

## Vegetation Monitoring Results, 2009-2014

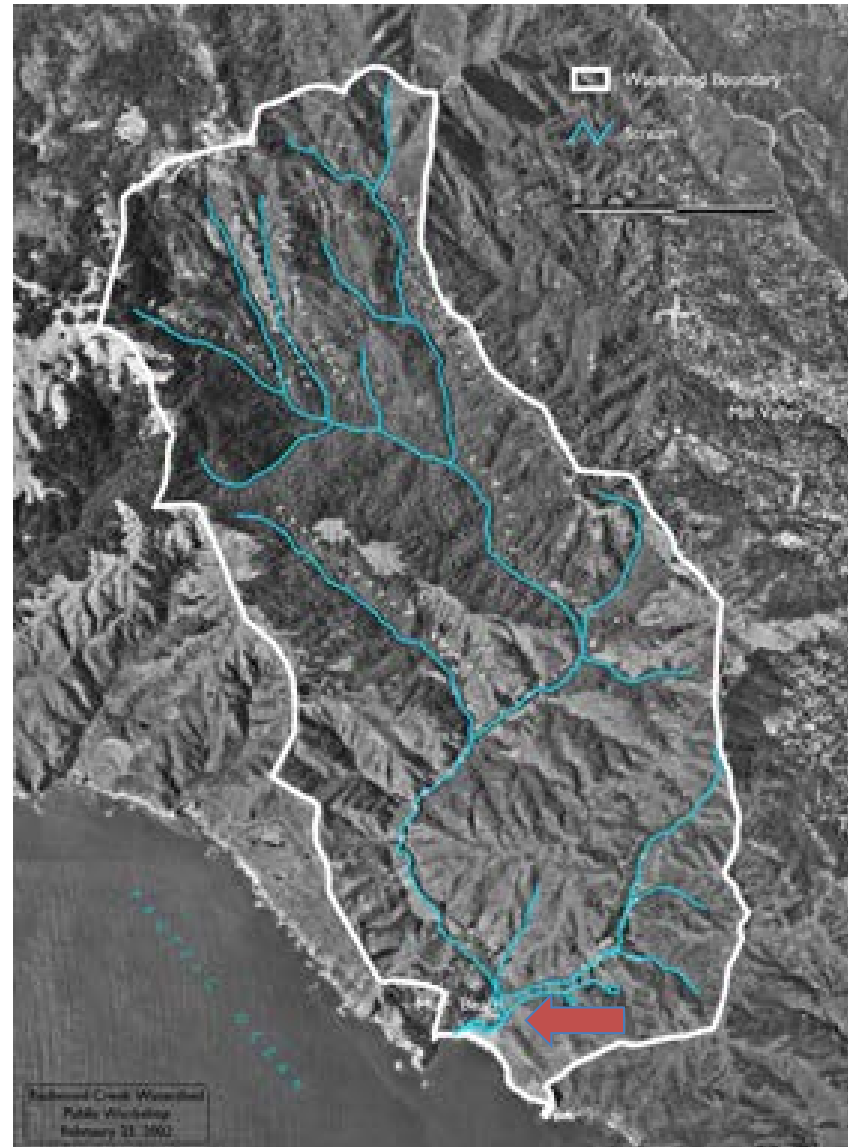
Wetland and Riparian Habitat Revegetation and Invasive Plant Management

## Redwood Creek Restoration at Muir Beach



# National Park Service

## Muir Woods Watershed





# National Park Service

Muir Beach



# National Park Service

Restoration Over 5 Years, 2009-2014



Before, 2008

The pasture in the foreground is a floodplain that is disconnected from Redwood Creek.

The creek is confined between a levee road through the wetland and the parking lot.



Midway, 2010

More updated with willows filled and alders



After, 2014

February heavy rain event

Reconnected riparian zone to new floodplain and tidal lagoon



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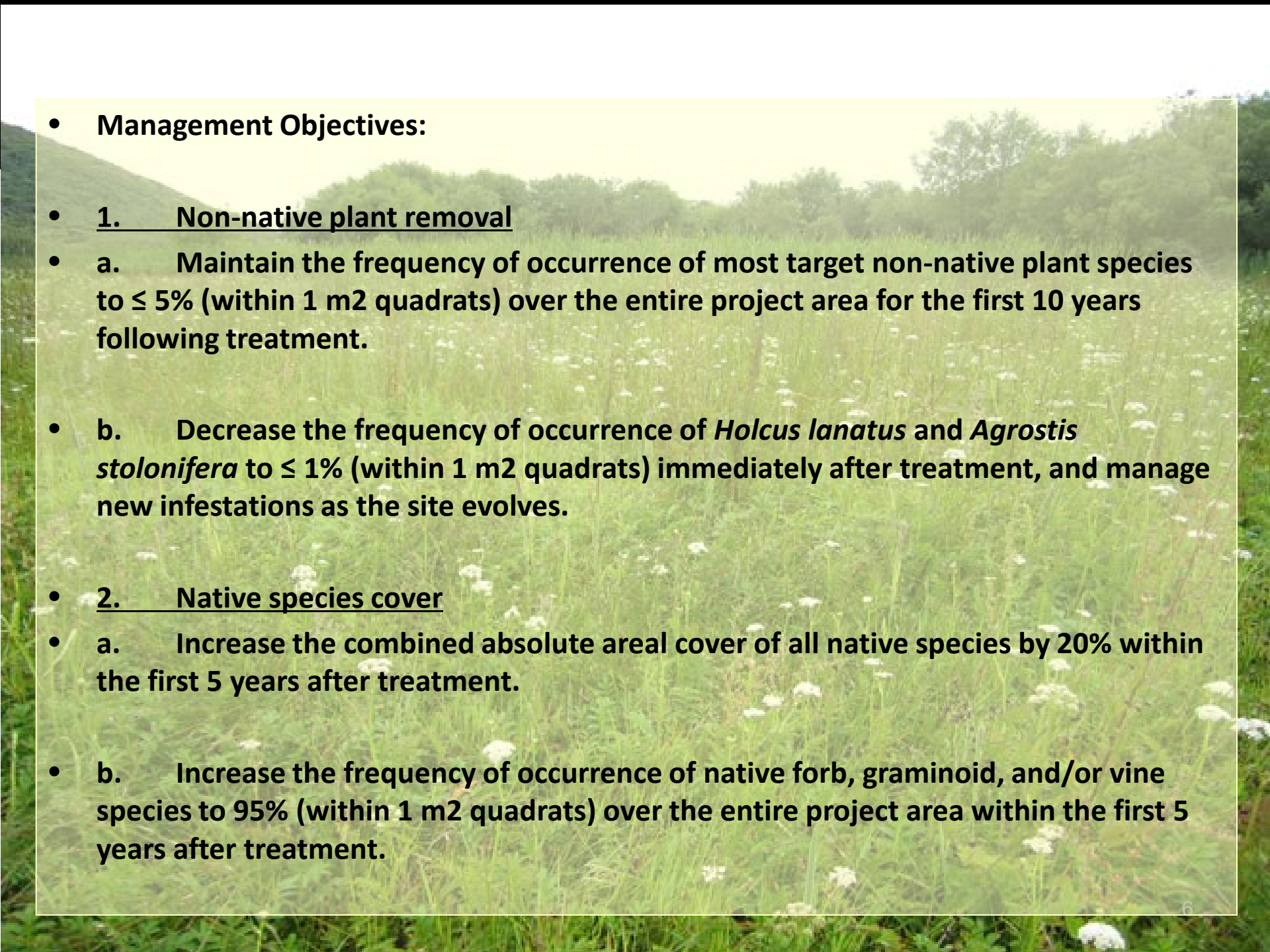
Four Phases of Construction 2010-2013



## Invasive plants removed during construction

- Cape-ivy (*Delaria odorata*)
- Kikuyu grass (*Pennisetum clandestinum*)
- Non-native cat tail (*Typha angustifolia*)
- Non-native blackberry (*Rubus discolor*)
- Tall Fescue (*Festuca arundinacea*)
- Harding grass (*Phalaris aquatica*)
- Lanceleaf water plaintain (*Alisma lanceolatum*)



