Developing an Exotic Plant Geodatabase for Saguaro National Park

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Abstract

Management and control of invasive, non-native or exotic plants presents a significant challenge for ecologists at Saguaro National Park in Arizona. In collaboration with park staff, the Center for Applied Spatial Analysis at the University of Arizona has developed an ArcGIS application for the capture and evaluation of spatial and non-spatial data related to exotic plant infestations in the park. The system utilizes ArcPad-equipped GPS receivers to collect spatial and attribute data in the field, and a file geodatabase to manage the data. The [Exotic Plants] Geodatabase includes historic as well as current data allowing park personnel to monitor change (spatial extent, percent cover, etc.) in exotic plant infestations over time, and to assess the effectiveness of management activities such as herbicide application. Going forward, the use of Geodatabase features such as coded value domains will improve both editing efficiency and overall data integrity.

Introduction

Invasive species have been described as organisms introduced, intentionally or otherwise, into non-native ecosystems where they change, degrade, or displace native populations and biotic communities. In the Sonoran Desert, non-native invasive grasses such as red brome (*Bromus rubens*) and buffelgrass (*Pennisetum ciliare*) have demonstrated the ability to radically alter floristic composition and structure, converting biologically diverse thornscrub communities to grassland monocultures unsuitable for many native plant and animal species.

Invasive plants can replace native species simply through direct competition for resources such as soil moisture and nutrients. Perhaps more importantly in the Sonoran Desert, invasives – buffelgrass in particular – can alter fire regimes by increasing fuel loads, and ultimately the frequency and intensity of fire. Fires produce high mortality among native Sonoran Desert

plants and animals, which are not fire adapted, and contribute to the further proliferation of buffelgrass, which responds positively to fire. The result can be fire prone landscapes unlikely to support the reestablishment of native plant populations.

Saguaro National Park (SNP) was established to protect and preserve Sonoran Desert plant and animal species, including the namesake Giant Saguaro (*Carnegiea gigantea*). The park is comprised of two districts, located east (Rincon Mountain District) and west (Tucson Mountain District) of Tucson, Arizona (Figure 1), and includes six biotic communities, ranging from the desert scrub found at the lowest elevations in both districts,

Figure 1: Tucson, Arizona vicinity with Saguaro National Park boundaries

to the mixed conifer forest found in the higher elevations of the Rincon Mountains (Figure 2).

Floristic surveys conducted during the past decade have identified 80 exotic plant species in Saguaro National Park. Though many of these species do not pose serious environmental threats, there are significant infestations of buffelgrass, which the Park Service describes as "the greatest non-native species threat the park has ever faced." (http://www.nps.gov/sagu/naturescience/invasive-plants.htm) Existing evidence suggests that left unchecked, infestations of buffelgrass and other invasives have the potential to permanently alter the park's ecosystem, possibly leading to localized extinctions of the iconic saguaros and other native plant and animal species in the park.

Figure 2: Typical Sonoran Desert thornscrub community, Saguaro National Park, Rincon Mountain District.

Efforts to control invasive plant species in the park are ongoing and include a variety of chemical and mechanical treatment methods, undertaken by both park staff and volunteers. Spatial data play an important role in these efforts, providing information about the locations and characteristics of exotic plant infestations. These data inform treatment efforts and are used to assess treatment effectiveness, and are also utilized in the compliance reporting associated with the use of certain chemical herbicides.

In 2009, a project to create a new database for the capture and management of the spatially referenced data representing exotic plant infestations in Saguaro National Park was completed by the University of Arizona's Center for Applied Spatial Analysis (CASA), working in collaboration with National Park Service ecologists. This project was supported by a grant from the Desert Southwest Cooperative Ecosystem Studies Unit (National Park Service). Replacing a previous application based on shapefiles, this application includes an ESRI ArcGIS 9.3 geodatabase ("ExoticPlantsGDB"), and utilizes the ArcPad Data Manager extension to facilitate data transfer between ArcPad 7.2 equipped GPS field units and the geodatabase. This approach provides several improvements over the previous shapefile-based system.

