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

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Manuscript Received: 05/08/2010
Manuscript Accepted: 08/11/2010

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 greenhouse 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 including long-term exclosure, medium-term exclosure, and grazable area due to the capability of carbon dioxide's sequestration of dominated species. Canopy cover's percentage of two dominated species *(Artemisia sieberi* Besser and *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 and *Stipa barbata* Desf. is different in three regions. It, of course, has not 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 is not valuable statistical difference in terms of total amount of carbon sequestration to three sites.

Key words: Carbon sequestration, The Industrial revolution, Greenhouse gases, *Artemisia sieberi* Besser, *Stipa barbata* Desf., Steppic rangelands.

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 is called total economic value (TEV) in which the indirect production of rangelands, as untradeable goods, is going to be notable in the world that regulation of greenhouse gases is one of them(15). Density of greenhouse gases 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 important gas of greenhouse gases (10) that its density is increasing after the 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 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 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 (*Helianthemum* sp.), *Dendrostellera lessertii* (Wikstr.) Van Tigeh., and sagebrush (*Artemisia sieberi*); plant's 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 is executable in each weather condition. The steppic rangeland of Iran has 46 million hectares which is formed the most area of country, so this research was carried out in 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.

Material and Method

Study Area Features

The area of study 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 $35^{\circ}26'$ (Fig. 1).

Fig. 1. Location of the Area of Study 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 most occurred in fall and winter and the least occurred in summer. Soils of area 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 area of study are divided into two sections including 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* and Trin. & Rupr. and *Salsola tomentosa* (Moq.) Spach in Kotschy Open area also has *Artemisia sieberi* Besser as main species. Floristic list of the area of study is given in table 1 (2), (7) (11).

Table 1. Floristic List of the Area of Study

Species	Family	Form life	Palatability degree
Artemisia sieberi	Compositae	Shrub	II
Stipa hohenackeriana	Gramineae	Perennial grass	II
Astragalus chaborasicus	Papilionaceae	Perennial forb	I
Poa sinaica	Gramineae	Perennial grass	I
Stipa barbata	Gramineae	Perennial grass	II
Salsola tomentosa	Chenopodiaceae	Shrub	II
Salsola laricina	Chenopodiaceae	Shrub	II
Noaea mucronata	Chenopodiaceae	Shrub	II
Acantholepis orientalis	Compositae	Annual forb	III
Acanthophyllum glandulosum Boiss.	Caryophyllaceae	Shrub	III
Acantholimon festucaceum	Plumbaginaceae	Shrub	III
Achillea tenuifolia	Compositae	Perennial forb	III
Alhagi camelorum	Papilionaceae	Perennial forb	III
Amberboa turanica	Compositae	Annual forb	III
Andrachne fruticulosa	Euphorbiaceae	Shrub	III
Dendrostellera lessertii	Thymelaeaceae	Shrub	III
Gypsophilla pilosa	Caryophyllaceae	Annual forb	III
Heliotropium aucheri	Chenopodiaceae	Annual forb	III
Stipagrostis plumosa	Gramineae	Perennial grass	III
Ephedra strobilacea	Ephedraceae	Shrub	III
Bromus tectorum.	Gramineae	Annual grass	III
Scabiosa flavida	Dipsacaceae	Annual forb	III
Salsola lanata	Chenopodiaceae	Shrub	III
Capsella bursa-pastoris	Brassicaceae	Annual forb	III
Peganum harmala	Zygophyllaceae	Perennial forb	III
Bromus danthoniae	Gramineae	Annual grass	II

Research Methods

In order to estimate the considering communities, stand area is determined under three sites including long term and mid-term exclosures and grazing area (GA). Every site is located on same gradient including 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 stocks of each species include old and young plants were 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 less than 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.

$$OC= 0.54\ OM \quad (1)$$

The collected data was processed in Excel 2003. The analysis of data was done by Spss v.17. In order to investigate and compare carbon sequestration between biomasses, ANOVA analysis was employed. For the purpose of comparison between the carbon sequestration rate of corresponding biomasses, independent t-test and between surface and subsurface biomasses for each site, paired t-test were employed.

Result Features of Soil Surface and Vegetation Cover

An abstracted result of soil surface and vegetation percentage from of cover 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 2. 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 3. The Canopy Cover of the Dominated 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 4. The Amount of Conversion 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 5. Comparison of the Carbon Sequestration 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 including long-term (45 EX) and mid-term (25 EX) exclosures and grazing area (AG) using independent t-test. As it shows, there is significant difference between subsurface biomasses of two species in the three sites while in the case of aerial phytomass, it is not meaningful.

