Plant Survey, Monitoring And Forage Management Methods

Determination of Plant Communities

An evaluation of vegetative communities or habitat description and mapping are generally required for most land development permit applications. Environmental Assessments (EAs) and Environmental Impact Studies (EISs) also require plant surveys. The potential presence of gopher tortoises (a protected species) requires an assessment of tortoise habitat and tortoise forage. The quality of the habitat for gopher tortoise foraging is an indicator of the potential presence and density of burrows in some proximity though not necessarily limited to the same habitat. The presence of good foraging habitat and habitat with good potential for burrows does not guarantee that tortoises are currently present nor does “poor” habitat necessarily mean that they are not present. As discussed in Chapter 3, the determination and designation of habitats by their most visible characteristics, usually type of trees, does little to address the real features of the habitat that pertain to supporting gopher tortoise populations. Vegetative community or habitat mapping needs to be done to the level that identification of gopher tortoise forage species and species diversity are addressed. Placing tortoises in habitat without addressing the long term forage potential is like locking them up in a box with enough food for the next five years but with no plan for how they will obtain sufficient, nutritional forage over the next 20 or 50 or 100 years. Looking at habitat just as a place for tortoises to burrow (based on soils and open space) is also not addressing the bigger issue of long term sustainable forage, not just for a current population but also for a growing population. Habitats are dynamic, with the potential for changing species associations, shifting relative population numbers and alteration of dominant canopy species in response to environmental changes and habitat maturity over time. Tortoise population foraging needs will depend upon a stable percentage of the dynamic habitat being consistently available as forage. Where tortoise populations are confined within limited habitat, the demand for forage within a dynamic habitat can reach crisis with apparently minor habitat shifts. It is for these reasons that planning for habitat monitoring is essential in addition to excellent initial habitat assessment when surveying for development relocations or for preserves where gopher tortoise populations can survive in perpetuity.

Determination of large-scale vegetative communities from aerial, IR or satellite maps (Plate 5.1) can be done with reasonable accuracy if the interpreter is experienced and if basic “ground truthing” is part of the process. While identification of over-story or open ground cover from such aerials or maps is fairly easy, the determination of diversity of species not in the over-story or open ground cover is not currently practical unless you have access to really high resolution satellite imagery. Cox et al. (1987) suggests that at a minimum there be 1 vegetative transect sampled for each habitat type larger than 8 acres in coverage or 30% of the total transects done for presence of burrows on a site. This data would be used to establish the HSI (Habitat Suitability Index) for the site. The quantitative measures of habitat variables used include canopy cover, shrub height, depth to water table, soil type, and level of disturbance in a fairly sophisticated mathematical model to result in an index (HSI). Two formulations for the HSI are described and neither had been verified at the time of publication. While this works as an academic evaluation of the habitat, the sampling methodology focuses on tree species, wire grass and general cover percentages and this methodology does not really address the presence or diversity of gopher tortoise forage species. This is particularly true if you recognize that wiregrass is only a frequent forage selection right after a burn when it is one of the first grasses to be available as forage. During a non-burn cycle wiregrass is specifically not selected by adult or juvenile tortoises as forage when other grasses or herbaceous forage species are available (Mushinsky et al. 2003). The other issue with this methodology is that it assumes that the habitat in which the burrows are found is also the significant foraging habitat and this is not necessarily true. Tortoises may find road spoil piles, sand dunes or old railroad raised beds as suitable for burrows but the habitats surrounding these may not provide quality or sufficient forage. Tortoises may travel regularly to adjacent areas for suitable and sufficient forage species. The presence and significance of these foraging areas in the larger picture of habitat protection and management may be overlooked if foraging species and foraging habitat is not addressed from the beginning.

In addition to needing accurate vegetative community descriptions and sometimes maps for permits, this information is needed as baseline data for any habitat management.

Collecting Baseline Vegetative Data and Monitoring Changes

The purpose of the plant sampling activities is to establish a baseline data set and then monitor changes in the vegetation within an area or community. To do this, there is a need to use both qualitative and quantitative sampling methods. This is especially true for the ground cover and shrub layers (potential tortoise forage). The tree cover of an area gives a good picture of the potential for enough “open area = sunlight” for good gopher tortoise forage to grow. Too much tree cover precludes sufficient light reaching the ground for tortoise forage plants. Shrub and tree species (like Brazilian Pepper, *Schinus terebinthifolius*) that produce allelopathic chemicals can crowd out important forage species. Wetland areas should not be overlooked. In drought periods the best forage still available for tortoises will be at the interfaces and drying bottoms of wetland areas. Be sure to note such areas and their vegetation as “potential forage” for drought or dry seasons.

The best vegetative survey and monitoring protocols to use for each site must be determined based on a number of factors. The current condition of the site is critical. The methods chosen for survey and monitoring will depend upon the answers to these questions:

1) How big is the property? What shape and size is (are) the contiguous sections?
2) Is the habitat currently being managed? If so, how? Are there burn sections?
3) Are there stated goals for the property? If so, what are they?
4) Has a vegetative survey been done previously? If so, it should be used as part of the baseline data and it should be used as a guide to help select sites for further survey and monitoring.

5) Has a survey been done for gopher tortoise burrows? If so, it should be used as a guide to help select sites for vegetative survey and monitoring.

6) What are the habitats or land uses on the surrounding properties? Are there barriers (fences, rivers, roads, etc.) between the site property and the surrounding properties? What are the potential access points (where tortoises could cross to get to forage) between properties? How could these access points be blocked to keep tortoises from leaving or protected if tortoises still require access to maintain sufficient forage)?

7) What are the surface and ground water conditions on the property? How do or could off-site situations affect the surface and / or ground water conditions of the property?

Suggested survey and monitoring protocols:

CASE I: No previous vegetative or tortoise survey data on the site is available

1. Identify and map vegetative communities (aerial photos, maps, soil maps, on site surveys). Establish a list of expected plant species based on communities and soils.
2. Baseline vegetative survey and thorough survey for tortoise burrows. Establish list of observed plant species and collect and identify unknowns. Establish positions of gopher tortoise pods (use protocols from Chapter 2). Determine existing known or potential gopher tortoise forage species and the relative forage importance and availability of those species.
3. Divide properties into sections (size of sections will vary according to overall size and shape of properties) based on vegetative and burrow surveys and place one or more 50-100 meter transects in each section based on the following:
   1) Placement of transects is based on the goal of monitoring the quality and quantity of tortoise foraging species and tortoise habitat. At least 1 transect in each section should begin in a tortoise pod and at least 1 transect should sample forage at the far range (about1000 meters) of tortoise foraging in that section.

2) Randomness is not necessary to meet goals but adequate sampling of each section is required- transects should encounter approximately 87% of expected species over seasons or by season- if not you need more transects). For sections that encompass one or two generally uniform plant communities you may find that two 100m transects per 50-100 acres are adequate and for other sections you may need 4 or more.

3) Transects should be oriented E-W or N-S when ever possible and be marked permanently so that repeated monitoring would be more easily accomplished. (invariably someone will forget to mark the orientation of a transect on the data sheet if GPS is not being used so if all transects are eat-west or north-south you have a better chance of finding the exact transect if that does occur. In the best possible scenario, all endpoints will be entered in a high resolution GPS system and will be marked permanently with metal stakes.

4) Follow the transect monitoring protocols in Methods Section.

4. After the first round of surveys, determine if the number of transects is sufficient and if not then add more transects.

CASE 2: Vegetative Community Maps and Tortoise Burrow Maps Available

1. Use vegetative communities map and aerial photos, tax maps, soil maps, and on site surveys of tortoise burrows to establish a list of expected plant species based on communities and soils.
2. Ground truth the existing maps while adding to or creating a baseline vegetative survey and ground truth the survey for tortoise burrows. Create or add to a list of observed plant species and collect and identify unknowns. Determine existing known or potential gopher tortoise forage species and the relative forage importance and availability of those species.
   Verify positions of gopher tortoise pods.
3. Divide properties into sections (size of sections will vary according to overall size and shape of properties) based on vegetative and burrow surveys and place one or more 50-100 meter transects in each section based on the following:

1) Placement of transects is based on the goal of monitoring the quality and quantity of tortoise foraging species and tortoise habitat. At least 1 transect in each section should begin in a tortoise pod and at least 1 transect should sample forage at the far range (about1000 meters) of tortoise foraging in that section (see Figure 5.1).

2) Randomness is not necessary to meet goals but adequate sampling of each section is required- transects should encounter about 87% of expected species over seasons or by season- if not you need more transects). For sections that encompass one or two generally uniform plant communities you may find that two 100m transects per 50-100 acres are adequate and for other sections you may need 4 or more.

3) Transects should be oriented E-W or N-S when ever possible and be marked permanently so that repeated monitoring would be more easily accomplished.

4. After the first round of surveys, determine if the number of transects is sufficient and if not then add more transects.

Vegetative Survey Techniques

Most of the vegetative survey techniques suggested are those used in any biological research project, except for the tree monitoring methods. The method of choice for most projects studying tree communities is a point-quarter (point-centered-quarter) method. However, this method is more difficult for technicians to duplicate over long periods of time and does not suit long-term habitat monitoring goals as well. If the only purpose for tree survey is to establish the limits to suitable gopher tortoise habitat then a less detailed and more general sampling of tree cover can be done as described in Cox et al. 1987. We have found that on sites where monitoring is the goal that permanent tree mapping and / or tagging along the survey belt transect reduces future labor input.

In setting up the survey methodology, use of random sampling is not a necessity and in fact can be a detriment for the purposes of establishing the suitability of foraging habitat. We have reviewed surveys and plans where the randomly selected transects or quadrats were not at all representative of the overall status of the vegetative community as tortoise forage. A very suitable site we re-surveyed had a previous survey with transects randomly selected that all passed through dense saw palmetto and revealed little diversity of forage species. Upon on-site review it was apparent that most of the site did contain a great diversity of forage species but the randomly selected transects just happened to pass through the few stands of saw palmetto that were present. If you want to determine the suitability of habitat as tortoise forage then be sure the sampling takes place in representative forage areas found on the site. A preliminary review of recent aerials and/or maps showing burrows and pods is one way to be more efficient when trying to identify locations for sampling forage.

Figure 5.1: Pods, Foraging Areas and Transect Requirements

METHODS FOR PLANT SAMPLING:

Herbaceous Ground Cover Belt Transect and Quarter Square Meter Quadrats

The herbaceous ground cover data can be collected using 0.25 square meter quadrats within a 50-meter long belt transect. Within this belt sample the 0.25 square meter quadrats should be oriented at each meter along the transect.

1. Stretch a 50-meter tape oriented N-S or E-W within your study area. To use these transects to determine the HSI (Cox 1987) use 30% of the same transects you established for the burrow survey. If this is a monitoring program then establish permanent transects within the identified gopher tortoise habitat areas, preferably passing through the center of pods where appropriate as long as the transect also passes through foraging areas as well (see Figure 5.1).
2. Beginning at the 1-meter mark, on the west boundary (on a north-south) or on the south boundary (of an east-west transect) place the quarter square meter quadrat so that one edge runs under and parallel to the tape. The meter mark on the tape should be positioned over the lower left corner of the quadrat.
3. Photograph the quadrat, making sure that the inner edges of the quadrat are in the frame.
4. Record data on data sheet (see sample data sheet Figure 5.2).

