Caragana Establishment, Survival and Regeneration in the Black Hills, South Dakota

Daniel W. Uresk, USDA Forest Service, Rapid City, SD 57702
Thomas M. Juntti, USDA Forest Service (Retired), Rapid City, SD 57701
Donald R. Dietz, USDA Forest Service (Deceased), Rapid City, SD 57701

Abstract

The purpose of this study was to determine the adaptability and potential wildlife value of Caragana also known as Siberian peashrub for establishment, survival, growth, regeneration, and nutritional qualities. This study was initiated in 1968 in the Black Hills, South Dakota on the McVey Burn (1939), within an open stand of a ponderosa pine forest. Bare rootstock was planted in 1968, and after 35 years survival was 74 percent. Average height was 3 m (10 feet) and plants did regenerate by seed bt did not expand into adjacent habitat. Ideal growing condition evaluated at 35 years, was in a closed tree canopy with 35 percent overstory and basal area 17.7 m^2/ha (77 ft^2/ acre). Open growing conditions was had exposed areas, canopy cover 17 percent and basal area 5.4 m^2/ha (24 ft^2/acre). Tree overstory cover on North facing slopes was approximately 2 times greater than on more open south facing slopes. Caragana has not shown signs of spreading from original planting sites. A model developed for habitat assignment defining Closed and Open tree overstory cover for growth, regeneration, and establishment for future sites was 90 percent accurate. Utilization of Caragana by deer based on volume (length x width x height) was 77 percent, 12 years after establishment, with greatest use on south facing slopes. Nutritional qualities of Caragana are generally greater than native shrubs for winter use, with only phosphorous being marginal. The adaptability of Caragana and its qualities makes this browse species suitable for white-tailed deer use for winters. Plantations of Caragana in key wintering areas for white-tailed deer on south facing slopes with Open tree overstory cover and low basal area is recommended for restoration on over browsed ranges.

Key Words: Deer, Browse, Nutrients, Plantations, Growth, Forage, Sagebrush

Introduction

A loss of deer habitat in the Black Hills of South Dakota has been documented for over 60 years, primarily with the deterioration of native browse plants (Berner 1953, Bever 1959). More recently, white-tailed deer (*Odocoileus virginianus*) has been in a steady decline (Peterson 1984, Deperno et al. 2002) which is related in part to heavy livestock grazing and consumption of shrubs, interspecific competition with elk (*Cervus canadensis*) (Wydeven and Dahlgren 1983, Uresk 1987, Uresk and Paintner 1985), and habitat loss due to land development.

Many native shrubs are not able to compete with livestock grazing that result in low plant vigor on over browsed ranges and competition with grasses and introduced species. Introduction of native or introduced shrubs may be the best way to improve the availability and utilization of browse species. Establishment from seeding depends upon adequate precipitation and absence of competition from grasses and with favorable temperatures in early spring (Dietz et al. 1980). Shrub planting is an alternative to seeding. However, there have been limited shrub planting trials in the Black Hills (McEwen and Hurd 1959). Dietz et al (1980) reported excellent results of establishing shrubs in the McVey Burn (wildfire 1939) area for browse improvement. Caragana or Siberian peashrub (*Caragana arborescens*) initially showed some promise based on

limited plantings and may have potential for increasing the availability of winter browse on the McVey Burn site compared to other browse plantings (Dietz et al. 1980). Results from this study will aid in considering improvement of white-tailed deer habitat in key wintering areas.

The objectives of this study for Caragana were 1) determine long term survival of plantings, 2) regeneration, 3) utilization by white-tailed deer and nutritional qualities and 4) determine potential habitat conditions for plantings within the Black Hills of South Dakota.

