

Investigation on Adaptability and Quantitative Properties of Redwood (*Sequoia sempervirens*) in North of Iran Forest Plantation

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Redwood 2-year seedlings were planted in 1982 as a pure of 156 hectares in north of Iran. In order to assess the compatibility and the the growth of this plant was measured quantitative characteristics such as diameter, Height, Crown diameter in 2010 (30 age). Inventory was done in this area by systematic random method with the intensity 15%. sample plots were 500 m². the result indicate, There is quite a significant difference with 99% confidence level ($P < 0.01$) between diameter at breast height of Redwood trees, But there is no significant difference between height and slenderness coefficient. The results of the factors examined include: slenderness coefficient (70.64), Diameter at breast height(20.87 cm), Height(14.7 m), Crown diameter(4.35 m), Volume at hectare (178.46 m³), Diameter increment (9.48 mm), Height increment (64.09 cm), Volume increment (8.06 m³).

Key words: *Sequoia sempervirens*, Height, Diameter, Slenderness coefficient.

With the use of reforestation, Man seeks to achieve new and relatively sustainable ecosystems. So, The selection of appropriate species and compatible with the viability and optimal growth and assessment of ecological effects of reforestation on species is of special importance. In a country like Iran, study of qualitative and quantitative characterization, compatibility and cultural operations in afforestation by fast-growing trees are the most

important measures of forestry and forest management for increased production and wood supply requirements (GorjiBahri and Hemati, 2004). Coniferous forests in northern Iran in 2000 is estimated at approximately 40,000 hectare (Asadollahi, 2000). From 1960 decade in order to rebuild the destroyed areas in north of Iran are annually done 30 to 40 thousand hectares of afforestation operation and restoration of forest by the forest organization and other sectors (Tabari, M. and Pourmajidian, 2001).

Sequoia sempervirens (D. Don) Endl. (Coast Redwood), is an important conifer species in wet temperate forests of northern California (Koch et al, 2004). Moreover, it grows very rapidly along the pacific coastal area of North America, beginning in southern Oregon and ending just south of Monterey, California (WhanSul et al., 2005). It commonly grows to 60 to 84 m in height and 2.4 to 3.6 m in diameter, with the current champion reaching 101 m in height. there is fairly

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solid evidence that before logging coast redwoods were the world's largest trees, with specimens measured at over 55,000 cubic feet (1,600 m³) (Van Pelt 2001). The oldest known coast redwood is about 2,200 years old and the current tallest tree of this species is measured 115.61 m (Earle, 2011). The theoretical maximum potential height of coast redwoods is limited to between 122 to 130 metres (400 to 427 ft), due to gravity and the friction between water and the vessels through which it flows (Koch et al, 2004).

The mild climate of the redwood forest region can be classed broadly as super-humid or humid. Annual precipitation varies between 640 and 3100 mm (25 and 122 in) and is mostly winter rain, although snow sometimes covers the highest ridges (Major, 1977). The natural range of redwood is limited to areas where heavy summer fogs from the ocean provide a humid atmosphere, although its successful growth in plantations or amenity plantings is not as limited. Redwood is among the most successful trees in the Central Valley of California, and at low elevations in the Sierra Nevada. It grows well at considerable distance from the ocean in New Zealand, France, Spain, and elsewhere (Kuser, 1976., Libby, 1981).

This species has spread in the United States from sea level to an altitude of 900-1000 meters. In the gentle slopes, Less than 300 meters above sea level is a significant growth. with increasing altitude of the height growth is reduced. Drought and increased are two factors limiting the spread of this species (gholizade, 2000).

Provinces in northern of Iran due to the proximity to the Caspian Sea have a suitable habitat for planting of this species. With regard to commercial and ecological value of the Redwood, The planting of this species was done as green belt with the aim to prevent rape to national resources, Study species compatibility, Promenade and tourists attract. This study examines the quantitative growth of Redwood in Tile Kenar forestry projects in north of Iran. In addition to evaluating the success or failure of plant this species in this habitat will investigate growth and development during the past years to measure characteristics such as diameter at breast height, height, slenderness coefficient, Volume, crown diameter.

