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Efficiency of canopy cover measurement of *Artemisia sieberi* stands by two sampling methods in different lengths (Case study: steppe vegetation of Baft region, Iran)

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Abstract

Seasonal and annual variations of canopy cover in shrub stands of arid ecosystems necessitae a closer look. This research was conducted in 2015 to establish a wheel-point device and evaluate its efficiency (precision, accuracy and time) for estimation of canopy percent in a pilot Artemisia stand in Khabr region of Baft, Kerman Province, Iran. Several transects with different lengths (30, 60, 90, 120, 150 and 180 m) were established using a randomized sampling block design with five replicates. Measurement of canopy percent of dominant species and the associated plants was carried out by transects as linear-contact (control treatment) and using wheel-point device. The standard deviation and relative error of each treatment, compared to control and the time criterion were considered for precision and accuracy of the sampling method and its efficiency. The relationship between control data and wheel-point method was presented by the help of a regression model. Results indicated that in the sampling through linear-contact method, the optimum length was 30 m for dominant species, associated plants and total species population. Also, results showed that in sampling through wheel-point device method for dominant species, the optimum transect length was about 60 m; while for the associated species and the total species population the optimum length was 120 and 150 m, respectively. According to the results of regression model on data from wheel-point method and the transect, coefficient of determination was 57 and 67% for the dominant and associated species, respectively.

Keywords: Wheel-Point, *Artemisia sieberi*, Precision, Efficiency.

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Introduction

Canopy of plant species refers to the vertical shadow of plant on the land and is estimated in percent (Gonsamo *et al.,* 2013). Canopy cover is often used as a criterion for classifying stand structure (Canfield, 1941). This important parameter has a close relationship with the production of plant species and is regarded as one of the production estimation methods (Asadpoor *et al*., 2011); in addition, it is considered as one of the effective parameters in assessing soil erosion and sedimentation (Mokhtariasl and Mesdaqi, 2007; Najafian *et al.,* 2010). Canopy cover of some shrubs provide a microclimate for other species (Shahrakht *et al.,* 2013). Through measuring this significant parameter, plant species composition can be quickly assessed in a specific region. Canopy index of species has been the subject of studies when interpreting the satellite images (Arzani *et al.,* 2009). This parameter is one of the determinants of range status and tendency and has plenty of applications in many range management programs. Some of the canopy measurement methods include the surface (latticed plots), point (point-phase, point-wheel, point-frame and point-transect), longitudinal (linear-contact) and imaging methods (Moqadam, 2005). Vegetation of a specific region and its plant population type, topographic conditions, the desired precision and speed of measurement have been discussed when using various sampling methods. Due to seasonal and annual variations of canopy cover in shrub stands of arid ecosystems (Abtahi *et al.,* 2009), more studies on this is necessary. Borhani (2001) studied vegetation and density estimation methods for Artemisia stands of Isfahan in three regions to compare the methods with respect to accuracy and time. Results have shown that among various methods of vegetation estimation in the three studied regions, the imaging and measuring methods of two perpendicular diameters inside the quadrate had no meaningful difference compared to the control treatment. Two theoretical vegetation estimation methods inside the quadrate (the divided estimation inside quadrate and estimation in a 10×10 cm area) had lower value than the control whereas the resultant estimation of two point methods were higher than control in the three regions. Fiala *et al.* (2006) compared five canopy cover estimation techniques including line-intercept, spherical densiometer, moosehorn and hemispherical photography and crown radii parameters in the western Oregon Cascades. Results showed that the level of difference between line-intercept and the other ground based methods depended on the abundance of trees with open, spreading crowns relative to the abundance of trees with compact crowns. Godı´nez-Alvarez *et al.* (2009) compared three methods including line-point tracking, point-network tracking and eye estimation for investigation of vegetation to assess the environment and for supervision. Qanbarian *et al.* (2009) investigated the efficiency of various measurement strategies in measuring and assessing the range vegetation of southern Zagros rangeland and concluded that the randomized systematic strategy had a higher efficiency concerning precision, accuracy and time as compared to the other strategies; mass strategy can be applied as the alternative approach for evaluation of the canopy. Arzani *et al.* (2011) in a study of the relationship between canopy, leaves and branches with the range production reported that canopy, leaves and branches in almost all species had a close and reliable relationship with the production. Moameri *et al.* (2011) applied the land imaging for measuring the vegetation of surface and density of range plants in Taleqan and stated that there was no meaningful difference between two methods of direct and imaging for almost all the species. Kgosikoma *et al.* (2012) measured canopy cover of rangelands by wheel point device and arrived at reliable results. Abate *et al.* (2012) evaluated rangelands of arid and semi-arid grazing areas of south east Ethiopia using wheel point and concluded that less desirable grass species dominated the heavily grazed sites while highly desirable grass species were most frequent on the light grazed areas. Kristen and Dexter (2013) studied three estimation methods of tree canopy and concluded that using the canopy estimation method by the means of USDA data and its complementary method (using the cameras next to the roads) is essential to estimate the jungle vegetation in cities. Gonsamo *et al.* (2013) resulted that photography was less time, labour and resource intensive, as compared to point based measuring techniques of canopy element cover and openness in the forest ecosystems.