Study Area

The study area was located on the McVey Burn, 16 km (10 miles) northwest of Hill City, South Dakota, near the center of the burn. It was a wildfire and encompassed 8,845 ha (21,857 acres) that burned in 1939 (Dietz et al. 1980). This area became one of the most used white-tailed deer ranges in the Black Hills during winter months. The elevation ranged from 1600 m to 1800 m (5249 feet to 5906 feet). Mean annual precipitation during the study period was about 51 cm (20 inches) and 80 percent of the moisture is from April to September. Current mean annual precipitation at Hill City, SD is 53 cm (21 inches) (Uresk and Dietz 2017). Growing season is approximately 89 days and temperatures range from -6.2^0 C (21^{0}F) to 35.5^0 C (96^{0}F).

The study area within the burn was an open stand of small immature ponderosa pines (*Pinus ponderosa*) with Saskatoon serviceberry (*Amalancher angustifolia*), Woods' rose (*Rosa woodsii*), little bluestem (Schizachyrium scoparium), prairie sagewort (*Artemisia frigida*), common snowberry (*Symphoricarpos albus*), and Kentucky bluegrass (*Poa pretenses*). Soils are of metamorphic schist parent material; top soil is 13-15cm (5-6 inches) (Dietz et al. 1980). Slopes range from 36 to 39 percent.

Methods

Ten rows (replications) of bare rootstock of Caragana were planted within an 8 ha (20-acre) area on the burn site (1939 wildfire) in the summer of 1968. Prior to planting, each individual plant location was grubbed to remove vegetation and planted 15 cm (6 inches) deep. Bare root plants were obtained from a nursery. Each replication consisted of Caragana planted within a row, 137 m (150 yards) in length along the contour of the slope at 2.4 m spacing (8 ft apart). Individual rows were marked with a rebar stake placed in the ground and information written on a metal tag tied to each stake. Each of the ten replications was planted with 56 plants for 560 plants. Plants were not protected from browsing.

Survival of plants was evaluated yearly for the first five consecutive years and then five additional years throughout the years including the 35th year. All parent plants (live and dead) were easily detected within rows. Heights of each plant were measured on each replicate (row). Regeneration from seeds of individual plants was counted in a 2.3 m^2 (25 ft^2) frame when densities were greater than 100 plants and when densities were less than 100 plants, they were counted within a 9.3 m^2 (100 ft^2) and standardized to plants/0.09 m^2 (1ft^2). All frames were spaced at a distance of 50 feet along each replication. Tree canopy cover (%) of ponderosa pine was estimated with a spherical densitometer at 15 m (50 foot) intervals at the same location. Basal area, m2/ha (ft^2/acre) was estimated with a 10-factor prism. Current annual growth of Caragana was collected during the winter and processed at the Rocky Mountain Research Station, Rapid City, SD. North and South Facing Slopes were defined and measured separately for basal area and canopy cover.

Caragana plants were measured for volume (length x width x height) pre and post use by white-tailed deer during winter months. The difference between pre and post volumes was estimated as use by deer. Pre was prior to deer arrival on the winter range and post was after the deer left the area.

All data were averaged by replicate (rows) for survival, height and density of Caragana, ponderosa pine (tree) canopy

cover, and basal area. The four variables (height, density, canopy cover, basal area) were subjected to a nonhierarchical cluster analyses (ISODATA) and standardized for equal weightings (Ball and Hall 1967, del Morel 1975). Stepwise discriminant analysis selected key variables to be used in the habitat stratification model. The model from discriminant analyses provided Fisher classification coefficients for assignment as to habitat stratification. Misclassification error rates or accuracy of model was estimated with cross validation using a jackknife or "leave one row out" procedure (SPSS 2003). All data were analyzed as means per replication (SPSS 2003).

Results

Survival rate was 74 percent after 35 years and the average height of Caragana was 3m (10 feet) and ranged from 1.2 to 5.8 m (4 to 19 feet) (Table 1). Regeneration averaged 1.4 plants/0.09 m^2 (1ft^2) and ranged from less than 0.2/0.09 m^2 to 4.5/0.09 m^2 (0.2 to 4.5 plants/ ft^2) (Table 1). Canopy cover of ponderosa pine ranged from 10 to 42 percent with a mean of 29 percent (Table 1). Mean basal area was 14 m^2/ha (61 ft^2/acre) ranging from 0.9 m^2/ha to 20.4 m^2/ha (4 to 89 ft^2/acre). A comparison of Caragana densities between north and south facing slopes was 0.95 /0.09 m (0.95/ ft^2) and 0.17/0.09 m^2 (0.17/ ft^2) (Fig. 1), respectively. North facing slopes had greater tree canopy cover (33%), compared to the south facing slopes (12%).

