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Effect of *Alnus subcordata*, *Acer insigne* and *Sequoia sempervirens* plantations on plant diversity in Hyrcanian forest of Iran

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Abstract. *Gheibi F, Akbarinia M, Kooch Y. 2015. Effect of* Alnus subcordata, Acer insigne *and* Sequoia sempervirens *plantations on plant diversity in Hyrcanian forest of Iran. Biodiversitas 16: 10-15.* Forest plantation is a common action in order to restore the degraded forests in Hyrcanian forests of Iran. This study compares the plant biodiversity in four 25-year-old stands of plantation, adjacent understorey of alder (*Alnus subcordata* C. A. Mey.), maple (*Acer insigne* Boiss.), sequoia or red wood (*Sequoia sempervirens* (D. Don) Endl.) and mixed stand (maple and sequoia), located in Salmanshahr of Mazandaran Province, northern Iran. Research carried out in, 10 sample plots with 20m × 20m area which taken by systematic-random in each plantation. All understorey species were identified, recorded and then the biodiversity indices (diversity, richness and evenness) were calculated. Our findings show that the planted species had significant effects on understorey diversity. Statistical comparisons revealed that the highest and lowest diversity (Simpson and Shanon-Winer) and richness (Margalef and Menhinic) indices occurred in sequoia and alder stands, respectively. The evenness indices (Camargo and Smith-Wilson) were significantly greater in maple, sequoia and mixed stands compared with the alder type. As a conclusion, floristic change trends were different according to the planted tree species. A good understanding of the complexity of vegetation processes requires long-term monitoring of vegetation change.

Key words: diversity, evenness, richness, sequoia, understorey.

INTRODUCTION

Biodiversity is necessary for mankind life duration, economical issues and for ecosystem stability and function (Singh 2002). Biodiversity is declining at an unprecedented rate and on a global scale. Indeed, loss of ecosystem functions and services associated with such declines has generated international debate (Zhou et al. 2006). Several causes have been identified to explain such loss, including increased land use by an expanding human population (Lambin and Geist 2006) and global climate change (Thuiller 2007). Biodiversity is often used to compare the forest ecosystems the ecological status of forest ecosystems and evaluate the forest communities and ecosystems (Esmailzadeh and Hosseini 2008). Forests support about 65% of the world's terrestrial taxa (Lindenmayer et al. 2006) and have the highest species diversity for many taxonomic groups including birds, invertebrates and microbes (Lindenmayer et al. 2006). High species diversity in ecosystems led to high food chain and more complex network environment (Lindenmayer et al. 2003). The layers of vegetation in a forest ecosystem support desirable habitats for these taxonomic groups. So forests in the world have the most contribution to biodiversity in terrestrial ecosystems. Loss of native species or alteration and introduction of invasive species through habitat destruction is considerable because of vicinity of forest ecosystems to human population centers (Pilehvar et al. 2010).

Caspian forests of Iran are located in the north of Iran and south coast of Caspian Sea, also known as the Hyrcanian forests (Takhtajan 1974; Kooch et al. 2014a,b). These forests cover 1.8 million hectares of land area. Approximately 60 percent of these forests are used for commercial purposes and the rest of them are degraded. They are suitable habitats for a variety of hardwood species such as beech, hornbeam, oak, maple, alder, and encompass various forest types including 80woody species (Marvie Mohadjer 2005). Today, the Caspian forests of Iran are depleting rapidly due to population growth, and associated socio-economic problems, industrial development and urbanism (Poorzady and Bakhtiari 2009). Forest plantation is a common action in order to restore the degraded forests in the Caspian region (Kooch et al. 2012; Mohammadnezhad Kiasari et al. 2013).

Forest plantations are being established at an increasing rate throughout much of the world, and now account for 5% of global forest cover (FAO 2001). Plantations can buffer edges between natural forests and non-forest lands, and improve connectivity among forest patches, which might be important for some populations (Cullen et al. 2004). The primary aim of almost all plantations is the production of large quantities of woodland fiber (e.g. for timber and pulp production). However, there are often important opportunities for biodiversity conservation within plantations (Hartley 2002). Various studies have found that plantations of native or exotic timber species can increase biodiversity by promoting woody understorey regeneration (Carnevale and Montagnini 2002). Plantations promote understorey regeneration by shading out grasses, increasing nutrient status of topsoil (through litter fall), and

facilitating the influx of site-sensitive tree species (Cusack and Montagnini 2006).

