MODEL FOR CLASSIFICATION AND MONITORING GREEN ASH—ECOLOGICAL TYPE IN THE NORTHERN GREAT PLAINS

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ABSTRACT

A multivariate statistical model was developed to classify seral stages and to monitor succession within the green ash (*Fraxinus pennsylvanica* Marshall)-chokecherry (*Prunus virginiana* L.)—western snowberry (*Symphoricarpos occidentalis* Hook.) ecological type on the northern Great Plains. Two key variables, green ash basal area (ft^2/acre) and Prunus species (% canopy cover) (Prunus species = chokecherry + American plum (*P. americana* Marshall)), provide all the information required for the model to classify seral stages and to be used to monitor trends within the ecological type. The model quantitatively identified four seral stages (early to late succession), all significantly different ($P < 0.001$), with an overall accuracy of seral stage assignment of 95%. It also showed that succession is not linear, but goes through multiple states among the four seral stages. These four defined seral stages provide resource managers with options to quantitatively evaluate and manage resources to meet objectives and monitoring plans. The model provides coefficients for application and input to qualitative state and transition models and is simple to use, reliable, repeatable, accurate and cost effective.

Keywords

Ecological type, succession, woodlands, monitoring, seral stages, diversity, state and transition models

INTRODUCTION

The study of vegetation dynamics has received increased emphasis over the last few decades. Investigation has been facilitated by advances in our knowledge of natural systems and by our increased capabilities to quantitatively analyze, model, and monitor community processes and functions (Glenn-Lewin and van der Maarel 1992). Concurrently, increased public awareness of natural resource management has dictated that public and private land managers be provided economical, yet powerful, quantitative tools to classify and monitor vegetation changes resulting from management decisions and activities.

Steady state and transition models to evaluate vegetation changes due to management activities and environmental conditions with ecological site descriptions have received much attention in recent years (Bestelmyer et al. 2003; Briske et al. 2005). However, these models are qualitative and based on expert opinion and personal judgments (Twidwell et al. 2013). Subjective estimates to determine vegetation trends and steady states of plant succession vary among observers, making it difficult to obtain consistent interpretations of successional processes (Kershaw 1973; Block et al. 1987).

State and transition models can be quantified by using multivariate statistical models that represent vegetation change related to environmental factors, management and plant succession (Uresk 1990; McLendon and Dahl 1983; Huschle and Hironaka 1980; MacCracken et al. 1983; Friedel 1991; Benkobi et al. 2007; Uresk et al. 2010a). These multivariate models with cluster analyses provide discrete groupings (plant phases or seral stages) that are related to key plants distributed throughout the ecological type. These models of plant succession allow resource managers to obtain quantitative measurements to evaluate ecological conditions found in rangelands and other environs. The approach outlined in this study can be applied to quantify state and transition models for community phases or seral stages and incorporated into current federal interagency ecological site descriptions (Bestelmeyer et al. 2003).

The concept of plant succession has been used in classification studies for western forests and rangelands for many years (Sampson 1919; Daubenmire 1952; Girard et al. 1989). Further, rangeland condition and classification methodologies have given managers a framework for evaluating vegetation changes in response to natural and man-induced disturbances.

Multivariate statistical models may offer a way to analyze quantitative data and to evaluate patterns of plant succession in an objective manner (Uresk 1990). Multivariate and ordination techniques have been successfully used to develop vegetation classifications, but none has provided practical tools for managers to use to quantify and monitor successional trends. The National Research Council (1994) provides reviews that discuss the values and limitations of these techniques.

Wooded draws, a complex of prairie woodlands composed primarily of the green ash ecological type, are generally a minor, but important component of the grasslands of the Great Plains. Although concentrated in some areas, they occupy approximately 1% of the total area in the Northern High Plains, which include Wyoming, North and South Dakota and Montana (Jakes and Smith 1982). These unique vegetation types are important wildlife habitats (Lesica and Marlow 2013). They not only provide forage and shelter for livestock, but also sustain soil and watershed stability, are a source of firewood, and enhance visual and species diversity in the prairie landscape (Girard et al. 1989). Livestock grazing is a predominant use of grasslands and associated woodlands, but has been implicated as the primary causative factor in degradation of the green ash ecological type (Severson and Boldt 1978; Lesica and Marlow 2013). The values of woodland habitats in Great Plains grasslands (Bjugstad and Sorg 1985) have dictated that these habitat types be properly managed. Knowledge of the current seral status and successional trend of green ash stands is a prerequisite for resource managers to determine compliance with desired plans for vegetation conditions and to implement management guidelines.

