 50 / 21950 ÷ 776 = 33.4

Weights; particulate

After- 3.41460

Before- 3.36485

.04975 gr. in sample

x 1.71

.085073 #in stack

x 1742

148 # per Acre

Particulate, # per ton

by total wt loss:

(3) $\frac{.0851}{25.0}$ (1702) = $\frac{X}{2000}$ = 6.8

by trash loading:

(z) $\frac{170.2}{18.0}$ = 9.5

by trash wt loss:**

(z-c) ___ =

Fire speed and wt loss:

5' in 1 min 20 sec at 63-8 #

Flame out 2 min 10 sec at 59-2 #

NOT ON PRINTOUT

**assumes ashes from tops and mid cane make negligible contribution to

Fire No. 1 Date 10-27-72 Time AM Comp NO Chr. HC 10 T 10

Fuel Cane Desig. D-1 FE 010 Type: F X, H ___, B ___

Weight on: Rack 36 " Weather ——

(I)

R.H. 70 %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture | Dry 60 / Wet 57 |
|---|---|---|---|---|---|
| Bot. tr. | 13-10 | 13-10 | | 15.8 W / 18.8 D | |
| Mid cane | 48-10 | (a) 35-0 | | | |
| Top tr. | 53-2 | 04-8 | (z) 18-2 | — W / — D | |
| Tops | (1) 66-10 | (b) 13-8 | | | |

End Fire (2) 46-8 9 min

Tot. loss (3) 20-2

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 35-6 | (2-4) 11-2 | (b-c) 2-6 | (÷b) 18 | (÷3) 12 |
| Mid cane | (5) 3-12 | (4-5) 31-10 | (a-c) 3-6 | (÷a) 10 | (÷3) 17 |
| Trash | (6) 0 | (5-6) 3-12 ** | (z-c) 14-6 | (÷z) 80 | (÷3) 72 |

Filter No. 901124 358 / 50 / 17900 ÷ 776 = 23 04

Weights; particulate

After- 3.3735
Before- 3.34935
.02415 gr. in sample
x 1.71
.041297 #in stack

x 1742
72 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0413\ (82.6)}{20.1} = \frac{X}{2000} = 4.1$$

by trash loading:

$$(z)\ \frac{82.6}{18.1} = 4.6$$

by trash wt loss:**

$$(z\text{-}c)\ \frac{82.6}{14.4} = 5.7$$

Fire speed and wt loss:

5' in 1 min 40 sec at 50-14#

Flame out 2 min 40 sec at 47-6 #

**assumes ashes from tops and mid cane make negligible contribution to final ash

SUGAR CANE FIRES

Fire No. 2   Dat 10-27-72   Time AM   mp X/O   Chr. HC 172 T

Fuel Cane   Desig. D-2 Fd 050   Type: F X, H __, B __

Weight on:   Rack 36 "   Weather ___

R.H. 64.5%

(2)

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture | |
|---|---|---|---|---|---|
| | | | | | Dry 64 |
| | | | | | Wet 57 |
| Bot. tr. | 12-4 | 12-4 | | 11.6 W / 19.8 D | |
| Mid cane | 67-0 | (a) 54-12 | | | |
| Top tr. | 72-0 | 5-0 | (z) 17-4 | W / D | |
| Tops | (1) 109-12 | (b) 37-12 | | | |

End Fire (2) 84-4   10 min

Tot. loss (3) 25-8

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 54-0 | (2-4) 30-4 | (b-c) 7-8 | (÷b) 20 | (÷3) 29 |
| Mid cane | (5) 5-0 | (4-5) 49-0 | (a-c) 5-12 | (÷a) 11 | (÷3) 23 |
| Trash | (6) 0 | (5-6) 5-0 ** | (z-c) 12-4 | (÷z) 71 | (÷3) 48 |

Filter No. 901125   4630 / 27150 ÷ 776 = 34.1 sec.

Weights; particulate

After- 3.28435

Before- 3.23905

.04530 gr. in sample

x 1.71

.077463 #in stack

x 1742

135 # per Acre

Particulate, # per ton

by total wt loss:

(3) $\frac{.0775}{25.5}$ (155.0) = $\frac{X}{2000}$ = 6.1

by trash loading:

(z) $\frac{155}{17.3}$ = 9.0

by trash wt loss:**

(z-c) $\frac{155}{12.3}$ = 12.6

Fire speed and wt loss:

5' in 2 min 10 sec at 88-8 #

Flame out 2 min 45 sec at 86-0 #

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 1 Date: 1-8-72 Time 9:15 Co NO Chr. HC 110 T

Fuel Cane Desig. E-1 Type: F X, H ___, B ___

FR 023

Weight on: Rack 36 " Weather ———

R.H. 73 %

(3)

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture | |
|---|---|---|---|---|---|
| | | | | | Dry 52 Wet 52 |
| Bot. tr. | 6-0 | 6-0 | | 36.5 W / 58.0 D | |
| Mid cane | 50-0 | (a) 44-0 | | | |
| Top tr. | 60-0 | 10-0 | (z) 16-0 | 34.5 W / 52.5 D | |
| Tops | (1) 109-4 | (b) 49-4 | | | |

End Fire (2) 89-8 9 min

Tot. loss (3) 19-12

| Weight off: | Scale | Wt. after fire (c) | Loss: Wt. | Loss: % | Loss: % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 48-8 | (2-4) 41-0 | (b-c) 8-4 | (÷b) 17 | (÷3) 42 |
| Mid cane | (5) 5-12 | (4-5) 42-12 | (a-c) 1-4 | (÷a) 3 | (÷3) 7 |
| Trash | (6) 0 | (5-6) 5-12 ** | (z-c) 10-4 | (÷z) 64 | (÷3) 52 |

Filter No. 901126 $\frac{514}{25700} \div 776 = 33$ c.f.

Weights; particulate

After- 3.42985

Before- 3.36980

.06005 gr. in sample

x 1.71

.102686 #in stack

x 1742

179 # per Acre

Particulate, # per ton

by total wt loss:

$(3)\ \frac{.1027 \;(205.4)}{19.8} = \frac{X}{2000} = 10.4$

by trash loading:

$(z)\ \frac{205.4}{16} = 12.8$

by trash wt loss:**

$(z-c)\ \frac{205.4}{10.3} = 19.9$

Fire speed and wt loss:

5' in 1 min 35 sec at 91-8 #

Flame out 4 min 30 sec at 89-14#

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 1 Date 11-9-72 Time 9:20 Temp 114 Chr. HC 110 T 115

1 day delay — Loaded nite before

Fuel Cane Desig. E-2 F.O. 023 Type: F X, H ___, B ___

Weight on: Rack 36 " Weather —

R.H. 60 %

| Mid 6-11-8 | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bots tr. | 11-4 | 11-4 | | 25.0 W / 33.8 D |
| Mid cane | 41-12 | (a) 35-8 | | |
| Top tr. | 54-4 | 7-8 | (z) 18-12 | 18.0 W / 21.5 D |
| Tops (Next AM) | (1) 123-8 (119-4) | (b) 69-4 | | |
| End Fire | (2) 96-4 | 9 min | | |
| Tot. loss | (3) 27-4 | | | |

Morning of Fire

Dry 54.5
Wet 47.5

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 38-0 | (2-4) 58-4 | (b-c) 11-0 | (÷b) 16 | (÷3) 40 |
| Mid cane | (5) 5-4 | (4-5) 32-12 | (a-c) 2-12 | (÷a) 8 | (÷3) 10 |
| Trash | (6) 0 | (5-6) 5-4 ** | (z-c) 13-8 | (÷z) 72 | (÷3) 49 |

Filter No. 901128 $\frac{512}{256} \div 77 = 33$ cft

Weights; particulate

After- 3.36230

Before- 3.32350

.03880 gr. in sample

x 1.71

.066348 # in stack

x 1742

116 # per Acre

Particulate, # per ton

by total wt loss:

$(3)\ \frac{.0663}{27.3} = \frac{X}{2000} = 4.9$ (132.6)

by trash loading:

$(z)\ \frac{132.6}{18.8} = 7.1$

by trash wt loss:**

$(z-c)\ \frac{132.6}{13.5} = 9.8$

Fire speed and wt loss:

5' in 1 min 45 sec at 101-0 #

Flame out 2 min 30 sec at 97-8 #

delay caused green lvs to dry more and more of them burned. at end of fire there were still some unburned lvs on the bottom screen.