   Be sure to also record the maximum height of the vegetation in each quadrat and an indication or measurement of soil moisture can provide very helpful monitoring data over time. These data are well suited to use in habitat profile graphs and can provide managers with clear visualizations of habitat changes and cycles over time.
5. Identify the vegetation, debris, open space. Estimate the cover class (or percentage) for each species present as well as for detritus and open soil. Identify species when possible. Also note if the plants are flowering, fruiting, dormant, or other interesting observations. If a ground cover cannot be identified, collect and label it with an unknown number. Sometimes the plants may be too young to identify. Samples should be taken to represent each species found in any of the quadrats. They may be pressed and placed in a plastic bag with a description and drawing

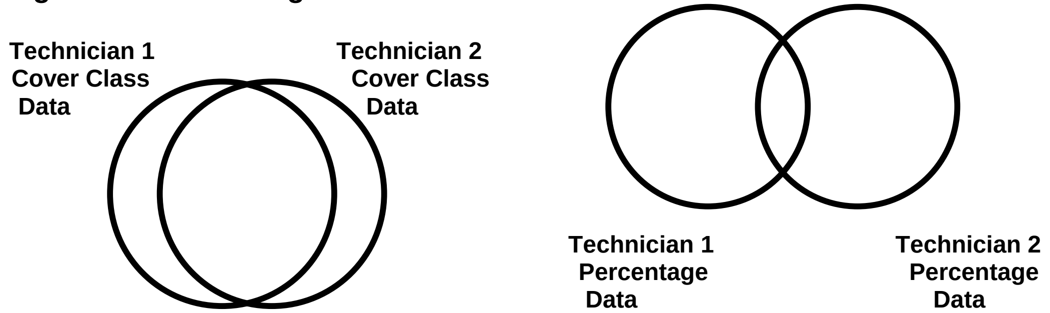
made on the data sheets or cards. Digital photographs can be helpful in identification but they are not a substitute for the actual specimen. Be sure to label each specimen clearly. Be sure to tape seeds to a card and / or put small seeds, fruits, flowers or other plant parts into a small jar (film canister) or separate plastic bag within the larger sample bag. If this is a permanent monitoring transect then try to collect a specimen of the same unknown species that is near but not on the monitoring transect.

4. Determine any types of invertebrates located in the quadrat of belt segment (e.g., ant mound, beetle burrow, two spiders, etc.)

COVER CLASS OR PERCENTAGE?

The estimation of percentages provides 100 possible different data choices for each and every estimation made. This creates a huge potential error. While it may be easier to estimate percentages within the square by overlaying a string or wire grid or a plastic grid dividing the quadrat into smaller squares (possibly into 4 parts, 9 parts or 16 parts or this can be done by taping string over pre-made marks on the quadrat PVC) that can be used to estimate the amount of ground covered by each species, even these percentage estimates will show high variability among different field technicians collecting data. The use of cover class provides more consistency and a smaller margin of error. Figure 5.2 illustrates the concept that two separate technicians taking data on the same quadrat are more likely to generate a larger overlap or consistency of data when given only seven choices of cover class (x, 1, 2, 3, 4, 5, 6) versus 100 possible choices of percentage.

Figure 5.2: Percentage vs. Cover Class



With percentage individual bias is much more evident – some technicians always use 10, 20, 30, etc. while others favor 15, 25, 35 and others may try to be “unbiased” and always choose 31 or 42 or 56.5 in an effort to be more “accurate”. In any case, with numbers 1 to 100 to choose from (or even more if technicians choose to use decimals) the use of percentages for a given area are always more likely to vary from one technician to the next in comparison with cover class.

Figure 5.2: Sample Herbaceous Cover Data Sheet

DATE__________

Air Temp.________ **Transect #_________**

Location_________ **GOPHER TORTOISE FORAGE DATA SHEET** **STAFF____________**

Orientation of Transect_______ **HERBACEOUS BELT TRANSECT: GROUND COVER QUADRATS**

.25 sq. meter quadrats in 50 meter long and .5 meter wide belt transect

QUADRAT #										
Max. Vegetation Height (in cm)										
Water level (in cm) / Soil Moisture / pH										
SPECIES # OR NAME OR UNKNOWN #										
Detritus										
Bare soil										
CC Total										

Cover Classes Range of Cover ___

X - covers less than 1%
1 - covers 1% to 5%
2 - covers 6% to 25%
3 - covers 26% to 50%
4 - covers 51% to 75%
5 - covers 76% to 95%
6 - covers 96% to 100%

Comments:

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Shrub and Understory Belt Transect: 50 Square Meter Belt Transect

The shrub and understory belt transect falls one meter on either side of the 50-meter central line. Woody shrubs over 0.3 meters in height will be identified and counted within this area. The various types of sampling (ground cover and shrub and understory) can be done at the same time.

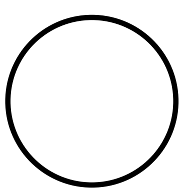
Figure 5.3: Designations of Plants to Be Sampled

HERBACEOUS:	non-woody species generally less than 0.5-meter tall but not necessarily
SHRUB:	woody plant species greater than 0.3-meter tall and with a dbh of less than 2.5 cm. Shrubs are separated from sapling trees by having multiple main stems.
UNDERSTORY:	sapling trees, less than 2.5 cm dbh and greater than 0.3 cm dbh are monitored with the shrubs
SUBCANOPY:	woody plant species greater than or equal to 2.5 cm dbh and under 10 cm dbh
CANOPY:	woody plant species of dbh greater than or equal to 10 cm

1. At the beginning of each survey or monitoring 50 meter transect, a line or meter tape should be strung parallel to the central meter tape 1meter out from both sides to produce a 100 m sq. (2 m X 50 m) belt transect. Use two poles 2 meters long to place across the tapes starting with one at the 0 meter mark and one at the 2 meter mark to create a square 2 meters on a side or 4 square meters. Always begin with 0 at the North or West end of the transect for

consistency over time. New technicians are less likely to be confused about which end to start at if these directions are always standard.

2. Following the same technique as for the ground cover, the cover class (or percentage of area) covered by understory and shrubs should be estimated for each species within each of these sampling squares. Strings can be fastened between the two poles to create sub-sections to make estimation easier.
3. Estimate the cover class (or percentage) of each quadrat or belt section that is open soil.
4. Determine any types of invertebrates located in the quadrat of belt segment (e.g., ant mound, beetle burrow, two spiders, etc.)
5. If you have not done this separately then now determine the cover class (or percentage) of each quadrat or belt segment covered by each herbaceous species and shrub species less than 0.3-meters tall. (Note: If a tree or shrub falls within the quadrat record the herbaceous species found under or around it. The space occupied by the tree or shrub trunk is classified as "non-herbaceous cover."



6. Identify species when possible. Also note if the plants are flowering, fruiting, dormant, or other interesting observations. If a ground cover cannot be identified, collect and label it with an unknown number. Sometimes the plants may be too young to identify. Samples should be taken to represent each species found in any of the quadrats. They may be pressed and placed in a plastic bag with a description and drawing made on the data sheets or cards. Be sure to label each specimen clearly. Be sure to tape seeds to a card and / or put small seeds, fruits, flowers or other plant parts into a small jar (film canister) or separate plastic bag within the larger sample bag.
7. Move the sampling quadrat to the next meter mark and repeat steps. Working within the belt transect can be meter by meter also. Record the data with a water proof pen on data sheet (see sample data sheet - Figure 5.3)
8. Remember that if this is a permanent monitoring transect, you want to only take samples when absolutely necessary from the transect area. Often the same unknown plant can be found in the area of the transect and so a sample does not have to be removed from the transect. Just be certain you have exactly the same species.

Plant Collections In The Field:

One excellent way to facilitate field work is to use 3" X 5" or 4" X 6" cards, a good drawing pencil, indelible fine line markers, and ziploc baggies for specimens in the field. Each unknown plant is placed in a baggie and its description is written on an accompanying card, which is also placed in the baggie. The unknown number is written on the baggie and on the card in the baggie. Unknowns too large to go into the baggie or animal unknowns have just a card with a drawing (and/or photograph #) and description. Organize these unknown baggies in a cloth bag, bucket, cooler or box which can be kept with the technician in the field. Plastic baggies are ideal because they don't tear when they get wet and they are light. Plants can be slightly field pressed between a sheet of folded paper put in the baggie, or very succulent plants can be pressed in a plant press and then placed in the baggie later. Plastic baggies can also be pressed inside a phone book or a plant press. As the data is recorded these unknowns provide a quick field reference so the same unknown number is not repeated. In most cases, projects do not require a permanent herbarium quality plant collection and such a well-done plant collection can be quite costly both in time and materials. A preserve that will be monitored and managed may warrant a permanent herbarium collection if the time and money are available.

Table 5.1 Unknown Numbering System For Field Work

Assign numbers to unknowns using the following system to facilitate data management so "unknown" numbers are not accidentally repeated:

UNKNOWN # = Location #,Transect #, specimen type (letter), specimen #, year

EXAMPLE: ABP-3G –S- 01-2001

This is unknown shrub specimen number 01 collected from Ashton Biological Preserve transect 3-GHI during 2001. By including the transect and the date in this number we can keep the overall numbers small and still avoid confusion.

PLANT LETTER CODES	ANIMAL LETTER CODES
T = tree	MM = mammal
S = shrub	BD = bird
G = grass	RP = reptile
H = herb	AM = amphibian
V = vine	FH = fish
E = aquatic emergent	TI = terrestrial invertebrate (on or above ground)
SU = aquatic submergent	WI = aquatic (water) invertebrate
A = algae	SI = subterranean invertebrate (in soil or underground)
F = fungi	
L = lichen	
M = moss	
N = fern	

The easy to do field collections described above are quite durable if done correctly and can be kept for months or even years with little deterioration. We always keep these collections in a cooler while in the field. They then can be pressed and dried later or when identifications cannot be made immediately of unknowns, we have kept fresh (not dried) specimens in the freezer for months and still had a perfect specimen to identify. A digital camera can be used to photograph each unknown species in addition to the sample. Do not depend solely upon pictures since these may be corrupted, not clear enough to be identifiable, or even mislabeled so that the actual data is no longer useable.

Trees: Canopy and Sub Canopy Monitoring Belt Transect:

The tree canopy / sub canopy monitoring belt transect will **lie 10 meters on either side of the transect line, resulting in a transect 20 meters wide and 50 meters long (1000 sq. meters).** Total area sampled equals 1,000 square meters of the 1,000 square meter plot.

The 50-meter by 20-meter belt transect will be the area surveyed for tree cover. Procedure:

1. The central meter tape should be in place with parallel lines 10 meters on each side.
2. The survey should begin at the north or west end (1 meter) and work toward the south or east end.
3. The 50 X 10 meter sides should be done separately to simplify the mapping of the trees. Complete one side and then the other or break entire area up into as many quadrats as you like for this task so you do not duplicate your efforts and do not miss any trees (see sample Data Sheet, Figure 5.7).
4. Each stem within the area should be identified, location plotted, and diameter, breast high (1.5 m above the ground) of those trees over 10 cm dbh should be taken. (Optional: Each tree within a permanent sampling plot or transect could be marked with a numbered metal tree tag. This would permit easy identification each time the site is surveyed and would be very helpful if staff doing the surveys vary from year to year.
5. Height of the tallest 10 trees of the dominate 3 species should be estimated to the nearest 10 m. Use the hypotenuse of a right triangle method to estimate tree height or the "boy scout" thumb method. Place one of the 10-meter (or 5m) poles upright in front of tree to be measured. Back away from the tree and hold you thumb outstretched up until your thumb appears to completely cover the pole. Now visualize how many "thumbs" it will take to cover entire tree and multiply times 10 m (or 5m) to get height of tree.

6. Each tree should be given a number and that number should identify that tree on both the data sheet (see sample data sheet 5.7) and on a grid map (GPS) of the area. Since these plots are off the trail, permanent numbers in the form of metal tags should be put on each tree larger than 4" dbh. After doing this step non-biologists can assist in data collection because they will not have to be able to identify the trees, just read the maps and find the numbers. At least once every few years a biologist should spot check to be sure tree numbers haven't been switched. Trees can be numbered in a way to indicate their location within the study area and their species.
7. Any dead, dying or obviously stressed standing trees within the monitoring area should be mapped and wildlife use noted.
8. Digital Images should be stored with appropriate back-up in addition to the hard copies which can be kept as part of the data log which should accompany the management plan.

Volunteers and Staff that are not experts at plant identification can still help with monitoring activities. These techniques are not complex and with the use of a digital camera materials can be made that will help volunteers identify the plants commonly found in the sampling area (Figures 5.8 and 5.9). Digital images were taken of representative quadrats at each of the sampling stations. These will help in comparing ground cover from one monitoring attempt to another. They will also help the botanist see what species was present in case of some identification confusion.

