U.S. Department of the Interior
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Bird Monitoring Protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas

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Important Note: This sampling protocol consists of this Protocol Narrative and the following Standard Operating Procedures (SOPs):

SOP 1: Preparations and Equipment Setup Prior to the Field Season
SOP 2: Training Observers
SOP 3: Using the Global Positioning System
SOP 4: Establishing and Marking Sampling Plots
SOP 5: Conducting the Variable Circular Plot Count
SOP 6: Documenting Habitat Variables
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I. Background and Objectives

Issue being Addressed and Rationale for Monitoring Grassland Bird Populations

Birds are an important component of park ecosystems, and their high body temperature, rapid metabolism, and high ecological position in most food webs make them a good indicator of the effects of local and regional changes in ecosystems. It has been suggested that management activities aimed at preserving habitat for bird populations, such as for neotropical migrants, can have the added benefit of preserving entire ecosystems and their attendant ecosystem services (Karr 1991, Maurer 1993). Moreover, birds have a tremendous following among the public, and many parks provide information on the status and trends of birds in the park through their interpretive program.

Native Great Plains grasslands and their constituent avian fauna once covered vast areas of the North American continent. During the last century, large portions of grassland landscapes were plowed for cropland or converted to livestock pasture (29% of shortgrass, 41% of mixed-grass, and 99% of tallgrass prairie; Knopf and Sampson 1997). Remaining grasslands have been altered through continued fragmentation and isolation, interruption of driving ecological processes such as periodic wildfire, and loss of significant faunal species, including bison (*Bos bison*), elk (*Cervus elaphus*), and wolves (*Canis lupus*).

While not to the extent of large native ungulates and mammalian predators, many grassland avian species have also demonstrated declining abundance as prairie habitat loss continues. Data collected during the U.S. Geological Survey's annual North American Breeding Bird Surveys (BBS) between 1966 and 1999 indicates that 70% of 29 grassland bird species show evidence of population declines (Sauer et al. 2000). Many prairie species such as the grasshopper sparrow (*Ammodramus savannarum*), eastern meadowlark (*Sturnella magna*), horned lark (*Eremophila alpestris*), bobolink (*Dolichonyx oryzivorus*), lark bunting (*Calamospiza melanocrys*), and dickcissel (*Spiza americana*) have declined at alarming rates (Sauer et al. 2003). The destruction and fragmentation of prairie landscapes, as well as the structural degradation resulting from fire suppression and changes in grazing regimes of remaining prairie habitats contribute to these declines.

Accumulation of litter and standing dead material are significant components in the structure of a tallgrass prairie. In the absence of fire and grazing, dead material accumulates, decreasing availability of nutrients and reducing solar radiation reaching the ground resulting in a homogeneous canopy dominated by big bluestem (*Andropogon gerardii*) and indiangrass (*Sorghastrum nutans*), with eventual invasion by woody plants where precipitation permits (Vinton and Collins 1997). Fire tends to remove accumulated dead material more evenly in grasslands than grazing that produces a heterogeneous mix of live and dead plant material. The season, frequency and spatial extent of fire and grazing interact to influence litter and standing

dead material accumulation, creating a mosaic in vegetation structure across the landscape (Glenn et al. 1992). The accumulation of litter and standing dead material and the resulting vegetation structure vary along an east (tallgrass) to west (shortgrass) gradient with mixed-grass prairies falling somewhere in between. Net annual production and the accumulation of dead material are significantly greater in eastern tallgrass prairies than western shortgrass prairies. Shortgrass prairies also develop a more heterogeneous canopy than tallgrass prairie, with bunchgrasses, such as blue grama (*Bouteloua gracilis*), and shrubs dominating (Lane 1995, Vinton and Collins 1997). Consequently, the accumulation of litter and standing dead material in shortgrass prairie systems is an insignificant component of vegetation structure.

Responses of avian communities to changes in habitat structure have received much attention in recent years (Cody 1981, 1985, Zimmerman 1997, Fitzgerald and Pashley 2000, Tappe et al. in press). Much of this work has been carried out in forested systems, which are structurally more diverse than grassland systems. However, work done by Zimmerman (1982, 1988, 1993) on the Konza Prairie Research Natural Area in the Flint Hills of Kansas has demonstrated how avian species respond to fire and grazing in a tallgrass prairie system. Zimmerman (1997) categorized three types of bird species inhabiting tallgrass prairie: grass/forb-dependent, woody-dependent and habitat-independent and recorded their responses to grazing and fire. Woody-dependent species are generally restricted to riparian corridors where woods are protected from fire. In prairies invaded by woody species, restoration of fire and grazing lead to a decline in woody species through removal of their habitat. Grass/forb-dependent species in tallgrass prairie generally respond well to moderate grazing that increases structural diversity. On the other hand, annual spring burns to promote warm season grass production have a negative influence on structural development by removing cool season grasses, forbs, litter and standing dead material, thus reducing habitat quality for grass/forb-dependent species. While some elements of habitat-avian community relationships are clearly understood for prairie systems, such as the response following removal of woody plants, others are not. The influence of habitat alterations on invertebrate communities and the birds that feed upon them is one component that is not fully understood.

It is against a backdrop of vanishing or altered prairie ecosystems and declining grassland bird populations that we propose monitoring avian communities on National Park Service lands. Long-term trends in the community composition and abundance of breeding bird populations provide one measure for assessing the ecological integrity and sustainability of prairie systems. Long-term patterns in community composition and species abundance in relation to changes in the structural diversity of vegetation resulting from fire and grazing will improve our understanding of the effects of various management actions.

Historical Development of Bird Monitoring in Prairie Parks

Trends in the composition and abundance of grassland bird populations have been proposed as a long-term indicator of prairie ecosystem integrity, which is defined as the capability to support and maintain a balanced, integrated, adaptive community of organisms having a community composition, diversity, and functional organization comparable to that of natural habitat of the region (Karr and Dudley 1981). During 1998 and 1999, as part of the design phase of the Prairie Cluster Prototype Long-term Ecological Monitoring Program (PC-LTEM) led by the U.S. Geological Survey, bird inventories and pilot monitoring work was conducted in eight prairie parks by Dr. Abby Powell of the USGS to identify the species present at each park and assess the feasibility of using grassland birds as indicators of ecosystem

integrity (Powell 2000). Work was conducted at Agate Fossil Beds National Monument (AGFO), Badlands National Park (BADL), Homestead National Monument of America (HOME), Pipestone National Monument (PIPE), Scotts Bluff National Monument (SCBL), Tallgrass Prairie National Preserve (TAPR), Theodore Roosevelt National Park (THRO), and Wilson's Creek National Battlefield (WICR). Powell (2000) concluded that Agate Fossil Beds National Monument and Tallgrass Prairie National Preserve were of sufficient size to support healthy grassland bird communities, but recommend against avian community monitoring in other PC-LTEM parks (HOME, PIPE, SCBL and WICR) because of their small size. Following Powell's recommendation, the PC-LTEM Program initiated a pilot project in the spring of 2001 to monitor avian communities at Agate Fossil Beds National Monument and Tallgrass Prairie National Preserve. Grassland bird monitoring may be of particular importance at Tallgrass Prairie National Preserve, where current management includes annual prescribed fire and heavy cattle grazing. As the park General Management Plan is implemented, greater structural diversity and improved avian habitat may be observed.

Measurable Objectives

There are two primary objectives for the monitoring described in this protocol:

1. Identify significant temporal changes in composition and abundance of bird communities at Agate Fossil Beds National Monument and Tallgrass Prairie National Preserve during the breeding season.
2. Improve our understanding of breeding bird – habitat relationships and the effects of management actions such as grazing and prescribed fire regimes on bird populations by correlating changes in bird community composition and abundance with changes in habitat variables.

II. Sampling Design

Rationale for Selecting this Sampling Design over Others

Hundreds of different sampling approaches have been used to quantify status or trends in bird populations and dozens of different monitoring programs are currently in place throughout North America to determine local, regional, or national trends in bird numbers. Most common survey methods allow simultaneous collection of information about species that share a common life history or habitat, but no single method will adequately sample the diversity of either habitats that birds occupy or life history groups such as seabirds, songbirds, raptors and shorebirds.

The sampling design described in this protocol involves a series of sampling stations laid out on a systematic grid that are sampled during 5 minute counts using the variable circular plot (VCP) methodology (Reynolds et al. 1980, Scott et al. 1986, Buckland et al. 1993, 2001, Fancy 1997, Nelson and Fancy 1999). Variable circular plots and line transect sampling are two types of distance sampling. Distance sampling has been used for more than 30 years to estimate animal abundance and is the best omnibus method currently available for determining relative abundance or trends for birds in most sampling situations. In practice, the method documented in this protocol is basically the same as point counts, such as those used in the Breeding Bird Survey (BBS), except that for each bird heard or seen during the count, its horizontal distance from the observer is estimated. In the case of line transect sampling, the observer walks down a transect and records either the perpendicular distance to each bird heard or seen, or else records the sighting angle and sighting distance instead of the perpendicular distance. Line transects are usually more efficient than VCP counts where they can be conducted because the observer

collects data continuously while walking along the transect, whereas during VCP counts the observer only records birds detected during 3-10 minute sampling periods from stations located along a transect or on a systematic grid. However, VCP counts are the preferred approach in patchy habitats where correlations between bird data and vegetation or other habitat information are sought and in dense, rugged or hazardous terrain where you need to watch your footing as you traverse the landscape. Another advantage of VCP counts is that data can be directly compared to historical point count data such as those obtained during BBS counts and can contribute to ongoing programs such as the National Point Count Database.

An important benefit of using the variable circular plot method is the ability to accommodate a wide range of bird species, each of which possesses a different singing style and each of which may occur in a variety of acoustically-different habitats (BCRIB 1999). VCP counts operate by essentially allowing the habitat to determine the size of the area being surveyed. The maximum detectable distance to a bird may change between different habitats, but the radius of the survey will also change. For example, surveys of grassland birds usually cover a larger area per point because of the absence of a screen of trees, and because bird species may be flushed at greater distances in open habitats (BCRIB 1999).

In addition to the rational for VCP counts given above, this protocol uses variable circular plot counts arranged in a systematic grid to address the two objectives for bird monitoring in prairie parks for the following reasons:

- A primary objective is to associate changes in bird community composition and abundance with long-term changes in vegetation that occur as a result of natural succession or various management actions (e.g., prescribed fire, grazing). We cannot (prior to the first year of the long-term sampling scheme) stratify the park into areas that will be subjected to different management regimes (e.g., grazed versus ungrazed) because the location and timing of future management will be based on feedback from adaptive management and other factors and cannot be predicted. Thus, the approach is to sample birds on a systematic grid that will allow inferences to be made to the entire park, and to later post-stratify the data to investigate changes in bird community composition and numbers as a result of different management regimes.
- Unadjusted point counts, such as those used in the Breeding Bird Survey, do not account for the number of birds missed during the counting interval. The number of birds that are counted at a sampling station is a combination of the number of birds that are actually there, and the proportion of them detected. Use of unadjusted point counts to calculate trends in abundance assumes that the proportion of birds detected is the same among species, observers and counting conditions, which is usually not the case. Without a measure of detectability, counts of birds are an unreliable measure of differences in the actual number of birds present (see Burnham 1981, Barker and Sauer 1995, Nelson and Fancy 1999). To obtain credible long-term trend data, and to allow comparisons among bird species and habitat types where detectability is expected to differ, we will incorporate distance measures to improve the quality of the data.
- By recording distances and by keeping track of whether a bird was detected during the first 3 minutes of the count or between minutes 3-5, we will be able to make direct comparisons between our data and those collected by others using the BBS or Ralph et al. (1995) methods.
- Our approach allows data from repeated surveys of the same area or areas with similar habitat characteristics to be combined to increase sample sizes. By combining surveys, it is

possible to develop detection functions for uncommon species for which few detections are recorded during any single survey.

