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## A Chromatographic and Ecological Study of The Columnar Junipers of Western North Dakota

John D. Staudinger

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A CHROMATOGRAPHIC AND ECOLOGICAL STUDY OF  
THE COLUMNAR JUNIPERS OF WESTERN NORTH DAKOTA

BY

JOHN D. STAUDINGER

B. A. DICKINSON STATE COLLEGE 1964

A THESIS

SUBMITTED TO THE FACULTY

OF THE

GRADUATE SCHOOL

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UNIVERSITY OF NORTH DAKOTA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE

GRAND FORKS, NORTH DAKOTA

JUNE

1966

THIS THESIS SUBMITTED BY JOHN D. STAUDINGER IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN THE UNIVERSITY OF NORTH DAKOTA IS HEREBY APPROVED BY THE COMMITTEE UNDER WHOM THE WORK HAS BEEN DONE.

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## INTRODUCTION

IN THE BADLANDS OF WESTERN NORTH DAKOTA, NUMEROUS LIGNITE BEDS HAVE BURNED, BAKING AND FUSING THE OVERLAYING CLAYS, SHALES, AND SANDS INTO A RED TO BROWNISH RED SUBSTANCE. THIS BAKED AND FUSED MATERIAL IS LOCALLY CALLED "SCORIA" BUT SHOULD BE MORE CORRECTLY CALLED CLINKERS (LAIRD, 1956).

TODAY THERE ARE STILL NUMEROUS BEDS OF LIGNITE BURNING IN THE BADLANDS. TWO OF THESE BURNING COAL VEINS (FIG. 1) ARE LOCATED IN SLOPE COUNTY (T. 136N, R. 102W, SEC. 12, 13, AND 14; AND IN R. 101W, SEC. 18) AND IN BILLINGS COUNTY (T. 140N, R. 101W, SEC. 23). JUNIPERS GROWING IN THE VICINITY OF THESE BURNING BEDS OF LIGNITE HAVE TAKEN ON A COLUMNAR FORM (PLATE I, FIG. 1 AND 2). THE DISTRIBUTION OF THE COLUMNARS IN SLOPE COUNTY IS GIVEN IN FIG. 2.

NOYCE (1959) REPORTED THAT HER FATHER, GEORGE C. CLARK, WAS THE FIRST SETTLER TO SEE THE BURNING COAL VEIN IN SLOPE COUNTY IN 1880, WHEN IT WAS "VERY" SMALL. NOYCE RECALLS THAT HER FATHER NOTED THE BURN AS COVERING 0.3 TO 0.5 OF AN ACRE AT THAT TIME. THE BURNING RATE OF THE COAL VEIN AS OBTAINED FROM NOYCE (PERSONAL COMMUNICATION) IS PRESENTED IN FIG. 3. THE TIME INTERVALS GO FROM 1880, WHEN FIRST SEEN BY A WHITE MAN, TO 1906 WHEN NOYCE MOVED TO THE AREA AND 1951 WHEN THE COAL VEIN CROSSED THE DIVIDE AND STARTED BURNING EASTWARD.

ANOTHER COAL VEIN LOCATED IN THE SOUTH UNIT OF THE THEODORE ROOSEVELT NATIONAL MEMORIAL PARK STARTED BURNING IN SEPTEMBER, 1951





Fig. 2.  
Distribution of columnar junipers.

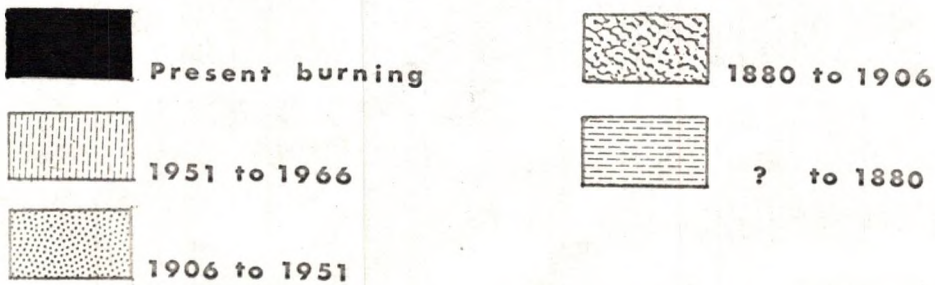
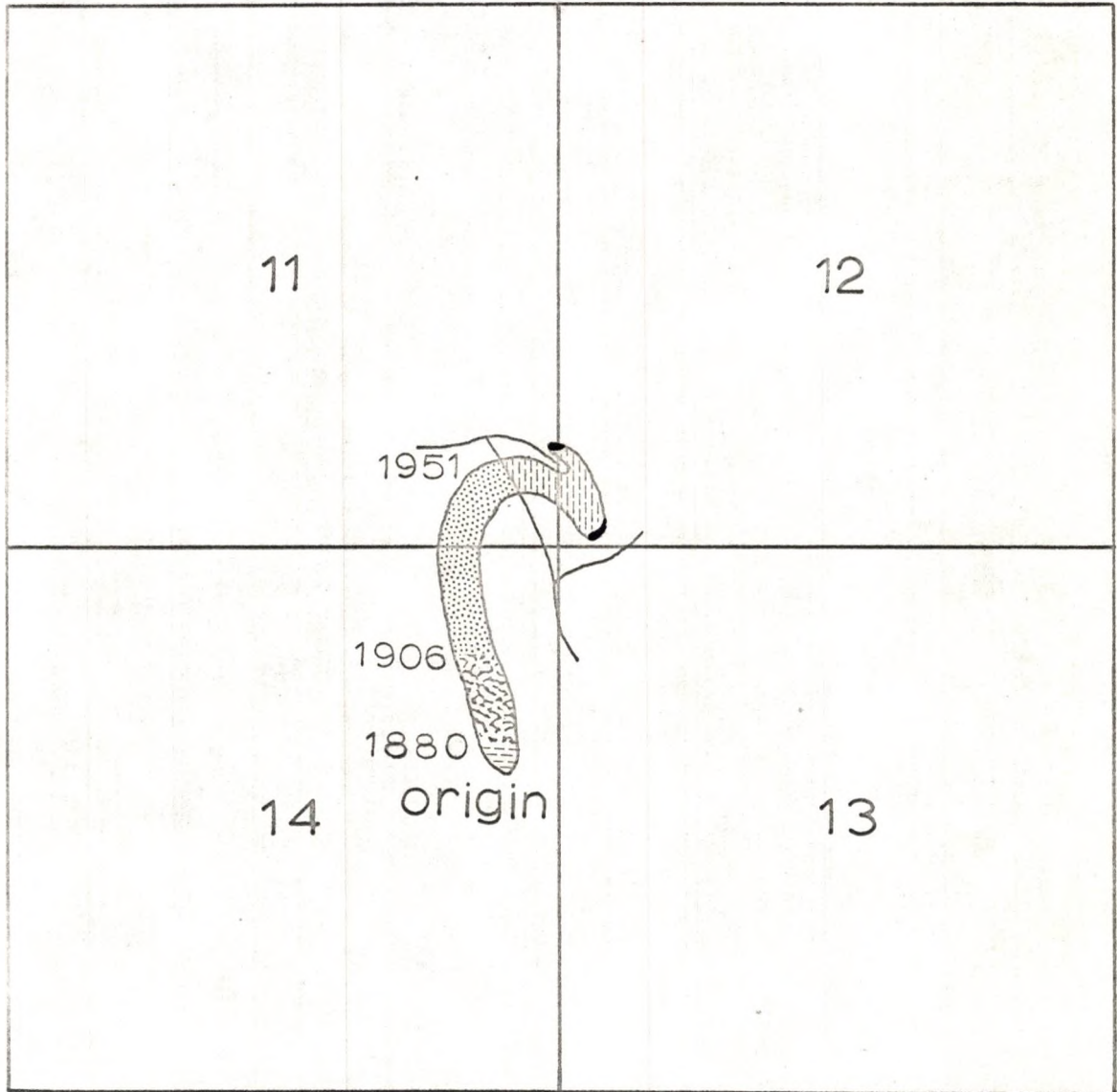


-3-

■ Burning Coal Vein  
▨ Columnar Juniper

▨ Juniperus scopulorum  
▨ Pinus ponderosa

Fig. 3.  
Burning rate of the coal vein in Slope County.



(ARTHUR SULLIVAN, PERSONAL COMMUNICATION). THIS COAL VEIN, IGNITED BY LIGHTNING, HAS JUNIPERS IN ITS VICINITY WHICH HAVE TAKEN ON A COLUMNAR FORM. JUNIPERS WHICH ARE 2 TO 5 FT. IN HEIGHT ARE COLUMNAR WHILE THOSE 6 TO 8 FT. IN HEIGHT HAVE A COLUMNAR FORM ON THEIR SUMMIT (PLATE V, FIG. 9 AND 10).

THE COLUMNAR JUNIPERS HAVE BEEN PREVIOUSLY CONSIDERED TO COMPRISE 1) MERELY A VARIETY OF JUNIPERUS SCOPULORUM SARG. (J. SCOPULORUM V. COLUMNARIS FASSETT); 2) AN ECOLOGICAL VARIANT OF TRUE J. SCOPULORUM; 3) A HYBRID BETWEEN J. SCOPULORUM AND ONE OF THE SEVERAL OTHER JUNIPER SPECIES THAT OCCUR IN THE AREA; OR 4) A DISTINCT SPECIES. FASSETT (1945) CONSIDERED THE COLUMNAR JUNIPERS TO BE A VARIETY DIFFERING FROM TRUE J. SCOPULORUM IN THE RATIO OF HEIGHT TO WIDTH OF TREES. THE HEIGHT OF J. SCOPULORUM TREES VARIES FROM 1 TO 2 TIMES THEIR WIDTH, WHILE THAT OF J. SCOPULORUM V. COLUMNARIS RANGES FROM 2.5 TO 3.0 TIMES THEIR WIDTH.