**assumes ashes from tops and mid cane make negligible contribution to final ash

Fire No. 1    Date 11-15-72    Time 9:10    Map N/I    Chr. HC 1/13 T ___

Fuel Cane    Desig. 6-1 (6-2) Ed 006    Type: F X, H ___, B ___

Weight on:    Rack 36 "    Weather ———

Mixed trash by mistake

(5)

R.H. 72 %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture | |
|---|---|---|---|---|---|
| | | | | | Dry 57 / Wet 52 |
| Bot. tr. | 5-12 | 5-12 | | Not W | |
| | | | | D | |
| Mid cane | 29-0 | (a) 23-4 | | taken | |
| Bot & 6-2 ~~Top~~ tr. | 35-12 | 6-12 | (z) 12-8 | / W | |
| | | | | D | |
| Tops | (1) 72-0 | (b) 36-4 | | | |

End Fire (2) 59-0    9 min

Tot. loss (3) 13-0

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 25-8 | (2-4) 33-8 | (b-c) 2-12 | (÷b) 8 | (÷3) 22 |
| Mid cane | (5) 4-4 | (4-5) 21-4 | (a-c) 2-0 | (÷a) 9 | (÷3) 15 |
| Trash | (6) 0 | (5-6) 4-4 ** | (z-c) 8-4 | (÷z) 66 | (÷3) 64 |

Filter No. 901129    441 / 50 / 22050 ÷ 776 = 28.5 cfm

Weights; particulate

After- 3.37045

Before- 3.33115

.03930 gr. in sample

x 1.71

.067203 #in stack

x 1742

117 # per Acre

Particulate, # per ton

by total wt loss:

$(3)\ \frac{.0672}{13.0}$ (134.4) $= \frac{X}{2000} = 10.4$

by trash loading:

$(z)\ \frac{134.4}{12.5} = 10.8$

by trash wt loss:**

$(z\text{-}c)\ \frac{134.4}{8.3} = 16.2$

Fire speed and wt loss:

5' in 2 min 20 sec at 61-2 #

Flame out 3 min 20 sec at 59-4 #

Photo Series Sent to Ed Lui

**assumes ashes from tops and mid cane make negligible contribution to final ash

# SUGAR CANE FIRES

Fire No. 3 Date 11-15-72 Time 11:00 [illegible]p N/O Chr. HC 110 T ___

Fuel Cane Desig. G-2 Type: F X, H ___, B ___

Weight on: Rack 36 " (Flood) Weather ___

R.H. 59 %

(6)

| G - top | Scale accum. | Plant wt. before fire | Total trash | % Moisture | Dry 60 / Wet 52 |
|---|---|---|---|---|---|
| Bott tr. | 5-12 | 5-12 | | ___ W | |
| Mid cane | 30-12 | (a) 25-0 | | ___ D | |
| Top tr. | 36-12 | 6-0 | (z) 11-12 | 14.0 W | Mixed G-1 + G-2 |
| Tops | (1) 79-0 | (b) 42-4 | | 11.3 D | |

End Fire (2) 64-4 7 min

Tot. loss (3) 14-12

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 25-0 | (2-4) 39-4 | (b-c) 3-0 | (÷b) 7 | (÷3) 20 |
| Mid cane | (5) 2-12 | (4-5) 22-4 | (a-c) 2-12 | (÷a) 11 | (÷3) 19 |
| Trash | (6) 0 | (5-6) 2-12 ** | (z-c) 9-0 | (÷z) 76 | (÷3) ~~76~~ 61 |

Filter No. 701131 $\frac{427.50}{2/350} \div 776 = 27.5$ cfm

Weights; particulate

After- 3.63785

Before- 3.61050

.02735 gr. in sample

x 1.71

.046769 #in stack

x 1742

81 # per Acre

Particulate, # per ton

by total wt loss:

$(3)\ \frac{93.6}{14.8} = \frac{X}{2000} = 6.3$ (0468)

by trash loading:

$(z)\ \frac{93.6}{11.8} = 7.9$

by trash wt loss:**

$(z-c)\ \frac{93.6}{9.0} = 10.4$

Fire speed and wt loss:

5' in 1 min 40 sec at 68-12 #

Flame out 2 min 30 sec at 64-4 #

**assumes ashes from tops and mid cane make negligible contribution to final ash

SUGAR CANE FIRES

Fire No. 1 Date 11-16-72 Time 1:30 P C NO Chr. HC ___ T ___ H.O

Fuel Cane Desig. H-1 (Fd c36) Type: F ✓, H ___, B ___

Weight on: Rack ___ " Weather ___

R.H. 53 %

Dry 60
Wet 51

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Botn tr. | 4-12 | 4-12 | | Not W |
| | | | | D |
| Mid cane | 22-4 | (a) 17-8 | | Taken |
| Top tr. | 25-8 | 3-4 | (z) 8-0 | W |
| | | | | D |
| Tops | (1) 68-12 | (b) 43-4 | | |

End Fire (2) 55-4 — 9 min

Tot. loss (3) 13-8

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 19-8 | (2-4) 35-12 | (b-c) 7-8 | (÷b) 17 | (÷3) 56 |
| Mid cane | (5) 2-0 | (4-5) 17-8 | (a-c) 0 | (÷a) 0 | (÷3) 0 |
| Trash | (6) 0 | (5-6) 2-0 ** | (z-c) 6-0 | (÷z) 75 | (÷3) 43 |

Filter No. 901132 Not isokinetic

Weights; particulate

After- 3.67040

Before- 3.65780

.01260 gr. in sample

x 1.71

.021545 #in stack

x 1742

38 # per Acre

probably low
Not isokinetic

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0215}{13.5}\ (43.0) = \frac{X}{2000} = 3.2$$

by trash loading:

$$(z)\ \frac{43.0}{8.0} = 5.4$$

by trash wt loss:**

$$(z\text{-}c)\ \frac{43.0}{6.0} = 7.2$$

Fire speed and wt loss:

5' in 1 min 35 sec at 58-6 #

Flame out 2 min 20 sec at 55-8 #

NOT ON PRINTOUT

all Figs. probably Low — Not isokinetic

**assumes ashes from tops and mid cane make negligible contribution to final ash

SUGAR CANE FIRES

Fire No. 3 Date 11-16-72 Time AM Crop NG Chr. HC 110 T

Fuel Cane Desig. H-2 Type: F ✓, H ___, B ___

Weight on: Rack 36 " Weather ———

R.H. 52 %

(7)

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bot. tr. | 6-4 | 6-4 | | 15.1 W<br>17.9 D |
| Mid cane | 28-12 | (a) 22-8 | | |
| Top tr. | 34-8 | 5-12 | (z) 12-0 | 13.6 W<br>15.7 D |
| Tops | (1) 66-4 | (b) 31-12 | | |

Dry 61
Wet 54.5

End Fire (2) 50-12 7 min

Tot. loss (3) 15-8

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 24-0 | (2-4) 26-12 | (b-c) 5-0 | (÷b) 16 | (÷3) 32 |
| Mid cane | (5) 3-4 | (4-5) 20-12 | (a-c) 1-12 | (÷a) 8 | (÷3) 12 |
| Trash | (6) 0 | (5-6) 3-4 ** | (z-c) 8-12 | (÷z) 73 | (÷3) 57 |

Filter No. 901133 $\frac{436}{21800}$ ÷ 776 = 28.5 cft.