The purpose of this study was to develop a model that can be used easily by resource managers within a tree dominated green ash (*Fraxinus pennsylvanica* Marshall)-chokecherry (*Prunus virginiana* L.) - western snowberry (*Symphoricarpos occidentalis* Hook.) ecological type on the northern Great Plains and to determine resource conditions. The objectives were: 1) to develop an ecological classification and monitoring model for the green ash ecological type, 2) to define and describe the seral stages, and 3) to provide sampling and monitoring protocols.

STUDY AREA

The study was conducted in southwestern North Dakota, western South Dakota, and western Nebraska along the Missouri River, Lake Sharpe, Oahe Reservoir, and associated tributaries. Green ash stands were inventoried and sampled on the drainages of the Little Missouri, Heart, Cannonball, Grand, Moreau, Cheyenne, White, and Niobrara Rivers, all of which drain into the Missouri River.

Vegetation—This ecoregion is a moderately dense, short to medium-tall grassland dominated by western wheatgrass (*Pascopyrum smithii* (Rydb.) Á. Löve), blue grama (*Boutelous gracilis* (Willd. ex Kunth) Lag. ex Griffiths), green needlegrass (*Nassella viridula* (Trin.) Barkworth), and buffalograss (*Buchloe dactyloides* (Nutt.) J.T. Columbus) (Kuchler 1964). Drainages may be dominated by shrubs or, in more mesic situations, trees. Common shrubs include silver buffaloberry (*Shepherdia argentea* (Pursh) Nutt.), western snowberry, chokecherry, Saskatoon serviceberry (*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roem.) and skunkbush sumac (*Rhus trilobata* Nutt.). Trees may include green ash, American elm (*Ulmus americana* L.), boxelder (*Acer negundo* L.), hackberry (*Celtis occidentalis* L.), and bur oak (*Quercus macrocarpa* Michx.). Plains cottonwood (*Populus deltoides* W. Bartram ex Marshall) and willows (*Salix* L. spp.) are common codominants on floodplains of lower order drainages. Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) is found on shallow soils of steep north facing slopes along drainages leading to the major rivers (Severson 1981). Plant nomenclature followed USDA-NRCS (2014).

Climate—The climate of the northern Great Plains is semi-arid continental and characterized by wide daily and seasonal fluctuations in temperature and by erratic precipitation. Average annual precipitation ranges from 13.8 in (354 mm) in southwestern North Dakota (Medora) to 18.3 in (464 mm) in northwestern Nebraska (Harrison). May and June are the wettest months and 75% of the annual precipitation falls from April through September. Locally severe thunderstorms are common in summer (Hansen et al. 1984). Mean annual precipitation at Bismarck, ND, is 16.4 in (417 mm) with an average maximum temperature of 52.7 °F (11.5 °C) and minimum temperature of 29.8 °F (-1.2 °C). Mean annual precipitation at Pierre, SD, is 17.7 in (450 mm); annual maximum and minimum temperatures are 59.2 °F (15.1 °C) and 35.2 °F (1.8 °C), respectively. At Chamberlain, SD, mean annual precipitation is 23.6 in (599 mm) with average maximum and minimum temperatures of 59.5 °F (15.3 °C) and 34.8 °F (1.6 °C), correspondingly (HPRCC, 2015).

Physiography and Vegetation—Topography is the most important factor delineating the distribution of the green ash- chokecherry-western snowberry ecological type (Girard et al. 1989; Hansen et al 1984). In North Dakota, green ash is restricted to the bottoms, lower sides, and north-facing slopes of intermittent drainages; hence, stand areas are generally long and narrow. The largest trees occur near the bottom of the stand where there is greater soil moisture (Hansen et al. 1984; Girard et al. 1989; Lesica and Marlow 2013). Southward into South Dakota and Nebraska, this type tends to be found only in bottoms and on lower north-facing slopes. Shrubs on upper drainages may replace trees where moisture becomes more limiting (Severson 1981).