DURING THE SUMMER OF 1965, A STUDY WAS UNDERTAKEN OF THE COLUMNAR JUNIPERS OF WESTERN NORTH DAKOTA TO ELUCIATE THE ANCESTRY OF THIS JUNIPER TAXON. THE PROJECT WAS DIVIDED INTO TWO PARTS, BIOSYSTEMATIC STUDIES AND ECOLOGICAL ANALYSIS OF THE COLUMNAR STANDS. PAPER CHROMATOGRAPHY WAS USED TO ASSAY WHETHER THE COLUMNAR JUNIPER HAS A HYBRID ORIGIN BETWEEN J. SCOPULORUM AND J. COMMUNIS V. DEPRESSA PURSH OR J. HORIZONTALIS MOENCH BOTH OF WHICH OCCUR IN THE STUDY AREA.

RECENT STUDIES HAVE SHOWN THE SIGNIFICANCE OF MODERN CHEMOTAXONOMIC METHODS IN COMPLEMENTING MORPHOLOGICAL, CYTOLOGICAL, AND ANATOMICAL DATA IN ELUCIDATION OF SYSTEMATIC RELATIONSHIPS OF DUBIOUS PLANT TAXA (ALSTON AND TURNER 1959, 1962, 1963; LESTER ET AL 1965; SMITH AND LEVIN 1963, TORRES AND LEVIN 1964; AND TURNER AND ALSTON 1959). SUCH CHEMOTAXONOMIC

TECHNIQUES AS PAPER CHROMATOGRAPHY HAVE BEEN OF PARTICULAR VALUE IN STUDIES OF HYBRIDIZATION, POLYPLOIDY, AND SPECIATION (SMITH AND LEVIN 1963 AND STEBBINS ET AL 1963).

CHEMICAL CRITERIA CAN BE USED AS RELIABLE TAXONOMIC CHARACTERS BECAUSE OF BIOCHEMICAL COMPLEMENTATION OF SPECIES-SPECIFIC CHEMICAL SUBSTANCES IN THE INTERSPECIFIC HYBRID DERIVATIVES. THE BIOCHEMICAL CONSTITUENTS OF THESE HYBRIDS FREQUENTLY REPRESENT A SUMMATION OF THE SUBSTANCES FOUND IN THE PARENTAL SPECIES; THAT IS, THE SPECIES-SPECIFIC CONSTITUENTS OF THE PARENTAL SPECIES ARE COMBINED IN THEIR HYBRID DERIVATIVE (ALSTON AND TURNER 1962, 1963).

THE ECOLOGY OF THE AREA WAS EXAMINED TO DETERMINE THE ENVIRONMENTAL FACTORS PRESENT WHICH LIMIT THE DISTRIBUTION OF THE COLUMNARS TO THE VICINITY OF THE BURNING LIGNITE DEPOSITS. SOIL AND COMMUNITY COMPOSITION WERE INCLUDED IN THE ECOLOGICAL STUDY.

## METHODS AND PROCEDURE

### CHROMATOGRAPHY

SAMPLES OF LEAF TISSUE OF THE 4 TAXA OF JUNIPERUS WERE COLLECTED FROM INDIVIDUAL PLANTS IN SLOPE AND BILLINGS COUNTIES DURING MARCH AND NOVEMBER OF 1964 AND JUNE, JULY, AND NOVEMBER OF 1965. NEEDLES WERE UTILIZED FROM THREE POSITIONS WITHIN THE CROWN TO MINIMIZE ANY CHROMATOGRAPHIC DIFFERENCES DUE TO AGE OF NEEDLES, CROWN POSITION OR EXPOSURE. A TOTAL OF 3 TO 10 SAMPLES FROM EACH TAXON WAS USED FOR EACH MONTH TO ASSAY INTRASPECIFIC CHROMATOGRAPHIC VARIABILITY. IN CERTAIN SPECIES OF PLANTS SEASONAL VARIATION IN THE CHEMICAL CONSTITUENTS HAVE BEEN REPORTED BY BLACK (1948). THEREFORE, LEAF SAMPLES FROM THE SAME PLANTS WERE COLLECTED AND CHROMATOGRAPHED PERIODICALLY OVER A ONE YEAR PERIOD TO DETERMINE IF A SEASONAL VARIATION EXISTS IN THE 4 TAXA OF JUNIPERUS STUDIED.

NEEDLES WERE OVEN DRIED AT  $55 \pm 3$  °C FOR 24 HOURS AND EXTRACTED FOR 24 HOURS WITH 2 ML OF 80 PER CENT METHANOL. A TOTAL OF 20 TO 25 DROPS OF THE EXTRACT WAS APPLIED IN A 1 INCH STREAK, WITH A PIPETTE ON WHATMANS NO. 2 FILTER PAPER (40 X 40 CM). EACH STREAK WAS ALLOWED TO DRY BEFORE THE NEXT APPLICATION WAS MADE. AFTER STREAKING, THE SHEETS WERE AIR DRIED FOR 30 MINUTES TO INSURE EVAPORATION OF THE METHANOL SOLVENT. THE CHROMATOGRAMS WERE RUN IN TWO DIMENSIONS BY THE ASCENDING METHOD. THE FIRST DIMENSION SOLVENT SYSTEM WAS UTILIZED FOR 24 HOURS, AND CONSISTED OF N-BUTANOL: GLACIAL ACETIC ACID: DISTILLED

WATER IN A RATIO OF 5:1:2 (v/v). CHROMATOGRAMS WERE RUN FOR 7 TO 9 HOURS IN THE SECOND DIMENSION UTILIZING 15 PER CENT ACETIC ACID. BOTH SOLVENT SYSTEMS RESULTED IN EXCELLENT SEPARATION OF THE INDIVIDUAL BIOCHEMICAL CONSTITUENTS.

THE CHROMATOGRAMS WERE EXAMINED UNDER ULTRAVIOLET LIGHT, ULTRAVIOLET LIGHT IN THE PRESENCE OF AMMONIA VAPOR, AND IN VISIBLE LIGHT. SPOTS WERE GROUPED BOTH BY COLOR AND BY  $R_f$  VALUES IN EACH DIMENSION. ONLY THOSE SPOTS WHICH OCCURRED FOR ALL PLANTS OF EACH TAXON WERE UTILIZED IN THIS STUDY AND DETECTED SUBSTANCES OCCURRING IN A LOW FREQUENCY WERE IGNORED, EXCEPT FOR SPOTS GOLD 1 AND 2 WHICH OCCURRED WITH 15 PER CENT FREQUENCY IN WINTER FOLIAGE AND 100 PER CENT FREQUENCY IN SUMMER FOLIAGE OF J. SCOPULORUM AND THE COLUMNAR JUNIPER. NO ATTEMPT WAS MADE TO IDENTIFY THE DETECTED CHEMICAL SUBSTANCES. PREVIOUS STUDIES BY SMITH AND LEVIN (1963), TORRES AND LEVIN (1964) AND OTHERS USING DIAZOTIZED SULFANILIC ACID HAVE ESTABLISHED THAT THE MAJORITY OF THE OBSERVED SPOTS WOULD BE PHENOLIC OR POLYPHENOLIC COMPOUNDS. FOR PURPOSES OF THIS STUDY, THE REPEATABILITY OF THE CHROMATOGRAPHIC PATTERNS AND THE PRESENCE OR ABSENCE OF SPECIES-SPECIFIC BIOCHEMICAL SUBSTANCES WERE IMPORTANT RATHER THAN THE IDENTITY OF THESE COMPOUNDS.

## ECOLOGY

### GROWTH AND DEVELOPMENT

ECOLOGICAL DATA WAS ACCUMULATED ON THE COLUMNAR JUNIPER TO DETERMINE THE EFFECTS THE ENVIRONMENT MIGHT HAVE ON THE PECULIAR GROWTH FORM. HEIGHTS AND WIDTHS OF THE COLUMNAR JUNIPERS WERE MEASURED TO CHECK THE RELIABILITY OF THE 2.5-3.0 RATIO OF HEIGHT TO WIDTH GIVEN BY FASSETT (1945) AS THE MORPHOLOGICAL DIAGNOSTIC CHARACTERISTIC OF THIS VARIETY.

THE STANDS WERE AGED BY EXAMINATION OF ANNUAL GROWTH RINGS FOR BOTH AGES OF THE STANDS AND THE GROWTH RATE OF THE COLUMNAR JUNIPERS. DIAMETERS OF THE COLUMNARS WERE MEASURED 1 FT. ABOVE THE GROUND. TREE HEIGHTS AND WIDTHS AND AGE TO HEIGHT, WIDTHS, AND DIAMETERS OF 78 RANDOMLY CHOSEN COLUMNAR JUNIPERS OF VARIOUS AGES WERE MEASURED. TREE HEIGHTS WERE ESTIMATED TO THE NEAREST 0.3 METERS AND THE WIDTHS TO THE NEAREST 2.5 CM. AGE DETERMINATIONS OF 47 RANDOMLY SELECTED COLUMNAR JUNIPERS WERE SAMPLED 0.3 METERS ABOVE THE GROUND WITH A SWEDISH INCREMENT BORER AND THE ANNUAL GROWTH RINGS COUNTED. THREE CORES ALONG THE VARIOUS RADII OF THE TREES WERE TAKEN IN ORDER TO ELIMINATE POSSIBLE ERRORS IN ANNUAL GROWTH RING COUNTS DUE TO MISSING OR PARTIAL RINGS CAUSED BY UNEQUAL GROWTH RATES.