Note: Occasionally, there is detectability issues in bird sampling that VCP and other estimation procedures cannot address. For example, there may be unobservable portions of the population (such as cryptic and silent females or nocturnal birds) that are not detected at all during counting, or it may be impossible to estimate detectability at the appropriate scale, for example when habitat-specific detectability exists in a rare species. In structurally complex habitats (e.g., forests in the northwest U.S. with very tall trees and multiple shrub and tree layers that make it impossible to see birds directly above the observer but high up in the canopy) it may be difficult or impossible to detect birds at close horizontal distances to the observer. Thus, even with a measure of detectability factored into estimates derived from counts of birds, such estimates may still be an unreliable measure of differences in the actual number of birds present in some situations. However, it is important to note that although data may be less reliable for species encountered at low rates, it is still valuable to collect the data, and pooling of data over time may allow certain limited analyses. Interpretation of survey data requires sensitivity to these extra-statistical limitations of the estimation procedures.

Site Selection

Sampling locations or 'plots' are selected as described in SOP #4, "Establishing and Marking Sampling Plots." Briefly, permanent sampling locations were selected by overlaying systematic grids of 400 x 400-m cells (originating from a random starting point) on park maps. Systematic sampling across the park will allow us to make park-wide inferences concerning the avian community. The orientation of each grid was rotated 45 degrees from North to prevent sampling sites from being influenced by man-made features (roads, fences, etc.) oriented along cardinal directions. In each park, the riparian corridor was identified as a separate stratum, with sampling extending 125 m on either side of the stream channel (Niobrara River, AGFO; Palmer and Fox Creeks, TAPR). The riparian stratum makes up 15.6% of the total park area (965 ha) at Agate Fossil Beds National Monument, and 5.3% of the total park area (4398 ha) at Tallgrass Prairie National Preserve. Within the riparian stratum, plots were located at 250-m intervals along the extent of the stream. Any plots from the overall park grid that fell within the riparian stratum were discarded. Sampling locations are not physically marked on the ground; rather UTM coordinates are maintained and located in the field with a GPS unit. Refer to SOP #3 "Using GPS" and SOP #4 "Establishing and Marking Sampling Plots" for navigation between sampling plots and plot establishment instructions.

This site selection approach allows flexibility to choose the appropriate reference frame to answer different monitoring questions. When making park-wide inferences, results from each stratum will be weighted by area and combined to give an overall park mean and variance. At the same time, more intensive sampling in the riparian corridor will ensure an adequate sample to describe habitat relationships specific to this less common, but important stratum. The systematic grid will also allow us to limit the reference frame appropriately when asking more specific monitoring questions (e.g. only those sampling points within particular management units would be used to compare the avian response to different fire or grazing regimes).

Population being Monitored

Sampling will be limited to the bird-breeding season (early May through mid-June), and sampling will include those species that may potentially breed in the park (see Appendix B).

Thus, the population being sampled includes breeding bird species within the park boundary that are present during the time that the survey is being conducted.

Sampling Frequency and Replication

An appropriate sampling frequency and intensity will be recommended following completion of a pilot project to assess the within and between year variability in bird occurrence and abundance (years 2001-2003). Once preliminary estimates of variability are available, we will examine the level of change that can be detected for a given sampling intensity.

For those species of greatest importance to the parks, the formula recommended by Buckland et al. (1993) will also guide determining the appropriate number of samples. Ideally, 60-80 detections per observer are needed to compute a distance function for each species (Buckland et al. 1993). However, it is possible to pool data from multiple surveys to obtain adequate sample sizes for development of these detection functions, and it is not necessary that all distance data be collected in a single survey. Also, if the detectability of a particular species is high and factors affecting detection rate are not complex, it is possible to obtain adequate results with fewer than 60 detections.

The maximum number of plots that can be sampled per year will be determined by personnel availability. Numerous studies have shown that differences among observers have a much greater effect on detection distances than other factors (Kepler and Scott 1981). We will maintain data consistency and quality by limiting bird data collection within a sampling season/park combination to a single bird observer. Thus, for any park, the sample size limit will be determined by the number of plots one person can sample in a 4-hour window each morning, multiplied by the number of field days possible within the six weeks of the breeding season.

The pilot project uses a 400-m grid spacing, resulting in 242 and 40 plots included within park boundaries for Tallgrass Prairie National Preserve and Agate Fossil Beds National Monument, respectively. Within the riparian strata, plots are placed at 250 m intervals, resulting in 18 riparian plots for Tallgrass Prairie National Preserve and 14 for Agate Fossil Beds National Monument. All plots will be sampled each year.

III. Field Methods

Field Season Preparations, Field Schedule and Equipment Setup

Prior to the field season each year, usually beginning in March or April, the observer(s) should review this entire protocol, including all of the SOPs. The observer should pay special attention to the tasks described in SOP #1 "Before the Field Season" and SOP #2 "Training Observers." Review of bird identification by sight and sound (see SOP #2) is particularly important each year, as the misidentification of a species is perhaps the most serious error one can make during a bird count with greater consequences than errors in estimating distances or double-counting a bird. All of the equipment and supplies listed in SOP #1 should be organized and made ready for the field season, and copies of the field data forms in Appendix A should be made, 25% of which should be on write-in-the-rain paper.

Staff workloads and unpredictable weather (e.g. delays in the onset of spring, periods of rain, spring storms) necessitate maintaining some flexibility in scheduling the sequence and duration of sampling trips. Sampling dates should be scheduled and logistics organized prior to the start of each field season. Twelve to fifteen VCP counts should be scheduled for completion each field day. Field trips up to ten days in length will be necessary to complete bird surveys

within the breeding season. In years when both Tallgrass Prairie National Preserve and Agate Fossil Beds National Monument are being surveyed, it is recommended that surveys be completed at Tallgrass Prairie National Preserve first, to accommodate differences in vegetation phenology.

Sampling Methods

The protocol comprises two data sets collected concurrently; bird abundance (VCP) and habitat measures. The bird crew should arrive at the park the afternoon prior to the first day of sampling to familiarize themselves with the area and the birds present. Each night, the group discusses the next day's plans and establishes the route for visiting bird plots. The birding crew arrives at the first plot each day before sunrise and begins sampling as soon as it is light enough to do so. The habitat crew follows the route of the bird observer, being careful to avoid walking to the next plot until bird observations are completed and the observer has moved on. Habitat sampling on a plot commences after bird observations are complete. Loud voices, motion, or walking through a plot may disrupt the birds and bias survey results. The bird observer completes counts around four hours after local sunrise and then joins the habitat crew. Each day, the habitat crew attempts to complete habitat work on all plots sampled for birds that morning. However, this is not always possible and some plots may need to be sampled at a later date. No habitat sampling should be scheduled after June 30. If for any reason a habitat subplot extends beyond park boundaries, the plot is dropped from sampling. Refer to SOP #5 "Conducting the Variable Circular Plot Count" for conducting bird counts and SOP #6 "Documenting Habitat Variables" for doing habitat work.

Before leaving the field each day, data sheets are checked for completeness and readability. All information pertinent to the plots sampled that day is recorded to avoid repeating or skipping sampling plots. The project manager is responsible for the safekeeping and organization of the data sheets, and ensuring that data get entered into the database.

Conducting the Variable Circular Plot Count

Variable Circular Plot Counts are a point count methodology that incorporates a measure of detectability into population estimates (Buckland et al. 2001). Details of how to conduct VCP counts during the breeding season and for filling in data forms are given in SOP #5 "Conducting the Variable Circular Plot Count" and are summarized here. All birds seen or heard at each plot are recorded during a 5 minute sampling period. Bird observations are separated into two time segments: those detected during the first 3 minutes of the count (to allow comparisons with BBS data), and any new birds detected during the final 2 minutes of the count. All birds, regardless of distance detected from the observer are counted and recorded. For most species, each individual bird will be recorded as a separate observation. For species that usually occur in clusters or flocks, the appropriate unit to record is the cluster or flock size, and not the individual bird.

When we conduct a VCP count, we are attempting to get an "instantaneous count" of birds present. Birds flushed from the plot when approached by the observer should be recorded and the count started as soon as the observer is at plot center. The method takes into account the fact that birds close to the observer have a higher probability of being detected (if they are not flushed) than birds far from the observer and that different species have different detection functions (i.e., the probability of detecting a bird at different distances from the observer). An important assumption of the method is that a bird exactly at the center of the plot has a probability of $p = 1$ of being detected, and that there is a high probability of detecting birds

within the first 5-10 meters of the plot center. The most important birds to detect are those very close to the observer (within the first 5-10 meters), and it is highly desirable that estimated distances be within 1-2 meters of actual distances for any bird within 20 m of the observer. However, all birds seen or heard should be recorded with an estimate of distance from the observer. Distances should be estimated to the nearest meter in the field (during subsequent data analysis, distances will be grouped into intervals to lessen the effect of errors in estimating distances); do not round distances off to the nearest 5 or 10 m. Birds far from the center of the plot usually have little effect on the resulting distance function; during data analysis, 5-10% of the furthest detection distances for each species will be truncated before a detection function is calculated.

Once a count is completed at a plot and the data sheet filled out the observer uses a GPS unit to navigate to the next plot to sample. Twelve to fifteen plots can be sampled each morning during a period when it is light enough to observe birds to four hours post sunrise.

Collecting Habitat Data

Habitat data are collected in a 50-m radius plot centered on each sampling point and in four nested 5-m radius and 1.78-m radius subplots. SOP #6 "Documenting Habitat Variables" gives a detailed description of how habitat data are collected; a brief summary is presented here.

Habitat data are collected to meet several objectives. Large-scale plot attributes such as vegetation type, slope, and water cover are relevant to bird community composition and also place the plot in a landscape context. Canopy structure and horizontal vegetation profile data (collected at 5-m radius scale) characterize habitat structure available to birds and also link bird data to park vegetation types. Similarly, ground cover and foliar cover of vegetation guilds (collected at the 1.78-m radius scale) allow us to integrate bird monitoring with more in-depth vegetation data collected as part of plant community monitoring. Integrating these monitoring projects will allow us to provide feedback to management on how grazing and fire regimes influence vegetation, which in turn affects bird community composition and abundance.

The collection of habitat data starts each morning after the first VCP count has been completed. The habitat crew samples VCP plots in the same order as the bird observer to avoid disturbing birds on plots where the bird count has not been conducted. The bird observer flags the center point of each VCP, making it easier for the habitat crew to find. The habitat crew navigates to the plots using a compass, a field map that includes compass bearings for the grid, and directions from the bird observer. Once the habitat crew arrives at a plot, they set up subplot one (plot center) and complete all habitat measures for this subplot and for the 50-m radius plot, before locating and completing subplots two, three and four.

IV. Data Management

Overview of Database Design

Microsoft Access 97 is the primary software environment for managing bird and habitat data. ESRI ArcInfo 8 serves as a tool for validation of spatial data residing in Access. Data products will be posted at the NPS I&M website: http://science.nature.nps.gov/im/monitor/protocoldb.cfm. Metadata for grassland bird monitoring data will be available at NPS I&M application server: http://science.nature.nps.gov/im/apps.htm. QA/QC guidelines in this document are based on recommendations of DeBacker et al. (2002) and S. Fancy at http://science.nature.nps.gov/im/monitor and citations therein.

The general data model for grassland bird monitoring consists of two sets of tables. One set manages bird abundance data the other associated habitat data. Abundance and habitat data are linked in time and space by way of standardized event and location tables. For data management purposes, it is probably easier to manage bird and habitat data separately. When the two are correctly linked, they can be integrated transparently for analysis. One issue that becomes readily apparent when managing the two data sets is that time-scale for bird observation events is in minutes and hours, whereas time-scale for associated habitat data is in days and weeks. While the location linkage is unaffected, this has consequences for the structure of the event-relationships. For example, tbl_SamplingPeriod is used rather than tbl_SamplingEvents in the database to accomidate the differences in time-scale between bird and habitat data collections.

