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Capability Investigation of Carbon Sequestration in Two Species (Artemisia *sieberi* Besser & *Stipa barbata* Desf) Under Different Treatments of Vegetation Management (Saveh, Iran)

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***Abstract*—**The rangelands, as one of the largest dynamic biomes in the world, have very capabilities. Regulation of greenhouse gases in the Earth's atmosphere, particularly carbon dioxide as the main these gases, is one of these cases. The attention to rangeland, as cheep and reachable resources to sequestrate the carbon dioxide, increases after the Industrial Revolution. Rangelands comprise the large parts of Iran as a steppic area. Rudshur (Saveh), as area index of steppic area, was selected under three sites include long-term exclosure, medium-term exclosure, and grazable area in order to the capable of carbon dioxide's sequestration of dominated species. Canopy cover's percentage of two dominated species *(Artemisia sieberi* Besser & *Stipa barbata* Desf) was determined via establishing of random 1 square meter plot. The sampling of above and below ground biomass style was obtained by complete random. After determination of ash percentage in the laboratory; conversion ratio of plant biomass to organic carbon was calculated by ignition method. Results of the paired t-test showed that the amount of carbon sequestration in above ground and underground biomass of *Artemisia sieberi* Besser & *Stipa barbata* Desf is different in three regions. It, of course, hasn't any difference between under and surface ground's biomass of *Artemisia sieberi* Besser in long-term exclosure. The independent t-test results indicate differences between underground biomass corresponding each other in the studied sites. Carbon sequestration in the *Stipa barbata* Desf was totally more than *Artemisia sieberi* Besser. Altogether, the average sequestration of the long-term exclosure was 5.842gr/m², the medium-term exclosure was 4.115gr/m², and grazable area was 5.975gr/m² so that there isn't valuable statistical difference in term of total amount of carbon sequestration to three sites.

***Keywords*—**Carbon sequestration, the Industrial Revolution, greenhouse gases, *Artemisia sieberi* Besser, *Stipa barbata* Desf, steppic rangelands

I. INTRODUCTION

RANGELANDS, as one of the biggest dynamic ecosystems in the earth, have the extended area of world terrestrials which produce many services and goods as direct and indirect yields. There is much valuable stuff in the rangeland that it is called total economic value (TEV) in which the indirect production of rangelands, as untradable goods, is going to be notable in the world that regulation of greenhouse gas is one of them [15]. Density of greenhouse gas of the earth's atmosphere has increased in the last century [8]. Consideration to share and value of rangeland to decreasing of these gases, therefore, is thinkable. Carbon dioxide is the most gases of greenhouse gas [10] that its density is increasing after industrial revolution. The vegetation of rangelands can reduce the gas as it is cheap and reachable in the world [17]. The vegetation absorbs the atmosphere's carbon dioxide in cycle of carbon photosynthesis's process and reserves them into organic carbon includes x-ose (e.g. fructose) so that is called carbon sequestration. Although the rate of carbon sequestration of rangelands is slight, its space can rectify it [16]. The rangeland area of Iran is 86.1 million hectares that is has basic role in sustainable development via programming of them [5]. Rehabilitation and improvement of these lands can sequestrate 1 billion of the organic carbons [16]. Sequestration capability of carbon by way of phytomass is different based upon plant species, place, and management methods [13]. The dominated species, on the other hand, has the most performance to sequestrate the carbon via canopy covers [9]. Investigation of grazing and exclosure impacts on carbon sequestration of sandy-degraded grasslands of north China has shown that overgrazing is caused to increase the bare ground and decrease the carbon reservation of soil-plant system so that it is increased by exclosure strategy and reestablishment of vegetation cover [18]. Another research has shown that from three species include rock rose (*Helanthemum* sp.), *Dendrostellera Lessertii* (Wikstr.) Van Tigeh, and sagebrush (*Artemisia sieberi*); plants stems have the highest exchanging of sequestration of organic carbon and sagebrush has more capability than the others to sequestrate the carbon [6]. Range exclosure is the simplest and cheapest way of rangeland rehabilitation that it is executable in each weather condition. Because the steppic rangeland of Iran has 46 million hectare which is formed the most area of country, this research was carried out on these area to understand the carbon sequestration of dominated species in steppic area for improving and rehabilitant of rangeland. It, therefore, is useful against air pollution and global changes of climate and sustainable development of environment.