#### MORPHOLOGY

FASSETT (1944) STATED THAT THE BEST MORPHOLOGICAL CHARACTER TO DISTINGUISH J. SCOPULORUM FROM J. HORIZONTALIS AND J. VIRGINIANA IS THE SIZE OF THE FOLIAR GLAND. IN J. SCOPULORUM THE GLAND IS ALWAYS LONGER THAN THE DISTANCE FROM THE GLAND TO THE TIP OF THE LEAF. IN J. VIRGINIANA AND J. HORIZONTALIS THE GLAND IS SHORTER THAN THE DISTANCE FROM THE GLAND TO THE LEAF TIP. THIS DIAGNOSTIC MORPHOLOGICAL CHARACTER OF J. SCOPULORUM WAS COMPARED TO THE COLUMNAR JUNIPER TO DETERMINE THE AFFINITY OF LEAF MORPHOLOGY BETWEEN THE TWO.

#### COMMUNITY COMPOSITION

THROUGHOUT THE SUMMER PLANTS WERE COLLECTED UNDER AND ADJACENT TO THE COLUMNARS AND ALSO IN THE SURROUNDING COMMUNITIES. THEIR RELATIVE



ABUNDANCE WAS DETERMINED BY VISUAL OBSERVATION. VOUCHERS OF THE COLLECTED SPECIMENS WERE DEPOSITED IN THE UNIVERSITY OF NORTH DAKOTA HERBARIUM.

#### SOIL-WATER RETAINING CAPACITY

SOIL FROM 6 STANDS OF COLUMNAR JUNIPERS WAS SAMPLED AT 1 FT. BELOW THE SURFACE. THESE SOIL SAMPLES WERE ANALYZED FOR WATER-RETAINING CAPACITY FOLLOWING A MODIFICATION USED BY CURTIS (1956). THE SOIL SAMPLES WERE PULVERIZED WITH A MORTAR AND PESTLE. THE SOIL CUPS WERE FILLED WITH AIR-DRIED SOIL TO A DEPTH OF ONE CENTIMETER AND PLACED FOR 30 MINUTES IN A TRAY CONTAINING A SMALL AMOUNT OF DISTILLED WATER. THE CUP AND SOIL WERE WEIGHED ON A TRIPLE-BEAM BALANCE AND THEN DRIED IN A SOIL OVEN (105 °C FOR 72 HOURS). THE CUPS WERE THEN WEIGHED AGAIN. THE FORMULA USED TO CALCULATE THE PER CENT WATER-RETAINING CAPACITY WAS:

$$\text{WRC} = \frac{\text{TOTAL WET WEIGHT} - \text{TOTAL DRY WEIGHT}}{\text{TOTAL DRY WEIGHT} - \text{WEIGHT OF CUP PLUS PAPER}} \times 100$$

## RESULTS

### CHROMATOGRAPHY

ANALYSIS OF THE CHROMATOGRAMS OF THE 4 TAXA OF JUNIPERUS ARE TABULATED IN TABLE 1, AND THE REPRESENTATIVE CHROMATOGRAPHIC PATTERNS OF EACH TAXON ARE DIAGRAMMED IN FIG. 4. SPOTS BLUE 5, 8 AND 14 AND PURPLE 2 AND 5 ARE SPECIES-SPECIFIC CONSTITUTE FOR THE "J. SCOPULORUM-COLUMNAR" COMPLEX. SPOTS BLUE 16, GOLD 6 AND 7, YELLOW 1 AND 3 APPEARED ONLY IN J. HORIZONTALIS, WHILE BLUE 15, YELLOW 2, FLESH 1 AND VIOLET 1 WERE SPECIFIC TO J. COMMUNIS V. DEPRESSA. JUNIPERUS HORIZONTALIS AND J. COMMUNIS V. DEPRESSA SHARED PURPLE 6, WHICH WAS ABSENT FROM CHROMATOGRAMS IN THE "J. SCOPULORUM-COLUMNAR" COMPLEX. JUNIPERUS COMMUNIS V. DEPRESSA SHARED BLUE 7 AND GOLD 2 WITH THE "J. SCOPULORUM-COLUMNAR" COMPLEX.

ALL THE BLUE SPOTS WERE DETECTED UNDER U-V LIGHT WITH THE EXCEPTION OF BLUE 10, WHICH APPEARED UNDER U-V LIGHT AND AMMONIA VAPOR. BLUE 12 WAS A VERY BRIGHT BLUE AND BLUE 4 WAS SMALL IN COMPARISON TO THE OTHER BLUES. SPOTS GOLD 1 AND 2 WOULD ONLY APPEAR IF THE CHROMATOGRAMS WERE LEFT IN AMMONIA VAPOR FOR 15 MINUTES. EVEN WITH THIS PRECAUTION, THEY WERE ABSENT FROM 15 PER CENT OF THE CHROMATOGRAMS OF THE WINTER FOLIAGE OF THE "J. SCOPULORUM-COLUMNAR" COMPLEX.

SEASONAL VARIATION WAS DETECTED IN LEAF MATERIAL OF THE "J. SCOPULORUM-COLUMNAR" COMPLEX. SPOTS BLUE 14 AND GOLD 1 AND 2 WERE PRESENT IN SUMMER FOLIAGE OF THE "J. SCOPULORUM-COLUMNAR" COMPLEX, BUT APPEARED WITH ONLY 15 PER CENT FREQUENCY IN WINTER FOLIAGE. THEREFORE, IN COLLECTING MATERIALS FOR A CHROMATOGRAPHIC STUDY IN JUNIPERUS CARE SHOULD BE

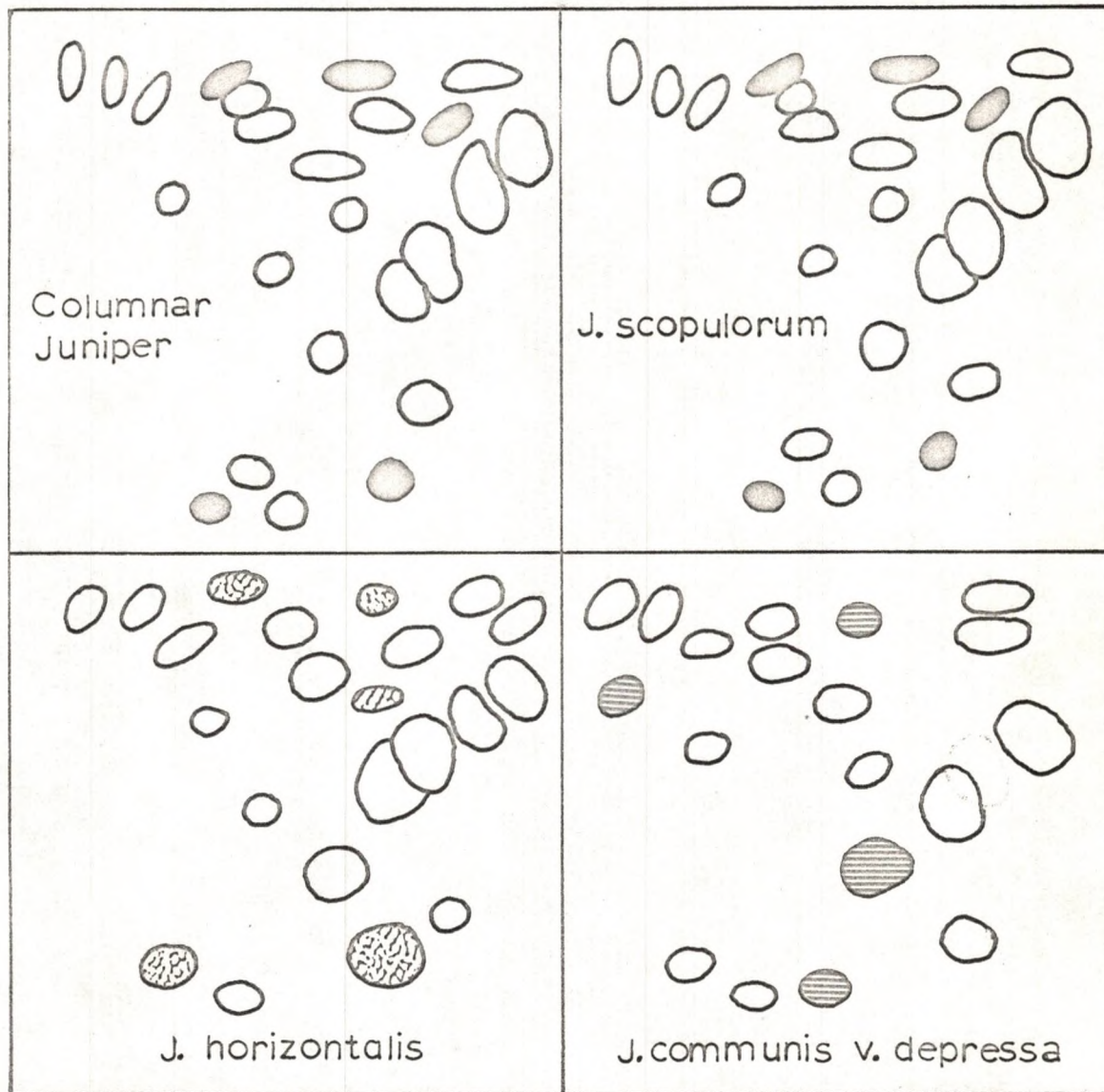
TABLE 1. DETECTED BIOCHEMICAL CONSTITUENTS ON THE CHROMATOGRAMS OF FOUR TAXA OF JUNIPERUS FROM WESTERN NORTH DAKOTA.