Weights; particulate

After- 3.63925

Before- 3.61150

.02775 gr. in sample

x 1.71

.047453 #in stack

x 1742

83 # per Acre

Particulate, # per ton

by total wt loss:

$(3)\ \frac{.0475\ (95.0)}{15.5} = \frac{X}{2000} = 6.1$

by trash loading:

$(z)\ \frac{95.0}{12.0} = 7.9$

by trash wt loss:**

$(z-c)\ \frac{95.0}{8.8} = 10.8$

Fire speed and wt loss:

5' in 1 min 30 sec at 53-4 #

Flame out 2 min 20 sec at 51-0 #

**assumes ashes from tops and mid cane make negligible contribution to final ash

SUGAR CANE FIRES

Fire No. 1. Date 12-5-72 Time 10:45 ...p No Chr. HC Yes T No

Fuel Cane Desig. 1A-1 / Fd 224 Type: F ✓, H___, B___

Weight on: Rack___" Weather Cloudy

(8)

R.H. 40 %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bott tr. | 4-4 | 4-4 | | 16.6 W / 20.0 D |
| Mid cane | 36-2 | (a) 31-14 | | |
| Top tr. | 40-4 | 4-2 | (z) 8-6 | 18.3 W / 22.4 D |
| Tops | (1) 79-0 | (b) 38-12 | | |

Dry 57.5
Wet 41.5

End Fire (2) 64-0 — 6 min

Tot. loss (3) 15-0

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 32-0 | (2-4) 32-0 | (b-c) 6-12 | (÷b) 18 | (÷3) 45 |
| Mid cane | (5) 1-4 | (4-5) 30-12 | (a-c) 1-2 | (÷a) 3 | (÷3) 7 |
| Trash | (6) 0 | (5-6) 1-4 ** | (z-c) 7-2 | (÷z) 85 | (÷3) 47 |

Filter No. 901138 363 / 30 / 28150 ÷ 726 = 38.5

Weights; particulate

After- 3.63135

Before- 3.57335

.03800 gr. in sample

x 1.71

.06498 #in stack

x 1742

113 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0650}{15.0}\ (130) = \frac{X}{2000} = 8.7$$

by trash loading:

$$(z)\ \frac{130}{8.4} = 15.5$$

by trash wt loss:**

$$(z-c)\ \frac{130}{7.7} = 18.3$$

Fire speed and wt loss:

5' in 1 min 30 sec at 65-0 #

Flame out 2 min 30 sec at 64-0 #

**assumes ashes from tops and mid cane make negligible contribution to

Fire No. 3 Date 12-5-72 Time 12:00 Crop 110 Chr. HC Yes T NS

Fuel Cane Desig. M-2 Fd copy Type: F ✓, H ___, B ___

Weight on: Rack 32 " Weather cloudy

Tops grouped 2'x2'

(9)

R.H. 48 %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture | |
|---|---|---|---|---|---|
| Bot. tr. | 4-8 | 4-8 | | 15.0 W / 19.5 D | Dry 52 / Wet 43.1 |
| Mid cane | 36-0 | (a) 31-8 | | | |
| Top tr. | 41-8 | 5-8 | (z) 10-0 | 19.6 W / 24.4 D | |
| Tops | (1) 85-12 | (b) 44-4 | | | |

End Fire (2) 66-12 6 min

Tot. loss (3) 19-0

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 31-12 | (2-4) 35-0 | (b-c) 9-4 | (÷b) 21 | (÷3) 48 |
| Mid cane | (5) 1-8 | (4-5) 30-4 | (a-c) 1-4 | (÷a) 4 | (÷3) 7 |
| Trash | (6) 0 ** | (6-5) 1-8 | (z-c) 8-8 | (÷z) 85 | (÷3) 45 |

Filter No. 901140 397.50 / 19870 ÷ 776 = 25.6

Weights; particulate

After- 3.67070

Before- 3.63290

.03780 gr. in sample

x 1.71

.06464 #in stack

x 1742

→ 112.2 # per Acre

Particulate, # per ton

by total wt loss:

$$\frac{128.2 \;\; .0646}{(3)\;\; 19} = \frac{X}{2000} = 6.7$$

by trash loading:

$$\frac{129.2}{(2)\;\; 10} = 12.9$$

by trash wt loss:**

$$\frac{129.2}{(z\text{-}c)\;\; 8.5} = 15.2$$

Fire speed and wt loss:

5' in 1 min 3 sec at 69-0 #

Flame out 2 min 10 sec at 67-0 #

**assumes ashes from tops and mid cane make negligible contribution to final ash

# SUGAR CANE FIRES

Fire No. 1 Date 12-7-72 Time 10:15 [Samp] 110 Chr. HC___ T___

Fuel Mid cane tlvs Desig. N-1 Fd 004 Type: F X, H___, B___

Weight on: Rack 36" Weather cloudy

R.H. 62%

(10)

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bot. tr. | 7-0 | 7-0 | | 22.2 W / 28.8 D |
| Mid cane | 49-8 | (a) 42-8 | | |
| Top tr. | 54-12 | 5-4 | (z) 12-4 | 20.8 W / 27.2 D |
| ~~Tops (1)~~ | — None used | (b) — | | |

Dry 52.5 Wet 46.5

End Fire (2) 40-12 8 min

Tot. loss (3) 14-0

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) — | (2-4) — | (b-c) — | (÷b) — | (÷3) — |
| Mid cane | (5) 1-0 | (2-5) 39-12 | (a-c) 2-12 | (÷a) 7 | (÷3) 20 |
| Trash | (6) 0 | (5-6) 1-0 ** | (z-c) 11-4 | (÷z) 92 | (÷3) 81 |

Filter No. 901141 446/22,300 ÷ 776 = 28.7 cu ft

Weights; particulate

After- 3.68075

Before- 3.65200

.02875 gr. in sample

x 1.71

.049163 #in stack

x 1742

85.6 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0492\ (98.4)}{14.0} = \frac{X}{2000} = 7.0$$

by trash loading:

$$(z)\ \frac{98.4}{12.3} = 8.0$$

by trash wt loss:**

$$(z-c)\ \frac{98.4}{11.3} = 8.7$$

089609 049163 2|.138772|.6 1.1 8

85.6 1561 2|241.7| 120.85

Fire speed and wt loss: Not taken

5' in — min — sec at — #

Flame out — min — sec at — #

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 2  Date 12-7-72  Time 11:00  C[illegible]p N/O  Chr. HC 110 T__

Fuel Cane (Double tops)  Desig. N-2 (pd 004)  Type: F X, H__, B__

Weight on:  Rack 36 "  Weather cloudy

(11)  R.H. 62 %

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Botz tr. | 5-8 | 5-8 | | 20.2 W / 25.3 D |
| Mid cane | 50-0 | (a) 44-8 | | |
| Top tr. | 55-4 | 5-4 | (z) 10-12 | 16.6 W / 19.7 D |
| Double Tops | (1) 128 ± | (b) 72-12 ± | | |

Dry 53.5  
Wet 47.0

End Fire (2) 105-8  7 min

Tot. loss (3) 22-8

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 46-0 | (2-4) 59-8 | (b-c) 13-4 | (÷b) 19 | (÷3) 60 |
| Mid cane | (5) 1-14 | (4-5) 44-2 | (a-c) 0-6 | (÷a) <1 | (÷3) <1 |
| Trash | (6) 0 | (5-6) 1-14 ** | (z-c) 8-14 | (÷z) 82 | (÷3) 40 |

Filter No. 901142  425 / 21,300 ÷ 775 = 27.4 cu ft

Weights; particulate

After- 3.69565

Before- 3.64325

.05240 gr. in sample

x 1.71

.089604 #in stack

x 1742

156.1 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0896 \;(179.2)}{22.5} = \frac{X}{2000} = 8.0$$

by trash loading:

$$(z)\ \frac{179.2}{10.8} = 16.6$$

by trash wt loss:**

$$(z\text{-}c)\ \frac{179.2}{8.9} = 20.1$$

Fire speed and wt loss: Not taken

5' in — min — sec at — #

Flame out — min — sec at — #

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 1    Date 2-14-72    Time 10:00    C NO    Chr. HC NO  T NO