Application Overview

Many of the functional requirements for the application were met through utilization of a relational database structure, implemented as an ArcGIS 9.3 file geodatabase. In the ExoticPlantsGDB, infestations are modeled as *occurrences*, point features that include attributes such as species. Related (via geodatabase relationship classes, described below) to each occurrence are any number of date-specific *assessments*, which represent the actual infestation geometry recorded in the field, along with attributes such as percent cover, number of plants, and phenology (the attribute set is based on North American Weed Management Association standards). This occurrence-assessment model (based on The Nature Conservancy's Weed Information Management System http://www.imapinvasives.org/GIST/WIMS/index.html) allows tracking of specific infestations over

Figure 3: Occurrences 1721, 1722, and 1723, along with an assessment polygon for occurrence 1723

time, and so can be used to assess treatment effectiveness. Figure 3 shows the spatial relationship between an occurrence and, in this case, a single assessment. It is likely that at the time of the next survey, the geometry of the infestation will be different, and a new assessment feature can be added, and related to the same occurrence.

In addition to the *Occurrence* feature class, a *ManagementAreas* feature class was created at the request of park staff. The management areas were defined by park ecologists, and delineate areas of extensive buffelgrass infestation and/or treatment. The density and distribution of invasives in these areas makes the application of the occurrence-assessment model impractical. The management areas are typically areas of special concern where, for practical reasons, assessment records reflect treatment extents, rather than the full extent of infestations. A relationship is maintained between the *ManagementAreas* and *AllAssessment* feature classes, similar to the occurrence-assessment relationship.

All exotic plant assessments are ultimately represented in the geodatabase as polygons. However, for practical reasons, the application was designed such that assessment data could be recorded in the field as either points, lines, or polygons; the geodatabase includes an assessment feature class for each geometry type. The three assessment feature classes are used primarily to record the spatial extent of infestations or treatments. Related (again, via geodatabase relationship classes) to each point, line, or polygon assessment feature class are data tables where species-specific information is recorded. Each record in the data table represents a single species; there may be multiple records in the data table tied to the same feature class record. This structure allows users to capture complete attribute data for all species associated with a single assessment geometry.

In order that all assessment records may be analyzed simultaneously, the geodatabase includes a feature class *AllAssessments* that includes polygon representations of all assessment records, regardless of whether they were originally recorded as points, lines, or polygons. For point and line features, this requires a buffer operation (based on values recorded by field personnel); conversion of point, line, and polygon assessment data into records in the *AllAssessments* feature class is done on the desktop using ModelBuilder routines (scripts) which were developed for the application. Maintenance of assessment data in the *AllAssessments* feature class gives users the ability to determine values such as gross or net area infested or treated by querying a single data source, as opposed to the previous system, which required an analyst to evaluate three shapefiles (one each for points, lines, and polygons), then combining the results. The *AllAssessments* feature class also simplifies generation of certain visualization products, particularly through generation (via a provided ModelBuilder routine) of the *MostRecentAssessment* layer, which displays the most recent assessment record for each occurrence.

The relationship between occurrence and assessment records is specifically expressed between the *Occurrence* and *AllAssessments* feature classes via the *rcOccurToAllAssess* relationship class. Although ArcPad users are able to view (read-only versions of) occurrence and related assessment data, *Occurrence* and *AllAssessments* records are created and edited on the desktop. The relationship between occurrence data and actual point, line, or polygon assessment records collected in the field is only implied. Figure 4 summarizes the structural relationships between the principal feature classes and tables in the geodatabase. The geodatabase schema, including
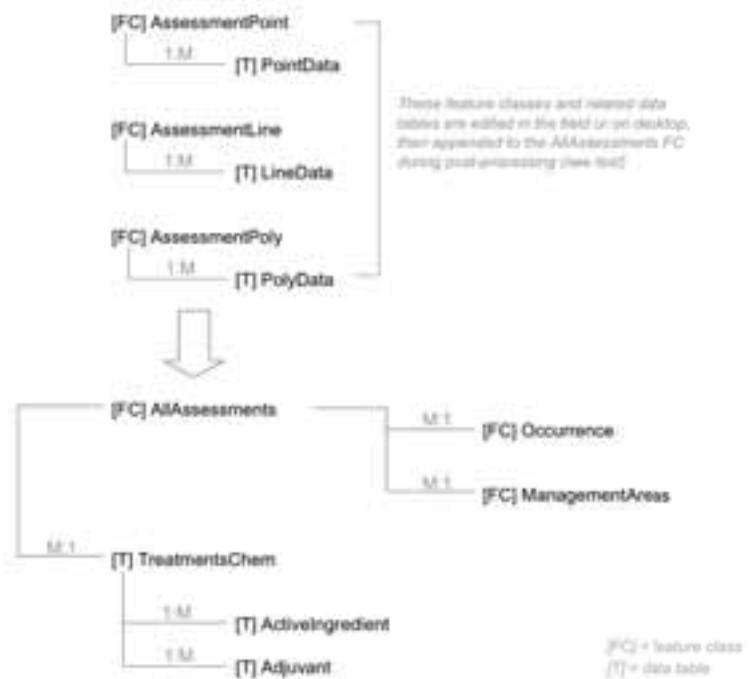

