



4-30-1987

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Recommended Citation

Brotherson, J. D.; Price, K. P.; and O'Rourke, L. (1987) "Age in relationship to stem circumference and stem diameter in cliffrose (*Cowania mexicana* var. *stansburiana*) in central Utah," *Great Basin Naturalist*. Vol. 47 : No. 2 , Article 21.

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AGE IN RELATIONSHIP TO STEM CIRCUMFERENCE AND STEM DIAMETER
IN CLIFFROSE (*COWANIA MEXICANA* VAR. *STANSBURIANA*)
IN CENTRAL UTAH

J. D. Brotherson¹, K. P. Price², and L. O'Rourke¹

ABSTRACT.—Cliffrose age in relation to stem circumference and stem diameter was studied in central Utah. Age-circumference and age-diameter predictor equations were developed from material obtained from 10 stands along a 65-km section of the Wasatch Mountains foothills. Ages estimated on material of known age by the two equations were highly similar. Age predictions were more accurate for young stems than for older stems. The oldest stem aged was 163 years.

Population biology seeks to understand and interpret variations in the numbers of organisms as they are distributed in time and space. Among the populations of a given species, differences in size of individuals, density, age structure, and morphological characters often reflect underlying variations in the genetics of those populations as well as the way in which they interact, survive, and reproduce in their individual environments. Successful reproduction in a species over ecological and evolutionary time and across a range of environments, combined with the development of wide variation in the attributes of its individual populations, is of interest. Measurement of population size, density, age structure, and morphological variation is enhanced when a reliable tool for aging the individuals of a population can be employed.

Studies of growth-ring variation in tree populations have been used extensively for dating (Douglas 1935, Glock 1937), reconstruction of past climates (Fruits 1971, Harper 1979), interpretation of successional dynamics (Burkhardt and Tisdale 1969, Barney 1972), and assessment of differences in the environments of selected habitats (Ferguson and Humphrey 1959, Fritts 1962, Stockton and Fritts 1973). Although trees have been the primary focus of such studies, papers dealing with habitat variations and age-prediction models for shrubs are available (Ferguson 1958, Ferguson and Humphrey 1959, Brotherson et al. 1980, Brotherson et al. 1984). Studies dealing with circumference-age rela-

tionships of shrubs and their value in the development of age-prediction models, interpretations of habitat factor differences, and successional dynamics are less known. Many western shrub species show asymmetrical stem growth; this suggests the need to understand the relationship between stem circumference and age for studies in population dynamics. This study considers stem diameter and stem circumference-age relationships of cliffrose (*Cowania mexicana* var. *stansburiana*) from sites in central Utah.

STUDY AREA

The study area is located along the gravelly shores of prehistoric Lake Bonneville on the west face of the Wasatch Mountains, Utah County, Utah, between American Fork Canyon on the north and Santaquin Canyon on the south, a distance of 65 km. Elevation varied little across the sites, averaging 1,562 m. Aspect varied between 140 and 330 degrees on a standard compass bearing. The cliffrose populations selected for study were chosen from the largest and most dense stands in the area. Soils, which varied from gravelly sandy loams to gravelly clay loams, were heavily skeletal (Price and Brotherson 1987), slightly basic (pH = 7.7), and very low in soluble salts. Soil mineral nutrient concentrations were also very low (Price and Brotherson 1987).

The Wasatch Mountains are primarily composed of sedimentary limestone formations

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TABLE 1. Predictor equations for cliffrose age along with deviations of estimated age from true age for stems of known material.

