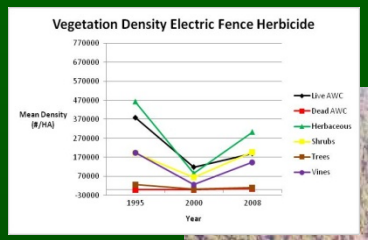
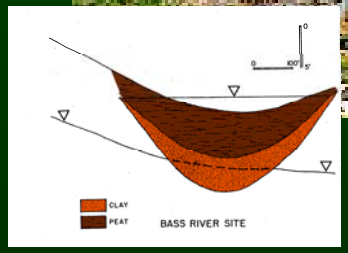
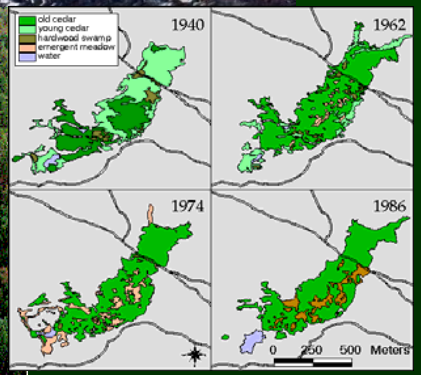
Data and Implications from the Long-term Atlantic White-cedar Project

George Zimmermann, Caroline DiGiovanni, & Stephen Mason
The Richard Stockton College of New Jersey







OVERVIEW

In 1989-90, in cooperation with the NJDEP and USFS, I started long term experiments to study the effects of numerous factors on AWC regeneration and restoration

TREATMENTS

Some of the factors studied on these experiments and their effect on AWC survival and growth (as well as all vegetation in general):

-deer herbivory
- electric fences
- repellent
- woven fence
- food patch

-AWC source
- natural regeneration (seed bank)
- direct seeding
- planted seedlings(sexual origin)
- planted stecklings (asexual propagation)

-slash loads

Controls were established for all above treatments

OVERVIEW

SITE/TREATMENTS

Brendan Byrne State Forest: 'Colletti' site: remeasured 2008 plus construction now of two new 1.5 acre deer exclosures in upland pine/oak forest and mature cedar stand….

FAILED CLEARCUT (1985)SITE

1A/B. Herbicide (Arsenal 9/90) /Electric fence(6/91)
a part of fence was removed (area **1B)** in 2000
remaining fence (1A) was removed in 2003
Treatment area 3.58 ha.

2. Herbicide (Arsenal 9/90)/No Deer Control Treatment area 0.29 ha.

3. Herbicide (Arsenal 9/90) /Hinder applied continuously to cedar (1990 -95)
Treatment area 0.30 ha.

4. Control /Control (no herbicide or deer exclusion techniques).
Treatment area 0.89 ha

OVERVIEW

SITE/TREATMENTS

Stafford Forge Wildlife Area: Three-foot site:
remeasured summer 2008

ILLEGAL LOGGING SITE

1. Electric fence (11/92-7/2003)/No Herbicide Treatment area 0.10 ha.

2. Electric fence (11/92-7/2003) **/**Herbicide (Arsenal 10/92 & 9/93)
Treatment area 0.10 ha.

OVERVIEW

SITE/TREATMENTS

Bass River State Forest Area: Bass River site: remeasured summer 2008

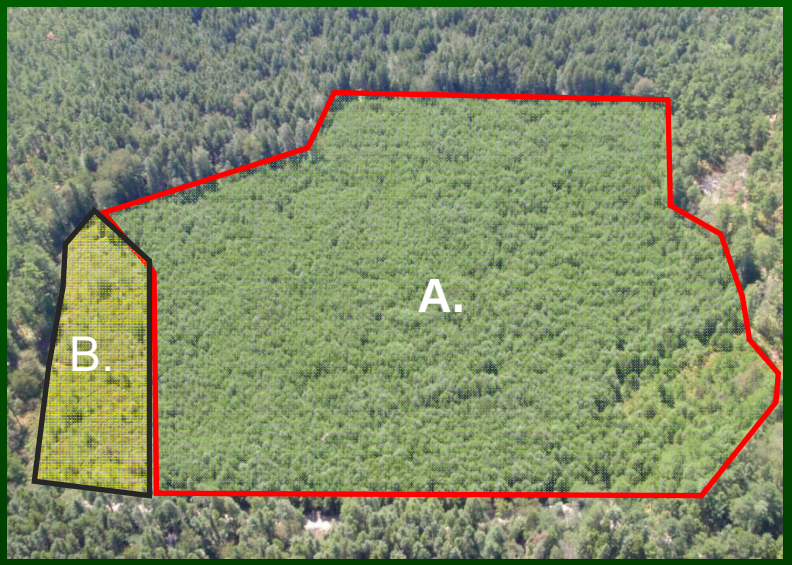
Electric fence erected in 1991, then expanded 11/1992. Powered down 2004. Arsenal applied to whole site in 1991. **CONVERSION SITE**

A. Original Forester plot seeded 4/16/91
B. Original Forester plot Control
C. Original Forester plot seeded 1/23/91
D. Original Forester plot Control
E. Plot seeded 1/23/91
F. Stockton plot seeded 7/31/91
G. Stockton plot seeded 4/16/91
H. Plot seeded 1/23/91
I. Plot seeded 1/11/93

OVERVIEW

SITE/TREATMENTS

Wharton State Forest Area: Penn Swamp site: remeasured 2008 plus construction now of two new 1.5 acre deer exclosures in upland pine/oak forest and mature cedar stand….



Electric fence erected in 1991, then expanded 11/1992. Powered down 2004. Arsenal applied to whole site in 1991 **CLEARCUT SITE (3.4 ha. 1989-90)**

A. Woven fence (10 ft. high erected 5/91, not maintained after 2003)/Slash trts.

B. Control (no deer exclusion)/Slash treatments

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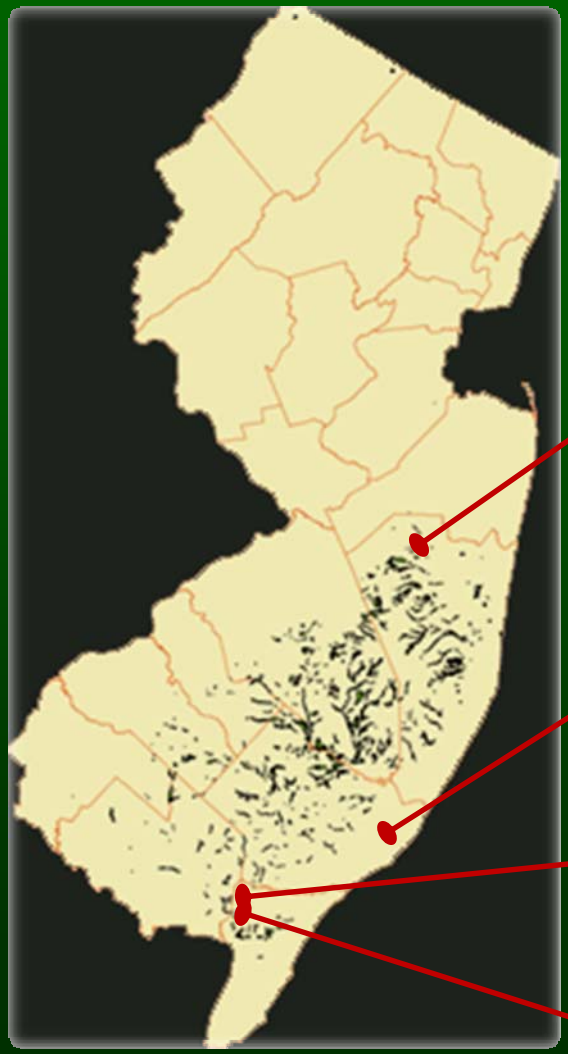
OVERVIEW

SITE/TREATMENTS

In 1996 we decided to stop collecting data on three sites:



JACKSON SITE

SORRENTINO SITE

BELLEPLAIN SITE

BELLEPLAIN SITE (food-patch)

OVERVIEW

MEASUREMENTS

PERMANENT PLOTS ESTABLISHED AT ALL SITES

Densities of all plants (per hectare) recorded by species, treatment regimes, health, and height classes :

<0.3m (1m ^{2} plot, all other height classes use 5m ^{2} plots for the rest)
≥0.3m to 0.6m
≥0.6m to 1.3m (in surveys before 2006 used ≥1.3meters)
≥1.3 to<3 m
3 to <5m (yellow height classes added from 2006 survey onward)
5 to <7m
≥7 meters

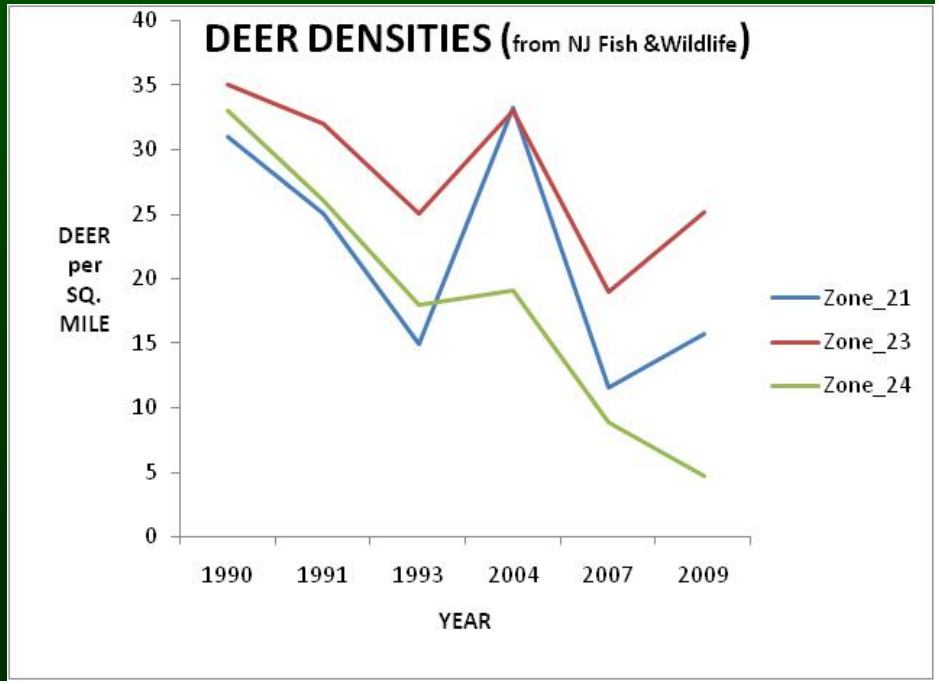
Data on percent ground covers and downed woody material are collected and analyzed.

Point sampling canopy trees (BAF 10 to 20)

Overview


2009-02-14 1:53:30 PM M 1/3 37°F
RECONYX


Reconyx IR
trigger camera


DEER DENSITIES (from NJ Fish &Wildlife)
DEER per SQ. MILE
40
35
30
25
20
15
10
5
0
1990
1991
1993
2004
2007
2009
YEAR
Zone_21
Zone_23
Zone_24