		TAXON			
		COLUMNAR JUNIPERS	<u>J. SCOPULORUM</u>	<u>J. HORIZONTALIS</u>	<u>J. COMMUNIS</u> <u>V. DEPRESSA</u>
DETECTED CHROMATOGRAPHIC SPOTS*	B 1	X	X	X	X
	B 2	X	X	X	X
	B 3	X	X	X	X
	B 4	X	X	X	X
	B 5	X	X	-	X
	B 6	X	X	X	X
	B 7	X	X	-	X
	B 8	X	X	-	-
	B 9	X	X	X	-
	B 10	X	X	X	X
	B 11	X	X	X	-
	B 12	X	X	X	X
	B 13	X	X	X	X
	B 14	X	X	X	-
	B 15	-	-	-	X
	B 16	-	-	X	-
	P 1	X	X	X	X
	P 2	X	X	-	-
	P 3	X	X	X	X
	P 4	X	X	-	X
	P 5	X	X	-	-
	P 6	-	-	X	X
	G 1	X	X	X	-
	G 2	X	X	-	X
	G 3	X	X	X	-
	G 4	X	X	X	X
	G 5	X	X	X	-
	G 6	-	-	X	-
	G 7	-	-	X	-
	Y 1	-	-	X	-
	Y 2	-	-	-	X
	Y 3	-	-	X	-
	F 1	-	-	-	X
V 1	-	-	-	X	

\* SPOTS AGREE WITH THOSE IN FIGURE 4.  
 THE SYMBOLS "B", "P", "G", "Y", "F", AND "V" ARE USED FOR BLUE, PURPLE, GOLD, YELLOW, FLESH, AND VIOLET. THE COLOR OF THESE SPOTS AS THEY APPEAR UNDER U-V LIGHT AND U-V LIGHT WITH AMMONIA VAPOR.

Fig. 4.

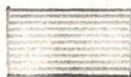
Representative chromatographic patterns of the four taxa of *Juniperus*.



Species specific to *Juniperus scopulorum-columnar* complex.



Species specific to *J. horizontalis*.



Species specific to *J. communis v. depressa*.

TAKEN TO COLLECT ALL LEAF MATERIAL DURING EITHER THE SUMMER OR THE WINTER MONTHS.

THE DATA SHOW THAT THE CHROMATOGRAPHIC PATTERNS OF J. SCOPULORUM AND THE COLUMNAR JUNIPER WERE IDENTICAL AND DID NOT DIFFER EVEN IN THE PRESENCE OR ABSENCE OF A SINGLE DETECTABLE CHEMICAL CONSTITUENT. CHROMATOGRAMS OF EACH OF THE OTHER 2 TAXA STUDIED DEVIATED FROM THIS "J. SCOPULORUM-COLUMNAR" PATTERN, WITH J. HORIZONTALIS CONTAINING 5 AND J. COMMUNIS V. DEPRESSA CONTAINING 4 SUBSTANCES ABSENT IN BOTH OF THE FORMER TAXA. CHROMATOGRAMS RAN ON J. VIRGINIANA V. CREBRA (STAUDINGER AND HADLEY 1965) CONTAINED SPECIES-SPECIFIC CHEMICAL CONSTITUENTS NOT FOUND IN THE "J. SCOPULORUM-COLUMNAR" COMPLEX. THE ISOLATION OF THE GEOGRAPHICAL RANGE OF THE COLUMNAR JUNIPER FROM THAT OF J. VIRGINIANA V. CREBRA ALSO DIMINISH THE POSSIBILITY OF IT BEING INVOLVED IN HYBRIDIZATION WITH J. SCOPULORUM.

## ECOLOGY

### GROWTH AND DEVELOPMENT

THE RATIO OF HEIGHT TO WIDTH OF THE 72 TREES OF COLUMNAR JUNIPERS EXAMINED STATISTICALLY SHOWED A POSITIVE CORRELATION OF 0.824 (FIG. 5). THE MEAN HEIGHT AND WIDTH OF THE 72 COLUMNARS EXAMINED WERE 16.07 AND 3.99 FT., RESPECTIVELY. NELSEN (1961) STUDIED 876 J. SCOPULORUM TREES IN THE NORTH DAKOTA BADLANDS AND FOUND THE MEAN HEIGHT TO BE 12.9 FT. AND WIDTH 10.16 FT. THE RATIO OF HEIGHT TO WIDTH IN THE COLUMNARS OF THE PRESENT STUDY WAS CONTINUOUS FROM 1.0 TO 6.6 WITH AN EXTREME OF 9.6 (TABLE 2). THE RATIO OF HEIGHT TO WIDTH IN NELSEN'S STUDY CALCULATES OUT TO 1.27 FOR THE 876 J. SCOPULORUM EXAMINED. THIS COMPARES TO A MEAN OF 3.88 IN THE 72 COLUMNAR JUNIPERS EXAMINED.

Fig. 5.

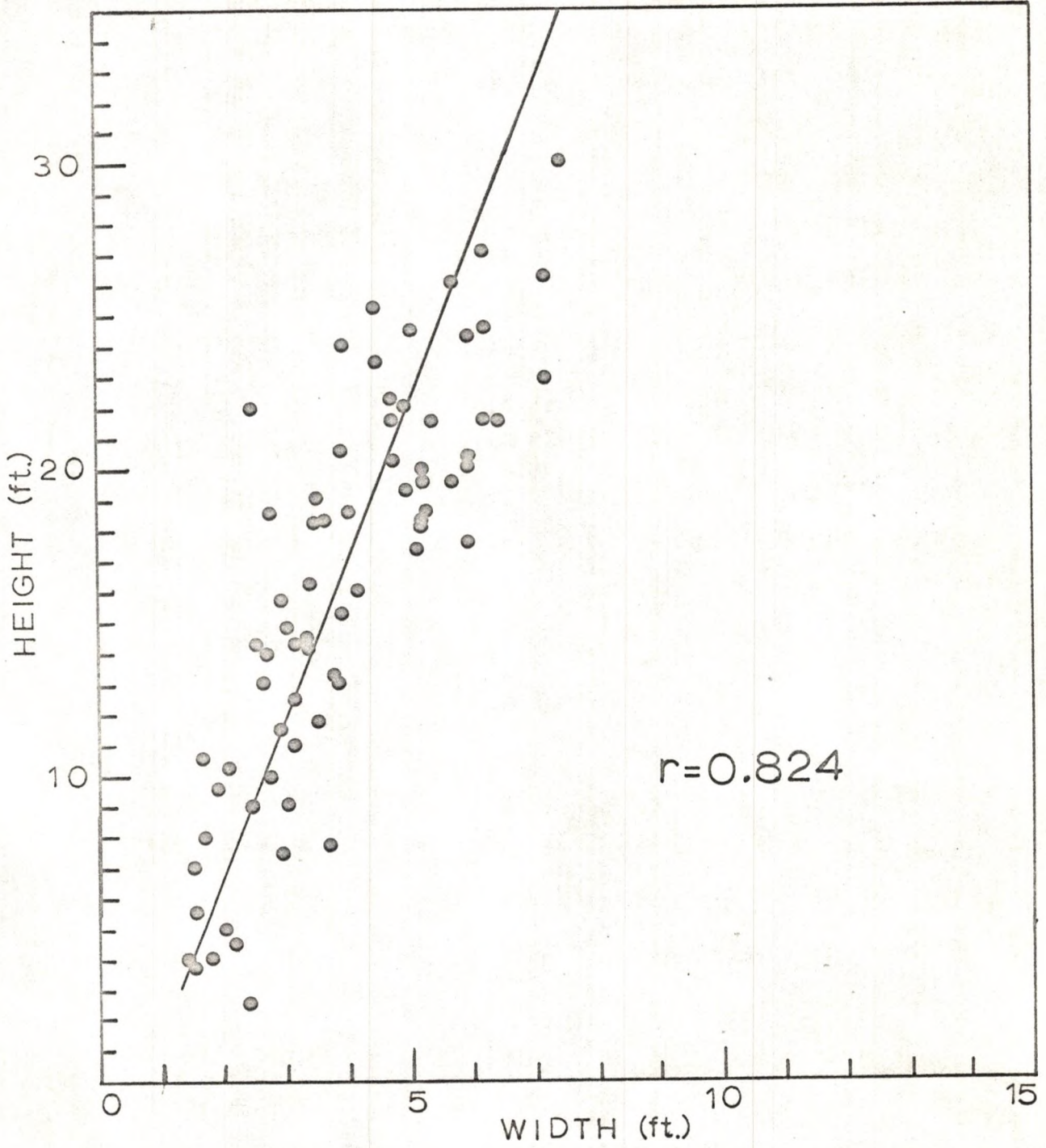


TABLE 2.

RATIOS OF HEIGHT TO WIDTH

9.6	4.7	3.8	3.2
6.6	4.6	3.8	3.2
6.2	4.5	3.7	2.9
6.0	4.5	3.6	2.9
5.6	4.5	3.6	2.7
5.4	4.4	3.5	2.5
5.3	4.4	3.5	2.4
5.3	4.4	3.5	2.4
5.3	4.3	3.4	2.4
5.2	4.3	3.4	2.3
5.2	4.2	3.4	2.2
5.1	4.2	3.4	2.2
5.0	4.1	3.4	2.1
4.9	4.0	3.4	2.1
4.8	4.0	3.3	2.0
4.8	4.0	3.3	1.7
4.8	3.9	3.3	1.6
4.8	3.9	3.3	1.2
4.7	3.8	3.2	1.1
4.7	3.8	3.2	1.1

AVERAGE 3.88

COUNTS OF ANNUAL GROWTH RINGS OF THE 47 COLUMNAR JUNIPERS EXAMINED SHOWED A MEAN AGE OF 54.5 YEARS WITH AN EXTREME OF 99 YEARS. THE AGE WAS COMPARED STATISTICALLY TO TREE HEIGHT, WIDTH AND DIAMETER, AND CORRELATION COEFFICIENTS WERE 0.795, 0.641, AND 0.772, RESPECTIVELY (FIG. 6, 7, AND 8).