Fuel Cane    Desig. 0-1 Fd 004    Type: F ✓, H ___, B ___

Weight on:    Rack YES " (SINGLE (see below))    Weather Clear - Cool

R.H. 24.5%

(12)

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture | Dry 51 / Wet 38 |
|---|---|---|---|---|---|
| Bots tr. | 3-0 | 3-0 | | 20.0 W / 25.1 D | |
| Mid cane | 47-8 | (a) 44-8 | | | |
| Top tr. | 52-8 | 5-0 | (z) 8-0 | 21.8 W / 27.9 D | |
| Tops | (1) 73-2 | (b) 20-10 | | | |

End Fire (2) 61-4    7 min

Tot. loss (3) 11-14

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 43-4 | (2-4) 18-0 | (b-c) 2-10 | (÷b) 13 | (÷3) 22 |
| Mid cane | (5) 1-2 | (4-5) 42-2 | (a-c) 2-6 | (÷a) 5 | (÷3) 20 |
| Trash | (6) 0 | (5-6) 1-2 ** | (z-c) 6-14 | (÷z) 85 | (÷3) 57 |

Filter No. 196

Weights; particulate

After- 3.42870

Before- 3.40335

.02535 gr. in sample

x 1.71

.04335 #in stack

x 1742

75.5 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0434 \ (86.8)}{11.9} = \frac{X}{2000} = 7.3$$

by trash loading:

$$(z)\ \frac{86.8}{8.0} = 10.9$$

by trash wt loss:**

$$(z-c)\ \frac{86.8}{6.9} = 12.6$$

Fire speed and wt loss:

5' in 1 min 20 sec at 63-4#

Flame out 2 min 20 sec at 61-8#

Lower screen as usual. but cane skirts. Nide at 7-20"

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 2    Date 2-14-72    Time ______    C ND    Chr. HC NO  T NO

Fuel CANE    Desig. O-2 (FD 014)    Type: F ✓, H ___, B ___

Weight on: Rack DOUBLE " RACK (see below)    Weather CLEAR

about R.H. 20 %

13

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bot. tr. | 3-6 | 3-6 | | 14.4 W / 16.9 D |
| Mid cane | 50-8 | (a) 47-2 | | |
| Top tr. | 56-4 | 5-12 | (z) 9-2 | 15.8 W / 18.7 D |
| Tops | (1) 95-2 | (b) 38-14 | | |

Dry / Wet — Forgot to take

End Fire (2) 80-12    8 min

Tot. loss (3) 14-6

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 47.2 | (2-4) 33-10 | (b-c) 5-4 | (÷b) 14 | (÷3) 37 |
| Mid cane | (5) 1-0 | (4-5) 46-2 | (a-c) 1-0 | (÷a) 2 | (÷3) 7 |
| Trash | (6) 0 | (5-6) 1-0 ** | (z-c) 8-2 | (÷z) 89 | (÷3) 56 |

Filter No. 197

Weights; particulate

After- 3.31725

Before- 3.28740

.02985 gr. in sample

x 1.71

.051044 # in stack

x 1742

88.9 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0510}{14.4} \cdot 1020 = \frac{X}{2000} = 7.1$$

by trash loading:

$$(z)\ \frac{102}{9.1} = 11.2$$

by trash wt loss:**

$$(z-c)\ \frac{102.}{8.1} = 12.6$$

Fire speed and wt loss:

5' in 1 min 20 sec at 83-8 #

Flame out 2 min 30 sec at 80-12 #

Note = 20-32

Lower screen 4" from rail

Top " 40" " "

Base of top stacks on table as

but top lbs. flop on top screen at 40"

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 3 Date: 2-14-72 Time____ Co____ Chr. HC___ T___

Fuel Cane Desig. P-1 (Fd 004) Type: F ✓, H___, B___

Weight on: Rack Double " (See below) Weather____

R.H. 15 %

(14)

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bots tr. | 5-0 | 5-0 | | 18.7 W / 23.0 D |
| Mid cane | 56-12 | (a) 51-12 | | |
| Top tr. | 61-0 | 4-4 | (z) 9-4 | 15.2 W / 17.9 D |
| Tops | (1) 98-0 | (b) 37-0 | | |

Dry 61
Wet 43

End Fire (2) 84-12 7 min

Tot. loss (3) 13-4

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 51-12 | (2-4) 33-0 | (b-c) 4-0 | (÷b) 11 | (÷3) 30 |
| Mid cane | (5) 1-8 | (4-5) 50-4 | (a-c) 1-8 | (÷a) 3 | (÷3) 11 |
| Trash | (6) 0 | (5-6) 1-8 ** | (z-c) 7-12 | (÷z) 84 | (÷3) 58 |

Filter No. 198

Weights; particulate

After- 3.44085

Before- 3.41200

.02885 gr. in sample

x 1.71

.04934 #in stack

x 1742

85.9 # per Acre

Particulate, # per ton

by total wt loss:

$$(3)\ \frac{.0433\ (86.6)}{13.3} = \frac{X}{2000} = 6.5$$

by trash loading:

$$(z)\ \frac{86.6}{9.3} = 9.3$$

by trash wt loss:**

$$(z\text{-}c)\ \frac{86.6}{7.8} = 11.1$$

Fire speed and wt loss:

5' in 1 min 10 sec at 88 #

Flame out 2 min 20 sec at 85 #

Lower screen 4" from rail
Top screen 30" from "
Nodes 41-55" but green tops still flat horizontal on top screen

**assumes ashes from tops and mid cane make negligible contribution to

SUGAR CANE FIRES

Fire No. 4   Date: 12-14-72   Time 4:00   Comp NO   Chr. HC NO  T NO

Fuel CANE   Desig. R-2 (M. 1004)   Type: F ✓, H___, B___

Weight on:   Rack DOUBLE " RACK   Weather CLEAR

R.H. 29 %

(15)

| | Scale accum. | Plant wt. before fire | Total trash | % Moisture |
|---|---|---|---|---|
| Bots tr. | 3-8 | 3-8 | | 14.7 W / 17.2 D |
| Mid cane | 45-8 | (a) 42-0 | | |
| Top tr. | 52-0 | 6-8 | (z) 10-0 | 16.2 W / 19.3 D |
| Tops | (1) 96-8 | (b) 44-8 | | |

Dry 55
Wet 42

End Fire (2) 81-4   7 min

Tot. loss (3) 15-4

| Weight off: | Scale | Wt. after fire (c) | Loss Wt. | Loss % | Loss % of total loss |
|---|---|---|---|---|---|
| Tops | (4) 41-8 | (2-4) 39-12 | (b-c) 4-12 | (÷b) 11 | (÷3) 31 |
| Mid cane | (5) 2-0 | (4-5) 39-8 | (a-c) 2-8 | (÷a) 6 | (÷3) 16 |
| Trash | (6) 0 | (5-6) 2-0 ** | (z-c) 8-0 | (÷z) 80 | (÷3) 52 |

Filter No. 199

Weights; particulate

After- 3.33170

Before- 3.30000

.03170 gr. in sample

x 1.71

.054207 #in stack

x 1742

94.4 # per Acre

Particulate, # per ton

by total wt loss:

$(3)\ \frac{.0542\ (108.4)}{15.3} = \frac{X}{2000} = 7.1$

by trash loading:

$(z)\ \frac{108.4}{10.0} = 10.8$

by trash wt loss:**

$(z-c)\ \frac{108.4}{8.0} = 13.6$

Fire speed and wt loss:

5' in 1 min 20 sec at 83-0 #

Flame out 2 min 10 sec at 81-4 #

Lower screen 8" above rack
top screen 6" "
Notes 50-60° Cane too short to place horizontal sloping

**assumes ashes from tops and mid cane make negligible contribution to final ash

UNITED STATES ENVIRONMENT[illegible]L PROTECTION AGENCY
Office of Air Quality Plan[illegible]and Standards
Research Triangle Park, No[illegible]th Carolina 27711

Encl 4

August 11, 1977

Mr. Bill Arlington
Florida Sugar Cane League, Inc.
Post Office Box 1148
Clewiston, Florida 33440

Dear Mr. Arlington:

In May, as I recall, I was contacted by representatives of the Palm Beach, Florida Health Department regarding the use of the emission factors for sugar cane burning as given in AP-42. I had been involved previously in the factor development work with Dr. Darley (of the University of California) and various groups in Hawaii. I was not directly involved in the preparation of the current AP-42 section, however, and thus had to go to the references for background. In discussions with the Palm Beach office, I indicated that the sugar cane tests were on Hawaiian cane, but that the emission factors should be essentially the same. I indicated, however, that I would question the loading factors as being appropriate for canes other than those similar to the Hawaiian cane.

