Turfgrass Culture
An Ecosystem Approach

Parwinder Grewal, Ph.D.
Distinguished Professor and Director

Center for Urban Environment and Economic Development
Ohio State University
Wooster, Ohio

Contents

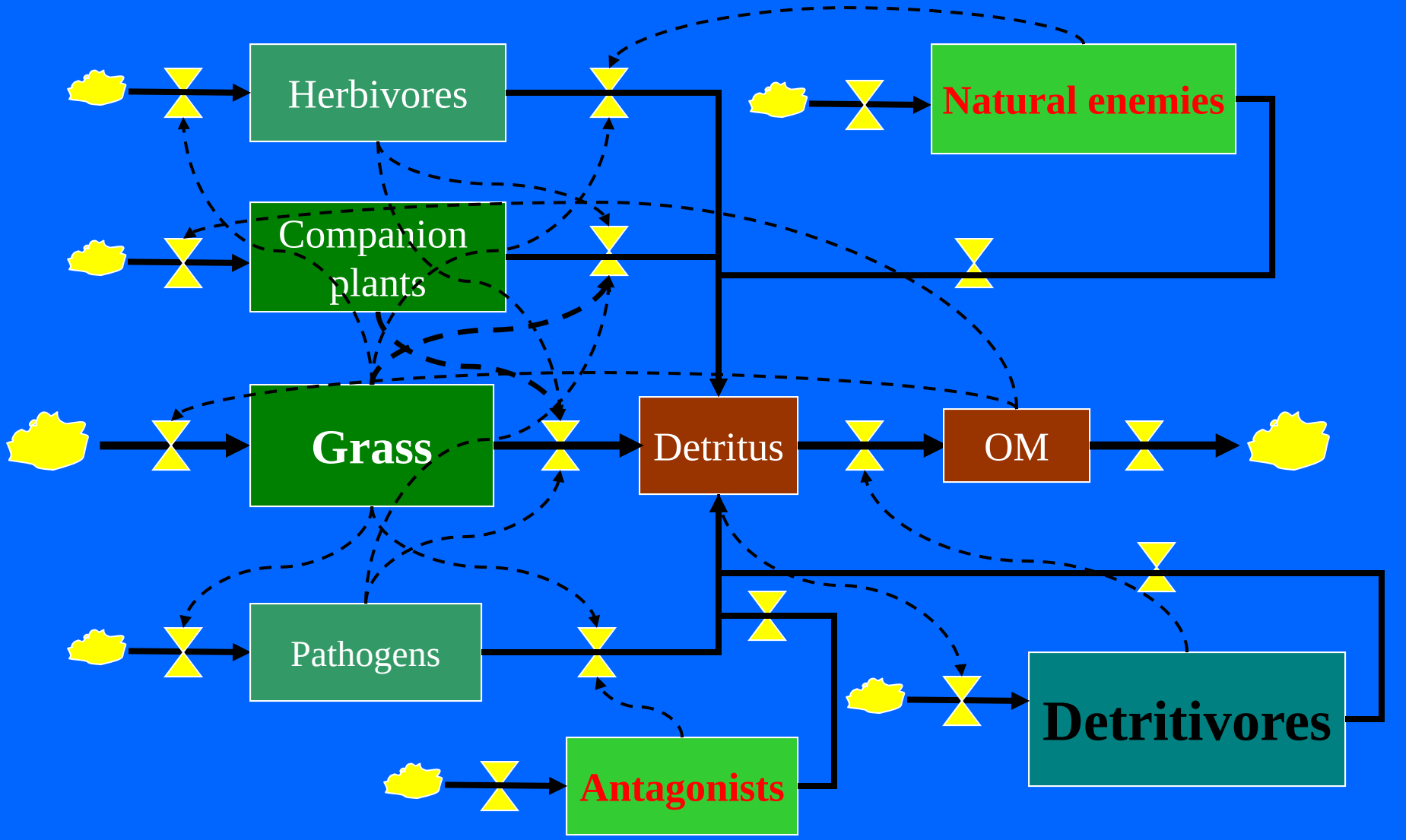
- Introduction
- Urban soils and nutrient management
- Turfgrass and weed competition and the role of mowing
- Mowing and grass resistance to insects
- Insect and weed interactions
- Biological control of insects
- IPM in commercial lawn management

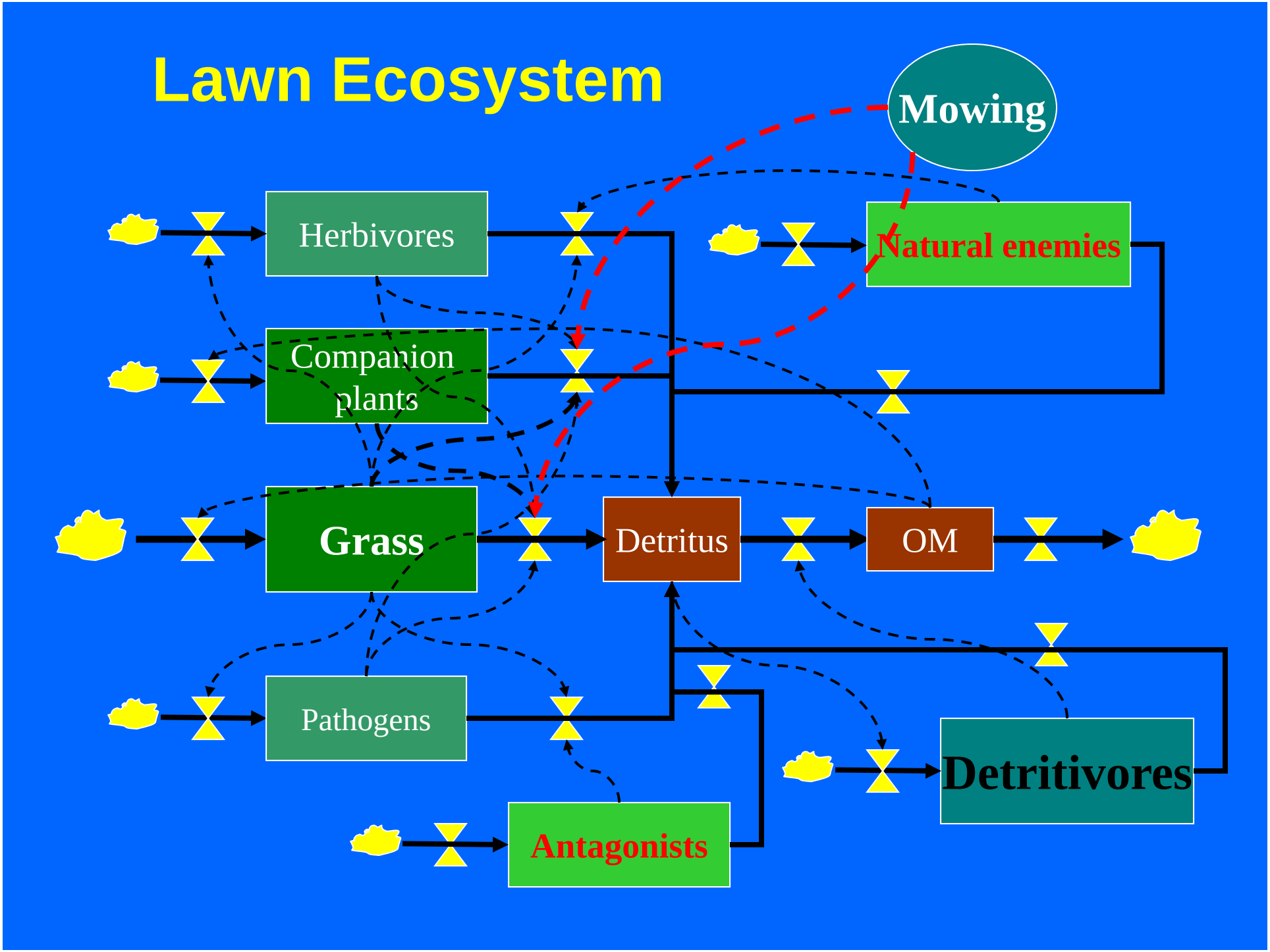
Ecosystem management
is a holistic approach that relies
on the manipulation of
ecological interactions among
system components to enhance
services while maintaining
system sustainability