DIGITAL PHOTOGRAPHS: It is very cost effective to use digital photographs to document the data from the site as well as create training materials (plant ID) for those monitoring the site. A photo log should accompany all of the photographs. In most digital cameras this can be entered as data with the photograph. In addition to the date and photographer, the data should include the location on the site or transect; specifically the point from which the photo was taken and the direction the photo was taken towards.

Figure 5.7: Tree & Shrub Data Sheet

DATE__________

Air Temp.________

Transect #________

Location_________

GOPHER TORTOISE HABITAT DATA SHEET

STAFF_____________

Orientation of Transect_____________4m sq. quadrats in 50 meter long and 2 meter wide belt transect

SHRUB/UNDERSTORY and / or TREE CANOPY COVER / DBH DATA SHEET

QUADRAT #										
Max. Height Dominate Species (in M) / dbh										
Water level (in cm) / Soil Moisture / pH										
SPECIES # OR NAME or UNKNOWN # - Tree Tag #-	CC / dbh	CC / dbh	CC / dbh	CC / dbh	CC / dbh	CC / dbh	CC / dbh	CC / dbh	CC / dbh	CC / dbh
Detritus										
Bare soil										
CC Total										

Cover Classes Range of Cover

X - covers less than 1%
1 - covers 1% to 5%
2 - covers 6% to 25%
3 - covers 26% to 50%
4 - covers 51% to 75%
5 - covers 76% to 95%
6 - covers 96% to 100%

Comments:
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Figure 5.8: Making Digital Images Useful

Transect A:
Photo 1A

Photo 1A: This view provides a sense of the openness of the habitat – which is an important indicator of current and future availability of tortoise forage. Repeated views from the same perspective over time can give easily visible indications for management needs.

Photo 2A: Close-up views can provide some details that can help with identifications and can give managers visual insight into the diversity of the ground cover which in Photo 2A appears to be mostly wire grass but actually there is a diversity of broadleaf potential forage species interspersed.

Permanent transects are useful for long term comparison of the habitat. Future data taken along these transects can be compared to the baseline and past data for indications of forage health and habitat development status. Future digital photos taken can be used to provide visual indications of habitat status. Specific indicators, such as presence of tree seedlings can be used to predict future ground cover and can indicate management needs.

Photo 2A

Storage of data in digital format and well as hard copy should be kept with the master copy of the management plan. The weakest link in the creation and use of management plans is the availability of all of accurate copies of the past data and management activities.

Once the plant photos have been taken it is easy to create a seasonal guide to the plants of your site. Photos can be organized by location, color, plant type or any other grouping that makes sense to your volunteers. These plant photos can be arranged on a page in small boxes and laminated for use in the field and these same photos can be placed in a computer file at a larger size with more information for study or later reference. This makes data collection for monitoring more accurate as well as more affordable. Well trained volunteers that are carefully supervised can utilize such materials to take the data required on a regular basis. If photos are taken as the data is collected; any errors or potential questions that arise with the volunteer data collectors can be easily solved by having the photos reviewed by a botanical expert.

Figure 5.9: Example of How Survey & Training Materials Can Be Created

1. Bracken Fern

3. Milk Pea

1. Bracken Fern
   (*Pteridium aquilinum*)

Bracken fern is a lower quality tortoise forage plant. It is eaten when it is very young and when it is dried. Bracken fern re-grows from the underground stem or rhizome. Burning at the right time of year for your area can reduce the level of bracken fern cover, which can compete with higher quality forage plants.

2. Gopher Apple
   (*Licania michauxii*)
This low shrub is frequently eaten by tortoises. They will consume fruits, leaves and flowers.

3. Milk Pea
   (*Galactia regularis*)
This high quality forage is a legume. Tortoises often eat the entire plant, roots and all. They also will eat the flowers and the seed pods.

4. Saw Palmetto
   (*Serenoa repens*)
Flowers and fruits of this shrub provide very important, high quality forage for tortoises. The fruits are eaten prior to the coldest time of the year when tortoises may go into their burrow for extended periods. Young leaves or fallen dried leaves may be eaten as well.

2. Gopher Apple

4. Saw Palmetto

This sample training sheet was created with a digital camera. Training materials can be designed to include plants known to be found on the preserve site and on the monitoring transects. Sheets can be designed for each season and can be laminated for better durability for long term use in the field.

DATA ANALYSIS

There will be standard data analysis techniques which will be done on all appropriate data collected and then some techniques that may be used for specific purposes only. GPS coordinates can be recorded to locate the position of the transect and any burrows near the transect.

1) List the current questions of concern to the habitat manager or others.

2) Examine the standard analyses that are done on all data.

3) Determine if additional analysis is required or if additional data must be collected to answer questions.

4) Print out information which applies to the question being answered and do the following:

   a. ground truth data analysis to be sure what appears in figures exists in fact.

   b. have data analysis and your conclusions reviewed by an outside expert to be sure you have not biased your interpretation of the data analysis.

5) Carry out additional analysis as needed or collect new data if warranted.

Vegetative data analysis techniques

Keep in mind that the data being collected involves recording percentages or cover class not actual numbers of individuals in all cases except for trees. Therefore analysis techniques must fit the type of data collected.

Figure 5.10: TYPES OF VEGETATIVE DATA COLLECTED

1) species occurrence and distribution
2) vegetation cover height
3) cover class (or percentage) of ground covered by each species
4) dbh of tree species mapped
5) actual plotting and numbers of tree species
6) flowering season and indication of reproduction

GROUND, SHRUB AND TREE COVER DATA ANALYSIS

Data collected from the ground, shrub and tree cover quadrats is used to calculate the frequency of occurrence, abundance, percent composition, species diversity, and species dominance.

METHODS FOR STATISTICAL ANALYSIS

1. **COVER CLASS:** ground cover data is recorded as a cover class which corresponds to a range of cover percentage for each quadrat.

Figure 5.11: Cover Class

COVER CLASS	RANGE OF COVER	MID-POINT
X	less than 1 %	0.5
1	1 to 5 %	2.5
2	6 to 25 %	15.0
3	26 to 50 %	37.5
4	51 to 75 %	62.5
5	75 to 95 %	85.0
6	96 to 100 %	97.5

adapted from Daubenmire (1959)

2. **FREQUENCY OF OCCURRENCE:** The number of quadrats in which a particular species occurred divided by the total number of quadrats sampled yields the percent frequency of occurrence. The frequency distribution of a species within the study area may indicate how "rare" a plant is or may point out its vulnerability to changing environmental factors. Plants evenly distributed throughout the study area, i.e., well-dispersed, will be less vulnerable to impacts than species that are "clumped" in frequency distribution.

3. **RELATIVE FREQUENCY:** The frequency of a species for a specific Study area divided by the total frequency for all species in the specific Study area. If species data is then sorted by Frequency of Occurrence and by Relative Frequency it is possible to see which species are most common within the sampled area. This information can then be compared with the other areas being monitored or with the same study area over time. Changes in species frequency can be

indicative of: season of the year in which sampling was done, normal vegetative succession, or environmental changes.

4. **AVERAGE COVER:** Percent cover is a measure of how much of the ground surface of a quadrat is covered by each species when considering a vertical projection of the plant on to the ground. (When viewed from directly above how much of the ground is hidden from view by the plant). Use the mid-points of the cover class ranges as shown in the table to calculate the average cover for each species by dividing the total of cover class mid-points by the total number of quadrats sampled within the sample area. For trees consider "canopy cover" and "basal area cover." The Canopy cover is the area covered by the canopy projected downward to the ground and the basal area cover is found by converting dbh data to basal area per individual.

Basal area = radius squared times pi

5. **RELATIVE COVER:** The relative percent cover is calculated by summing the average cover for all species in the study area and dividing this into the average cover of each species in the study area. The sum of all the relative cover figures for a study area should be 100. Do not include nonliving detritus, or open ground categories in relative cover calculations.

6. **SIMILARITY INDEX:** Ruzicka's Similarity Index is used to quantify the similarity of vegetation between two sampling periods or two sampling locations. Species which are most similar will have an index of 100 and those with no similarity will have an index of zero. Ruzicka's Index compares the relative percent cover of the two data sets from different years or from different locations. Sum the minimum relative percent cover for all species in the data set and divide by the sum of the maximum relative percent cover of the data set then multiply by 100. This test could be used to test the success of a burn regime in returning an area to natural upland vegetation. A similarity test of the same study area from years before the burn and years after the burn should drop below 30 percent. A similarity test of the study area in years after with burn with a known upland area of

Ruzicka's Similarity Index

(Sum of Minimum % Cover/ Sum of Maximum % Cover) 100 = % Similarity between samples

the type desired should exceed 60 percent and increase over time until there is over 90 percent similarity in species composition and frequency.

Figure 5.12: Similarity Index

SIMILARITY INDEX no similarity 0 to most similar 100					
	Relative Percent Cover				
Species	Yr 1	Yr 2	Yr 3	Minimum	Maximum
A	40	22	36	22	40
B	55	82	77	55	82
C	1	0	0.5	0	1
Totals				77	123
Ruzicka's Index = (77/123) X 100 = 62.60 or a greater than 60 percent similarity between same Study area vegetation samples over the three year period.					

7. **DENSITY:** The total number of species found in the sample area divided by the total number of samples (quadrats) then multiplied by 10,000 square meter/hectare divided by the area of one quadrat. This will give the absolute density of species per hectare and is extremely useful when looking at wildlife use of habitat, identification of ecotonal zones, and long-range environmental impacts on vegetation and wildlife.

Tree Density is equal to the number of trees of a species per unit area. The absolute density of a species is calculated from the overall tree density and the percentage of samples containing that species. The relative tree density compares the density of each tree species to the densities of all tree species sampled.

A sudden decrease in species density in an area would indicate the need for immediate investigation into the cause(s) if they are not already known — for example the area was cleared by a wildfire or scoured by unusually high flood waters.

8. **DOMINANCE:** The average percent cover of a species times 10,000 square meters/hectare divided by the area of one quadrat. In other words the total of cover class mid-points of a species divided by the number of quadrats sampled times 10,000 sq. meters/hectare divided by the area of one quadrat.

9. **RELATIVE DOMINANCE:** The dominance for a species is divided by the dominance for all species and multiplied by 100. Dominance values for a species should remain consistent within a non-successional habitat but will change over time within successional habitats or in habitats where impacts have occurred.

10. **SPECIES DIVERSITY:** Diversity is a measure of the general distribution of all species within a study area in accordance with abundance for comparison with other study areas or for comparison with that same study area over time. There are a number of commonly used species diversity indices. These indices are a form of derived statistics and do not represent an absolute that can be used to dictate management strategy. Thomas et al (1973) and Brower et al (1990) give listings of the more commonly used diversity indices.

> Diversity indices are really multivariate variance measures of individual organisms across species (Green 1979). Each index has been created for a specific purpose and can only be meaningful within that context. Simpson's Index "D" looks at the expected number of species in a random sample of "m" individuals and the contribution of each individual is proportional to the probability of appearing in a sample of "m" individuals. This index is often used for vegetative studies.

Using Simpson’s Index

Convert all relative cover "i" values to an abundance value between 0.00 and 1.00, "E", by dividing by 100. Then square the abundance value and sum these to calculate "F." Subtract the sum of the squares of all abundance values from 1.00 to determine the Simpson Index "D."

Simpson’s Diversity Index

i/100 = E, Sum of "E squared" = F, 1.00 - F = D for that species

Diversity indices are expressed as numbers between 0.00 and 1.00 with the higher values corresponding to lower diversity. In other words, the closer to 1.00 the greater the dominance within the sample of one or several species. Poole (1974) indicates that the only truly objective indicator of species diversity for a system is the actual number of species.

Some examples of when reduction in diversity can occur include: when herbicides are applied to an area, when drought removes water-dependent vegetation, when structures shade out light dependent species, or when exotic species invade and out-compete the native species.