MATERIALS AND METHOD

The study area has a gentle slope which is known Tile Kenar forestry projects, it is located in watershed 38 in south of agricultural land in Abas Abad city, Mazandaran province, Iran, with latitude 36° 30' 00", 36° 41' 30" and longitude 50° 07' 30", 50° 25' 00" (figure 1). Based on information recorded in the meteorological station (the years 1976 to 2006), The average annual rainfall is 1174.9mm, The average annual relative humidity and the average annual temperature are 85% and 16°C.

Redwood 2-year seedlings were planted in 1982 as a pure. Afforestation area are 156 hectares in this area. In order to evaluate the compatibility and performance Redwood in 2010 (age 30) was selected 15 hectares of area has afforested. For this purpose, the planting area maps were prepared. Inventory network placed on it. 22 point as the center of the sample plots was determined for the field data collection within the afforestation. Inventory was done in this area by systematic random method. network size were 50m×50m. Inventory was conducted with the Intensity 15%. So that in the center of each grid was considered sample plots of 500 m² with form of circle. Quantitative properties of Redwood were measured in each sample profile, such as diameter at breast height, height and crown diameter. By dividing height to diameter (H/D) was calculated slenderness coefficient for each tree.

Normality of quantitative data was evaluated by using of Kolmogorov-Smirnov test. data was analysis by using MINITAB 15 of statistical software and One-way Anova of variance test. Comparison of average was done by Tukey test in probability level of 0.05.

RESULTS

By measuring the diameter at breast height in 22 sample plots, Redwood trees were classified in diameter classes 5, 10, 15, ..., 60 and the frequency of trees in per diameter class was determined. As is noticeable in figure 2, Species studied in 20 cm diameter class after then 15 and 25 cm has the highest frequency. Distribution in diameter classes represents an even aged curve that crooked to the left.

Table 1. Analysis of variance diameter at breast height , Height, Slenderness coefficient of *Sequoia sempervirens* 22 sample plots under study

Factors	Source Changes	Degrees of freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F
Diameter at breast height	Sample plot	21	10134	483	4.63**
	Error	379	39534	104	
	Total	400	49669		
height	Sample plot	21	304.2	14.5	0.72ns
	Error	51	1026.9	20.1	
	Total	72	1331.1		
slenderness coefficient	Sample plot	21	7648	364	0.54ns
	Error	51	34541	677	
	Total	72	42189		

Table 2. Mean Comparison of diameter at breast height , Height, Slenderness coefficient of *Sequoia sempervirens* 22 sample plots under study

Sample plot	Diameter at breast height (cm)	Height (m)	Slenderness coefficient
1	17.23±8.06	15.37±3.83	89.45±53.68
2	31.55±19.39	12.73±2.74	43.87±6.41
3	17.15±5.68	10.66±4.74	70.93±3.17
4	18.20±7.25	12.56±2.8	54.90±21.04
5	20.40±10.16	11.05±3.18	43.45±7.71
6	23.36±10.74	14.88±2.37	56.20±17.15
7	17.50±7.34	11.7±0.42	66.05±30.62
8	13.74±6.84	13.9±4.43	101.1±4.37
9	19.17±8.82	12.87±3.67	68.58±18.04
10	23.53±8.30	13.45±3.37	60.65±16.81
11	22.40±9.44	12.98±9.44	60.97±27.56
12	23.18±12.25	18.47±6.7	62.93±17.91
13	22.60±9.71	12.4±6.3	69.65±23.82
14	10.00±5.68	12.7±1.83	127.0±13.15
15	20.10±14.04	13.7±8.34	87.25±60.46
16	20.59±9.62	16.67±4.96	78.00±25.03
17	27.24±9.37	17.9±5.93	59.85±14.66
18	24.50±11.89	15.6±4.91	69.07±39.75
19	20.58±10.54	16.4±2.26	66.80±21.78
20	14.60±6.95	12.45±3.6	63.20±11.60
21	24.80±13.43	15.75±3.66	68.72±36.73
22	26.83±9.81	16.1±5.59	59.18±8.33

Table 3. Means of factors examined for *Sequoia sempervirens* in 22 sample plots

Slenderness coefficient	Total mean			Mean annual increment			
	Diameter at breast height(cm)	Height(m)	Crown diameter(m)	Volume at hectare(m ³)	Diameter increment (mm)	Height increment (cm)	Volume increment (m ³)
70.64	20.87	14.7	4.35	178.46	9.48	64.09	8.06