Restoration /Regeneration

Penn Swamp

1990

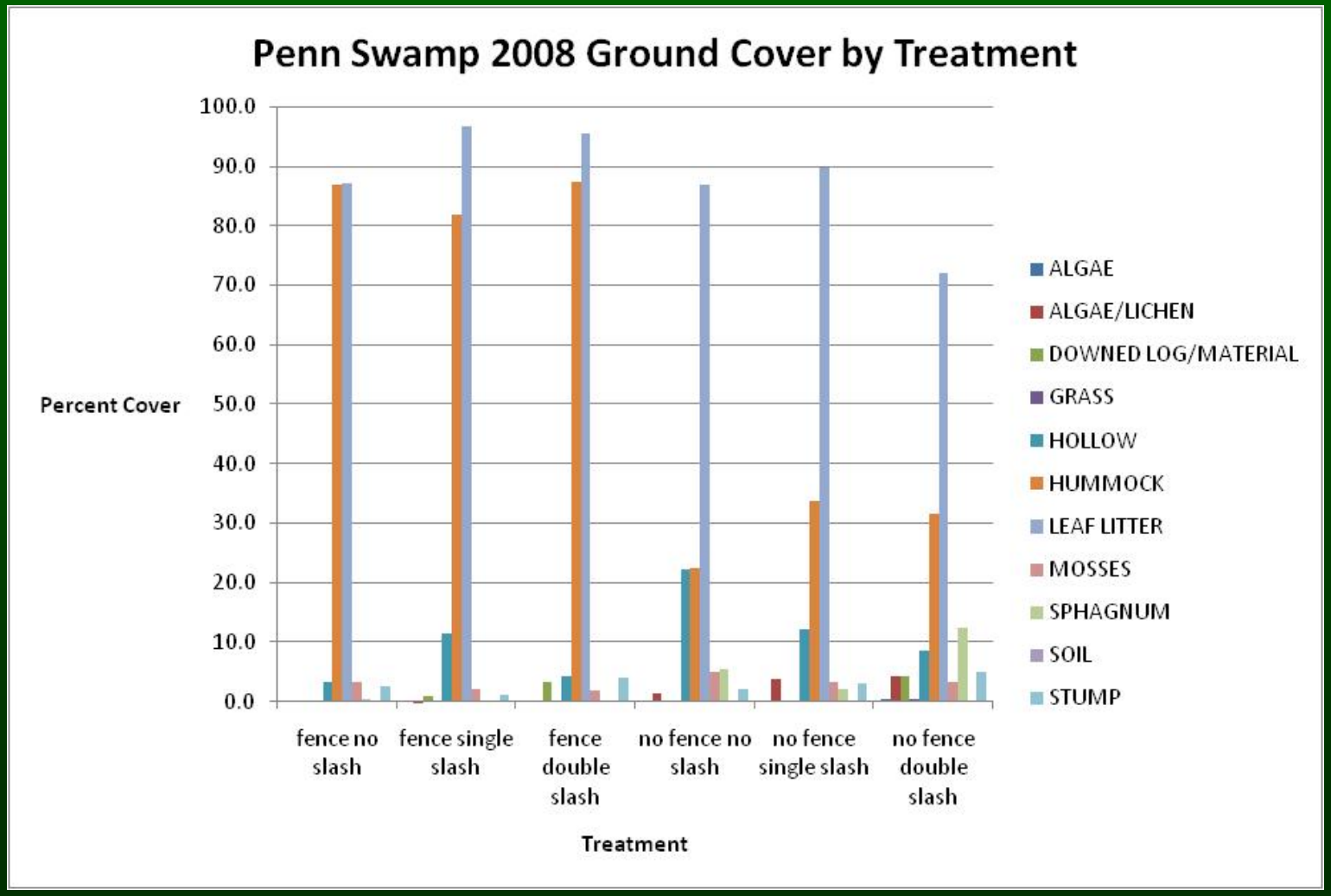
1996

2000

2008

Restoration /Regeneration

Penn Swamp Study



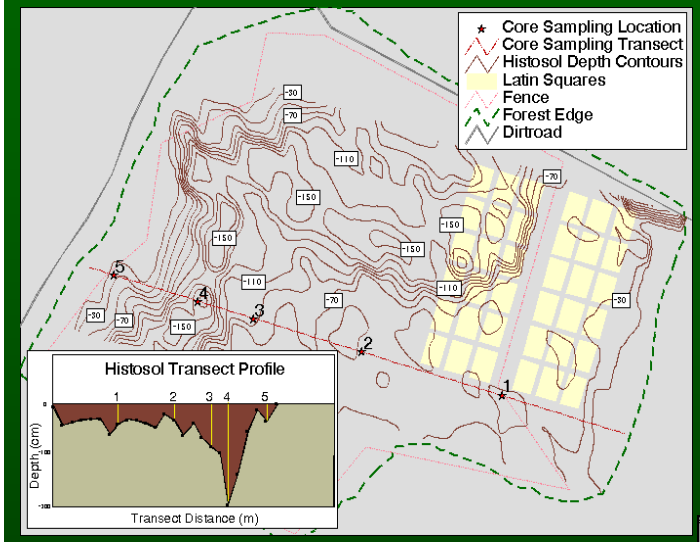
Close to full sunlight,
1 to 2 layers

Averaged 82.3%
of full sunlight,
2 to 3 layers

Averaged 53.5%
of full sunlight,
3 to 4 layers

Restoration /Regeneration

Penn Swamp Study: Additional Studies

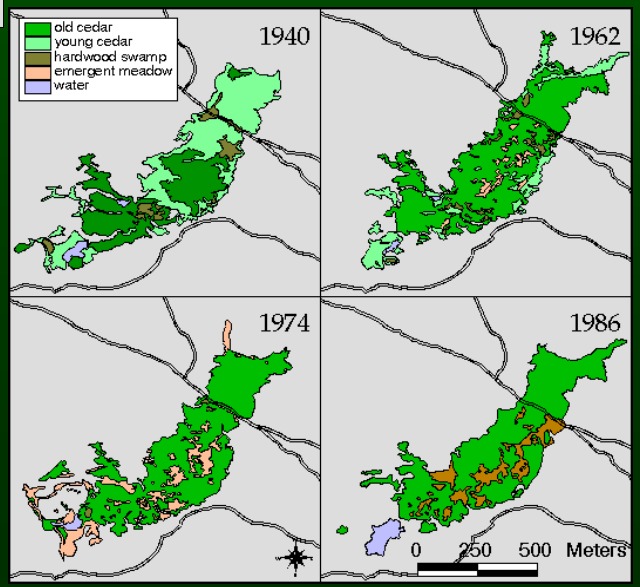


Histosol mapping

-Age at 186 cm. histosol depth is 9,998 YBP

-Histosol deposition rates are between 1.4 to 1.8 cm. per 100 years

-Fire frequencies (by 2 cm intervals) in peat cores was between 0.50 and 0.66.



Aerial Photo Analysis

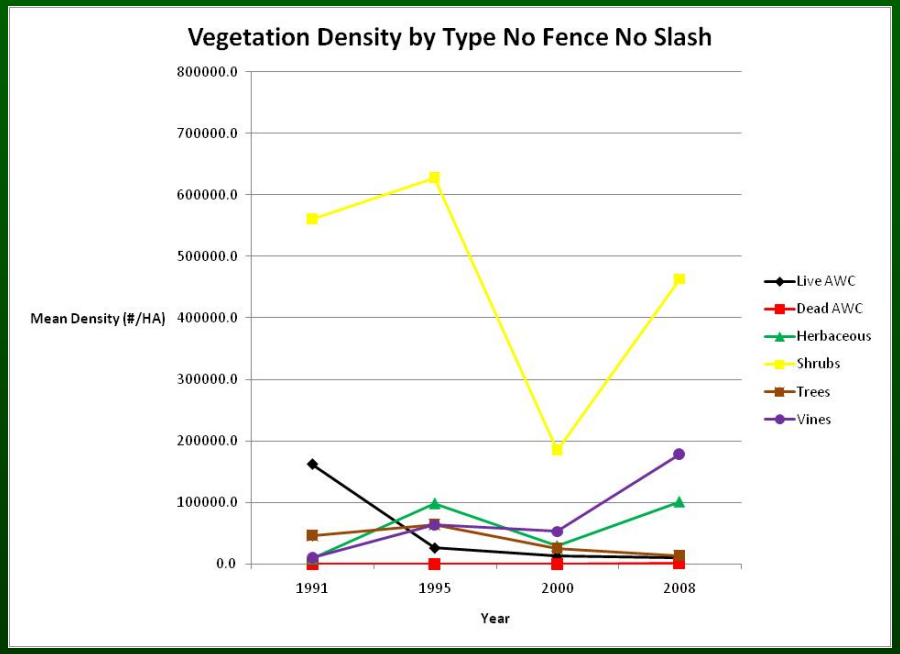
-1940 stand shows at least two distinct age classes of cedar. Older cedar seem to be in wetter and inaccessible areas (hard to log).

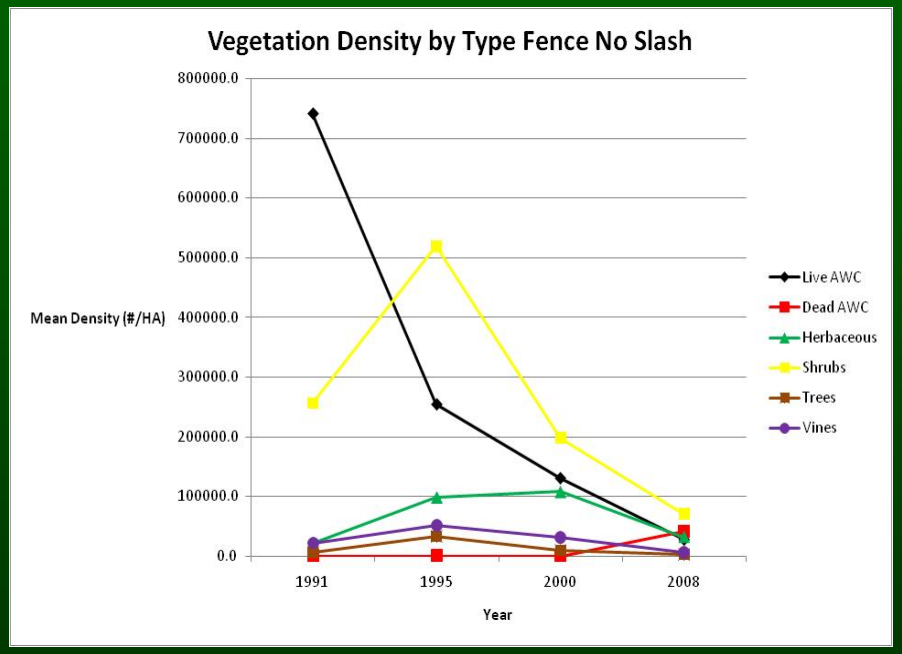
-1962 photo shows a series of gaps formed. Field verification found windthrow. Some gaps regenerated to cedar, others didn't.

-Overall highly dynamic situation in 46 year period.

RESTORATION /REGENERATION

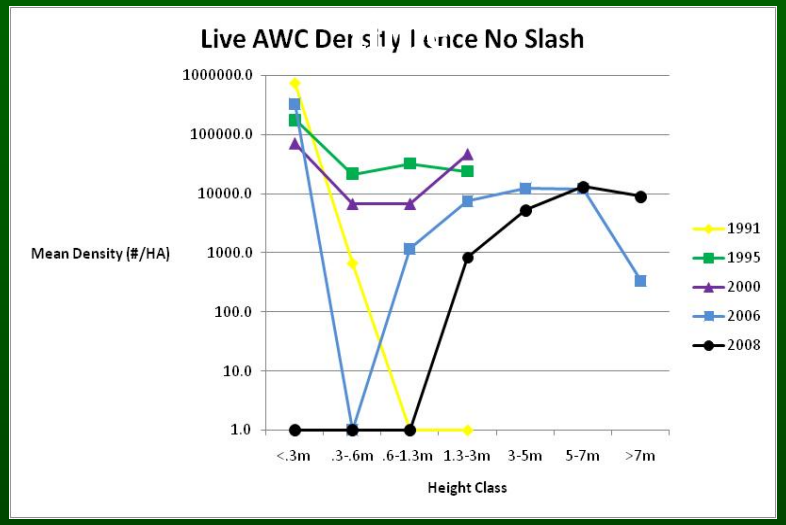
Penn Swamp: plant type over time
example of fence (deer) effects