Numerous studies have shown that the establishment of plantations or restoration plantings on degraded lands can ameliorate unfavorable microclimatic and soil conditions, and provide habitat for seed-dispersing wildlife, there by greatly accelerating natural forest regeneration (Carnus et al. 2006). Previous studies investigated the effect of different land use and also cover on plant biodiversity with different condition (Nagaike 2002; Esmailzadeh and Hosseini 2008; Pilehvar et al. 2010, Taleshi and Akbarinia 2011; Mohammadnejad Kiasari et al. 2013). Here we designed to investigate and compare the plant diversity in the stands of 25-year-old plantation (sequoia, maple, alder and sequoia-maple mixed). The results of this study can be useful for forest plantation and conservation of biodiversity in degraded lands located in northern forests of Iran and same situation. This information also can be used as the database for further research.

MATERIALS AND METHODS

Site characteristics

The study area is located at the Tilekenar district of Salmanshahr in Mazandaran Province, in the north of Iran, between 36°39'36″N-36°40'01″N and 51°09'55″ E-51°10'18″ E at the coast of Caspian sea (Figure 1). Study stands were located at an altitude of 250 m above sea level and with gentle slope (0-5%). Annual rainfall averages 1300 mm, with wetter months occurring between September and February. In the dry season from April to August, monthly rainfall usually averages less than 40 mm for four months. The soils have textures of loam and clay loam with an acidic pH in the top layers; in the deep layers, soil textures were clay and silty clay and soil pH was less acidic. Previously this area was dominated by degraded natural forests containing native tree species such as *Quercus castaneifolia*, *Zelkova carpinifolia*, *Parrotia persica*, *Carpinus betulus*, *Diospyros lotus* and *Buxus hyrcana*. While 25 years ago after clear cutting (in small areas in degraded natural forests), reforestations have been established (within 3×3 m spaces) in this area with some native species including alder (*Alnus subcordata* C. A. Mey.), maple (*Acer insigne* Boiss.), as well as exotic species of sequoia or red wood (*Sequoia sempervirens* (D. Don) Endl.) and mixed stand (maple and sequoia).

Data collection and diversity measures

Research done in, 10 sample plots with 400 m^2 (20m×20m) areas taken by systematic-random in each plantation. The entire understorey species were identified, recorded and then the values of diversity (Simpson and Shanon-Wiener indices), richness (Margalef and Menhinic indices) and evenness indices (Camargo and Smith-Wilson indices) were calculated by using PAST and Ecological Methodology software's as follow (Mesdaghi 2001, 2005):