11. **SPECIES RICHNESS:** The total number of species identified represents species richness. Monitoring analysis looks at species richness over time as a direct comparison. Species richness is not a derived variable and represents a value which can be compared directly in a time series. The only qualifier for using species richness is to make certain that the sample size and study area being compared is the same from one sampling time to the next. Don't try to compare "apples and oranges."

12. **STRATIFICATION:** The maximum height of species within each quadrat should be recorded and graphed to provide a stratification profile of the study area. These graphs can be compared over time to provide a picture of the growth or changes within the study area.

13. **IMPORTANCE VALUE:** These derived values can be used to rank the relative importance within the habitat sampled of each tree species. The relative frequency, relative density, and relative cover are added together to get an importance value number between 0 and 300. Species can then be sorted in order of importance value with the most important having the number closest to 300.

Management implications for habitat by looking at importance value include measuring the success of a burn regime, noting the increasing "importance" values of exotic species as a potential problem, or using the shift in importance values over time as an indicator of potential environmental impacts.

REGRESSION ANALYSIS:

When looking at a variety of factors in relationship to habitats, communities, or plant and animal populations a regression analysis can be used to determine whether one set of data has any relationship to another set of data. This can allow for making predictions of outcomes of management decisions (modeling) and be used as confirmations of management decisions. A multiple linear regression analysis predicts the value for a single dependent variable based on the values or one or more independent variables. SAS, SPSS, EXCEL, and LOTUS have the capacity to run this test.

LONG-TERM DATA ANALYSIS

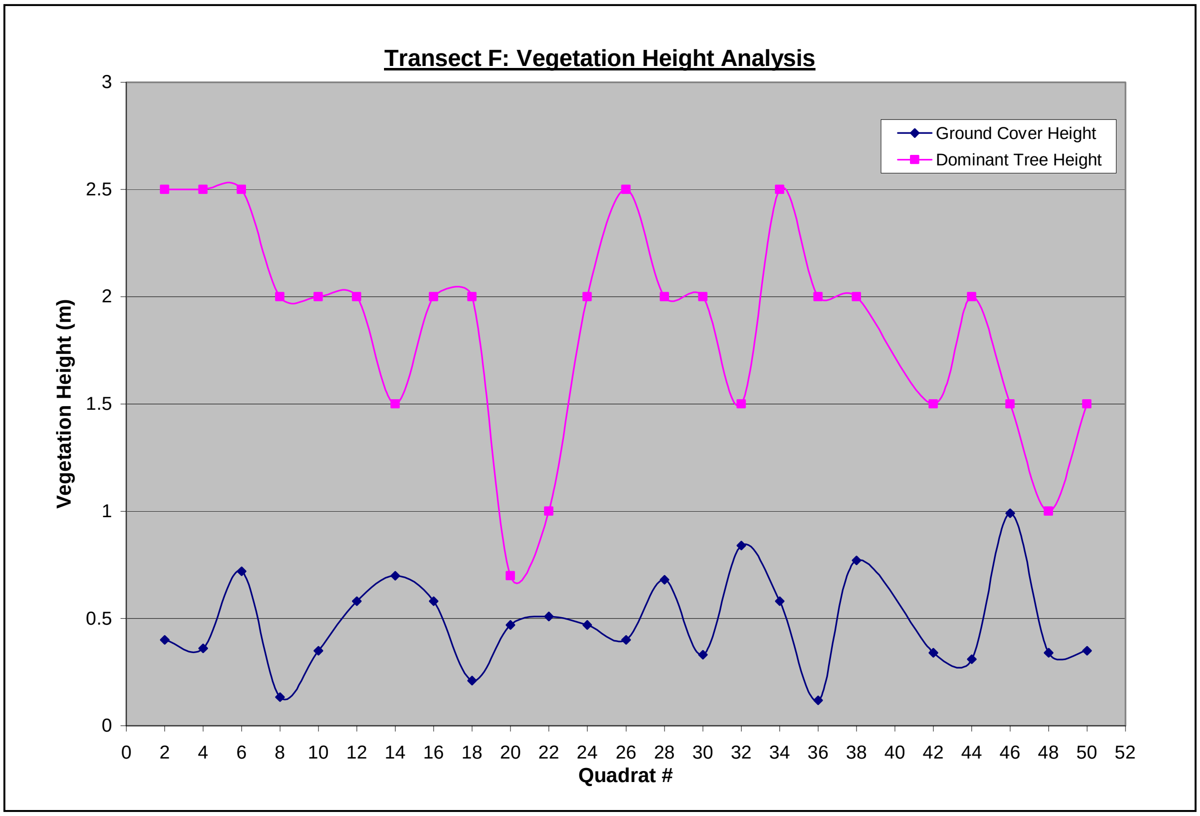
Biodiversity of forage species and long-term sustainability of forage habitat is key to the long-term survival of gopher tortoise populations. Following a complete survey in all seasons of forage habitat, yearly sampling should be done to provide data on the changes occurring in the forage habitat. These changes may be ones initiated by management practices towards restoration goals or they may be natural successional changes that in the long run are not good for tortoise forage.

These changes would initiate responsive management to push back succession and maintain good foraging habitat.

Analysis of data several years of data looks at the similarities and the differences in the habitat from your desired state or model. Simpson's Index "D" looks at the expected number of species in a random sample of "m" individuals and the contribution of each individual is proportional to the probability of appearing in a sample of "m" individuals. This index is often used for vegetative studies. Ruzicka's Similarity Index is used to quantify the similarity of vegetation between two sampling periods or two sampling locations. Species which show the most similarity in relative cover between samples in two years or at two locations will have an index of 100. Species with no similarity will have an index of 0. This index compares the relative percent cover of the two data sets from different years or locations by summing the relative percent cover for all species in the data set and dividing by the sum of the maximum relative percent cover of the data set and multiply by 100.

The purpose of data analysis is to simplify, not complicate the process of making good management decisions. Academic research utilizes many complex processes for taking and analyzing data that are not necessary for everyday management monitoring. However, the data that is taken should be collected in a consistent manner, stored in a way that can allow for long-term utilization, and be analyzed in a manner that everyone can understand. Simple analysis is not necessarily “bad” analysis. It is important to use analysis techniques not just “my observations say” which more often than not are biased and incorrect as has been shown many times. The data frequently reveal things that were not obvious or were counter intuitive. One simple analysis technique is to use a profile (Stratification). This is simply a graph of the transect data - usually vegetation height, but relative cover can also be used. This graphically provides a manager that does not go into the field frequently a sense of the area being sampled. Note the areas of high tree cover in Figure 5.13. This image can reveal bare ground, low areas of grassy vegetation, trees, and thickets. In conjunction with photographs, a manager can get a good image of the site.

Figure 5.13 Graph of tree and ground cover height



Management of Forage:

The ability to take data and interpret its meaning relative to management actions is usually the most difficult part of any forage management plan. Numbers are meaningless out of context. The manager must look at the over all picture including the analysis of plant species quality as forage and importance as forage as well as the species richness, density, frequency of occurrence and diversity. In order to understand how the data collected and overall knowledge of how gopher tortoises interact with forage can result in management decisions we have provided a summary (table 5.2) of information helpful to managers. Remember that even an area with good forage cover may not support a tortoise population in perpetuity if that forage does not include diversity over the seasons or does not provide enough high quality forage species. A species can be eaten and thus designated a forage species yet it may not ultimately represent an important species for the tortoise populations at that location. In other words, the forage species may exist in such small numbers normally within the vegetative community or it may be present for such a short time or it may produce high numbers of individuals that still represent by the nature of their physical structure very little biomass or it may be in a particular location where soils or climate minimize its growth – all instances where its importance as forage to tortoises will be limited.

A REVIEW OF POINTS A MANAGER NEEDS TO CONSIDER

1. A tortoise may eat **160 or more species of plants** during the year. We know that the selection of species gopher tortoises are known to feed on is around 400. This does not tell us how many species a tortoise must have to stay happy and healthy. It does give us an indication of the species diversity that indicates a good habitat. Note that wire grass alone is a very poor indicator of tortoise forage management.
2. Tortoises appear to have two modes of forage, that for grasses which is normally within 100 m diameter of the tortoises burrow. The other is for various species of broadleaf plants. Searching for the species and apparently the condition of the plant may commonly take a tortoise more than 1000m away from its primary burrow.
3. Managers should take into account that some plants have anti-herbiviory methods which stop foraging by herbivores like tortoises. This may cause a tortoise to have to move some distance from its burrow to feed on some common food species since those individual plants that are commonly fed on will produce these like having high concentrations of tannic acid in the leaves.
4. Tortoises feed on specific parts of some species of plants at various stages in their life cycle and not at all on other. For example blackberries are eaten as they sprout and of course the fruits are eaten. Mature leaves are rarely eaten.
5. When managing for tortoises it is important to establish a mosaic of burn plots that are burned at different times of year. Summer burns are appropriate however; there is a higher diversity of plants if there are also non-growing season burns as well.

6. The smaller the tortoise preserve or the habitat on a site, the greater the need for on going monitoring and responsive management.
7. Probably the most important measurement of good habitat besides diversity is canopy cover (tree and shrub). The magic number for tortoises appears to be a canopy cover of 60% or less.
8. Make sure that monitoring plots are situated where they are testing the forage of the tortoises on site.
9. Tortoises appear to move around the habitat (given there is enough room) and individuals and possibly pods may be from several hundred meters to several kilometers (miles) while in some habitats where there is optimal forage, they tend to move much less.
10. If fire cannot be used then mechanical means should be evaluated to determine it can sustain the diversity required. Grazing cattle should also be considered since we have found they are quite effective in some habitats.
11. Monitoring should include periodic soil sampling and when possible forage analysis for protein and various nutrients.

TABLE 5.2: SUMMARY OF IMPORTANT TOPICS & QUESTIONS FOR MANAGERS

TOPICS & QUESTIONS WE NEED ANSWERED	HOW WE STUDY & FACTORS CONSIDERED	WHAT HAS BEEN FOUND AND IMPLICATIONS FOR MANAGEMENT STRATEGIES
DIGESTIBILITY OF TORTOISE FORAGE PLANT PARTS **1. What parts of plants are eaten by tortoises?** **2. Which plants and plant parts are most important to keep accessible as tortoise forage?**	- Stomach contents - Feces Analysis - "Bite" Observations - Lab Experiments - Selection of Presented Plant Parts - Video taping of feeding - Following & Observing	Studies have shown that like many herbivores, gopher tortoises maintain a microflora in their digestive tract to breakdown the cell wall (cellulose, lignin) parts of their diet, making more nutrients and energy available to the tortoise. Little money or time has been spent on studying the digestibility of forage plants eaten by tortoises. However, most plant species foraged by tortoises are also eaten by cows, sheep or goats and data has been collected on the digestibility of plants eaten by these economically important mammal species. Feeding trials with *Geochelone*, a South American tortoise, indicated a 4 times faster intake and transit time for fruits than for foliage; significant cell wall fermentation occurred with foliage and not with the fruits. Suggests simultaneous intake of fruits may impact digestibility of grasses. Digestibility of forage plants is seasonal, as annual plants cycle they show distinct changes in levels of certain chemicals (like tannins), loss of moisture and proteins – nitrogen, and increase in less digestible cell wall carbohydrates.
SPECIES OF PLANTS USED AS FORAGE **1. Which species of plants should be maintained or restored to be used as tortoise forage?**	- Transects and Surveys - "Bite" Observations - Selection of Presented Plant Parts - Exclusion Plots - Feces Analysis - Video taping of feeding - Following & Observing See forage comparison table	Data on plant forage species has been in the literature but incomplete since the 1940s. Forage observations and feces analysis have been widely used to add to the list of species consumed. Presentation of broken off food items and feces analysis are not as likely to give clear data on the actual selection process and species. Many species observed to be consumed in great quantities like Asteraceae and Fabaceae are digested completely or almost entirely, leaving no trace to be found in fecal analysis. Presentation in laboratory conditions of broken off, clipped or dried plant matter is often misleading and a poor indicator of species selection in the wild. Plants that are broken off may produce anti-herbivory chemicals that repel selection when in the wild the species would be consumed.
SEASONALITY AND AVAILABILITY OF FORAGE SPECIES **1. How does the seasonality of forage species affect choices for management?**	- Transects, Surveys and Observations of Foraging - Seasonal Selection of Plant Parts - Selection Limited by Availability	Depending upon the specific latitude, forage species will cycle according to whether they are annuals, biennials, or perennials. The drought or rainfall conditions, first and last dates of freezing (where it applies) and any unusual conditions due to storms or hurricanes will affect the setting of flowers and fruit. Management activities (burning, grazing or mowing) can also change the plant cycles – pushing plants back into a growth phase and holding off reproduction, keeping the leafy parts available for forage longer.