#### MORPHOLOGY

FASSETT (1944) STATED THAT THE BEST MORPHOLOGICAL CHARACTER TO DISTINGUISH J. SCOPULORUM FROM J. HORIZONTALIS AND J. VIRGINIANA IS THE SIZE OF THE FOLIAR GLANDS. IN J. SCOPULORUM THE GLAND IS ALWAYS LONGER THAN THE DISTANCE FROM THE GLAND TO THE TIP OF THE LEAF. IN J. VIRGINIANA AND J. HORIZONTALIS THE GLAND IS SHORTER THAN THE DISTANCE FROM THE GLAND TO THE LEAF TIP. THE GLAND DISTANCE IN THE COLUMNAR JUNIPER, LIKE J. SCOPULORUM IS LONGER THAN THE DISTANCE FROM THE GLAND TO THE TIP OF THE LEAF.

#### COMMUNITY COMPOSITION

PLANT SPECIES OCCURRING IN THE COLUMNAR JUNIPER STANDS WERE IDENTIFIED AND RELATIVE ABUNDANCE RECORDED BY VISUAL OBSERVATION. SPECIES OCCURRING UNDER THE COLUMNAR JUNIPERS AND IN THE ADJACENT COMMUNITIES WITH THEIR RELATIVE ABUNDANCES ARE LISTED IN TABLE 3. THE DOMINANT SPECIES UNDER AND ADJACENT TO THE STANDS OF COLUMNAR JUNIPERS ARE FALSE SOLOMON'S SEAL (SMILACINA STELLATA DESF.), NORTHERN BED-STRAW (GALIUM BOREALE L.) AND LEWIS' WILD FLAX (LINUM LEWISII PURSH). FALSE SOLOMON'S SEAL WAS DOMINANT IN JUNE AT WHICH TIME NORTHERN BED-STRAW BECAME DOMINANT AND LASTED UNTIL AUGUST.



Fig. 6.

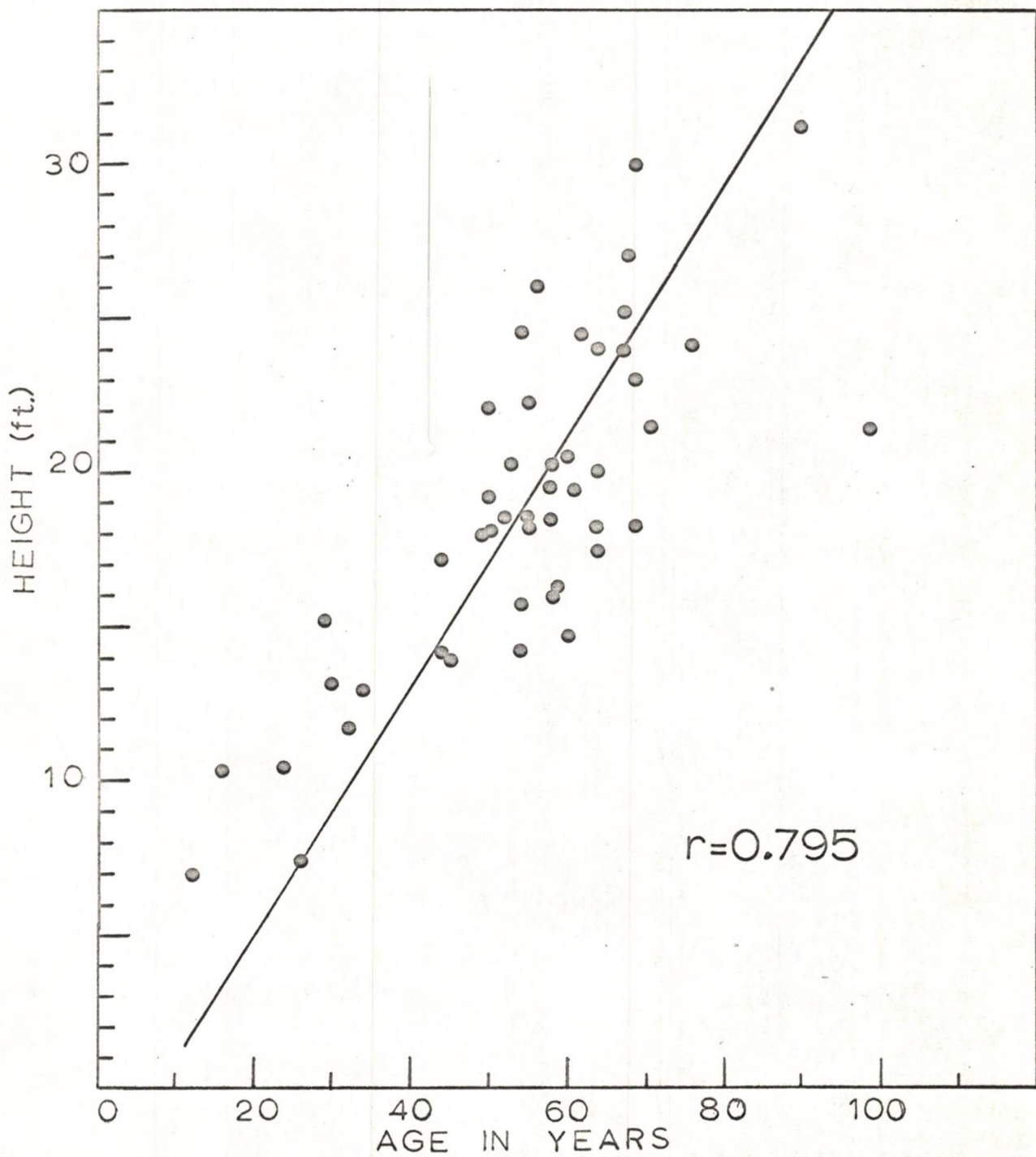
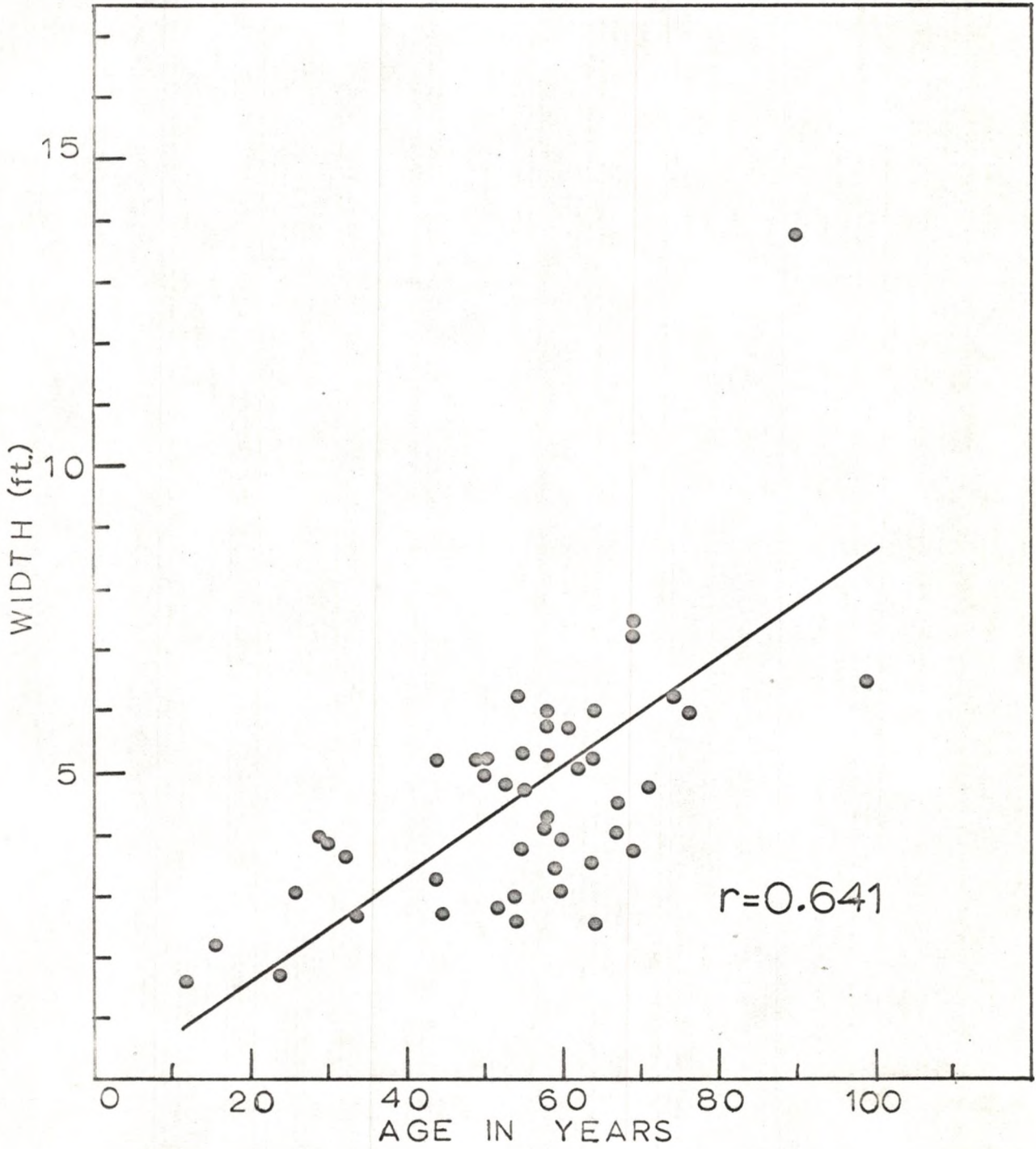


Fig. 7.