Estimator factor	Prediction equation	r ²	Sig. level	Deviation of estimated age from true age		
				\bar{x}	SD	CV
Diameter	$\hat{y} = 6.801 + 14.209x$	0.69	0.001	5.8	4.8	1.2
Circumference	$\hat{y} = 5.450 + 4.728x$	0.73	0.001	6.1	5.1	1.2

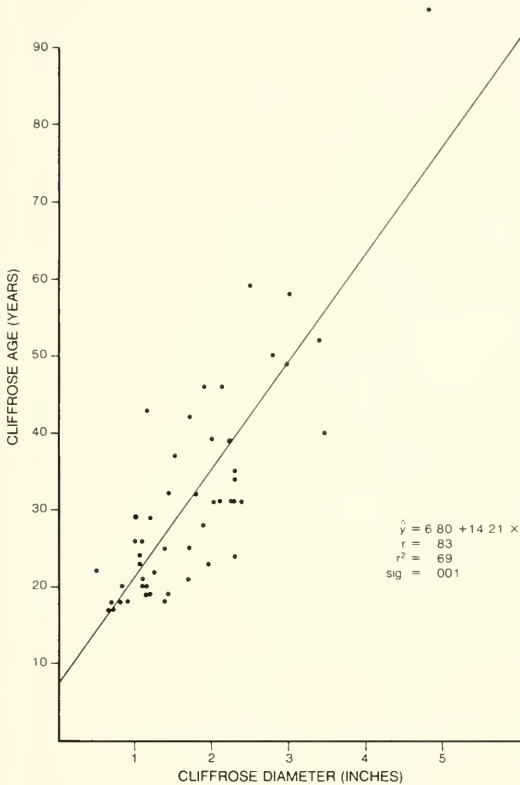


Fig. 1. The relationship between stem diameter and stem age in cliffrose in central Utah.

high in calcium carbonate. Rainfall in the area averages 422 mm (NOAA 1922–72), with approximately 280 mm falling between October and April (USDA 1972). The average annual temperature is 10.6 C, with a frost-free period averaging 150 days.

Cliffrose, rubber rabbitbrush (*Chrysothamnus nauseosus*), and *Artemisia tridentata* dominated the site overstory. The understorey was dominated by annuals of which cheatgrass (*Bromus tectorum*), madwort (*Alyssum alyssoides*), Japanese brome (*Bromus japonicus*), tumblemustard (*Sisymbrium altissimum*), and cutleaf filaree (*Erodium cicutarium*) were the most important. The

perennial bluebunch wheatgrass (*Agropyron spicatum*) was also important in the understorey (Price and Brotherson 1987).

METHODS

Ten study sites, each 10 x 10 m (0.01 ha), were selected from the above communities. Five stems, each from randomly selected individuals, were obtained from the 10 sites for a total of 50 stems. Stems were sectioned diagonally, polished with fine sandpaper, and the annual growth rings counted twice (independently) at the widest part of the stem with the aid of a stereoscopic microscope (Ferguson 1970, Brotherson et al. 1980). One ring was assumed to equal one year of growth. Stem diameters and circumferences were measured with a diameter tape.

Linear regressions of age on diameter and age on circumference generated stem diameter–age and stem circumference–age predictor equations (Brotherson et al. 1980). The predictor equations were then checked by estimating the stems of known age. The predictor equations were also used to predict mean ages of the 10 populations.

RESULTS AND DISCUSSION

Cliffrose in central Utah generally grows on escarpments with southwest exposures having greater than 40% slope. The populations studied in this report were located along what had once been the gravelly shoreline of old Lake Bonneville. Adjacent, finer-textured soils that accumulated on the bottom of the lake apparently create a barrier to the species, confining it to the better-drained, lighter-textured soils of the ancient beach. The sites are typically exposed to environmental severities and are subject to wide variations in environmental extremes. Successful inhabitants of these sites must withstand a broad range of environmental fluctuations. Often such envi-