TOPICS & QUESTIONS WE NEED ANSWERED	HOW WE STUDY & FACTORS CONSIDERED	WHAT HAS BEEN FOUND AND IMPLICATIONS FOR MANAGEMENT STRATEGIES
NUTRIENT AND MINERAL CONTENT OF FORAGE – REGIONAL AND SEASONAL VARIATION **1. How does the nutrient and mineral content of forage vary by region?** **2. How does the nutrient and mineral content of forage vary by season?**	- Effects of Plant Life Cycle - Determine Soil Fertility - Micronutrient Variability - Comparison with other Herbivore diets - Check for Nutrients Tied Up by Various Actions - Record of Management Strategies to Enhance	Nutrient content of plants is dependent upon the nutrients available for uptake in the water and soils and on the specific physiology of the species. Herbaceous species are generally higher in protein, carbohydrates, fat and calcium than annual and perennial grasses. Fertilizers and/or contaminants in soils affect nutrient availability and uptake. Moisture content in plants decreases seasonally from spring to fall, depending upon region of the state and drought status. Succulents (*Opuntia, Sesuvium, Portulacca*) keep their moisture content relatively stable year-round. Nitrogen, phosphorus, potassium, zinc, and fats also decline on the same seasonal pattern as moisture. Iron, manganese, copper, calcium, magnesium, sulfur, and sodium remain fairly stable all year and are more regionally affected in accordance with availability in soil and water. Little work has been done specifically on *G. polyphemus* forage plants but there is a lot of data for Florida and the S.E. on these factors in plants used by cattle, sheep, and goats. Some studies have shown significant differences in mineral and nutrient values relative to soils and watershed. Some material from the extensive studies done on the Desert Tortoise, *G. agassizii*, is applicable to the forage species used by the gopher tortoise.
CHEMICAL CONTENT OF FORAGE **1. How does the chemical content of forage affect tortoise selection of forage?**	- Anti-herbivory strategies - Chemical changes (daily, seasonal) - Antibiotic and anti-fungal	Plants have evolved many anti-biotic, anti-fungal and anti-herbivory strategies and maintain a delicate balance between attraction strategies for pollination and seed distribution and protection against all out consumption. Presence of hairs, thorns, thick bark or cell walls and strong aromatic or irritant chemicals deter herbivory. Anti-biotic and anti-fungal chemicals are produced in response to injury. These same anti-herbivory, anti-biotic and anti-fungal chemicals can serve medicinal or supplemental or interactive digestive purposes. Tannins reduce protein availability to the herbivore in forage. Various animal species have been repeatedly found to select specific plant species in response to injury or illness. The same ability of the tortoise to "recognize" specific plants by smell could also be used to identify the presence of useful chemical compounds needed for long term health.

TOPICS & QUESTIONS WE NEED ANSWERED	HOW WE STUDY & FACTORS CONSIDERED	WHAT HAS BEEN FOUND AND IMPLICATIONS FOR MANAGEMENT STRATEGIES
NUTRIENT & MINERAL REQUIREMENTS OF GOPHER TORTOISES **1. What are the nutrient and mineral requirements of hatchling and juvenile tortoises?** **2. What are the nutrient and mineral requirements of adult gopher tortoises?**	- Lab Experiments - Feeding Studies - Stomach contents - Feces Analysis - “Bite” Observations	Very little is known about juvenile gopher tortoise feeding behaviors or nutritional requirements. It is assumed that the growth required of a hatchling to survive to adult hood demands quality forage with good nutritional value. Nutritional value to the tortoise of a plant ingested is not constant or independent of the chemical content and interactions with chemical content of other ingested plant species. Associative effects between foods can result in gain or negation of nutrient value. Additions of fermentable sugars and nitrogen support higher microbial populations to digest forage. Intake of seemingly small amounts of animal/insect matter may provide a greater nutritional benefit as an associative effect. Adult females have higher calcium requirements and occasionally ingest calcium-rich soils/rocks to replenish lost reserves during egg laying. The flexibility of the marginals and shell is related to the level of calcium in the diet. In spring tortoises require green vegetation to replenish their fat reserves lost during “hibernation” or down times when they don’t come out of the burrow. Tortoises are also known to ingest bone and feces of other animals including cow dung. Tortoises fed a diet too rich in protein or calcium in captivity grow raised scutes. Studies have shown that in the Desert tortoise a calcium to phosphorus ratio of 2:1 is required for proper shell and skeletal formation. Nitrogen is required to form urates for potassium excretion and water is required for urine production. Tortoises that are dehydrated may stop eating until they can void urates.
FORAGE SELECTION STRATEGIES **1. How do tortoises locate forage species?** **2. Why and how do tortoises select specific species and specific parts of species to eat?**	- Selection of Presented Plant Parts - “Bite” Observations - Filming of feeding	Nutritional and chemical content of forage may be detectable using highly developed senses of smell and possibly taste. Memory may play a role in relocation of previously found forage items. Diet interactions may have an impact on selection; items may be rejected or selected on the basis of their effect (positive or negative) on ability to obtain nutritive or other chemicals from other forage ingested simultaneously. Plants produce different chemicals and move nutrients into tissues based on seasonal cycles, reproductive cycles and at different times of day or in response to herbivory or injury. Highly selective tortoise foraging at certain times may be in response to these plant cycles, as revealed to the tortoise by sight, smell, and/or taste.

TOPICS & QUESTIONS WE NEED ANSWERED	HOW WE STUDY & FACTORS CONSIDERED	WHAT HAS BEEN FOUND AND IMPLICATIONS FOR MANAGEMENT STRATEGIES
FREQUENCY OF ENCOUNTER **1. How do the physical layout of the preserve and the distribution of forage species affect tortoise access to forage plants?**	- Map Access to Forage and Impediments to access - Identify Tortoise forage "Attractors"	Important forage species must be widely distributed and accessible so that all tortoises in the population can find an uncontested foraging area. If a preserve is over 30 acres, and only a small area contains important forage species (Legumes, Asters, broad-leafed grasses) then that area may be accessible only to a local pod of tortoises and other pods will have to search off-site, compete or do without.
FORAGE DISPERSAL OVER HABITAT **1. How do plant species distribute over the foraging area available to tortoises?** **2. How does isolation of a preserve affect forage plant dispersal?** **3. How does nearby development affect forage species in a preserve?**	-Short-term Factors; seed dispersal by wind, water, animals, storms - Long-term Considerations presence of seed bank and seed source - Record access of forage to tortoises over season	In any natural ecosystem, there is an intricate balance by which plants utilize animals and natural conditions (wind, water) to disperse their seeds and provide continuation or expansion of the plant species. In changing or stressed habitats, these mechanisms may break down as certain animal species are eliminated or as seed source from other properties that previously allowed un-inhibited access now are isolated from the forage areas. Without a replenished seed bank or without healthy seed source the forage population health and the dispersal mechanisms will continue to deteriorate. Isolated preserves over time can suffer great biodiversity loss due to loss of seed source from previously natural areas which originally surrounded them that become developed. They can also suffer from exotic incursions from developed areas. Seed banks can be replenished to a limited degree by making sure that management practices do not interrupt the production of seed at the end of the season and that the seeds are dispersed, not destroyed by burning at the wrong time.
EXOTIC PLANT SPECIES **1. Are any exotic species beneficial to tortoises as forage?** **2. How does the presence of exotics, even beneficial ones, affect the quality and quantity of forage species?**	- Beneficial "Exotic" Forage Species - Competition with Forage Species	Landscaping trends in recent years have resulted in exotics from all over the globe becoming accessible to tortoises for foraging either as invaders in their natural foraging habitat or in yards and other landscaped areas that tortoises can "visit" off their usual site. Tortoises often bring the seeds of the exotics back into their native feeding area to become an invader, sometimes crowding out their important native forage species. Some exotic species are high in nutrients or are specially adapted to drought conditions and therefore provide higher quality forage during dry times. This can be a short-time positive help to the tortoise population – like providing hay to deer in super-cold seasons. Exotic grasses, often brought in as pasture grasses since the 1940s, may out-compete native species in some situations and provide sustained forage even in the cold months. Exotic species used as forage must be carefully studied to be sure that their competition with native forage does not out weigh the benefits they provide. Many of the exotic species foraged by tortoises have become widely "naturalized" in the S.E. and are not likely to be eliminated from the habitat.

TOPICS & QUESTIONS WE NEED ANSWERED	HOW WE STUDY & FACTORS CONSIDERED	WHAT HAS BEEN FOUND AND IMPLICATIONS FOR MANAGEMENT STRATEGIES
IMPACTS OF PESTICIDES & HERBICIDES **1. Is it safe to use pesticides and herbicides in gopher tortoise foraging areas?**	- Testing for Toxicity Inadequate - Retention (whole or in part) in Forage - Impact on Tortoises	Forestry practices suggest that pesticides and herbicides used today are “non-toxic”, biodegradable and not harmful to gopher tortoises. Investigation into the methods by which these chemicals are tested indicated that there is no proof that they are not taken up and ingested by tortoises. The potential for long term storage of certain compounds in the reptile body exists. No studies have been done directly on gopher tortoises to investigate the potential for harm. Minimal use of pesticides and herbicides is recommended until studies provide more concrete data.
FORAGE MANAGEMENT STRATEGIES **1. What management methods work best for tortoise foraging areas?**	- Burning (fire lanes, frequency, timing) - Mechanical (Mowing, Plowing, Planting) - Chemical (Herbicides, Fertilizers, Pesticides) - Biological (cattle grazing)	Comparative studies of the effectiveness of management strategies still indicate that burning is the best strategy in those habitats where it is a natural factor (sandhills, scrub and flatwoods). Timing is very important as well as frequency of burning. If burning is not available then some form of clearing will be necessary. Cows work well. Mechanical clearing or mowing is good also. Chemicals should be an absolute last resort since we really do not have any data on how they are taken up in vegetation and thus passed on to tortoises as they forage. One of the common causes of plant species loss in managed areas is burning too frequently, at the wrong season or having burns that are too hot. Tortoise populations living in pasture lands that have been grazed (but not over-grazed) for 30-50 years generally continue to do well when pasture continues to be managed with grazing, and other activities normal to pasture management as long as they have access to surrounding habitats with more species diversity. Use of pesticides and fertilizers should be analyzed and care taken in how and when these are applied. Heavy machinery used in pasture management can often be fatal to gopher tortoises. Grazed pastures often can support large tortoise populations and grazing helps keep the protein levels high in grasses. Auffenberg and Franz (1982) indicate that tortoises are not common in maintained pastures but more recent studies 1992-2004 have found that as available habitats are being lost, tortoises are more commonly found in managed pastures and ruderal habitats as well as remnant scrub and sandhills.