Cluster analyses (ISODATA) resulted in two distinct stratifications, defined as Closed and Open habitat, based on tree overstory canopy cover and basal area (Table 2). Closed growing conditions for Caragana are defined with a mean tree canopy cover of 35 percent and basal area of 17.7 m^2/ha (77 ft^2/acre). Mean heights and densities were 4 m (13 feet) and 1.7/0.09 m^2 (1. plants per ft^2), respectively. Open growing conditions were variable for trees with open areas. Ponderosa pine canopy cover was 17 percent and basal area 5.4 m^2/ha (24 ft^2/acre). Height and density of Caragana was 1.4 m (4.6 feet) with 0.6 plant/0.09 m^2 (0.6 plant/ft^2), respectively.

Discriminant analyses provided Fisher's classification coefficients (model) to predict and assign the habitat conditions for future site selections for planting of Caragana (Table 3). An example of applying the Fisher discriminant function coefficients with new data to determine the assignment for habitat stratification (Closed, Open) is determined by multiplying pine basal area (m^2/ha) for each row (Table 3). The products are summed (+ and -) including the constants for the score in each row. The greatest positive or the least negative score assigns the habitat stratification for Caragana. Mean values describing each stratification (Closed and Open) are presented in Table 2. Accuracy of habitat assignment is 90 percent.

Utilization of Caragana by white-tailed deer during the winter months (12 years after planting) was 77 percent based on volume (length x width x height) of the plants, pre and post measurements (Messner and Uresk 1980). Mean values of nutritional

Table 1. Overall means and ranges of key variables for Caragana and ponderosa pine after 35 years in the Black Hills of South Dakota. Standard errors (in parentheses).

Variables	n	Mean	Minimum	Maximum
Height (m)	10	3.1 (0.5)	1.2	5.8
Density (plants/0.09 m^2)1	10	1.4 (0.4)	0.2	4.5
Pine Overstory Cover (%)	10	29.3 (3.2)	10.1	42.2
Pine Basal Area (m^2/ha)	10	14.0 (2.1)	0.9	20.5

n= number of replications.
[1] 0.09 m^2 = 1ft^2

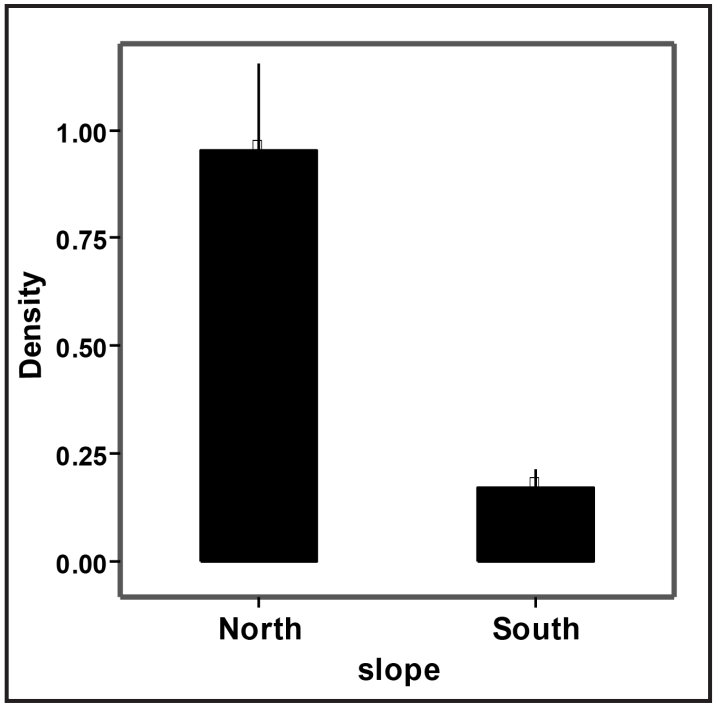

Figure 1. Regeneration (Density/0.09 m^2 ± standard error) of Caragana on north vs south facing slopes at 35 years after initial planting in the Black Hills of South Dakota. North facing slopes had a ponderosa pine overstory (33%) and south facing slopes are more open (12% overstory).