- 
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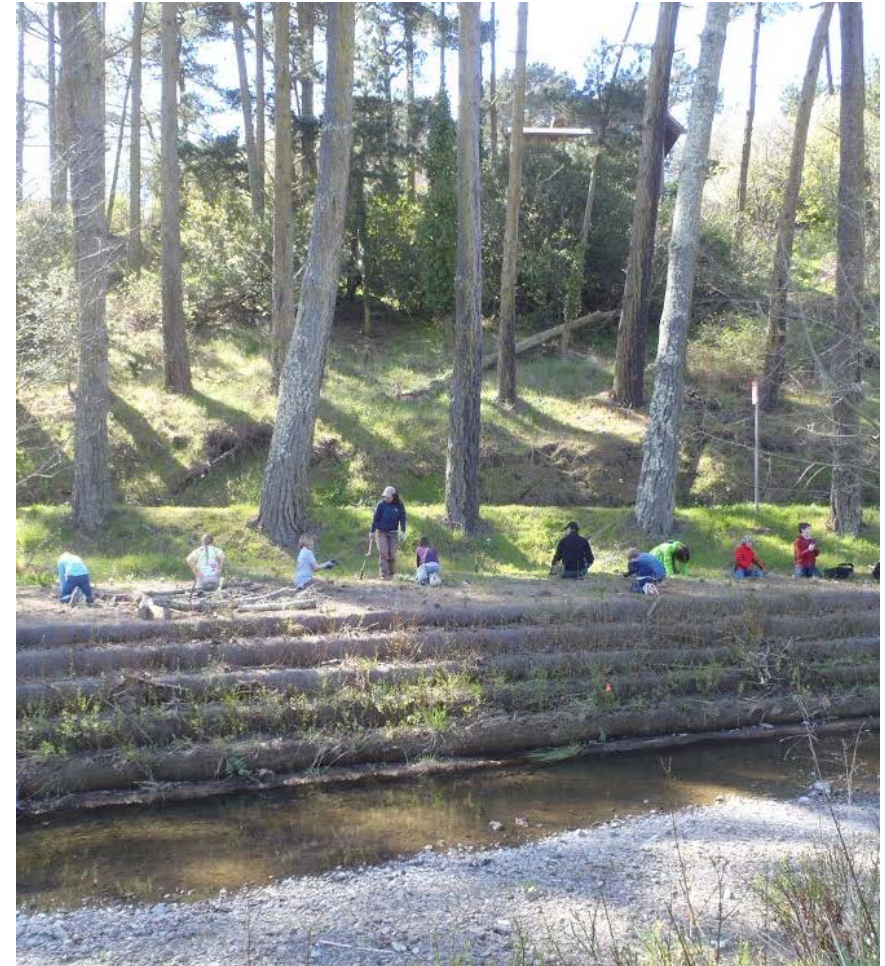


# National Park Service

Re-establishing ecosystem processes



Riparian channel – goal to establish bank stabilization, habitat structure and resilience



Overstory tree cover- goal is to establish native primary productivity: Increase leaf mass, plant height, resource use efficiency, and nutrient cycling

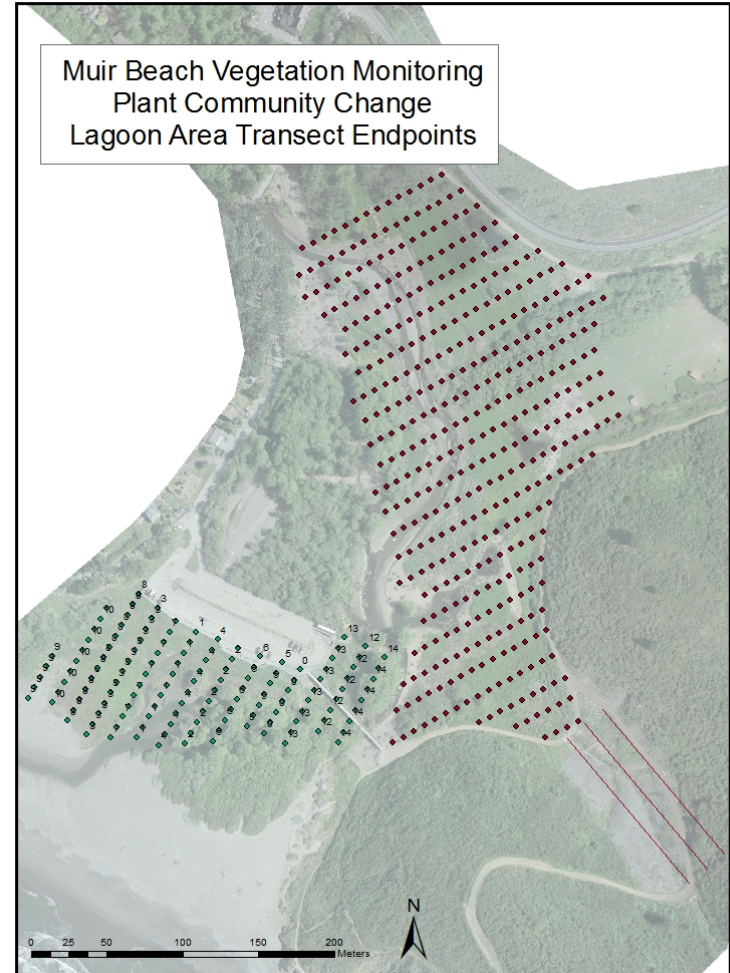
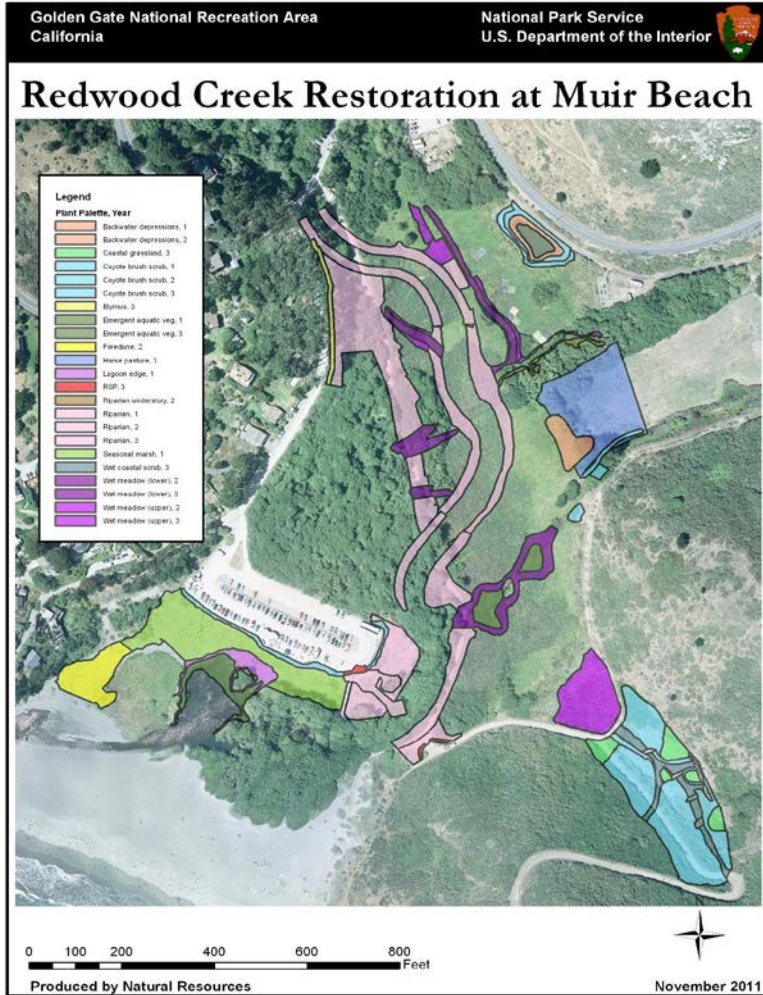