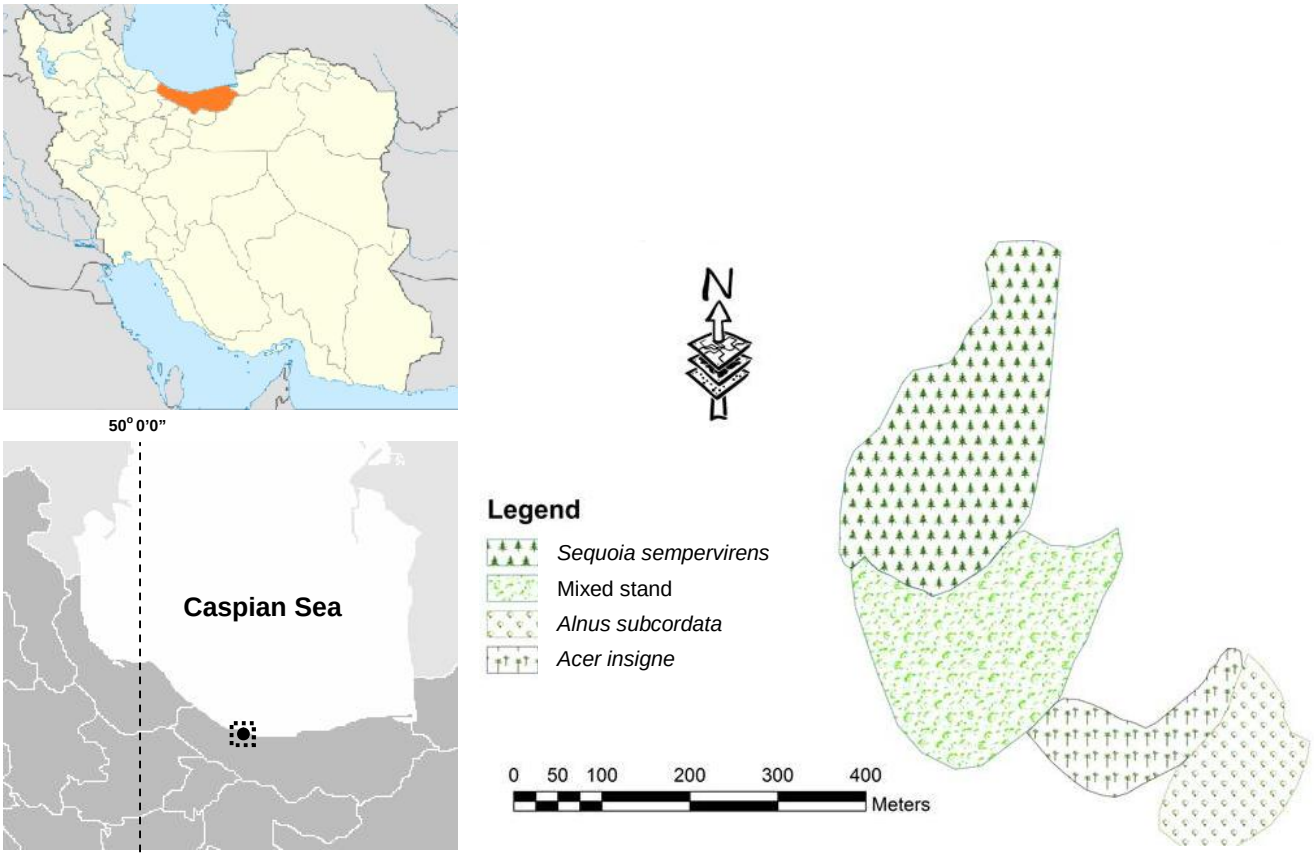

Figure 1. Site locations of study area in Mazandaran Province, north of Iran.

$$S = 1 - \sum_{i=1}^{s} \left[\frac{ni\,(ni-1)}{N\,(N-1)} \right] \quad \text{.....(1)}$$

Where, S is Simpson index; *s* is the number of species; *ni* is the number of *ith* species in sample; N is the number of all species.

$$H = -\sum_{i=1}^{s} \left[P_I \, Ln\,(P_I) \right] \quad \text{.....(2)}$$

Where, H is Shannon-Wiener index; *s* is the number of species; *PI* is the proportion of individuals found in the *ith* species.

$$R = \frac{s-1}{Ln\,N} \quad \text{.....(3)}$$

Where, R is Margalef index; *s* is the number of species; *N* is the number of all species.

$$R = \frac{s}{\sqrt{N}} \quad \text{.....(4)}$$

Where, R is Menhinic index; *s* is the number of species; *N* is the number of all species.

$$E = 1..0 - \left[\sum_{i=1}^{s} \sum_{j=i+1}^{s} \left[\left| P_i - Pj \right| / S \right] \right] \quad \text{..... (5)}$$

Where, E is Camargo species evenness indexes; *Pi* is the ratio of *ith* species to all species; *Pj* is the ratio of *jth* species to all species; *S* is the number of species.

$$E_{Var} = 1 - \left[\frac{2}{p} \right] \left[\arctan \left\{ \frac{\sum_{i=1}^{s} \left[Log \sum_{e}^{(ni)} - \sum_{j=1}^{s} Log_{e}^{(nj)/S} \right]^2}{S} \right\} \right] \quad \text{..(6)}$$

Where, E_{var} is Smith and Wilson index; *ni* is the number of *ith* species in sample; *nj* is the number of j^{th} species in sample; *S* is the number of all species.