Based on the importance of canopy percent as an effective parameter in assessing other parameters such as production, status, tendency, erosion and sediments, it is of considerable importance in the rangeland studies to introduce a suitable method for measuring this significant parameter which will also reduce field operations, costs and expert judgements while having a sufficient precision and accuracy. Although the linear-contact method is the most precise one in measuring the canopy, there may be some errors in sampling due to wind and dry and semi-dry climates (it requires longer transects). In addition to these limitations, the linear-contact method is time consuming although it presents correct results. In order to reach correct conclusions from the sampling of canopy in the shrubbery during a short period and eliminate the interfering effect of sampling conditions such as wind and transect length, it seems useful to also use the wheel-point device.

According to high surface of shrubbery in Kerman and appropriateness of wheel-point method for measuring the canopy of these rangelands (Mesdaqi, 2004) on the one hand and lack of this device in the departments, research centers and universities on the other, this research aimed also at designing a wheel-point device, determining its efficiency (precision, accuracy and time) in a pilot shrubbery and comparing the canopy cover percent in different lengths measured by wheel-point device and linear-contact transect method as control treatment.

Materials and Methods

Case study

An *Artemisia sieberi* vegetation was selected in a region around Khabr National park of Baft, Kerman Province, Iran in 2015 located between longitudes 56° 7' 27" and 56° 4' 42" and latitudes 28° 2' 45" and 28° 8' 54" with similar climatic and topographic conditions. The regionhas been exploited in a grazing management design since 2004. Annually, 920 livestock graze the rangelands with the area of 4000 ha in the region (Bagheri *et al.,* 2014).

Mean rainfall is 275 mm for a 30-year period (1981-2011) based on the climatology station of Dehsard (Bagheri *et al.,* 2014). Embrothermic curve of the study area has been illustrated in Figure 1. Temperature indices including moderate, absolute maximum and absolute minimum have been estimated as 15, 40 and 6.6 °C, respectively according to the synoptic station of Baft during 1981-2011, relative moisture percent is 28.8% and the soil texture is sand-loamy (Bagheri *et al.,* 2014).

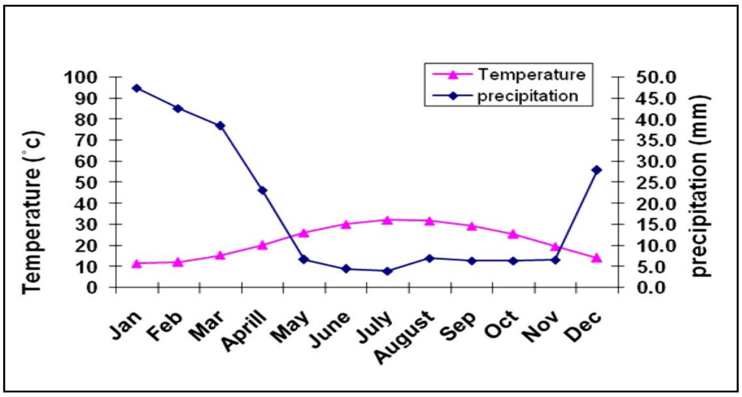


Figure 1. Embrothermic curve of the study area.

Research methodology

First section of this paper refers to the design of wheel-point device. After designing the device with two sharp bars for sampling and several components such as handle and wheel, the diameter is designed with the harvest intervals of 1 m on the ground based on dimention and individual distance of *Artemisia sieberi* populations in Khabr shrub lands; and the sampling is performed systematically (Figure 2).