The primary table for storing bird abundance contains information about bird species and bird distance from observer as well as flock size, age, sex, whether the observation was a flyover and species code (AOUcode). Supporting tables include water and climatic information, observers and the period of observation. A locations table provides detailed location information associated with each sampling point.

A habitat subplot table serves as the star table about which all other habitat information is linked. Small look-up tables are linked to this table by way of multiple junction tables. This facilitates many-to-many relationships in Microsoft Access. Small attribute tables provide the values for pick-lists on data-entry forms, thereby reducing possible error during data entry (see Data Verification and Editing below).

Data Entry

A number of features have been designed into the database to minimize errors that occur when field data is transcribed to the database for storage and analysis. Forms are used as portals for data entry into the database. Standardized identifiers (e.g. sample event or plot) are selected from list of easily interpreted codes. Species and habitat data is entered into fields linked to appropriate tables. Look-up tables contain project specific data and prohibit entry of data into a field if a corresponding value is not included in the look-up table. Consequently, only valid names or measures may be entered and spelling mistakes are eliminated. Species or habitat measures are selected using a pick list or by typing the beginning of the name. While typing, the form searches for a similar entry, typically locating the desired species after typing only a few characters.

If a species name or habitat measure is not accepted during data entry, it may be the result of a name change or it may be a new species or habitat measure. To check the current nomenclature for a data variable, a nomenclature update form is attached to the Access data file via a button. If the species or habitat measure name has changed, the form will indicate the current accepted name. If the species or habitat measure is new to the nomenclature update form, a form is provided to update the nomenclature table with the new attribute data.

Data Verification and Editing

Data verification immediately follows data entry and involves checking the accuracy of computerized records against the original source, usually paper field records. While the goal of data entry is to achieve 100% correct entries, this is rarely accomplished. To minimize transcription errors, our policy is to verify 100% of records to their original source by staff familiar with project design and field implementation. Further, 10% of records are reviewed a

second time by the Project Manager and the results of that comparison reported with the data. If errors are found in the Project Manager's review, then the entire data set is verified again. Once the computerized data are verified as accurately reflecting the original field data, the paper forms are archived and the electronic version is used for all subsequent data activities.

Although data may be correctly transcribed from the original field forms, they may not be accurate or logical. For example, a canopy height of 1125 m instead of 11.25 m or a temperature of 95°C instead of 9.5°C is illogical and almost certainly incorrect, whether or not it was properly transcribed from field forms. The process of reviewing computerized data for range and logic errors is the validation stage. Certain components of data validation are built into data entry forms (e.g. range limits). Data validation can also be extended into the design and structure of the database. As much as possible, values for data-entry forms have been limited to valid entries stored in the look-up tables.

Additional data validation can be accomplished during verification, if the operator is sufficiently knowledgeable about the data. The Project Manager will validate the data after verification is complete. Validation procedures seek to identify generic errors (e.g. missing, mismatched or duplicate records) as well as errors specific to particular projects. For example, validation of bird data includes database query and comparison of data among years. One query detects records with a location ID from a park and a period ID from a different park. Another query counts the number of subplots per plot (typically there are 4) to assure that all subplots were entered. Finally, data are compared to previous years to identify gross differences. For example, *Sturnella neglecta* or *S. magna* may be recorded this year, but *Sturnella spp.* the previous. During the entry, verification and validation phases, the Project Manager is responsible for the data. The Project Manager must assure consistency between field forms and the database by noting how and why any changes were made to the data on the original field forms. In general, changes made to the field forms should not be made via erasure, but rather through marginal notes or attached explanations. Once validation is complete, the data set is turned over to the Data Manager for archiving and storage.

Spatial validation of database sample coordinates can be accomplished using ArcGIS (ESRI, Inc.). Because Tweety is maintained as an Access database, it can be imported directly into ArcCatalog (ArcGIS, ESRI, Inc.) as an OLE DB object. Fields "StartUTMX" and "StartUTMY" of the locations table can then be used to validate the UTM coordinate values for point locations stored in Access against the original GPS coordinates.

Metadata Procedures

Preliminary notes for metadata were developed using the Electronic Metadata Guide (developed by G. Lienkaemper, USGS FRESC, Corvallis, OR - see Appendix A of SOP # 7). Metadata are then entered into the National Park Service Inventory and Monitoring Dataset Catalog (Ver. 2002.1). Then an extended report from Dataset Catalog is generated. The Dataset Catalog report tool can be used to generate output in the text-based FGDC-compliant metadata format. The output file should be validated and parsed into html format using the USGS metaparser command tool with the following syntax "mp –e efile –h hfile infile."

Data Archival Procedure

Data sets are rarely static. They often change through additions, corrections, and improvements made following the archival of a data set. There are three main caveats to this process:

- Only make changes that improve or update the data while maintaining data integrity.
- Once archived, document any changes made to the data set.
- Be prepared to recover from mistakes made during editing.

Any editing of archived data is accomplished jointly by the Project Manager and Data Manager. Every change must be documented in the edit log and accompanied by an explanation that includes pre- and post-edit data descriptions. The reader is referred to Tessler & Gregson (1997) for a complete description of prescribed data editing procedures and an example edit log.

Prior to any major changes of a data set a copy is stored with the appropriate version number. This allows for the tracking of changes over time. With proper controls and communication, versioning ensures that only the most current version is used in any analysis. Versioning of archived data sets is handled by adding a three digit number to the file name, with the first version being numbered 001. Each additional version is assigned a sequentially higher number. Frequent users of the data are notified of the updates, and provided with a copy of the most recent archived version.

Once the data are archived, any changes made to the data must be documented in an edit log. At this point forward, original field forms are not altered. Field forms can be reconciled to the database through the use of the edit log. Secure data archiving is essential for protecting data files from corruption. Once a data set has passed all QA/QC procedures specified in the protocol, a formal entry is made in the I&M Data Set Catalog. Subsequently, an electronic version of the data set is maintained in a read-only format on the program server. Backup copies of the data are maintained at the Wilson's Creek visitor center, and an additional digital copy is forwarded to the NPS Inventory and Monitoring Program Archive. Tape backups of the bird project databases are made twice weekly. Two backup copies are maintained at the PC-LTEM building and two additional copies at the Wilson's Creek National Battlefield Visitor Center, Republic Missouri. Once-a-month, one tape copy is placed into permanent archive.

Currently, data are available for research and management applications on request, for database versions where all QA/QC has been completed and the data have been archived. Data can also be transferred using e-mail (most Access files are smaller than 10 Mbytes or can be compressed into .zip files) or ftp where available. As mentioned in the introduction, the plan is to make grassland bird monitoring data available for download directly from the NPS I&M Monitoring webpage. In addition, metadata will become available directly from the NPS I&M metadata server. Data requests should be directed to:

Gareth Rowell, Data Manager
Wilson's Creek National Battlefield
6424 W. Farm Road 182
Republic, MO 65738-9514
gareth_rowell@nps.gov

V. Analysis and Reporting

A critical component of any long-term monitoring protocol is a consistent and systematic way of analyzing and reporting on information (data) collected. That being said, it is also important that the data analysis and reporting requirements be flexible enough to accommodate new and varied analytical methods and reporting styles as they become available. Data

visualization, geostatistics and time-series analysis are but three analysis methods that may be employed with this protocol as the size and complexity of the database increases through time. SOP # 8 "Data Analysis" gives step-by-step details on how to: 1) determine species abundance, bird species richness, diversity and evenness, 2) estimate abundance of common species, adjusted for detectability using Distance 4.0 analysis, 3) calculate descriptive statistics for habitat variables and 4) examine the relationships between bird species abundance and habitat conditions by way of correlation analysis. All calculations are made at the plot level so means and standard errors can be calculated by habitats, across habitats or average for park wide inferences. These parameters should be analyzed each time a survey is completed.

Bird Data Analysis

Species richness is defined as the total number of bird species observed on a plot. Community diversity, calculated using the Shannon Diversity Index (Shannon, 1949), measures the equitability of species across samples. The disparity among species abundance is calculated using Pielou's "J" (Pielou, 1969). To compensate for an observers inability to detect all individuals present during a survey, Distance 4.0 is used to obtain more accurate and robust estimates of population sizes for common species (Buckland et al., 2001). Relative occurrence (individual / plot visit) of each bird species is compared between surveys each time a new one is conducted to determine changes in the status of a population.

Habitat Data Analysis

Summary reports for habitat attributes at the 50 m plot level are required for "permanent" and "semi-permanent" features. For permanent features, the values for slope, aspect and topographic position are measured, reported and assigned to a permanent locations table within the database only once. Semi-permanent plot features, those not expected to change much including percent cover of upland prairie, riparian woodland, road cover and water cover are recorded each time a survey is conducted, with these changes reported.

The bulk of habitat data is collected at the 5 m subplot level with the first subplot located at plot center and three remaining ones located at a distance of 50 m from center plot and 120° offset from one another. Permanent subplot features include azimuth from plot center to a subplot as well as slope and aspect of each subplot. Like permanent attributes measured on plots, permanent features for subplots are measured only once and stored in a table within the database. Subplot features that are reported on each time a survey is conducted include tree tallies, canopy height, canopy coverage, basal area, ground and foliar coverage, horizontal vegetation coverage and structural diversity. Values reported for each subplot feature are either averaged or used in calculations to establish single values representing each plot, see SOP # 8 "Data Analysis" for details.

Reporting

In an effort to disseminate findings in a timely manner, reports should be completed by March 31 of the year following data collection. More extensive summary reports should be completed every five to ten years depending on how fast habitat conditions are changing and how critical summary information is to setting management goals influencing bird populations within a park. Summary reports may be used in place of annual reports for the year in which the last data is collected. Refer to SOP # 9 "Reporting" for details on report structure and style. Also see, "Status Report 2001-2003: Grassland Bird Monitoring at Agate Fossil Beds National

Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas" (Peitz and Rowell, draft) for content included in a report and reporting style.

Tables in a report should be placed within the text or immediately following the literature cited section (see Appendix B). Tables should be numbered in sequence regardless of where they are located. Table headers are placed at the top of a table. Horizontal lines are used to separate the table heading from column headings, column headings from the table and to signify the end of the table. Vertical lines should not appear on a table.

Figures (including pictures) should be placed within the text of a report or immediately following tables behind the literature cited sections (see Figure 6.01.1. Spatial arrangement of vegetation subplots). Figures should be numbered in sequence regardless of where they are located. Figure captions are placed below the figure if it is included in the text or on a separate sheet of paper preceding the figure if included after the literature cited section. Both tables and figures should contain information not presented in the body of the text. Also, tables and figures should not duplicate information already presented in the body of the text.

VI. Personnel Requirements and Training

Roles and Responsibilities

The project manager is the lead ecologist for implementing this monitoring protocol, and is supervised by the Program Coordinator for the PC-LTEM Program. Because of the need for a high level of training and consistency in implementing the protocol, the project manager will usually be the person conducting the VCP counts in the field. The data management aspect of the monitoring effort is the shared responsibility of the project manager and the data manager. Typically, the project manager is responsible for data collection, data entry, data verification and validation, as well as data summary, analysis and reporting. The data manager is responsible for data archiving, data security, dissemination and database design. The data manager, in collaboration with the project manager, also develops data entry forms and other database features as part of quality assurance and automates report generation. The data manager is ultimately responsible that adequate QA/QC procedures are built into the database management system and appropriate data handling procedures followed.