# National Park Service

Planning for invasion resistance and long term monitoring



Plant palettes designed for diverse functional traits and plant fitness





# National Park Service

Planning for invasion resistance broadcast seed



## Seed mix selected for robust

Redwood Creek Restoration at Muir Beach			
Seed Request 2015-2016			
SPECIES	COMMON NAME	TOTAL GOAL (g)	total goal in Lbs
<i>Elymus glaucus</i>	Blue wild rye	457	1.01
<i>Eschscholzia californica</i>	California poppy	2	0.00
<i>Helenium puberulum</i>	Sneeze weed	236	0.52
<i>Heracleum maximum</i>	Cow parsnip	44	0.10
<i>Hordeum brachyantherum</i>	California barley	185	0.41
<i>Juncus bufonius</i>	Toad rush	18	0.04
<i>Juncus effusus</i>	Common bog rush	71	0.16
<i>Madia sativa</i>	Tarweed	152	0.34
<i>Mimulus guttatus</i>	Seep monkeyflower	4	0.01
<i>Navaretia squarrosa</i>	Skunk weed	8	0.02
<i>Oenanthe sarmentosa</i>	Water parsley	962	2.12
<i>Persicaria punctata</i>	Smartweed	478	1.06
<i>Potentilla anserina</i>	pacific cinquefoil	56	0.12
<i>Nasturtium officinale</i>	watercress	1	0.00
<i>Rubus ursinus</i>	blackberry	33	0.07
<i>Isolepis cernua</i>	Low bulrush	1	0.00
<i>Scirpus microcarpus</i>	Small-fruited bullrush	33	0.07
<i>Scrophularia californica</i>	Bee plant	41	0.09
<i>Stachys chamissonis</i>	Hedge nettle	11	0.02
<i>Stipa pulchra</i>	Purple needle grass	0	0.00
<i>Urtica dioica</i>	Stinging nettle	106	0.23
<i>Ambrosia chamissonis</i>	Ambrosia	119	0.26
<i>Abronia latifolia</i>	Yellow sand verbena	40	0.09
		<b>3058</b>	6.75
		g	lbs





# National Park Service

## Riparian habitat revegetation



### Riparian and wetland habitat revegetation



**Trees:** *Alnus rubra* (Red alder)

*Myrica californica* (California wax myrtle)

*Sambucus racemosa* (Red elderberry)

*Salix lasiolepis* (Arroyo willow)

*Cornus sericea* (Coast dogwood)

#### **Understory & marsh:**

*Lonicera involucrata* (honeysuckle)

*Rubus parviflorus* (thimbleberry)

*Artemisa californica* (Mugwort)

*Urtica dioica* (stinging nettle)

*Scripus microcarpus* (small fruited rush)

*Juncus effuses* (common bog rush)

*Juncus lesueurii* (diamond rush)

*Carex praegracillis* (Meadow sedge)

*Elymus triticoides* (Creeping wild rye)

*Potentilla anserina* (Pacific cinquefoil)

*Distichilis spicata* (Salt grass)

*Eleocharis macrostachya* (Common spikerush)

*Scripus pungens* (Common threesquare)

*Oenanthe sarmentosa* (Water Parsley)

*Rumex salicifolius* (Willow dock)

*Hordeum brachantherum* (California meadow barley)

70,000 locally collected grown container plants and division beds



# National Park Service

## Vegetation Plant Community Change



### Sampling Objectives:

1. Detect 20% change in combined absolute aerial cover of all native functional guilds within first 5 years after treatment.
2. Detect 10% absolute change in frequency of occurrence (within 1 m<sup>2</sup> quadrats) of *Holcus lanatus*, *Agrostis stolonifera*, and native and non-native functional guilds across the entire sampling area for the first 10 years after treatment.
3. Estimate frequency of occurrence (within 1 m<sup>2</sup> quadrats) to within +/- 3% absolute for most target non-native plant species, with a 90% confidence level.
4. Estimate combined frequency of occurrence (within 1 m<sup>2</sup> quadrats) of native forb and native graminoid functional guilds to within +/- 3% absolute, with a 90% confidence level.



# National Park Service

## Vegetation Monitoring



Conducted July and August  
Annually for first 5 years

Over 500 quadrats along  
semi-permanent transects  
with NPS and GGNPC staff



# National Park Service

## Invasive plant monitoring and target species



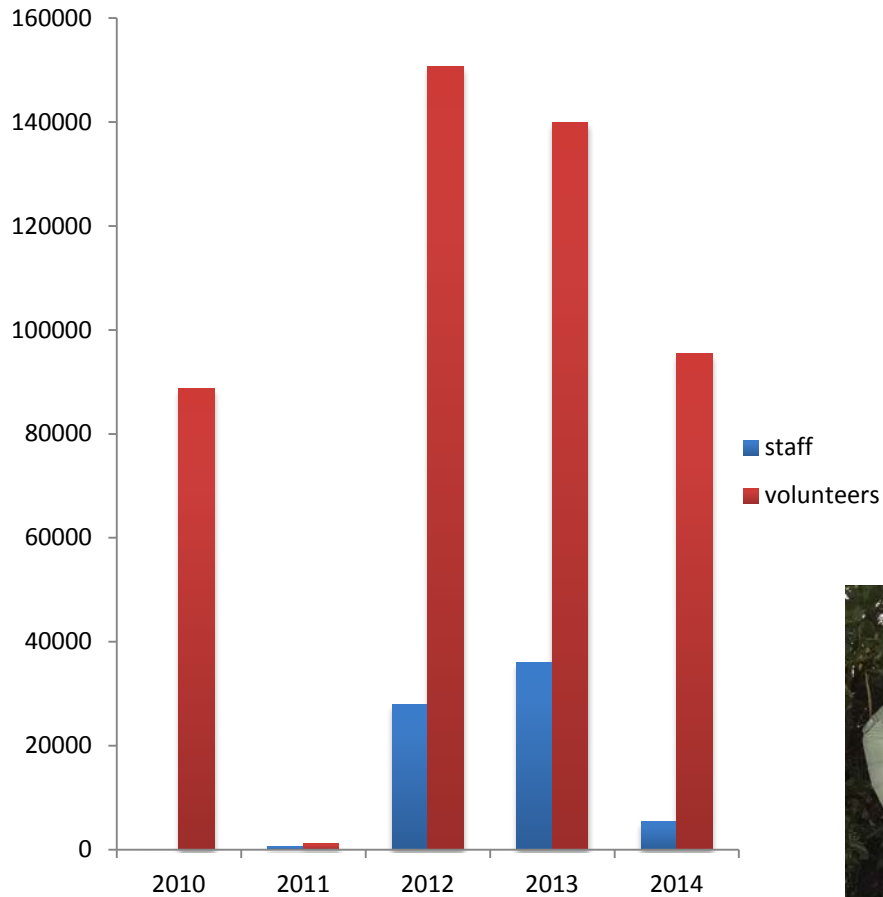
Forbs		Target (T) or Change Detect (Δ)
<i>Carduus pycnocephala</i>	Italian thistle	T
<i>Conium maculatum</i>	posion hemlock	T
<i>Cirsium vulgare</i>	bull thistle	T
<i>Dipsacus sativus</i>	teasel	T
<i>Pseudognaphalium luteoalbum</i>	Jersey cudweed	Δ
<i>Foeniculum vulgare</i>	fennel	T
<i>Hirschfeldia incana</i>	short-pod field mustard	T
<i>Lotus corniculatus</i>	birds foot trefoil	T
<i>Picris echinoides</i>	Bristly Ox Tongue	Δ
<i>Plantago major</i>	Common plantain	Δ
<i>Rumex conglomeratus</i>	Clustered dock	Δ
<i>Raphanus sativa</i>	wild radish	T
<i>Sonchus asper</i>	sow thistle	Δ
<i>Trifolium repens</i>	white clover	Δ
<i>Trifolium fragiferum</i>	strawberry clover	Δ
<i>Vinca major</i>	periwinkle	T
Graminoids		
<i>Agrostis stolonifera</i>	creeping bentgrass	Δ
<i>Cortaderia sp.</i>	jubata/pampas grass	T
<i>Dactylis glomerata</i>	orchard grass	T
<i>Ehrharta erecta</i>	panic veldt grass	T
<i>Festuca arundinaceae</i>	Tall Fescue	T
<i>Lolium multiflorum</i>	Italian rye grass	Δ
<i>Pennisetum clandestinum</i>	kikuyu grass	T
<i>Phalaris aquatica</i>	Harding grass	T
<i>Polypogon monspeliensis</i>	rabbits foot grass	Δ
<i>Polypogon interruptus</i>	Ditch beard grass	Δ
<i>Rannunculus repens</i>	buttercup	Δ
<i>Typha angustifolia</i>	narrow-leaved cattail	T