II. MATERIAL AND METHODS

Study Area Features

Study area is located on rangeland around Saveh city of Central Province as steppic index of central Iran. Longitude of area is $50^\circ 53'$ and latitude is $35^\circ 26'$ (Figure 1).

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Fig. 1 Location of the study area in Iran regional map

Altitude from free sea level is 1100 m and general slope is 3-5 %. Moderate annual rainfall is 206.4 mm which the most of it occurs in fall and winter and the least of it occurs in summer. Area soils are classified brown-eroded soils with alluvial material. Texture of surface soil is clay loamy and sub-surface soil is heavy-gravelly texture. The slope aspects are eastern and northeast. Exclosures of the study area are divided into two sections include long-term exclosure (45 years, 30 ha, hereinafter 45 EX) and mid-term exclosure (25 years, 20 ha; hereinafter 25 EX). Dominated species are Artemisia sieberi Besser and Stipa barbata Desf along with Stipa hohenackeriana Rupr & Trin., and Salsola Tomentosa Moq. Open area also has Artemisia sieberi Besser as main species. Floristic list of the study area is given in table 1 [2], [7], [11].

TABLE I
FLORISTIC LIST OF THE STUDY AREA

Species	Family	Form life	Palatability degree
Artemisia sieberi Besser	Compositeae	Shrub	II
Stipa hohenackeriana Rupr	Gramineae	Perennial grass	II
Astragalus chaborasicus Boiss.	Papilionaceae	Perennial forb	I
Poa sinaica Steud	Gramineae	Perennial grass	I
Stipa barbata Desf	Gramineae	Perennial grass	II
Salsola tomentosa Moc	Chenopodiaceae	Shrub	II
Salsola laricina Pall	Chenopodiaceae	Shrub	II
Noea mucronata Forsk	Chenopodiaceae	Shrub	II
Acantholepis orientalis Lesse	Compositeae	Annual forb	III
Acanthophyllum glandulosum Bois	Caryophyllaceae	Shrub	III
Acantholimon festucaceum Jau	Plumbaginaceae	Shrub	III
Achillea tenuifolia Lam	Compositeae	Perennial forb	III
Alhagi camelorum Fisch	Papilionaceae	Perennial forb	III
Amberboa turanica Llgin	Compositeae	Annual forb	III
Andrachne fruticulosa Boiss	Euphorbiaceae	Shrub	III
Dendrostellera lessertii Wikstr	Thymelaeaceae	Shrub	III
Gypsophilla pilosa Huds	Caryophyllaceae	Annual forb	III
Heliotropium aucheri Boiss	Chenopodiaceae	Annual forb	III
Stipagrostis plumose L	Gramineae	Perennial grass	III
Ephedra strobilacea Lehm	Ephedraceae	Shrub	III
Bromus tecorum L	Gramineae	Annual grass	III
Scabiosa flavida Bois&Hauske	Dipsacaceae	Annual forb	III
Salsola lanata Pall	Chenopodiaceae	Shrub	III
Capsella bursa-pastoris L	Brassicaceae	Annual forb	III
Peganum harmala L	Zygophyllaceae	Perennial forb	III
Bromus danthonicae Trin	Poaceae	Annual grass	II

Research Methods

Stand area, in order to estimate the considering communities, is determined under three sites include long term and mid term exclosures and grazing area (GA). Every site is located on same gradient include altitude, slope, and slope aspect. Sample size was obtained 2 square meters by minimal area [14]. It was 1 square meter in the long term exclosure. Sample volume was calculated 40 plots per site using statistical method [12]. Sampling was carried out via quite random method. Two dominated species of sagebrush (Artemisia sieberi) and silver feather grass (Stipa barbata) [6] were selected in order to obtain the aerial phytomass by way of clipping method [1]. Hence, 25 plant stock of each species, include old and young plants, was clipped from 1 cm of soil surface. One soil profile was dug along side of each bush so that all roots with 1 diameter [6] along subsurface biomass were clipped. About 150 grams from each section include aerial and subsurface biomasses were collected in order to determine the carbon and moisture percentage.