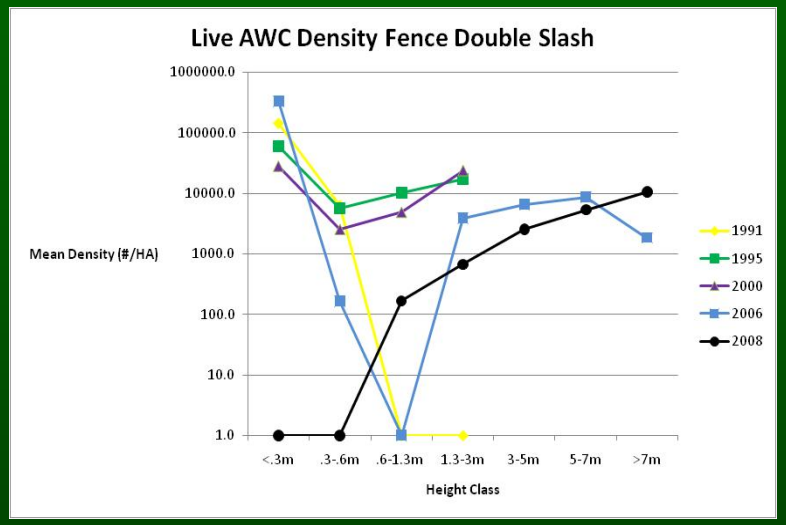


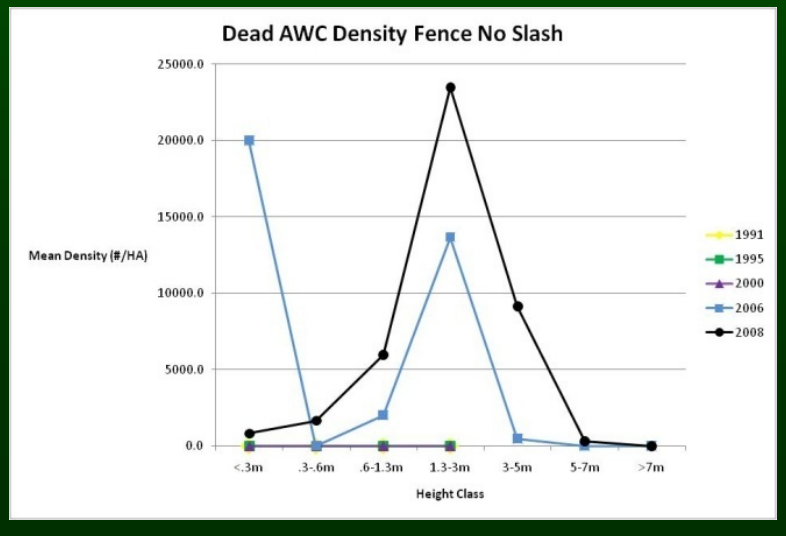


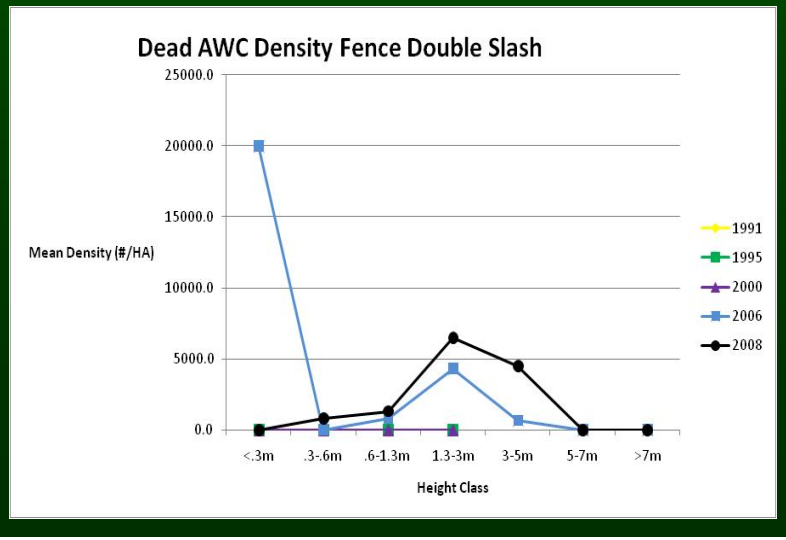
RESTORATION /REGENERATION

Penn Swamp: AWC/slash effects over





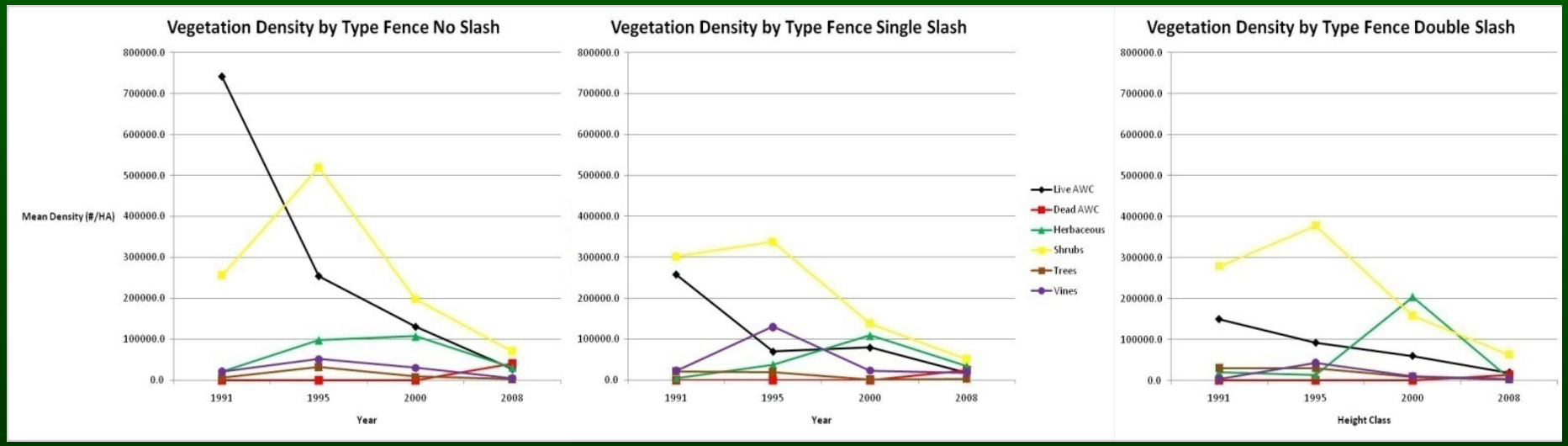




RESTORATION /REGENERATION

Penn Swamp: plant type over time

example of slash load effects 2008



RESTORATION /REGENERATION

Penn Swamp: Some conclusions

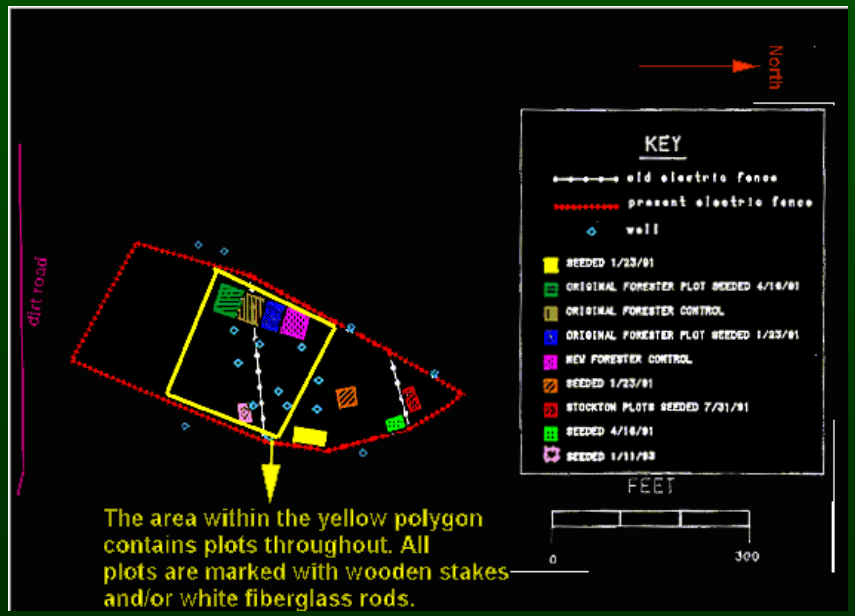
Ground view (1990) as clearcut is finished

Deer have had a profound negative influence on cedar reproduction and changed the structure and general composition of the swamp. Currently at 18 years since the experiment started , plant species diversity is *higher* in the area unprotected from deer. In 2008 Dr. Gerry Moore conducted plant species surveys in Spring, Summer & Fall off and on plot . He found 28 species in the unprotected area versus 9 species in the former fenced area.

Slash loads at Penn Swamp have *probably* not had a biologically negative effect on cedar or vegetation as a whole when deer are excluded

Penn Swamp is a complex forest ecosystem (even before this experiment) that must be managed as such

Restoration /Regeneration

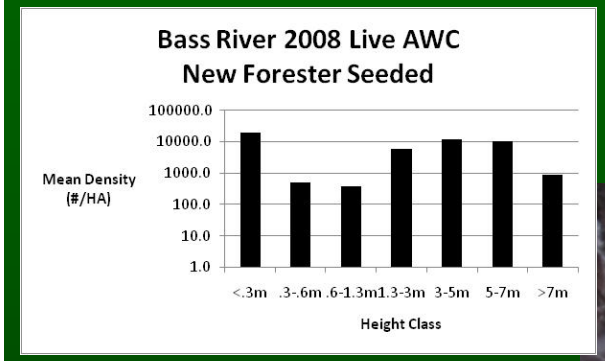


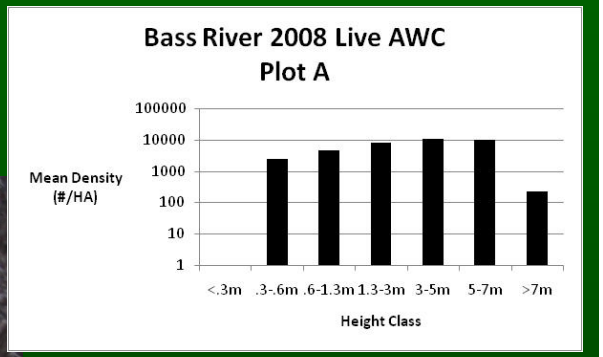
Bass River Site:

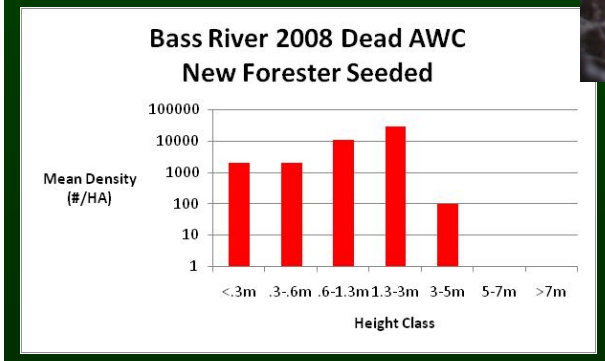
This 0.64 hectare site is located on a larger upland pine 13.7 hectare upland pine clear-cut performed in 1989. A part of this clear-cut seemed to be wetter and previously possess a few swamp hardwoods. It was decided to try introducing white-cedar by sowing cedar seed in a number of sub-areas that were all enclosed by a 5 strand electric fence. A fire came through the area in 1999 killing a small portion of the white-cedar. But the majority of the cedar are doing quite well.

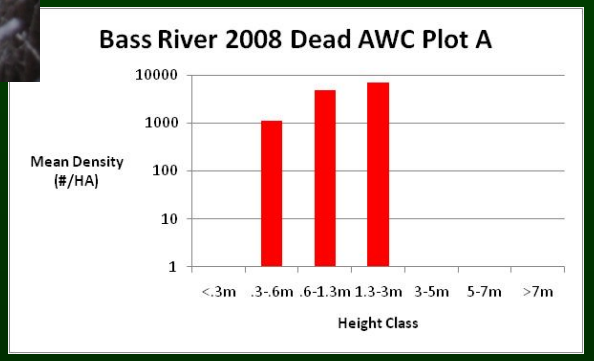
RESTORATION /REGENERATION

Bass River Site: some treatment data

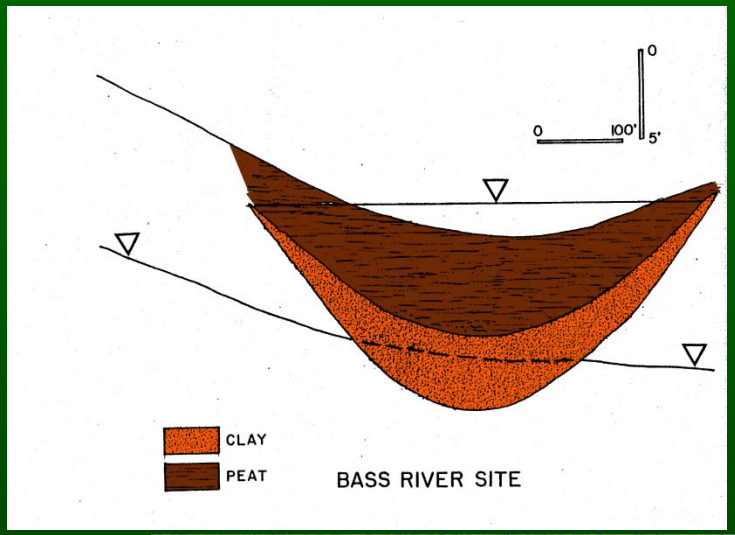








RESTORATION /REGENERATION



Dr. Claude Epstein, hydrologist at Richard Stockton College , put in a series of wells and conducted numerous studies through the years. He and his students mapped a clay lens under the site and determined that all water at the site was from precipitation perching on this impervious layer.

Implications

Claude Epstein (1995) defined six distinct hydrogeologic types in the NJ Pinelands:

-Ponded wetlands

-Perched wetlands

-Unconfined groundwater discharge wetlands

-Leaky confined or "artesian" groundwater discharge wetlands

-Stream inundated wetlands

-Tidally induced freshwater wetlands

Each type has ramifications for cedar growth & survival based on drought periodicity, flooding, water table depths, etc…….

RESTORATION /REGENERATION

Brendan Byrne State Forest Site:

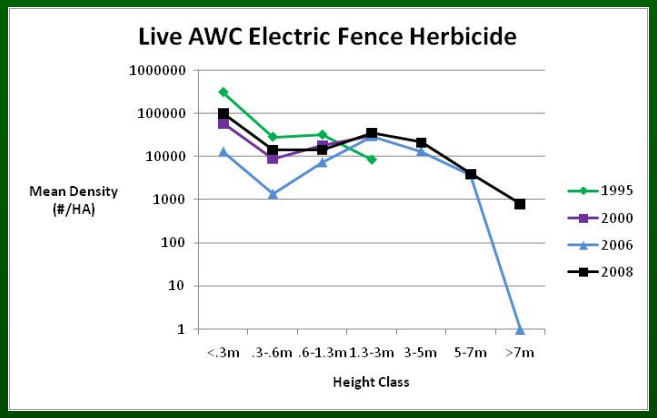
This site was an AWC clear-cut of 5.07 hectares done in 1985. It failed to regenerate for 5 years until we started the experiments in 1990.

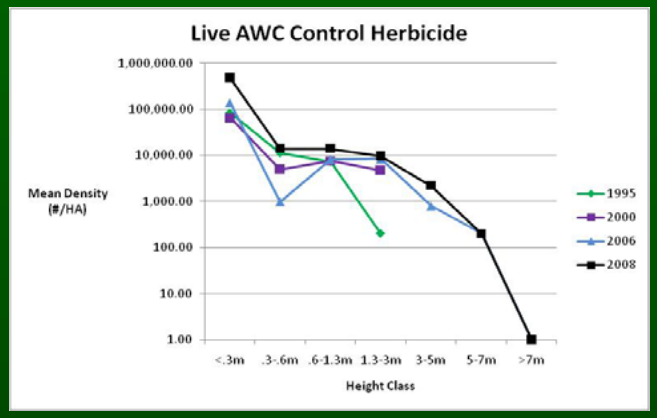
The treatments clearly show the 'success' of electric fence/herbicide in creating a dense 'traditional' cedar stand

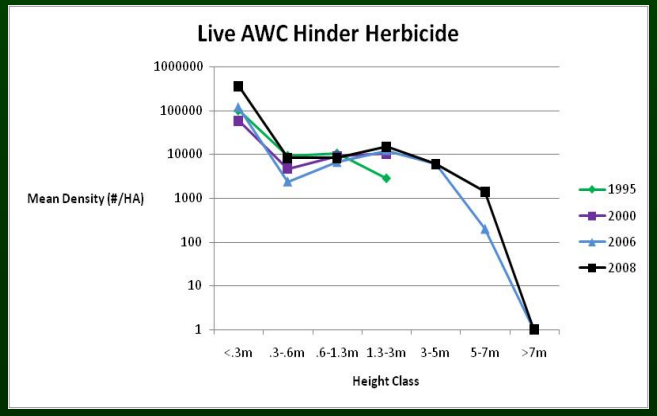
BUT some of the other treatments produced 'different' plant communities and interesting lessons…..

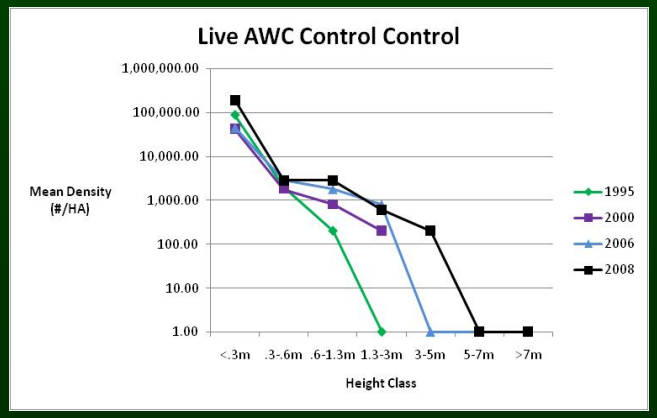
RESTORATION /REGENERATION

Colletti site (Brendan Byrne State Forest)