According to the understanding of the information given to me be the Palm Beach office, however, about 30-35% of the Florida cane weight was believed to be consumed by the burning operation. Based on this figure, and applying data I had on Mississippi cane production of roughly 35 tons/acre, I surmised that perhaps the 11 tons/acre "loading factor" would not be too far off. They replied that it was the only information they had and would use it in their emission inventory calculations.

Since these discussions, you have assured me that the "30-35% burned" figure is not typical and is too high, perhaps by a factor of two or more. I have no basis to refute this figure, but do not feel I can initiate a revision of AP-42 on this level of information. I do plan to add a footnote to the existing loading factor in AP-42 to make it clear that it is applicable to Hawaiian cane and probably differs elsewhere.

You have indicated an interest in conducting a test, or series of tests, to provide a more appropriate number. I encourage such a study and suggest that either Palm Beach County Health Department, the State of Florida and/or some level of agricultural agency be involved to assure that there would not be claims of bias and that such data would be generally accepted. I would be willing to include such results in AP-42 for use by other groups. If interest warrants, I will also try to investigate the development and inclusion of loading factors specific to Mississippi, Louisiana, and Texas canes if they are found to differ significantly.

Currently, we do not have any funds available for assisting in the study of these loading factors. I do not think the expense would be great, however. Perhaps one of the other groups mentioned might have funds or manpower available to assist. If the level of emissions involved were of such consequence as to involve a State Implementation Plan revision, perhaps EPA Region IV offices in Atlanta would be interested.

I have had a copy of Supplement 7 to AP-42 mailed to you under separate cover and you should receive it shortly.

I appreciate your interest in these loading factors and will be interested, in turn, in any results which we can use to further improve AP-42. I await the results of any study that you might develop and stand ready to assist to the level that I can.

Sincerely yours,

James H. Southerland

James H. Southerland, Chief
Source Analysis Section
Air Management Technology Branch

cc: John Bosch, MD-14
Michael ~~Robert~~ Martin, Palm Beach Counth Health Department
Mr. G. T. Helms, Chief, Air Branch, Region IV, Atlanta

Mr. Mike ~~Robert~~ Martin
Palm Beach Counth Health Dept.
826 Everina St.
West Palm Beach, Fla. 33401

*Florida Sugar Cane League, Inc.*
POST OFFICE BOX 1148
CLEWISTON, FLORIDA 33440
(813) 983-9151



August 8, 1977
Monday

Mr. Jim Southerland, Environmental Engineer
Office of Air Quality Planning and Standards
Environmental Protection Agency
Research Triangle Park, North Carolina 27711

August 5

Dear Jim:

As per our phone conversation of last Friday, I have enclosed a copy of Ed Lui's July 26th letter to me and a copy of the data he supplied. I believe the data verifies that the fuel loading factor for sugarcane field burning shown in the supplement No. 6 to the AP-42 originated in Hawaii. Your confirmation of this will be appreciated.

Again, thanks for all the help and cooperation.

Sincerely,

Bill Arlington

Bill Arlington
Environmental Specialist

BA/cw

Enclosure

HSPA

July 26, 1977

Mr. Bill Arlington
Environmental Specialist
Florida Sugar Cane League, Inc.
P.O. Box 1148
Clewiston, Florida 33440

Dear Bill:

Enclosed is information that may be helpful to you in solving your present problem.

The first is a table showing the dates of sampling, the field being harvested, the variety harvested and the sample designation. As shown in the table, three varieties were included in the test. No significance should be attributed to the varieties tested or to the number of samples of each variety. Selection of the variety samples was based strictly on the field selected for harvest by the plantation.

The second enclosure contains the data and analysis for the field weight loss study. These data were used to calculate the amount of fuel actually burned per acre during the test. I have highlighted the average weight loss in yellow. This figure was used in calculating the emission rate for cane burning in Hawaii.

I am sure you have a copy of the Darley report but I enclose one anyway since it describes the procedures used in the test. The weight loss procedures are described generally on pages 3 and 4. I have highlighted the appropriate sections.

On pages iv and 12 of the report, Darley shows maximum particulate emissions of 8.4 lb/ton and 133 lb/acre at 99% confidence. The basis for the weight (lb/ton) factor is obvious. The basis for the area (lb/acre) factor is the area (5' x 5') from which the sample was harvested extrapolated to a full acre. The area factor was rejected for use in Hawaii because the burning conditions in the test tower were not exactly the same as those in the field. On the other hand, it was felt that the weight factor would likely be representative in spite of the differences. Thus the emissions of particulate matter from cane burning in Hawaii are (8.4 lb/ton) x (10.9 tons/acre) x (number of acres burned).

91.6

HAWAIIAN SUGAR PLANTERS' ASSOCIATION
99-193 AIEA HEIGHTS DRIVE • PH: (808) 487-5561 • MAILING ADDRESS: PO BOX 1057 • AIEA • HAWAII 96701

We do not believe that any of the area emission factors computed by Darley can be generally applied. The difficulty you face is in determining the weight loss for your conditions. While it may seem obvious that your weight loss would be less than ours due to lighter cane tonnages, I would hate to speculate on the amount. You should plan your own testing program to determine a figure.

I hope this information is of use to you. Please call me if you have any questions.

Very truly yours,

Ed

Edward J. Lui
Director of Environmental Affairs

EJL/slp

Enclosures

Hawaiian Sugar Planters' Association

## POLLUTION STUDIES

### CANE BURNING TESTS
at Oahu Sugar Company

| DATE | FIELD | VARIETY | | UNBURNED | BURNED |
|---|---|---|---|---|---|
| 10/17/72 | 029 | 49-3533 | | B-1, B-2 | B-1, B-2 |
| 10/18/72 | 043 | 50-7209 | | C-1, C-2 | C-1, C-2 |
| 10/24/72 | 050 | 57-5026 | | D-1, D-2 | --- |
| 10/25/72 | 050 | " | | --- | D-1, D-2 |
| 11/6/72 | 023 | 49-3533 | | E-1, E-2 | --- |
| 11/8/72 | 023 | " | (*) | F-1, F-2 | E-1, E-2<br>F-1, F-2 |
| 11/13/72 | 006 | " | | G-1, G-2 | --- |
| 11/14/72 | 006 | " | | H-1, H-2 | --- |
| 11/15/72 | 006 | " | | --- | G-1, G-2<br>H-1, H-2 |
| 11/20/72 | 006 | 50-7209 | | I (Trash Only) | |
| 11/21/72 | 006 | " | | J | " |
| 11/27/72 | 063 | " | | K | " |
| 11/28/72 | 063 | " | | L | " |
| 12/4/72 | 004 | " | | M-1, M-2 | --- |
| 12/5/72 | 004 | " | | N-1, N-2 | M-1, M-2<br>N-1, N-2 |
| 12/11/72 | 004 | " | | O-1, O-2 | --- |
| 12/12/72 | 004 | " | | P-1, P-2 | O-1, O-2<br>P-1, P-2 |
| 12/20/72 | 084 | 49-3533 | | 30 Bags Top Trash | |

