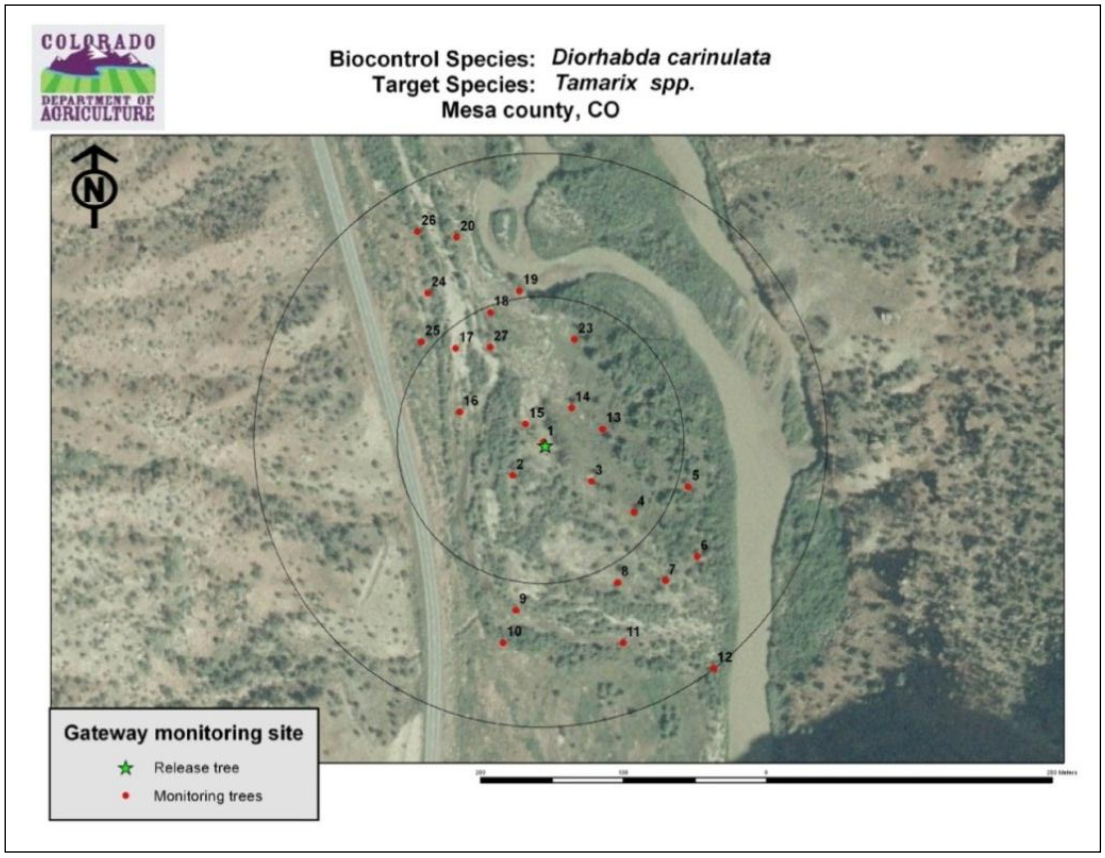
Colorado Department of Agriculture, Palisade Insectary
Tamarisk Monitoring Protocol

Monitoring Site Setup:
Preparation for a monitoring site begins by visiting potential sites to determine tamarisk density, accessibility to marked trees, tree size and selection of a central release tree (tree #1). The majority of tamarisk stands are very dense as expected when dealing with invasive species, however a site location should comprise of a stand where walking through an area of approximately 400 m to either end is difficult, but possible. Marked trees should be isolated such that walking around the entire tree is possible and tree size should not exceed much more than 5 meters as visual observations are necessary to measure insect abundances. The number of ants is also noted since they may have an impact on future beetle releases. If beetles are already present at a potential site location, predation is not an issue for successful beetle establishment.

Once the initial site survey has taken place, the site can be set up in office to help in the overall symmetry, randomness, and ease of setup at the site. The release point and the aerial photo of the area are uploaded into ArcMap. Using the marked point of the centrally located release tree (tree #1) two buffer rings are created at 100 and 200 meters. Once the buffer rings are designed in ArcMap, 24 permanent monitoring trees are selected in the field radiating out from tree #1, creating a total of 25 marked trees. There will be 12 marked trees approximately ten meters apart between the release point and the 100 meter line and 12 more marked trees between the 100 and 200 meter lines.