Statistical analysis

The normality of the variables was checked by the Kolmogorov-Smirnov test, while Levene's test was used to examine the equality of the variances. Differences in biodiversity indices (diversity, richness and evenness) among afforested stands were tested with ANOVA One-way analysis. Duncan's test was used to separate the averages of the dependent variables which were significantly affected by treatment. Significant differences among treatment averages for different parameters were tested at $P \leq 0.05$.

RESULTS AND DISCUSSION

A total number of 47 plant species were identified in the studied stands (Table 1).Our findings show that the planted species had significant effects on understorey diversity (Table 2). Statistical comparisons revealed that the highest and lowest diversity (Simpson and Shanon-Winer) and richness (Margalef and Menhinic) indices occurred in sequoia and alder stands, respectively (Figure 2a, b , c, d). The evenness indices (Camargo and Smith-Wilson) were significantly greater in pure maple and sequoia as well as mixed stands compared with the alder type (Figure 2 e,f).

In the early stages after clear cutting due to high intensity light herbaceous plant diversity rapidly increased and sometimes invasive species are dominant (Humphery et al. 2003). Diversity index is the combination of species richness and evenness that have both the species richness and evenness in a quantity collects (Brockway et al. 1998). Biodiversity in a plantation area increase when trees are cut down to grow seedlings during planting seedlings in a change of fluctuate.

In the present study, the most dominant species in all stands belongs to those after the destruction of the natural area expand sand shows the breakdown of natural ecosystem of the destroyed area (Marvie Mohadjer 2005). Initially, study area was in the natural forest and slowly become dilapidated due to human influences, and to preventing the process of destruction and human poaching into forest plantation of exotic and native species has been suggested. The destruction of the ecosystem stops and with time recover and return to the natural ecosystem would be require a lot of time finally what is visible the plantation was able to stop the destruction. Various species richness shows that the numbers of plant species in an area are achieved. So far, a large number of species richness, which was invented by the index counts the total number of species (Maguran 1988), as is most celebrated for species richness (Kent and Coker 1992). Our findings showed that the number of species in the stands of sequoia and mixed are more than others, as shown in Figure 3, by the Margalef index. The simple stand most common criterion for assessing species richness of habitats and plant communities is the number of species (Humphrey et al. 1996).

The broken branches in sequoias stand were more detected than other stands that cause more light to penetrate into the stand and may cause a higher diversity in sequoia stand. Dense canopy of alder and maple perhaps is one reason for the low number of species on the forest cover plantation compared to sequoia stand. The result of Fallahchai and Hashemi (2012) research showed that Shanon-Winer diversity index had greater amounts in the *Pinus taeda* stand than to the other broad-leaved stands. As shown indifferent researches that planting of tree species in a plantation canopy over time, that larger trees are also wider and it would reduce the variation in stand plantation. Plant diversity will be reduced with closing of canopy cover gradually (Kuksina and Ulanova 2000).Since the sequoia stand that is a species of conifers, its soils are more

acidic than other sand presence of higher percentage of ferns can be a reason for the higher diversity and richness of the stand.

Barbier et al. (2008) in their review study on the effect of tree on herbaceous species diversity and the mechanisms affecting boreal forests also concluded that presence of acidic friendly (Acidophilus) under a canopy of conifers species diversity in these populations will increase. Also, the effect of these have on the soil and encourage more herbaceous plants that are more oriented toward acidic soils to increase some parameters in this stand (Humphery et al. 2002). As alder species belong to those that leaves earlier and shed it after other therefore over the years a massive canopy will be emerge which with the high humidity of the stand can also reduce biodiversity. The numerical value of the indices was not too different, because after 25 years since plantation the plantation covers of different stands become similar to each other.