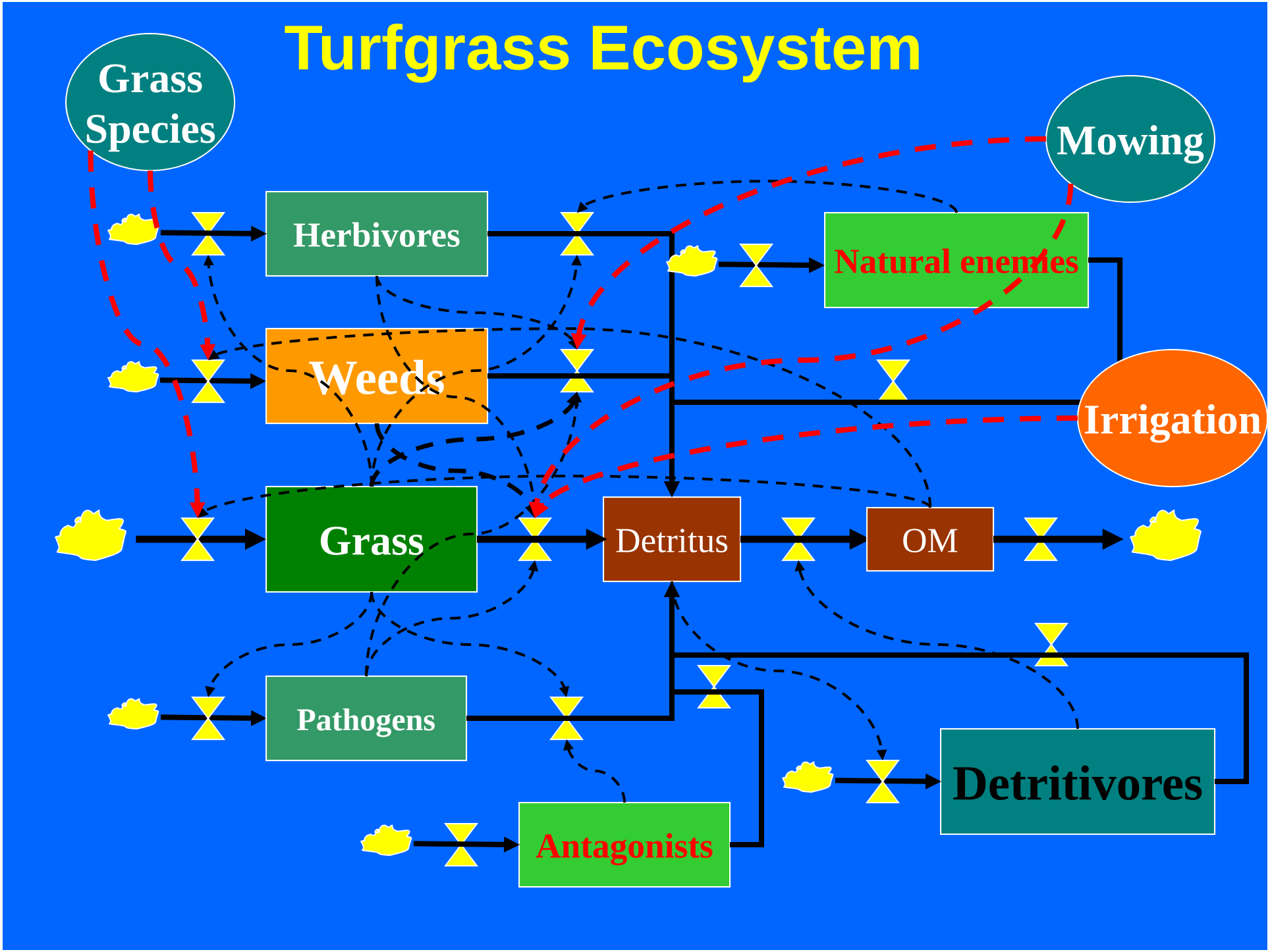
Ecosystems** are complex structures represented by **abiotic** resources and a diverse assemblage of component **species**, their **products** and **function**, represented by **fluxes of energy and matter

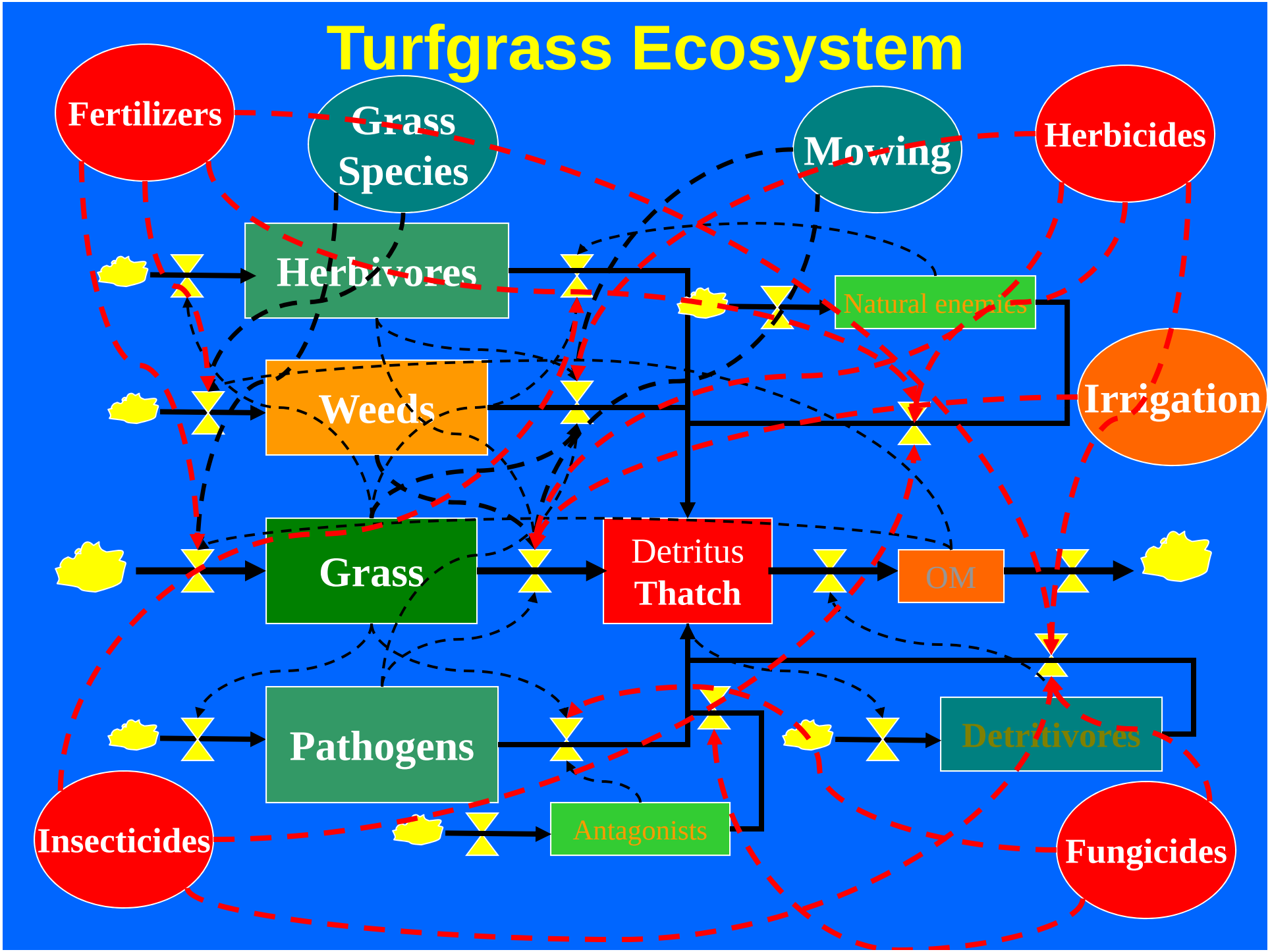
Tracing the evolution of the turfgrass lawn ecosystem