Figure 4: Relationships between principal geodatabase feature classes and tables

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record layouts for each feature class and table, is included as Appendix A.

Tables containing chemical treatment data are also related to the *AllAssessments* feature class (Figure 4). These relationships facilitate certain analyses required for compliance reporting, such as determination of net area treated, herbicide application rates, etc. Chemical treatment data are generally recorded in the field on paper forms and added to the geodatabase on the desktop.

Relationships and Key Attributes

The ExoticPlantsGDB utilizes geodatabase relationship classes to define a number of permanent relationships between records in the various feature classes and tables. The relationship classes improve data editing efficiency and allow users to query and analyze records in related tables without the need to define additional relates or joins. In most cases, the system generated OBJECTID serves as the key attribute in each relationship class, and is recorded in the related table as the foreign key. Using the OBJECTID as the key variable means users are not required to manually maintain record identity schemes, since ArcGIS creates and maintains the OBJECTID values for new and existing records, ensuring that conflicts are avoided.

Within certain limitations, these relationships – in particular the relationships between the point, line, and polygon assessment feature classes and tables - are maintained by ArcPad Data Manager when checking data out to and in from the GPS receivers. Relationship classes maintained in the ExoticPlantsGDB are summarized in Table 1.

Table 1: Summary of geodatabase relationship classes

	Relationship Class	Origin feature class/table Primary key	Cardinality	Type	Destination feature class/table Foreign key	
Related data are available for field edit (in ArcPad)	rcPointAssessments	AssessmentPoint (fc) OBJECTID	1:M	Simple	PointData (table) ShapeID	
	rcLineAssessments	AssessmentLine (fc) OBJECTID	1:M	Simple	LineData (table) ShapeID	links one or more species-specific assessment records to assessment geometry records
	rcPolyAssessments	AssessmentPoly (fc) OBJECTID	1:M	Simple	PolyData (table) ShapeID	
Related data are edited only on the desktop	rcChemTreatToAllAssess	TreatmentsChem (table) OBJECTID	1:M	Simple	AllAssessments (fc) ChemTreatmentID	links assessment data with treatment records
	rcChemTreatToAI	TreatmentsChem (table) OBJECTID	1:M	Composite	ActiveIngredient (table) ChemTreatID	links one or more active ingredient and/or adjuvant records with the primary chemical treatment record
	rcChemTreatToAdjuvant	TreatmentsChem (table) OBJECTID	1:M	Composite	Adjuvant (table) ChemTreatID	
	rcOccurrenceToAllAssess	Occurrence (fc) OBJECTID	1:M	Simple	AllAssessments (fc) OccurrenceID	links one or more assessment records with an occurrence
	rcMgmtAreaToAllAssess	ManagementAreas (fc) OBJECTID	1:M	Simple	AllAssessments (fc) ManagementArea	links one or more assessment records with a management area

Field Data Collection

Park staff use a number of ArcPad equipped GPS receivers to collect spatial and attribute data for exotic plant infestations in the field, and it is not uncommon for multiple field crews to be recording exotics data simultaneously at different locations in the park. Additionally, logistical constraints mean that new exotics records collected on a given GPS unit may not be able to be checked in to the geodatabase for several days after collection. The application, therefore, is

required to support the simultaneous collection of exotics data on multiple devices, and to accurately maintain the primary key field – the unique identifier – for each new record collected.