Figure 2. Images of wheel-point device designed for sampling and the *Artemisia sieberi* stands studied.

After specifying a site with the dominant species of *Artemisia sieberi* in Khabr, Baft, sampling was carried out. First, some transects with different lengths (30, 60, 90, 120, 150 and 180 m) were established using the randomized sampling with five replicates in order to measure canopy cover percent through transect and the made device.

Canopy cover percent between lengths in the two methods were compared using ANOVA test and comparison of average canopy cover percent was implemented using Duncan test method. The line transect method was considered as control treatment (Fiala, 2003; Moqadam, 2005).

After measuring the contact length of species and to measure the canopy percent, the control treatment was used to select the optimum length in comparison with wheel-point device. Then, standard deviation, relative error and time criterion were regarded as the precision (Equation 1), accuracy (Equation 2) and sampling time indices for assessing and ranking the efficiency (Mosaee Sanjarei and Basiri, 2008) as below formulas:

$$\Pr ecision = \sqrt{\frac{(x_i - \bar{x})^2}{(n-1)}} \qquad (1)$$

$$Accuracy = (w - c) \qquad (2)$$

where, x_i is the ith observation, $\bar{x}$ is sample mean, n is the sample number, w is estimation of the determined length in wheel-point method and c is estimation of the related length in linear-contact transect method.

Efficiency was evaluated in the three following scenarios to determine the optimum length of sampling using two methods of transect (control) and wheel-point:

1. Regarding the dominant species.
2. Regarding the associated species.
3. Regarding the dominant and associated species (all the species).

The relationship between control and wheel-point data was fitted with the best regression model.

The length of transects were 30, 60, 90, 120, 150 and 180 m which were equally spaced (30 m) and this variable was considered as independent variable (*X*). The relationship between response variable (measured cover percentages) (*Y*) and independent variable (*X*) was evaluated by linear regression model. One of the important assumptions of linear regression is the normality of response variable (*Y*) that was tested using Kolmogorov-Smirnov normality test. Therefore, for the two methods of sampling through wheel points and transects, two regression lines were plotted.

Results

Floristic list

According to Table 1, in the sampling and regardingto the highest rate of canopy cover percent, only sagebrush (*Artemisia sieberi*) was introduced as the dominant species. The result illustrates that majority of the associated species with *Artemisia sieberi* are shrubs with lower canopy cover percent (Table 1).

Table 1. Floristic list of Artemisia type of study area.

Species name	Species role in vegetation type	Family	Vegetation form	Palatability class	Longtime life
Acantholimon festucaceum	Associated	Plumbaginaceae	Shrub	II	Perennial
Alyssum marginatum	Associated	*Cruciferae*	Forb	II	Annual
Astragalus albascolinus	Associated	Papilionaceae	Shrub	III	Perennial
Artemisia sieberi	Dominant	Asteraceae	Shrub	II	Perennial
Bromus tectorum	Associated	Gramineae	Grass	III	Annual
Boissiera squrrosa	Associated	Gramineae	Grass	III	Annual
Echinops gedrosiacus	Associated	Asteraceae	Forb	II	Perennial
Lactuca orientalis	Associated	Asteraceae	Shrub	I	Perennial
Launaea acanthodes	Associated	Asteraceae	Shrub	III	Annual
Noaea mucronata	Associated	Chenopodiaceae	Shrub	III	Perennial
Stipa barbata	Associated	Gramineae	Grass	II	Perennial

Statistical data

These results showed the effects of sampling length on canopy cover of dominant and associated species are significant in each method. Comparing mean of canopy cover percent using Duncan method in Table 3 depicts differences of each sampling length by index. Results illustrate irregular changes of sagebrush and associated species canopy cover in the linear contact transect and wheel-point device with increasing of sampling length (Table 2).

Table 2. ANOVA test of canopy cover obtained by linear-contact and wheel-point methods.

Sampling methods	Sampling length (m)	Df	Sagebrush	Associated species
			F	F
Linear-Contact Transect	Length	5	20.262**	48.547**
	Error	24		
	Total	30		
Wheel-Point Device	Length	5	23.566**	15.239**
	Error	24		
	Total	30		

** -Significant in 0.99 confidence level.

Table 3. Comparing mean of canopy cover percentage estimated in linear-contact and wheel-point methods through Duncan test method.