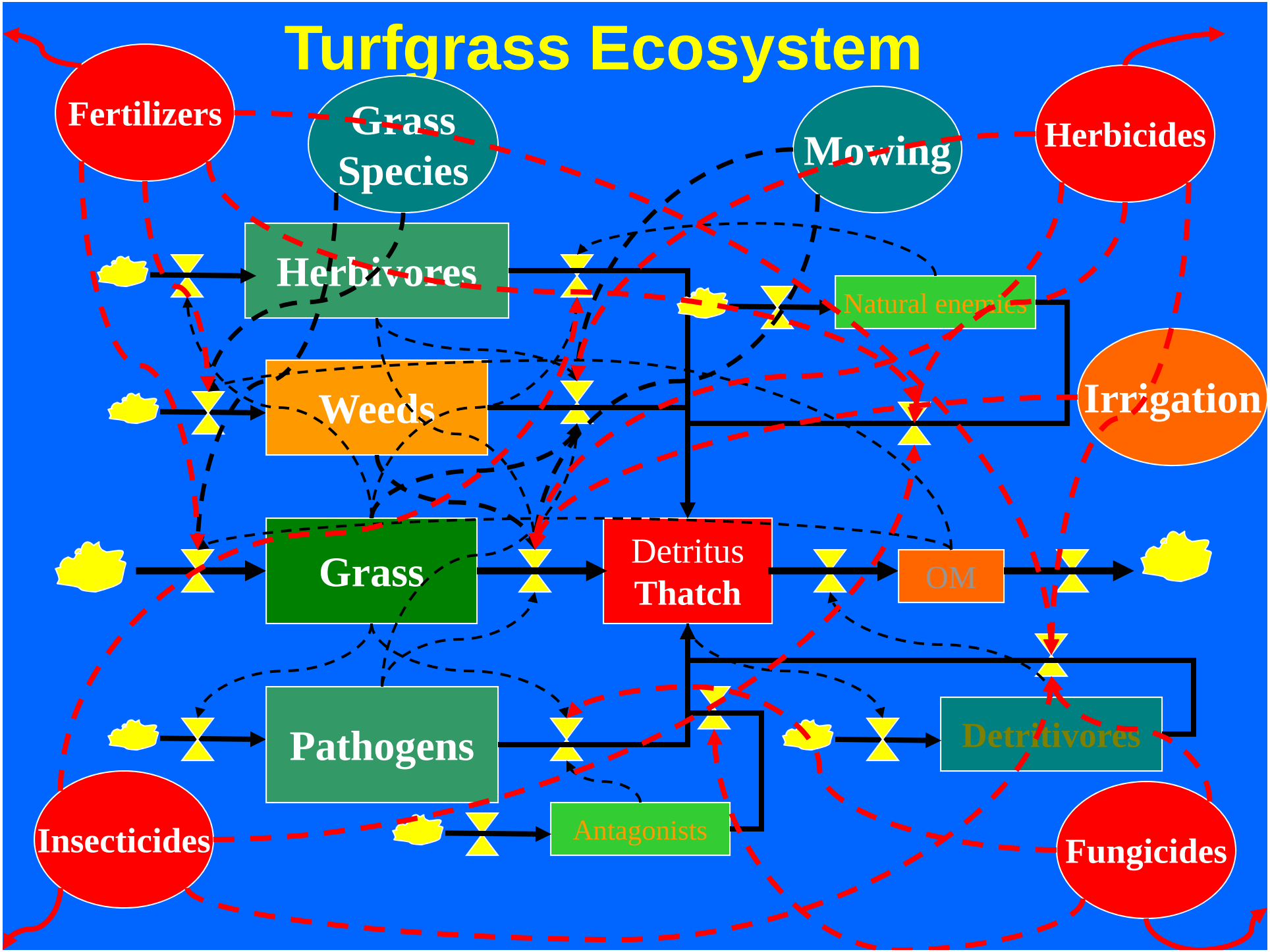
Natural Grasslands

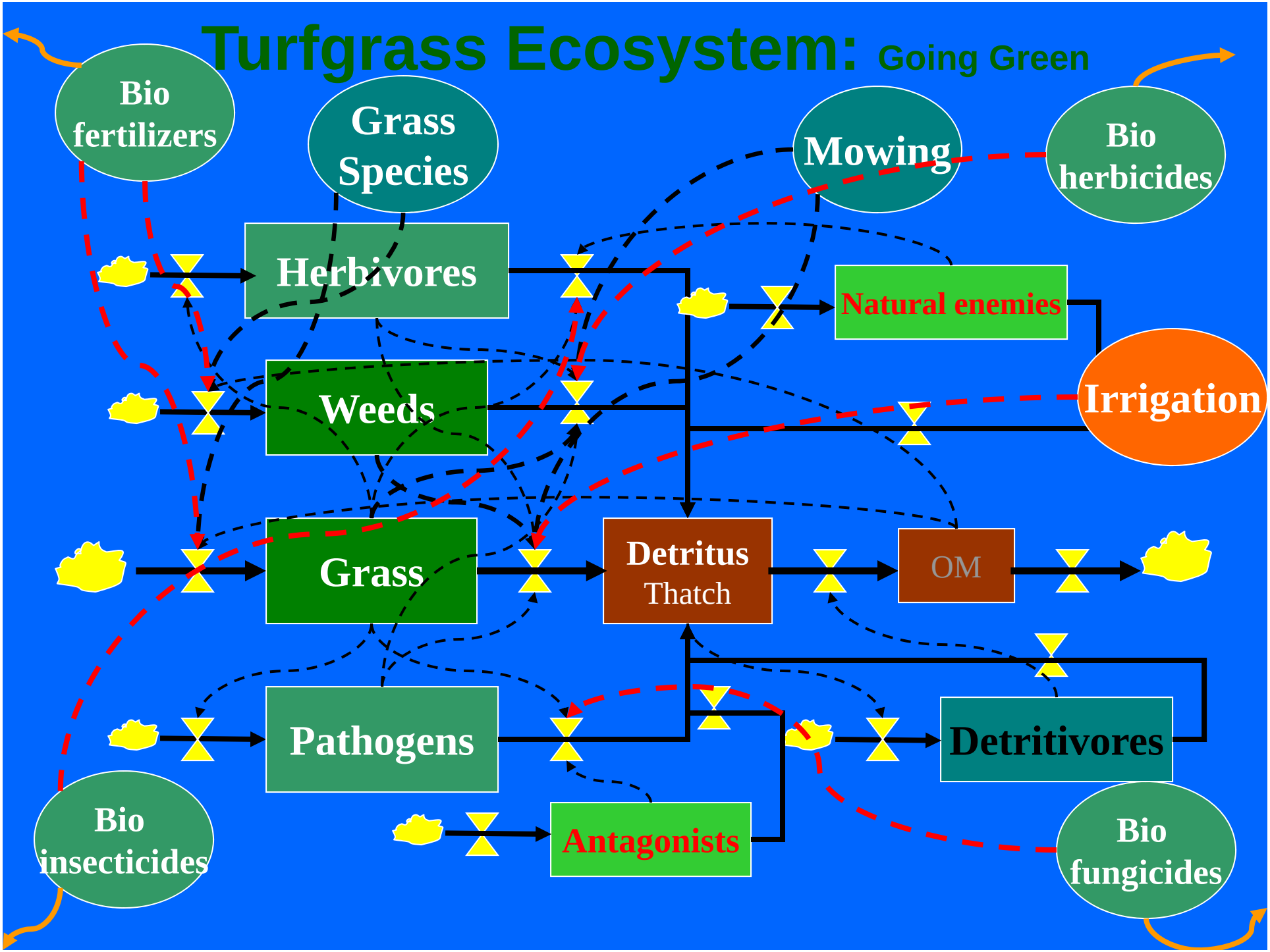


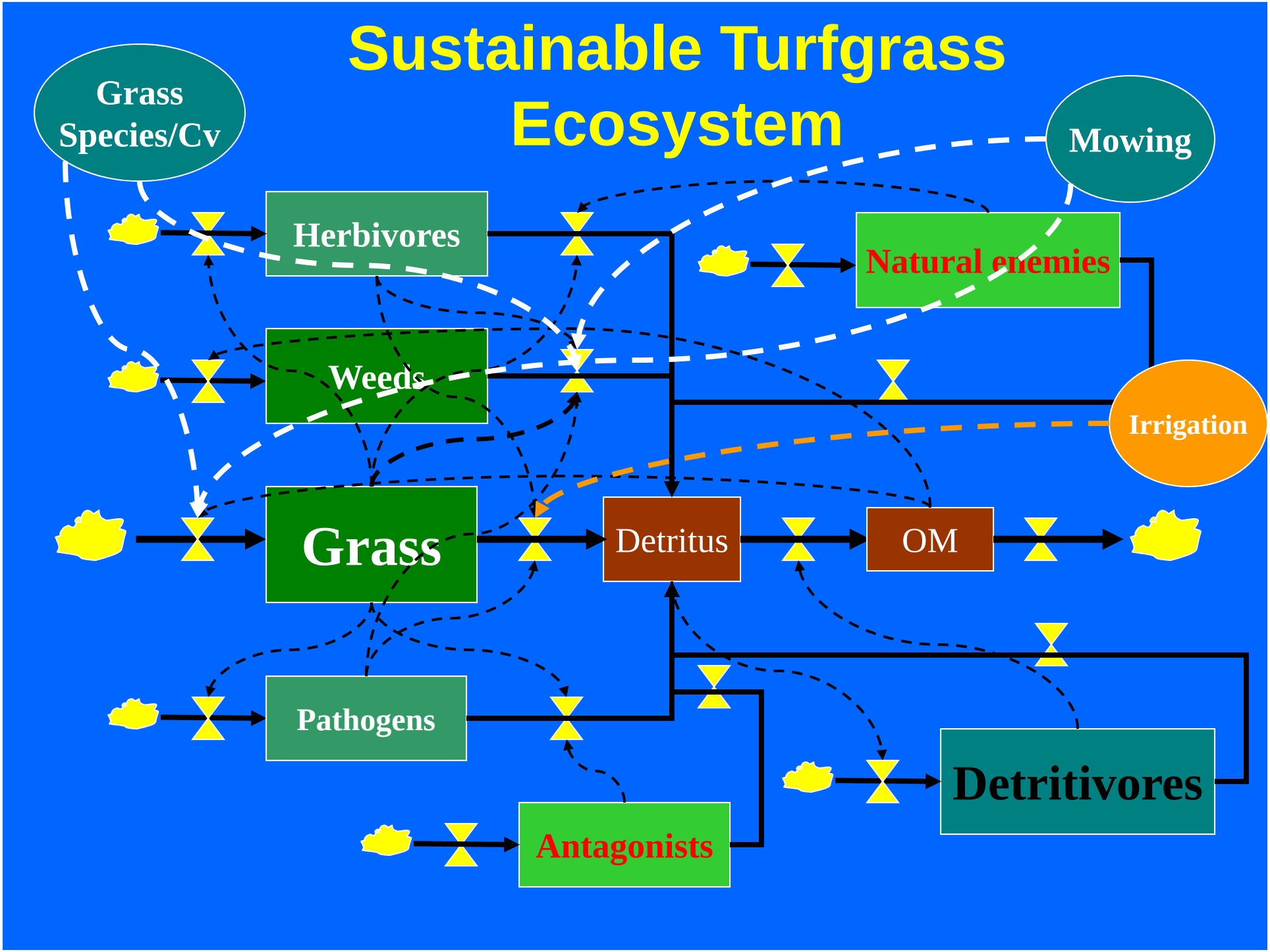

Lawn Ecosystem
Mowing
Herbivores
Natural enemies
Companion plants
Grass
Detritus
OM
Pathogens
Detritivores
Antagonists


Turfgrass Ecosystem
Grass Species
Mowing
Herbivores
Natural enemies
Weeds
Irrigation
Grass
Detritus
OM
Pathogens
Detritivores
Antagonists


Turfgrass Ecosystem
Fertilizers
Grass Species
Mowing
Herbicides
Herbivores
Natural enemies
Weeds
Irrigation
Grass
Detritus Thatch
OM
Pathogens
Detritivores
Insecticides
Antagonists
Fungicides


Turfgrass Ecosystem
Fertilizers
Grass Species
Mowing
Herbicides
Herbivores
Natural enemies
Weeds
Irrigation
Grass
Detritus Thatch
OM
Pathogens
Detritivores
Insecticides
Antagonists
Fungicides