Table 2. ANOVA for biodiversity indices in the studied stands

Biodiversity indices		**F-value**	**Sig.**
Diversity	Simpson	7.161	.000**
	Shannon-Wiener	5.426	.001**
Richness	Margalef	3.374	.019**
	Menhinic	9.812	.000**
Evenness	Camargo	11.011	.000**
	Smith and Wilson	9.331	.000**

Note: **Different is significant at the 0.01 level.

Table 1. Average percentage of floor coverings in the studied stands.

Scientific name	**Sequoia**	**Maple**	**Alder**	**Mixed**
Brachypodium pinnatum (L.) P.Beauv.	0.1	0.14	0	0.06
Carex sylvatica L.	1.53	1.76	2.57	1.34
Conyza bonariensis (L.) Cronq.	0	0.18	0	0
Oxalis corniculata L.	0	0.08	0	0
Oplismenus undulatifolius (Ard.) P. Beauv.	14.94	15.68	51.7	20.64
Calystegia sepium (L.) R.Br.	0	0.2	0.64	0.23
Cyclamen coum Miller.	0	0.1	0	0
Primula heterochroma Stapf.	0	0.12	0.24	0
Parietaria officinalis L.	0	0.54	0	0
Pteris cretica L.	5.26	0.44	0.82	11.54
Urtica dioica L.	0	0.06	0	0.04
Scutellaria tournefortii Benth.	0	0.04	0.12	0
Viola alba L.	1.78	1.26	1.06	1.31
Fragaria vesca L.	0.12	0.04	0	0.04
Geum urbanum L.	0	0	0.42	0
Prunella vulgaris L.	0	0	0.88	0
Hypericum androsaemum L.	0.02	0	0.04	0
Polystichum aculeatum (L.) Roth	1.9	0	0.56	1.7
Clinopodium vulgare L.	0	0	0.38	0
Solanum nigrum L.	0	0	0.1	0
Stellaria media (L.) Cyr.	0	0	0.1	0
Cardamine impatiens L.	0	0	0.06	0
Phytolacca aquatica L.	0	0	0.13	0
Plantago major L.	0.02	0	0	0
Hedera pastuchovii Woron.	0.14	0	0	0.08
Danae racemosa (L.) Moench	0	0	0	0.06
Phyllitis scolopendrium (L.) Newm.	0.04	0.04	0	0.44
Lamium album L.	0	0	0.26	0
Sanicula europaea L.	0.38	0	0	0.04
Smilax excelsa L.	0.38	0.24	0.36	0.36
Pteris dentate Forssk	0.1	0	0	0
Mentha aquatica L.	0.2	0	0	0
Microstegium vimineum (Trin.) A. Camus.	0.62	0.39	0.51	2.08
Carpesium cernuum L.	0.24	0	0	0.2
Pimpinella affinis Ledeb	0.22	0	0	0
Ajuga reptans L.	0.26	0	0	0.3
Potentilla reptans L.	0.16	0	0	0.12
Tamus communis L.	0.04	0	0	0.09
Athyrium filix-femina (L.) Roth	3.66	0	0.2	1.6
Setaria viridis (L.) P. Beauv.	0.1	0	0	0
Mercurialis perennis L.	0.06	0	0	0.44
Ruscus hyrcanus Woron.	0.76	0.78	1.26	0.7
Sambucus nigra L.	0.06	0	0.58	1.5
Rubus persicus Bioss.	0.08	0.04	0.06	0.4
Melissa officinalis L.	0	0	0	0.04
Ilex spinigera (Loes) Loes	0	0	0	0.6
Unknown	0	0	0	0.4

