Habitat Manipulations for Arthropod Pest Management: Biological Controls

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“Designing Landscapes to Produce Ecosystem Services”

Lovell and Johnston. 2009, Ecol. & Society 14: online #44.

- Opportunities: design multifunctional elements throughout landscapes
- Increase spatial heterogeneity - adding semi-natural landscapes
- Patch, corridor, matrix: focus on P & M
- Agric. ex.: fencerows, woodlands, hedgerows, live fences, riparian buffers…
- Urban: wetlands, yards, gardens, stormwater handlers, green spaces, roads…

Increasing biodiversity and landscape heterogeneity. Redundancy leads to stability.
Diversifying the Agro-ecosystem, Exploiting Habitat Structure & Function, Designing pest-stable environments, “Putting the Ecosystem to Work”

- Any type of habitats: hedge rows, shelter belts, backyards, rain gardens, etc.
- Inside or outside cropping areas
  - cover crops
  - inter- companion- plantings
  - trap cropping
- Multifunctions
- Associational resistance
Function vs Philosophy - practical vs dogma -

• Native plants vs exotics
• “Rising tide effects all boats”
  – augmentation of biological controls
  – targeted pest suppression
• Something that is doable and works
• Net positive – few side effects
• Customizable but “idiot proof”
Understory and Vegetation Management in Crops

- Cover crops
- Trap crops
- Intercrops
- Season – key to functions
- Think spatio-temporal!
Functions of Cover Crops

- Erosion prevention
- Nitrogen enhancement
- Soil organic matter increase
- Augmentation of beneficial arthropods
- Vegetation suppression

Adding plant species to a habitat changes it: Improves or disturbs??
Side Effects of Cover Crops

- Pest increases
  - Nematodes
  - Arthropods
- Invasive weed outbreaks
- Competition for nutrients, water
- Increased costs - establishment
- More intensive mgmt – timing
- Unexpected consequences?
Examples

Cover and Trap Crops In Pecan

Cover crops - hairy vetch and red clover, spring - aphids

Jim Dutcher, UGA, pecan, fall-stink bugs
Fall Cover and Spring Augmentation Crops

Crimson clover is not so tolerant of shading or mowing as is subterranean clover. Photo by Bob Bugg.

Hairy vetch and crimson clover may be used as cover crops in pecan orchards. Tifton, GA. Photo by Bob Bugg.
RI Fire Ants - “Ant” in the Ointment. Can Be a Problem!

- Beneficials
- Cover crops
- Other ant spp.
- Pesticides: mound drench, bait, trunk spray
- Ant pest suppression: PW, HSW, NC (do trunk only)
- Eat lacewing eggs and others
Ex. Target - Mole Crickets

- Introduced (invasive, exotic) turf pests
- Classical biological control
  - Natural enemies in native country
  - Parasites, predators, pathogens
- Nematodes, fly *Ormia* sp.
- *Larra bicolor*, parasitic wasp
- *Spermacoce verticillata* plant
Larra bicolor &

a Nectar Source is

Spermacoce verticillata

Abdomens:

males larger & orange,
females are reddish
R. Mizell, Crape Myrtle Beauty With Biological Control

- Crape myrtle less susceptible to weather
- Crape myrtle aphids – host specific
- Occur in summer – other species low
- Exotic – non preferred
- Honeydew
- Support native beneficials
- Lady birds, brown and green lacewings, wasps, bigeyed bugs, minute pirate bugs, assassin bugs, others.
Crape Myrtle: Before and After the Arrival of New Lady Beetles.

• Natives used the exotic aphids extensively

• *Harmonia axyridis* and *Coccinella septempunctata* arrived in 1993

• Broad habitat and prey host range

• Out compete native predators for aphids

• Reduced numbers of native beneficials until by 2000 very few natives were observed

• Side effects of classical biological control
Effects of *H. axyridis* on Natives

- Direct - head to head competition - low
- Indirect competition for food, finding, converting
- Breadth of habitats and hosts
  - Bottlenecks – weather extremes
- Red imported fire ants – competitive edge?
- Chemical pesticides
- Physiology
- Now #1 APHID Predator in pecan and other crops in most places!
Beneficials

In 1984, 85

Herbert & Mizell. 2009. EE

NO parasites!