TOPICS & QUESTIONS WE NEED ANSWERED	HOW WE STUDY & FACTORS CONSIDERED	WHAT HAS BEEN FOUND AND IMPLICATIONS FOR MANAGEMENT STRATEGIES
FORAGE ASSESSMENT **1. How can we assess the actual availability of tortoise forage in any given area?** **2. How can we assess the quality of the available tortoise forage in any given area?**	- Assessment by Experts - Timing of Assessment - Assessment Techniques a. "amount" to be assessed b. location relative to pods c. cover class vs. %	Initial forage assessment should be by experts familiar with plant species. The initial assessments should be in all seasons to develop a complete species list – it this is not possible then the best season to do an assessment in is late spring to early summer. Auffenberg and Franz (1982) used a system of 100% clipping to compare gopher tortoise food resources in different habitats during June-July. Longleaf pine oak upland had 60.kg/hectare of forbs and 337.4 kg/hectare of grasses; Mixed pine-oak had 15.2 kg/hectare of forbs and 122.0 kg/hectare of grasses; xeric hammock had 2.0 kg/hectare of forbs and 2.9 kg/hectare of grasses; sand pine-scrub oak had 9.4 kg/hectare of forbs and 3.1 kg/hectare of grasses; ruderal habitats had 225.4 kg/hectare of forbs and 519 kg/hectare of grasses. The best assessment for a preserve or habitat is a series of walking transects completed over all seasons and a series of permanent transects for tree and shrub survey and ground cover survey. Cover class (Daubenmire 1959) provides a more consistent quantitative measure that is easier for volunteers and multiple data takers to use than using percentage. Mapping of vegetative communities, tortoise burrows and pods and profiles of forage species across the habitat can help assess the position of forage relative to tortoise pods. Quality of the available forage can be assessed by making comparison with a "model" of quality forage. Research is continually adding new species and new information that can be added to the model.
FORAGE MONITORING **1. How can we monitor forage health and quantity ?** **2. How can we use monitoring data to make management decisions?**	- Monitoring Schedule & Location - Amount of Forage to Monitor - Staff and techniques	Long-term monitoring does require that data be maintained and that a schedule and permanent transects be established. Experts are not required to carry out long term monitoring as long as a careful monitoring plan has been created and data analysis is carried out. Long term monitoring must be consistent. The best monitoring for a preserve or habitat is a series of permanent transects completed over all seasons for tree and shrub survey and ground cover survey. Cover class provides a more consistent quantitative measure that is easier for volunteers and multiple data takers to use than using percentage. If all seasons cannot be surveyed then each year another season should be surveyed and thus similar seasons data can be compared every 4 years. Mapping of vegetative communities, tortoise burrows and pods and profiles of forage species across the habitat can help management monitor forage relative to tortoise pods. Volunteer and staff should be trained in monitoring techniques.

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Specific sources: Bjorndal, Karen A. 1987; Bjorndal, Karen A. 1991; Church, D.C. 1977; Grover and DeFalco 1995; McArthur, D.E., S.C. Sanderson and B.L. Webb, 1994; Moskovits, D.K. and K.A. Bjorndal 1990; Robbins, et al. 1987; Obst, F.J. 1986.

Table 5.3 Acceptable To Unacceptable Management Practices On Tortoise Forage And Habitat

PRACTICE	MOST ACCEPTABLE	ACCEPTABLE	NOT ACCEPTABLE
Establishing Conservation Goal(s) For The Site	If the site is a conservation lands Site, then the primary goal should be established based on biodiversity tied directly to those species and densities required by the tortoise population. If it is a park, pasture, silviculture or similar multiple use plan, then tortoise forage requirements have top priority.	Tortoise forage needs are considered over an above plant community needs, management will be responsive to these needs but will consider other species needs. These are monitored carefully. When necessary, non-native grasses like Bahia may be used to suppliment the grass foraging needs.	No concern for management and monitoring of the habitat is required or planned. The primary goal is to sustain a habitat such as scrub habitat that has a much lower carrying capacity for tortoises than is planned for residency.
MANAGEMENT PLAN	The management plan is responsive to the monitoring program and insures that the tortoise habitat and forage needs are being met. Budget is appropriate.	The management plan is responsive to the monitoring program and insures that the tortoise habitat and forage needs are being met. Budget is still in need of help.	The management plan is not responsive to declining conditions and budget is not responsive. Monitoring is not done in a way that can drive responsiveness.
VEGETATIVE MONITORING	Monitoring takes place in a manner that will provide the manager with data and analysis that will allow responsive management to occur. This includes measuring forage diversity based on assumed tortoise forage diversity and required populations of commonly used species. Monitoring is funded and is done as required.	Monitoring takes place in a manner that will provide the manager with data and analysis that will allow responsive management to occur. This includes measuring forage diversity based on assumed tortoise forage diversity and required populations of commonly used species. Monitoring is only funded to the minimum requirements. More budget assistance is needed.	Monitoring is considered a luxury and site management is based on gut feeling or just the way things look. Monitoring is the first activity cut. It is attempted but curtailed because the methods and analysis were too complex and costly. Monitoring is done less frequently than allows for proper analysis or data is not stored routinely and in a useable manner.

Data Analysis for Management Decision Making and Implementation

The initial data taken on any site should be stored in digital format as well as hardcopy. The data sheets from all current and future field work on a site should be stored in a notebook specifically for the **DATA** which is imperative to the usefulness of a management plan. The lack of long term storage and review of preserve data is often the greatest weakness of any management strategy. Make careful data storage and accessibility for review and a definite schedule for review and analysis of that data a priority. Without regular review and implementation of management actions the effort put towards data collection, analysis and storage is wasted. Every team member should know what data is collected and where and how it is stored.

The hardest part of writing or implementing a management plan is the interpretation of the data and what it means in terms of management actions. This section is designed to help provide some ideas on how baseline and future data related to direct management actions. There are certain factors related to the stated management goals that should be considered. They are outlined in TABLE 5.3. The priority of each and how it affects management actions may be different as the management goals change or evolve over time. In all cases, the time and money spent to collect data and store data is only cost effective if in the end that data is analyzed and used in making management decisions that result in implemented actions. Over the past 20 years the move towards habitat restoration and efforts at modeling the complexities of habitats and communities has resulted in a plethora of strategies, data and models. Of these, some provide us with useful data and methodologies applicable to the management of forage. Of most importance is the understanding of the staff doing the analysis and the manager responsible for the implementation of the management strategies that all systems are dynamic and that there has not yet been created a suitably perfect model of what an ideal gopher tortoise foraging and burrowing area would be for all possible habitat types. That said, there are some useful models and data available. All data analysis and management decisions based first on the basic assumptions driving the system. The assumptions for any Preserve Management Plan are as follows:

ASSUMPTION 1: Restoration of habitat by making remedial changes to or additions to abiotic and biotic factors based on our limited knowledge of what actually constitutes natural habitat may result in a return to more “natural” ecosystem processes and support long term sustainability.

ASSUMPTION 2: Restoration, Management and Monitoring of any properties for gopher tortoises and other protected species historically present on the site or similar sites will result in fulfillment of the primary goal of creating a sustainable ecosystem with natural flora and faunal communities that were likely to have existed on a given site before the 1850's.

ASSUMPTION 3: The data used for analysis and on which decisions are being based has been collected and maintained in an appropriate and comparable manner over time as laid out in the various methodology sections, regardless of any staff changes.

ASSUMPTION 4: Management can maintain the "will" as well as the financial and physical capabilities to review the analyzed data on a regular schedule and implement indicated management actions.

Factor 1 – Over all Plant Species Richness and Species Diversity and Seasonal Plant Species Richness and Species Diversity and MANAGEMENT

Plant Species Richness (**s**) is a simple measure of the number of different plant species present at any given time. It is not a derived variable and represents a value that can be compared directly in a time series if the area being studied is the same from one sampling time to the next and if the sampling techniques are comparable.

In general, this number needs to be high to provide variety of species for foraging. But, this number (**s**) is only useful when analyzed in the context of current and past conditions and when the methods used to determine it are comparable. Plant species richness may be very low (s = 27) in an open pasture but the quantity of forage species present in that pasture may be very high at certain times. This is good for intensive bulk feeding but would not supply all the tortoise's nutritive needs if it were the only forage available to the tortoise year round. If the pasture were dominated by Bahia grass (*Paspalum notatum*) and the tortoise restricted to that pasture with no access to other seasonal vegetation then the forage biomass available to the tortoise would be very low to non-existent for 3 to 6 months depending upon the region.

TABLE 5.4: TORTOISE FORAGE MANAGEMENT FACTORS AND PRIORITIES

FACTOR	PRIORITY 1-10 with 1 being the highest	RELEVANT DATA	MANAGEMENT ACTION INDICATED
1. Over all plant species richness and species diversity and Seasonal plant species richness and species diversity	1	List of species from general walking survey and transects.	Add appropriate species or make changes in actions to encourage addition of species if richness is less than 100 in late Spring, Summer or Fall
2. % Forage species and Frequency of Occurrence; Density of Forage Species	1	List of species from survey and transects	Add or encourage appropriate forage species if less than 50%; Desirable frequency of occurrence and relative density will vary with species: grasses and legumes should be10-30% and incidental species 2-10%.
3. Over all Quality of forage: Species Diversity, Health	1	Photo data and transect data	Eliminate stresses to forage; improve conditions
4. Over all Quantity of forage: Frequency and average cover	1	Estimates from aerials and transect data; tortoise data	Improve conditions and add to quantity
5. Presence of competing, non-forage exotic species	3	Survey and transect data	Eliminate competing non-forage exotics
6. % canopy cover – current over-all and species density	2	Estimates from aerial photos; transect data	Reduce canopy cover if more than 60%
7. % canopy cover in 3 years – prediction from transect data	2	Estimates from aerials and transect data extrapolation	Reduce contributors to future canopy cover if will be more than 60% in 3-5 years
8. % sub-canopy/shrub cover – current	2	Estimates from aerial photos; transect data	Reduce canopy cover if more than 60%
9. % sub-canopy/shrub cover in 3 years – prediction from transect data	2	Estimates from aerials and transect data extrapolation	Reduce contributors to future canopy cover if will be more than 60% in 3-5 years
10. Stress to forage plants from drought or flood or other natural actions	3	Weather data and knowledge of sensitive forage species responses	Consider remedial actions to mitigate effects of stress – irrigation, re-seeding, etc.
11. Stress to forage plants from human land use	3	Land use data on site and from surrounding sites	Consider remedial actions to mitigate effects of stress
12. Status of Seed bank on site	4	From survey and transects status of seed bank	If decline is evident take remedial actions
13. Stress to seed bank on site	4	Weather and management action data; transect data	Consider remedial actions to mitigate effects of stress
14.Status of Seed Source on-site	2	From survey and transects status of seed source	If decline is evident take remedial actions
15. Stress to Seed Source on-site	2	Weather and management action data; transect data	Consider remedial actions to mitigate effects of stress
16. Status of Seed Source off-site	3	From survey and transects status of seed source	If decline is evident take remedial actions
17. Stress to Seed Source off- site	3	Weather and management action data; transect data	Consider remedial actions to mitigate effects of stress
18. Competition for forage species	2	Survey and management data on other species	Consider remedial actions to mitigate effects of stress

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A **management response** to this situation, like when managing for cattle (and remember that tortoises are much like cattle in some of their foraging needs) would be to over-seed warm-season perennial grasses with cool/dry season forage species (Stanley 1999) to maximize year-round forage availability. Obviously, this pasture example is not the ideal for developing native vegetation forage habitat, but in many preserves the presence of such pastures is a reality. The same principle applies to natural forage; cool/dry season native plant species that would naturally be found in the habitat should be part of the species management plan. If such species are not present or have been previously eliminated from the "Species Richness" of the site, then the current management actions should include ways to re-establish these species.

The availability of plant species to the tortoises for forage must be considered – both over season and over physical space. The Species Richness for the entire preserve may be very high but if only 60% of those species are forage species and if only 60% of those are even accessible or available to the tortoises due to any number of factors (roads, barriers, canals, distance, land use) then the high Species Richness number is in reality meaningless to the management of the tortoise forage. Also Species Richness is a snapshot in time – it can be very high in percentage of forage species in one season but very low in another season.

Some examples of the species richness in Florida preserves and natural areas (where part or all of the preserve is managed for gopher tortoises) are found in TABLE 5.6 and suggest that a species richness of less than 70 at any given time (with the exception of pastures) within a single season is probably too low to sustain good tortoise forage and that a species richness of 100 would be a probable target for most natural areas with the exception of old pastures and coastal beach strands which may only expect a species richness of 35-40 but have a high percentage of actual forage species. Depending upon the location and historical habitat of the preserve, a species richness based on surveys in all seasons should be between 150 and 400.