Table 4. Mean comparison of mean annual increment and growth in diameter, height, and volume of *Sequoia sempervirens* in Abas Abad project with other different area

area	Age	Diameter (cm)	Height (m)	Volume (m ³)	Diameter increment (mm)	Height increment (cm)	Reference
Iran-Abas Abad	30				9.48	64.09	this study
Iran-Chamestan	24				17.45	83.12	Mostafanejad and Sadati, 2008
Iran-Chamestan	19				16.8	80	Mostafanejad and Dastmalchi, 2004
Iran-Gilan	9				6.33	24.44	SaghebTalebi and Dastmalchi, 1998
Iran- Gilan	9				4.88	13.33	SaghebTalebi and Dastmalchi, 1998
Iran-Behshahr	9				20.56	90.77	Khorenke and Dehbandi, 2000
California	108				19.7	-	Olsen et al,1990
Caucasia	40				11.4	58	Dudarev et al, 1975

In this study, by using data were studied the relationship between slenderness coefficient and height with diameter at breast height. The curves were drawn for this species. Pay attention to figure 3 the height curve of Redwood stand is rising parabola in 22 sample plots. correlation coefficient equation between diameter and height is $Y = 6.4047 \ln(x) - 5.536$ and $R^2 = 0.669$ but the slenderness coefficient curve is descending parabola. this index is reduced by increasing age and diameter of stand (figure 4).

Pay attention to table 1, There is quite a significant difference with 99% confidence level ($P < 0.01$) between diameter at breast height of Redwood trees in 22 sample plots. It means, this species has a distribution in different diameter classes. But there is no significant difference between height and slenderness coefficient. Table 2 shows the mean comparison of diameter (cm), height (m), and slenderness coefficient in 22 sample plots. Averages were compared by using Tukey test at a significant level of 0.05 percent. The average maximum of diameter was observed in a sample plot of 2 (31.55 cm) and the average minimum of diameter was observed in a sample plot of 14 (10 cm). the average maximum and minimum of height belonged to sample plots of 12 (18.47) and 3 (10.66). The average maximum and minimum of slenderness coefficient were observed in sample

plots of 14 (127) and 2 (43.87) (table 2). Average factors examined (Slenderness coefficient, Diameter at breast height, Height, Crown diameter, Volume at hectare, Diameter increment, Height increment, Volume increment) are shown in 22 sample plots in Table 3.