Initial site setup:

1) Establish the area of the monitoring site
2) Find the release tree or tree #1
3) Using the GPS unit, create a waypoint of tree #1

In office set up:

1) Using ArcView/ArcMap add aerial image of area if possible.
2) Upload tree #1 waypoint.
3) Create a 100m and 200m buffer rings around tree#1.
4) In ArcPad, create a new PointZ shapefile and quickform with the attributes described below in monitoring methods.
5) Download monitoring shapefiles and tree #1 waypoint onto GPS unit.

Site Equipment Checklist:

-GPS unit

-Tape measure

-Flagging

-Numbered tags

-Camera

-Pages w/numbers (for photographs)

1 - 0, 3 thru 9

2 - 1 & 2

-Notebook w/data sheets

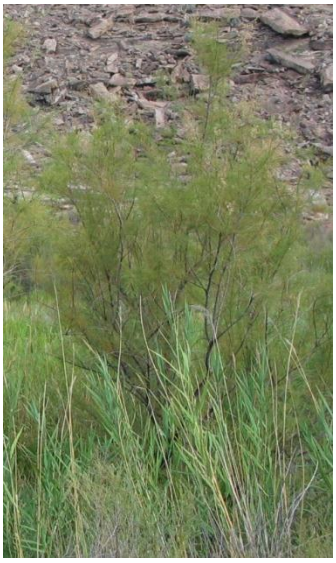
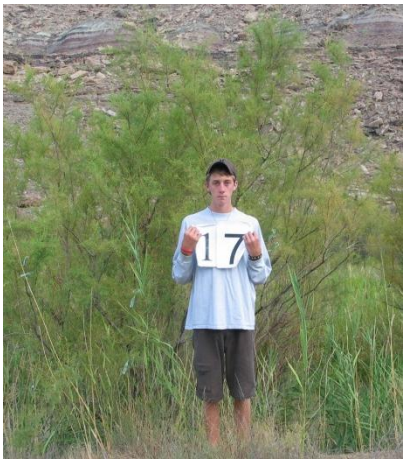
Onsite Setup:

1) Navigate to tree #1 point.
2) Mark with flag, and numbered tag.
3) Take photo of tree with numbered page in front of tree for ease of identification and comparisons over time.
4) Monitor marked trees as described in monitoring methods below.
5) Enter data either in Quickform (ArcPad) or on data sheets, if possible both.
6) Find second tree and repeat steps 2-5. Continue until you have 13 trees within the 100 meter buffer ring spaced as equally as possible and 12 within the 100m and 200m buffer rings. Reminder: the trees that are selected should be easily accessible. You should be able to walk around the entire tree, it has to be alive and try to avoid trees that are too tall to monitor.

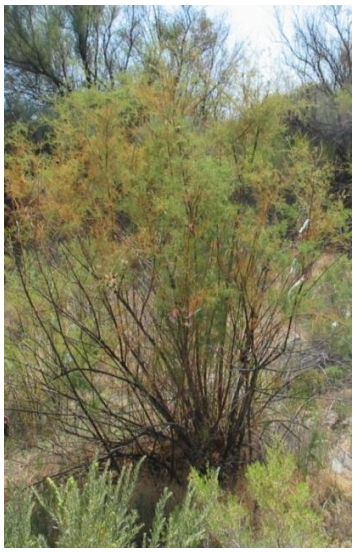
Monitoring Methods:

1. Estimating Damage to the Canopy (% brown, % yellow, % re-growth)

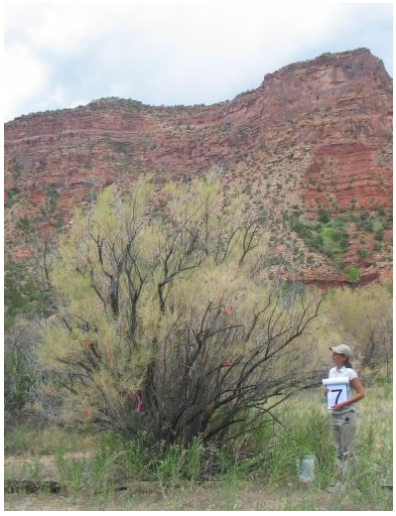
(% Brown) The percent of foliar damage by beetles (*Diorhabda spp.*) is estimated by examining the entire canopy of each tree to determine the approximate amount of damage as a percentage out of total canopy cover with later assignment into categories consisting of 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, and 96-100%. Adults and larvae of tamarisk beetles chew holes in the small tamarisk leaves, thereby killing more plant material than they actually consume (Deloach et al. 2004). Foliage damaged by beetles turns brown before eventually withering completely and falling from the branches. In assessing beetle damage, estimates are not made of how much damaged leaf material has fallen from the tree. Instead, the percentage of foliage remaining on the tree that has turned brown versus green is estimated. Complete defoliation of a tree by beetles is indicated by the appearance of 100% brown foliage throughout the canopy (see pictures below).

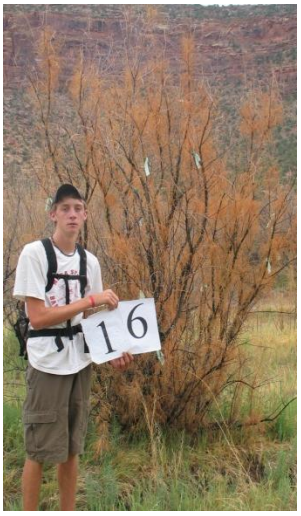



Low beetle damage (~5%-15-% brown)



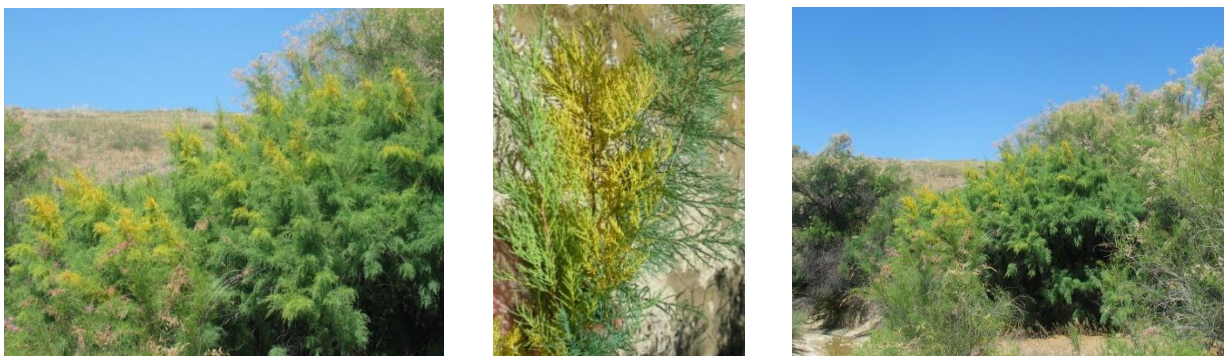
Medium beetle damage (~40%-50% brown)



High beetle damage (~95%-100% brown)

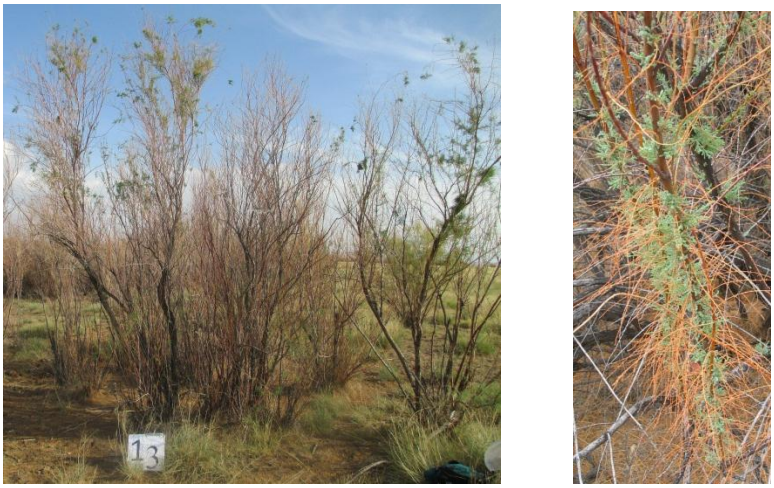
(*% Yellow)* The percent of foliar damage by leafhoppers (*Opsius stactogalus*) is estimated by examining the entire canopy as well. In contrast to foliage damaged by the beetle, foliage damaged by the phloem feeding leafhopper appears bright yellow and stippled (such damage is especially apparent in the canopy at locations where leafhopper abundance is high). This distinctly yellow foliage can be estimated the same way as beetle damage (percent yellow out of total canopy).