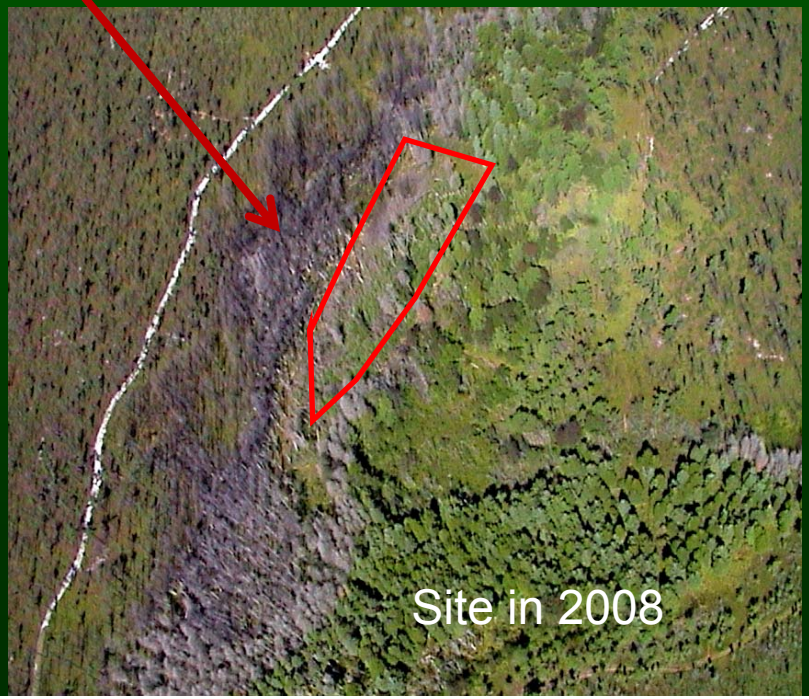






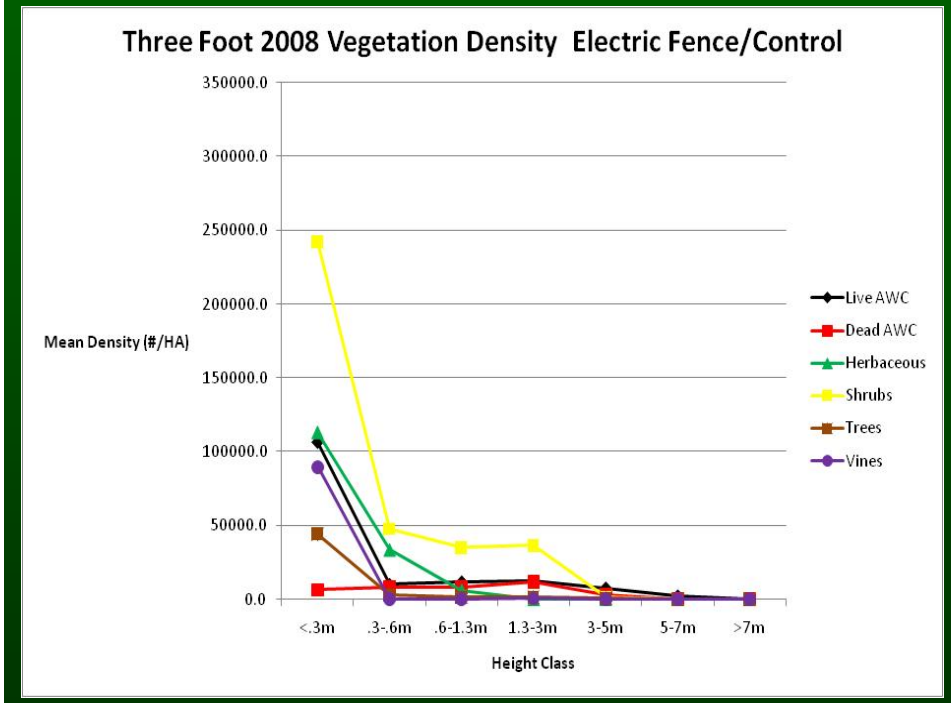
RESTORATION /REGENERATION

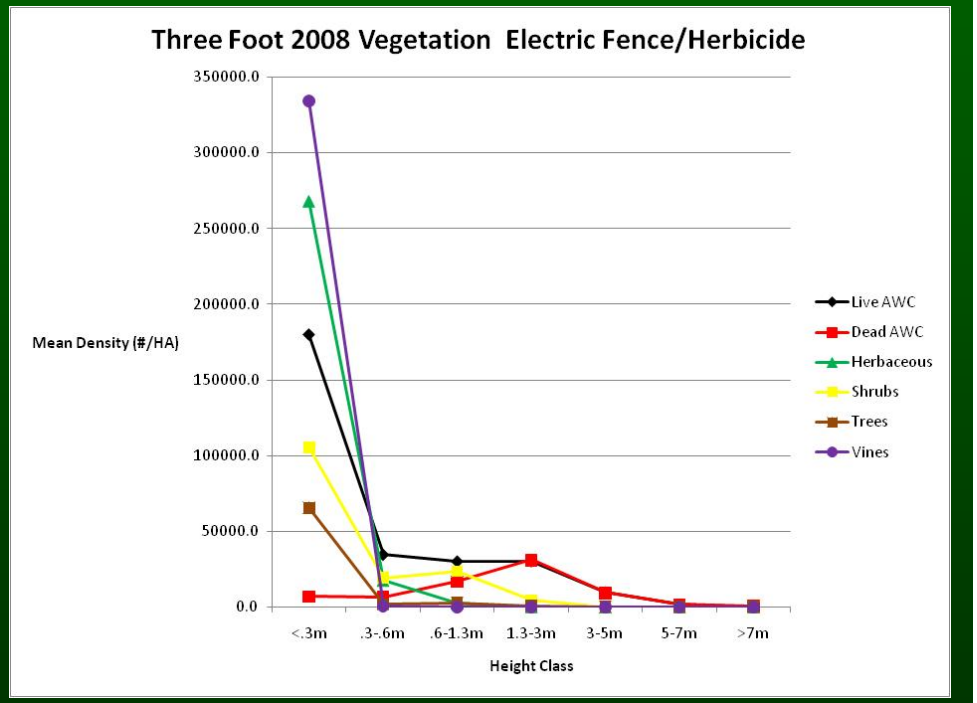
Three-foot Site (Stafford Forge area):
This site was illegally logged and last summer most of the surrounding residual mature cedar stand (and some of the treatment area) burned in a wildfire…...



Restoration /Regeneration

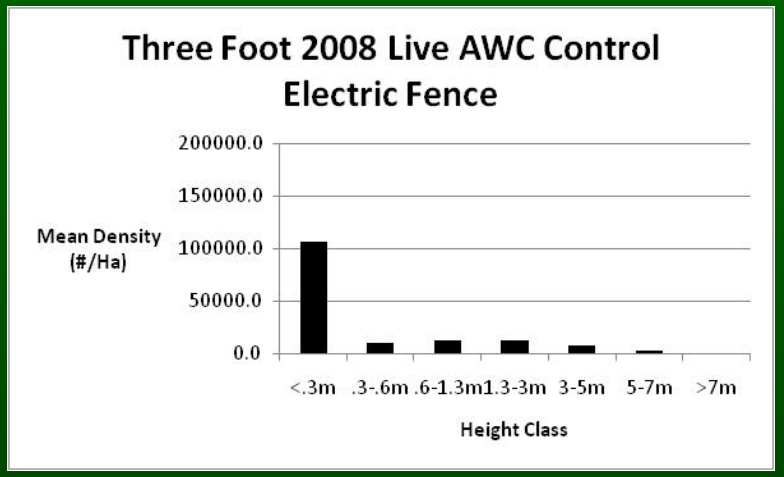
Three-foot site: 2008 vegetation by treatments

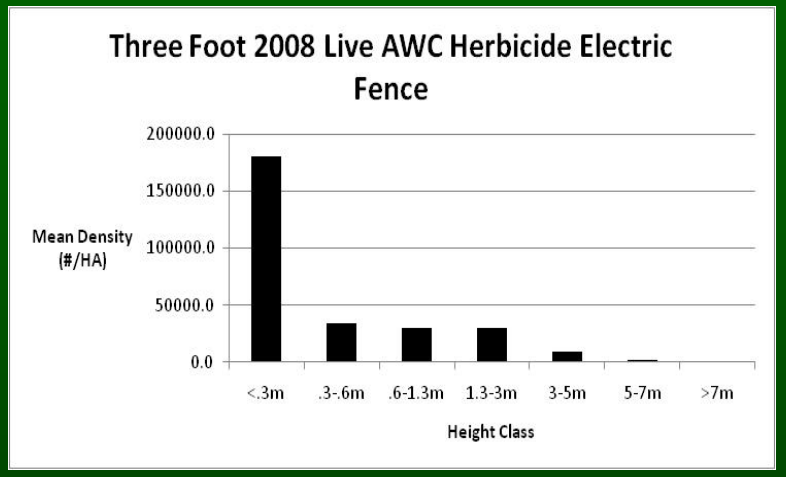


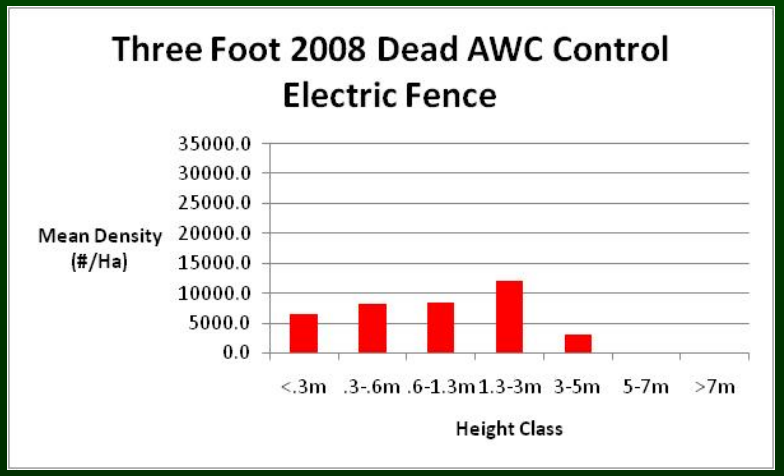


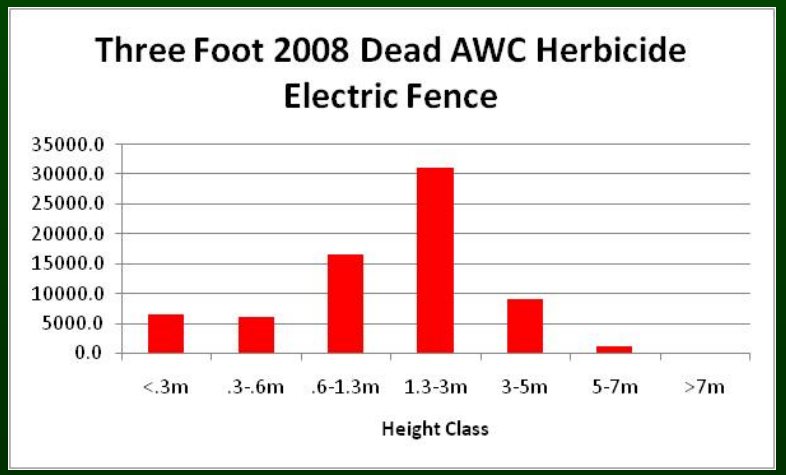
RESTORATION /REGENERATION

Three-foot site: 2008 AWC live/dead by treatment









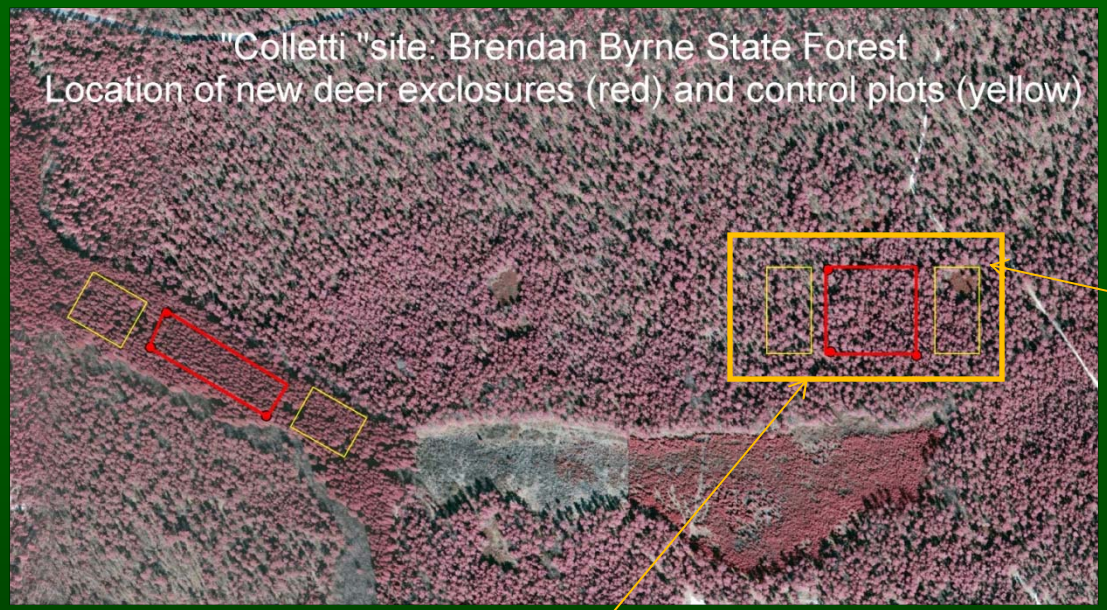
Implications

Fire has already partially impacted 2 of the 4 long-term sites. The Penn Swamp peat core samples showed fire to be common through the thousands of years since the peat started to form (fire frequencies of 0.50 to 0.66!)- and given the NJFS plan for creating some old growth stands plus protection of investment in long-term research on areas such as Colletti and Penn Swamp which contain new exclosures- there is a need for upland reduced-fuel buffers…….

Some of the surrounding residual mature cedar stand at Three-foot was destroyed in a recent fire. There used to be *Helonias* in this stand but no more…..