TABLE 5.5: Comparisons of Species Richness of Preserves

Preserve, Location and Size	Species Richness	Families Represented	Herbaceous Species	Exotics	Forage Species	% Forage Species	MODEL FOR SAMPLE PRESERVE (L – M – H)
Preserve, Alachua Co.; 100 acres	***387	81	250	5	375	97	M
Preserve, Alachua Co.; 35 acres	**221	72	195		199	90	M
Pinellas Co.; 18,000 acres	**155	64	107	4	134	86	H
Sanibel-Captiva;	+248	75	225	54	206	83	H
Gulf Ridge	+135	59	109	23	109	81	H
Mid-Gulf Coast	+78	55	65	7	68	87	H
Lake Sumter; 40 acres / pasture	**44	20	42	4	40	91	M
Lake Sumter; 30 acres	**70	31	62	5	67	96	M
Hillsborough Co.; 20,000 acres	++78	30	70		78	100	H
Collier County; 68 Acres-Example of Forage Level too Low	*61	30	48	4	21	34	L

*** From one season one sample survey**
**** From more than one season surveys**
***** From multiple seasons and multiple years surveys**
+ From on-site survey
++ From Scat analysis only – Macdonald and Mushinsky, 1988

Factor 2 – % Forage species and Frequency of Occurrence; Relative Density of Forage Species

A list of forage species compiled from literature and from our research is compared to the species found at our SAMPLE PRESRVE to identify forage species and the percentage of the total species that are forage species is then determined. The frequency of occurrence of particular species is calculated by dividing the total number of quadrats in which the species occurs by the total number of quadrats sampled and yields a percent frequency of occurrence. Frequency of Occurrence gives a quick indication of how “rare” a plant is and may point out its vulnerability to changing environmental factors. Well distributed plants in a preserve with a higher frequency of occurrence are less likely to be eliminated or impacted by events like flooding, wild fire, over grazing or clearing on part of a site. Species that are “clumped” in a portion of the preserve are more vulnerable.

TABLE 5.6: EXAMPLE of Climate and Gopher Tortoise Foraging Analysis

Seasons As Determined by Temperature for SAMPLE PRESERVE	Begins in this area	Probable Tortoise Activity	Implications for Management of Tortoise Forage Plant Species
FALL (Av. temp. falls to 60° F or lower after July)	11/4 - 12/1	Foraging mid-day and afternoon. Stay in burrow on cool days.	Tortoises depend upon ripe fallen fruit and leaves to fill gut for colder winter days. Do not implement any management that removes fallen fruits or leaves.
WINTER (Av. Max. temp. 75° F or lower after July)	12/1 - 1/1 First freeze after 12/15	Foraging only at mid-day if sunny and warmer; on freezing and cold days or periods stay in burrow for up to several weeks	Tortoises feed on warm days and benefit from presence of hardy legumes such as clovers and plant species that like cool weather.
SPRING (Av. max. temp. rises to 75° F after Dec.)	2/1 or earlier Last freeze after 1/15 and before 2/15	Foraging mid-day to late afternoon if warm. Come out to bask and begin foraging earlier as days warm up.	Tortoises depend upon eating a selection of young sprouts from a diversity of species and on new grasses. Not a good time to burn unless it is a very selective burn.
SUMMER (Av, max temp rises to 88° F or higher after Dec.)	5/1 or earlier	Forage in early AM and late PM to after dusk. Tortoises have been seen foraging in pre-dawn hours on very hot days and after dark.	Plants very stressed in summer heat. Moisture is a priority in some years. Tortoises need clear access to lower areas with more moisture and succulent growth even in drought.

Temperature data from Fernald and Purdum, 1996

The relative density percent of forage species is determined by dividing the total number of forage species found in the sampled area by the total number of samples (quadrats) then multiplied by 10,000 square meters/hectare divided by the area of one quadrat.

For example, after a fall survey and limited winter survey the total number of forage species found in one area to be sampled, “Tortoise Relocation Area 1” (TRA1), was 83 out of a total of 106 species found. The **Relative Density** of forage species for TRA1 was only .6% of the total relative density possible. The results from this first survey showed that while forage species plants exist as 83% of the total species present, they only represent a small amount of the possible density of plants across the total area of TRA 1 and therefore the availability of these species to widely distributed tortoise pods would be limited. This was a fall and winter survey but it is indicative of the stress tortoises would encounter in finding forage during these months. Assessing the gopher tortoise forage availability year round in the central to northern part of the Gopher Tortoises’ range is very important. Insufficient forage during times preceding inactivity can be devastating. On the other hand, it is not uncommon for tortoises to remain active for much of the year in the southern portion of the range (south Florida) where the annual minimum daily temperature exceeds _______degrees Celsius (60 F) and has only 10-20% of the days from December to February with a temperature below _____C (40 F) and 50-60% of the days from December to February in which the temperature exceeds _____C (75 F). It is only during rare record low temperature years, that this area has reached temperatures of ____C (20-25 F). The first freeze in this area is generally after December 15 and the last freeze is usually after January 15 and before February 15. In these areas forage must be available year round to support the almost year round activity.

Management strategies for tortoise forage would need to consider the availability of forage species to pods of tortoises distributed throughout a preserve area. If the presence of the primary quantity of forage species is limited to only a few areas then there will be a lot of competition among tortoises for these forage areas which in turn reduces the potential for number of tortoises/acre that the preserve can support (carrying capacity).

TABLE 5.7: SUMMARY OF SAMPLE PRESERVE FORAGE SPECIES AVAILABILITY

	SAMPLE Preserve Baseline Data*	**Expected For Target Restored Habitat***	**Restoration/ Management**
Species Richness for Site 2003-2004 Surveys/Transects Fall-Winter	106	198-225	Survey in all seasons.
➢ Tree/Shrub Species	25	23	Eliminate Brazilian Pepper & Melaleuca
➢ Tree/Shrub Genera	21	20	Eliminate Melaleuca & Schinus
➢ Tree/Shrub Families	17	17	Eliminate Myrtaceae
➢ Herbaceous Species	81	188-219	Encourage development from seed bank and add seed source
➢ Herbaceous Genera	62	70-80	
➢ Herbaceous Families	26	40-65	
➢ Grasses	14	18-25	
➢ Forage Species	88	100-200	Reduce competition, encourage development from seed bank/seed source- add seed source
➢ Forage Genera	67	70-100	
➢ Forage Families	30	50-60	
% Forage Species	83%	80-90%	
Plant Genera Represented	83 Genera		
Plant Families Represented	41 Families		

* Baseline data only represents Fall and Winter so additional species are expected to already be present on the site when it is sampled in Spring and Summer

Organization follows Wunderlin, 1998

FACTORS Analysis – Sample Preserve

Species Richness – 106 This is adequate and likely to be higher when survey is done in additional seasons (Spring and Summer).

Forage Species % - 83% This is very good and likely to be higher when survey is done in additional seasons (spring and summer).

Frequency of Occurrence – The forage species data analyzed represent fall and winter and are thus limited. Most of the forage species sampled were not widely distributed but the wider distribution of key winter forage species (grasses, sedges, asters, madders and chocolate weed.

Relative Diversity of Forage Species – This was very low with a relative diversity of forage species of .6% indicating that forage species are clumped or located in only a few regions rather than widely distributed. This makes them vulnerable to impacts.

Management Implications –

1) **Eliminate or reduce competition from some exotics**
2) **Encourage development from seed bank – by burning or clearing to allow growth from seed bank**
3) **Enhance seed source – Inventory surrounding areas serving as seed source. Bring in seed source from a suitable site in mulch.**

Box 5.4

Factor 3: Over all Quality of forage: Species Diversity, Health

From baseline data the present quality of the forage at the SAMPLE PRESERVE can be judged as moderate.

Species diversity is a characteristic of a community that indicates species structure within the habitat and is different from species richness. Diversity, often called species heterogeneity, refers to the number of different species present in nearly equal or substantial abundance and is a measure of the general distribution of all species within the preserve or an area of the preserve in accordance with abundance comparisons. This is only useful in context and should not be used as the sole indicator of a needed management action. Species diversity indices are a form of derived statistics and do not represent an absolute. Plant species diversity ideally should be based on data that spans all the seasons. Diversity by season can be a useful indicator but should not be used as a sole indicator.

A high species diversity indicates a large number of equally or nearly equally abundant species. The community can have many species of low abundance but only a few of equal abundance and therefore have moderate or low species diversity. A group of species that represent high diversity in a community will have a low dominance. A pine plantation has a high dominance and a diverse, well-managed pine savannah will have a low dominance. Tortoises in general will do well in a community with low dominance.

Factor 4: Over all Quantity of forage: Frequency and Average Cover

Quantity of forage can be determined (as done in ecological studies) by totally clipping the surface vegetation, identifying, drying and weighing the material to determine biomass present. Estimates of biomass can be done for most general habitats. Presence of bare ground and low average cover is an indicator of a lower quantity of forage biomass. The baseline cover figures indicate a lower quantity of initial biomass in the seasons sampled. The Average cover for the area was

38.72. The area that was burned had an average cover of 42.16 and after the burn it was 18.6 – this illustrates the comparative measure of cover, very low following the burn. **A good indication of sufficient quantity of tortoise forage would be average cover figures of 50.00 and above with a preference between 70-80.00 for average cover for forage species.**

Factor 5: Presence of competing, non-forage exotic species

The problems with exotics, particularly the exotic tree *Melaleuca* and the shrub *Schinus* as well as some unwanted grass species are well known in Florida. These exotics often out-compete local forage species and the tree exotics shade out forage habitat. The SAMPLE PRESERVE is currently engaged in exotics removal. Management techniques used to remove exotics should not be undertaken at the expense of the health of the future tortoises. It is important to know the retention of the specific chemicals in plant tissue, soil and water and how these may later affect tortoises feeding on the forage.

Factor 6: % Canopy Cover – current over-all and species density

The total number of species found in the sample area divided by the total number of samples (quadrats) then multiplied by 10,000 square meter/hectare divided by the area of one quadrat will give the absolute density of species per hectare and is extremely useful when looking at wildlife use of habitat, identification of ecotonal zones, and long-range environmental impacts on vegetation and wildlife. The absolute density of the SAMPLE PRESERVE using the baseline data is 38,196 plants per hectare. The tree canopy cover is moderate in the areas sampled and the overall average ground cover (42.16) indicates sufficient open ground to provide area for new seed to take root – this quality is important in forage development. Open ground, however also indicates that less biomass is available to serve as forage as to hold moisture. The xeric conditions can make it difficult restore missing species from the over-all flora.

Factor 7: % canopy cover in 3 years – prediction from transect data

With sufficient seasonal data over several years to establish a good baseline it is possible to extrapolate the continued increase in tree/shrub canopy cover. At this time the data indicate that ground cover is such that new species could be established (it also could allow influx of exotics) and that the tree/shrub canopy in certain areas will continue to fill in unless more management is undertaken.

Factor 8: % sub-canopy/shrub cover – current

The current sub-canopy sapling/shrub cover is dense in some areas and will present an impediment to forage species health if not burned on a regular (3-5 year) basis.

Factor 9: % sub-canopy/shrub cover in 3 years – prediction from transect data

With sufficient seasonal data over several years to establish a good baseline it is possible to extrapolate the continued increase in sapling/shrub sub-canopy cover. At this time the data indicate that ground cover is such that new species could be established (it also could allow influx of exotics) and that the sapling/shrub sub-canopy in certain areas will continue to fill in unless more management is undertaken.