Vines		Target (T) or Change Detect (Δ)
<i>Calystegia silvatica ssp. purpurea</i>	morning glory	Δ
<i>Delaria odorata</i>	Cape-ivy	T
<i>Hedera helix/canariensis</i>	English ivy	T
<i>Rubus discolor</i>	Himalayan blackberry	T
Shrubs		
<i>Genista monspessulana</i>	French broom	T
Trees		
n/a		

Species Removed from the List		Target (T) or Change (Δ)
<i>Arthrothea prostrata</i>	capeweed	T
<i>Alisa lanceolata</i>	lance-leaf water plantain	T
<i>Cotula coronopifolia</i>	brass buttons	Δ
<i>Erechtites glomerata</i>	Austaralian fireweed	Δ
<i>Erechtites minima</i>	Australian fireweed	Δ
<i>Rumex acetosella</i>	sheep sorrel	Δ
<i>Solanum sp.</i>	nightshade	Δ
<i>Hordeum murinum</i>	foxtail	Δ
<i>Avena barbata</i>	wild oats	Δ
<i>Briza maxima</i>	ratlesnake grass	Δ
<i>Bromus diandrus</i>	riggut brome	Δ
<i>Bromus hordeaceus</i>	soft chess brome	Δ
<i>Echinochloa crs-galli</i>	barnyard grass	Δ
<i>Vulpia myuros</i>	rattail fescue	Δ
<i>Cupressus macrocarpa</i>	Monterey cypress	T
<i>Myoporum laetum</i>	lollipop tree	T
<i>Pinus radiata</i>	Monterey pine	T