The previous shapefile-based system used custom scripts to generate and maintain the primary key values for the exotic plant records, but this approach led to certain complications, such as duplicated records. As described above, the ExoticPlantsGDB application utilizes the OBJECTID generated by ArcGIS as the key attribute for each feature class and table; this approach is facilitated by ArcPad Data Manager, which helps maintain unduplicated OBJECTID values as data are checked in to the geodatabase from the field units.

In addition to ArcPad-equipped GPS receivers, exotic plant data may be captured using consumer grade GPS receivers and paper data forms. In these instances, records are added to the geodatabase directly through desktop editing sessions.

Project specifications required that to the extent possible, previously collected (legacy) data be incorporated into the new geodatabase. Ultimately, more than 5500 shapefile records collected over the prior decade were added to the *AllAssessments* feature class, and new related *Occurrence* records were created as appropriate. This process involved standardizing the existing attribute data to conform to the coded value domains used in the ExoticPlantGDB, and also buffering the point and line records based on patch width and length values present in the original datasets. Because some existing records were missing values for some attributes altogether, and because values in the existing datasets did not necessarily conform to the new geodatabase coded value domains, a certain amount of interpretation and/or revision was required when assigning values to fields defined as non-nullable and/or having coded value domains.

Summary of Application Capabilities

As described in the preceding sections, the ExoticPlantGDB application supports the following:

- Ability to track changes in specific infestations through time

- Recording information for multiple exotic species present at a given location

- Collection of exotics data using point, line, or polygon spatial representation

- Representation of all exotics assessment data into a single (polygon) feature class, allowing simultaneous analysis of all records (regardless of whether data were originally represented as points, lines, or polygons)

- Capture and support analysis and reporting of chemical treatment information

- Simultaneous collection of exotics data using multiple GPS units

- Field data collection using either ArcPad-equipped GPS receivers or paper data forms

- Integration of legacy data into the new geodatabase

Additionally, extensive documentation was prepared to accompany the ExoticPlantsGDB. This documentation describes in detail the procedures for collecting exotics data in field, data check in/check out, and maintenance of the geodatabase on the desktop. Complete metatdata for each geodatabase feature class and table was also created.

Discussion

Spatial data play an important role in Park Service efforts to manage invasive plant species in Saguaro National Park. Although park staff were using ArcGIS to capture and manage exotics data prior to this project, there were significant shortcomings with the previous shapefile-based system. Moving to the geodatabase led to many improvements, such as the standardization of data values through the use of coded value domains, and through the elimination of unintended missing values by defining certain attributes as non-nullable. ArcGIS geodatabases, such as the ExoticPlantsGDB, allow for facilitated data validation during post processing, which further enhances data integrity.

Utilization of the ArcPad Data Manager along with ArcPad 7.2 equipped GPS units led to other improvements. The ability of ArcPad 7.2 to maintain certain geodatabase relationships between tables allows users to record multiple species information for a single location without the need to duplicate geometries. Using the ArcPad Data Manager extension to move data to and from GPS units meant that the ArcGIS generated OBJECTID could serve as the key field in the various feature classes and tables, eliminating the need for the scripts previously used to generate the key attribute values.

Constraints with ArcPad as it is currently implemented (7.2), did, however, contribute to application limitations, primarily related to the inability of ArcPad to support geodatabase relationships other than those defined such that a feature class is the origin, and a table is the destination. For example, the relationship between treatment records and assessment records is not supported, because treatment records (the origin) are maintained in a table, and assessment records (destination) in a feature class (see Figure 4 and Table 1). A similar situation contributed to the decision to create new occurrence records on the desktop only (and not in the field). In both cases, however, the issue is complicated by the requirement that assessment data may necessarily be captured as points, lines, or polygons: the geodatabase relationships relate occurrence and treatment records to the *AllAssessments* feature class, which is not created in field, but is generated on the desktop during post processing.

Also, the simple development of custom data entry screens for ArcPad, such as might be achieved through ArcGIS ApplicationBuilder, is not supported for applications such as the ExoticPlantsGDB where groups of related tables are checked out to field GPS units.

Limitations not withstanding, the ExoticPlantGDB application should provide ecologists at Saguaro National Park with a more comprehensive and accurate database for use in management of invasive plants than the shapefile records that were previously in use.