Factor 10: Stress to forage plants from drought or flood or other natural actions

Forage species vary in their ability to withstand drought. Because many of the species in these areas are adapted already to xeric conditions, they can survive longer than some more mesic species in times of drought. Data taken in years when rainfall is deficient will indicate the sensitive species as they drop out of the available forage. When drought conditions improve it will be important to be sure that these species return to the flora or that they are restored. Like drought, flood also eliminates some sensitive species and in addition can bring in competitors that are better adapted to the conditions. Sample carefully after flooding to see that new exotics are not brought into the forage areas.

Factor 11: Stress to forage plants from human land use

Continued monitoring of surrounding land use, proposed use and presence of exotic species on surrounding lands is vital. Run-off of herbicides, fertilizers, and pollutants from surrounding lands can severely impact the quality and quantity of forage.

Factor 12: Status of Seed bank on site

A number of recent studies (Longleaf Pine Restoration Project, 2001 - Eglin AFB restoration) have looked at the status of existing seed banks (seeds retained in the sub-surface soil) and the rate of recovery from those banks. Following a burn, clearing activities or a flood, seeds “banked” in the soil can re-establish forage plants. No good estimates have been done of the life of all forage species. In general, (forage studies, Forage Handbook) the life of forage seeds is listed as less than 1 year. Of a selection of seeds produced in one year, a certain percentage of those in the soil will sprout if conditions are right; most sprout or die in the first year but a few may survive to sprout in successive years. The hardiness of see varies by species. Dependence upon a seed bank to restore a more natural flora to an area is ”iffy” at best. Your seed bank most likely will contain many of the exotics and other species you are trying to remove from the surface layer. Sand allows easy percolation downward of seed material. The distances that seeds can travel for dispersal or re-colonization have also not been adequately studied. Seed dispersal can depend upon wind, animal vectors, water and catastrophic events. If the surrounding areas are still in natural vegetation then many of the seeds found on-site in the seed bank could come from the surrounding areas as well as the on-site vegetation. This can be good and bad – exotics on surrounding properties that you have already eliminated can easily come back into your seed bank and re-establish at a later date.

Factor 13: Stress to seed bank on site

On site stresses to a seed bank include burns, too frequent burns, burns that are too hot, floods, pollutants, deep plowing, influx of seed predators, influx of competing seeds, lack of access to soil (as in concrete or paved parking areas) and a host of other potential stresses. Protection of the seed bank is vital for long-term sustainability of the habitat and its forage species.

Factor 14: Status of Seed Source on-site

Seed source refers to the living plants from which the seeds come. A site that has long-term sustainability should have sufficient on-site seed source and should maintain the distribution mechanisms by which that seed source is spread over the site. Seed source for forage species may require a variety of management methods. Most obvious it the timing of burns so that a particular group developing seed – like some aster species - will not be eliminated or severely reduced by the burn. Burning at the right time can help distribute seeds and open habitat so seeds can take root.

Factor 15: Stress to Seed Source on-site

Stresses to seed source can be natural (diseases, fungi, herbivores) or caused by humans like pollutants, over grazing, alteration of ground water, herbicides, insect pests, and many more. We know very little about the diseases and insect pests of wild forage species, and since many of these are commonly thought of as weeds, they are rarely studied. General thought about the status of the seed source in the process of management planning for a site can help reduce the impacts to the seed source and increase the longevity of the forage on-site.

Factor 16: Status of Seed Source off-site

The status of the seed source plants on surrounding properties and even several properties away – depending upon dispersal methods – will have important implications for the long-term sustainability of the forage habitat on-site. Exotic seed source off-site can be the source of new exotic incursions. Plant survey of surrounding properties and communication with their owners on management practices can be important in deciding upon management strategies.

Factor 17: Stress to Seed Source off- site

Stress to off-site seed source can be a major factor in alteration of the forage species structure on-site. The primary source of seed may be a mature plant stand off-site. With the elimination of that mature stand, there may be no further new seed source until on-site individuals mature. For annuals, off-site seed source helps increase on-site recruitment and can help “fix” the results of a burn at the wrong time. Stresses to off-site seed source are similar to those on-site – burns, pollution, herbicides, pesticides, illness, injury, fungi, insect pests, and many more. Conservation easements and management plans for surrounding properties can be beneficial for the long term survival of the on-site forage habitat.

Factor 18: Competition for forage species

Competition among plant species is studied extensively for lawn care and for cattle and other economically valuable herbivore foraging. Usually the grasses foraged by tortoises are the same species foraged by cattle so there is some useful information from that industry on maintaining the health of forage. However, the “lawn care” industry and the cattle industry often see some tortoise forage species as weeds and competitors, taking resources from grasses. A well managed tortoise forage area needs grasses and adequate access to a great diversity of plant species from which the tortoise selects at various times of the year. Dominance by any one species is not good for tortoise forage. Access to areas with a different combination of species is important and appears to be a regular part of the gopher tortoise’s yearly foraging. Do not eliminate “weedy” foraged species from natural tortoise foraging areas, unless the species is an exotic that tends to take over. Neighboring lawns often provide seeds and enticement to tortoises to forage on exotic competitors and then they will bring the seeds back to the preserve.

A REVIEW OF POINTS A MANAGER NEEDS TO CONSIDER

1. A tortoise may eat **160 or more species of plants** during the year. We know that the selection of species gopher tortoises are known to feed on is around 400. This does not tell us how many species a tortoise must have to stay happy and healthy. It does give us an indication of the species diversity that indicates a good habitat. Note that wire grass alone is a very poor indicator of tortoise forage management.

2. Tortoises appear to have two modes of forage, that for grasses which is normally within 100 m diameter of the tortoises burrow. The other is for various species of broadleaf plants. Searching for the species and apparently the condition of the plant may commonly take a tortoise more than 1000m away from its primary burrow.
3. Managers should take into account that some plants have anti-herbiviory methods which stop foraging by herbivores like tortoises. This may cause a tortoise to have to move some distance from its burrow to feed on some common food species since those individual plants that are commonly fed on will produce these like having high concentrations of tannic acid in the leaves.
4. Tortoises feed on specific parts of some species of plants at various stages in their life cycle and not at all on other. For example blackberries are eaten as they sprout and of course the fruits are eaten. Mature leaves are rarely eaten.
5. When managing for tortoises it is important to establish a mosaic of burn plots that are burned at different times of year. Summer burns are appropriate however; there is a higher diversity of plants if there are also non-growing season burns as well.
6. The smaller the tortoise preserve or the habitat on a site, the greater the need for on going monitoring and responsive management.
7. Probably the most important measurement of good habitat besides diversity is canopy cover (tree and shrub). The magic number for tortoises appears to be a canopy cover of 60% or less.
8. Make sure that monitoring plots are situated where they are testing the forage of the tortoises on site.
9. Tortoises appear to move around the habitat (given there is enough room) and individuals and possibly pods may be from several hundred meters to several kilometers (miles) while in some habitats where there is optimal forage, they tend to move much less.

10. If fire cannot be used then mechanical means should be evaluated to determine it can sustain the diversity required. Grazing cattle should also be considered since we have found they are quite effective in some habitats.

11. Monitoring should include periodic soil sampling and when possible forage analysis for protein and various nutrients.

TABLE 5.9: COMPARISON OF FAMILIES FOUND IN ANONYMOUS TORTOISE PRESERVES IN VARIOUS HABITATS

FAMILY NAME	SW COAST*	GULF RIDGE*	MID-GULF COAST*	INLAND SW	ISLAND	INLAND CENTRAL	BIOLOGICAL PRESERVE	PRIVATE PRESERVE
Acanthaceae						X	X	X
Agavaceae	X	X	X	X	X		X	X
Aizoaceae	X		X		X			
Alismataceae							X	X
Amaranthaceae	X	X	X		X		X	X
Anacardiaceae	X	X	X	X	X		X	X
Annonaceae							X	X
Apiaceae	X	X	X	X	X			
Apocynaceae	X	X			X			
Araliaceae	X	X						
Araucariaceae		X						
Arecaceae	X	X	X	X	X	X	X	X
Asclepiadaceae	X	X	X		X	X	X	X
Asteraceae	X	X	X	X	X	X	X	X
Blechnaceae	X	X	X		X			
Boraginaceae	X	X	X		X		X	X
Brassicaceae	X			X	X		X	X
Bromeliaceae	X	X	X	X	X	X	X	X
Buddlejaceae	X	X					X	X
Burseraceae	X	X	X					
Cactaceae	X	X		X	X	X	X	X
Campanulaceae	X	X	X	X			X	X
Caricaceae	X		X					
Caryophyllaceae							X	X
Casuarinaceae	X	X	X		X			
Celastraceae	X							
Chenopodiaceae	X		X	X	X		X	X
Chrysobalanaceae	X	X	X			X	X	X
Cistaceae						X	X	X
Combretaceae	X	X	X		X			
Commelinaceae	X	X					X	X
Connvolvulaceae	X		X		X	X	X	X
Crassulaceae	X							
Cucurbitaceae	X	X	X				X	X
Cupressaceae					X			
Cycadaceae							X	
Cyperaceae	X	X	X		X	X	X	X
Davalliaceae	X		X				X	
Dennstaedtiaceae	X						X	X
Dioscoreaceae			X				X	
Droseraceae							X	
Ebenaceae						X	X	X
Empetraceae							X	X
Ericaceae						X	X	X
Eriocaulaceae				X			X	X
Euphorbiaceae	X	X	X	X	X	X	X	X
Fabaceae (Leguminosae)	X	X	X	X	X	X	X	X
Fagaceae						X	X	X
Gentianaceae	X		X		X		X	X
Goodeniaceae					X			

Guttiferae							X	X
Haemodoraceae							X	X
Iridaceae	X	X			X	X	X	
Juncaceae	X		X				X	X
Krameriaceae							X	
Lamiaceae	X	X	X		X	X	X	X
Lauraceae	X	X			X		X	X
Lentibulariaceae							X	X
Liliaceae					X		X	X
Linaceae							X	X
Loasaceae	X							
Loganiaceae	X				X		X	X
Lycopodiaceae							X	X
Lythraceae	X	X			X			
Malvaceae	X	X	X	X	X		X	X
Melastomataceae						X	X	X
Meliaceae					X			
Moraceae	X	X	X		X		X	X
Myricaceae	X		X		X		X	X
Myrsinaceae	X	X	X		X			
Myrtaceae	X	X	X				X	X
Nephrolepidaceae	X	X					X	
Nyctaginaceae	X				X			
Oleaceae	X	X	X		X			
Onagraceae	X	X	X	X	X		X	X
Orchidaceae	X	X			X		X	X
Osmundaceae								
Oxalidaceae						X	X	X
Papaveraceae					X		X	X
Passifloraceae	X	X	X				X	X
Phytolaccaceae	X	X	X	X	X		X	X
Pinaceae						X	X	X
Plantaginaceae					X		X	X
Primulaceae	X	X	X		X		X	X
Poaceae (Gramineae)	X	X	X	X	X	X	X	X
Polygalaceae		X		X	X	X	X	X
Polygonaceae	X	X	X	X	X	X	X	X
Polypodiaceae	X	X	X					X
Portulaceae		X		X	X		X	X
Psilotaceae	X	X	X		X		X	
Pteridaceae		X	X	X	X			
Rhizophoraceae	X				X			
Rosaceae						X	X	X
Rubiaceae	X	X	X	X	X	X	X	X
Rutaceae	X	X	X		X			
Salicaceae	X		X					X
Sapindaceae	X				X			
Sapotaceae	X	X	X		X		X	
Scrophulariaceae	X	X	X	X	X	X	X	X
Smilacaceae	X	X	X	X	X	X	X	X
Solanaceae	X	X	X	X	X		X	X
Sterculiaceae	X	X						
Surianaceae					X			
Thelypteridaceae			X					
Theophrastaceae	X							
Turneraceae	X		X	X			X	X
Typhaceae	X	X			X			

Ulmaceae					X			
Urticaceae	X	X		X	X		X	
Violaceae						X	X	X
Vitaceae	X	X	X	X	X	X	X	X
Vittariaceae	X	X						
Verbenaceae	X	X	X	X	X		X	X
Xyridaceae	X		X	X		X	X	X
TOTAL FAMILIES	76	59	55	30	64	30	81	72