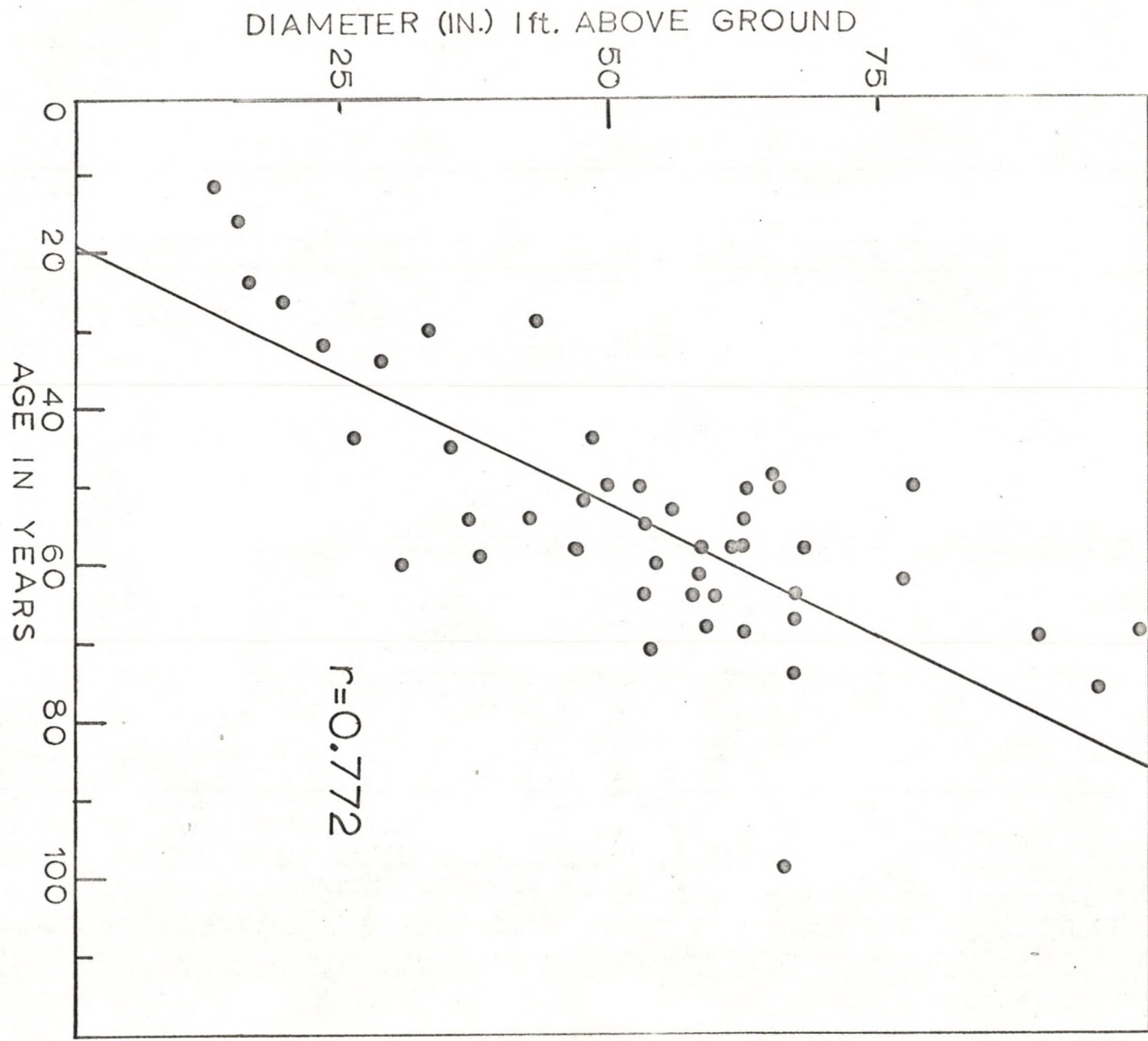


Fig. 8.

TABLE 3.

LIST OF PLANT SPECIES COMMON TO FIVE SCATTERED COLUMNAR JUNIPER STANDS IN THE BADLANDS OF WESTERN NORTH DAKOTA IN COMPARISON WITH THEIR ABUNDANCE IN ADJACENT COMMUNITIES. D, DOMINANT; A, ABUNDANT; FRE, FREQUENT; OCC, OCCASIONALLY; R, RARE. LIFE-FORM: T, TREE; S, SHRUBS; G, GRASS OR SEDGE; AND F, FORB. THE SCIENTIFIC NOMENCLATURE FOLLOWS THAT OF STEVENS (1950).

SPECIES	LIFE FORM	IMPORTANCE IN AREA	IMPORTANCE UNDER COLUMNARS
<u>ACHILLEA LANULOSA</u> NUTT.	F	FRE	OCC
<u>ACTINELLA ACAULIS</u> (PURSH) NUTT.	F	FRE	---
<u>AGROPYRON REPENS</u> (L) BEAUV.	G	A	---
<u>AGROPYRON TRACHYCAULUM</u> (LINK) MALTE.	G	FRE	---
<u>ALLIUM TEXTILE</u> NELS. AND MACBR.	F	A	OCC
<u>ANDROPOGON FURCATUS</u> MUHL.	G	FRE	---
<u>ANDROPOGON SCOPARIUS</u> MICHX.	G	A	---
<u>ANEMONE PATENS</u> L.	F	A	FRE
<u>ARTEMISIA CANA</u> PURSH.	S	A	R
<u>ARTEMISIA TRIDENTATA</u> NUTT.	S	A	---
<u>ASPERUGA PROCUMBENS</u> L.	F	FRE	---
<u>ASTER PTARMICOIDES</u> (NEES.) T. AND G.	F	A	OCC
<u>ASTRAGALUS MISSOURIENSIS</u> NUTT.	F	FRE	---
<u>ASTRAGALUS TENELLUS</u> PURSH.	F	FRE	---
<u>BOUTELOUA CURTIPENDULA</u> (MICHX) TORR.	G	FRE	OCC
<u>BOUTELOUA GRACILIS</u> (HBK) LAG.	G	A	OCC
<u>BUCHLOE DACTYLOIDES</u> (NUTT) ENGELM.	G	A	---
<u>CALOCHORTUS NUTTALLII</u> T. AND G.	F	FRE	---
<u>CAMPANULA ROTUNDIFOLIA</u> L.	F	A	OCC
<u>CAREX FILIFOLIA</u> NUTT.	G	A	---
<u>CASTILLEJA SESSILIFLORA</u> PURSH.	F	A	---
<u>CRYPTANTHA BRADBURIANA</u> PAYSON.	F	FRE	---
<u>ECHINACEA ANGUSTIFOLIA</u> (DC) HELLER.	F	FRE	OCC
<u>ERIGERON GLABELLUS</u> NUTT.	F	FRE	OCC
<u>ERIOGONUM FLAVUM</u> NUTT.	F	FRE	OCC
<u>ERIOGONUM MULTICEPTS</u> NEES.	F	FRE	OCC
<u>FRAXINUS PENNSYLVANICA</u> V.			
<u>LANCEOLATA</u> (BORKH) SARG.	T	FRE	OCC
<u>FRTILLARIA ATROPURPUREA</u> NUTT.	F	FRE	---
<u>GALIUM BOREALE</u> L.	F	A	A
<u>GAURA COCCINEA</u> PURSH.	F	FRE	---
<u>GLYCYRRHIZA LEPIDOTA</u> (NUTT) PURSH.	F	FRE	OCC
<u>GRINDELIA SQUARROSA</u> (PURSH) DUNAL.	F	FRE	OCC

SPECIES	LIFE FORM	IMPORTANCE IN AREA	IMPORTANCE UNDER COLUMNARS
<u>HORDEUM JUBATUM</u> L.	G	FRE	OCC
<u>JUNIPERUS COMMUNIS</u> V. <u>DEPRESSA</u> PURSH.	S	A	A
<u>LACTUCA PULCHELLA</u> (PURSH) DC.	F	FRE	OCC
<u>LIATRIS PUNCTATA</u> HOOK.	F	FRE	OCC
<u>LINUM LEWISII</u> PURSH.	F	A	A
<u>LINUM RIGIDUM</u> PURSH.	F	A	OCC
<u>LUPINUS PUSILLUS</u> PURSH.	F	FRE	R
<u>MONARDA FISTULOSA</u> L.	F	FRE	OCC
<u>OENOTHERA SERRULATA</u> NUTT.	F-	FRE	R
<u>ORTHOCARPUS LUTEUS</u> NUTT.	F	A	OCC
<u>PETALOSTEMUM CANDIDUM</u> MICHX	F	FRE	---
<u>PETALOSTEMUM PURPUREUM</u> VENT.	F	A	OCC
<u>PLANTAGO PURSHII</u> R. AND S.	F	A	OCC
<u>POA PALUSTRIS</u> L.	G	A	FRE
<u>POLYGALA ALBA</u> NUTT.	F	FRE	OCC
<u>POTENTILLA FRUTICOSA</u> L.	S	A	OCC
<u>PRUNUS VIRGINIANA</u> L.	S	FRE	FRE
<u>PSORALEA ESCULENTA</u> PURSH.	F	FRE	---
<u>RATIBIDA COLUMNIFERA</u> (NUTT) WOOTON AND STANDL.	F	A	OCC
<u>RHUS TRILOBATA</u> NUTT.	S	A	FRE
<u>ROSA WOODSII</u> LINDL.	S	FRE	OCC
<u>SALIX PEDIOLARIS</u> J. E. SMITH	S	A	---
<u>SENECIO CANUS</u> HOOK.	F	FRE	R
<u>SHEPHERDIA ARGENTEA</u> NUTT.	S	A	---
<u>SMILACINA STELLATA</u> (L) DESF.	F	A	D
<u>SOLIDAGO MISSOURIENSIS</u> NUTT.	F	FRE	OCC
<u>SPHAERALCEA COCCINEA</u> (NUTT) RYDB.	F	FRE	R
<u>STIPA COMATA</u> TRIN. AND RUPR.	G	FRE	---
<u>STIPA VIRIDULA</u> TRIN.	G	FRE	OCC
<u>SYMPHORICARPUS OCCIDENTALIS</u> HOOK.	S	FRE	OCC
<u>TARAXACUM OFFICINALE</u> WEBER.	F	FRE	---
<u>YUCCA GLAUCA</u> NUTT.	F	A	---

SOIL-WATER RETAINING CAPACITY

THE WATER-RETAINING CAPACITY OF SOIL TAKEN FROM 6 STANDS OF SCATTERED COLUMNAR JUNIPERS HAD A MEAN OF 47.9 PER CENT WATER. THE SOIL IN THE STUDY AREA WAS SANDY. THE SANDY SOIL ALONG WITH THE MEAN OF 47.9 PER CENT WATER-RETAINING CAPACITY SHOWS THE PREFERENCE OF THE COLUMNAR JUNIPERS FOR WELL DRAINED SLOPES, ALTHOUGH PLATE II, FIG. 3 SHOWS A COLUMNAR JUNIPER GROWING IN A MARSHY AREA.