Feature Classes, Tables, and their Attributes

AllAssessments *Polygon Feature Class*	Updated on the desktop during post processing. Derived polygon representation of records from AssessmentPoint/Line/Poly and their related data tables, Point/Line/PolyData (see below). This feature class is specifically related to the chemical treatment data tables, and provides values used to calculate (net) area treated. Also related to occurrence records. Includes records derived from the previously existing Merge and Access data. Source of records in "Most Recent Assessment" layers. Coded value domains are indicated, where applicable; see source feature class/table descriptions for additional details.

OBJECTID system variable	System generated Primary Key for this Table. (This is the foreign key *OccurrenceID* in the assessment feature classes/tables.)
SHAPE system variable	system generated coordinate geometry for the record

MergeID
long

Computed by ModelBuilder tool during post processing. Indicates the data source and OBJECTID from that source.

source	*value range*	*derivation*
Access Point	10,000-19,999	10,000+OBJECTID
Access Line	20,000-29,999	20,000+OBJECTID
AccessPoly	30,000-39,999	30,000+OBJECTID
PointMerge	100,000-199,999	100,000+OBJECTID
LineMerge	200,000-299,999	200,000+OBJECTID
PolyMerge	300,000-399,999	300,000+OBJECTID
AssessmentPoint+PointData	1,000,000-1,999,999	1,000,000+OBJECTID
AssessmentLine+LineData	2,000,000-2,999,999	2,000,000+OBJECTID
AssessmentPoly+PolyData	3,000,000-3,999,999	3,000,000+OBJECTID

District text 5	Park district. Computed by ModelBuilder tool during post processing. - coded values domain [DistrictCodes]
ManagementArea text 36	Identity of management area as represented in ManagementAreas feature class. Computed by ModelBuilder tool during post processing. coded values domain [MgmtAreas] REMOVED to allow for continious editing of the MA feature class
ChemTreatmentID long	Foreign key, OBJECTID in the TreatmentsChem table.
AssessmentDate date	Assessment date.
Species text 12	Genus and specific epithet. - coded values domain [SpeciesCodes]
PercentCover double	Estimated cover, per species. - coded values domain [CoverClasses]
NofPlants text 7	Estimated or actual number of plants, per species. - coded values domain [NofPlants]
LifeStage text 12	Phenology or growth form. - coded values domain [Phenology]
TreatmentType text 2	General treatment method, if any. - coded values domain [TreatmentCode]
PercentTreated double	Fraction of infestation treated. Included in calculation of net area treated. - coded values domain [FractionTreated]
SiteLocation text 254	Optional text entry field for details regarding site location or navigation.
Comment text 254	Optional entry, including flags for post-processor.
Recorder text 24	Identity of individual(s) recording observation data.
DataDevice text 16	Identifies GPS unit, or desktop (paper form) data entry.
PreviousID text 12	Key ID value from source data for records derived from previously exisiting datasets (Access or Merge).
CompareDate date	Scratch field for post processing; system generated values used in determination of the most recent AllAssessment records.
SHAPE_Length double	System generated perimeter length in meters.