Green ash is the dominant tree in all stages, but American elm has been found in enough stands to warrant the designation of a separate phase in North Dakota (Girard et al. 1989). The status of these communities is, however, nebulous because of the presence of Dutch elm disease which has significantly impacted American elm trees in some areas of North Dakota with a large number of trees dead or dying (A. Duxberry, 2015. ND Game and Fish, personal communication). While many trees have not been infected, the nature of these woodlands will change if the disease reaches epidemic proportions. Boxelder, hackberry, and bur oak also occur in these habitats; the latter two becoming more prevalent in South Dakota. Scattered Rocky Mountain junipers will also be found in some green ash habitat types.

A shrubby border between the woodlands and grasslands also characterizes this ecological type. The border is in stair-step form beginning with the shorter grasses on the uphill side to shrub species of western snowberry, Wood's rose (*Rosa woodsii* Lindl.), skunkbush sumac, and silverleaf buffaloberry; then to taller species such as chokecherry and American plum. The border then grades into the green ash woodland (Hansen and Hoffman 1988; Girard et al. 1989).

Chokecherry, western snowberry, American plum, Saskatoon serviceberry and Wood's rose are the most common shrubs in the woodland understory. The herbaceous layer contains many species and dominance is commonly shared among them in stands that exhibit little disturbance. Girard et al. (1989) identified 48 species in the herbaceous layer of the green ash/chokecherry ecological type. Lesica and Marlow (2013) reported 137 species occurring in green ash woodlands. Kentucky bluegrass (*Poa pratensis* L.) becomes more prevalent and even dominant when the stand is disturbed (Hansen et al. 1984; Hansen and Hoffman 1988).

Soils—Soils of this habitat type are generally unstable. Since this habitat type is formed in an erosional topography along intermittent drainages, headcuts (gullies) are common in the bottoms and small slumps are often found along the sides (Girard et al. 1989). In the North Dakota badlands, side area soils have been described as Entisols or intergrades such as Entic Haploborolls and bottom soils as Fluvaquentic Haploborolls (Butler et al. 1986). Surface soils of green ash draws in northwestern South Dakota were moderately fertile with high nutrient levels, except for phosphorus and nitrogen which were low. Soils were fine-textured with moderately high cation exchange capacity and saturation percentages. They were nonsaline-nonalkaline with low amounts of exchangeable sodium (Voorhees and Uresk 1992).

METHODS

Data collection and analyses followed procedures described by Uresk (1990) with additions to this design to account for tree parameters. A preliminary survey of the study area was undertaken to assess the range of variability within the green ash ecological type. Study sites were selected so the full range of seral stages based on plant succession of this type could be accounted for in the sampling design.

Data were collected initially on 23 sites. Each site was randomly selected within one of three perceived seral stages, early, mid, and late (Cochran 1977; Thompson et al. 1998; Levy and Lemeshow 1999). Within each site, a single 65.6 ft X 131.2 ft (20 m X 40 m) macroplot was established. In green ash woodlands with narrow draws, two plots were established, each 32.8 ft X 131.2 ft (10 m X 40 m). The two plots were combined and analyzed as one plot. Diameter at breast height (dbh) was measured on all trees within the macroplot that had a dbh greater than 1 inch (2.54 cm). These data were converted to total basal area for the 65.6 ft X 131.2 ft (20 m X 40 m) macroplot and then to basal area per acre.

Two parallel 99 ft (30 m) transects were set 66 ft (20 m) apart within the macroplot. Canopy cover class (Daubenmire 1959) was obtained for each plant species (other than tree species), total graminoid, forb, shrub, and plant litter. Canopy cover was determined in 30, 7.9 in X 19.7 in (20 cm X 50 cm) frames on each transect for 60 microplots. Overstory tree cover (%) was collected at 1 m intervals along each transect by a box prism (moosehorn). We recorded presence or absence of overstory and estimated percent cover from the number of positive hits. All macroplot data were averaged by variable for data analyses.