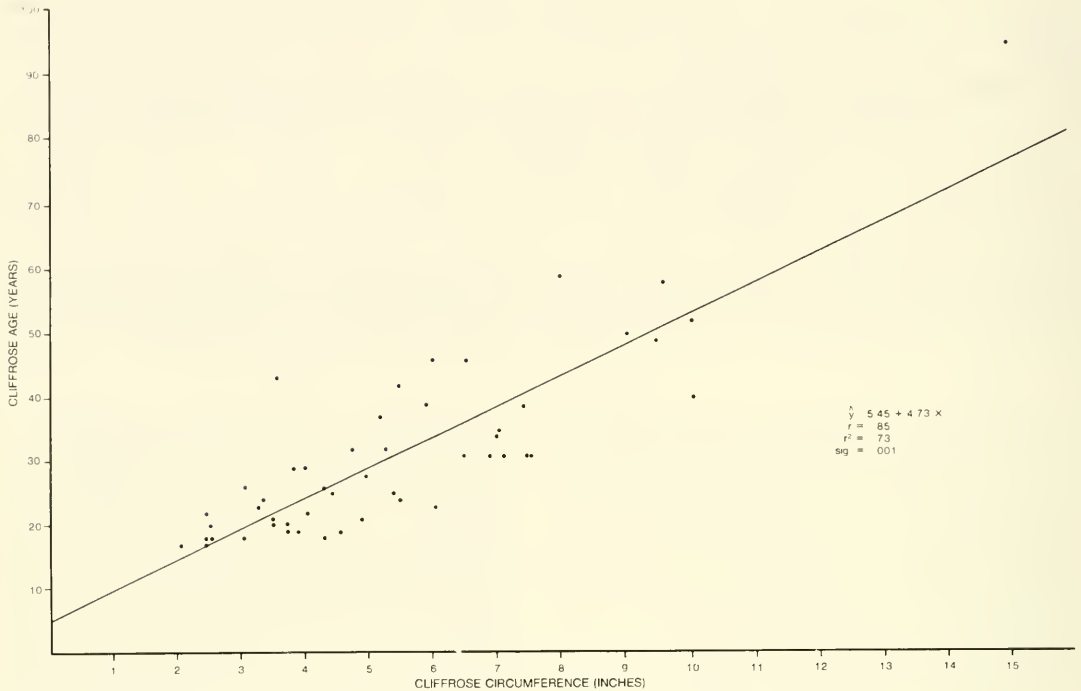


Fig. 2. The relationship between stem circumference and stem age in cliffrose in central Utah.

ronmental variation is evidenced in differential growth rates, varying plant heights, and morphology of individuals of separate populations. Such was the case with respect to our 10 populations. For example, average length of annual twig growth varied across these populations from a low of 2.0 cm to a high of 13.3 cm, indicating variable growth rates between the different populations.

Cliffrose stem diameters ranged from 0.5 inches to 4.8 inches, and the circumferences varied from 2.44 inches to 15.06 inches. Linear regression was used to establish age-diameter ($r^2 = 0.69$) and age-circumference ($r^2 = 0.73$) predictor equations (Table 1, Figs. 1 and 2). Both equations were significant at the 0.001 level. The slightly better fit of the circumference equation is due to the irregular growth patterns of the cliffrose stems. This irregular growth form (asymmetrical) made it very difficult to measure the stem diameters, especially under field conditions. The diameters were measured at the widest part of the stem.

When the two predictor equations were used to estimate stem ages from original material (stems used to generate the equations),

the estimated ages showed no significant difference (Table 1). The diameter-age predictor equation estimated the ages more accurately than did the circumference-age predictor equation. However, there were no significant differences between true age and estimated age. Stem diameter and stem circumference were plotted against one another (Fig. 3). The relationship is significant ($p \leq 0.001$; $r^2 = 0.98$), indicating that either diameter or circumference may be used to determine the age of cliffrose in this area. However, circumference measurements may be more accurately obtained in the field because of the irregular growth patterns of the cliffrose stems.

Results indicate that the predictor equations are more accurate for young stem age than for older stem age (Fig. 4). When the deviation of predicted age from true age is plotted against true age, the difference increases as cliffrose stems get older. Similarly, as the stems of mountain mahogany (*Cercocarpus*) get older, they grow slower and show smaller widths in their growth rings (Brotherston et al. 1980).