Qualifications and Training

The most essential component for the collection of credible, high-quality data on birds is a competent observer. This cannot be overemphasized. Various studies have shown that observer bias is one of the most noteworthy bias factors in trend analysis of songbird populations (Scott et al. 1986, Sauer et al. 1994, Kendall et al. 1996).

As well as being able to visually identify birds, field observers must be proficient at identifying species by their songs and calls. Therefore, recordings of birds in the study area, especially for the less common or unexpected species should be provided for surveyors. Observers should be tested frequently on their ability to identify bird calls. Good hearing ability is essential because many birds, particularly in forested habitats, are detected by sound only. Differences in hearing ability between observers may strongly affect survey results (Ramsey and Scott 1981).

The quality of the observer will determine the quality of the data. Time should also be invested in training personnel to estimate the distance from themselves to singing birds within different habitats. This will require training in the field (see SOP #2, "Training Observers") to

become proficient with the use of a laser rangefinder and to gain experience with estimating distances to different species in different habitat types.

The project manager and a staff botanist will assist in training the bird crew to conduct habitat monitoring. Observers doing habitat work should familiarize themselves with the PC-LTEM standard cover classes and vegetation guilds described in SOP #6. Prior to the field season, observers should practice estimating cover of different vegetation guilds and ground cover categories within 1.78-m practice plots. If habitat monitoring cannot be practiced prior to the field season, a staff botanist will accompany the bird crew on the first field trip of the year.

VII. Operational Requirements

Annual Workload and Field Schedule

Breeding bird surveys will begin no sooner than the first full week of May and extend no later then the second full week of June, a period that coincides with the peak-breeding activity of most birds. Inclement weather and personnel workloads will preclude the scheduling of sampling events to specific annual dates. Bird surveys may be scheduled for the third week of June if spring green-up is unusually late. Habitat monitoring should be completed no later than June 30, in order for habitat measures to accurately reflect conditions experienced by breeding birds. Monitoring efforts will require a three to four person crew. Approximately five to seven field days are required to complete bird sampling at Agate Fossil Beds National Monument, and three to four weeks at Tallgrass Prairie National Preserve. Twelve to fifteen VCP counts should be scheduled for completion each field day.

Facility and Equipment Needs

The nature of bird survey work does not require special facilities beyond normal office space and equipment storage needs. Table 1.01.1 is a list of field equipment needs for one crew. If two or more crews work simultaneously, equipment requirements will increase accordingly.

Startup Costs and Budget

Personnel expenses for field work are based on a crew of three to four people: an ecologist or biologist to conduct the bird counts, a botanist to initially work with or train the crew to conduct habitat sampling, and two seasonal biological science technicians. Five to seven field days should by planned for Agate Fossil Beds National Monument and approximately 21 days for Tallgrass Prairie National Preserve. Field costs will vary somewhat from year to year depending on the skill level and size of the crew. Data management personnel expenses include staff time of biological science technicians, the project manager and data manager. Startup cost for equipment include the purchase of equipment and supplies listed in Table 1.01.1, as well as maintenance and or replacement of equipment shared among multiple projects (e.g. GPS units, cameras).

Estimated Costs	TAPR	AGFO
Field Work (Salary)	18,000	6,000
Field Work (Travel)	5,600	1,200
Data Management/Reporting (Salary)	8,100	2,600
Startup Equipment Costs	1,200	1,200
Annual equipment/supplies	1,400	1,000
Total	34,300	12,000

Procedure for Revising the Protocol

Over time, revisions to both the Protocol Narrative and to specific Standard Operating Procedures (SOPs) are to be expected. Careful documentation of changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis. The MicroSoft Access® database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected.

The rationale for dividing a sampling protocol into a Protocol Narrative with supporting SOPs is based on the following:

- The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol.
- The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.
- When a SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.
- All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

The steps for changing the protocol (either the Protocol Narrative or the SOPs) are outlined in SOP #11, "Revising the Protocol." Each SOP contains a Revision History Log that should be filled out each time a SOP is revised to explain why the change was made, and to assign a new Version Number to the revised SOP. The new version of the SOP and/or Protocol Narrative should then be archived in the PC-LTEM Protocol Library under the appropriate folder.

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Appendix A. Field data forms for recording (a) bird detections, (b) habitat variables, and (c) location data for new sampling stations. These forms should be copied onto write-in-the-rain paper and taken into the field. The database has data entry screens that mimic these forms.

(a) Field Data Form – Variable Circular Plot Counts
Use one of these forms each time that a 5 minute count is conducted.

(b) Habitat Data Form
Use one of these forms once each year at each plot that is sampled.

(c) New Location Data Form
This form should be filled out each time that a new plot location is established. The data from this form is entered into the Locations table of the database.

Field Data Form – VARIABLE CIRCULAR PLOT COUNTS

LocationID: ______________________________ OR Park: AGFO TAPR and Location Description: ______________________________

Survey: ______________________ Date (mm/dd/yyyy): _________________ Start Time (hhmm): ________ Observer Initials: _______

Conditions:
Temperature (C): ______ Wind (0-6): ______ Rain (0-5): ______ Clouds (0-100): ______ Noise (0-3): _______ Protocol Version: ________

Time Interval	Observ. #	Species	Distance (m)	DT	Sex	Age	Flock Size	Prev. Plot	# Fly Over	Comments
0-3	1									

Variable Circular Plot Count Data Form: Categories, Definitions and Descriptions.

Codes (Beaufort scale) used to record wind strength during bird counts.

Wind Code	Explanation
0	Calm, smoke rises vertically (< 2 km/h)
1	Smoke drifts (2-5 km/h)
2	Light breeze felt on face, leaves rustle (6-12 km/h)
3	Leaves and twigs in constant motion (13-19 km/h)
4	Small branches move, raises loose paper, dust rises (20-29 km/h)
5	Fresh breeze, small trees sway (30-39 km/h)
6	Strong breeze, large branches moving, wind whistling (40-50 km/h)

Codes used to record precipitation codes during bird counts.

Rain Code	Explanation
0	No rain
1	Mist or fog
2	Light drizzle
3	Light rain
4	Heavy rain; difficult to hear birds
5	Snow

Codes used to record level of background noise as it effects observer's ability to hear birds.

Noise Code	Explanation
0	quiet; normal background noises; no interference
1	low noise; might be missing some high-pitched songs/calls of distant birds
2	medium noise; detection radius is probably substantially reduced
3	high noise; probably detecting only the loudest/closest birds

Codes used to record the type of detection (Detection Type, DT) of birds during a count.

DT Code	Explanation
1	heard first, but not seen (i.e., detected initially by sound) during the 5-min count
2	seen first (regardless of whether it was later heard or not) during the 5-min count
4	heard first, but then seen (a DT of 1 can be changed to a 4) during the 5-min count
8	heard between plots or not within the 5-minute sampling period
9	seen between plots or not within the 5-minute sampling period

Field Data Form - PRAIRIE BIRD HABIAT MONITORING DATA FORM

Park Code: _____ **Date** (mm/dd/yyyy) _____ **Observer(s) Initials:** _____

Management Unit: _____ **Plot:** _____ **Riparian Corridor:** Yes No

PLOT ATTRIBUTES: (50m radius)

Slope (°): _____ **Var:** high med low **Aspect (°):** _____ **Var:** high med low

Topographic position:
level lower-slope mid-slope upper-slope escarpment/face ledge crest depression draw

Vegetation Type:	**Cover Class:**	**Vegetation Type:**	**Cover Class:**	**Road Cover:**	**Cover Class:**
Upland Prairie		Other: _____		Paved	
Riparian Woodland (TAPR)		Other: _____		Pasture	
Other: _____				**Water Cover:**	
Other: _____				Stream	
Other: _____				Pond	

Plot Notes: _____

SUBPLOT: _____ **Random Azimuth (°)** _____ **Slope(°):** _____ **Aspect (°)** _____

TREE TALLY (by dbh size class)

Species	<1.0 cm	1.1 – 2.5 cm	2.6 – 8.0 cm	8.1 – 15.0 cm	15.1 – 23.0 cm	23.1 – 38.0 cm	>38.0 cm

CANOPY HEIGHT: (m)
Hardwood: _____
Conifer: _____

CANOPY COVER: (dots covered out of 96)
Hardwood: 1___ 2 ___ 3 ___ 4 ___
Conifer: 1___ 2 ___ 3 ___ 4 ___
Total: 1___ 2 ___ 3 ___ 4 ___

BASAL AREA: (cruz-all tree count -- use 10 factor)
Hardwood: _____
Conifer: _____

GROUND COVER:	**Cover Class:**	**FOLIAR COVER** (by guilds)**:**	**Cover Class:**
Deciduous Litter		Warm Season Grass	
Conifer Litter		Cool Season Grass	
Grass Litter		Forbs	
Bare Soil		Moss and Lichen	
Rock		Shrubs & Vines	
Woody Debris		Tree Seedlings	
Unvegetated		Total Foliar Cover (< 1.5 m tall)	

HORIZONTAL VEGETATION PROFILE BOARD:
5-m distance: 0.50 m: _____ 0.75 m: _____ 1.0 m: _____ 1.25 m: _____ 1.5 m: _____ 1.75 m: _____ 2.0 m:_____

15-m distance: 0.50 m: _____ 0.75 m: _____ 1.0 m: _____ 1.25 m: _____ 1.5 m: _____ 1.75 m: _____ 2.0 m:_____

VEGETATION PROFILE (D = Deciduous, H = Herbaceous, C = Conifer)

0–1 m	1–2 m	2–3 m	3–4 m	4–5 m	5–6 m	6–7 m	7–7.5 m

Subplot Notes: _____

Prairie Bird Habitat Data Form: Categories, Definitions and Descriptions.

Vegetation Type

TAPR		AGFO	
	Prairie		Upland prairie
	Riparian woodland		Upland disturbance
	Brome fields		Western wheatgrass prairie (river terraces)
	Upland disturbance		Annual-dominated floodplain disturbance
			Willow shrubland
			Wetland (cattail-iris marsh and rush-sedge wetland)

Cover Class Definitions and Cut-point Descriptions

Cover class	Definition	Upper cutpoints for 50 m radius plot	Upper cutpoints for 5 m radius plot	Upper cutpoints for 1.78 m radius plot
0	None present			
1	Trace to 1 %	A circle of radius 5.00 m	A circle of radius 0.50 m	A circle of radius 0.18 m
2	1 – 5 %	A circle of radius 11.18 m	A circle of radius 1.12 m	A circle of radius 0.40 m
3	5 – 25 %	A circle of radius 25.00 m	A circle of radius 2.50 m	A circle of radius 0.89 m
4	25 – 50 %	A circle of radius 35.36 m	A circle of radius 3.54 m	A circle of radius 1.26 m
5	50 – 75 %	A circle of radius 43.30 m	A circle of radius 4.33 m	A circle of radius 1.54 m
6	75 – 95 %	A circle of radius 48.73 m	A circle of radius 4.87 m	A circle of radius 1.73 m
7	95 – 100 %	Full plot radius	Full plot radius	Full plot radius

New Location Data Form (use this form to record coordinates for new sampling locations)

Park: _____ Project: _____ LocationID: _____

Description: _____

UTM Coordinates:

UTMX: _____ UTM Zone: _____

UTMY: _____ Error (m): _____

Latitude: _____ Datum: NAD83

Longitude: _____

Ending Coordinates for Transects:

UTMX end: _____

UTMY end: _____

Latitude end: _____

Longitude end: _____

Elevation: _____ Vertical Error (m): _____

Aspect: N NE E SE S SW W NW How was accuracy determined? _____

Slope (deg): _____ _____

New Location Data Form (use this form to record coordinates for new sampling locations)

Park: _____ Project: _____ LocationID: _____

Description: _____

UTM Coordinates:

UTMX: _____ UTM Zone: _____

UTMY: _____ Error (m): _____

Latitude: _____ Datum: NAD83

Longitude: _____

Ending Coordinates for Transects:

UTMX end: _____

UTMY end: _____

Latitude end: _____

Longitude end: _____

Elevation: _____ Vertical Error (m): _____

Aspect: N NE E SE S SW W NW How was accuracy determined? _____

Slope (deg): _____ _____

Appendix B. List of avian species recorded during breeding seasons (May-June) at Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Sources of data includes Graetz et al. 1995 (a), Powell 2000 (b), and Litchtenberg and Powell 1999 (c).