Preliminary data examination of the grand means for canopy cover (%) for 23 sites removed minor species and annuals with < 1% canopy cover and mean basal area for American elm (1 ft^2/a or 0.2 m^2/ha). Total cover for graminoids, forbs, shrubs, and plant litter were not included in model development. Preliminary examination reduced the number of variables to 11 for further analyses. Stepwise discriminant analyses were used for initial data reduction of the 11 variables on the three perceived seral stages from field observations (early, mid, late) (Uresk 1990). This initial data reduction resulted in two variables for model development-- green ash basal area and canopy cover of Prunus species (chokecherry + American plum). These two variables were subjected to a non-hierarchical clustering procedure, ISODATA (Ball and Hall 1967; del Moral 1975) which grouped the 23 macroplots into four distinct clusters (seral stages). However, two seral stages had limited sample sizes of 3 and 4 sites. Based on these analyses, an additional 26 sites were sampled for green ash basal area and Prunus species and western snowberry canopy cover. The resulting 49 sites were re-analyzed with cluster analyses (ISODATA) which grouped the sites into four clusters (seral stages). Stepwise discriminant analysis applied to the four clusters (seral stages) estimated the compactness of the clusters and identified key variables (green ash basal area and Prunus) for the model. The analysis provided Fisher classification coefficients for seral stage classification and monitoring within the green ash ecological type (SPSS 2003; Uresk 1990). All variables were entered in the final analyses to determine if the two selected variables would be consistent in the model development. Misclassification error rates were estimated with SAS (1988, 2012) and SPSS (2003) using a cross validation procedure or "leave one site out". The cross validation procedure was repeated for each of the sites for a true error rate. The developed model was subjected to field-testing by collecting data from additional sites (approximately, 20-30 sites) in western North and South Dakota, including sites outside the original study area.

RESULTS

A total of 35 plant species were sampled for canopy cover (%) in addition to basal area of green ash and overstory canopy cover (%). Cover of total graminoid, forb, shrub, and litter was not included in the analyses. After initial data reduction, 11 variables are presented with means, minimum, and maximum values (Table 1). The mean basal area of green ash averaged 37 ft^2/acre (8.5 m^2/ha) and ranged from < 1 to 101 ft^2/acre (23 m^2/ha). Prunus species had a mean canopy cover of 24 % and ranged from 0 to 71%. Western snowberry was common throughout most of the green ash woodland system, ranging from 0 to 75% canopy cover with a mean of 15%. Green ash overstory cover ranged from 0 to 92% with a mean of 50%.

The non-hierarchical cluster analysis (ISODATA) grouped the 49 sites into 4 distinct seral stages ($P < 0.001$) based on 2 variables (Table 2). Stepwise discriminate analysis defined 2 key variables (basal area of green ash and Prunus species) for model development as the best predictive variables for classification of seral stages and monitoring within the green ash ecological type. The distributions of the two variables throughout the seral stages show the biological dynamics from late to early succession (Figure 1, Table 2). Green ash basal area dominated the late and early intermediate seral stages with means of 84 ft^2/acre (19 m^2/ha) and 41 ft^2/acre (9 m^2/ha), respectively. Prunus species were most abundant only in the late intermediate seral stage with 50% canopy cover. Both green ash and Prunus species were minor components in the early seral stage with a basal area of 13 ft^2/acre (3 m^2/ha) for green ash and a canopy cover of 6% for Prunus species. Each key variable individually and collectively characterized the vegetation dynamics of the model within the green ash ecological type.

Fisher's discriminant function coefficients (SPSS 2003) provided the biotic potential of the 2 key variables for predicting and classifying seral stage dynamics within the green ash ecological type (Table 3). An example for applying the Fisher discriminant functions with new field data collected for the two key variables is presented in Table 4. Site values for green ash basal area (ft^2/acre) and canopy cover (%) of Prunus species were 44 ft^2/acre (10 m^2/ha) and 26, respectively. To determine seral stage assignment, one multiplies green ash basal area and Prunus species canopy cover by the coefficients for each seral stage (row),

Table 1. Canopy cover (%), basal area (ft^2/a), standard error (in parentheses) and range of common plant species for Green Ash ecological type (n = 23 sites).