Sampling methods	Sampling length (m)	Sagebrush	Associated species
		Mean±Standard Deviation	Mean±Standard Deviation
Linear-Contact Transect	30	25.46 BC± 0.55	9.00 C± 0.43
	60	24.98 C± 0.95	12.92 A ± 0.63
	90	24.92 C± 0.26	10.94 B ± 0.85
	120	23.85 D± 1.57	10.33 B ± 0.82
	150	24.77 B± 1.69	8.27 D ± 0.23
	180	26.01 A± 2.70	7.33 E ± 0.42
Wheel-Point Device	30	31.116 D ± 2.25	19.084 A ± 2.22
	60	38.532AB ± 0.85	19.121 A ± 2.90
	90	40.470 A ± 0.87	15.147 B ± 2.09
	120	38.032 B ± 1.23	13.800 BC ± 1.96
	150	33.558 C ± 1.89	11.405 CD± 1.63
	180	36.532 B ± 1.90	10.470 D ± 1.64

Scoring and ranking to select the optimum harvest length

According to Table 4, increasing the sampling length was time consuming in both linear contact transect and wheel-point methods. The irregular changes of standard deviation (as precision index) of the associated species were seen with increasing the sampling length of linear contact transect and wheel-point methods. There existed rising changes in standard deviation of dominant species in wheel-point method with increasing the sampling length. In spite of irregular changes of sagebrush accuracy, a lowering rate of associated species was seen by increasing sampling length in the wheel-point method (Table 4).

After considering their scores, sampling in different lengths of transects were performed considering the dominant, associated and total species and the efficiency of the three mentioned scenarios. The results have been shown in Table 5. Ranking was implemented such that the lower scores assigned better ranks (Table 5).

Table 4. Precision, accuracy and time indices in linear-contact and wheel-point methods.

Sampling methods	Sampling length (m)	Time (s)	Sagebrush			Associated species		
			Standard deviation (precision)	Mean	Mean difference with control (accuracy)	Standard deviation (precision)	Mean	Mean difference with control (accuracy)
Linear-Contact Transect	30	300	0.555	25.460	0.000	0.434	9.000	0.000
	60	595	0.951	24.980	0.000	0.634	12.917	0.000
	90	805	0.259	24.920	0.000	0.851	10.944	0.000
	120	1005	1.573	23.850	0.000	0.820	10.333	0.000
	150	1275	1.689	24.770	0.000	0.226	8.267	0.000
	180	1566	2.701	26.010	0.000	0.425	7.333	0.000
Wheel-point Device	30	240	2.251	31.116	5.656	2.225	19.084	10.084
	60	390	0.846	38.532	13.555	2.905	19.121	6.204
	90	510	0.869	40.470	15.552	2.092	15.147	4.203
	120	633	1.227	38.032	14.185	1.956	13.800	3.467
	150	783	1.886	33.558	8.789	1.632	11.405	3.139
	180	938	1.904	36.532	10.518	1.636	10.470	3.136

[*] for determining the efficiency of dominant and associated species, time equals two-third and one-third of the whole sampling, respectively.

Table 5. Efficiency characteristics in linear-contact and wheel-point methods.