Leafhopper damage (~20-25% Yellow)

(% Regrowth) In cases where beetle defoliation has occurred early to mid-season, marked tamarisk trees may regrow new foliage that same season. Like beetle and leafhopper damage, the percent of foliar regrowth is estimated by examining the entire canopy of each marked tree to determine the approximate amount of regrowth foliage as a percentage out of total canopy cover. In most cases regrowth follows complete defoliation and makes up 100% of canopy cover. Measuring becomes difficult when part of the canopy of the tree is regrowth and part is the original non-damaged foliage. It is important to remember these are approximate estimates and error will occur. The main objective of knowing when and approximately how much damage is present (low vs. high) is still achieved even if these estimates are very rough.

In example:
Percent green foliage (non-damaged) + regrowth (new foliage post beetle defoliation) + yellow foliage (leafhopper damage) or brown foliage (beetle damage) = 100%



100% Regrowth foliage

2. Estimating Damage to Branches (% dead wood)

Similar to estimating canopy condition (beetle damage versus undamaged foliage), the percent of branch death or dead tamarisk biomass (dead wood) is estimated as a percentage out of the total branches for individual trees. Branch flexibility, color (red versus gray), and foliage presence or absence, indicates whether branches are living or dead. The percent of dead biomass is estimated two or more times per season if possible (late May to early June, July, and August) along with measurements of tree height and width. These measurements of percent dead biomass are averaged for one mean estimate per season. Tree mortality is determined by the absence of green foliage on all branches of individual trees over an entire monitoring season (May-August).

0-5% Dead wood

~40% Dead wood

~60% Dead wood

100% Dead wood

3. Estimating Canopy Width and Height

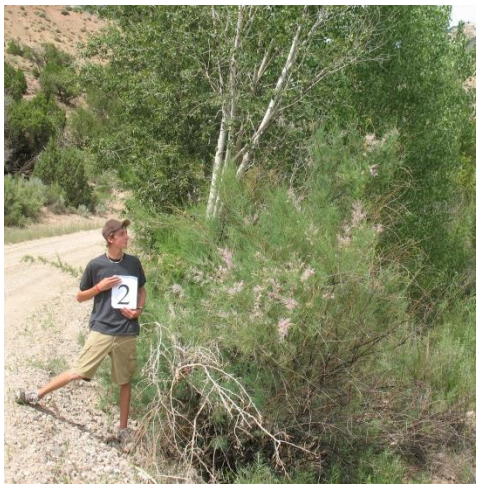
Measures of canopy width and height are also taken as a means of determining increasing and decreasing canopy size over time. Two perpendicular widths are taken of the distance across the green canopy (undamaged foliage) and one height from base of trunk to the tallest green foliage.

4. Estimating the Percent of Flowering Canopy

Flowers are estimated as a percent out of total canopy cover for individual trees with assignment to categories ranging from 0, 1-10%, 11-50%, 51-95%, and 96-100%. Flower condition is indicated by assignment to a rank consisting 1=buds, 2=flowers, and 3=old blooms.

1-10% Flowers

11-50% Flowers



11-50% Flowers

51-95% Flowers

5. Estimating Insect Abundance

Beetle abundance is estimated using in situ estimates of total adult and larvae abundances over individual tree canopies. Observers carefully scan each tree by walking around the tree and examining individual branches to estimate the total abundance of adults and larvae. Assignment to categories ranging from 0, 1-10, 11-50, 51-100, 101-500, 501-1000, and 1000+ are made once a consensus of approximate beetle density per tree is reached by the observers for both adults and larvae. An estimate of mean abundance for each site at each census date can then be determined from the 25 estimates of approximate beetle density (for individual trees).