# National Park Service

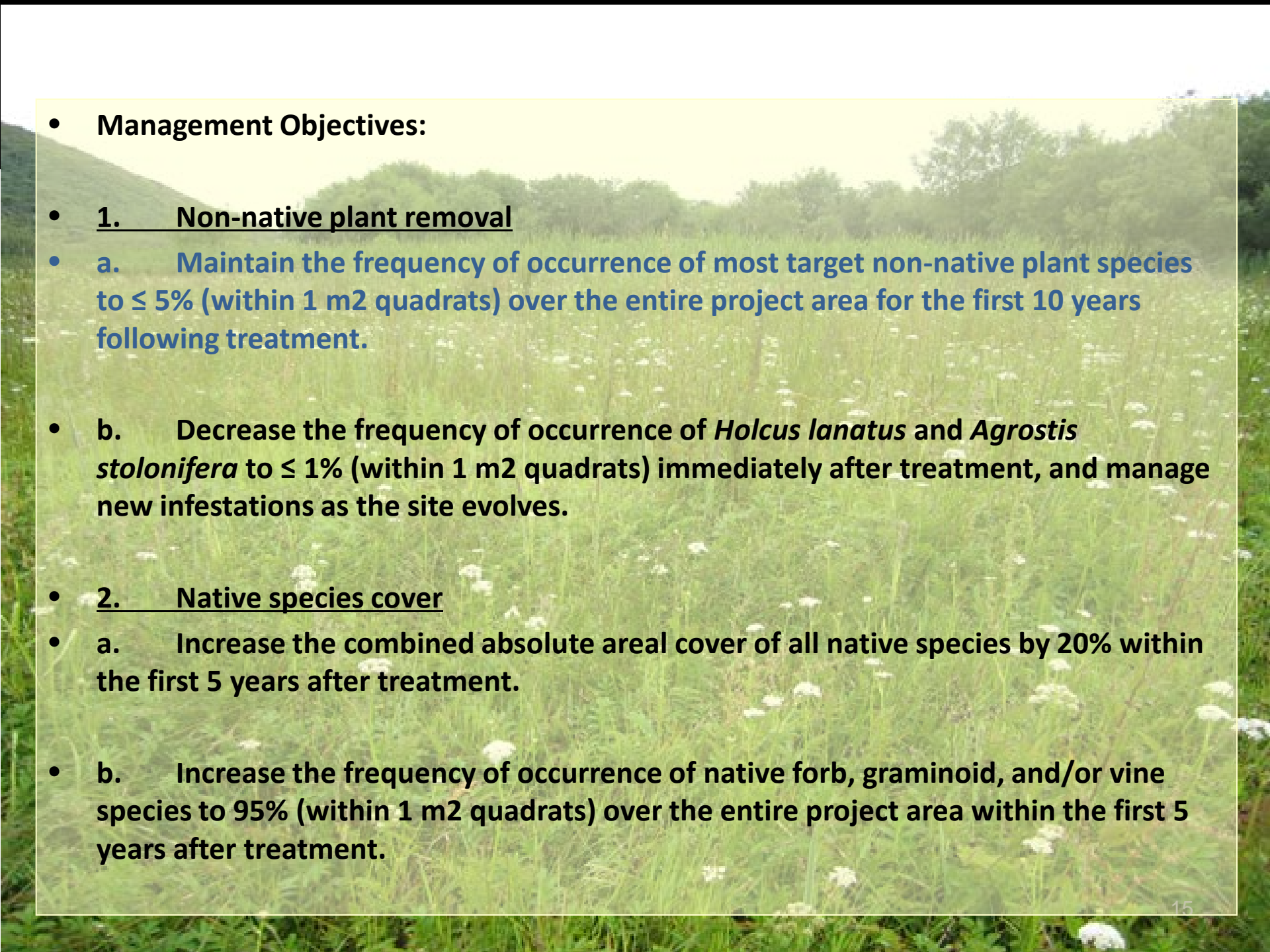
## Invasive plant



Over 70,270 staff hours and 476,040 volunteer hours = **546,210** hours



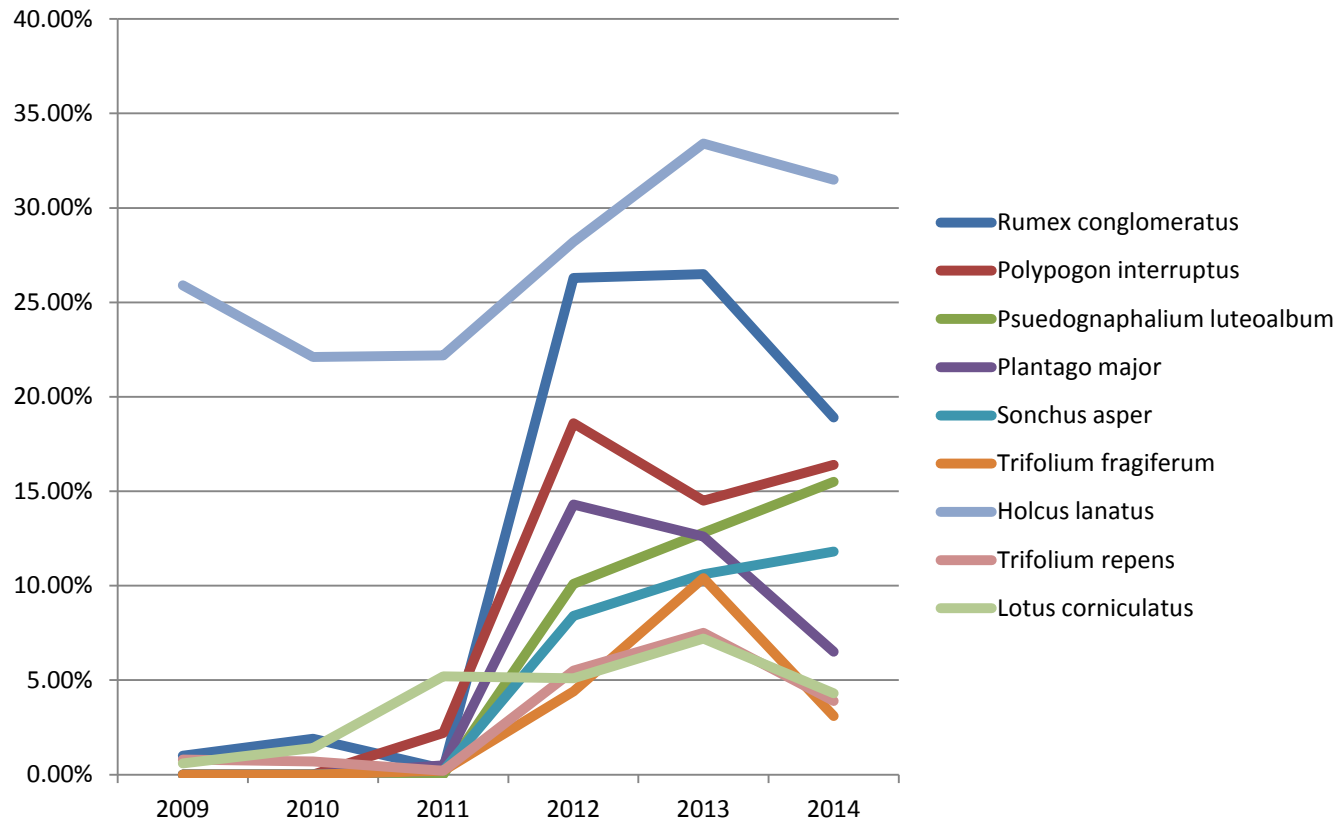


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# National Park Service



## Change in frequency of non-native species



Changes in frequency of top nine non-native plant species with the greatest absolute change as measured in 1 m<sup>2</sup> quadrats, 2009-2014.

Absolute Change: Rumex conglomeratus (18.0%), Polypogon interruptus (16.4%), Psuedognaphalium luteoalbum (15.5%), Plantago major (6.5%), Sonchus asper (11.8%), Trifolium fragiferum (3.1%), Holcus lanatus (5.6%), Trifolium repens (3.2%), Lotus corniculatus (3.7%)

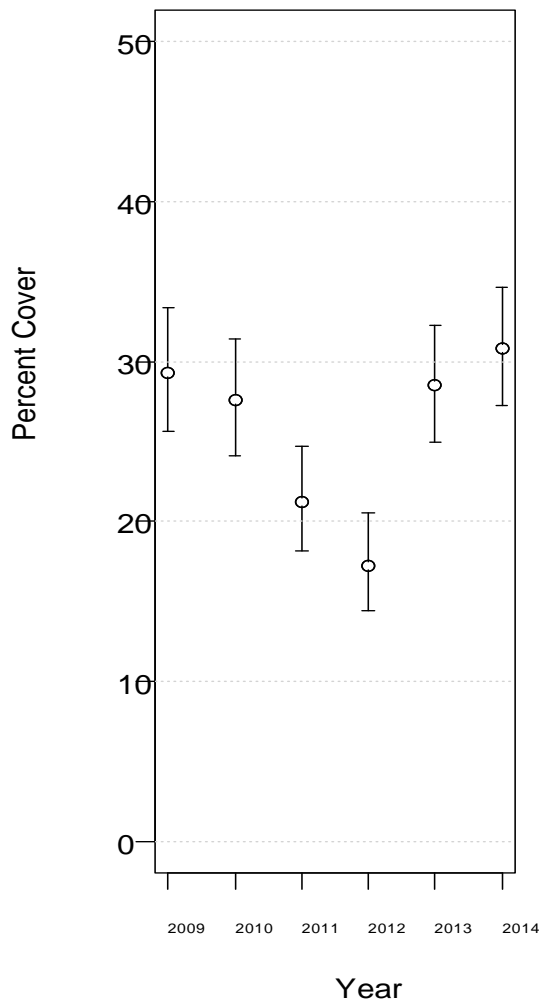


# National Park Service

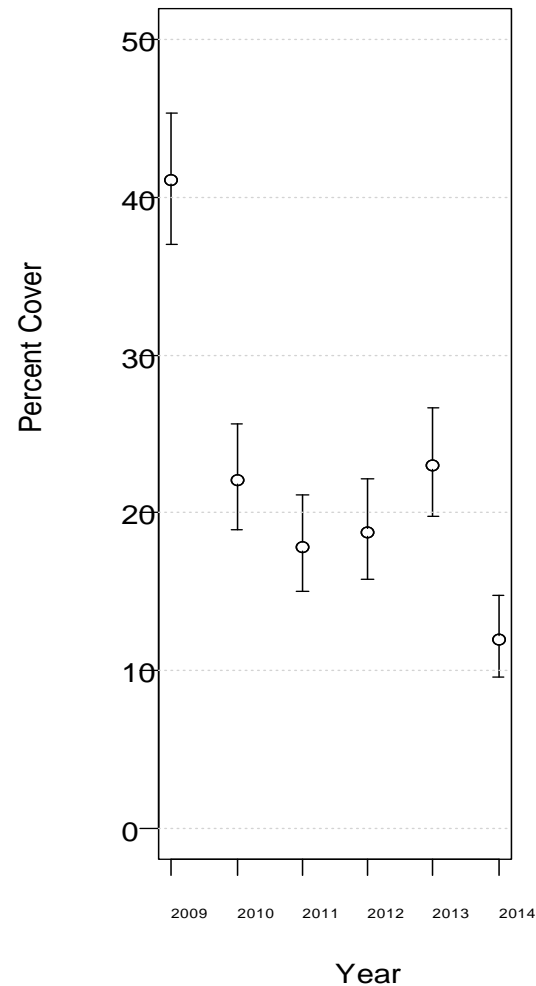


## Cover of native and non-native graminoids

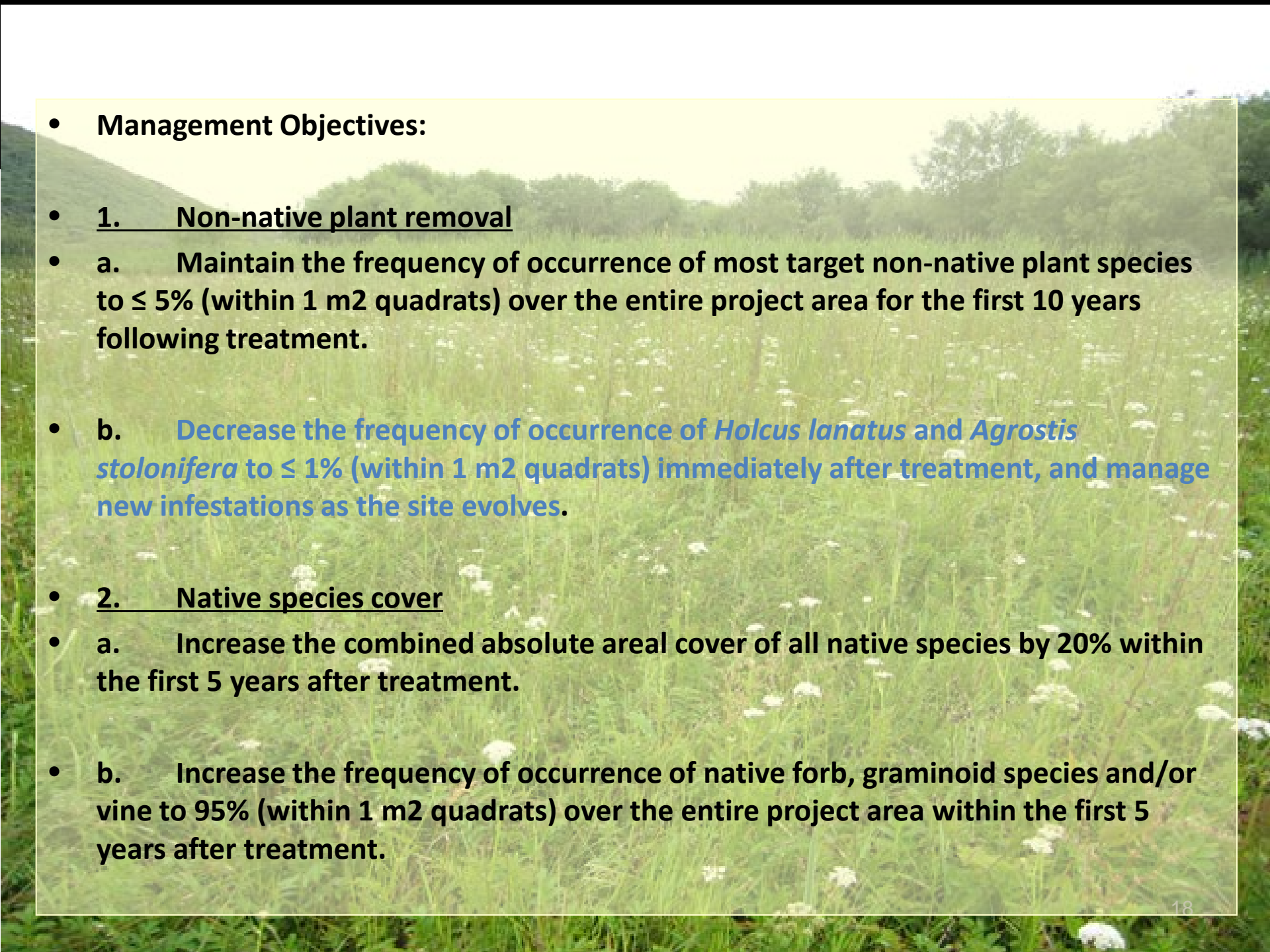
Cover of Native Gram  
95% confidence intervals