**Fig. 1.** Map of the study area located in Abas Abad, Mazandaran, Iran

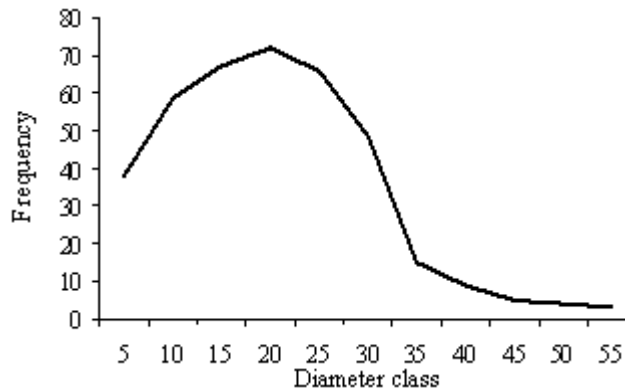


Fig. 2. Diagram of distribution in diameter classes in Redwood even aged

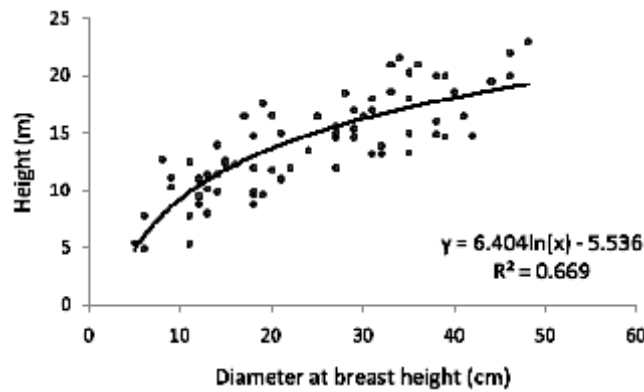


Fig. 3. Height curve of *Sequoia sempervirens* in north of Iran

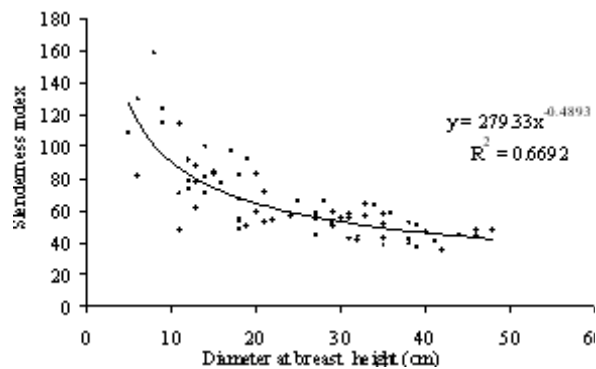


Fig. 4. Slenderness coefficient curve of *Sequoia sempervirens* in north of Iran

DISCUSSION

In a pure and even aged stand distribution of trees in diameter classes is almost like a normal curve (Zobeiri, 2000). Pay attention to figure 2 crooked to the left of the diagram focuses

on young and even aged in the stand under study. Habitat conditions and fertility cause the most trees are concentrated in the central part and smaller frequency get away from the central part with different reasons. Redwood 30-year has largest frequency in diameter classes 15, 20 and 25. The

result is the highest in this classes (figure 2). Mostafanejad and Dastmalchi (2004) during a similar study in north of Iran (Chamestan city) stated, Rewood 19 years has the highest frequency in the middle diameter classes (30 to 35 cm). Due to the fast-growing in Rewood species and competition between each other, there is a noticeable growth during this period in diameter growth of some trees of this species. Bysilvicultural operations (thinning), distribution graphs of plants will transform, Density of trees will less in the middle and two sides of the diagram are graphicto the right and left.

Height of trees is one of quantitative characteristics that show fertility status of the habitat and trees competitive position in stand. the average of height growth is 14.70 (table 3). by assessing height growth in all plotes can be stated, There is no noticeable difference in height growth in sample plots (table 2). This means that over 28 years afforest of the region has maintained its even eaged form. (Mostafanejad and Sadati, 2008) with evaluation of compatibility and performance three species of Taxodiaceae family in north of Iran (chamestan city) said: Redwood to other species of this family has better condition of the diameter and height growth baut it has the lowest of quality of the trunk. They also stated, species of Taxodiaceae family are successful and adaptable species and with good growth of diameter and height have culture and development capability in the same conditions. Most of the factors studied in this study compared with results from other researchers in the table 4. As is noticeable, Afforest project, with the Redwood in chamestan and behsharl is more successful this project in this study. So, we can say this forest plantation need to farm Interference for production of wood. Coast redwood is one of the most valuable timber species in California with 899,000 acres (3,640 km²) of redwood forest, all second growth, managed for timber production (IUCN. 2011).

Curve of slenderness coefficient shows, This ratio decreases with increasing diameter at breast (figure 4). slenderness coefficient is Important factor for to evaluate the stability in forest stand. It is suitable guide for the development of forest plantations. Classified based on slenderness coefficient (H/D), The value of this ratio over 100 is very unstable, Between 80 and

100 unstable for stand, Less than 100 is stable (Memarian et al, 2006). Mean of slenderness coefficient was 70.64 in studied stand (table 3) that pay attention to classification was done, forest plantations is stable and its status is normal. But a review of Table 2, we can be stated, sample plotes of 8 with slenderness coefficient over 100 is very unstable. So, this plotes have crisis condition and it is necessary, Should be done farm operations as soon as is possible for achieving stability and sustainability in stand.

CONCLUSION

Recommended by farm operations with appropriate intervals to provide increase the diameter and height growth and managed for timber production. Redwood has the best habitat in the mountains where there is more precipitation from the incoming moisture off the sea and it has a significant growth less than 300 meters above level of sea. Its better should be selected regions with such characteristics for planting this species in north of Iran. Culture as one of fast growing species and industrial is recommended in Similar area in terms of soil properties and climate.

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