1000+ Beetles

5. Leafhopper and Splendid Tamarisk Weevil Abundances

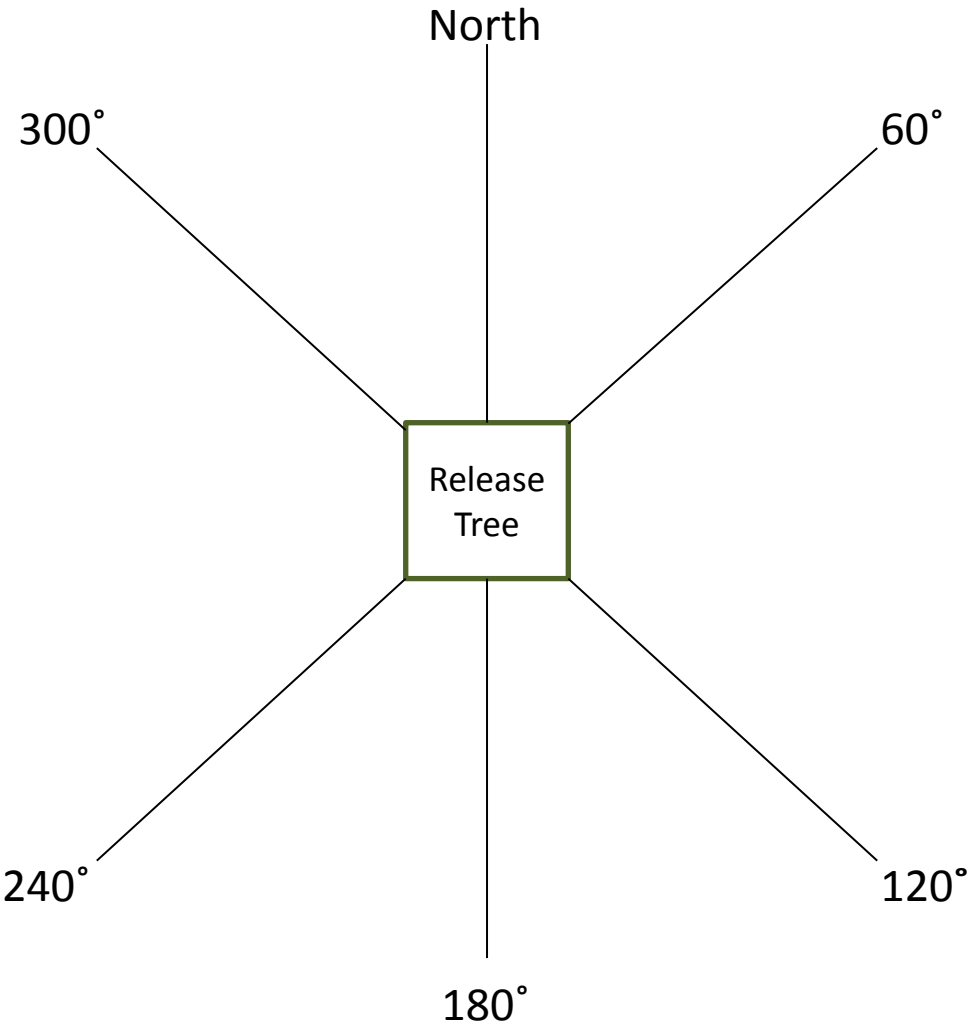
Abundances of these insects are not estimated visually due to their size, but an optional branch tap survey can be utilized for a proportional quantitative assessment. The branch tap method involves tapping at least 3 branches, 3-4 times into a sweep net and counting the captured arthropods in each of the three samples. The monitoring form attached below includes space for this information at the bottom of the data sheet if this method is utilized. Beetle abundances can also be captured with this method and should at least be noted if this method is used. If this method is too time consuming, a yes or no of insect presence will suffice (leafhoppers or splendid tamarisk weevils). Tamarisk beetle eggs are also noted this way (yes or no).


Splendid tamarisk weevil & Tamarisk leafhopper

Monitoring Plant Community Composition at Tamarisk Sites:

1. Site Level Plant Composition (the point intercept method)

The point intercept method is applied to capture information on the vegetation community structure (Herrick et al. 2005). Site level plant cover and composition is monitored using the point-intercept method. At each site, point intercepts are performed every meter along six 50 m transects radiating at intervals of 60º from a centrally located release tree (below). At each of these points, the pin flag is dropped and all plant species intercepting the pin flag are identified. This results in a total of 306 pin-drops which is sufficient to assess cover, of each guild, with high precision.