Species or variable	Mean	Minimum	Maximum
Western wheatgrass (%) *Pascopyrum smithii*	1.4 (0.6)	0.0	11.5
Sideoats grama (%) *Bouteloua curtipendula*	2.0 (1.2)	0.0	18.8
Sedge species (%) *Carex* spp.	1.0 (0.3)	0.0	6.5
Canada wildrye (%) *Elymus canadensis*	1.7 (0.5)	0.0	9.8
Green needlegrass (%) *Nassella viridula*	1.2 (0.5)	0.0	10.3
Green ash (BA in ft^2/a)[1] *Fraxinus pennsylvanicus*	37.4 (4.0)	0.1	100.9
Prunus (%)[1] *Prunus* spp.	24.1 (3.2)	0.0	70.9
Western snowberry (%)[2] *Symphoricarpos occidentalis*	15.0 (2.4)	0.0	75.2
Saskatoon serviceberry(%) *Amelanchier alnifolia* (%)	2.4 (1.2)	0.0	23.6
Skunkbush sumac (%) *Rhus trilobata*	1.6 (0.6)	0.0	11.0
Overstory ash cover (%)	50.1 (6.5)	0.0	91.7
Graminoid cover	**13.2 (2.6)**	**<1**	**49.2**
Forb cover	**4.5 (1.0)**	**0.0**	**16.1**
Shrub cover	**34.6 (3.7)**	**7.1**	**69.9**
Litter cover	**74.6 (3)**	**34.6**	**97.5**

[1] Key variables in model, n = 49. Prunus species (chokecherry + American plum)
[2] Important variable within green ash ecological type, n = 49.

and the products are summed (+ and -), including the constant for the score. The greatest positive or least negative score when all scores are negative is the seral stage assignment. In this example the seral stage assignment was early intermediate with a score of 3.975. Cross validation results of the model showed an overall accuracy of 95% (SAS 2012). Additional information on data collection, plot establishment, seral classification, trend monitoring and programs may be downloaded from the USDA Forest Service website (Uresk et al. 2010b): http://www.fs.fed.us/rangelands/ecology/ecologicalclassification/index.shtml and may be used on personal data assistants (PDAs) and personal computers to directly assign the seral stage.

Table 2. Key variables in model for Green Ash ecological type through four seral stages with standard errors (in parentheses).

		MEANS	
Seral Stage	**n**	**Green Ash BA (ft^2/a)**	**Prunus spp Cover (%)**
Late	9	84 (5)	31 (6)
Late intermediate	15	31 (4)	50 (3)
Early intermediate	10	41 (3)	7 (2)
Early	15	13 (3)	6 (2)

n = number of sites

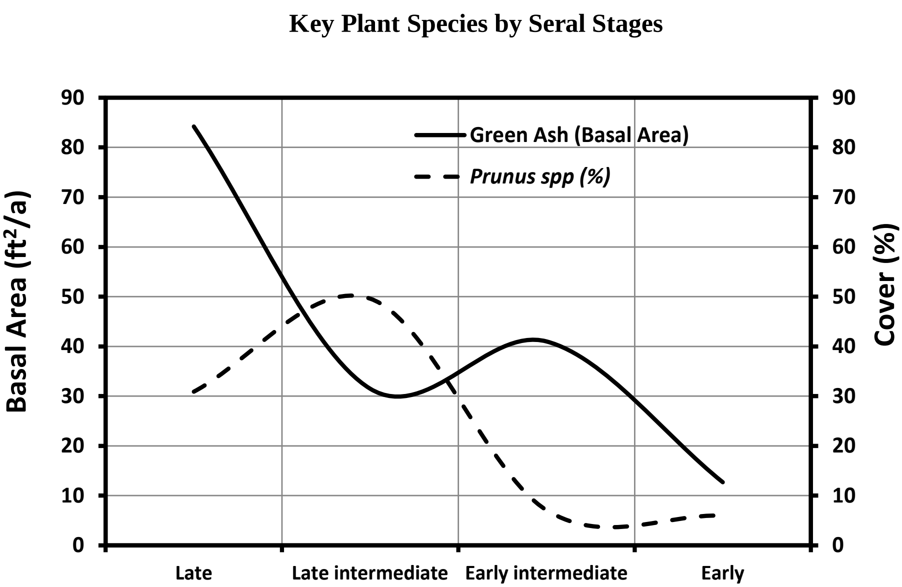

Figure 1. Means of key variables, Green Ash (basal area, ft^2/acre) and canopy cover (%) of Prunus species (chokecherry + American plum) displayed throughout four seral stages in the Green Ash ecological type on the northern Great Plains.

DISCUSSION

Successional change in green ash woodlands is generally a slow process, and visual estimates to determine successional stages are highly variable among observers. However, whereas an early successional stage can be determined from a late successional stage, but with limited accuracy, other seral stages are very difficult to define by observations alone. The model developed herein has the advantage of accurate seral stage classification. It is quantitative and can be used to describe tree and other plant dynamics throughout the woodland system using only two key variables, basal area of green ash and % cover of Prunus species.