Table 2. Means of key variables and standard errors (Parentheses) for Caragana establishment within Closed and Open tree cover habitat stratification related to ponderosa pine overstory canopy and basal area at 35 years after establishment in the Black Hills of South Dakota.

Variable	Closed (n=7)[1]	Open (n=3)
Height (m)	4.0 (0.4)	1.4 (0.1)
Density (plants/0.09 m^2)[2]	1.7 (0.5)	0.6 (0.2)
Pine Overstory Cover (%)	34.6 (1.7)	16.9 (5.3)
Pine Basal Area (m^2 /ha)	17.7 (0.6)	5.4 (2.8)

[1] Replications

[2] 0.09 m^2 = 1ft^2

Table 3. Fisher's discriminant function coefficients for ponderosa pine basal area (m2/ha) stratified into two management options for planting Caragana in the Black Hills of South Dakota.

Variable[1]	Closed (n = 7)[2]	Open (n = 3)
Pine Basal Area (m^2/ha)	2.182	0.665
Constant	-20.037	-2.492

[1] Measurement Conversion: 1 m^2/ha = 4.356 ft^2/acre.

[2] Replications. Accuracy of stratification 90%.

constituents (%, oven dry basis) evaluated are: Protein (13.6), Acid Detergent Fiber (49.3), Acid Detergent Lignin (15.3), Ash (3.2), Calcium (1.0), and Phosphorus (0.1). Other nutritional values of native shrubs in the Black Hills for comparisons and related to deer requirements are presented by Dietz et al (1972a).

Discussion

Caragana known as Siberian pea shrub (legume) was introduced into the United States during the mid-1700s and is native to Siberia and Manchuria (Dietz et al. 2008). It occurs from southern Russia to China. The species readily adapts to a wide range of soils and unshaded areas. Contrary to information reported in the literature, the current study within a ponderosa pine forest provided different results. Caragana adapted to shaded, closed tree canopy cover, and was less common in open sunny areas as reported by others (Dietz et al. 2008, Shortt and Vamosi 2012, USDA-Forest Service 2019, USDA-NRCS 2019). Overall, regeneration at 35 years was 1.4 plants per 0.09m^2 (ft^2). The number of plants represents an expanding population in shaded areas only, but very few plants are located outside the planted study area. Thus, from initial plantings to 35 years, Caragana is expected to have little potential for spreading beyond the initial planted site.

Caragana grew best in the model defined Closed habitat with tree overstory canopy (35 years after initial planting) that averaged 35 percent canopy cover and basal area of 17.7 m^2/ha (77 ft^2 per acre). Regeneration was occurring within and among the rows but was not spreading throughout the area by seeds. However, in contrast, Caragana was planted adjacent to an aspen (*Populus tremuloides*) deciduous forest and invaded the stand with open areas in Canada, requiring control (Henderson and Chapman 2006). Tree canopy cover in Black Hills ponderosa pine forest was variable in the Open habitat with exposed sunny areas. Little to no regeneration of Caragana and limited growth was present in this habitat.

Caragana densities on north facing slopes under ponderosa pine canopy cover was approximately two times greater than on open south facing slopes. Plants on south facing slopes were shorter than north facing slopes, although few individual shrubs escaped browsing. South facing slopes are warmer, drier, and received more browsing from white-tailed deer. Other factors may also contribute to less regeneration and growth of Caragana. Generally, Caragana has been planted extensively as shrub strips, windbreaks on farmlands in open sunny areas, and is only tolerant to marginal shade (Dietz et al. 2008, Shortt and Vamosi 2012, USDA-Forest Service 2019, USDA-NRCS 2019).