Common name / Code	Scientific name	TSN	AGFO		TAPR
Great Blue Heron / GBHE	Ardea herodias	174773	Xa	Xb	Xc
Green (Green-backed) Heron / GRHE	Butorides virescens	174793			X
Turkey Vulture / TUVU	Cathartes aura	175265	X		X
Canada Goose / CAGO	Branta canadensis	174999			X
Wood Duck / WODU	Aix sponsa	175122	X	X	X
Mallard / MALL	Anas platyrhynchos	175063	X	X	X
Blue-winged Teal / BWTE	Anas discors	175086	X		
Northern Harrier / NOHA	Circus cyaneus	175430	X		
Red-tailed Hawk / RTHA	Buteo jamaicensis	175350	X	X	X
Swainson's Hawk / SWHA	Buteo swainsni	175367	X		X
Golden Eagle / GOEA	Aquila chrysaetos	175407	X		
Prairie Falcon / PRFA	Falco mexicanus	175603	X		
American Kestrel / AMKE	Falco sparverius	175622	X	X	X
Wild Turkey / WITU	Meleagris gallopavo	176136	X	X	X
Sharp-tailed Grouse / STGR	Tympanuchus phasianellus	175841	X		
Greater Prairie-chicken / GRCH	Tympanuchus cupido	175834		X	X
Northern Bobwhite / NOBO	Colinus virginianus	175863		X	X
Ring-necked Pheasant / RPHE	Phasianus colchicus	175905	X	X	
Virginia Rail / VIRA	Rallus limicola	176221	X		
Sora / SORA	Porzana Carolina	176242	X		
American Avocet / AMAV	Recurvirostra americana	176721	X		
Killdeer / KILL	Charadrius vociferus	176520	X	X	X
Upland Sandpiper / UPSA	Bartramia longicauda	176610	X	X	X
Wilson's Phalarope / WIPH	Phalaropus tricolor	176736	X		
Common Snipe / COSN	Gallinago gallinago	176700	X		
Black Tern / BLTE	Chlidonias niger	176959	X		
Rock Dove / RODO	Columba livia	177071		X	X
Mourning Dove / MODO	Zenaida macroura	177125	X	X	X
Black-billed Cuckoo / BBCU	Coccyzus erythropthalmus	177834			X
Yellow-billed Cuckoo / YBCU	Coccyzus americanus	177831			X
Great Horned Owl / GHOW	Bubo virginianus	177884	X		X
Short-eared Owl / SEOW	Asio flammeus	177935		X	
Barn Owl / BNOW	Tyto alba	177851	X		
Common Nighthawk / CONI	Chordeiles minor	177979	X	X	X
Chimney Swift / CHSW	Chaetura pelagica	178001			X
Ruby-throated Hummingbird / RTHU	Archilochus colubris	178032			X
Belted Kingfisher / BEKI	Ceryle alcyon	178119	X		X
Northern Flicker / NOFL	Colaptes auratus	178154		X	X
Pileated Woodpecker / PIWO	Dryocopus pileatus	178166			X
Red-headed Woodpecker / RHWO	Melanerpes erythrocephalus	178186			X
Red-bellied Woodpecker / RBWO	Melanerpes carolinus	178195			X
Downy Woodpecker / DOWO	Picoides pubescens	178259	X		X
Hairy Woodpecker / HAWO	Picoides villosus	178262			X
Eastern Wood-pewee / EAWP	Contopus virens	178359			X
Western Wood-pewee / WEWP	Contopus sordidulus	178360	X		
Yellow-bellied Flycatcher / YBFL	Empidonax flaviventris	178338			X
Acadian Flycatcher / ACFL	Empidonax virescens	178339			X
Great Crested Flycatcher / GCFL	Myiarchus crinitus	178309			X
Scissor-tailed Flycatcher / STFL	Tyrannus forficatus	178293			X
Eastern Phoebe / EAPH	Sayornis phoebe	178329			X
Say's Phoebe / SAPH	Sayornis saya	178333	X	X	

Appendix B. List of avian species, cont'd.

Common name / Code	Scientific name	TSN	AGFO		TAPR
Cassin's Kingbird / CAKI	Tyrannus vociferans	178288		X	
Western Kingbird / WEKI	Tyrannus verticalis	178287	X	X	X
Eastern Kingbird / EAKI	Tyrannus tyrannus	178279	X	X	X
Loggerhead Shrike / LOSH	Lanius ludovicianus	178515	X	X	X
White-eyed Vireo / WEVI	Vireo griseus	178991			X
Yellow-throated Vireo / YTVI	Vireo flavifrons	179009			X
Warbling Vireo / WAVI	Vireo gilvus	179023			X
Red-eyed Vireo / REVI	Vireo olivaceus	179021			X
Blue Jay / BLJA	Cyanocitta cristata	179680			X
American Crow / AMCR	Corvus brachyrhynchos	179731	X	X	X
Horned Lark / HOLA	Eremophila alpestris	554256	X	X	X
Northern Rough-winged Swallow / NRWS	Stelgidopteryx serripennis	178443	X	X	X
Bank Swallow / BANS	Riparia riparia	178436	X	X	X
Cliff Swallow / CLSW	Hirundo pyrrhonota	178453	X	X	
Barn Swallow / BARS	Hirundo rustica	178448	X	X	X
Black-capped Chickadee / BCCH	Parus atricapillus	178699			X
(Eastern) Tufted Titmouse / ETTI	Parus bicolor	178738			X
White-breasted Nuthatch / WBNU	Sitta carolinensis	178775			X
House Wren / HOWR	Troglodytes aedon	178541	X		X
Bewick's Wren / BEWR	Thryomanes bewickii	178562			X
Carolina Wren / CARW	Thryothorus ludovicianus	178581			X
Rock Wren / ROWR	Salpinctes obsoletus	178614	X	X	
Marsh Wren / MAWR	Cistothorus palustris	178608	X		
Blue-gray Gnatcatcher / BGGN	Polioptila caerulea	179853			X
American Robin / AMRO	Turdus migratorius	179759	X		X
Swainson's Thrush / SWTH	Catharus ustulatus	179788			X
Eastern Bluebird / EABL	Sialia sialis	179801			X
Mountain Bluebird / MOBL	Sialia currucoides	179811	X		
Gray Catbird / GRCA	Dumetella carolinensis	178625	X		X
Northern Mockingbird / NOMO	Mimus polyglottos	178620			X
Brown Thrasher / BRTH	Toxostoma rufum	178627	X	X	X
European Starling / EUST	Sturnus vulgaris	179637		X	X
Tennessee Warbler / TEWA	Vermivora peregrina	178855			X
Northern Parula / NOPA	Parula americana	178868			X
Yellow Warbler / YWAR	Dendroica petechia	178878	X		X
Common Yellowthroat / COYE	Geothlypis trichas	178944	X	X	X
Yellow-breasted Chat / YBCH	Icteria virens	178964			X
Summer Tanager / SUTA	Piranga rubra	179888			X
Eastern (Rufous-sided) Towhee / EATO	Pipilo erythrophthalmus	179276			X
Spotted (Rufous-sided) Towhee / SPTO	Pipilo maculatus	554380	X	X	
Chipping Sparrow / CHSP	Spizella passerina	179435			X
Field Sparrow / FISP	Spizella pusilla	179443			X
Clay-colored Sparrow / CCSP	Spizella pallida	179439		X	
Vesper Sparrow / VESP	Pooecetes gramineus	179366		X	X
Lark Sparrow / LASP	Chondestes grammacus	179371	X	X	X
Lark Bunting / LARB	Calamospiza melanocorys	179312	X	X	
Grasshopper Sparrow / GRSP	Ammodramus savannarum	179333	X	X	X
Chestnut-collared Longspur / CCLO	Calcarius ornatus	179530		X	
Northern Cardinal / NOCA	Cardinalis cardinalis	179124			X
Rose-breasted Grosbeak / RBGR	Pheucticus ludovicianus	179139			X
Black-headed Grosbeak / BHGR	Pheucticus melanocephalus	179140		X	
Blue Grosbeak / BLGR	Guiraca caerulea	179145	X	X	X
Indigo Bunting / INBU	Passerina cyanea	179150			X
Lazuli Bunting / LAZB	Passerina amoena	179151	X	X	
Dickcissel / DICK	Spiza Americana	179165	X		X
Bobolink / BOBO	Dolichonyx oryzivorus	179032	X		
Eastern Meadowlark / EAME	Sturnella magna	179034			X
Western Meadowlark / WEME	Sturnella neglecta	179039	X		X

Appendix B. List of avian species, cont'd.

Common name / Code	Scientific name	TSN	AGFO		TAPR
Yellow-headed Blackbird / YHBL	Xanthocephalus xanthocephalus	179043	X		
Red-winged Blackbird / RWBL	Agelaius phoeniceus	179045	X		X
Great-tailed Grackle / GTGR	Quiscalus mexicanus	179109			X
Common Grackle / COGR	Quiscalus quiscula	179104	X	X	X
Brown-headed Cowbird / BHCO	Molothrus ater	179112	X	X	X
Orchard Oriole / OROR	Icterus spurious	179064	X	X	X
Baltimore (Northern) Oriole / BAOR	Icterus galbula	179083		X	X
American Goldfinch / AMGO	Carduelis tristis	179236	X	X	X
House Sparrow / HOSP	Passer domesticus	179628			X

Appendix C. Plant species and community guilds by park.

Agate Fossil Beds National Monument, Nebraska.

Scientific Name	Common Name	Plant Community Guild
Allium textile	Onion	Forb
Ambrosia psilostachya	Western ragweed	Forb
Ambrosia trifida	Giant ragweed	Forb
Amphiachyris dracunculoides	Broomweed	Forb
Andropogon hallii	Sand bluestem	warm season grass
Arabis holboellii	Rock-cress	Forb
Arenaria hookeri	Sandwort	Forb
Aristida purpurea	Purple three-awn	warm season grass
Artemisia campestris	Wormwood, sage, mugwort	Forb
Artemisia dracunculus	Wormwood, sage, mugwort	Forb
Artemisia frigida	Prairie-sagewort	Forb
Asclepias pumila	Milkweed	Forb
Asclepias speciosa	Showy milkweed	Forb
Asclepias viridiflora	Green milkweed	Forb
Aster ericoides	Squarrose white wild aster	Forb
Astragalus ceramicus	painted milkvetch	Forb
Astragalus crassicarpus	Ground-plum, prairie plum	Forb
Astragalus gracilis	Milk-vetch	Forb
Astragalus laxmannii var. robustior	Prairie milkvetch	Forb
Astragalus lotiflorus	Lotus milk-vetch	Forb
Astragalus missourienses	Nuttall milk-vetch	Forb
Astragalus sericoleucus	Milk-vetch	Forb
Astragalus spatulatus	Milk-vetch	Forb
Astragalus spp		Forb
Bouteloua curtipendula	Side-oats grama-grass	warm season grass
Bouteloua gracilis	Blue grama-grass	warm season grass
Bromus japonicus	Japanese brome	cool season grass
Bromus tectorum	Downy brome	cool season grass
Calamovilfa longifolia	Sand-reed	warm season grass
Calylophus serrulatus	Evening-primrose	Forb
Camelina microcarpa	Small-seed false flax	Forb
Carex filifolia	Sedge	grass-like (cool season grass)
Castilleja sessiliflora	Downy paintbrush	Forb
Chamaesyce serpens	Round-leaved spurge	Forb
Chenopodium berlandieri	Pitseed goosefoot	Forb
Chenopodium pratericola	Narrow-leaf goosefoot	Forb
Cirsium canescens	Thistle	Forb
Cirsium flodmanii	Prairie thistle	Forb
Cleome serrulata	Stinking clover	Forb
Comandra umbellata	Bastard toad-flax	Forb
Conyza canadensis	Horseweed	Forb
Corispermum hyssopifolium	Bugseed	Forb
Coryphantha vivipara	Pincushion cactus	Forb
Croton texensis	Texas croton	Forb
Cryptantha cana	Borage	Forb
Cryptantha celosioides	Borage	Forb
Cymopterus acaulis	Wild parsley	Forb
Dalea candida var. oligophylla	White prairie clover	Forb
Dalea purpurea	Purple prairie clover	Forb

Appendix C. Agate Fossil Beds National Monument, Nebraska, cont'd.