Bass River site 1999 fire

Implications

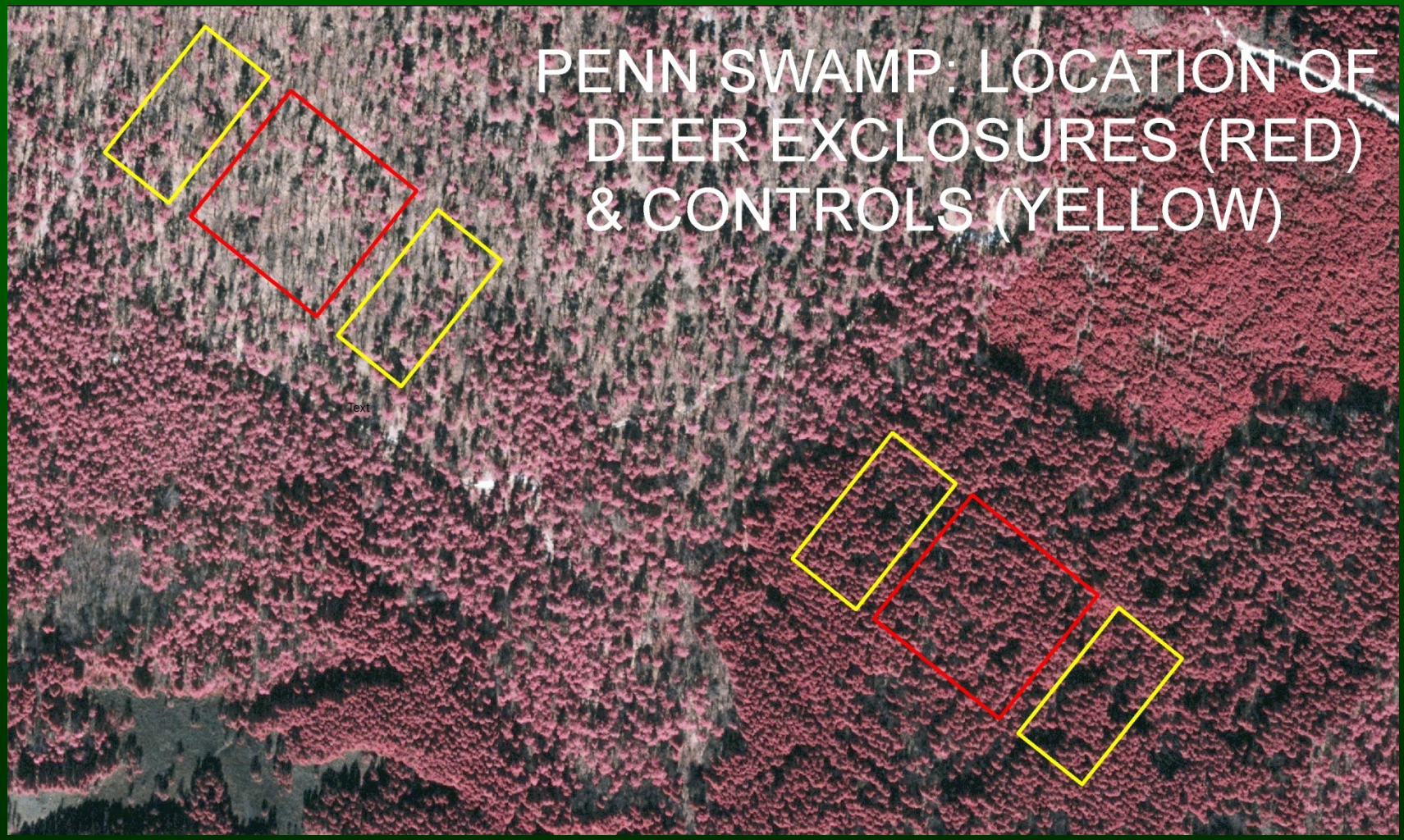


To start protecting Colletti and Penn Swamp, New Jersey Forest Fire wardens have been planning , or in this case carrying out prescribed burns to reduce the probability of fire to this research site and cedar stand…..

Implications

Our experiments to date have shown the impact of deer to be complex and in need of more in-depth study. The New Jersey Fish & Wildlife Service have provided funds to expand the experiments with four new exclosures.

Implications



Implications

Our experiments have demonstrated that different treatments produce different AWC communities with many different ecological characteristics such as :

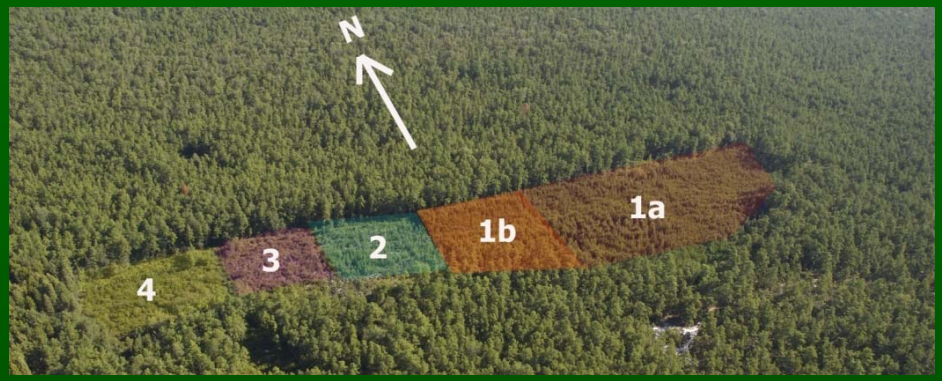
Species composition
Density
Vertical and horizontal spatial characteristics
Ground covers

To that end, and given the small size of most treatments, we felt a look at
insects would help us understand some faunal responses to these community differences so we have been and will continue to conduct insect trapping at sites……

Implications

Implications

PITFALL TRAP RESULTS
FROM 1 WEEK
BY TREATMENT



		1b	2	3	4
Orders of insects					
Roaches	Blattodea			1	
Beetles	Coleoptera	12	10	29	10
True Flies	Diptera	38	20	10	112
True Bugs (Stink Bugs, Assasin Bugs, etc)	Hemiptera	7	6	21	16
Wasps, bees, ants	Hymenoptera	17	20	35	31
Moths and butterflies	Lepidoptera		1		1
crickets, grasshoppers, katydids	Orthoptera				
lice	Psocoptera		1	1	
fleas	Siphonaptera				
thrips	Thysanoptera		1	2	5
Order of "non" insects					
mites, ticks	Acarina	72	57	99	178
spiders	Aranaea	72	31	41	60
springtails	Collembola	826	679	955	735
slugs	Pulmonata	2	2		10
Pseudo scorpions	Pseudoscorpionida	1			
Class					
millipedes	Diplipoda	3	2	1	1
earth worms	Oligochaeta	2			
	Total	1052	830	1195	1159

Implications

IT COSTS A LOT OF ME TO KEEP DEER OUT & WHEN YOU CARRY THOSE COSTS FOR EVEN A MODEST ROTATION IT ADDS UP- NOT COOL ……..

Implications

It is costing about $12200 to put in about 6 acres of deer fence in New Jersey. Compounded at a modest interest rate of 2% for a modest rotation length of 50 years equals $32,837.37. We cannot keep asking the public for these dollars – we must use our fiber in creative ways on a landscape basis- one way to assuage costs is possibly low thinnings which can make a few thousand dollars per acre in cedar stands….

Implications

Another possibility is to forgo immediate deer exclusion in some cases (when you are working from an already present cedar seed bank-like at Colletti) and see what happens. Deer populations vary and you might be able to bring cedar back in biologically significant numbers without a fence or aided by just an initial herbicide treatment. You may sacrifice high cedar densities and fastest height growth but still produce a community with cedar.

COLLETTI : Control(no deer exclusion)/Herbicide Treatment 2008

Acknowledgements

NJDEP: New Jersey Forest Service
New Jersey Fish & Wildlife
New Jersey Fire Service

U.S. Forest Service

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Brooklyn Botanic Garden
Dr. Gerry Moore

Philadelphia Academy of Natural Sciences
Dr. Jon Gelhaus, Greg Cowper

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past & present
including
the ‘new’ 2008-9 team:

Caroline DiGiovanni

Andrew Lancioni

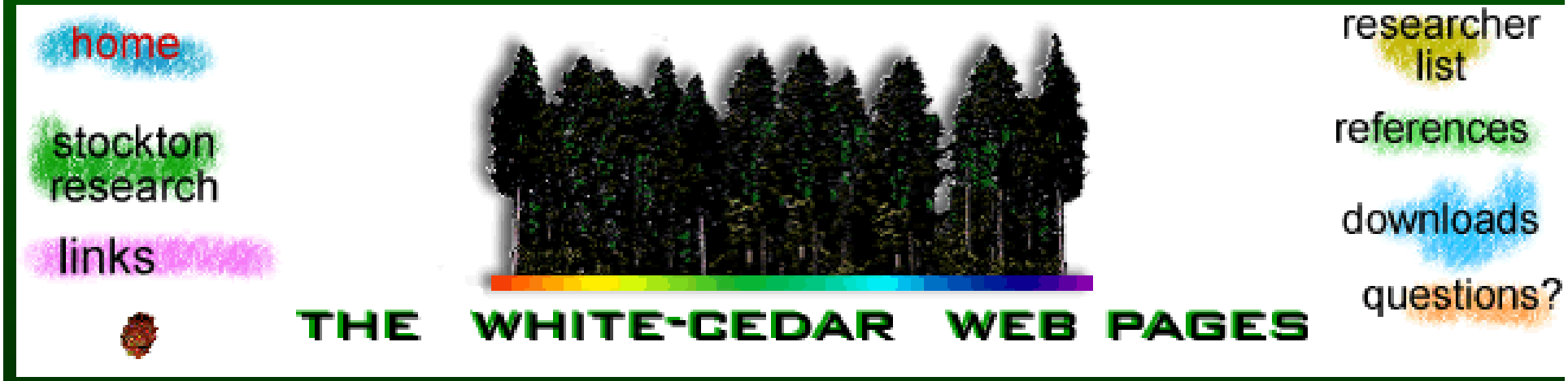
Stephen Mason

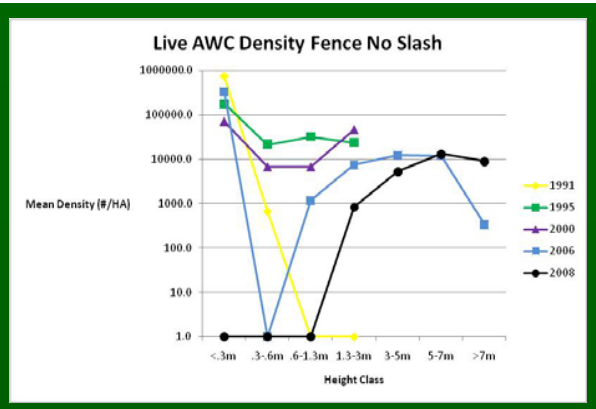
Andrew Riviello

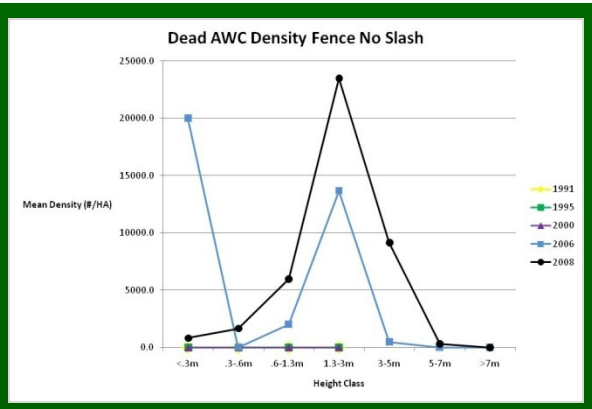
For more information…..

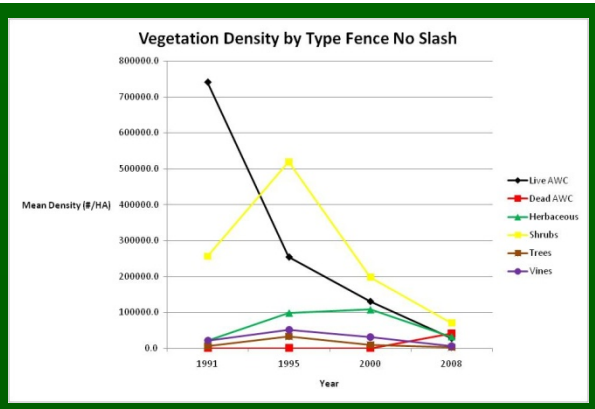
Go to my Atlantic White-cedar Web Pages:

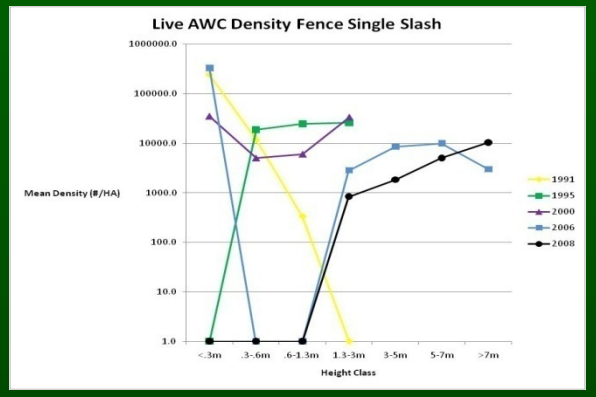
www.stockton.edu/~wcedars

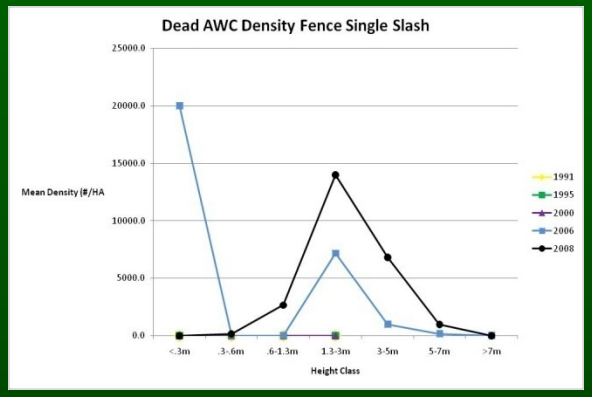


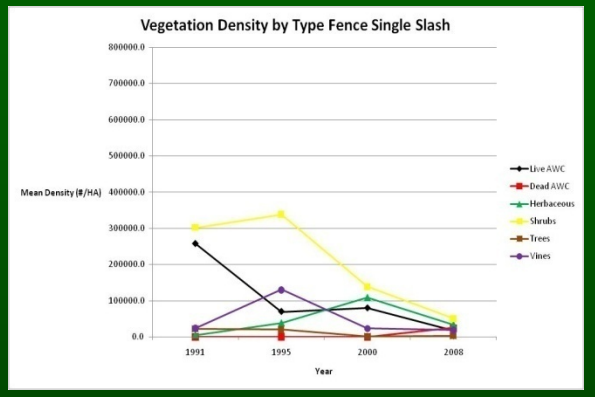


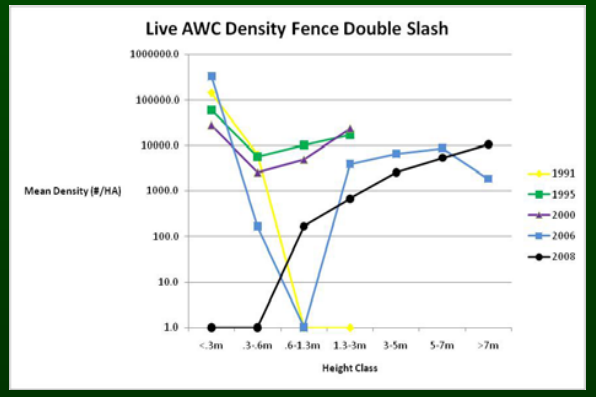


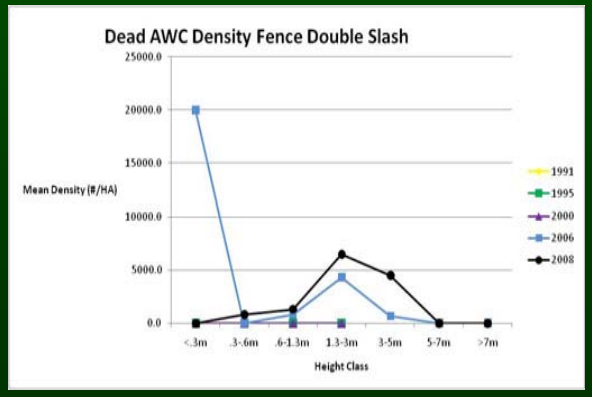


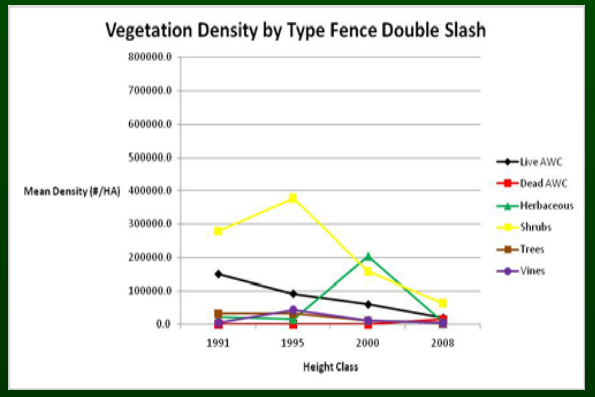




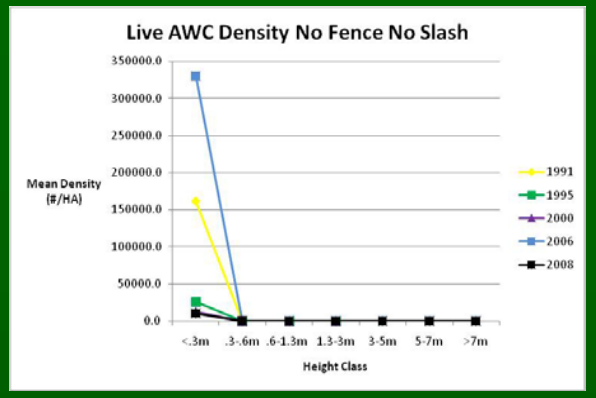


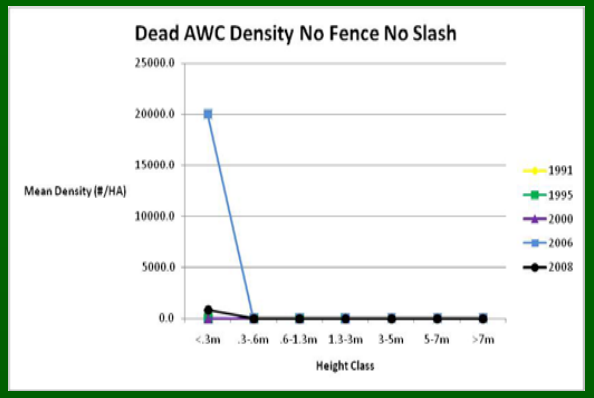


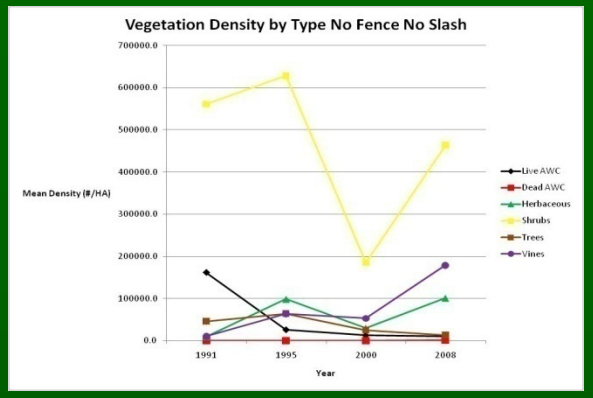


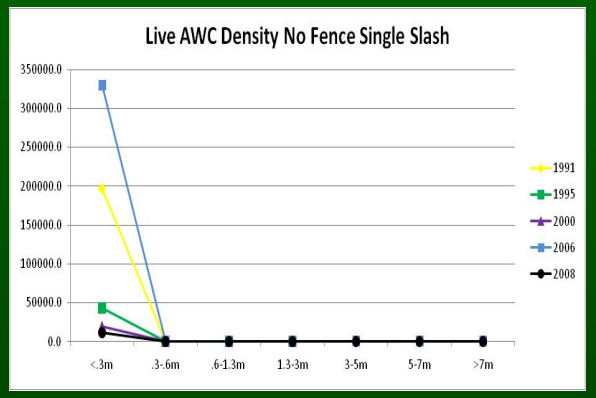


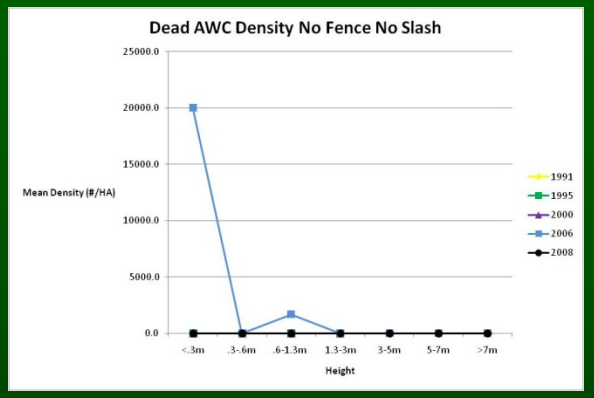
PENN SWAMP FENCE TREATMENTS

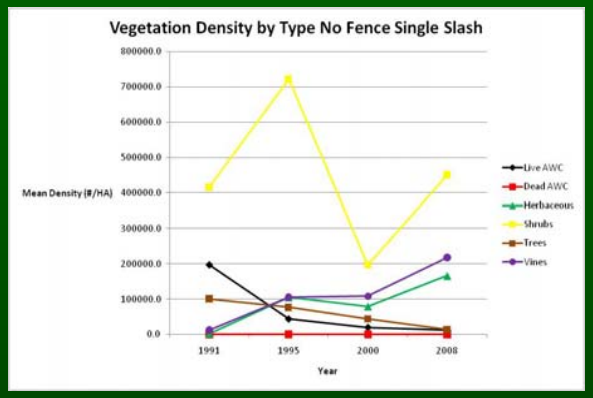


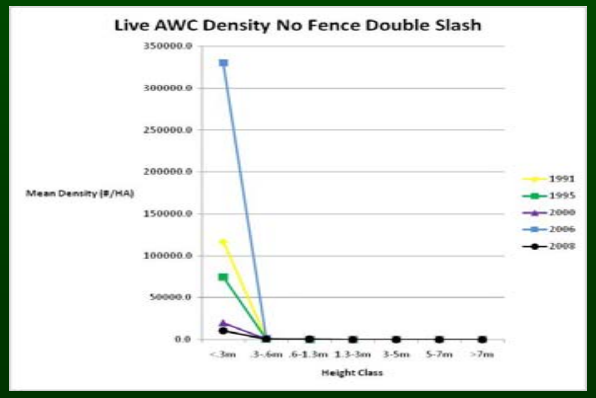


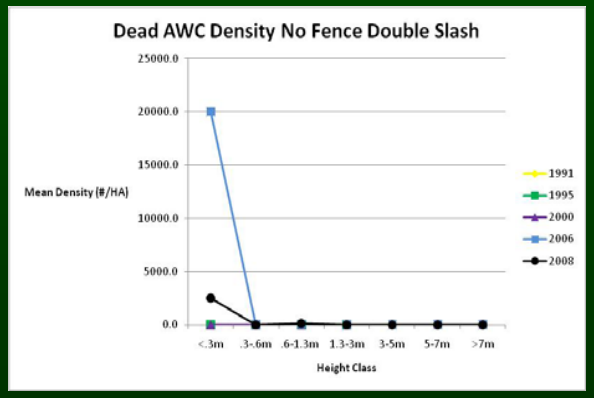


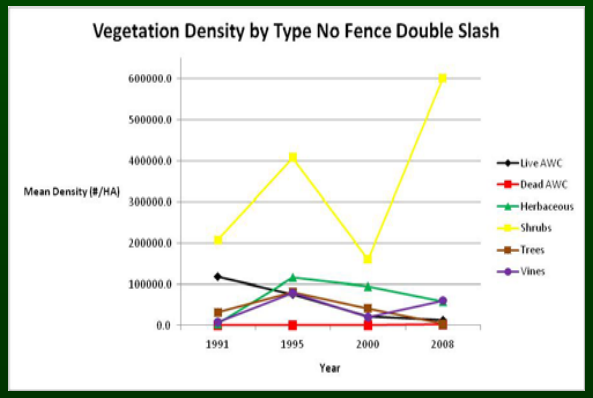




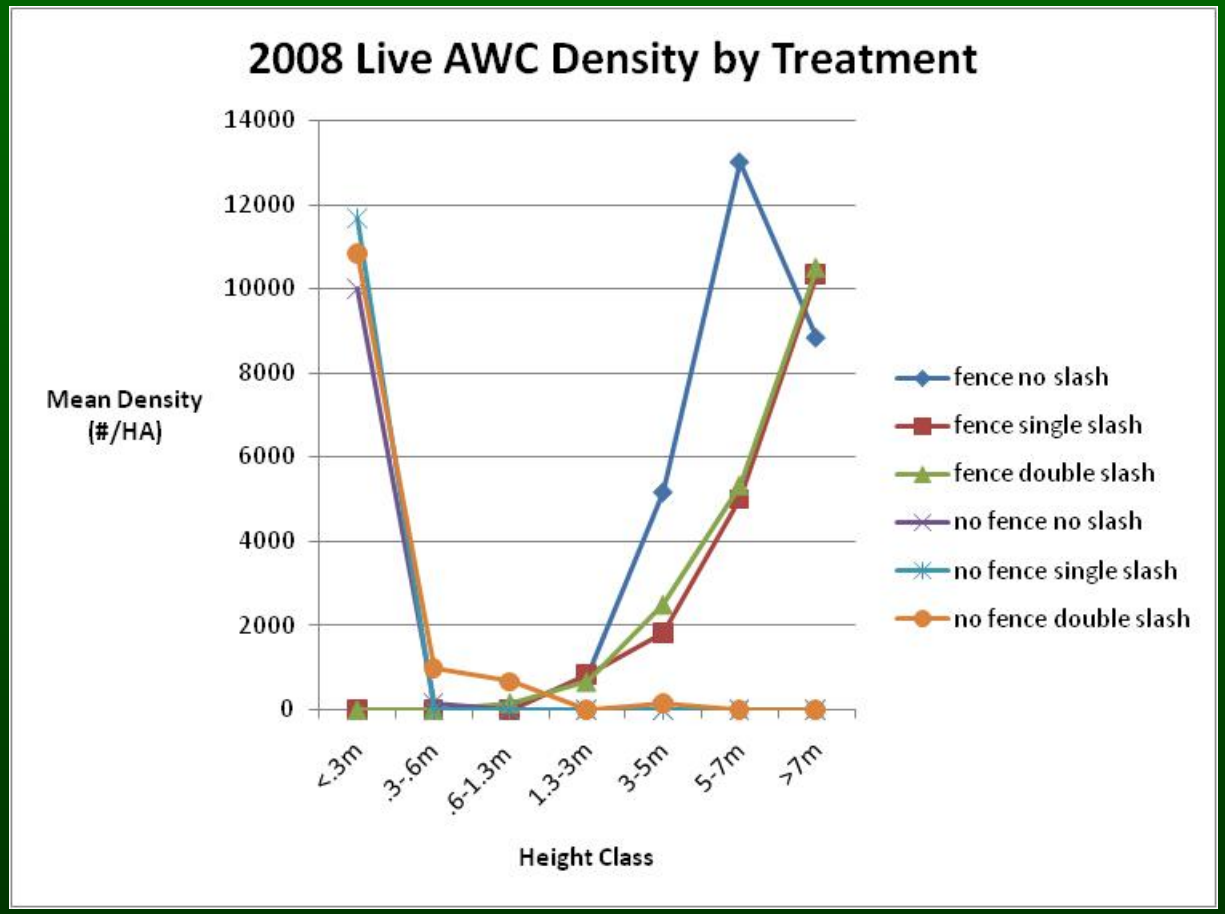




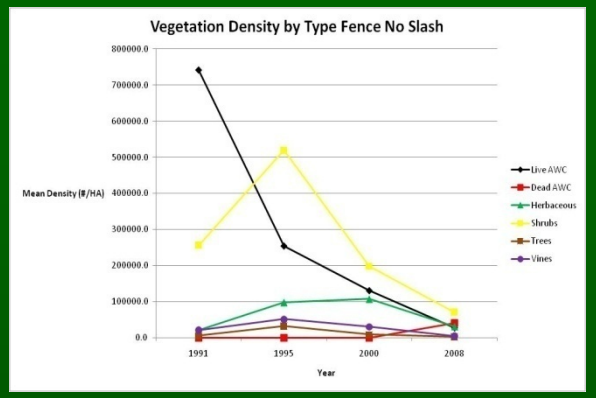


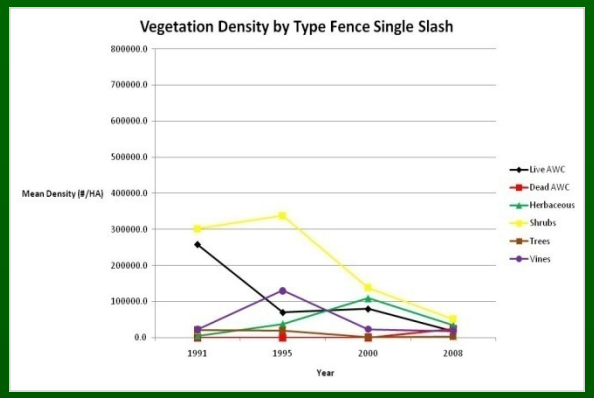


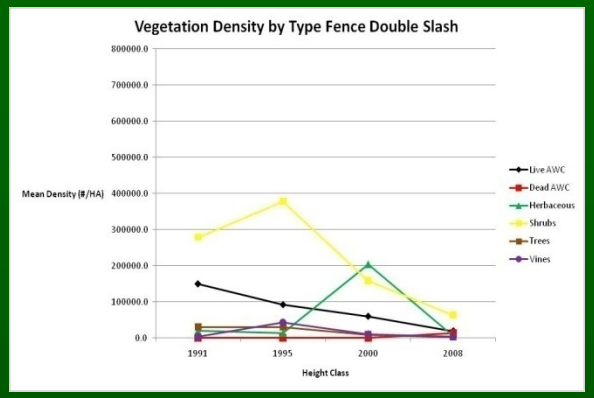
PENN SWAMP NO FENCE TREATMENTS

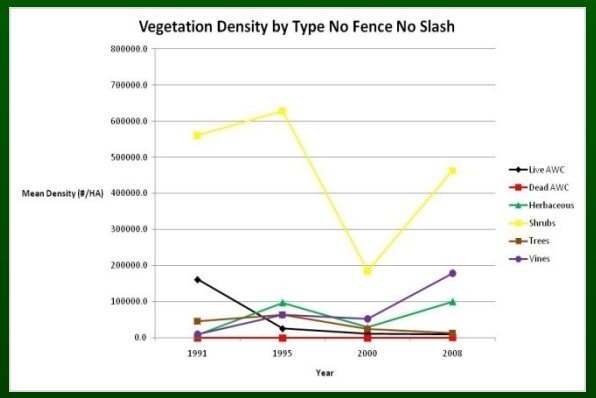

2008 Live AWC Density by Treatment
Mean Density (#/HA)
14000
12000
10000
8000
6000
4000
2000
0
<.3m
.3-.6m
.6-1.3m
1.3-3m
3-5m
5-7m
>7m
Height Class
fence no slash
fence single slash
fence double slash
no fence no slash
no fence single slash
no fence double slash