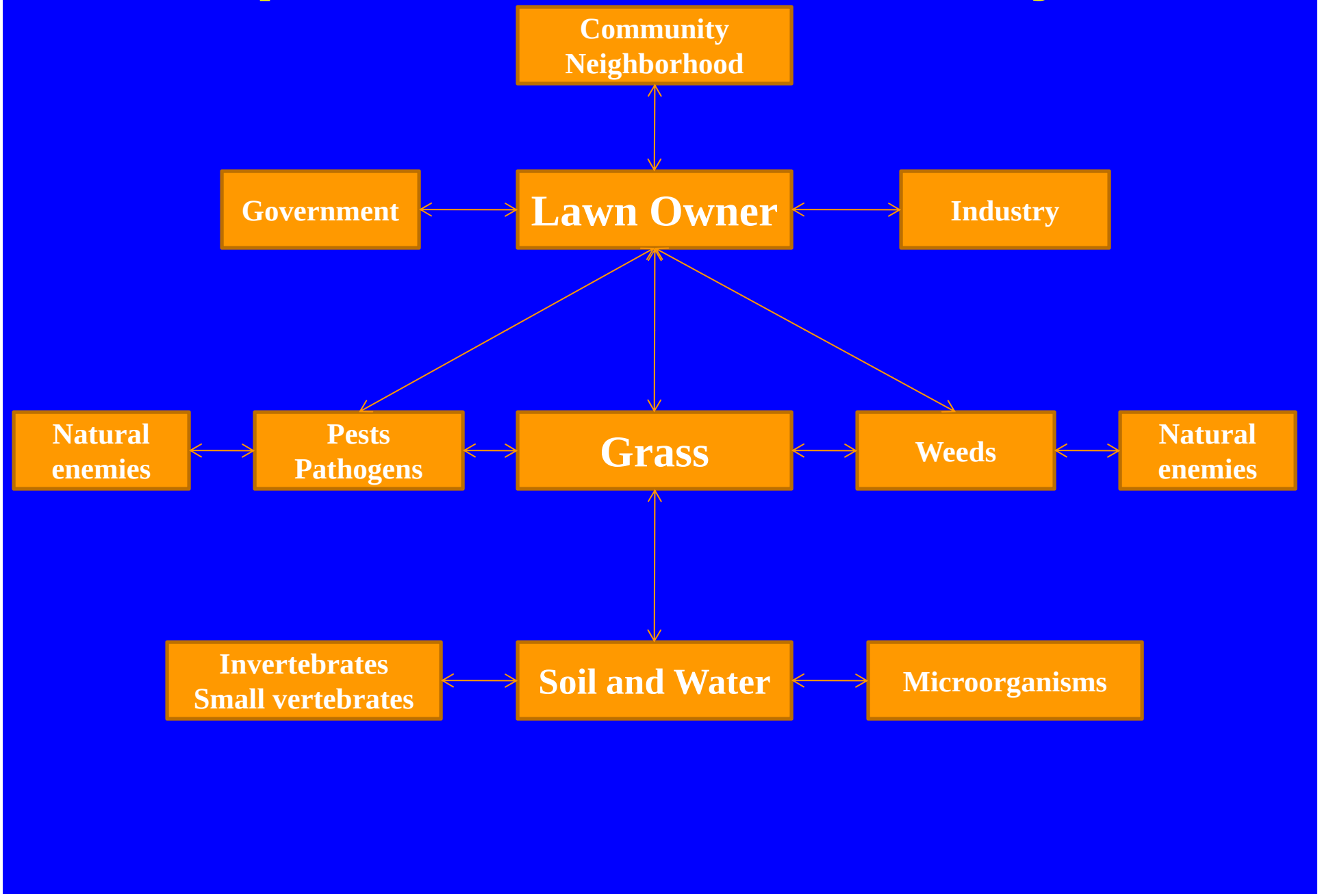

Turfgrass Ecosystem: Going Green
Bio fertilizers
Grass Species
Mowing
Bio herbicides
Herbivores
Natural enemies
Weeds
Irrigation
Grass
Detritus
Thatch
OM
Pathogens
Detritivores
Bio insecticides
Antagonists
Bio fungicides


Sustainable Turfgrass Ecosystem
Grass Species/Cv
Mowing
Herbivores
Natural enemies
Weeds
Irrigation
Grass
Detritus
OM
Pathogens
Detritivores
Antagonists

Commercial lawn management system relies on sludge hammers

Not green enough = apply fertilizer
Weeds = apply herbicide
Insects = apply insecticide
Disease = apply fungicide

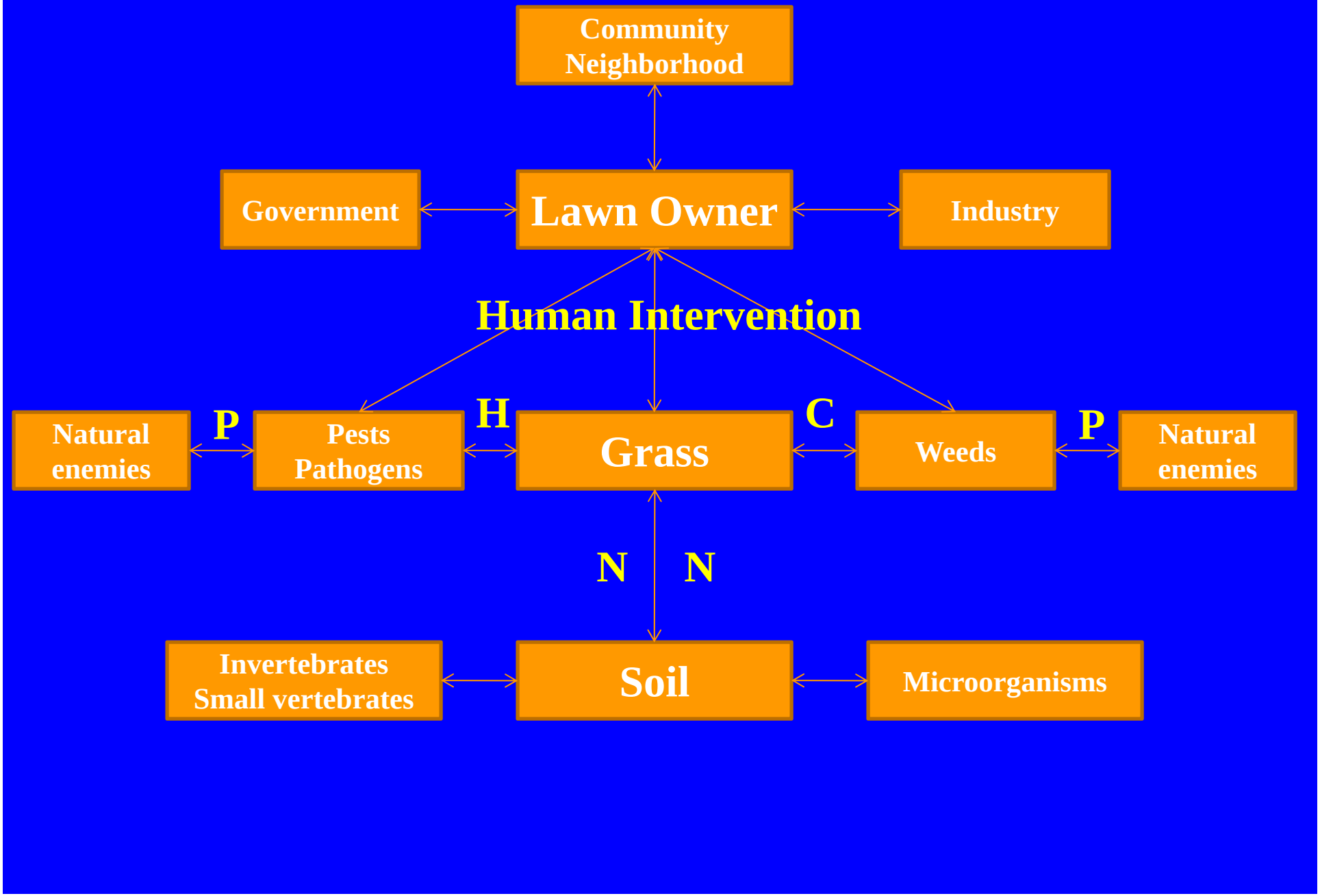
Components of Lawn Ecosystem



Five ecological principles of lawn ecosystem management

- Nutrient Cycling
- Competition
- Herbivory
- Predation and Parasitism
- Human Intervention

Principles of Lawn Ecosystem Management



Five ecological principles of lawn ecosystem management

- Nutrient Cycling
- Competition
- Herbivory
- Predation and Parasitism
- Human Intervention

Urban Soils

- **Poor structure**
- **May lack topsoil**
- **May have inefficient nutrient cycling**

- **University turfgrass research has mainly been conducted on plots established on well-prepared topsoil**

Questions on Urban Soils

- **Do lawns established on subsoil lack essential plant nutrients?**
- **Do lawns established on subsoil lack beneficial soil organisms?**
- **Can compost amendment improve soil nutrient and biological conditions?**
- **Are lawns established on subsoil more prone to nutrient run-off?**

Experimental design & plot setup:

Four main treatments with 12 replications:

1. Subsoil
2. Subsoil + Compost
3. Topsoil
4. Topsoil + Compost

Topsoil (0-6 inch); subsoil (below 12 inch)

Compost: EarthPro™ Premium Compost, from KB Compost Services Inc., Akron, OH. Soil:compost = 4:1


LEPPO RENT
Bobcat
334
Bobcat

Plot Establishment

4 degree cross angle slope

Plot Establishment: 7 x 5 ft

Plots seeded with endophytic tall fescue at 7 lb/1,000 sq ft in May 2006; watered daily