(*) "F" Series samples ruined. Airlines failed to notify Dr. Darley about arrival of samples.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | After | | | | | | | | |
| [illegible] | F-1 | Before | 4.5 | 5.5 | 10 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

| A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Sample | Stage | Top | Trash Bottom | Total | Top | Cane Middle | Pieces Bottom | Total | Ash lbs. |
| 10[illegible]2 | B-1 | Before | 3.5 | 8.5 | 12.0 | 31.5 | 74 | 37 (12) | 142.5 | |
| | | After | | | | 47 | 50 | 56 | 153 | 3.54 |
| | B-2 | Before | 5.5 | 6.0 | 11.5 | 37.5 | 125.75 | 43 (13) | 206.25 | |
| | | After | | | | 42 | 55 | 46 | 143 | 1.86 |
| 10/18/72 | C-1 | Before | 8 | 5.25 | 13.25 | 29 | 56 | 74 (21) | 159 | |
| | | After | | | | 51 | 47 | 62 | 160 | 4.98 |
| | C-2 | Before | 5.5 | 13 | 18.5 | 29 | 62 | 74 (25) | 165 | |
| | | After | | | | 54 | 49 | 59 | 162 | 2.89 |
| 11/6/72 | E-1 | Before | 13 | 5 | 18 | 43 | 91 | 59 (19) | 193 | |
| | | After | | | | 60 | 71 | 91 | 222 | 3.8 |
| | E-2 | Before | 12 | 8.5 | 20.5 | 50 | 100 | 40.5 (27) | 190.5 | |
| | | After | | | | 85 | 65 | 50 | 200 | 10.9 |
| 11/8/72 | F-1 | Before | 8.5 | 12.5 | 21 | 41 | 75 | 60 | 176 | |
| | | After | | | | 94 | - | 72 | 166 | 4.6 |
| | F-2 | Before | 8.5 | 7.5 | 16 | 72 | 67 | 71 | 210 | |
| | | After | | | | 76 | 57 | 73 | 206 | 5.5 |
| [illegible]72 | G-1 | Before | 7 | 6.5 | 13.5 | 47.5 | 57.5 | 44.5 (13) | 149.5 | |
| | | After | | | | 53 | 42 | 45 | 140 | 5.3 |
| | G-2 | Before | 8 | 7.75 | 15.75 | 65 | 66.5 | 46 (14) | 177.5 | |
| | | After | | | | 50 | 49 | 54 | 153 | 2.3 |
| 11/15/72 | H-1 | Before | 5.5 | 4 | 9.5 | 47 | 36 | 30 (14) | 113 | |
| | | After | | | | 72 | 51 | 55 | 178 | 3.5 |
| | H-2 | Before | 6.5 | 7 | 13.5 | 40 | 40 | 45 (15) | 125 | |
| | | After | | | | 53 | - | 30 | 83 | 2.5 |
| 12/4/72 | M-1 | Before | 4.25 | 4.5 | 8.75 | 40 | 47.5 | 42 (15) | 129.5 | |
| | | After | | | | 61 | 56 | 36 | 153 | 1.74 |
| | M-2 | Before | 6 | 5 | 11 | 46.5 | 44 | 46 (19) | 136.5 | |
| | | After | | | | 71 | 51 | 39 | 161 | 1.20 |
| 12/5/72 | N-1 | Before | 5.5 | 7.5 | 13 | 43.5 | 43 | 32 (14) | 118.5 | |
| | | After | | | | 57 | - | 52 | 109 | 2.46 |
| | N-2 | Before | 5.5 | 6 | 11.5 | 38 | 45 | 47 (23) | 130 | |
| | | After | | | | 61 | - | 39 | 100 | 1.56 |
| 12/11/72 | O-1 | Before | 4 | 4 | 8 | 24 | 46 | 15 (17) | 85 | |
| | | After | | | | 49 | - | 40 | 89 | 2.2 |
| | O-2 | Before | 6.5 | 4 | 10.5 | 42 | 46 | 23 (14) | 111 | |
| | | After | | | | 50 | - | 51 | 101 | 0.8 |
| 12/12/72 | P-1 | Before | 4.5 | 5.5 | 10 | 39 | 52.5 | 21 (13) | 112.5 | |
| | | After | | | | 37 | - | 65 | 102 | 0.6 |

| Date | Plot | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | After | | | | 61 | [illegible] | [illegible] | [illegible] | |
| | M-2 | Before | 6 | 5 | 11 | 46.5 | 44 | 46 | 136.5 | |
| | | After | | | | 71 | 51 | 39 | 161 | 1.20 |
| 12/5/72 | N-1 | Before | 5.5 | 7.5 | 13 | 43.5 | 43 | 32 | 118.5 | |
| | | After | | | | 57 | - | 52 | 109 | 2.4[illegible] |
| | N-2 | Before | 5.5 | 6 | 11.5 | 38 | 45 | 47 | 130 | |
| | | After | | | | 61 | - | 39 | 100 | 1.5[illegible] |
| 12/11/72 | O-1 | Before | 4 | 4 | 8 | 24 | 46 | 15 | 85 | |
| | | After | | | | 49 | - | 40 | 89 | 2.2 |
| | O-2 | Before | 6.5 | 4 | 10.5 | 42 | 46 | 23 | 111 | |
| | | After | | | | 50 | - | 51 | 101 | 0.5 |
| 12/12/72 | P-1 | Before | 4.5 | 5.5 | 10 | 39 | 52.5 | 21 | 112.5 | |
| | | After | | | | 37 | - | 65 | 102 | 0.6 |
| | P-2 | Before | 7 | 4 | 11 | 54 | 43.5 | 34.5 | 132 (154) | |
| | | After | | | | 83 | - | 49 | 132 | 1.[illegible] |

| SUMMARY 1972 DATA | | N | Σx | Σx² | Mean | | SD | |
|---|---|---|---|---|---|---|---|---|
| Trash | Top | 20 | 134.75 | 1021.8125 | 6.7 | | 2.4 | 36[illegible] |
| | Bottom | 20 | 132.0 | 997.625 | 6.6 | | 2.6 | 39[illegible] |
| | Total | 20 | 266.75 | 3832.1875 | 13.3 | 13.3 | 3.8 | 29 |
| Before Cane & trash | Top | 20 | 859.5 | 39460.25 | 43.0 | | 11.5 | 27[illegible] |
| | Middle | 20 | 1218.25 | 84172.5 | 60.9 | | 22.9 | 38[illegible] |
| | Bottom | 20 | 884.5 | 44451.75 | 44.2 | | 16.8 | 38[illegible] |
| | Total | 20 | 2962.25 | 462188.06 | 148.1 | 148.1 | 35.1 | 24 |
| After Cane & trash | Top | 20 | 1206 | 77120 | 60.3 | | 15.2 | 25 |
| | Middle | 12 | 643 | 35153 | 53.6 | | 8.0 | 15 |
| | Bottom | 20 | 1064 | 60606 | 53.2 | | 14.5 | 27 |
| | Total | 20 | 2913 | 453721 | 145.6 | 145.6 | 39.4 | 2[illegible] |
| Ash | | 20 | 66.24 | 346.5292 | 3.3 | 3.3 | 2.6 | 7[illegible] |

Difference (13.3+148.1)-(145.6+3.3)= 12.5 lbs./25 ft.$^2$

Burned 7.7% of load = 10.9 tons/acre

Trash: Top = 50.5%

Cane pieces: Top = 29% Middle = 41%

Trash as percent total 8.3%

297/18 = 16.5 × 43560/(25×2000) = 14.4 tons/acre

Additional Data Desirable: Leaf materials as percent of top and middle cane pieces.