	SHAPE_Area double	System generated feature area in square meters; used in area treated calculations.
	OccurrenceID long	Foreign key, references OBJECTID in the Occurrence feature class.
Occurrence *Point Feature Class*		Identifies a specfic infestation, by species. In some cases, this may be a complex of infestations/patches.
	OBJECTID system variable	System generated Primary Key for this Table. (This is the foreign key *OccurrenceID* in the assessment feature classes/tables.)
	SHAPE system variable	System generated coordinate geometry for the record.
	Species text 12	Genus and specific epithet. - coded values domain [SpeciesCodes] - not nullable
	Status text 24	Describes management activity status. - coded values domain [ActiveStatus] - not nullable - default value: undefined
	Recorder text 24	First initial and last name of person capturing data - Alias: Recorder - not nullable
AssessmentPoint *Point Feature Class*		This feature class and its related table PointData are edited in the field by ArcPad users. Location and geometry of one or more assessment (point representation). A given feature may be related to multiple species specific PointData records.
	OBJECTID system variable	System generated Primary Key for this Table. (This is the foreign key ShapeID in the related PointData table.)
	SHAPE system variable	System generated coordinate geometry for the record.
	AssessmentDate *Alias: AssessDate* date	Assessment date - ArcPad: users are prompted with the current date - tap to accept - Desktop: must be keyed in manually - but this accomodates entering data from field forms collected on earlier dates - desktop format: mm/dd/yyyy (ex:4/1/2008 or 12/30/2007) - not nullable
	BufferRadius *Alias: TotalWidth* double	Half-width of area to be represented by point. Users identify total width, via discrptions (labels) present in the CVD. - coded value domain [RadiusValues] - not nullable
	Recorder *Alias: RecorderName* text 24	Identity of individual(s) recording observation data. - not nullable
	DataDevice *Alias: DeviceID* text 16	identifies GPS unit, or desktop (paper form) data entry - coded values domain [DataEntryMethod] - not nullable
	SiteLocation text 254	Optional text entry field for details regarding site location or navigation. - default value: optional
	Audited text 24	Audit status for CheckIn QA/QC; identity of post processor - not nullable - default value: "not audited"
AssessmentLine *Line Feature Class*		This feature class and its related table LineData are edited in the field by ArcPad users. Location and geometry of one or more assessment (linear representation). A given feature may be related to multiple species specific LineData records. Attribue set like AssessmentPoint, above, but also includes *SHAPE_Length*, a system generated field representing the feature length in meters.
AssessmentPoly *Polygon Feature Class*		This feature class and its related table PolyData are edited in the field by ArcPad users. Location and geometry of one or more assessment (polygon representation). A given feature may be related to multiple species specific PolyData records. Attribue set like AssessmentPoint, above, but also includes *SHAPE_Length*, a system generated field representing the feature length in meters, and *SHAPE_Area*, a system generated field representing the feature area in square meters.

PointData
Table

Species specific assessment data other than geometry and location.
Related to AssessmentPoint records (via a Geodatabase relationship class).
Field editable: ArcPad users access the table after creating a new geometry record (AssessmentPoint),
or by selecting an existing shape and adding a new table record related to that shape.

OBJECTID
system variable

system generated Primary Key for this Table.

Comment
text 254

Optional entry, including flags for post-processor.
- default value: optional

Species
Alias: SpeciesName
text 12

Genus and specific epithet.
- coded values domain [SpeciesCodes]
- not nullable

PercentCover
Alias: PctCover
double

Estimated cover, per species.
- coded values domain [CoverClasses]
- not nullable

NumberOfPlants
Alias: #ofPlants
text 7

Estimated or actual number of plants, per species.
- coded values domain [NumberOfPlants]
- not nullable

LifeStage
Alias: Life_Stage
text 12

Phenology or growth form.
- coded values domain [Phenology]
- not nullable

TreatmentType
Alias: TreatType
text 2

General treatment method, if any.
- coded values domain [TreatmentCode]
- not nullable
- default value: NT (No Treatment)

PercentTreated
Alias: PctTreated
double

Fraction of infestation treated. Included in calculation of net area treated.
- coded values domain [FractionTreated]
- not nullable
- default value: 0 (No Treatment)

ShapeID
double

This is the foreign key to the assessment geometry. Will automatically
populate for ArcPad users.
- not nullable

LineData
Table

Species specific assessment data other than geometry and location.
Related to AssessmentLine records (via a Geodatabase relationship class).
Field editable: ArcPad users access the table after creating a new geometry record (AssessmentLine),
or by selecting an existing shape and adding a new table record related to that shape.
Attribue set like PointData, above.

PolyData
Table

Species specific assessment data other than geometry and location.
Related to AssessmentPoly records (via a Geodatabase relationship class).
Field editable: ArcPad users access the table after creating a new geometry record (AssessmentPoly),
or by selecting an existing shape and adding a new table record related to that shape.
Attribue set like PointData, above.

TreatmentsChem
Table

Data based on information recorded on hard copy forms by field staff and added to the database on the desktop.
General information about treatment events; chemical specific data are recorded in separate, related tables.
Also related to AllAssessments (provides area and cover measures).

OBJECTID

system generated Primary Key for this Table. (This is the foreign key
ChemTreatmentID in the ActiveIngredient, Adjuvant, and AllAssessments)

TreatmentDate
date

Date of treatment event.
- desktop format: mm/dd/yyyy (ex:4/1/2008 or 12/30/2007)
- not nullable

Method
text 16

Application method.
- coded values domain [MethodChemical]
- not nullable
- default value ?