Percentage of Lacewing pupae emerging to adult – ad libitum diet

Figure 3-3. Percentage of lacewing emerging on ad libitum diet with orthogonal contrasts for the cultivars ‘Byers Wonderful White’ (BW), ‘Carolina Beauty’ (CB), ‘Apalachee’ (Apa), ‘Natchez’ (Nat), ‘Sioux’ (Sio), ‘Tuscarora’ (Tus), and ‘Lipan’ (Lip). Columns followed by different levels are different at P<0.05 Tukey’s HSD. Contrasts marked by asterisks such that *P<0.05; **P<0.01.
Monticello Pecan Orchard

Seasonal Abundance of *H. axyridis*

![Graph showing seasonal abundance of Harmonia axyridis](image)
Crape Myrtle Cultivars for Augmentation of Beneficials

- ‘Biloxi’: highest CMA, negatives unknown
  - tall, pink, resistant to powdery mildew (PM)
- ‘Comanche’: highest CMA, negatives unknown
  - medium, pink, resist. PM
- Tuscarora’: med-high CMA,
  - best tested on lacewings,
  - tall, pink, resist. PM
Heteroanthericity
Anthers of Two Types

John Herbert’s Dissertation
Syrphid Flies Use Crape Myrtle Pollen
Major Native Pollinators Found on Crape Myrtle

- **Bombus fraternus**
  - *Apidae*

- **Bombus impatiens**

- **Agapostemon splendens**
  - *Halictidae*

- **Colletes spp.**
  - *Colletidae*

- **Xylocopa micans**
  - *Apidae*

- **Xylocopa virginica**
Pollinators on Crape Myrtle

Bombus fraternus

Asilidae: Laphria sp.? Mimic?
Honey Bees Use Crape Myrtle

NOTE: We have 3-5 other smaller bee species that remain to be identified from crape myrtle.
Conclusions

- Crape myrtle CV is important and affects use by each species of bee
- Landscape augmentation - species specific
- Native and non-natives affected
- Crape myrtle appears to be heavily used by both groups
- Important landscape component as exotic
Extrafloral Nectaries

Plant Nectar Source
Not on the Flower

Pub. available @:
http://edis.ifas.ufl.edu/in175
Plant Extrafloral Nectaries
Selected Species w/ EFN
EFN - Used By Other Insects
Plant Extrafloral Nectaries

Elderberry, *Sambucus* sp.
Extrafloral Nectaries Facts
(EDIS pub: http://edis.ifas.ufl.edu/in175)

• 2000 plant species have them
• Location: leaf laminae, petioles, brachys, stipules, pedicles, fruit, etc.
• Size, shape and secretions vary by species
• Flow rate and occurrence: pattern, fruiting
• Vines: high frequency of EFN – ant “roads”
• Nutrients – differ from floral nectar
Extrafloral* vs Floral Nectaries: Chemical Content

• Amino acids: EFN have more:
  – Cysteine group, lysine, asparagine, tyrosine, methionine

• Proteins

• Sugars similar- sucrose, fructose, glucose

• Fatty acids (lipids)

** Other such plant structures: domatia, Beltian and Mullerian bodies
What Florida Plants Have EFNs?

- Passion flower, *Passaflora spp.*
- Elderberry, *Sambucus* spp.
- Fruit trees, *Prunus* spp., peach, wild cherry
  - Single gene in peach, “JunePrince’ none
- Common vetch, *Vicia* sp.
- Partridge pea, *Cassia* spp.
- *Hibiscus* spp.
- Beans- *Phaseolus* spp., many legumes
- Cotton cvs
Multifunctional Plots
Pollinators, Natural Enemies, Butterflies, Wildlife, Trap crop, Cover crop
Trap Crops

Example used to impart the underlying mechanisms.

Mechanisms also apply to augmentation of beneficials.
4 Major Species of Stink & Leaffooted Bugs In Southeast

- *Euschistus servus*
- *Nezara viridula*
- *Chinavia hilaris* (was *Acrosternum hilare*)
- *Leptoglossus phyllopus*
Other Common Phytophagous Stink Bugs

Euschistus
Thyanta
Banasa
Oebelus
Proxs
Brochymena
*Piezodorus
*Halyomorpha
*Megacopta

*New invasive species - bad
Common Stink Bug
Immature Life Stages
Other True Bugs

Largus succinctus L.