Scientific Name	Common Name	Plant Community Guilds
Descurainia pinnata	Tansy-mustard	Forb
Descurainia sophia	Herb-sophia, tansy-mustard	Forb
Ellisia nyctelea	Water-pod	Forb
Elymus elymoides	Wild rye	cool season grass
Elymus lanceolatus ssp. Lanceolatus	Wild rye	cool season grass
Equisetum laevigatum	Smooth scouring rushes	Forb
Erigeron bellidiastrum	Fleabane	Forb
Erigeron pumilus	Fleabane	Forb
Eriogonum annuum	Annual eriogonum	Forb
Eriogonum cernuum	Nodding wild buckwheat	Forb
Eriogonum flavum	Yellow wild buckwheat	Forb
Erysimum asperum	Western wallflower	Forb
Euphorbia glyptosperma	Ridge-seeded spurge	Forb
Euphorbia missurica	Prairie spurge	Forb
Euphorbia robusta	Spurge	Forb
Gaura coccinea	Scarlet gaura	Forb
Gaura parviflora	Gaura	Forb
Gutierrezia sarothrae	Matchbrush	Forb
Hedeoma drummondii	Drummond false pennyroyal	Forb
Hedeoma hispidum	Mint	Forb
Helianthus annuus	Common sunflower	Forb
Helianthus petiolaris	Plains sunflower	Forb
Heterotheca villosa	Golden aster	Forb
Hymenopappus filifolius var. polycephalus	Aster	Forb
Iva xanthifolia	Big marsh-elder	Forb
Kochia scoparia	Summer-cypress	Forb
Koeleria macrantha	Junegrass	cool season grass
Lactuca Serriola	Prickly lettuce	Forb
Lactuca tatarica var. pulchella	Blue lettuce	Forb
Lappula occidentalis var. occidentalis	Western stickseed	Forb
Lathyrus polymorphus	Vetchling, wild pea	Forb
Lepidium densiflorum	Prairie-pepperweed	Forb
Lesquerella arenosa	Great Plains bladderpod	Forb
Lesquerella ludoviciana	Mustard	Forb
Liatris punctata	Blazing star, gay feather	Forb
Linum puberulum	Plains flax	Forb
Linum rigidum	Stiffstem yellow flax	Forb
Lithospermum incisum	Narrow-leaved puccoon	Forb
Lupinus plattensis	Lupine	Forb
Lupinus pusillus	Lupine	Forb
Lygodesmia juncea	Skeleton-weed	Forb
Machaeranthera grindelioides	Rayless aster	Forb
Machaeranthera pinnatifida ssp. Pinnatifida var. pinnatifida	Aster	Forb
Melilotus ssp.	M. albus , M. officinalis	Forb
Mirabilis hirsuta	Hairy umbrella-wort	Forb
Mirabilis linearis	Narrow-leaved umbrella-wort	Forb
Muhlenbergia pungens	Muhly	warm season grass
Musineon tenuifolium	Parsley	Forb
Oenothera albicaulis	Evening-primrose	Forb
Oenothera cespitosa	Evening-primrose	Forb

Appendix C. Agate Fossil Beds National Monument, Nebraska, cont'd.

Scientific Name	Common Name	Plant Community Guilds
Oenothera nuttallii	White-stemmed evening-primrose	Forb
Oenothera villosa	Evening-primrose	Forb
Opuntia fragilis	Little prickly pear	Forb
Opuntia macrorhiza	Plains prickly pear	Forb
Opuntia polyacantha	Plains prickly pear	Forb
Orobanche fasciculata	Clustered broom-rape	Forb
Oryzopsis hymenoides	Indian ricegrass	cool season grass
Oxytropis sericea	White locoweed	Forb
Paronychia depressa	Whitlow-wort	Forb
Paronychia sessiliflora	Nailwort	Forb
Pascopyrum smithii	Western wheatgrass	cool season grass
Penstemon angustifolius	Beard-tongue	Forb
Penstemon eriantherus	Beard-tongue	Forb
Phacelia hastata	Phacelia	Forb
Phlox andicola	Phlox, Sweet William	Forb
Phlox hoodii	Phlox, Sweet William	Forb
Physalis hispida	Plains-sandhill ground cherry	Forb
Plantago patagonica	Wooly plantain	Forb
Poa pratensis	Kentucky bluegrass	cool season grass
Poa secunda	Bluegrass	cool season grass
Polygonum ramosissimum	Smartweed	Forb
Psoralea esculenta	Breadroot scurf-pea	Forb
Psoralidium lanceolatum	Pea, Bean	Forb
Psoralidium tenuiforum	Gray scurf-pea	Forb
Rhus trilobata	Squaw-bush	woody (shrubs and vines)
Ribes americanum	Gooseberry	woody (shrubs and vines)
Rumex venosus	Veiny dock	Forb
Salix exigua	Sandbar willow	woody (shrub and vines)
Salsola spp.	Russian thistle (S. kali or S. collina)	Forb
Schizachyrium scoparium	Little bluestem	warm season grass
Senecio canus	Gray groundsel	Forb
Senecio riddellii	Groundsel, ragwort	Forb
Silene drummondii	Drummond's campion	Forb
Sisymbrium altissimum	Tumbling-mustard	Forb
Sphaeralcea coccinea	Scarlet mallow	Forb
Sporobolus cryptandrus	Sand dropseed	warm season grass
Stipa comata	Needle-and-thread grass	cool season grass
Symphoricarpos occidentalis	Western snowberry	woody (shrubs and vines)
Taraxacum officinale	Common dandelion	Forb
Tetraneuris acaulis	Bitterweed	Forb
Thermopsis rhombifolia	Buckbean	Forb
Townsendia grandiflora	Easter daisy	Forb
Tradescantia occidentalis	Prairie spiderwort	Forb
Tragopogon dubius	Fistulous goat's beard	Forb
Viola nuttallii	Yellow prairie violet	Forb
Vulpia octoflora	Six-weeks fescue	cool season grass
Yucca glauca	Soap plant	woody (shrubs and vines)

Appendix C. cont"d.

Tallgrass Prairie National Preserve, Kansas

ScientificName	Common Name	Plant Community Guild
Acalypha ostryifolia	Rough-pod copperleaf	Forb
Acalypha spp		Forb
Acalypha virginica	Virginia copperleaf	Forb
Achillea millefolium	Common yarrow	Forb
Aegilops cylindrica	Jointed goatgrass	cool season grass
Aesculus glabra	Western buckeye	woody (shrub or small tree)
Agalinis aspera	Tall false foxglove	Forb
Agalinis densiflora	Fineleaf gerardia	Forb
Agalinis spp.-TAPR		Forb
Agalinis tenuifolia	Slender gerardia	Forb
Agastache nepetoides	Catnip giant hyssop	Forb
Ageratina altissima	Tall ageratina	Forb
Agrimonia parviflora	Many-flowered agrimony	Forb
Agrostis hyemalis	Ticklegrass	cool season grass
Alisma subcordatum	Water plantain	Forb
Alliaria petiolata	Garlic-mustard	Forb
Allium canadense	Onion	Forb
Alopecurus carolinianus	Carolina foxtail	cool season grass
Amaranthus blitoides	Prostrate pigweed	Forb
Amaranthus retroflexus	Rough pigweed	Forb
Amaranthus rudis	Water hemp	Forb
Amaranthus spinosus	Spiny pigweed	Forb
Ambrosia artemisiifolia	Common ragweed	Forb
Ambrosia psilostachya	Western ragweed	Forb
Ambrosia trifida	Giant ragweed	Forb
Ammannia coccinea	Purple ammannia	Forb
Amorpha canescens	Lead-plant	woody (shrubs and vines)
Amorpha fruticosa	False indigo	woody (shrubs and vines)
Amphiachyris dracunculoides	Broomweed	Forb
Andropogon gerardii	Big bluestem	warm season grass
Androsace occidentalis	Western androsace	Forb
Anemone caroliniana	Carolina anemone	Forb
Antennaria neglecta	Field pussytoes	Forb
Apocynum cannabinum	Hemp dogbane	Forb
Aquilegia canadenis	Wild columbine	Forb
Arctium minus	Common burdock	Forb
Arenaria serpyllifolia	Thyme-leaved sandwort	Forb
Arisaema dracontium	Dragonroot	Forb
Aristida oligantha	Prairie three-awn	warm season grass
Arnoglossum atriplicifolium	Pale indian plantain	Forb
Arnoglossum plantagineum	Tuberous Indian plantain	Forb
Artemisia ludoviciana	White sage	Forb
Asclepias amplexicaulis	Clasping milkweed	Forb
Asclepias asperula	Antelope horns	Forb
Asclepias spp.		Forb

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Asclepias stenophylla	Narrow-leaved milkweed	Forb
Asclepias sullivantii	Smooth milkweed	Forb
Asclepias syriaca	Common milkweed	Forb
Asclepias tuberosa	Butterfly-weed	Forb
Asclepias verticillata	Whorled milkweed	Forb
Asclepias viridiflora	Green milkweed	Forb
Asclepias viridis	Ozark milkweed	Forb
Aster drummondii	Hairy heart-leaved wild aster	Forb
Aster ericoides	Squarrose white wild aster	Forb
Aster laevis	Smooth wild aster	Forb
Aster oblongifolius	Aromatic wild aster	Forb
Aster sericeus	Western silvery wild aster	Forb
Astragalus Crassicarpus	Ground-plum, prairie plum	Forb
Astragalus lotiflorus	Lotus milk-vetch	Forb
Baptisia australis	blue wild indigp	Forb
Baptisia bracteata var. leucophaea	Plains wild indigo	Forb
Bassia scoparia	Summer cypress	Forb
Bidens aristosa	Coreopsis beggar-ticks	Forb
Bidens cernua	Nodding beggar-ticks	Forb
Bidens frondosa	Beggar-ticks	Forb
Bothriochloa bladii	Caucasian bluestem	warm season grass
Bothriochloa saccharoides	Silver bluestem	warm season grass
Botrychium virginianum	Rattlesnake fern	Forb
Bouteloua curtipendula	Side-oats grama-grass	warm season grass
Bouteloua gracilis	Blue grama-grass	warm season grass
Bouteloua hirsuta	Hairy grama-grass	warm season grass
Brickellia eupatorioides	Aster	Forb
Bromus inermis	Smooth brome	cool season grass
Bromus japonicus	Japanese brome	cool season grass
Bromus tectorum	Downy brome	cool season grass
Buchloe dactyloides	Buffalo-grass	cool season grass
Buglossoides arvensis	Corn gromwell	Forb
Cacalia plantaginea	Tuberous Indian plantain	Forb
Callirhoe alcaeoides	Pale poppy-mallow	Forb
Callirhoe involucrata	Purple poppy mallow	Forb
Callitriche heterophylla	Water starwort	Forb
Calylophus serrulatus	Evening-primrose	Forb
Calystegia macounii	Macoun's bindweed	Forb
Camelina microcarpa	Small-seeded false flax	Forb
Capsella bursa-pastoris	Shepherd's purse	Forb
Carduus nutans	Musk thistle	Forb
Carex amphibola	Eastern narrowleaf sedge	grass-like (cool season grass)
Carex blanda	Sedge	grass-like (cool season grass)
Carex brevior	Sedge	grass-like (cool season grass)
Carex davisii	Davis sedge	grass-like (cool season grass)
Carex emoryi	Emory sedge	grass-like (cool season grass)
Carex frankii	Frank's sedge	grass-like (cool season grass)
Carex gravida	Heavy sedge	grass-like (cool season grass)
Carex hystericina	Bottlebrush sedge	grass-like (cool season grass)
Carex meadii	Sedge	grass-like (cool season grass)