Laboratory and Statistical Analyses

Ignition method was used to obtain the conversion factor of carbon sequestration of biomass into organic carbon [1], [4], [6]. The surface and subsurface biomasses of two species were floured after drying in oven under 40 degree Celsius within 15 hours. Then, 10 samples, 2 grams, were provided from each biomass [6]. Samples were burned by oven about 5 hours in 600 degrees Celsius [3]. Obtained ash, after exiting from oven, set up in desiccator to cool and then it was weighted. The rate of organic carbon (OC) for each biomass was calculated by ash weight, primary weight, and ratio of organic carbon to organic material (OM) (equation 1. [1], [4]). Conversion factor for each organ was calculated by primary weight percentage and percentage of the organic carbon.

OC= 0.54 OM (1)

The collected data was processed in Excel 2003. The analysis of data was done by Spss v.17. In order to investigation and comparison of carbon sequestration between biomasses, ANOVA analysis was employed. For the purpose of comparison between the carbon sequestration's rate of corresponding biomasses, independent t-test and between surface and subsurface biomasses for each site, paired t-test were employed.

III. RESULTS

Features of Soil Surface and Vegetation Cover

An abstracted result of soil surface and vegetation cover's percentage from average of plots' estimation is given in table 2. Cover and litter percentages in the mid-term exclosure was more than the long-term exclosure and open area. Percentages of bare ground and grit in the grazing area, however, were more than the others.

TABLE II
THE FEATURES OF SOIL AND GROUND COVER

Treatment	Bare ground (%)	Vegetation cover (%)	Litter (%)	Grit (%)
45 EX	34.1	38.5	15.2	12.2
25 EX	30.9	45.3	18.3	5.5
GA	51.8	22.8	3.2	22.2

Determination of the Canopy Cover's Percentage of Two Dominant Species

The canopy cover percentage of Artemisia sieberi Besser and Stipa barbata Desf in each site is presented in table 3.

TABLE III
THE CANOPY COVER OF THE DOMNIATED SPECIES OF STUDY AREA

Species	45 EX	25 EX	GA
Artemisia sieberi Besser	10.77	13.39	16.52
Stipa barbata Desf	6.95	3.34	4.25

Determination of the Conversion Factor to Organic Carbon

Table 4 shows the abstracted results from determination of the conversion factor of surface and sub-surface's biomasses of sagebrush and silver feather grass in the two sites. It also points that the conversion factor of sagebrush organs is increasing from exclosure areas to open area. The amount of organic carbon of phytomass has separately been calculated for each species using formula 1.

TABLE IV
THE AMOUNT OF CONVERSITON FACTOR OF PHYTOMASS TO THE ORGANIC CARBON IN THE THREE AREAS (G/M2)

Treatment	45 EX		25 EX		GA	
Species	Aerial phytomass	subsurface phytomass	Aerial phytomass	subsurface phytomass	Aerial phytomass	subsurface phytomass
Artemisia sieberi	0.971	1.021	0.746	0.543	0.763	0.497
Stipa barbata	1.044	2.446	0.784	2.042	0.810	3.905
Average	1.007	1.733	0.765	1.292	0.786	2.201

Comparison of the Carbon Sequestration between Aerial and Sub-surface's Biomasses in Each Species from Each Site

The results of the paired t-test analysis has shown that aerial and sub-surfaces' biomasses of sagebrush have significantly differed in the 25 EX and GA sites while in this case, all sites fore silver feather grass have meaningfully differed each other (Table 5).