Table 6. Comparison of the Carbon Sequestration 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. The analysis showed that there are significant differences between two species in three areas (Table 7).

Table 7. 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 areas of study Area

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 (Fig. 2).

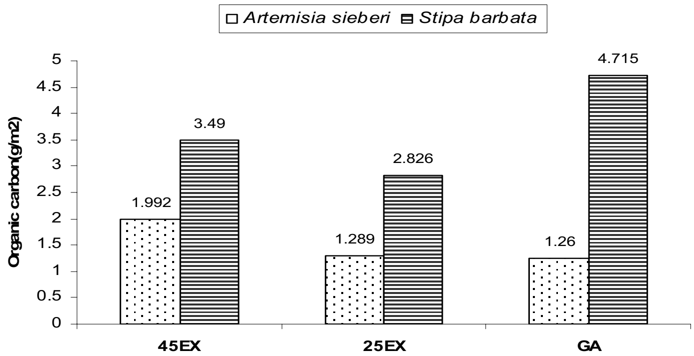

Fig. 2. Total Carbon Sequestration of Two Species

Discussion and Conclusion

In this study, we have shown that grazing livestock is one of the most effective factors upon the vegetation cover and the bare ground. 75 percent of GA is formed by bare ground and 36% is for 25 EX as Zhao *et al.* (2000) have also reported. Ironically, 45 EX has bare ground less than 25 EX which can be explained after 45 years closing of this area and ungrazed activities of vertebrate and invertebrate organisms such as rabbits and ants, the percent and density of plants species, especially dominant species, *Artemisia sieberi* Besser, have been decreased, because annual plant species is occupying the vacant surfaces (11). This study showed that vegetation and litter have been died out due to grazing and other living things activities, the percent of bare ground increased and the rate of wind erosion consequently increased. Although the rate of erosion has not been calculated, the soil motion, way of spilling particles, soil particles, accumulated soil bottom of shrubs and wind erosion are seen as Yong *et al.* (2003) has reported the similar results. Conversion factor of the biomass weight to organic carbon showed that the ability of carbon sequestration in parts of *Stipa barbata* Desf in every square meter is less although it is dominated species in the study area. This result is opposite of Hill *et al.* (2003) opinions who expressed dominant species performs the most percent of canopy cover in carbon sequestration. It is because of mineral changes in parts of plant organs. If the rate of minerals be high, conversion factor will be less as Bordbare *et al.* (2006) have pointed out. The rate of carbon sequestration to above ground biomass of *Artemisia sieberi* Besser in comparison to underground biomass in GA and 25 EX has significantly different, but it is not seen in 45 EX. This difference can be justified by the ants activities which surround baseline of this species and accumulating of carbon into soil by decomposition of died root. Above and below ground biomass of *Stipa barbata* Desf. are significantly different. The rate of carbon sequestration of ground biomass of this species (g/m² per unit area) is almost twice and sometimes more than triple, especially in the GA. Hence, above biomass caused the difference and could have significant effect on rate of carbon sequestration of the entire species. This species is more effective than *Artemisia sieberi* Besser. It can be due to lack of the vertebrate and invertebrate activities and the lack of roots decomposition. The rate of carbon sequestration of above and underground biomass in the three sites has significantly shown the 99% difference so that classification of Duncan test of them has divided into two groups include 45 EX in one group, and 25 EX and GA in other group. The same results for *Stipa barbata* Desf are obtained. These results confirm 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 site is more than above biomass, however this result for *Artemisia sieberi* Besser is obtained only in 45 EX reverse of two other sites. This finding shows that different parts of vegetation have different ability to sequestrate the carbon as Bordbar *et al.* (2006) and Frozeh *et al.* (2008) have revealed it. There is one reality that despite of different responses of the carbon sequestration of two mentioned species in the exclosure condition; the carbon sequestration under exclosure management, regardless of grazed condition, has not totally changed, so the rate is 5.482 g/m² in 45 EX, 4.115 g/m² in 25 EX, and 5.975 g/m² in GA. Systemic management of vegetation, therefore can perform an important role in the carbon sequestration through different species. Hence, presence of two mentioned species in a wide area of Iran is necessary in order to achieve the sustainable management. It can show us better utilization of vegetation on the basis of the species abilities to produce the forages for animal and sequestrate the carbon.

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