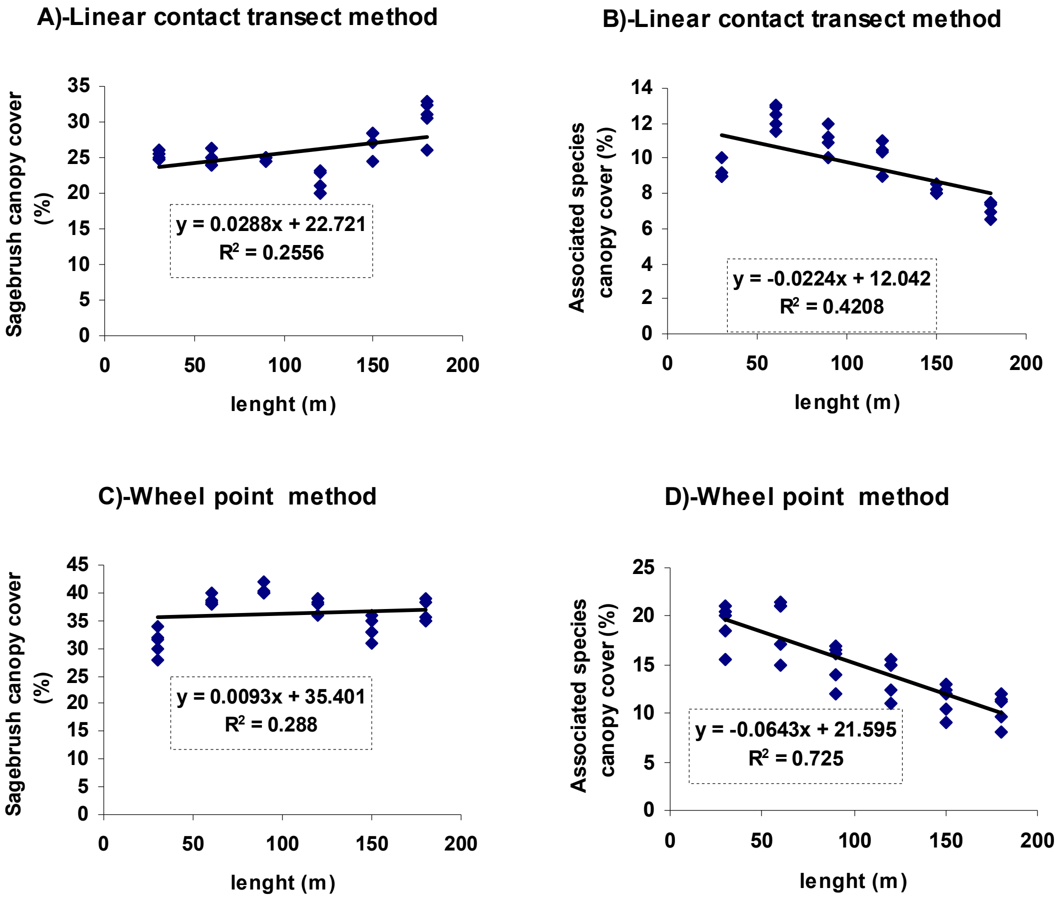
Sampling methods	Sampling length (m)	Sagebrush		Associated species		Time	Efficiency of dominant and associated species	Efficiency of dominant species	Efficiency of Associated species
		Standard Deviation (precision)	Mean difference with control (accuracy)	Standard Deviation (precision)	Mean difference with control (accuracy)				
Linear-Contact Transect	30	2	1	3	1	1	1	1	1
	60	3	1	4	1	2	2	3	2
	90	1	1	6	1	3	3	2	5
	120	4	1	5	1	4	5	4	6
	150	5	1	1	1	5	4	5	3
	180	6	1	2	1	6	6	6	4
Wheel-point Device	30	6	1	5	6	1	5	2	5
	60	1	4	6	5	2	3	1	6
	90	2	6	4	4	3	6	3	4
	120	3	5	1	3	4	2	5	1
	150	4	2	2	2	5	1	4	2
	180	5	3	3	1	6	4	6	3

[*] for determining the efficiency of dominant and associated species, time equals two-third and one-third of the whole sampling, respectively.

Presentation of regression model

Linear regression model between lengths of transect as independent variable (X) and response variable as estimated cover percentages (Y) is illustrated in Figure 3. The results showed better relation for the associated species in comparison with sagebrush species in linear-contact and wheel-point methods.

Results of regression model of wheel-point and control data for estimating the dominant and the associated species have been presented in Figure 4. It should be noted that drawing the graphs after testing logarithmic, linear, powered and exponential and regression models through trial and error method led to the selection of the best regression model. In this respect, regression model results indicated that the model of wheel-point data was not linear to estimate the dominant and associated species as compared to the control.


A)-Linear contact transect method

B)-Linear contact transect method

C)-Wheel point method

D)-Wheel point method

Figure 3. The linear regression model between canopy cover or response variable (*Y*) and length of transects as independent variable in linear-contact transect method (A and B graphs) and wheel-point method (C and D graphs).