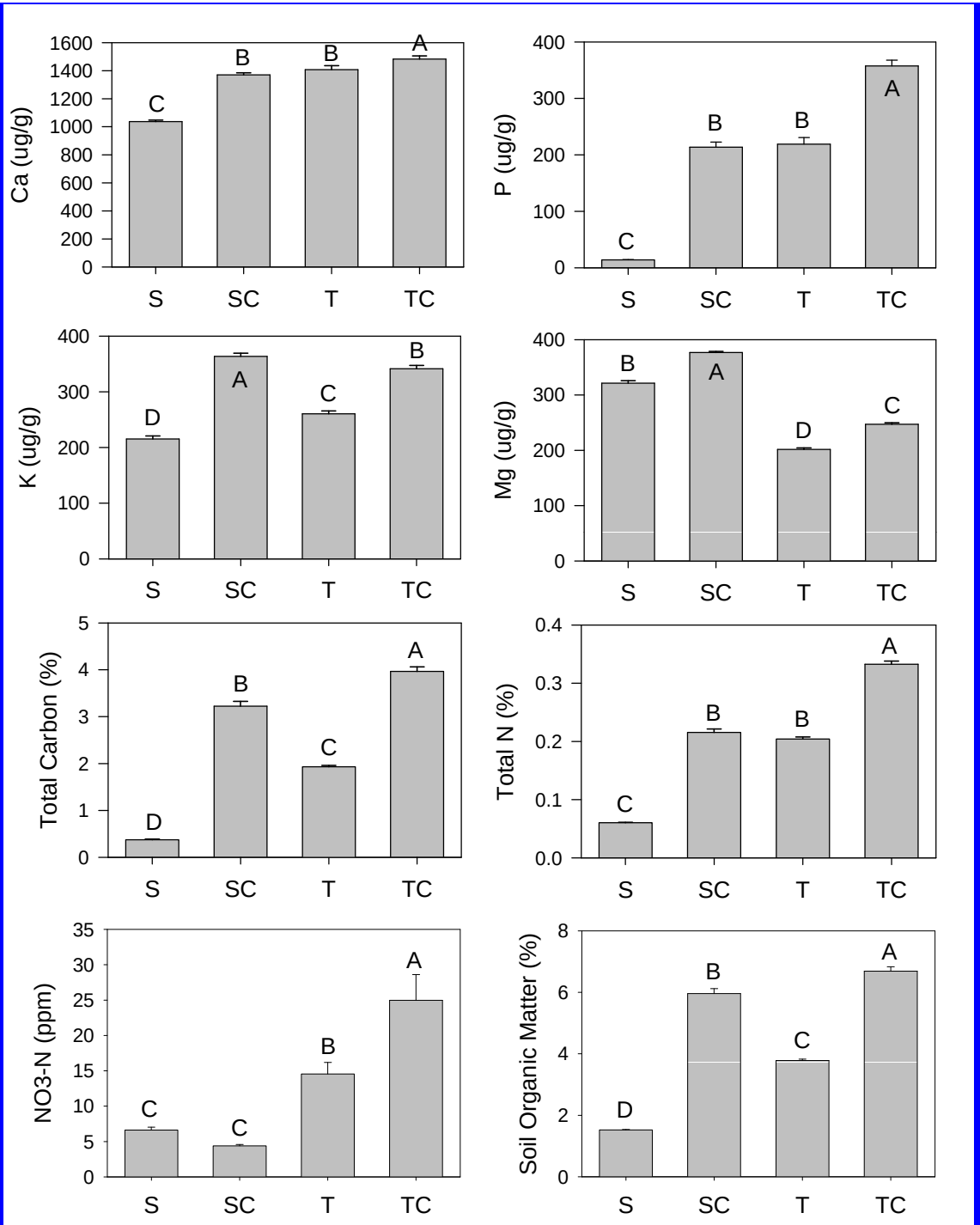
Turfgrass establishment (2 weeks)

Soil Nutrient Analysis:

Major nutrients

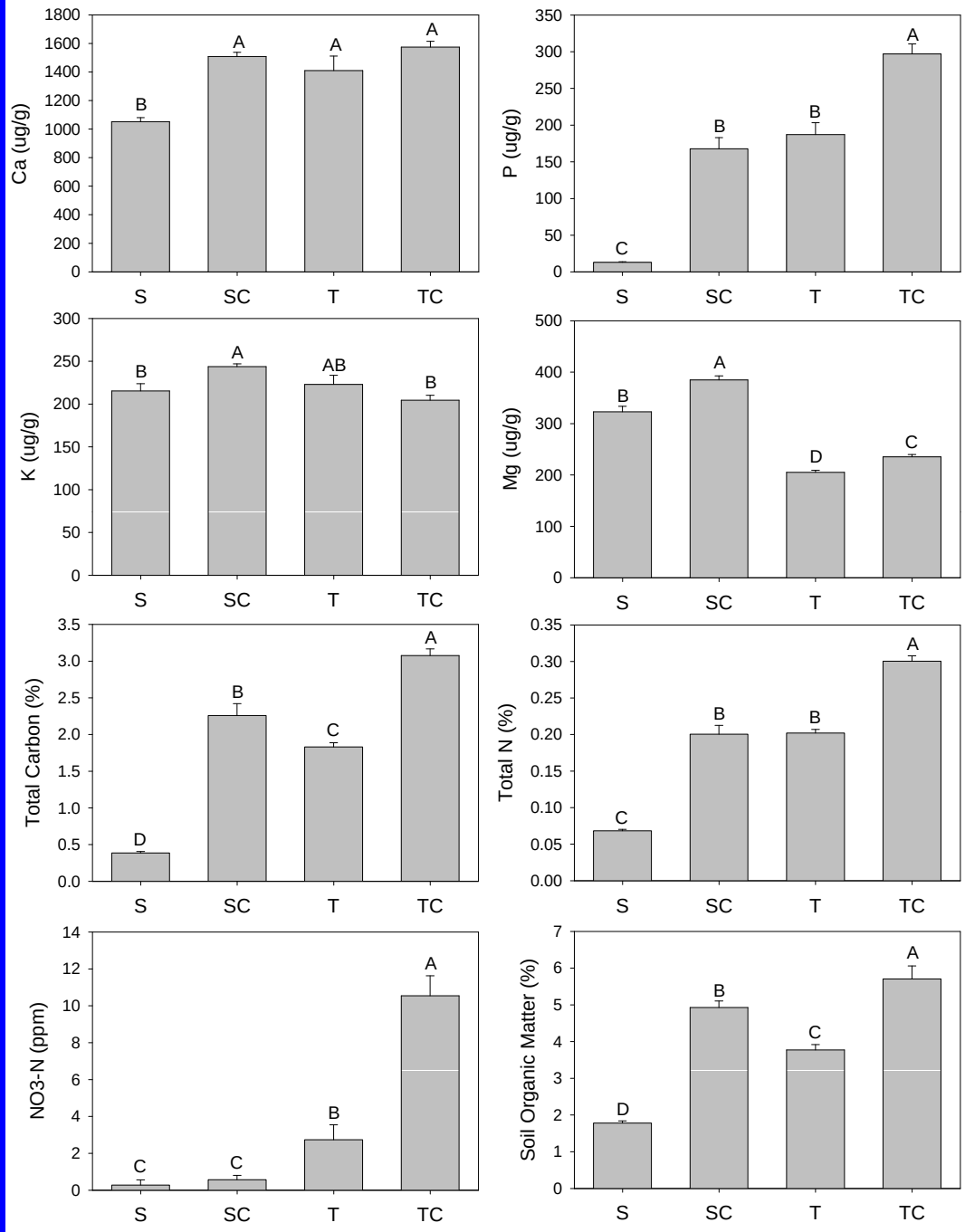
Microbial biomass

Organic matter



Initial nutrient levels: May 2006

Nutrients after one year

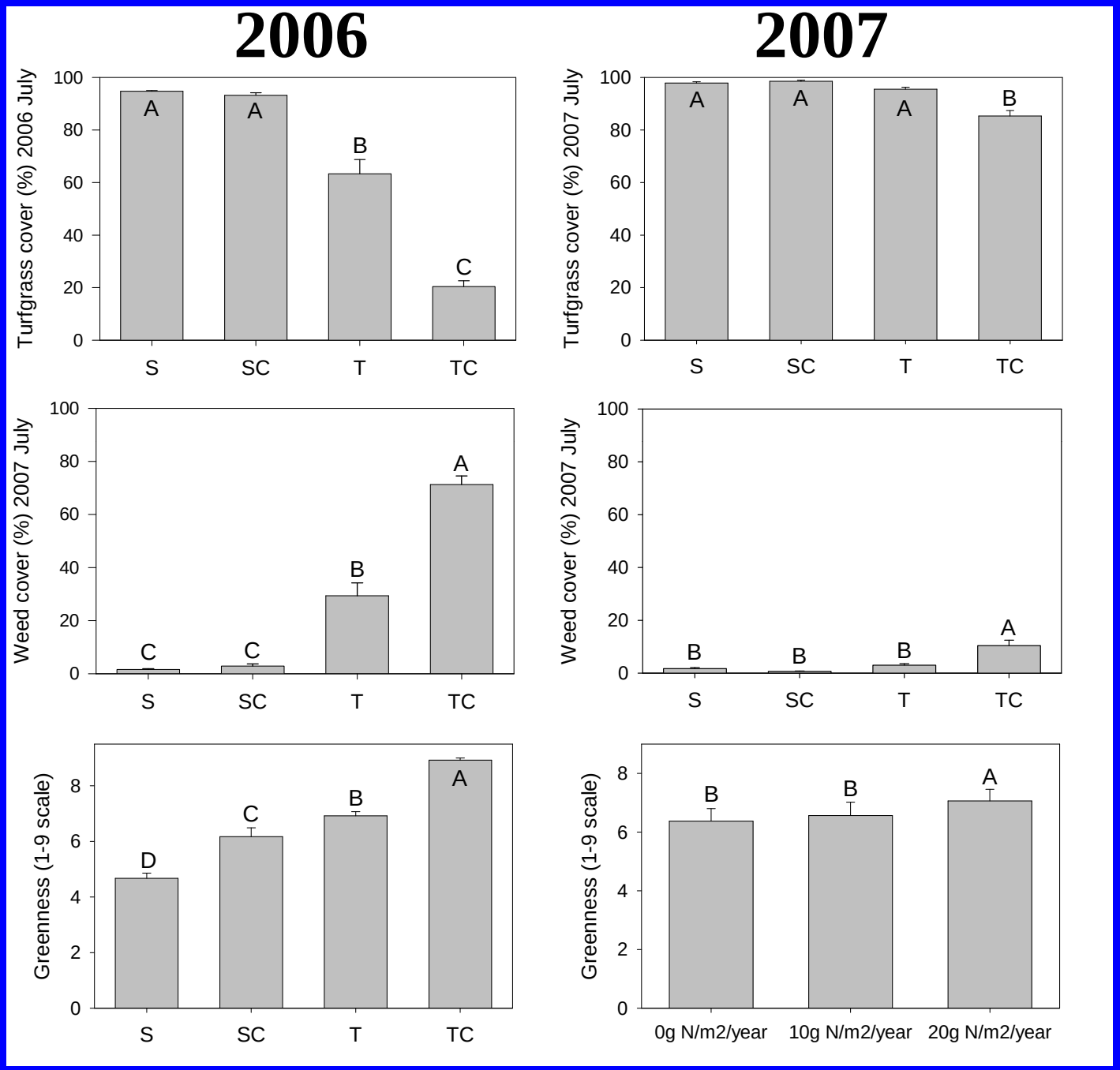


Turfgrass quality assessment:

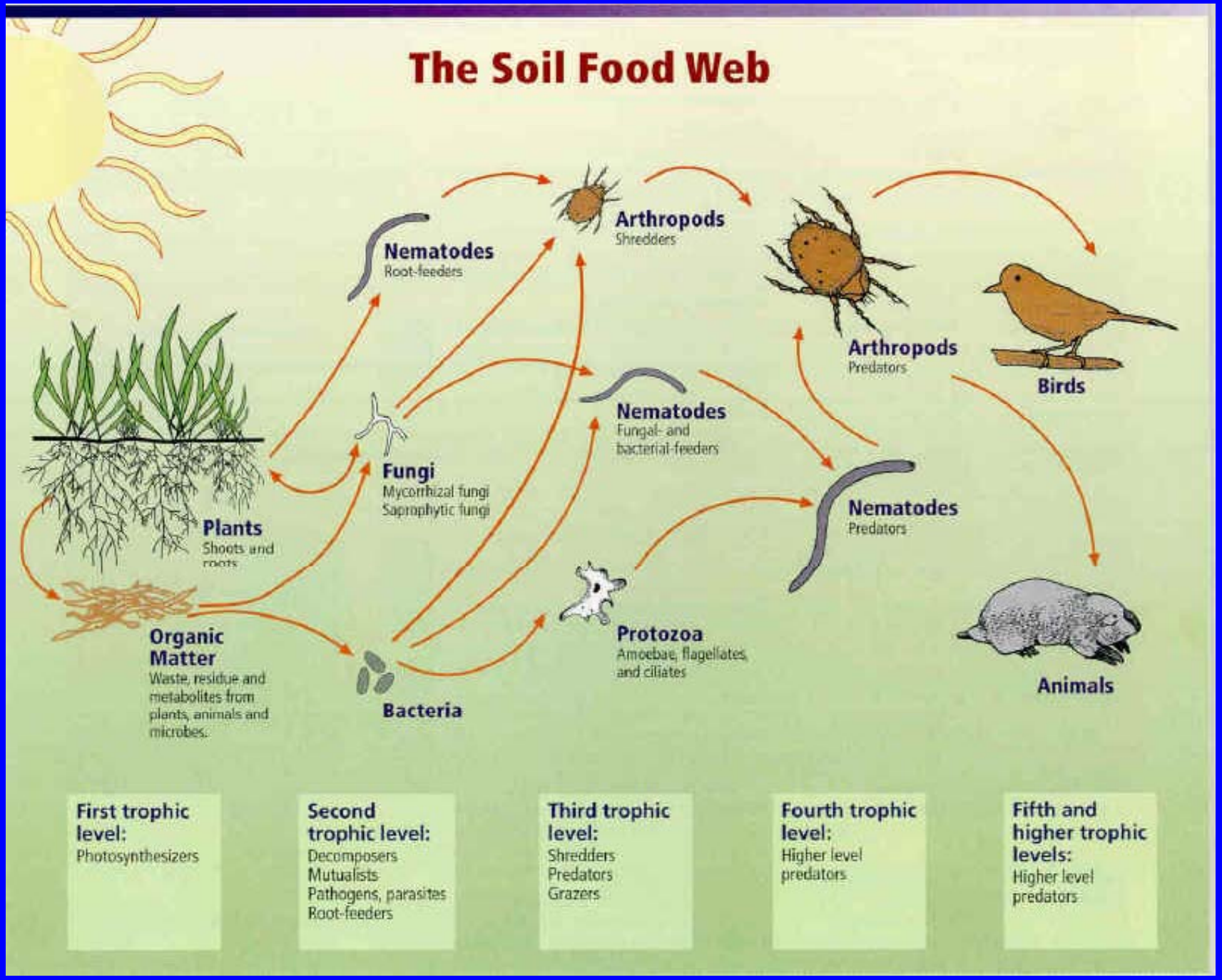
Turfgrass cover

Weed cover

Turfgrass quality (greenness)


2006
2007
Turfgrass cover (%) 2006 July
Turfgrass cover (%) 2007 July
Weed cover (%) 2007 July
Weed cover (%) 2007 July
Greenness (1-9 scale)
Greenness (1-9 scale)
S
SC
T
TC
0g N/m2/year
10g N/m2/year
20g N/m2/year
Turf cover
Weed cover
Turf quality

The Soil Food Web



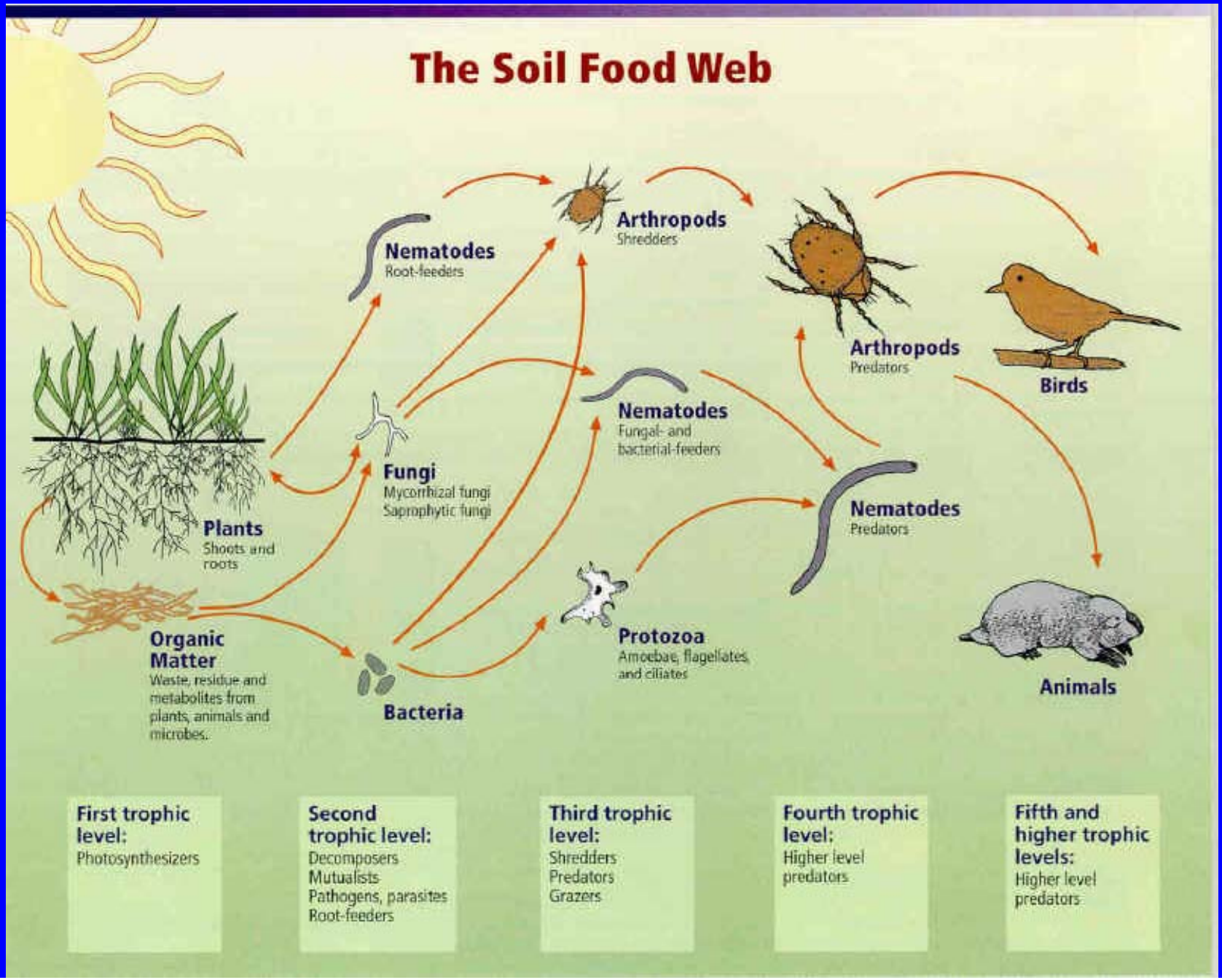
Functions of the Soil Food Web

- Decomposition of Organic Matter
- Cycling of Minerals and Nutrients
- Sequestration of Carbon
- Detoxification of Pollutants
- Biological Regulation of Pests