Acanthocephala femorata
Predacious Stink Bugs & Other Good Bugs

From lower left:
Alcaecorrhynchus grandis
Podisus maculiventris
Euthyrhychus floridanus
Apiomerus floridensis
Phytophagous vs Predacious

Plant feeder ‘phytophagous’

Predator
Stink Bug Natural Enemies
Wasp Egg Parasites & Tachinid Flies
Understanding Bug Behavior & Dynamics

- Phenology
- Food quality
- Movement
- Landscape level processes
  – structures
  – corridors, barriers, matrices
  – ‘edge effect’ strong
Temporal and Spatial Distributions

Where are the bugs in space and time?

Think spatio-temporally!
Florida Stink Bug Trap
Dr. Russell F. Mizell, III, Inventor

- Captures many Hemiptera species
  - Both phytophagous and predacious
- Visual attraction is primary
- Baits can be easy deployed
- Materials: 4 right triangles
  - 1/4” masonite, screen wire,
  - 1/4” x 4’ metal rod, twist ties
- “Triangle’s dimensions:
  - 4’ high, 11” base, 1” top
- Deploy in the open
NFREC-Quincy Location

Looking at *Euschistus* spp.
Locations with High Populations of *Euschistus servus* (scale neutral)
Movement Mechanisms?

What is driving the behavior?

How can we exploit it?

Think spatio-temporal!
Differential Use of Sorghum Growth Stages by *E. servus* and *L. phyllopus*

**Mean *E. servus* per Sorghum Head**

- *E. servus* adults
- *E. servus* nymphs

**Mean *L. phyllopus* per Sorghum head**

- *L. phyllopus* adults
- *L. phyllopus* nymphs
Some Crop Plant Examples Follow.

See accompanying handout for list of other species by function.
Triticale for Spring

- Fall, early spring planting
- Range in hgt, phenology - cvs
- Beneficials
- All 4 bug species +
- Ratoons
- Hairy/common vetch + crimson clover = beneficials

**Beneficials = natural enemies, pollinators**
Buckwheat

• Cheap, easy
• Fast maturing – 4-5 wks
• Ratoon, easy plant
• Soil temp, frost – good
• All 4 species +
• Organic crop
• “RELAY” crop
• Beneficials!!
Sorghum

• Maturity - 70-90 days
• Soil temp & frost - kills
• Ratoons well
• Germplasm – variable
• All 4 species +
• Beneficials
• Pots
• Organic
Pearl Millet

- Cheap, easy
- Low soil temp & frost - bad
- Ratoons
- 70-90 days to maturity
- Beneficials
- Pots
- Germplasm - variable
- Organic crop
- All 4 species +
Sunflower

- Cheap, easy
- Low soil temp & frost - good
- Beneficials!!!!!
- Containers
- Germplasm - variable
- Organic crop, biodiesel
- Ratoon - no
Japanese Millet: ’Barnyardgrass’

Echinochloa crus-galli

• Cheap, easy
• Maturity 6-7 weeks
• Beneficials
• Containers
• Germplasm
• All 4 species +
• Short attraction time
• 3-4’ in height
• Can be invasive - aquatic
Other Species w/Potential? Field Peas & Okra

Field Peas
• Cheap - easy
• Extrafloral nectaries
• Previous work+
• Height-short; trellis?
• Cultivars

Okra: (containers)
• Cheap, must manage!
• Beneficials, EFN
• Rootknot nematodes neg.
• Ratoons
Other Species w/Potential?
Hemp Sesbania (Y/N?),
Hairy Indigo, \textit{Crotolaria} – (N)

Hemp Sesbania: ??
• Height – tall - barrier
• Not all SB species
• \textit{Oebalus} spp.
• Invasive

Hairy indigo – weedy, nematode suppressor+

Showy Crotalaria - poisonous to cattle
Other Species w/Potential?
Browntop Millet – No; Wildlife

- Cheap, easy
- Doesn’t last long
- 5-6 weeks
- Height - short
- Attracts beneficials, pollinators
- +Oebalus spp.
- Weedy - invasive
### Research: Multifunctional Plots Augment Ecological Services?

Handout Provided

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<th>Common Name</th>
<th>Season of Service</th>
<th>Pollinators</th>
<th>Beneficial Insects²</th>
<th>Butterflies</th>
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Mechanism

• Food quality very important!!!
  – not “preference”*, generalists
• Life stages and species differ somewhat – very close
• Phenology (timing) related statistic
• Driving variable!