Subject ______ HAWAII DEVELOPMENT IRRADI[ATOR]

Source ______ Hawaii State Department of Agric[ulture]

Period Covered From ______ To ______ Proj. No. ______

By ______ Date ______ Page ______ of ______

ENCL 5

Florida Sugar Cane League, Inc.
POST OFFICE BOX 1148
CLEWISTON, FLORIDA 33440
(813) 983-9151



December 9, 1977

Mr. T. G. Helms, Chief
Air Branch, Region IV
United States Environmental
Protection Agency
345 Courtland Street
Atlanta, Georgia 30308

and

Mr. James H. Southerland, Chief
Source Analysis Section
United States Environmental
Protection Agency
Office of Air Quality Planning
and Standards
Research Triangle Park, North Carolina 27711

Gentlemen:

This letter is intended to serve as a basis for our discussion with you in Atlanta on Monday, December 12, 1977. The purpose of the meeting is to discuss the need and justification for reducing the "fuel loading" factor as previously used in EPA manual AP-42 for burning sugarcane as it relates to Florida.

As you know, the emission and loading factors have been based on studies done on Hawaiian sugarcane by Dr. Ellis Darley of the University of California at Riverside and the Hawaii State Department of Agriculture. Recently, Dr. E. R. Hendrickson of Environmental Science and Engineering talked with Dr. Darley and he? strongly emphasized that the Hawaii loading factors should not be used for Florida because the nature and amount of cane are so different. Hawaii's average production per acre is 92 tons and in Florida it is 33 tons (five year average, 1970-75). In Hawaii the cane grows for 2 years before harvest and in Florida cane is harvested after 1 year or less of growth.

millable cane

33 millable
11 trash ...

33/92 x 11 = ~~3.95~~

Based on the position of Dr. Darley and our own knowledge of the dissimilarities between sugarcane in the two areas, the Florida Sugar Cane League believes EPA should adopt a more realistic loading factor for Florida.

We believe the tonnage ratio is adequate justification for EPA to revise its loading factor for Florida because the vast majority of combustible material is sugarcane leaves that have dried. Since leaves form at about the same interval on the stalk during the growing period, the taller, longer and more dense growth produces proportionately more leaves and thus more dry combustible material. This ratio would produce 3.9 tons per acre for Florida as opposed to 11 tons for Hawaii ~~(33/92 x 11 = 3.9 tons)~~.

Following our meeting with Palm Beach County officials on August 25, 1977, on this matter, we agreed to cooperate in a research study to more precisely quantify the loading factor for Florida, provided funding could be arranged. We reiterate our willingness to cooperate in such a study, if EPA feels a study is necessary. However, in recent weeks Dr. Joe Orsenigo, Director of Research for the League, has searched the literature and found some studies which lend support to the premise that combustible material is highly correlated with tons of cane per acre. We felt you would want to have the benefit of this data and the following summary, with attachments, is provided:

Evans and Hardy, reporting from Trinidad in 1948, concluded that the ratio of sugarcane stems (stalks) to total trash stripped from the plants is about 4:1. They concluded that a 40 T/A crop will be accompanied by about 10 T of trash consisting of tops, green leaves and dry leaves. Not all of the trash is combustible. (Evans, L. J. C. and F. Hardy. 1948. Yields of Sugarcane Trash. Trop. Agr. 23 (12):224,225.)

The trash content of Cl. 41-223 sugarcane in Florida was determined by Clayton and Churchill in the 1971-72 season. Table 1 of their article lists green and total trash contents. They concluded that 8 to 10% trash was burned off in pre-harvest. They do not cite the cane tonnages or methodology used, but in a personal communication, Mr. Clayton stated that the tabular values were based on the averages of three 400-pound samples per date working in cane of about 35 T/A.

With reference to Table 1, on 12-16-71, a total trash content of 27.9% in unburned cane was reduced to 18.0% following burning; a reduction of 9.9%. If we assume a 3:1

relationship between millable stalks and non-millable above ground cane (trash), the 35 T/A yield would translate to about 47 T/A total plant material in the field. The 9.9% applied to 47 T/A yields about 4.7 T/A trash burned off in 35 T/A cane, equivalent to about 4.4 T/A for 33 T/A cane. (Clayton, Joe E. and Donald B. Churchill. 1973. Cleaning Sugarcane During Harvest: Cleaning Rolls or Pneumatics. Amer. Soc. Sugar Cane Tech. 1972 Mtgs. Proc. 2 (NS):143-146.)

Irvine partitioned CP 65-357 sugarcane in Louisiana. Dead leaves which had shed from the plant were not recovered. He reports only dead leaves attached to the plant at sampling and all percentages are based on a total plant basis, including stubble and roots. Table 1 illustrates the following percentages of total plant weight for these respective parts subject to combustion: leaf blade, 11.1%; leaf sheathes, 4.3% and dead leaves, 4.3%. Expressed proportionately on an aerial plant portion basis, these percentages are equal to: 12.4, 4.8, and 4.8, respectively. The estimated burnable portions of the above fractions are: 20, 25, and 100%, respectively which suggests that fire consumes about 2.5% leaf blade, 1.2% sheathes, and 4.8% dead leaves for a total of 8.5% of the above ground plant. If 1.5% is added for unrecovered dead leaves, a total of 10% of the above ground plant material is burned. This would equal 4.0 T/A for 40 tons total cane per acre. (Irvine, J. E. 1977. Distribution of Carbohydrates and Potassium in Sugarcane Parts. Amer. Soc. Sugar Cane Tech. 1976 Mtgs. Proc. 6(NS):53-57.)

reasonable?

$4.0 \times \frac{44}{40} = 4.4$ tn/acre

The University of Florida "green vs burned cane" study was not designed to answer the fuel loading question, but it may be applicable to estimating the amount of material consumed in the pre-harvest burn. This study indicates trash values of 4.74% for burned cane and 13.04% for green cane, a trash reduction of 8.30% (Table 10). If we can assume that this trash reduction represents the actual percentage loss applied proportionately to the standing crop on a 3:1 relationship betweenmillable stalk and non-millable above ground cane, 40 tons total cane per acre would yield about 30 tons of millable cane and 10 tons of non-millable material. At the equivalent 11% trash reduction through burning, the fuel load would equal about 4.4 tons per acre (40 x 11%). (Orsenigo, J. R. 1978. A Harvest Comparison of Green and Bürned Sugarcane. Univ. of Florida - IFAS Tech. Bul. 794. IN PRESS.)

We believe this data adds support to our contention that cane tonnage and the amount of combustible material are highly correlated and that Florida cane produces on the order of 4 tons of combustible material per acre. The League believes that EPA is fully justified in revising the AP-42 manual accordingly for Florida sugarcane. In the interest of fairness, we therefore make the request that you do this in the manual now being revised.

Should EPA later wish to have a study conducted in Florida, and the necessary funds are obtained, we, of course, would be willing to cooperate.

Sincerely yours,

Nelson Fairbanks

J. Nelson Fairbanks
Vice President & General Manager

JNF:dd
Enclosures
cc: Environmental Quality Committee
Technical Subcommittee
Mr. Frank J. Gargiulo - PBCHD
Mr. Eugene J. Sacco - PBCHD
Mr. Mike Martin - PBCHD
Dr. E. R. Hendrickson
Dr. J. R. Orsengio
Mr. Bill Arlington

3.9
4.0
4.4
4.4
4.4
5.4 4.1

ENCL 6 ~~File Copy~~

# Palm Beach County Health Department

P.O. BOX 29, WEST PALM BEACH, FLORIDA 33402

C.L. BRUMBACK, M.D., M.P.H.
DIRECTOR

Please Address
Reply To: ESE-WPB

January 13, 1978

Mr. James H. Southerland
Environmental Engineer
Chief, Source Analysis Section
Office of Air Quality Planning and Standards
U.S.E.P.A., Mail Drop-14
Research Triangle Park, N.C. 27711

Dear Mr. Southerland:

On December 21, 1977, I met with Mr. Barney Eiland, Agricultural Engineer,Sugarcane Harvesting Research Unit, United States Department of Agriculture, Belle Glade, Florida to discuss and take part in a trash determination study. The research unit concentrates its work on new varieties of sugarcane which is being considered for commercial use. Mr. Eiland stated that these research varieties are quite similar to commercial varieties and would give me an idea of the amount of material which would be capable of being burned during a typical Florida sugarcane burn.