Nematodes:

A tool for monitoring the soil food web health

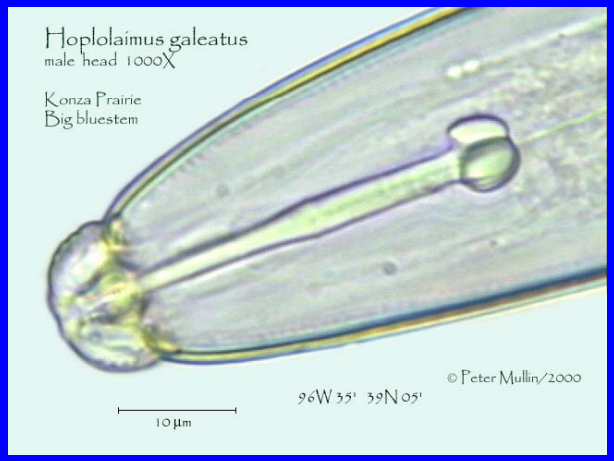
Nematodes occur at multiple trophic levels



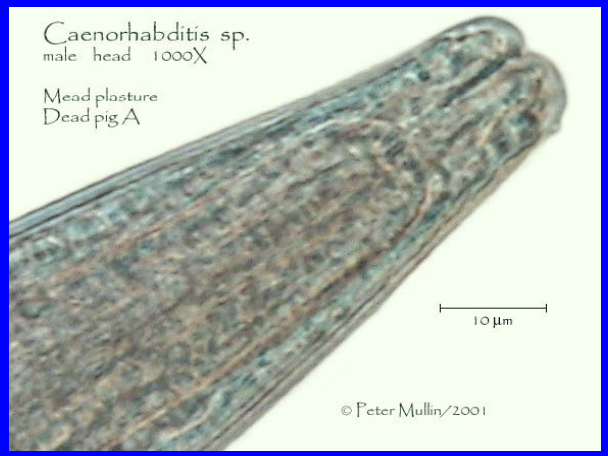
Nematodes are easy to identify and enumerate

Wilsonema

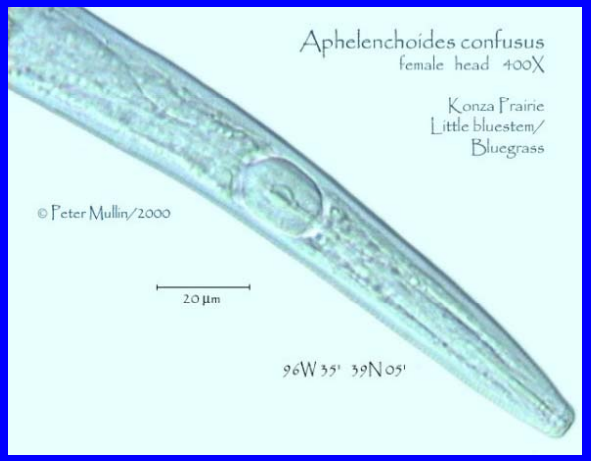
Nematode mouth parts depict their feeding habit



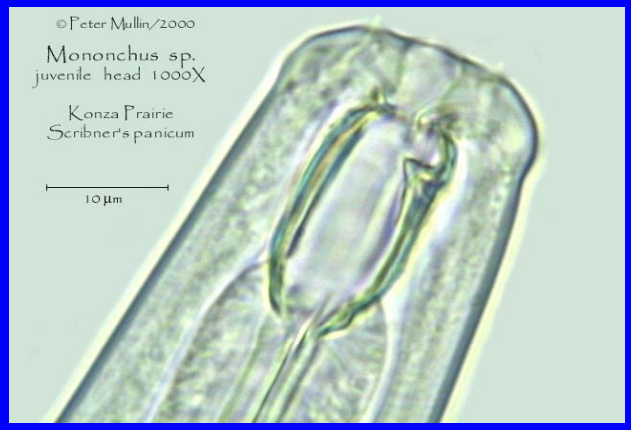
Plant-parasitic



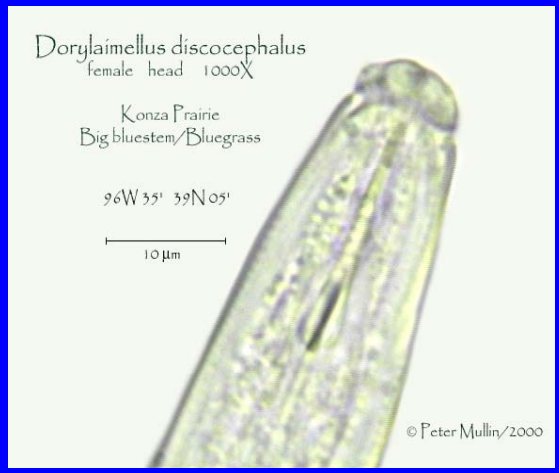
Bacterivores



Fungivores

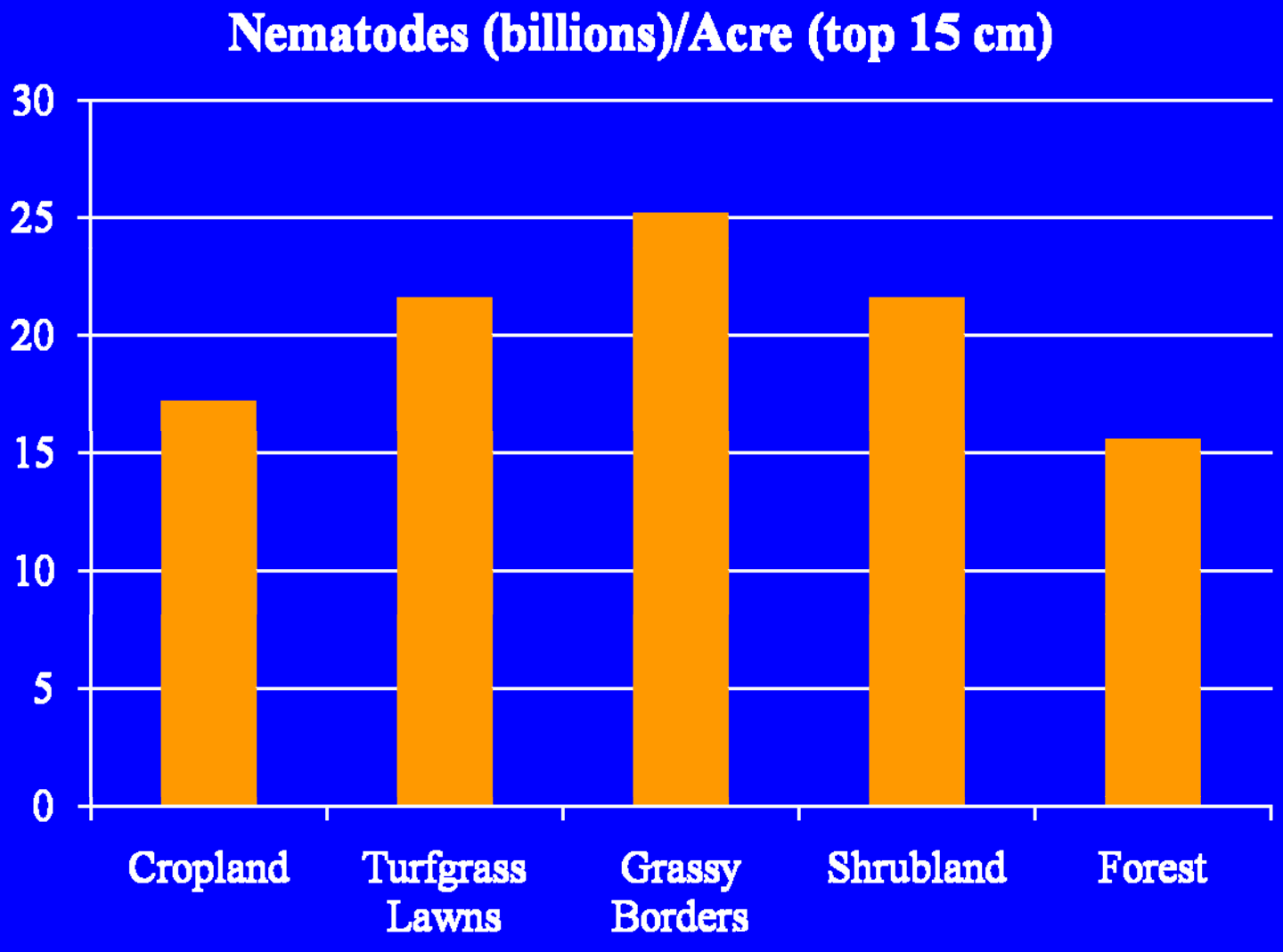


Predatory



Omnivores

Nematodes are the most abundant animals in the soil



Many nematodes per sample

Bacterivores	Fungivores	Predators	Omnivores	Plant Parasites
Acrobeles (2)	Aphelenchoides (2)	Mononchus (4)	Alaimus (4)	Aglenchus (2)
Acrobeloides (2)	Aphelenchus (2)	Mylonchulus (4)	Aporcelaimus (4)	Criconemoides (3)
Bunonema (1)			Discolaimus (5)	Filenchus (2)
Cephalobus (2)			Dorylaimus (4)	Helicotylenchus (3)
Chiloplacus (2)			Eudorylaimus (4)	Heterodera (3)
Cuticularia (1)			Pungentus (4)	Hoplolaimus (3)
Diplogaster (1)				Malenchus (2)
Eucephalobus (2)				Paratylenchus (2)
Monhystera (1)				Pratylenchus (3)
Panagrolaimus (2)				Psilenchus (2)
Pelodera (1)				Rotylenchus (3)
Plectus (2)				Telotylenchus (2)
Rhabditis (1)				Tylenchorynchus (3)
Turbatrix (1)				Tylenchus (2)
Wilsonema (2)				