• Application – tools, trap crops
Trap Crop Approach

- Small area w/ highly competitive hosts
- Economical - $$$
- Strategic placement (GIS/GPS)
  - adjacent (?) to cash crops (Potting et al. 2005)
  - must intercept them!!!!! Think Spatio-Temporal!
- Minimize side effects & mgmt difficulties
- Combine with other tactics
- For all growing seasons
# Cash Crop-Trap Crop Coincidence (phenology)

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<th>Apr</th>
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Characters: maturity date, longevity, ratooning, other

Think Spatio-Temporal!
What Are the Ideal Features of Trap Crops?

- Attract required pests (multiple species)
- Seeds available (natives?)
- Economical -$$$
- Culture & management - seasons
- Minimal side effects (invasive, other pests)

Think Spatio-Temporal!
Trap Crop Ideal Features, cont.

- Maturity time – length, cv range
- Good duration (ratooning)
- Height – barrier
- Interception – before enter food crop
- Multi-functions (beneficials, poll., wildlife)
- Special note*: native vs exotic plant use

Must have something that works!
Trap Crop Specifics

Fall-Spring:
• Triticale (crimson clover, h or c vetch (F)- NE)
• Sunflower, buckwheat (Sp), barnyard grass

Spring-Fall
• Sorghum, millets, sunflower, buckwheat
  – barnyard grass, field peas, okra (pots?),
• Maturity times – multiple CVs
• Ratoon – after heading
• Use multiple tactics
Trap Crop Novel Features

• Ratooning = **Mowing**
  – At strategic time
  – All plant species **NOT** amenable
  – Saves plantings by extending efficacy
  – Saves $$ - less input time & costs
  – Negative: same location – double cropping
How to Exploit Sorghum Maturity Range & Ratooning

Physical attributes - cvs? Height, color, etc.
Where do you place them relative to the cash crop for interception?
Containers for Portability, Visual/chemical Cues Enhance

Yellow trap – Attraction - 4X increase in *H. axyridis*
Some Other Ideas

Physical properties, barriers:

- **Height**: trap crop via cultivar selection
- **Configuration of plants**
  - short to tall toward cash crop
  - density of trap crop plants
- **Trellis of vines like field peas**: height
- **Exploit visual components**
  - Use of visual repellent – UV mulch
  - Use best colored cultivar
- **Artificial materials**: netting, etc.
Trap Crop Spatial Orientation
Interplanting- NO!!!
Edge Interception – Yes!

Think Spatio-Temporal!
Spatial Configurations
Aerial Plats

Unknowns
Default – Ring It

With Knowledge:
Source- Sink Approach

Cash
Crop

Open fields

Plot size: one tractor implement width

Think Spatio-Temporal!
Management in the Trap Crop

- Insecticides?
- Mechanical
  - by hand
  - sweep net
- Vacuum device
- Blower – catcher

4’ x 7’ PVC frame with netting + blower
Containers as Portable Trap Crops and Monitoring Methods
Trap Crop Summary

Fall-Spring:
- Triticale (crimson clover, hairy vetch) (F)
- Sunflower, buckwheat (Sp)

Spring-Fall
- Sorghum, millet, sunflower, buckwheat
  - okra, field peas, others
- Multiple species and cultivars
- Ratoon – after heading
- Portable containers, greenhouse starts
- Remove pests: by hand, vacuum or spray
- Add in other tools: traps, pheromones, BC, etc.
Multifunctional Plots - Mizell

- Beneficials
- Pollinators
- Butterflies
- Trap crops
- Wildlife
Birds-Wildlife
Butterflies & Moths
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Special Comments

• Small parasitic wasp (parasitoids): often require very small flowers to get nectar from; cannot reach into large

• Predator-prey behavior relative to augmentation: general vs targeted
Pest-Natural Enemy Interactions

- Crop characteristics
- Crop diversity
- Temporal arrangement
- Spatial arrangement
- Surrounding environment
- Management intensity

Altieri et al. 1993
Predator and Prey Dynamics
“Lag and Ratios”

Time Units

Number / leaf

Pests
Beneficials
Predator and Prey Dynamics: Change the Average Pest Density

Number / leaf

Time Units

Pests

Beneficials
The End

Thank You!

Questions

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