PercentBrown
text 8

Estimated percent of treated vegetation appearing dead or dormant.
- coded values domain [PctBrown]
- not nullable

GallonsUsed
double

Gallons of mixed formula used. Accurate data entry is essential, otherwise ModelBuilder tools that
summarize chemical treament data will produce inaccurate results.

TransHours
double

Combined crew transportation hours.
- range domain [Hours]

HikeHours
double

Combined crew hiking hours.
- range domain [Hours]

| | PrepHours | Combined crew preparation hours. |
| | double | - range domain [Hours] |

| | SprayHours | Combined crew chemical application hours. |
| | double | - range domain [Hours] |

| | HoursTTL | Total person-hours for treatment - sum of all four 'Hours' fields. |
| | double | - range domain [Hours] |

| | CrewLeader | Identity of crew leader. |
| | text 25 | |

| | NumberInCrew | Number of NP staff involved in treatment. |
| | short | - range domain [PersonCount] |

| | Comment | optional |
| | text 254 | |

ActiveIngredient
Table

Active ingredient data for chemical treatment events. These records are related to records in the TreamentsChem table and provide information about the mixture.
Data based on information recorded on hard copy forms by field staff and added to the database on the desktop.
There can be multiple records in this table related to a given TreatmentsChem record.

OBJECTID	System generated Primary Key for this Table.

| BrandName | Trade name of active ingredient. |
| text 24 | - coded values domain [BrandName] |

| OuncesAI | Ounces AI *used* in treatment. |
| double | |

| ConcentrationiAI | Fractional concentration of AI in mixture (examples: "5" "10" "1" (e.g. 5%, 10%, 1%)) |
| double | - range domain [Concentration]; values allowed from 0 to 100 |

ChemTreatID	Foreign key to TreatmentsChem table; references TreatmentsChem *OBJECTID*.
long	This field may be populated by using the attributes editor to enter treatment data, as described in the documentation (i.e. manual data entry is not necessary).
	- not nullable

Adjuvant
Table

Adjuvant data for chemical treatment events. These records are related to records in the TreamentsChem table and provide information about the mixture.
Data based on information recorded on hard copy forms by field staff and added to the database on the desktop.
There can be multiple records in this table related to a given TreatmentsChem record (or no records).

OBJECTID	System generated Primary Key for this Table.

Adjuvant	Generic compound name for active ingredient.
text 24	- coded values domain [Adjuvants]
	- not nullable

| OuncesAdjuvant | Ounces adjuvant *used* in treatment. |
| double | - not nullable |

ChemTreatID	Foreign key to TreatmentsChem table; references TreatmentsChem *OBJECTID*.
long	This field may be populated by using the attributes editor to enter treatment data, as described in the documentation (i.e. manual data entry is not necessary).
	- not nullable

GPSControlPoints
Point Feature Class

Control point data collected to confirm the proper functioning of various GPS receivers.
These records are collected at known control locations to evaluate locational accuracy of GPS data.

OBJECTID	System generated Primary Key for this Table.
system variable	

| SHAPE | System generated coordinate geometry for the record. |
| system variable | |

DataDate	Assessment date
Alias: Date	- ArcPad: users are prompted with the current date - tap to accept
date	- not nullable

Recorder	Identity of individual(s) recording observation data.
Alias: RecorderName	- not nullable
text 24	

DataDevice	identifies GPS unit, or desktop (paper form) data entry
Alias: DeviceID	- coded values domain [DataEntryMethod]
text 16	- not nullable

	ControlLocation
	Alias: Point Location
	text 36
		Identification of control point (known location)
		    - coded values domain [ControlPoints]
		    - not nullable
		    - CVD includes "other: see comments" option

	Comment text 100	Optional comments field.
ManagementAreas *Polygon Feature Class*	OBJECTID system variable	System generated Primary Key for this Table.
	SHAPE system variable	System generated coordinate geometry for the record.
	AreaName text 36	Management area name - not nullable See notes in documentation regarding editing this feature class.
	SHAPE_Length double	System generated perimeter length in meters.
	SHAPE_Area double	System generated feature area in square meters; used in area treated calculations.