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Carex mulilenbergii	Muhlenberg sedge	grass-like (cool season grass)
Carex spp.		grass-like (cool season grass)
Carex vulpinoidea	Fox sedge	grass-like (cool season grass)
Ceanothus americanus	New Jersey tea, redroot	woody (shrubs and vines)
Ceanothus herbaceus	Prairie-redroot	woody (shrubs and vines)
Celastrus scandens	American bittersweet	vine
Cenchrus longispinus	Sandbur	warm season grass
Cephalanthus occidentalis	Buttonbush	Shrub
Cerastium brachypodum	Mouse-ear chickweed	Forb
Ceratophyllum demersum	Hornwort	Forb
Chaerophyllum procumbens	Spreading chervil	Forb
Chamaecrista fasciculata	Showy partridge pea	Forb
Chamaesyce glyptosperma	Ridge-seed spurge	Forb
Chamaesyce missurica	Missouri spurge	Forb
Chamaesyce nutans	Eyebane	Forb
Chamaesyce prostrata	Spurge	Forb
Chenopodium album	Lamb's quarters, pigweed	Forb
Chenopodium berlandieri	Pitseed goosefoot	Forb
Chenopodium simplex	Mapleleaf goosefoot	Forb
Chenopodium spp.		Forb
Chloris verticillata	Windmill finger-grass	Cool season grass
Cirsium altissimum	Tall thistle	Forb
Cirsium undulatum	Wavy-leaved thistle	Forb
Clematis pitcheri	Pitcher's clematis	vine
Clematis terniflora	Sweet autumn virginbower	woody (shrubs and vines)
Commelina erecta	Erect dayflower	Forb
Conium maculatum	Poison hemlock	Forb
Convolvulus arvensis	Field-bindweed	Forb
Conyza Canadensis	Horseweed	Forb
Coreopsis grandiflora	Bigflower coreopsis	Forb
Cornus drummondii	Rough-leaved dogwood	woody (shrubs and vines)
Corydalis micrantha	Slender corydalis	annual-biennial
Crataegus mollis	Downy hawthorn	woody (shrub or small tree)
Croton capitatus	Woolly croton	Forb
Croton monanthogynus	Prairie-tea, one-seed croton	Forb
Croton spp		Forb
Croton texensis	Texas croton	Forb
Cucurbita foetidissima	Buffalo-gourd	Forb
Cynanchum laeve	Honey vine	Forb
Cyperus esculentus	Yellow nutsedge	cool season grass
Cyperus lupulinus	Houghton flatsedge	cool season grass
Cyperus odoratus	Fragrant flatsedge	cool season grass
Cyperus setigerus	Roughedge flatsedge	cool season grass
Cyperus spp.		grass-like (cool season grass)
Cyperus strigosus	False nutgrass	cool season grass
Cystopteris tennesseensis	Tennessee bladder fern	Forb
Dalea aurea	Golden prairie clover	Forb
Dalea candida	White prairie clover	Forb
Dalea multiflora	roundhead prairieclover	Forb
Dalea purpurea	Purple prairie clover	Forb
Dalea spp		Forb

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Datura stramonium	Jimson weed	Forb
Delphinium carolinianum spp. Virescens	Prairie larkspur	Forb
Descurainia pinnata	Tansy-mustard	Forb
Desmanthus illinoensis	Bundleflower	Forb
Desmodium cuspidatum	Big tick-trefoil	Forb
Desmodium illinoense	Prairie tick-trefoil	Forb
Desmodium sessilifolium	Sessile tickclover	Forb
Desmodium spp.		Forb
Dichanthelium acuminatum	Panic grass	cool season grass
Dichanthelium oligosanthes	Panic grass	cool season grass
Dichanthelium spp.		cool season grass
Digitaria cognata	Carolina crab grass	cool season grass
Digitaria sanguinalis	Hairy crabgrass	warm season grass
Draba branchycarpa	Mustard	Forb
Draba cuneifolia	Mustard	Forb
Draba reptans	Mustard	Forb
Dyssodia papposa	Fetid marigold	Forb
Echinacea angustifolia	Prairie coneflower	Forb
Echinochloa crus-galli	Barnyard grass	warm season grass
Echinochloa muricata	Rough barnyard grass	warm season grass
Eclipta prostrata	Yerba-de-tajo	Forb
Eleocharis compressa	Spike-rush	grass-like (cool season grass)
Eleocharis macrostachya	Longstem spike sedge	cool season grass
Eleocharis obtusa	Blunt spike sedge	cool season grass
Eleocharis spp.		grass-like (cool season grass)
Ellisia nyctelea	Water-pod	Forb
Elymus canadensis	Canada wild rye	cool season grass
Elymus spp.		cool season grass
Elymus virginicus	Virginia wild rye	warm season grass
Equisetum laevigatum	Smooth horsetail	warm season grass
Eragrostis cilianensis	Stinkgrass	warm season grass
Eragrostis spectabilis	Purple lovegrass	warm season grass
Erigeron philadelphicus	Philadelphia daisy	Forb
Erigeron spp.		Forb
Erigeron strigosus	Rough fleabane	Forb
Eriochloa contracta	Prairie cupgrass	warm season grass
Erysimum repandum	Bushy wallflower	Forb
Erythronium mesochoreum	Midland fawn lily	Forb
Escobaria missouriensis var. missouriensis	Missouri coryphanthe	Forb
Euonymus atropurpurea	Wahoo	shrub
Eupatorium altissimum	Tall Joe-Pye weed	Forb
Euphorbia corollata	Flowering spurge	Forb
Euphorbia cyathophora	Fire-on-the-mountain	Forb
Euphorbia dentata	Toothed spurge	Forb
Euphorbia marginata	Snow-on-the-mountain	Forb
Euphorbia spathulata	Prairie spurge	Forb
Euthamia gymnospermoides	Great Plains flat-topped goldenrod	Forb
Evolvulus nuttallianus	Evolvulus	Forb
Festuca subverticillata	Nodding fescue	cool season grass
Fuirena simplex	Umbrella grass	cool season grass

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Galium aparine	Cleavers	Forb
Galium circaezans	Forest bedstraw, wild licorice	Forb
Galium triflorum	Sweet-scented bedstraw	Forb
Gaura longiflora	Large flowered gaura	Forb
Gaura mollis	Velvety gaura	Forb
Geranium carolinianum	Carolina crane's-bill	Forb
Geum canadense	White avens	Forb
Glandularia canadensis	Rose verbena	Forb
Glyceria striata	Fowl mannagrass	cool season grass
Glycyrrhiza lepidota	Wild licorice	Forb
Grindelia squarrosa	Curly-top gumweed	Forb
Hedeoma hispidum	Mint	Forb
Hedyotis nigricans var. nigricans	Madder	Forb
Helianthus annuus	Common sunflower	Forb
Helianthus maximiliani	Maximilian sunflower	Forb
Helianthus pauciflorus	Stiff sunflower	Forb
Helianthus salicifolius	Willow-leaved sunflower	Forb
Helianthus spp.		Forb
Helianthus tuberosus	Jerusalem artichoke	Forb
Heliopsis helianthoides	False sunflower	Forb
Heterotheca canescens	Golden aster	Forb
Hieracium longipilum	Long-haired hawkweed	Forb
Holcus lanatus	Common velvet-grass	cool season grass
Hordeum pusillum	Little barley	cool season grass
Hybanthus verticillatus	Nodding green violet	Forb
Hymenopappus scabiosaeus	Carolina woollywhite	Forb
Hypericum perforatum	Common ST. Johns-wort	Forb
Ipomoea hederacea	Ivyleaf morning-glory	Forb
Iva annua	Annual sumpweed	Forb
Juncus dudleyi	Dudley rush	cool season grass
Juncus interior	Rush	grass-like (cool season grass)
Juncus spp.		grass-like (cool season grass)
Juncus tenuis	Path rush	cool season grass
Juncus torreyi coville	Torrey's rush	cool season grass
Justicia americana	Water willow	Forb
Kochia scoparia	Summer-cypress	Forb
Koeleria macrantha	Junegrass	cool season grass
Krigia cespitosa	Sunflower	Forb
Kummerowia stipulacea	Korean clover	Forb
Lactuca ludoviciana	Western wild lettuce	Forb
Lactuca Serriola	Prickly lettuce	Forb
Lactuca spp.		Forb
Lamium amplexicaule	Henbit	Forb
Laportea canadensis	Nettle	Forb
Leersia oryziodes	Rice cut-grass	warm season grass
Lemna minor	Duckweed	Forb
Lepidium densiflorum	Prairie-pepperweed	Forb
Lespedeza capitata	Bush-clover	Forb
Lespedeza violacea	Violet lespedeza	Forb
Lespedeza virginica	Slender bush lespedeza	Forb
Leucospora multifida	Leucospora	Forb

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Liatris aspera	Lacerate blazing star	Forb
Liatris mucronata	Gayfeather	Forb
Liatris punctata	Blazing star, gay feather	Forb
Liatris spp.–TAPR	L. mucronata, L. punctata	Forb
Linum sulcatum	Grooved yellow flax	Forb
Lithospermum Incisum	Narrow-leaved puccoon	Forb
Lobelia cardinalis	Cardinal-flower	Forb
Lobelia siphilitica	Blue lobelia	Forb
Lomatium foeniculaceum	Yellow wild parsley	Forb
Ludwigia peploides	Floating evening primrose	Forb
Lycopus americanus	American bugleweed	Forb
Lythrum alatum	Winged loosestrife	Forb
Medicago lupulina	Black medick	Forb
Melilotus albus	White sweet clover	Forb
Melilotus officinalis	Sweet clover	Forb
Menispermum canadense	Moonseed	woody (shrubs and vines)
Mentha arvensis	Field mint	Forb
Mentzelia oligosperma	Stickleaf mentzelia	Forb
Mimosa nuttallii	Catclaw sensitive brier	Forb
Mirabilis albida	White four o'clock	Forb
Mirabilis linearis	Narrow-leaf Four o'clock	Forb
Mirabilis nyctaginea	Heart-leaved umbrella-wort	Forb
Mirabilis spp. – TAPR	M. albida, M. linearis	Forb
Monarda fistulosa	Wild bergamot	Forb
Monolepis nuttalliana	Poverty weed	Forb
Muhlenbergia frondosa	Muhly	warm season grass
Muhlenenbergia cuspidata	Muhly	cool season grass
Myagrum perfoliatum	Bird's-eye cress	Forb
Myosotis verna	Early scorpion grass	Forb
Myosurus minimus	Tiny mousetail	Forb
Myriophyllum heterophyllum	Water milfoil	Forb
Nepeta cataria	Catnip	Forb
Nothocalais cuspidata	Wavyleaf agoseris	Forb
Nothoscordum bivalve	Lily	Forb
Oenothera biennis	Common evening-primrose	Forb
Oenothera macrocarpa	Wing-fruit evening-primrose	Forb
Oenothera speciosa	White evening-primrose	Forb
Oligoneuron rigidum	Rigid goldenrod	Forb
Onosmodium molle	Western false gromwell	Forb
Opuntia macrorhiza	Plains prickly pear	Forb
Osmorhiza longistylis	Anise root	Forb
Oxalis dillenii	Southern yellow wood-sorrel	Forb
Oxalis spp.	wood-sorrel	Forb
Oxalis violacea	Violet wood-sorrel	Forb
Packera plattensis	Prairie ragwort	Forb
Panicum capillare	Witch-grass	warm season grass
Panicum dichotomiflorum	Fall panicum	warm season grass
Panicum obtusum	Vine-mesquite	warm season grass
Panicum virgatum	Switchgrass	warm season grass
Parietaria pensylvanica	Pennsylvania pellitory	Forb
Parthenocissus quinquefolia	Virginia-creeper, woodbine	woody (shrubs and vines)