Basal circumference measurements were taken on 30 randomly selected individuals per

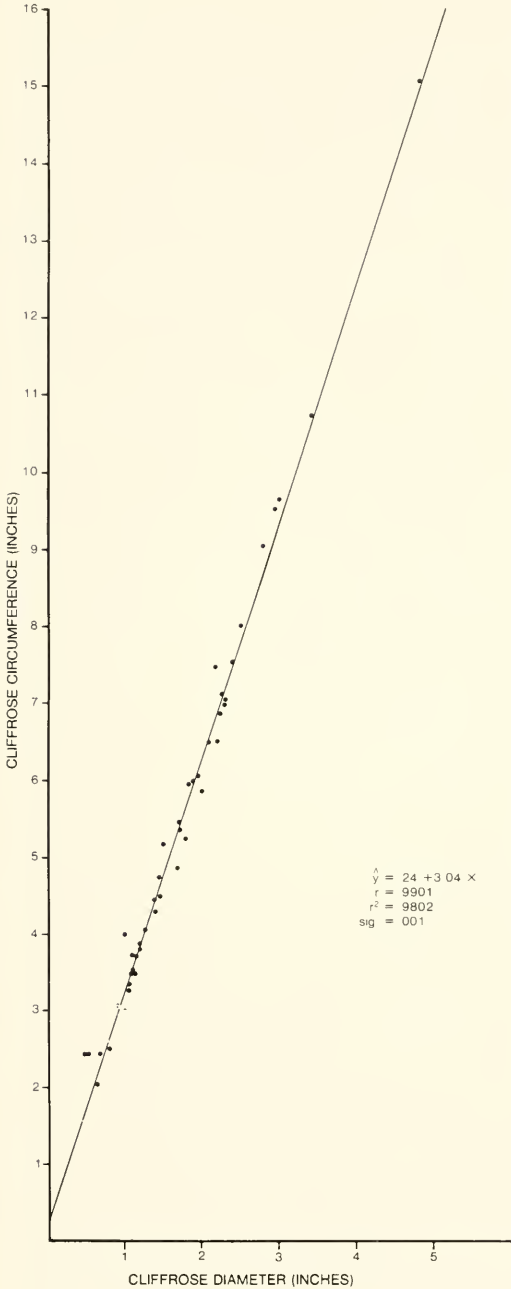


Fig. 3. The relationship between stem diameter and stem circumference in cliffrose in central Utah.

site for 9 of the 10 sites. One site had only 18 living individuals. From these basal measurements (288 individuals), the plants of each stand were aged. The youngest individual found was 11 years old and the oldest 163 years. When the ages for all individuals of a

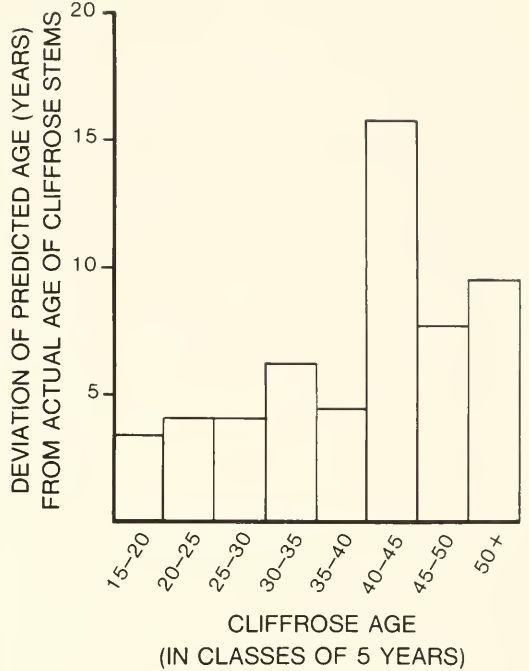


Fig. 4. The relationship of the difference between predicted age and true age in cliffrose in central Utah.

specific site were averaged, the youngest population was 28 years and the oldest 69 years. Average community age was found to be negatively correlated with cliffrose density ($p \leq 0.05$) and positively with a hedging index ($p \leq 0.001$), indicating that the longer the population has been established, the taller and less dense the individuals become. This, we feel, is due to the impact of wildlife (specifically mule deer) on cliffrose plants, since they are preferred forage for these animals.

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