This monitoring Protocol has been designed to address two main questions:

1. Changes in the abundance of the targeted plant species.
2. Changes in the vegetation community at the site level.

2. *Plant Composition under Individual Tamarisk Trees (the meter squared method)*

Plant cover and composition under marked tamarisk trees is measured using a one meter pvc square divided into four smaller (.25 m) squares using string whereby plant type and density are estimated using six cover classes. Under each tree, two 1 m² plots are established ~ 1m from the trunk in cardinal east and west directions. In each of these plots, cover classes of bare ground, woody debris, and each plant species is also estimated by cover class, i.e. cheatgrass would receive a score of six (below). The midpoint of cover classes are used in analyses.

Cover Class	1	2	3	4	5	6
	1-5%	5-25%	25-50%	50-75%	75-95%	95-100%
(midpoints)	2.5%	15%	37.5%	62.5	85%	97.5%

This monitoring Protocol has been designed to address two main questions:

1. Changes in the abundance of vegetative species near the targeted plant species.
2. Changes in the vegetation community at the tree level.

Location Date: __________________ Shapefile code: __________________________

Tamarisk and Diorhabda Monitoring Datasheet

Category levels	1=1%-5% 2=6%-25% 3=26%-50% 4=51%-75% 5=76%-95% 6=96%-100%						
Tree #							
% Green foliage							
% Brown (beetle)							
% Yellow (leafhopper)							
% Regrowth foliage							
% Dead wood (branches)							
width tree1 (cm)							
width tree2 (cm)							
height (cm)							
% Flower **1=Buds** **2=Blooms** **3=Old Blooms**	N=0 L=1-10 M=11-50 H=51-95 C=96-100	N=0 L=1-10 M=11-50 H=51-95 C=96-100	N=0 L=1-10 M=11-50 H=51-95 C=96-100	N=0 L=1-10 M=11-50 H=51-95 C=96-100	N=0 L=1-10 M=11-50 H=51-95 C=96-100	N=0 L=1-10 M=11-50 H=51-95 C=96-100	N=0 L=1-10 M=11-50 H=51-95 C=96-100
Tamarisk beetle adult range	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000
Larval Stage	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
Larvae Range	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000	L=1-10 ML=11-50 M=51-100 MH 101-500 H=501-1000 V= >1000
eggs	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Coniatus (splendid weevil)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Opsius (leafhopper)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
B=Beetles C=Coniatus O= Opsius or others of concern (ants/spiders)	B= C= O= B= C= O= B= C= O=	B= C= O= B= C= O= B= C= O=	B= C= O= B= C= O= B= C= O=	B= C= O= B= C= O= B= C= O=	B= C= O= B= C= O= B= C= O=	B= C= O= B= C= O= B= C= O=	B= C= O= B= C= O= B= C= O=
Comment							

Tamarisk/Vegetation Transect Monitoring

Date:

Site Name:

Location of central point

Latitude:

Longitude:

T	= Tamarisk
A.G.=	Annual Grass
P.G. =	Perennial Grass
L	= Litter
B.S. =	Bare Soil
C.G =	Cheat Grass
R.K =	Russian Knapweed
H.	= Halogeton
R.B =	Rabbit Brush
W.S =	Wyoming Sage
A.H. =	Ant Hill
W.A. =	Water
C.P. =	Clasping Pepperweed
S.B. =	Salt Brush
K.	= Kochia
H.C. =	Hoary Cress
M.W.=	Mountain Whitetop
S.W=	Seep weed

METERS	0^0 NORTH	60^0	120^0	180^0 SOUTH	240^0	300^0
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METER	0^0 NORTH	60^0	120^0	180^0 SOUTH	240^0	300^0
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Notes:

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S.W=	Seep weed

Vegetation Meter Squared Data Sheet

Site _____ Date_____

Cover Class	1	2	3	4	5	6
	1-5%	5-25%	25-50%	50-75%	75-95%	95-100%

Tree # _____

Species	E	W
Bare Ground		
Woody debris 0 to 1 in.		
>1 in.		

Tree # _____

E	W

Tree # _____

E	W