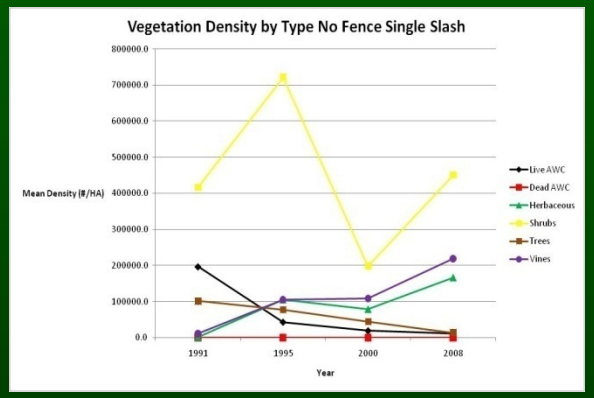
PENN SWAMP

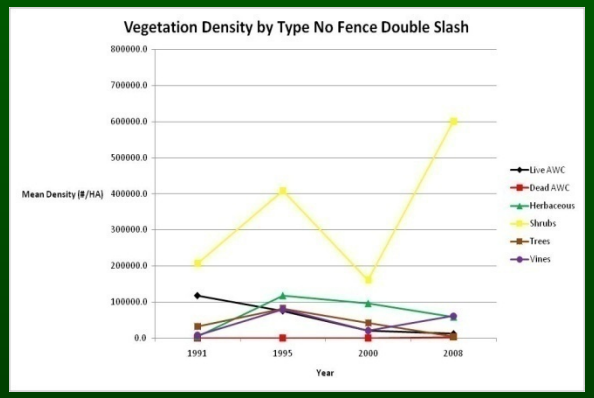




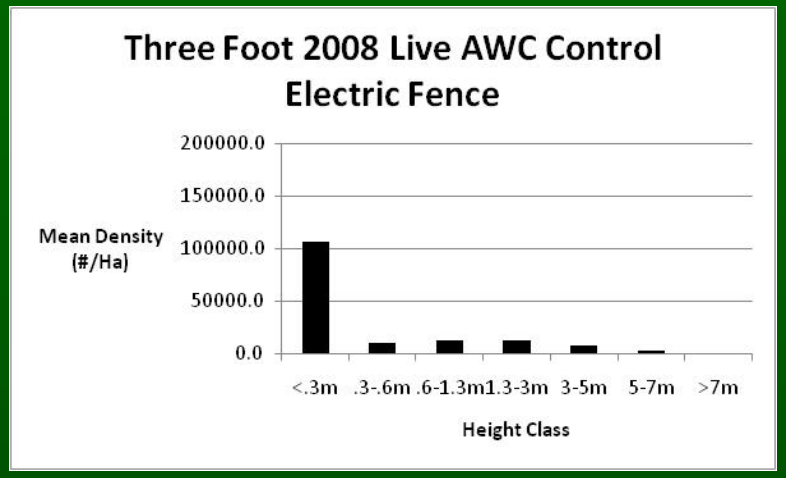


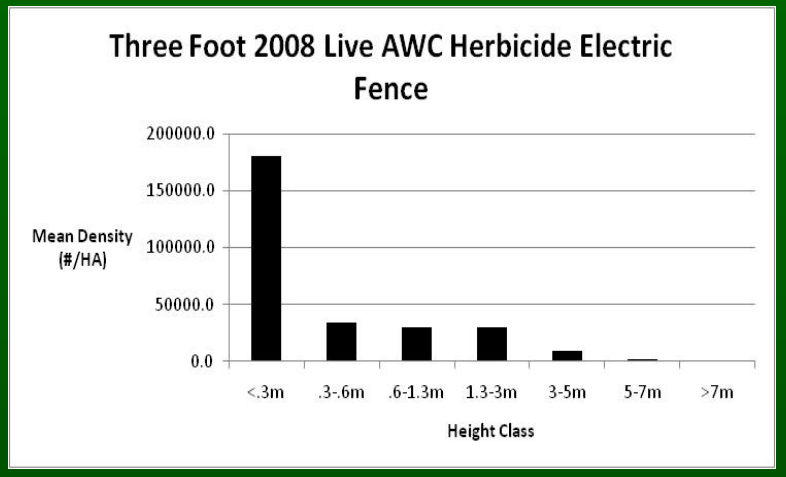


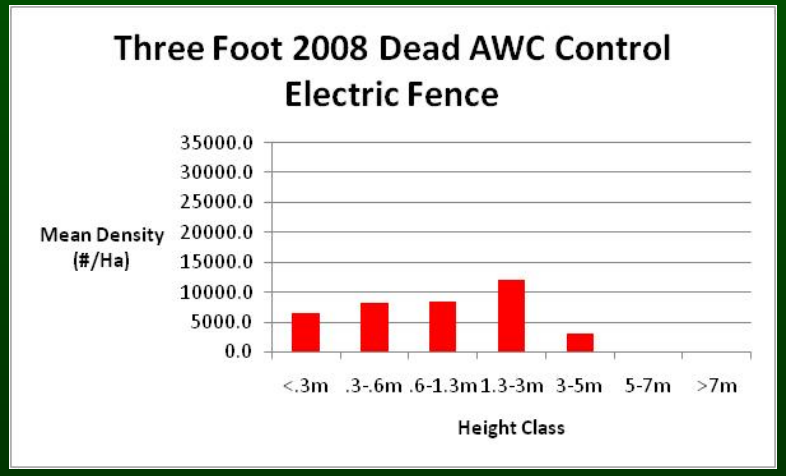


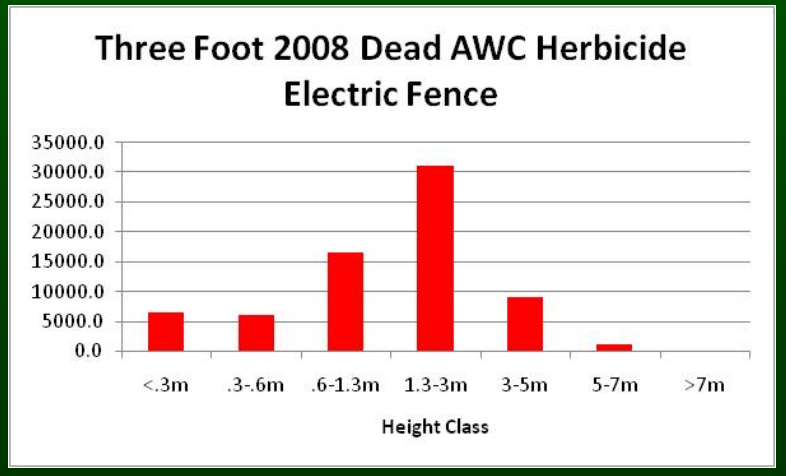


PENN SWAMP same scale

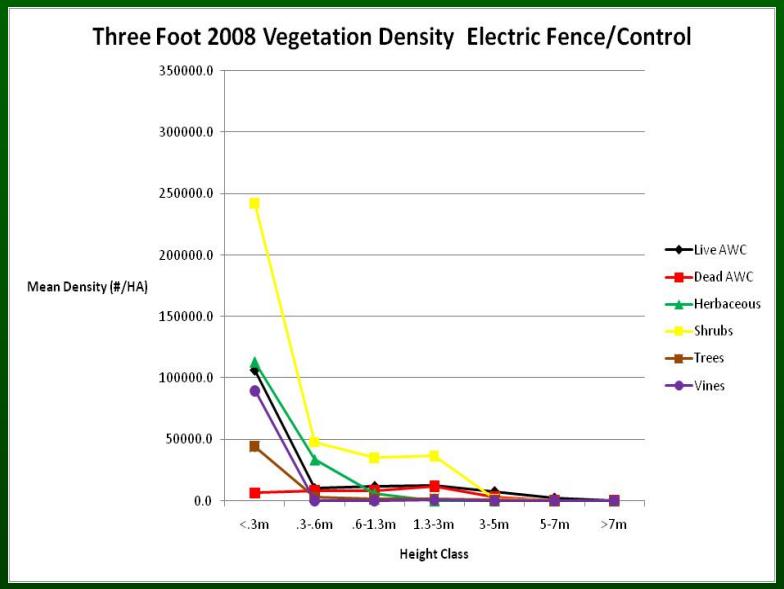


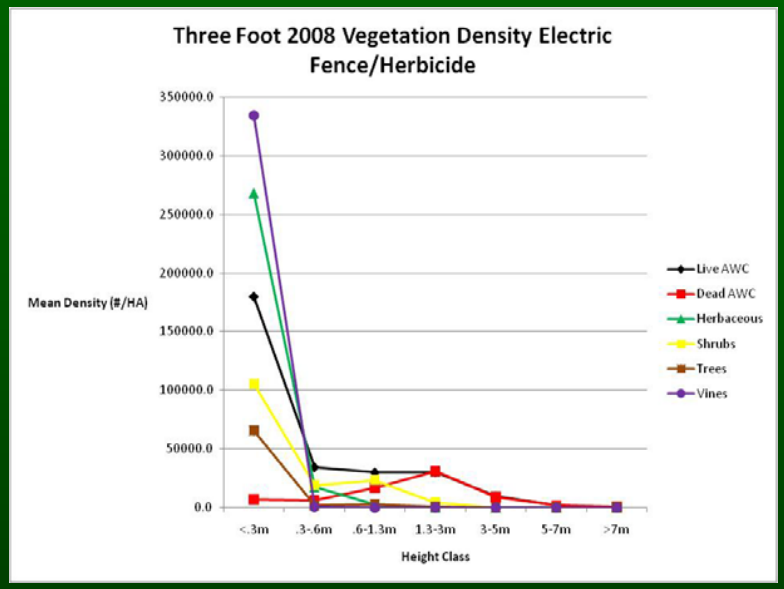




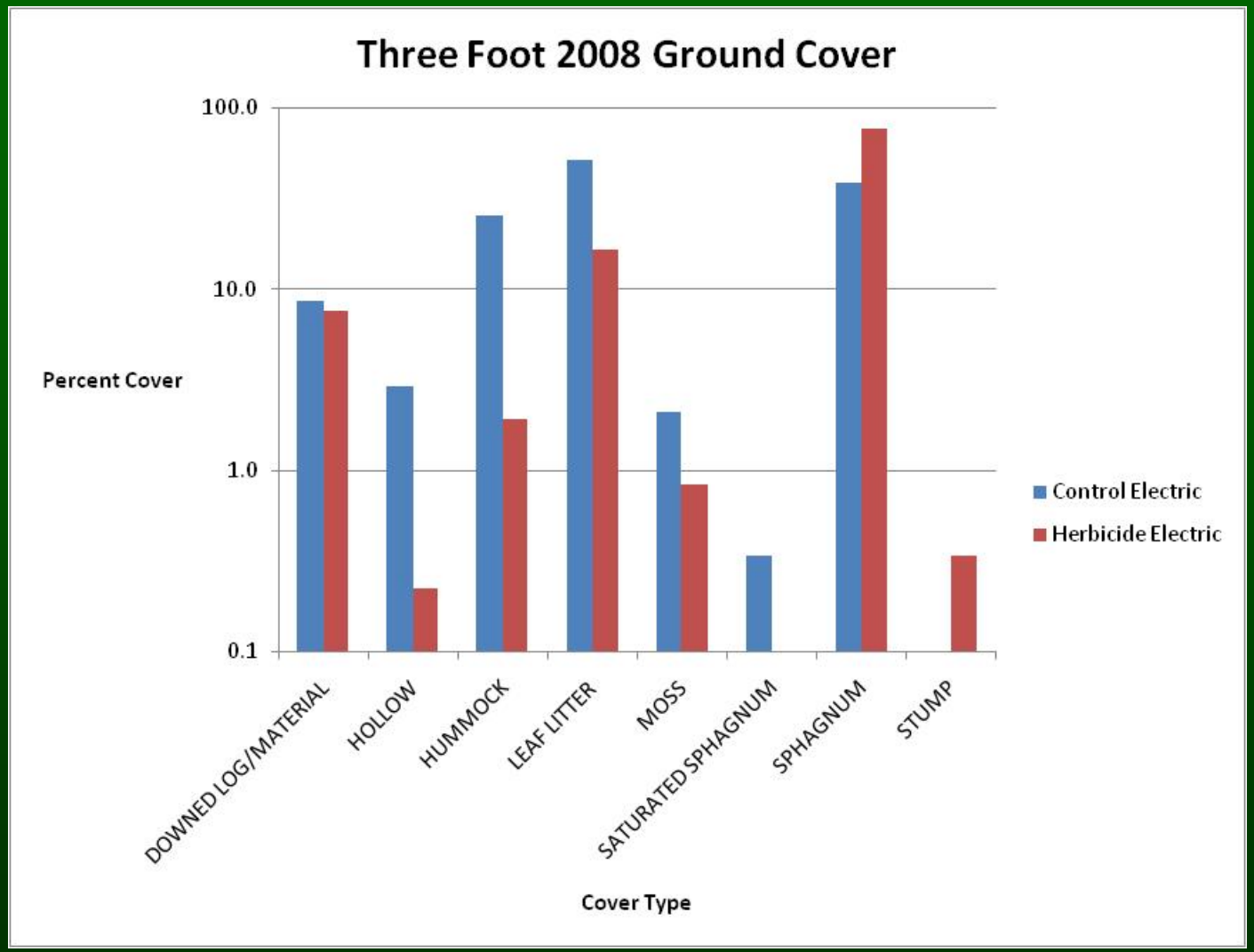


Three foot AWC

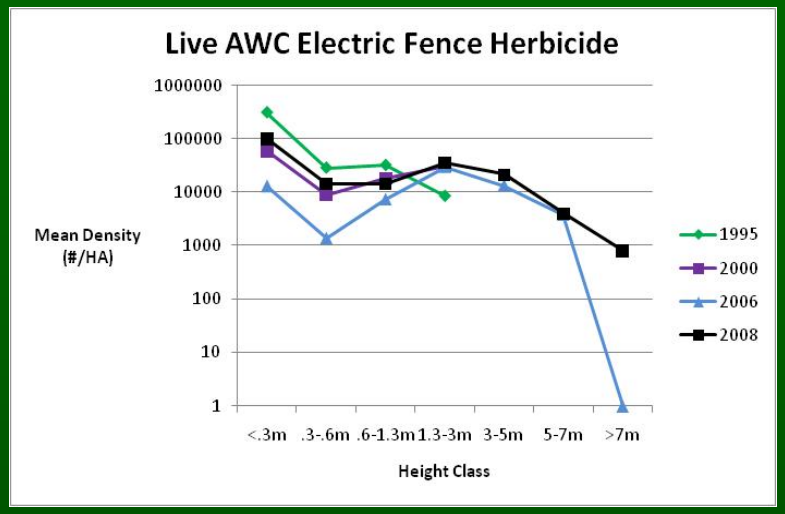


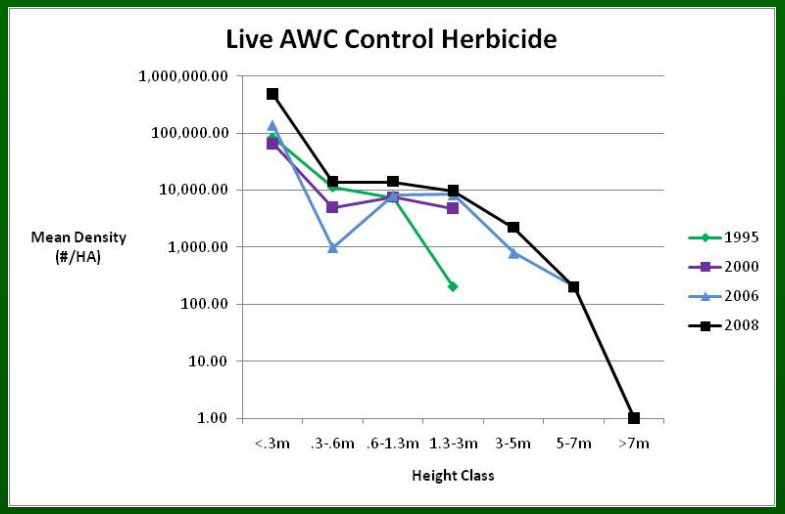


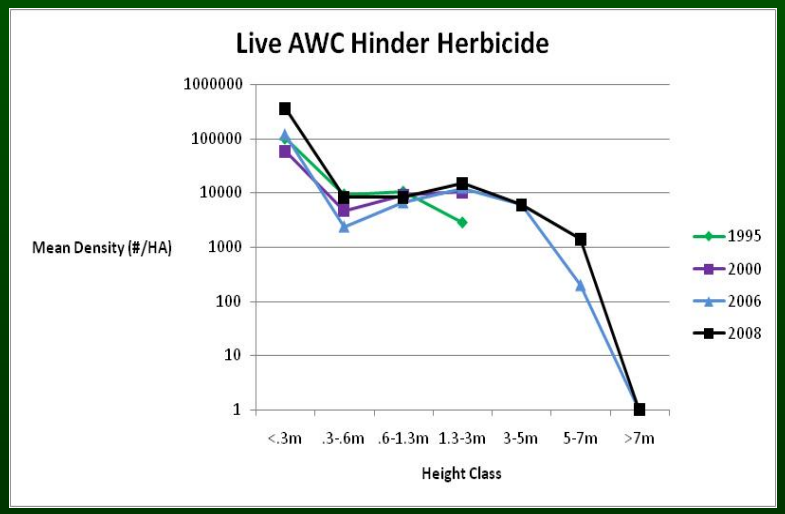
Three foot all veg 2008

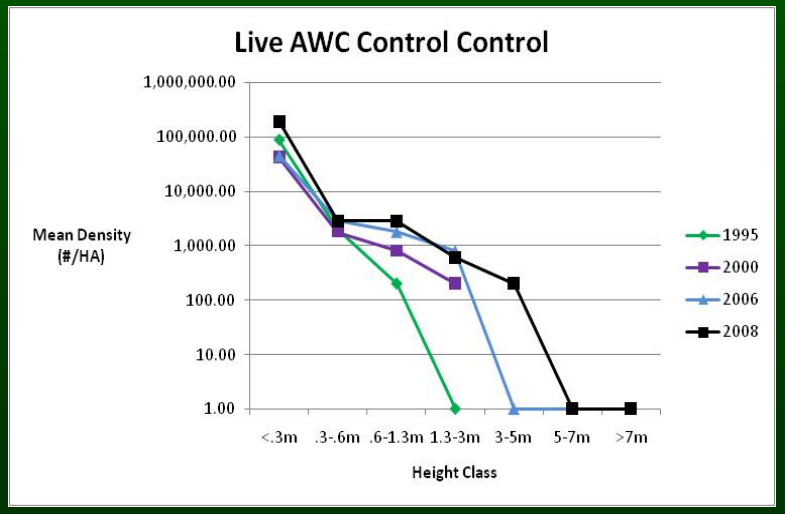


Three foot ground cover 2008

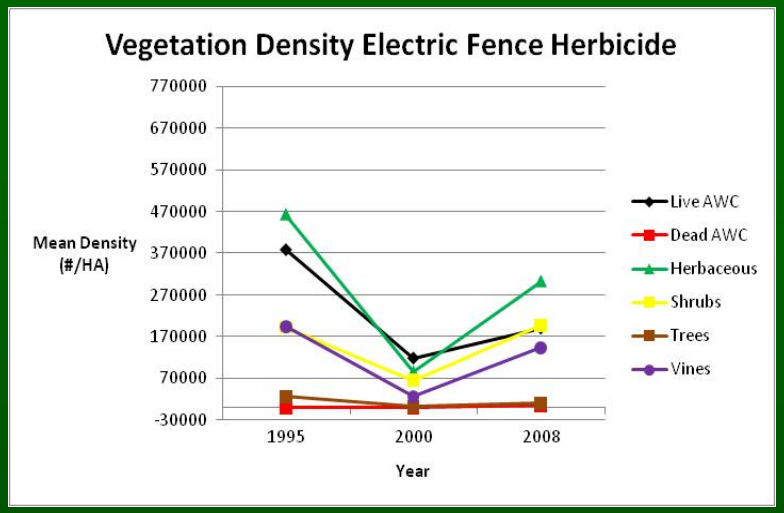

Live AWC Electric Fence Herbicide
Mean Density (#/HA)
1000000
100000
10000
1000
100
10
1
<.3m
.3-.6m
.6-1.3m
1.3-3m
3-5m
5-7m
>7m
Height Class
1995
2000
2006
2008

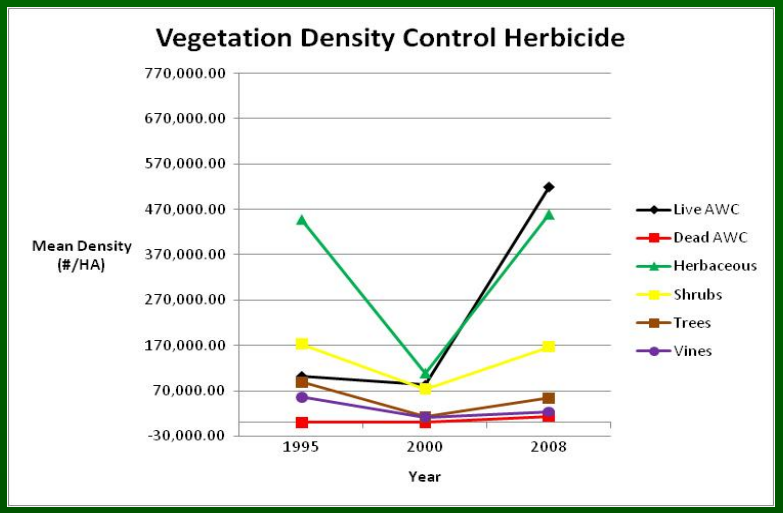

Live AWC Control Herbicide
Mean Density (#/HA)
1,000,000.00
100,000.00
10,000.00
1,000.00
100.00
10.00
1.00
<.3m
.3-.6m
.6-1.3m
1.3-3m
3-5m
5-7m
>7m
Height Class
1995
2000
2006
2008

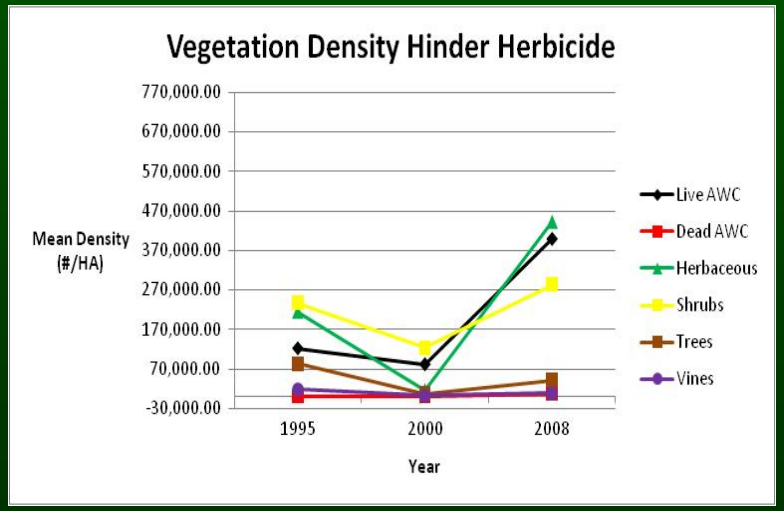

Live AWC Hinder Herbicide
Mean Density (#/HA)
1000000
100000