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Pascopyrum smithii	Western wheatgrass	cool season grass
Paspalum pubiflorum	Hairyseen paspalum	warm season grass
Paspalum spp.-TAPR		warm season grass
Pediomelum argophyllum	Silver-leaf scurf pea	Forb
Pediomelum esculentum	Breadroot scurf-pea	Forb
Pediomelum tenuiflorum	Wild alfalfa	Forb
Pellaea atropurpurea	Purple cliff-brake	Forb
Pennisetum glaucum	Yellow foxtail	warm season grass
Penstemon cobaea	cobaea beardtongue	Forb
Penstemon grandiflorus	Large beard-tongue	Forb
Penstemon tubiflorus	Tube beard-tongue	Forb
Penthorum sedoides	Ditch stonecrop	Forb
Phlox divaricata	Forest phlox	Forb
Phlox spp.		Forb
Phryma leptostachya	Lopseed	Forb
Phyla lanceolata	Northern frog fruit	Forb
Physalis heterophylla	Clammy ground cherry	Forb
Physalis longifolia	Longflower ground cherry	Forb
Physalis pumila	Prairie ground cherry	Forb
Physalis spp.		Forb
Physalis virginiana	Virginia ground cherry	Forb
Phytolacca americana	Pokeweed, pokeberry	Forb
Plantago patagonica	Wooly plantain	Forb
Plantago rhodosperma	Plantain	Forb
Plantago rugelii	American plantain	Forb
Plantago spp.		Forb
Plantago virginica	Pale-seeded plantain	Forb
Poa arida	Plains bluegrass	cool season grass
Poa pratensis	Kentucky bluegrass	cool season grass
Poa spp.		cool season grass
Polanisia dodecandra	Clammy-weed	Forb
Polygala verticllata	Whorled milkwort	Forb
Polygonatum biflorum	Solomon's seal	Forb
Polygonum lapathifolium	Pale smartweed	Forb
Polygonum pensylvanicum	Pink smartweed	Forb
Polygonum persicaria	Lady's-thumb	Forb
Polygonum punctatum	Dotted smartweed	Forb
Polygonum ramosissimum	Smartweed	Forb
Polygonum scandens	False buckwheat	Forb
Polygonum virginianum	Jumpseed	Forb
Polytaenia nuttallii	Nuttall's prairie parsley	Forb
Portulaca oleracea	Common purslane	Forb
Potamogeton foliosus	Leafy pondweed	Forb
Potamogeton nodosus	Longleaf pondweed	Forb
Prenanthes aspera	Rough rattlesnake root	Forb
Prunella vulgaris	Selfheal	Forb
Prunus americana	American wild plum	Tree/shrub
Prunus virginiana	Choke cherry	Tree/shrub
Psoralea argophylla	Silvery scurf-pea	Forb
Psoralea esculenta	Breadroot scurf-pea	Forb

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Psoralidium tenuiflorum	Gray scurf-pea	Forb
Ranunculus sceleratus	Cursed crowfoot	Forb
Ratibida columnifera	Columnar coneflower	Forb
Rhus aromatica	Fragrant sumac	shrub
Rhus glabra	Smooth sumac	woody (shrubs and vines)
Ribes aureum	Buffalo currant	shrub
Ribes missouriense	Missouri gooseberry	woody (shrubs and vines)
Rorippa nasturtium	Watercress	Forb
Rosa arkansana	Dwarf prairie rose	woody (shrubs and vines)
Rosa multiflora	Multiflora rose	shrub
Ruellia humilis	Fringeleaf ruellia	Forb
Ruellia strepens	Acanthus	Forb
Rumex altissimus	Pale dock	Forb
Rumex crispus	Curly dock	Forb
Rumex spp.	Dock	Forb
Sagittaria brevirostra	Arrowhead	Forb
Salvia azurea	Sage	Forb
Salvia reflexa	Lance-leaved sage	Forb
Sambucus canadensis	Common elder	woody (shrubs and vines)
Sambucus nigra	Common elderberry	Tree/shrub
Sanicula canadensis	Black snakeroot	Forb
Schizachyrium scoparium	Little bluestem	warm season grass
Schoenoplectus tabernaemontani	Soft-stem bulrush	cool season grass
Schrankia nuttallii	Sensitive brier	Forb
Scirpus atrovirens	Darkgreen bulrush	cool season grass
Scirpus pallidus	Pale bulrush	cool season grass
Scirpus pendulus	Rusty bulrush	cool season grass
Scrophularia marilandica	Maryland figwort	Forb
Scutellaria parvula	Little skullcap	Forb
Senecio plattensis	Platte groundsel	Forb
Senna marilandica	Wild senna	Forb
Setaria spp.		warm season grass
Setaria viridis	Green foxtail-grass	warm season grass
Sicyos angulatus	Bur cucumber	Forb
Sida spinosa	Prickly spinosa	Forb
Silene antirrhina	Catchfly, campion	Forb
Silene stellata	Starry campion	Forb
Silphium integrifolium	Showy rosinweed	Forb
Silphium laciniatum	Compass-plant	Forb
Sisyrinchium campestre	Blue-eyed grass	Forb
Smilax tamnoides	Catbrier	woody (shrubs and vines)
Solanum carolinense	Horse-nettle	Forb
Solanum elaeagnifolium	Silver-leaf nightshade	Forb
Solanum rostratum	Buffalo-bur	Forb
Solidago canadensis	Common goldenrod	Forb
Solidago Canadensis var. gilvocanescens	Common goldenrod	Forb
Solidago missouriensis	Missouri goldenrod	Forb
Solidago petiolaris	Downy goldenrod	Forb
Solidago rigida	Stiff goldenrod	Forb
Solidago spp.		Forb

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Sonchus asper	Prickly sow thistle	Forb
Sorghastrum nutans	Indian grass	warm season grass
Sorghum halepense	Johnson grass	warm season grass
Spartina pectinata	Prairie cordgrass	warm season grass
Spermolepis inermis	Western spermolepis	Forb
Spiranthes cernua	Nodding ladies' tresses	Forb
Spiranthes vernalis	Twisted lady's tresses	Forb
Sporobolus asper	Tall dropseed	warm season grass
Sporobolus compositus	Rough dropseed	warm season grass
Sporobolus neglectus	Dropseed	warm season grass
Sporobolus spp.		warm season grass
Stellaria media	Common chickweed	Forb
Stenosiphon linifolius	Stenosiphon	Forb
Strophostyles helvula	Annual woolly bean	Forb
Strophostyles leiosperma	Small-flowered woolly bean	Forb
Symphoricarpos orbiculatus	Coralberry	woody (shrubs and vines)
Symphyotrichum drummondii	Drummond aster	Forb
Symphyotrichum ericoides	White aster	Forb
Symphyotrichum lanceolatum	Simple panicled aster	Forb
Symphyotrichum oblongifolium	Aromatic aster	Forb
Symphyotrichum sericeum	Silky aster	Forb
Taraxacum officinale	Common dandelion	Forb
Teucrium canadense	American germander	Forb
Thalictrum dasycarpum	Purple meadow rue	Forb
Thelesperma filifolium	Greenthread	Forb
Thlaspi arvense	Field penny-cress	Forb
Toxicodendron radicans	Common poison-ivy	woody (shrubs and vines)
Tradescantia bracteata	Sticky spiderwort	Forb
Tradescantia ohiensis	Ohio spiderwort	Forb
Tragia betonicifolia	Many-flowered noseburn	Forb
Tragia ramosa	branched noseburn	Forb
Tragopogon dubius	Goats beard	Forb
Tribulus terrestris	Puncture vine	Forb
Trichostema brachiatum	Blue curls	Forb
Tridens flavus	Purpletop	warm season grass
Trifolium repens	White clover	Forb
Triodanis leptocarpa	Narrow-leaved triodanis	Forb
Triodanis perfoliata	Round-leaved triodanis	Forb
Tripsacum dactyloides	Eastern gammagrass	warm season grass
Typha latifolia	Common cattail	Forb
Ulmus pumila	Siberian elm	Tree/shrub
Urtica dioica ssp. Gracilis	Nettle, stinging nettle	Forb
Verbascum blattaria	Moth mullein	Forb
Verbascum thapsus	Common mullein	Forb
Verbena bracteata	Prostrate vervain	Forb
Verbena hastata	Blue vervain	Forb
Verbena simplex	Narrow-leaved vervain	Forb
Verbena stricta	Hoary vervain	Forb
Verbesina alternifolia	Wingstem	Forb

Appendix C. Tallgrass Prairie National Preserve, Kansas, cont'd.

ScientificName	Common Name	Plant Community Guild
Vernonia baldwinii	Western ironweed	Forb
Veronica anagallis-aquatica	Water speedwell	Forb
Veronica arvensis	Corn speedwell	Forb
Veronica peregrina	Purslane speedwell	Forb
Vicia americana	American vetch	Forb
Viola bicolor	Violet	Forb
Viola nephrophylla	Blue prairie violet	Forb
Viola pedatifida	Wood violet	Forb
Viola pratincola	Violet	Forb
Viola sororia	Downy Blue violet	Forb
Viola spp.		Forb
Vitis riparia	Frost grape	woody (shrubs and vines)
Vulpia octoflora	Six-weeks fescue	cool season grass
Xanthium strumarium	Common cocklebur	Forb
Yucca glauca	Yucca	Forb
Zanthoxylum americanum	Common prickly ash	woody (shrubs and vines)
Zigadenus nuttallii	Nuttall's deathcamas	Forb
Zizia aurea	Common golden alexanders	Forb

Appendix D. Common tree species found on Tallgrass Prairie National Preserve, Kansas.

Scientific Name	Common Name	Plant Community Guild
Acer negundo	Box elder	Tree
Acer saccharinum	Silver maple	Tree
Carya cordiformis	Bitternut Hickory	Tree
Carya illinoensis	Pecan	Tree
Catalpa bignonioides	Catalpa	Tree
Celtis occidentalis	Hackberry	Tree
Cercis canadensis	Redbud	Tree
Cornus drummondii	Rough-leaved dogwood	Tree
Fraxinus pennsylvanica	Green ash	Tree
Gleditsia triacanthos	Honey locust	Tree
Gymnocladus dioica	Kentucky coffee tree	Tree
Juglans nigra	Black Walnut	Tree
Juniperus virginiana	Red cedar	Tree
Maclura pomifera	Osage-orange	Tree
Morus alba	White mulberry	Tree
Platanus occidentalis	Sycamore	Tree
Populus deltoides	Eastern cottonwood	Tree
Quercus macroarpa	Bur oak	Tree
Robinia pseud-acacia	Black locust	Tree
Salix amygdaloides	Peachleaf willow	Tree
Salix caroliniana	Carolina willow	Tree
Salix nigra	Black willow	Tree
Ulmus americana	American elm	Tree