Long-term survival of Caragana was highly successful at 74 percent after 35 years. Other native shrubs planted on the McVery Burn had lower survival rates from initial planting to 10 years, ranging from 0 to 31 percent (Dietz et al. 1980). These plants included, chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), silverberry (*Elaeagnus commutata*), silver buffaloberry (*Shepherdia argentea*), common juniper (*Juniperus communis*), antelope bitterbrush (*Purshia tridentata*) and mountain mahogany (*Cercocarpus montanus*).

The multivariate model developed (Closed and Open habitat stratification) can be used to quantify the relationship of Caragana height, tree canopy cover, and basal area in assigning stratifications for future plantings that will be successful in providing key wintering areas for deer. This model is 90 percent accurate and quantitative. Each habitat stratification provides characteristics of Caragana related to height and density, associated with tree canopy cover and basal area. Depending upon management objectives for establishment of Caragana in key winter areas for deer, two options are available, closed and open habitats.

Utilization of Caragana (plant volume) by white-tailed deer was 77 percent during the winter months 12 years after planting

and greatest on south facing slopes (Messner and Uresk 1980). A quicker snowmelt on south facing slopes than on north facing slopes allows deer easier access and longer access during the winter.

Nutritional qualities from winter samples of Caragana (current annual growth) are generally greater than native browse to meet winter requirements of white-tailed deer in the Black Hills based on studies by Dietz (1972a). Caragana has excellent nutrient values for maintaining and meeting white-tailed deer requirements for survival during the dormant winter season. Phosphorus is marginal for deer during winter months. Shrubs are also important food sources for both domestic, wild herbivores, birds, and other wildlife (Swihart and Yahner 1983, USDA-NRCS 2019, Dietz et al. 2008). Caragana is extremely important in providing pollinators with flowers and abundant seeds for insects (bees), many bird, and small mammal species that require food and shelter throughout summer and winter months (D. Mergen 2019, personal communication).

Based on deer use of Caragana, it is important to know the nutrient values as related to nutritional requirements of the animals during winter months. Dietz (1972a) presents an overview of shrubs, nutritional values and requirements for white-tailed deer in the Black Hills, SD. Native shrubs in the Black Hills generally have lower nutritive values for maintaining white-tailed deer during winter months than Caragana (Dietz 1972b, Dietz et al. 1980).

Shrub planting trials for improving white-tailed deer winter range have been limited in the Black Hills (Dietz et al. 1980). Caragana, based on survival, growth habits, utilization, and the nutritional qualities for a winter browse species has the potential to enhance the nutritional requirements and survival of deer during winter months on south facing slopes. The combination of characteristics possessed by the Caragana makes it suitable for wildlife "rescue" winter plantations on south facing slopes where native vegetation has been over utilized by livestock and native shrubs reduced or eliminated and not regenerating.

Acknowledgements

The authors would like to thank Charles P. Pase (Deceased), Wildlife Habitat Project Leader, for help with design and initiation of the study. Special thanks are extended to Harold Messner, Roger Kerbs for initial plantings and data collections. Thanks to the Black Hills National Forest for providing the research areas. Appreciation is extended to Drs. Dale Bartos and Daryl Mergen for providing reviews of the manuscript.

Literature Cited

Ball, G.H. and D.J. Hall. 1967. A clustering technique for summarizing multivariate data. Behavioral Science 12:153–155.

Berner, L.M. 1953. Deer management in the Black Hills of South Dakota. [Part I). South Dakota Conservation Digest 20:8-13.

Bever, W. 1959. Deer, land, people. South Dakota Conservation Digest 26:2-8.

del Morel, R. 1975. Vegetation clustering by means of ISODATA: revision by multiple discriminant analysis. Vegetation 29:179–190.

Deperno, C.S., J.A. Jenks, S.L. Griffin, L.A. Rice and K.F. Higgens. 2002. White-tailed deer habitats in the Black Hills. Journal of Range Management 55:242-252.