10000
1000
100
10
1
<.3m
.3-.6m
.6-1.3m
1.3-3m
3-5m
5-7m
>7m
Height Class
1995
2000
2006
2008

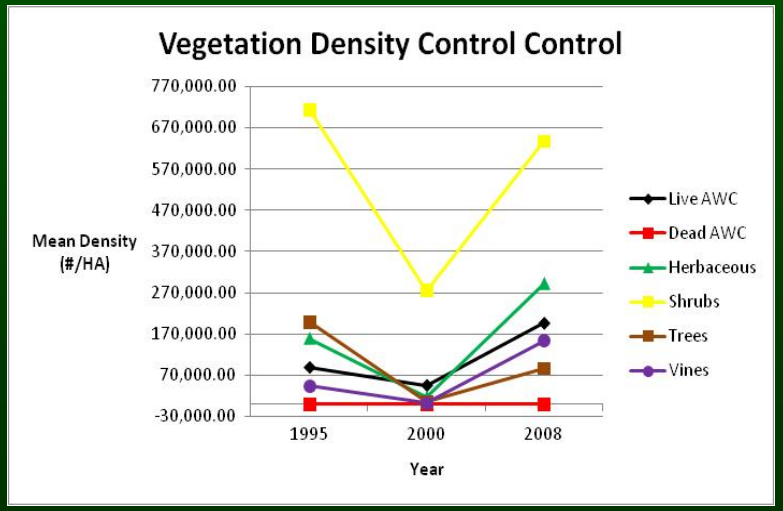

Live AWC Control Control
Mean Density (#/HA)
1,000,000.00
100,000.00
10,000.00
1,000.00
100.00
10.00
1.00
<.3m
.3-.6m
.6-1.3m
1.3-3m
3-5m
5-7m
>7m
Height Class
1995
2000
2006
2008

Colletti


Vegetation Density Electric Fence Herbicide
770000
670000
570000
470000
370000
270000
170000
70000
-30000
Mean Density (#/HA)
1995
2000
2008
Year
Live AWC
Dead AWC
Herbaceous
Shrubs
Trees
Vines


Vegetation Density Control Herbicide
770,000.00
670,000.00
570,000.00
470,000.00
370,000.00
270,000.00
170,000.00
70,000.00
-30,000.00
Mean Density (#/HA)
1995
2000
2008
Year
Live AWC
Dead AWC
Herbaceous
Shrubs
Trees
Vines


Vegetation Density Hinder Herbicide
770,000.00
670,000.00
570,000.00
470,000.00
370,000.00
270,000.00
170,000.00
70,000.00
-30,000.00
Mean Density (#/HA)
1995
2000
2008
Year
Live AWC
Dead AWC
Herbaceous
Shrubs
Trees
Vines


Vegetation Density Control Control
770,000.00
670,000.00
570,000.00
470,000.00
370,000.00
270,000.00
170,000.00
70,000.00
-30,000.00
Mean Density (#/HA)
1995
2000
2008
Year
Live AWC
Dead AWC
Herbaceous
Shrubs
Trees
Vines

Colletti