Table 3. Fisher's classification discriminant function coefficients used for classification of seral stages based on basal area (ft^2/a) of green ash and canopy cover (%) of Prunus spp. (American plum, chokecherry) in a Green Ash ecological type.

Species	Late	Late intermediate	Early intermediate	Early
Green ash	0.497	0.099	0.260	0.072
Prunus spp.	0.071	0.350	-0.033	0.022
Constant	-23.415	-11.632	-6.607	-1.905

Table 4. An example of assigning seral stages by using Fisher's discriminant coefficients with basal area 44 (ft2/a) of green ash and canopy cover 26 (%) of Prunus spp (American plum, chokecherry) with new data collected from the field.

	Green Ash		Prunus spp				
Seral Stage	**(Coeff[1] *Var[2])**	+	**(Coeff *Var)**	+	**Constant**	=	**Score**
Late	(0.497 * 44	+	0.071 * 26)	-	23.415	=	0.299
Late Intermediate	(0.099 * 44	+	0.350 * 26)	-	11.632	=	1.824
Early Intermediate	(0.260 * 44	-	0.033 * 26)	-	6.607	=	**3.975**[3]
Early	(0.072 * 44	+	0.022 * 26)	-	1.905	=	1.835

[1] Coeff = Fisher's coefficients used for classification.
[2] Var = variable, basal area (ft2/a) and canopy cover (%).
[3] Assigned seral stage.

This green ash model for classification of seral stages and monitoring with the key variables, basal area of green ash and canopy cover of Prunus species, provides a quantitative tool for management. Data collections for these two key variables are required to provide input to the model, which has an accuracy of 95% in classifying seral stages. Data collection for these two variables may be conducted on plots yearly or once every few years with a suggested minimum of two macroplots per section or per mile of woodlands within the ecological type. See the USDA-Forest Service website for additional information on establishment of plots for data collection at Uresk et al. (2010b): http://www.fs.fed.us/rangelands/ecology/ecologicalclassification/index.shtml.

The model coefficients developed herein can be incorporated into the conceptual state and transitions models currently used by USDA Forest Service, Natural Resource Conservation Service (NRCS), and Bureau of Land Management (BLM) (USDA-NRCS 2013) that are qualitative (Twidwell et al. 2013). The green ash model with the key variables is displayed as nonlinear in Figure 1 when they progress through all four seral stages. Ash succession may progress from late to early stages by passing through the intermediate stages rapidly or may be static for many years at a seral stage.

Finally, monitoring trends of the green ash system over time can be quantitatively documented and validated for recovery or deterioration of resource areas as affected by livestock grazing, fire or climatic changes. Overgrazing the green ash understory (shrubs and young trees) by livestock has been a source of degradation of green ash woodlands that has affected the vigor of plants and diversity and abundance of species. The early intermediate seral stage resulting in a greater basal area of green ash is the result of livestock grazing, leaving only trees with very few understory plants. This is common throughout the northern Great Plains. However, shrub-ash tree stands have also degenerated because they are reaching the end of their life spans (Boldt et al. 1978). Disease and construction of livestock ponds (influencing hydrology of wooded draws) are other factors that negatively influence the ecology of green ash woodlands.

Although livestock have been implicated as a damaging agent, it is possible that, when carefully managed, they could be used to alter seral stages to meet management objectives (Severson and Urness 1994; Uresk and Boldt 1986). The statistical model developed for classification and monitoring the green ash ecological type can be used to quantify the relationship of livestock grazing at various intensities, including no grazing. Monitoring successional trends in green ash woodlands can be used to determine grazing levels and/or stocking rates necessary to restore or maintain a desired successional status to meet management objectives.

Green ash succession, progressing from an early to the late seral stage, can be a slow process and may require mechanical or herbicide treatment to control invasive grasses and shrubs (Boldt et al. 1978; Severson and Boldt 1978; Uresk and Boldt 1986; Uresk et al. 2009; Lesica 2009; Lesica and Marllow 2013). Herbicides applied to densely formed grass sod of Kentucky bluegrass and smooth brome (*Bromus inermis* Leyss.) had a positive effect on survival of green ash seedlings in ash woodlands (Lesica 2009; Lesica and Marlow 2013). In addition, control of Russian olive trees (*Elaeagnus angustifolia* L.), a non-native species, may be necessary where this species has invaded.