Cover of Non-native Gr  
95% confidence intervals



Cover of native graminoids declined during construction phases and increased with outplanting. Cover of non-native graminoids declined with invasive plant management.

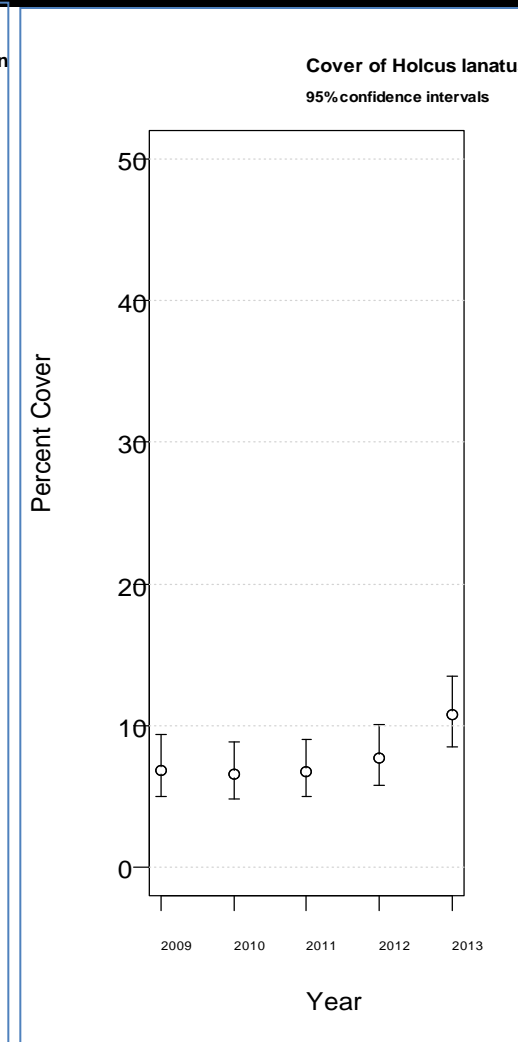
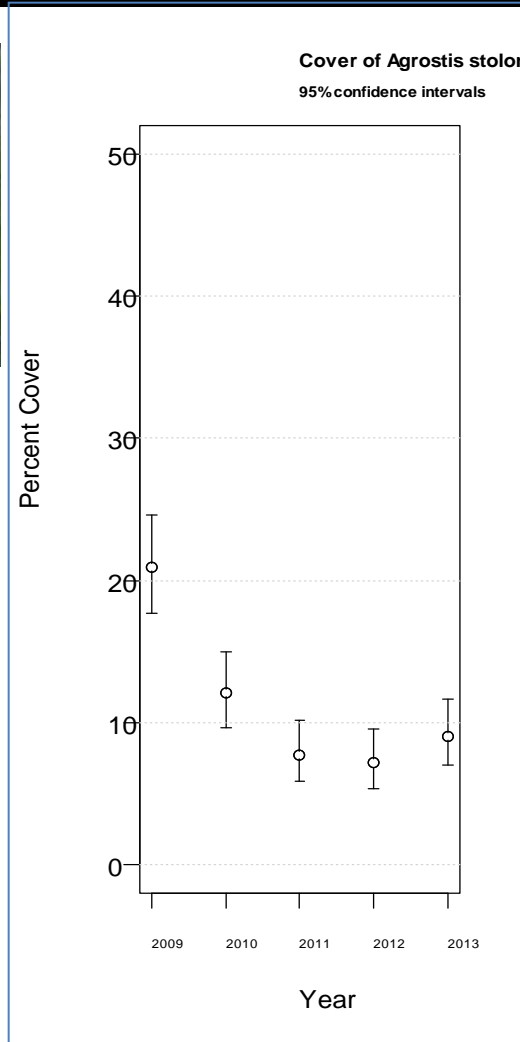
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# National Park Service



## Cover of Creeping Bent Grass and Purple Velvet Grass



Cover of non-native *Agrostis stolonifera* steadily declining with an overall decrease in frequency of 5.9%.

Cover of *Holcus lanatus* has increased with a overall 5.6% relative increase in frequency

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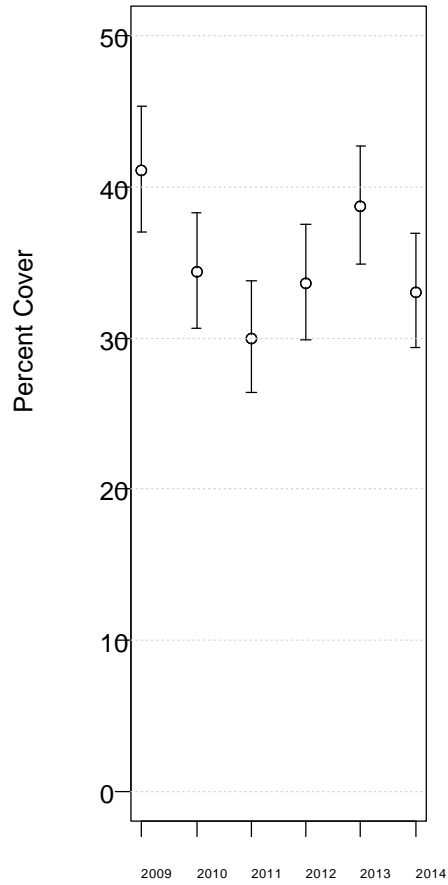


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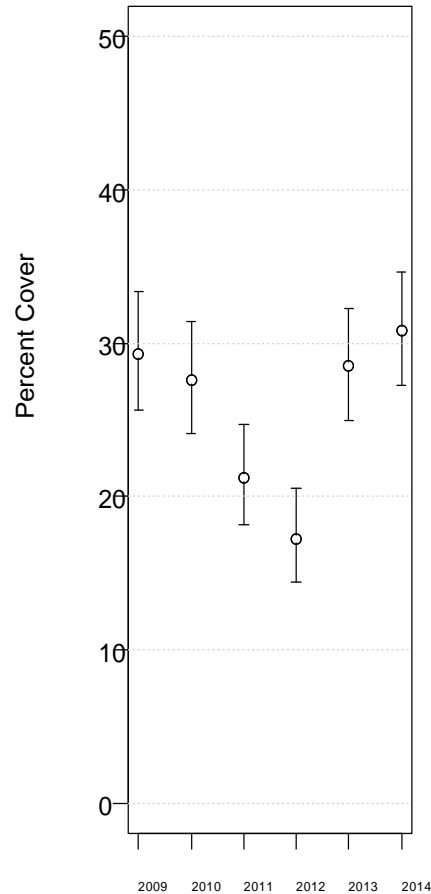