## DISCUSSION

EVIDENCE FROM A WIDE RANGE OF PLANT TAXA INDICATES THAT THE CHEMICAL CONSTITUENTS OF INTERSPECIFIC HYBRID DERIVATIVES FREQUENTLY ARE A SUMMATION OF THOSE FOUND IN THE PARENTAL SPECIES. CHROMATOGRAPHIC EVIDENCE ON THE 4 TAXA OF JUNIPERUS SEEMS TO ELIMINATE THE POSSIBILITY OF THE COLUMNAR JUNIPER HAVING RESULTED FROM HYBRIDIZATION INVOLVING EITHER J. COMMUNIS V. DEPRESSA OR J. HORIZONTALIS WITH J. SCOPULORUM, FOR EACH OF THE TWO TAXA POSSESSES SPECIES-SPECIFIC BIOCHEMICAL SUBSTANCES NOT FOUND IN THE PROPOSED INTERSPECIFIC HYBRID DERIVATIVE. THE GEOGRAPHICAL RANGE OF THE COLUMNAR JUNIPERS IS ISOLATED FROM THAT OF ANY ADDITIONAL JUNIPERUS SPECIES, BESIDES THE AFOREMENTIONED THREE, AND THIS WOULD APPEAR TO DIMINISH THE PROBABILITY OF ANOTHER SPECIES BEING INVOLVED IN A HYBRIDIZATION WITH J. SCOPULORUM. CHROMATOGRAPHIC DETERMINATIONS ON SPECIMENS ALONG A TRANSECT FROM A GROVE OF "TYPICAL" J. SCOPULORUM TO ONE OF "TYPICAL" COLUMNARS INVOLVING "INTERMEDIATE" FORMS SHOWED NO DIFFERENCES AMONG ANY OF THESE SPECIMENS.

THE SIMILARITY OF THE CHROMATOGRAPHIC PATTERNS OF J. SCOPULORUM AND THE COLUMNAR JUNIPER COULD RESULT EITHER FROM THE COLUMNAR BEING A VARIETAL OR AN ECOLOGICALLY-INDUCED POLYMORPHIC TYPE OF J. SCOPULORUM WITH THE PHENOTYPIC EXPRESSION REQUIRING A CERTAIN ENVIRONMENT FOR EXPRESSION. ECOLOGICAL EVIDENCE SUPPORTS THE HYPOTHESIS THAT THE COLUMNAR IS AN ECOLOGICALLY-INDUCED POLYMORPHIC TYPE OF J. SCOPULORUM. TRANSPLANTED COLUMNAR JUNIPERS FROM THE VICINITY OF THE BURNING COAL VEIN WILL REVERT TO A J. SCOPULORUM FORM WITHIN 2 TO 5 YEARS, PLATE IV,

FIG. 7 AND 8. A NUMBER OF TREES, IN SOME STANDS UP TO 5 PER CENT, WITH THE FORM OF TRUE J. SCOPULORUM ARE SCATTERED THROUGHOUT THE DISTRIBUTION OF THE COLUMNAR JUNIPERS. THESE TREES HAD LARGE TRUNKS AND HAD PROBABLY COMPLETED THEIR GROWTH BEFORE THE LIGNITE IN THE COAL VEIN WAS IGNITED. MINOR MODIFICATIONS OF THE HEIGHT/WIDTH RATIO OF THESE TREES UNDOUBTEDLY HAS OCCURRED, BUT THE BASIC GROWTH FORM WAS ESTABLISHED PRIOR TO THE START OF THE FIRE. A CLOSE ESTIMATE OF THE AGES OF THESE J. SCOPULORUM TREES COULD NOT BE OBTAINED. DUE TO THE VARYING RADII OF THESE TREES ACCURATE CORE COUNTS COULD NOT BE MADE, ALTHOUGH THE CORE COUNTS WERE ALL OVER 100 YEARS.

A SECOND HYPOTHESIS CONCERNING THE OCCURRENCE OF THE COLUMNAR FORM IS THAT THE SOIL CHARACTERISTICS MAY BE RESPONSIBLE FOR THE PECULIAR GROWTH FORM. THE OCCURRENCE OF OLD J. SCOPULORUM TREES GROWING AMONG THE COLUMNAR JUNIPERS, HOWEVER, SEVERELY DIMINISHES THIS POSSIBILITY.

EVIDENCE SUPPORTING THE PROXIMITY TO THE BURNING COAL VEIN AS A CAUSAL FACTOR IN ESTABLISHING THE GROWTH FORM OF THE COLUMNAR JUNIPER IS AVAILABLE IN THE SOUTH UNIT OF THE THEODORE ROOSEVELT NATIONAL PARK (PLATE V, FIG. 9 AND 10). IN 1951 A PRAIRIE FIRE IGNITED AN EXPOSED VEIN OF LIGNITE COAL. THE GROVES OF J. SCOPULORUM IN THE VICINITY HAVE SINCE TAKEN ON A COLUMNAR FORM. TWO SMALL COLUMNARS WITH THE SAME STEM DIAMETER (1 INCH ABOVE THE GROUND) ARE SHOWN IN PLATE IV, FIG. 7. THE DIFFERENCE IN THE GROWTH SUGGESTS THAT THE CAUSAL "SUBSTANCE" EMITTED BY THE BURNING LIGNITE AND AFFECTING THE JUNIPERS IS OF A GASEOUS NATURE.

THERE IS A SEASONAL COLOR VARIATION IN THE JUNIPERS IN WHICH THE WINTER FOLIAGE IS BROWN, BLUE OR GREEN. MINKLER AND RYKER (1959)



FOUND THAT THE WINTER FOLIAGE COLOR IN THE EASTERN REDCEDAR (J. VIRGINIANA L.) DIFFERS WITH LOCATION AS WELL AS SEASONALLY. FASSETT (1943) FOUND THAT THE CROWN FORM OF J. VIRGINIANA V. CREBRA VARIES IN ITS RATIO OF HEIGHT TO WIDTH ACROSS ITS DISTRIBUTION. TREES IN NEW YORK AND NEW JERSEY HAVE A RATIO OF 7.5, WHILE TREES IN GEORGIA MAY BE ONLY TWICE AS TALL AS WIDE. SINCE THE DISTRIBUTION OF THE COLUMNAR JUNIPER IS LIMITED TO THE VICINITY OF THE BURNING COAL VEINS IN NORTH DAKOTA AND TRANSPLANTING IT FROM THE VICINITY WILL CAUSE IT TO REVERT TO THE J. SCOPULORUM FORM, THE COLUMNAR FORM MAY BE A PHENOTYPIC EXPRESSION INDUCED BY THE ENVIRONMENT.

THE AREAS SURROUNDING THE BURNING COAL VEIN WERE EXAMINED FOR POSSIBLE EVIDENCE THAT THE FUMES GIVEN OFF BY THE BURNING LIGNITE WERE HAVING AN EFFECT ON OTHER SPECIES IN ADDITION TO THE COLUMNAR JUNIPER. IN ONE CASE JUNIPERUS COMMUNIS V. DEPRESSA HAD TAKEN ON A "COLUMNAR" FORM (PLATE III, FIG. 5 AND 6). THIS WAS THE SOLE EXAMPLE OBSERVED IN EITHER AREA.

O. A. STEVENS (PERSONAL COMMUNICATION) HAS INFORMED ME THAT ONLY 1 OF APPROXIMATELY 40 COLUMNAR TREES TRANSPLANTED TO THE NORTH DAKOTA STATE UNIVERSITY CAMPUS OF FARGO HAS COME TRUE TO TYPE. RANCHERS IN THE VICINITY OF AMIDON, NORTH DAKOTA HAVE ALSO TRANSPLANTED COLUMNAR JUNIPERS. FOR EXAMPLE, BOB HANSON OF THE LOGGING CAMP RANCH HAS 4 COLUMNARS AND LESTER FRITZ OF BELFIELD HAS 2 COLUMNARS WHICH WERE TRANSPLANTED IN 1958. ALL OF THESE TREES HAVE REVERTED BACK TO THE FORM OF J. SCOPULORUM (PLATE IV, FIG. 7 AND 8).

A JUNIPER OF UNKNOWN SPECIES AND HAVING A COLUMNAR APPEARANCE HAS BEEN SEEN NEAR SARGENT, NEBRASKA (D. L. GREEN, PERSONAL COMMUNI-

CATION), AND OTHER COLUMNAR JUNIPERS HAVE BEEN REPORTED BY E. NIELSEN (CITED IN FASSETT, 1945) AT SPANISH POINT NEAR WILLISTON, NORTH DAKOTA AND IN CENTRAL MONTANA (D. A. STEVENS, PERSONAL COMMUNICATION).

THE COLUMNAR NEAR SARGENT, NEBRASKA MAY BE J. VIRGINIANA WHICH GROWS NATURALLY IN A COLUMNAR FORM. I PLAN TO VISIT THIS AREA IN THE NEAR FUTURE TO DETERMINE ITS SPECIES. E. NIELSEN (PERSONAL COMMUNICATION) VISITED SPANISH POINT NEAR WILLISTON, NORTH DAKOTA IN ABOUT 1931 WHEN HE TOOK THE PHOTOGRAPH OF THE COLUMNARS SHOWN TO FASSETT. I VISITED SPANISH POINT DURING THE SUMMER OF 1965 AND DID NOT SEE ANY COLUMNARS. FURTHERMORE, THE PEOPLE IN THE AREA DID NOT RECALL SEEING ANY JUNIPERS WITH A COLUMNAR FORM.