Management for all four ecological seral stages within the ecological type enhances plant and animal diversity. A mosaic of desired seral stages of green ash woodlands across the landscape is considered optimal for plant and animal species (Lesica and Marllow 2013; Rumble and Gobeille 1998; Rumble and Gobeille 2001; Severson and Carter 1978; MacCracken and Uresk 1984). A single seral stage will not be practical for multiple-use management because plant and animal species vary among seral stages. To meet plant and animal species diversity, we recommend that 10-15% of the green ash woodlands be in early and late seral stages and the remainder within early intermediate and late intermediate stages as a mosaic across the landscape (Kershaw 1973, Mueller-Dombois and Ellenberg 1974).

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Land cover in the Northern Great Plains has changed considerably in the last several decades. While a significant proportion of the landscape has been cultivated for over one hundred years, the intensity of cultivation, crop type, and more. Land cover in the Northern Great Plains has changed considerably in the last several decades.Â Whereas VLF lightning emissions can be used to deduce physical parameters such as lightning type and peak current, VHF emissions can be used to perform precise 3d mapping of individual radiation sources, which can number in the thousands for a typical CG flash. These new dual-band sensors will be used to monitor lightning activity in hurricanes in an effort to better predict intensification cycles. Within the Northern Great Plains mixed-grass prairie ecosystem, black-tailed prairie dog colonization is an issue of concern for livestock producers (Miller et al., 2007). Competition between prairie dogs and livestock is a major concern for land managers looking to optimize beef production while still conserving wildlife species (Augustine and Springer, 2013).Â Consistency in error rates for plant communities appears to indicate stability in the 2015 and 2016 RF models which used identical training sites on consecutive yearly satellite imagery. However, when comparing yearly predicted plant community maps, differences between community classifications are slightly more pronounced, indicating the models may not be as stable as predicted based solely on the OOB error rates. Ecological classification. In the Russian Federation with its vast uninterrupted plains, zones delineating the major vegetation types agree conveniently with climatic zones and, in a way, also with major soil types. Typically, these zones tend to run in semi parallel belts in a slightly northwesterly to southeasterly direction. Topography, watercourses and variation in soil conditions become relevant at the rayon [a small territorial administrative division] or rather at the (former) Kolkhoz or Sovkhoz level. It was at this unit level that grassland description was to be refined and effected f

Land cover in the Northern Great Plains has changed considerably in the last several decades. While a significant proportion of the landscape has been cultivated for over one hundred years, the intensity of cultivation, crop type, and management practices have changed in response to shifts in government policy, commodity prices, access to water, and technological advances. Changes in land cover impact a wide variety of ecosystem processes and services, including carbon balances, climate, hydrology and water quality, and biodiversity. A consistent record of historical land cover is required to The Northern Great Plains Inventory and Monitoring Network (NGPN) includes 13 park units in North and South Dakota, Nebraska, Wyoming, and eastern Montana. The Network includes Agate Fossil Beds, Devils Tower, Jewel Cave, and Scotts Bluff National Monuments (AGFO, DETO, JECA, and SCBL); Fort Laramie, Fort Union Trading Post, and Knife River Indian Villages National Historic Sites (FOLA, FOUS, and KNRI); Badlands, Theodore Roosevelt, and Wind Cave National Parks (BADL, THRO, and WICA); Missouri National Recreational River (MNRR)Â The second step was to develop conceptual ecological models of the predominant ecosystems associated with Network parks, including key ecosystem drivers, stressors, and processes. The Commission's 1997 report, Ecological Regions of North America, provides a framework that may be used by government agencies, non-governmental organizations, and academic researchers as a basis for risk analysis, resource management, and environmental study of the continent's ecosystems.[1] In the United States, the EPA and the United States Geological Survey (USGS) are the principal federal agencies working with. the CEC to define and map ecoregions.Â The classification system has four levels, but only Levels I and III are shown on this list. Level I divides North America into 15 broad ecoregions; of these, 12 lie partly or wholly within the United States. Fifty Level II regions were created to allow for a narrower delineation of Level I areas.