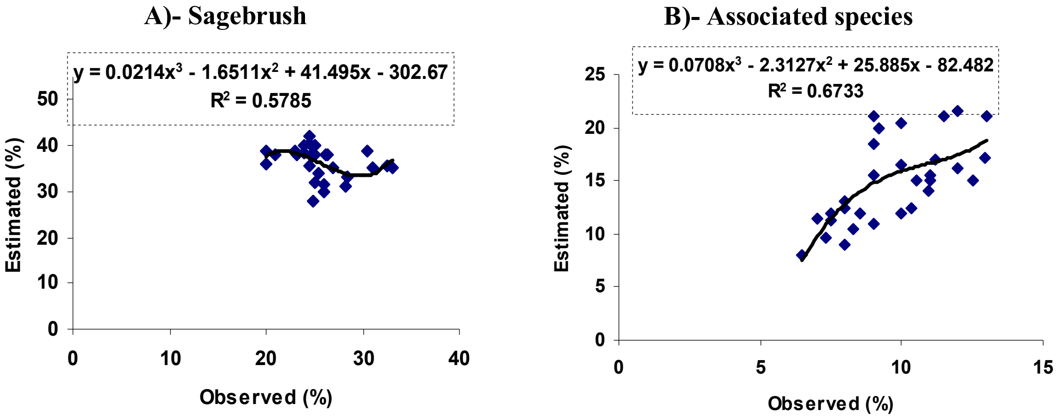


Figure 4. The regression model between wheel-point device estimated data and linear-contact transect as observed data for dominant species (A graph) and the associated species (B graph).

Discussion

Research results indicated that in sampling with the control treatment with three states of dominant, associated and total species, the optimum sampling length was 30 m. Accordingly, we propose that for sampling with control treatment in future researches in similar regions, the transect length should not exceed 30 m since the increased sampling length is unlikely to lead to the increased efficiency.

Results indicated that in sampling with the wheel-point method, the optimum harvest transect length is 60, 120 and 150 m concerning the dominant, associated and total species, respectively. According to the results obtained by the regression model of wheel-point and control data, determination of coefficient has been given as 57 and 67% for the dominant and associated species, respectively. These models illustrate a satisfactory relationship between the two used methods and indicate a non-linear relationship between wheel-point and transect data concerning the dominant and associated species. It seems that in the regression model, the wheel-point method estimates well in places with more and less dominant vegetation. Furthermore, when the vegetation percent of the associated species is increased, the wheel-point method estimates with more deviations in contrast to the increased associated species. Therefore, it is suggested that the efficiency of wheel-point method is investigated in dense Artemisia stands with low and moderate densities of the dominant and associated species.

Regression results demonstrated that the wheel-point and control data may be more precise in the estimation of the associated species as compared to the dominant ones; though this research has been conducted in a pilot design in Baft, Kerman showing that the data are relatively close to the transect ones. Based on the research results, the optimum transect length was 150 m for the wheel-point method and we propose that other regression models be developed for Artemisia types in highly harvested areas for and afterwards, the optimum length is determined. Also, the efficiency evaluation of wheel-point method with regard to other vegetative types such as shrubbery and rangelands with forbs and wheat is worth studying in future. Since the sampling time with wheel-point method is considerably shorter in comparison with the control treatment, we propose that in addition to the elimination of designed device faults, its efficiency should be assessed for other vegetation properties in order to enhance and allocate the device for each plant population while sampling to distinguish the device faults.

Wheel diameter of the designed device was set such that it records one harvest at the area of 1 m. Although the diameter has no problem for sampling the Artemisia stands, for extending the use of this device in different vegetative forms, it may be suggested that a variety of devices are designed with various diameters in order to improve the precision, accuracy and time indices.

Given the possibility of using several small tools and installing them on the wheel handle with low cost and short sampling time, we suggest that instead of taking notes by paper and pen in the wheel-point method, at least 5 to 7 secondary means are installed on the device. As such, it is possible to allocate each secondary means to one specific species in the Artemisia stands. Considering the field experience of user, we can predict that sampling time will be reduced by means of the introduced device and in addition, it enables us to achieve the appropriate results with regard to canopy statistics during a short period of time.

Since, no powerful regression relationship was found between sampling lengths and canopy cover of dominant species and the associated species measured by each method (including wheel-point device and linear-contact transect method) and as sampling lengths significantly affected these variables based on Duncan test, we suggest researchers to have a serious attention to sampling lengths as the affecting factor on results.

Conclusion

According to the results of this research, measuring canopy cover of sagebrush and the associated species using wheel-point needs longer line in comparison to line contact transect method and efficiency of the wheel-point for the associated species of *Artemisia sieberi* was 10% better than the line contact transect method. Considering the good relationship between wheel-point device and linear-contact transect method for measurement of dominant and the associated species for canopy cover estimation, the wheel-point device is selected to reliably assess *Artemisia sieberi* stands is Kerman Province and other similar regions of Iran.

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