## Native cover

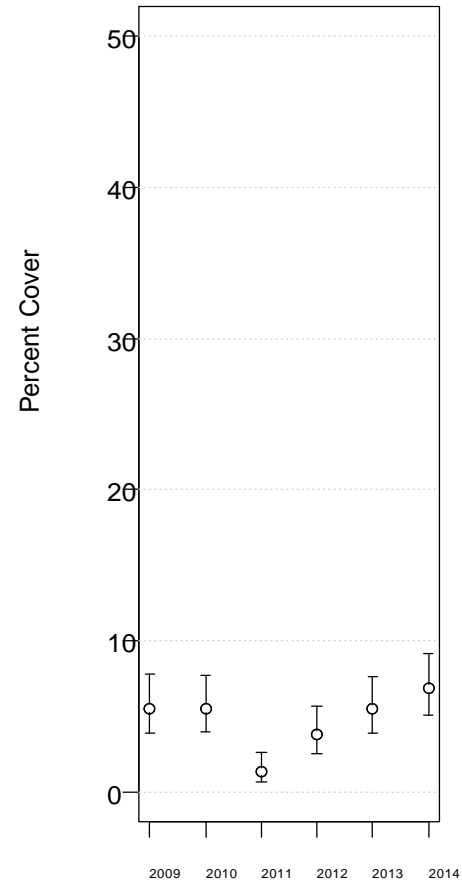
**Cover of Native Forbs**  
95% confidence intervals



**Cover of Native Graminoids**  
95% confidence intervals



**Cover of Native Vines**  
95% confidence intervals



Year

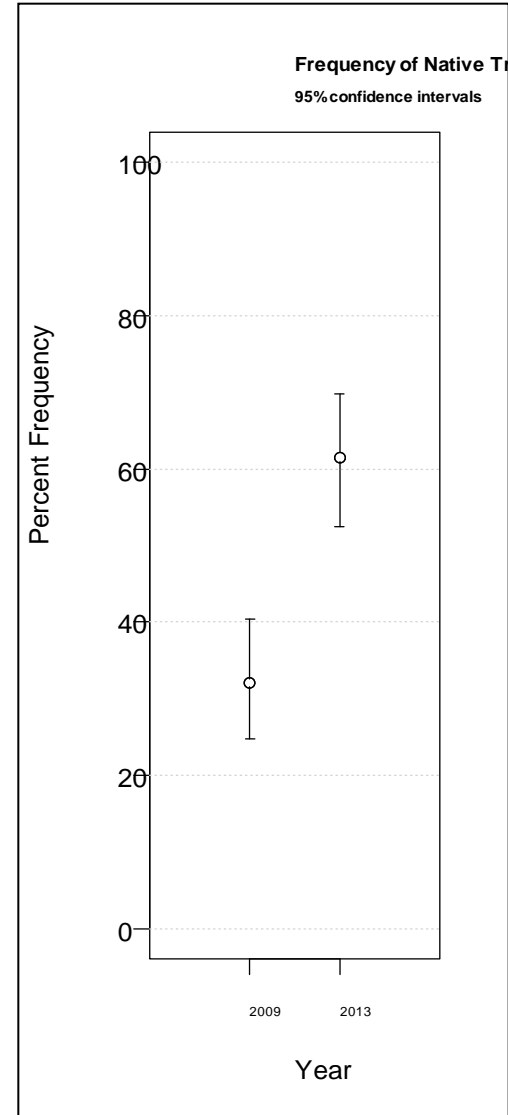
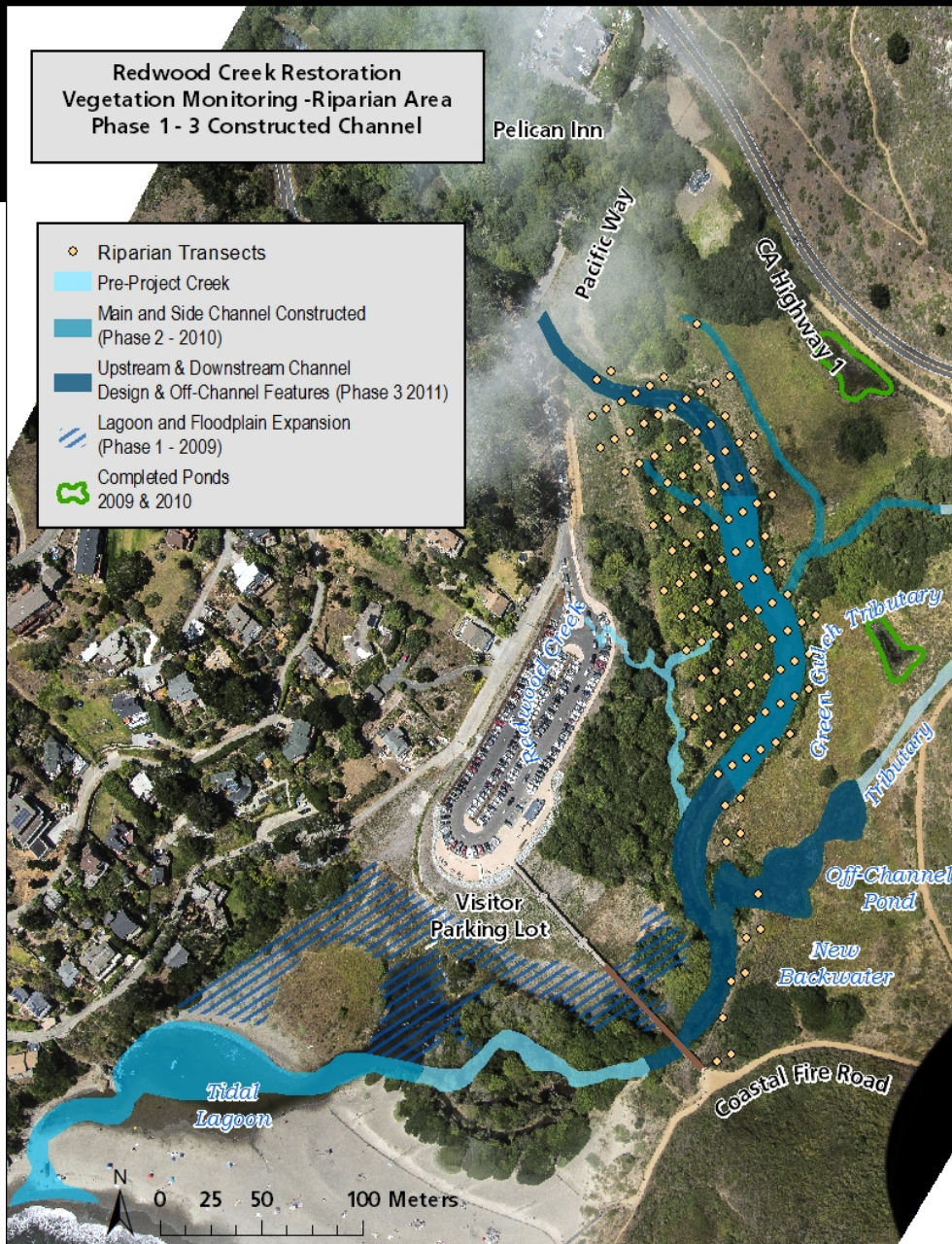
Year

Year

Change in the cover of native, forb, graminoids, and vines from 53.1% to 68.3% (an increase of 5.2%) from 2009 to 2014.