Mr. Eiland's trash study involved eleven research varieties and one commercial variety. A five stalk sample taken from each group was cut. The cane was cleaned and separated into five sections to be weighed. These sections are:

A. Clean 5 - Stalk Weight
B. 5 - Stalk Dry Attached Leaves
C. Dry Ground Trash
D. 5 - Stalk Green Leaves Weight, and
E. 5 - Stalk Top Weight.

An assumption was made that all the dry attached leaves and dry ground trash was consumed during a burn.

In addition to the actual weight of material per the above divisions, the number of plants (cane stalks) per acre would be needed to determine the loading factor. The number of plants per acre varied between 25,000 to 35,000, average being about 30,000. Using the average allowed us to set up a simple problem to find the amounts of material per acre which can be burned. The total dry trash weight multiplied by the # plants/acre divided by 2,000 (conversion of pounds to tons) divided by the number in our sample yields the tonnage of material burned.

Example: Total dry trash X # plants per acre ÷ 2,000 ÷ 5 = Tons material burned.

The following is a summary of the data collected for two varieties which represents the two major commercial varieties harvested in Florida. Each data point represents the average of three samples:

1. Variety: CP74-1028 (a research variety similar to commercial variety CP63-588, which comprises approximately 35% of the sugarcane acreage)

   Clean 5-Stalk Weight : 24.0 lbs.
   5-Stalk Dry Attached Leaves : 1.0 lbs.
   Dry Ground Litter : 0.71 lbs
   5-Stalk Green Leaves : 2.34 lbs.
   5-Stalk Top Weight : 1.0 lbs.

This variety would have a total dry weight of 1.71 lbs.
(1.71 X 30,000 ÷ 2,000 ÷ 5 = 5.13 Tons)

2. Variety: CL41-223 (commercially grown, 15% of the sugarcane acreage).

   Clean 5-Stalk Weight : 14.08 lbs.
   5-Stalk Dry Attached Leaves : 0.96 lbs.
   Dry Ground Litter : 0.26 lbs.
   5-Stalk Green Leaves : 3.13 lbs.
   5-Stalk Top Weight : 1.31 lbs.

This variety would have a total dry weight of 1.25 lbs.
(1.25 X 30,000 ÷ 2,000 ÷ 5 = 3.75 Tons)

If we were to take the Total Dry Weight for the twelve samples that comprised the Trash Test (the two varieties above would be included), the average for the twelve varieties would have an average total dry weight of 1.67 lbs.
(1.67 X 30,000 ÷ 2,000 ÷ 5 = 5.01 Tons)

It would appear that the loading factor for Florida sugarcane may be in the 5 ton per acre range. However, this factor would be increased when the fields had been treated with chemicals, paraquat or polaris, or the result of freeze damage. Paraquat is a defoliant and polaris is a sucrose enhancer. Both affect the moisture content of the green cane leaf. Although the actual affect on the loading factor is not known, it was estimated that approximately 1 Ton per acre could be added to the fire load.

Another problem that may enter into the loading factor determination is that of a second burn which reduces the amount of trash left in the field after harvesting. This agency is aware that this practice is used occasionally but the numbers of acres and quantity of material burned is not known.

Also enclosed for your information are copies of several studies which may be of some help to provide a realistic fuel loading figure for Florida sugarcane.

Should you have any further questions concerning this matter, please contact the undersigned.

Sincerely,

For the Director, Division of Environmental Sciences and Engineering

Michael J Martin

Michael Martin
Pollution Control Specialist I
Air Pollution Control

FJG/MM/SLP

Enc.

PBCHD
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25 nodes per stalk, Florida cane = 10-14 green leaves per stalk and 12-15 dry leaves per stalk.

1/3 of yield of cane per acre is the total trash content.

1/2 of the total trash content is combustible material.

Average yield of cane per acre 33T/acre

1/4 44 = 11 tons total

1/3 of 33T/acre = 10.89 total trash

1/2 of 33 = 5.5 T/acre

1/2 of total trash 10.89 = combustibles

1/2 of 10.89 = 5.445 T/acre burned.

5.5

Dessicants (paraquat) applied to a cane field can make up to a 5% difference in trash content.

5.445 T/acre x .05 - 0.27225

5.445 + 0.27225 = 5.71725 Loading factor.

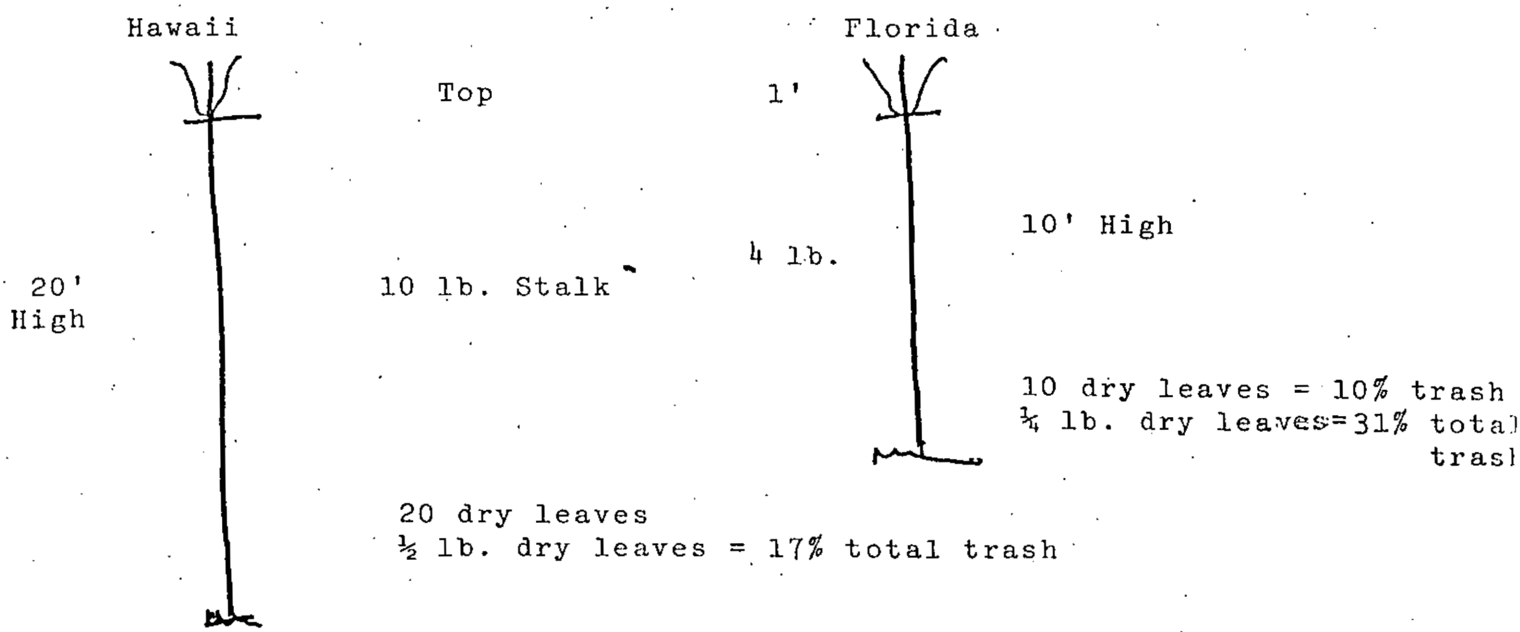
Hawaii Cane

Average yield 90T/acre

with about 12% combustible

Twice as much leaf material.

90 x .12 = 10.8 T/acre combustible.



Study
Factors:
Yield per acre - heavy medium, light Sample taken from a row 25'-35' in length.
5 to 10 samples
Hand strip samples
Take sample - 3 rows inside field
100 ft. from end of row.
Take as soon as possible.