TABLE V
COMPARISON OF THE CARBON SEQESTRATION BETWEEN AERIAL AND SUB-SURFACE'S BIOMASSES IN THE BOTH SPECIES OF SITES

Treatment	Species	t statistic	df	Sig.(2-tailed)
45 EX	*Artemisia sieberi*	0.488	9	0.63 ns
	Stipa barbata	6.17	9	0.00**
25 EX	*Artemisia sieberi*	3.87	9	0.00**
	Stipa barbata	5.46	9	0.00**
GA	*Artemisia sieberi*	6.93	9	0.00**
	Stipa barbata	9.65	9	0.00**

** Indicates statistical difference at the level of 99% (P <0.01)
ns Indicates no significant

Comparison of the Carbon Sequestration between Two Species' Biomasses in the Study Areas

Table 6 shows the comparison of carbon sequestration between sagebrush and silver feather grass in the three sites include long-term (45 EX) and mid-term (25 EX) exclosures and grazing area (AG) using independent t-test. As it shows, there is significantly difference between subsurface biomasses of two species in the three sites while about aerial phytomass, it is not meaningful.

TABLE VI
COPARISON OF THE CARBON SEQESTRATION BETWEEN TWO SPECIES' BIOMASSES IN THE THREE SITES

Treatment	Biomass condition	t statistic	df	Sig.(2-tailed)
45 EX	Aerial phytomass	0.62	18	0.54 ns
	Subsurface phytomass	5.49	10.37	0.00**
25 EX	Aerial phytomass	0.67	10.65	0.51 ns
	Subsurface phytomass	7.08	10.19	0.00**
GA	Aerial phytomass	0.79	11.46	0.44 ns
	Subsurface phytomass	10.86	9.20	0.00**

** Indicates statistical difference at the level of 99% (P <0.01)
ns Indicates no significant

Comparison of Three Sites for the Carbon Sequestration of Two Species' Aerial and Sub-surface's Biomasses

In order to compare the mount of carbon sequestration of aerial and sub-surface's biomasses of silver feather grass and sagebrush in the three sites, ANOVA analysis has been done that there are significantly differences between two species in three areas (Table 7).

TABLE VII
ANOVA RESULTS OF THE COMPARISON OF THREE SITES

Species	Biomass condition	45 EX	25 EX	GA	F
Artemisia sieberi	Aerial phytomass	0.97a	0.74 b	0.76b	28.1**
	Subsurface phytomass	1.02 a	0.54 b	0.49b	29.0**
Stipa barbata	Aerial phytomass	1.04 a	0.78 b	0.81b	4.1**
	Subsurface phytomass	2.44 a	2.04 a	3.90b	14.2**

Note: Uncommon alphabet in each row presents that there is difference between them (p-value< 0.01)

Comparison of the Carbon Sequestration of Two Species' Aerial and Sub-surface's total Biomasses in the study areas

Biomasses of two species on the carbon sequestration totally investigated in this research that the most carbon sequestration (gr/m^2) occurred on grazing area from silver feather grass. It also understood that sagebrush has totally had the least carbon sequestration in the grazing area (Figure 2).