Dietz, D.R. 1972a. Nutritive value of shrubs. Pp. 289-302. *in* Proceedings of symposium: Wildland shrubs-their biology and utilization. 1971 July; Logan, UT. USDA-Forest Service. GTR INT-1. Ogden, UT: Intermountain Forest and Range Experiment Station.

Dietz, D.R. 1972b. Deer habitat evaluation in the Black Hills: Food habits and physical condition of white-tailed deer in relation to food production and nutritive quality. USDA-Forest Service. Progress Report. 33 p. Rapid City SD. Rocky Mountain Forest and Range Experiment Station.

Dietz, D. R., D.W. Uresk, H.E. Messner and L.C. McEwen, 1980. Establishment, survival and growth of selected browse species in a ponderosa pine forest. USDA-Forest Service. Research Paper RM-219. 11 p. Fort Collins, CO. Rocky Mountain Forest and Range Experiment Station.

Dietz, D.R., P.E. Slabaugh and F.T. Bonner. 2008. Caragana arborescens Lam.: Siberian pea shrub Pp. 321-323 in Bonner, Franklin T.; Karrfalt, Robert P., eds. The Woody Plant Seed Manual Agriculture Handbook No. 727. Washington, DC. US. Department of Agriculture, Forest Service.

Henderson, D.C. and R. Chapman. 2006. Caragana arborescens invasion in Elk Island National Park, Canadian Natural Areas Journal.26: 261-266.

McEwen, L.G. and R.M. Hurd. 1959. Deer exclosures. South Dakota Conservation Digest. 26:38-40.

Messner, H.E. and D.W. Uresk. 1980. Caragana (Caragana arborescens) production, nutrition, and utilization by white-tailed deer in western South Dakota. Society for Range Management, 33rd Annual Meeting, San Diego, California, February 11-14, 1980, Abstracts and Position Statements. P.52.

Petersen, L. E. 1984. Northern Plains. pp. 441-448. in L.K. Hall, ed. White-tailed deer: Ecology and management. Wildlife Management Institute. Harrisburg, PA: Stack pole Books.

Shortt, K.B. and S.M. Vamosi. 2012. A review of the biology of the weedy Siberian pea shrub, Caragana arborescens, with an emphasis on its potential effect in North America. Botanical Studies 53:1-8.

SPSS. 2003. Statistical procedures for social science. SPSS Base 12.0 for Windows User Guide. SPSS Inc., Chicago, IL, 667 pp.

Swihart, R.K. and R.H. Yahner. 1983. Browse preferences of jackrabbits and cottontails for species used in shelterbelt plantings. Journal of Forestry. 81:92-94.

Uresk, D.W. 1987. Diets of cattle in the Black Hills of South Dakota. pp. 33-35. in H.G. Fisser, ed. Proceedings: 16th Wyoming shrub ecology workshop; 1987 May 26-27; Sundance, WY. Laramie, WY: University of Wyoming, Department of Range Management.

Uresk, D.W. and W.W. Paintner. 1985. Cattle diets in a ponderosa pine forest in the northern Black Hills. Journal of Range Management 38:440-442.

Uresk, D.W. and D.R. Dietz. 2017. White-tailed deer habitat and winter diets in the Black Hills, South Dakota. Intermountain Journal of Sciences 23:22-34.

USDA-NRCS. 2019. The PLANTS Database. Available at: http://plants.usda.gov. [Cited 10 July 2019]. National Plant Data Team, Greensboro, NC 27401-4901 USA.

USDA-Forest Service. 2019. Invasive Trees and Shrubs. In-USDA Forest Service. Available at: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_037724.pdf. [Cited 10 July 2019]. National Plant Data Team, Greensboro, NC 27401-4901 USA.

Wydeven, A.P. and R.B. Dahlgren. 1983. Food habits of elk in the Northern Great Plains. Journal of Wildlife Management 47: 916-923.

Received 13 December 2019
Accepted 14 February 2020