# Riparian Creek monitoring

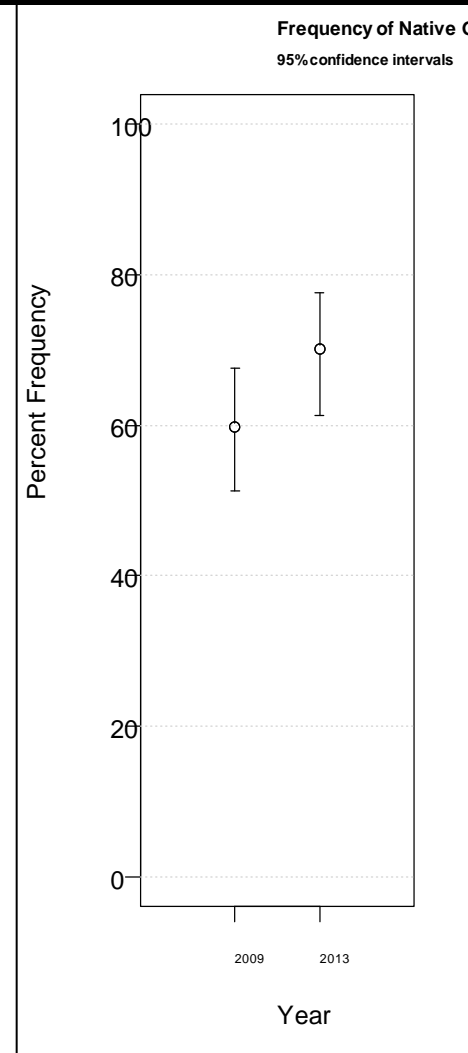
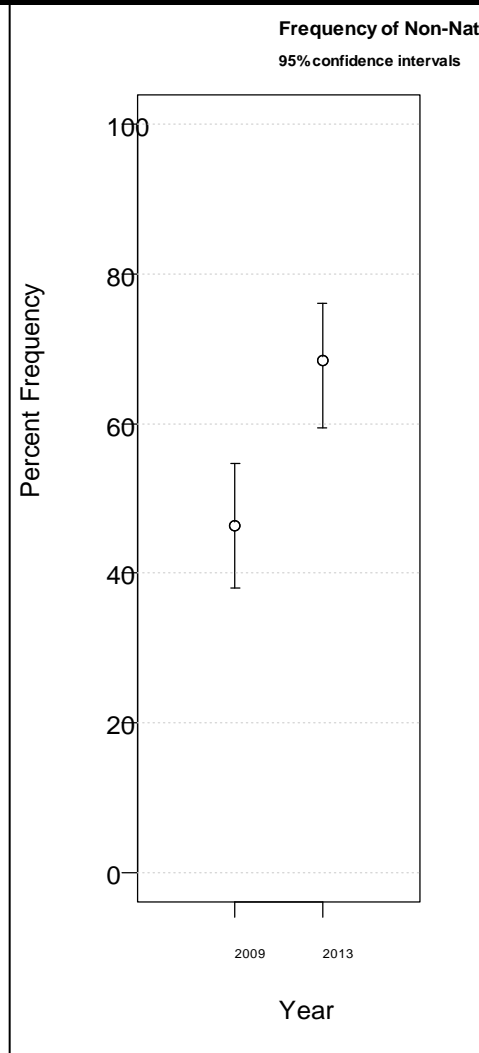


Change in Frequency of Year 1 (2009) and Year 5 (2013) of native trees (32% increase) in the riparian corridor.



# National Park Service

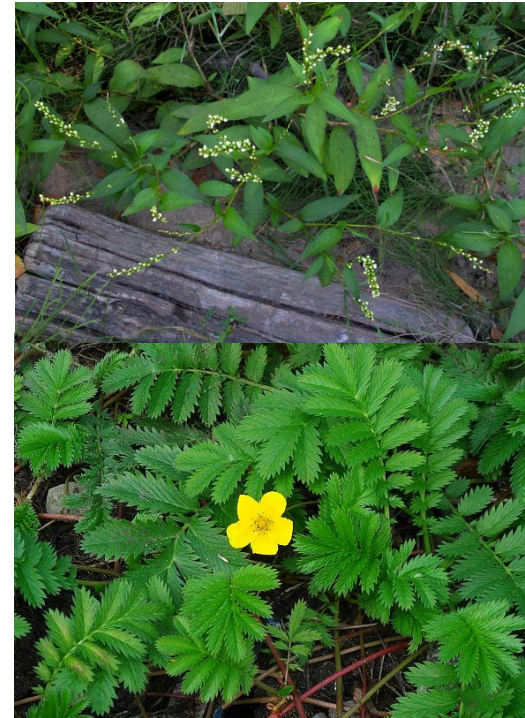
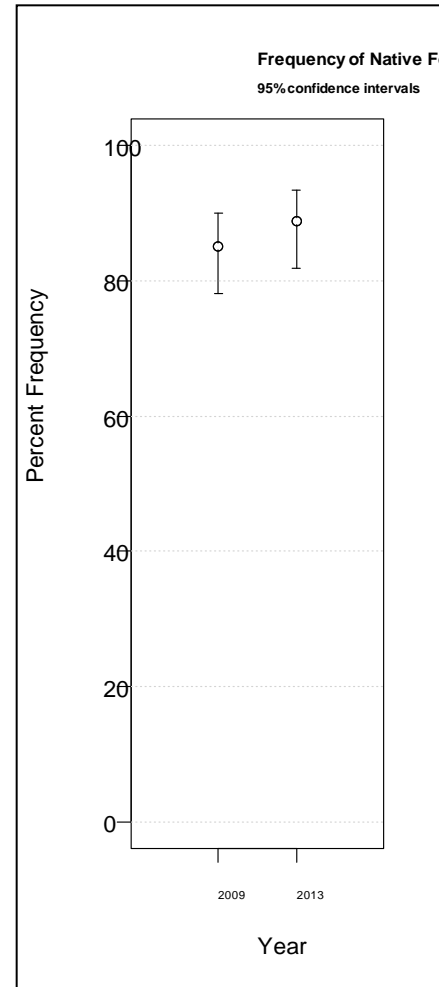
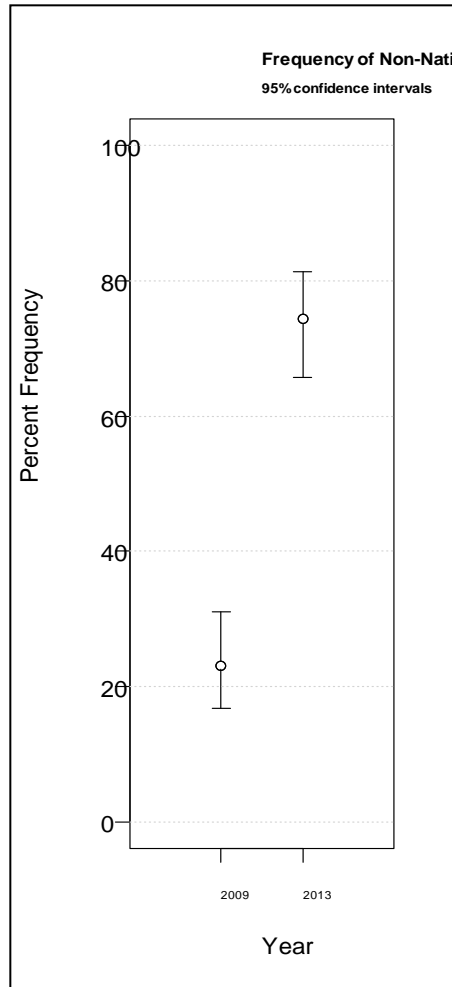
## Change in Frequency in Riparian Corridor



Change in Frequency of Year 1 (2009) and Year 5 (2013) of non-native forbs (23% increase), native forbs (8% increase) in the riparian corridor.

# National Park Service

## Change in Frequency in Riparian Corridor



Change in Frequency of Year1 (2009) and Year 5 (2013) of non-native forbs (51% increase), native forbs 3% increase) in the riparian corridor.



# National Park Service

Tree Cover



2010 before and 2014 after







A reduction in cover and/or frequency of certain target non-native plants to less than  $\leq$  5% including *Conium maculatum*, *Hirschfeldia incana*, *Raphanus sativa*, *Agrostis stolonifera*, *Festuca arundinacea*, *Pennisetum clandestinum*, *Phalaris aquatica*, *Typha angustifolia*, *Calystegia silvatica*, *Delairea odorata*.

The two target species for monitoring: *Holcus lanatus* increased of which *Agrostis stolonifera* has had significant decreases in cover since 2009.

A decrease in the cover of non-native graminoid species, coupled with a smaller decrease in cover of native graminoid species.

An increase of 9.5% in the combined (with trees) native plant cover across the site.



# National Park Service

Thank you!