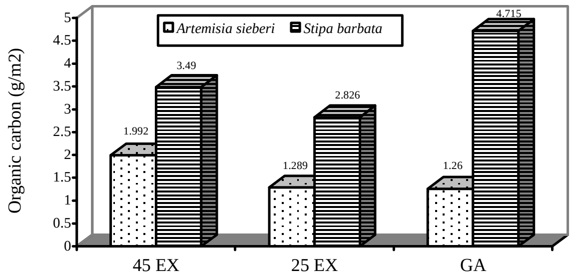

Fig. 2 Total carbon sequestration of two species

IV. DISCUSSION AND CONCLUSION

In the study, we have shown that grazing livestock is on of the most effective factors upon the vegetation cover and the percent of bare ground so that the rate of bare ground along with places covered rock and grovel, in GA has the most amounts and equals to 75% and in 25 EX has the lees amount and equals 36.4%. It's similar to [19]. In 45 EX passed 45 years ago due to exclosure and lack of livestock grazing, the activity of vertebrate and invertebrate organisms (such as rabbits and ants) have been increased, as a result it is caused the death and decreased the number of plant species, especially dominant species, *Artemisia sieberi* Besser, which plant species is resident of annual forbs [11], so it caused the bare ground's rate is more and percent of vegetation is a bit lees from 25 EX. This study showed that while vegetation and litter has been died out due to grazing livestock and other live factors, the percent of bare ground also increased and as a result, rate of wind erosion also increased. However, the rate of erosion has not been calculated, but considering soil motion and way of spilling particles and soil particles and congregation in bottom of shrubs, wind erosion completely is clear. Yong Zhong So et al (2003) has a reported such similar results. In the Rudshur Saveh, sampling of vegetation showed that *Artemisia sieberi* Besser has the most canopy cover surface and *Stipa barbata* Desf as a second dominant species area. However, obtained results from determination of converting coefficient of weight of biomass to organic carbon showed the ability of carbon sequestration is less to species of *Stipa barbata* Desf in every square meter. It's not similar to [9]. Because he expressed dominant species performs the most percent of canopy cover in carbon sequestration. The differences in rate of coefficient of converting biomasses to organic carbon due to mineral changes so that in parts of plant that rate of minerals has been high, converting coefficient has had less. Bordbare et al, 2006 in his study has acquired similar results. The rate of carbon sequestration above ground biomass of *Artemisia sieberi* Besser in comparison to under ground biomass in GA and 25 EX, differences of significance has statistically shown, but this difference in 45 EX isn't seen. This difference can be as a result of ant activity surrounding plant baseline of this species and in the end decomposition root and arrival of carbon into soil. Statistic differences in relation to comparison of above and ground biomass of *Stipa barbata* Desf has been significant. The rate of carbon sequestration of ground biomass of this species (g/m² per unit area) is almost twice and sometimes more than triple (in the GA), hence, above biomass caused difference and could have significant effect in rate of carbon sequestration of the entire species in comparison to *Artemisia sieberi* Besser has had. Reason for this way carbon lack of activity of vertebrate and invertebrate organisms and lack of decomposition root is. Comparison resulted from the rate of carbon sequestration of above and ground biomass in the three sites with each other using ANOVA, existence statistical difference level of 99% has shown. So that in Classifieds Duncan test on the above and underground biomass of *Artemisia sieberi* Besser in three sits, two was distinct groups (45 EX in one group and 25 EX, GA in another group). In relation to *Stipa barbata* Desf and in comparison to above biomass of three sits of two groups (45EX in one group and 25EX, GA in another group) in comparison to ground biomass of this species of two groups so that this difference of exclosures in one of group and the GA alone were in a separate group. These results confirm is that reaction of different plant species respond to different management operations [13]. The carbon sequestration in the ground biomass of *Stipa barbata* Desf in each of studied site is more than above biomass but this case about *Artemisia sieberi* Besser is only in 45 EX is true and in the other two areas have reverse result. This finding shows that port of different vegetation parts is different in the carbon sequestration, it's similar to results of [4], [6]. Above all results represent the reality that despite of different responses of the carbon sequestration's stipulation of two mentioned species rather exclosure condition; totally, the carbon sequestration under exclosure management than condition of grazing rangeland hasn't changed, so that in 45 EX the rate has been 5.482 g/m², in 25 EX 4.115 g/m², and GA 5.975 g/m², respectively. Systemic management of vegetation, therefore, can play an important role in the carbon sequestration through increased performance to different species. Among appearance of categories these two species under study in a wide area of Iran, explanatory that in order to achieve sustainable management, optimize utilization of vegetation can be an important factor in regulating the abundance and freshness species so as to reach forage and extraction the carbon sequestration option.

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