G. F. PAYNE AND W. E. BOOTH (PERSONAL COMMUNICATIONS) RECALL SEEING JUNIPERS WITH A COLUMNAR FORM IN MONTANA BETWEEN BUTTE AND ANACONDA. PAYNE STATED:

THE ONLY PLACES I HAVE SEEN COLUMNAR JUNIPERS HAVE BEEN WHERE FUMES FROM THE COMBUSTION PROCESS ARE PRESENT. IN THE CASE OF THE BUTTE AREA THE COLUMNAR JUNIPERS APPEAR IN AN AREA HEAVILY AFFECTED BY FUMES FROM A CHEMICAL PROCESSING PLANT...IN THE BUTTE AREA THE MORE OR LESS COLUMNAR FORMS ARE MIXED WITH PYRAMIDAL AND ROUNDED FORMS.

AS STATED EARLIER THESE ROUNDED FORMS OF J. SCOPULORUM ARE ALSO SEEN IN THE COLUMNAR STANDS NEAR AMIDON IN SLOPE COUNTY AND ARE ATTRIBUTED TO AGE. THE AREA IN MONTANA WILL BE VISITED THIS SUMMER TO OBTAIN ADDITIONAL INFORMATION ON THE COLUMNAR GROWTH FORM IN THAT AREA.

## CONCLUSION AND SUMMARY

THE COLUMNAR JUNIPERS OF WESTERN NORTH DAKOTA HAVE BEEN PREVIOUSLY CONSIDERED TO COMPRISE 1) A HYBRID BETWEEN JUNIPERUS SCOPULORUM AND J. HORIZONTALIS OR J. COMMUNIS V. DEPRESSA; 2) A VARIETY OF J. SCOPULORUM (J. SCOPULORUM V. COLUMNARIS FASSETT); 3) AN ECOLOGICAL VARIANT OF TRUE J. SCOPULORUM OR; 4) A DISTINCT SPECIES.

POSSIBLE CAUSES WHICH MAY BE POSTULATED FOR THE COLUMNAR FORM ARE, 1) HYBRIDIZATION BETWEEN J. SCOPULORUM AND ONE OF THE OTHER JUNIPERS IN THE AREA, 2) SOIL CHARACTERISTICS, AND 3) THE PROXIMITY TO THE BURNING COAL VEINS WITH THE GASES EMITTED BEING THE PROBABLE CAUSAL FACTOR IN ESTABLISHING THE GROWTH FORM OF THE COLUMNAR JUNIPER.

A PAPER CHROMATOGRAPHIC STUDY OF THE THREE MOST LIKELY PARENTAL SPECIES AND THE COLUMNAR JUNIPER WAS INITIATED TO OBTAIN ADDITIONAL INFORMATION ON THE PROBABLE HYBRID ANCESTRY OF THE COLUMNAR JUNIPER. IN ADDITION, HEIGHTS AND WIDTHS OF THE COLUMNAR JUNIPER WERE MEASURED TO CHECK THE RELIABILITY OF THE 2.5-3.0 RATIO GIVEN BY FASSETT AS THE MORPHOLOGICAL DIAGNOSTIC CHARACTERISTIC OF THIS VARIETY.

THE CHROMATOGRAPHIC DATA SHOW THAT THE PATTERNS OF J. SCOPULORUM AND THE COLUMNAR JUNIPER WERE IDENTICAL AND DID NOT DIFFER IN A SINGLE DETECTABLE CONSTITUENT. BIOCHEMICAL CONSTITUENTS OF A HYBRID SHOULD BE A SUMMATION OF THE SUBSTANCES FOUND IN THE PARENTAL SPECIES. THE OTHER TWO SPECIES DIFFERED FROM THIS "J. SCOPULORUM-COLUMNAR" PATTERN WITH J. HORIZONTALIS CONTAINING 4 AND J. COMMUNIS V. DEPRESSA CONTAINING 5 SUBSTANCES NOT FOUND IN THE "J. SCOPULORUM-COLUMNAR" COMPLEX. THIS DIMINISHES THE PROBABILITY OF THE COLUMNAR JUNIPER RESULTING FROM

HYBRIDIZATION.

THE PRESENCE OF OLD J. SCOPULORUM TREES IN THE STANDS OF COLUMNAR JUNIPERS DIMINISHES THE PROBABILITY OF THE COLUMNAR FORM RESULTING FROM SOIL CHARACTERISTICS. THE WIDE VARIATION IN HEIGHT TO WIDTH OF THE COLUMNARS, GOING FROM "TYPICAL" COLUMNARS IN THE VICINITY OF THE BURNING COAL VEIN TO "INTERMEDIATE" FORMS AT A DISTANCE OF 1.5 MILES ANT TO "TYPICAL" J. SCOPULORUM AT 2 MILES FROM THE BURNING COAL VEIN. THIS DIMINISHES THE POSSIBILITY OF THE COLUMNAR JUNIPER BEING A VARIETY AS BASED ON THIS MORPHOLOGICAL CHARACTERISTIC GIVEN BY FASSETT.

EVIDENCE SUPPORTING THE PROXIMITY OF THE COAL VEIN AS A CAUSAL FACTOR IN ESTABLISHING THE GROWTH FORM OF THE COLUMNAR JUNIPERS IS AVAILABLE IN BILLINGS COUNTY, WHERE ANOTHER BURNING COAL VEIN HAS JUNIPERS IN THE VICINITY WITH A COLUMNAR FORM. ALSO IF COLUMNAR JUNIPERS ARE REMOVED FROM THE VICINITY OF THE COAL VEIN, THE TREES WILL REVERT BACK TO THE FORM OF J. SCOPULORUM IN 2 TO 5 YEARS. THE COLUMNAR JUNIPERS APPEAR, THEREFORE, TO BE AN ECOLOGICALLY-INDUCED POLYMORPHIC TYPE OF TRUE J. SCOPULORUM WITH THE PHENOTYPE REQUIRING A CERTAIN ENVIRONMENT FOR EXPRESSION.

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PLATE I

FIG. 1. A STAND OF COLUMNAR JUNIPERS ON A NORTH-FACING SLOPE. NOTE THE JUNIPERS WITH THE ROUNDED JUNIPERUS SCOPULORUM FORM, EFFORTS TO DATE THESE JUNIPERS WERE FRUITLESS. BUT IN ALL CASES THEIR TRUNKS WERE LARGER THAN THE TRUNKS OF THE COLUMNARS. NOTE THE MANY BRANCHES IN THESE ROUNDED CROWN JUNIPERS, WHEREAS IN THE COLUMNARS THERE IS ONE MAIN TRUNK.

FIG. 2. THIS COLUMNAR JUNIPER HAS A RATIO OF 9.6 IN HEIGHT TO WIDTH. IT IS 26 FT. HIGH AND 2.7 FT. WIDE AT ITS MAXIMUM WIDTH. THE SHRUB AT ITS BASE IS JUNIPERUS COMMUNIS V. DEPRESSA. THIS DWARF JUNIPER IS USUALLY DEPRESSED AS IN FIG. 5, HERE IT IS 4 FT. HIGH.

1



2





PLATE II

- FIG. 3. THE COLUMNAR JUNIPERS IN THE UPPER PART OF THIS PLATE SHOW THE PREFERENCE OF THE COLUMNARS FOR NORTH OR NORTH-WEST FACING SLOPES. THE COLUMNAR JUNIPER IN THE MID-RIGHT IS GROWING ON A MARSHY AREA.
- FIG. 4. THE VARIATION IN HEIGHT AND WIDTH OF THESE TWO SMALL COLUMNARS IS APPARENT. BOTH HAVE DIAMETERS OF 1.5 INCHES AT GROUND LEVEL.

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PLATE III

FIG. 5. JUNIPERUS COMMUNIS V. DEPRESSA GROWING ON A SIDE HILL NEAR  
THE COLUMNAR JUNIPERS.

FIG. 6. THIS ABNORMAL FORM OF J. COMMUNIS V. DEPRESSA IS GROWING ON  
A SANDY HILLSIDE. THIS WAS THE ONLY PLANT OF J. COMMUNIS V.  
DEPRESSA SHOWING THIS FORM.

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PLATE IV

FIG. 7. THIS "COLUMNAR" JUNIPER WAS TRANSPLANTED TO THE LESTER FRITZ'S RANCH IN 1958, AT THAT TIME IT HAD A COMPACT COLUMNAR FORM.

FIG. 8. THESE "COLUMNAR" JUNIPERS WERE TRANSPLANTED TO THE LOGGING CAMP RANCH IN THE 1920's. SHOWN HERE ARE 3 OR THE 4 JUNIPERS TRANSPLANTED. ALL HAVE REVERTED BACK TO THE JUNIPERUS SCOPULORUM FORM.

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PLATE V

FIG. 9. THIS PHOTOGRAPH WAS TAKEN NEAR THE BURNING COAL VEIN IN THE SOUTH UNIT OF THE THEODORE ROOSEVELT NATIONAL MEMORIAL PARK. ALL THE SMALL JUNIPERS HAVE A COLUMNAR FORM WHILE THE OLDER JUNIPERS ARE COLUMNAR ON THEIR SUMMITS.

FIG. 10. THIS PHOTOGRAPH, ALSO TAKEN IN THE SOUTH UNIT OF THE PARK, DEMONSTRATES THE COLUMNAR EFFECT ON A HIGH RIDGE ABOUT ONE QUARTER OF A MILE EAST OF THE BURNING COAL VEIN.

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