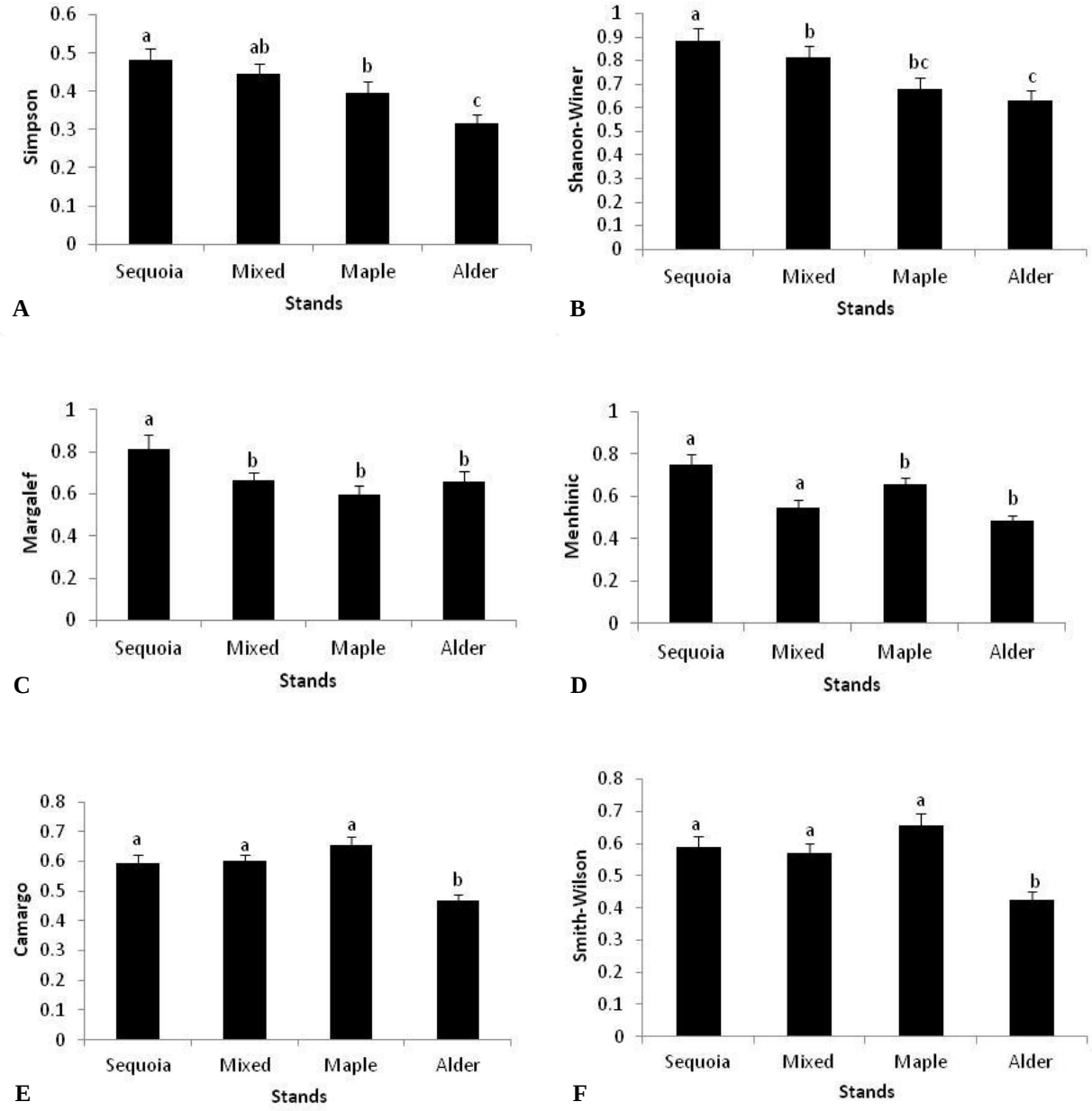

Figure 2. Average values of Simpson (A) and Shanon-Wiener (B) Margalef (C) and Menhinic (D) Camargo (E) and Smith-Wilson (F) indices for understorey.

Here we designed to investigate and compare the plant diversity in the stands of 25-year-old plantation (sequoia, maple, alder and sequoia-maple mixed). Our findings indicated that the floristic change trends were different according to the planted tree species. It is recommended to preserve biodiversity of the north forest of the country in destructed areas with planting of such species as sequoia mixed with native species. Since, this study examined a 25 year old plantation biodiversity which within this duration numerous species entered and disappeared so it is suggested such studies be conducted to document succession years and biodiversity in this area again in the following years. It is recommended that these trees planted in degraded lands and clear cut areas in small zones.

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