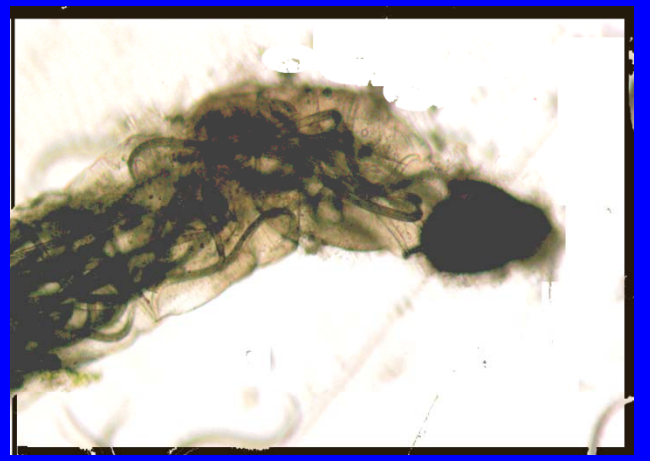
Nematodes Regulate Pest Populations

Mole cricket

Wax worm

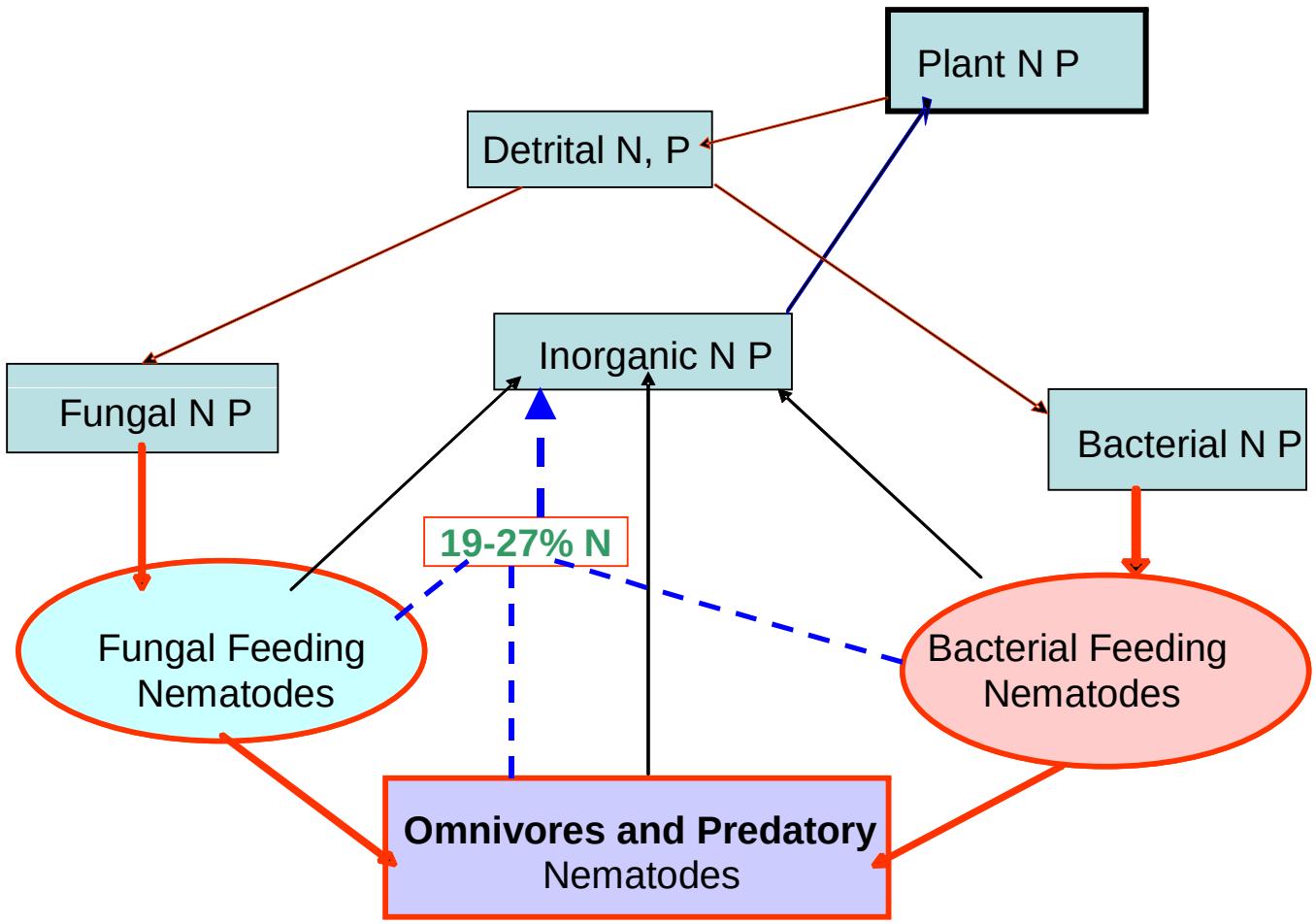
White grub

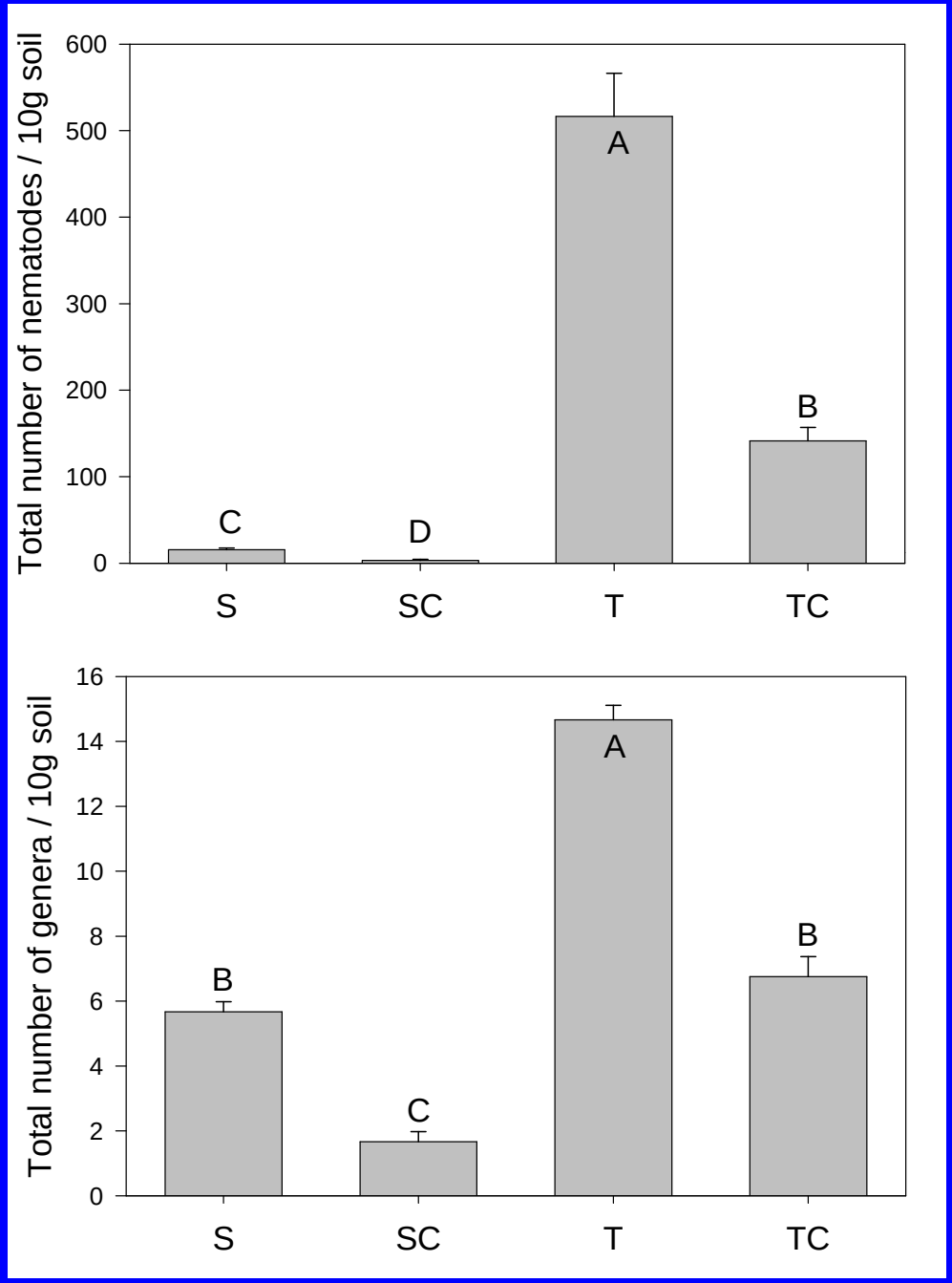
Beet army worm



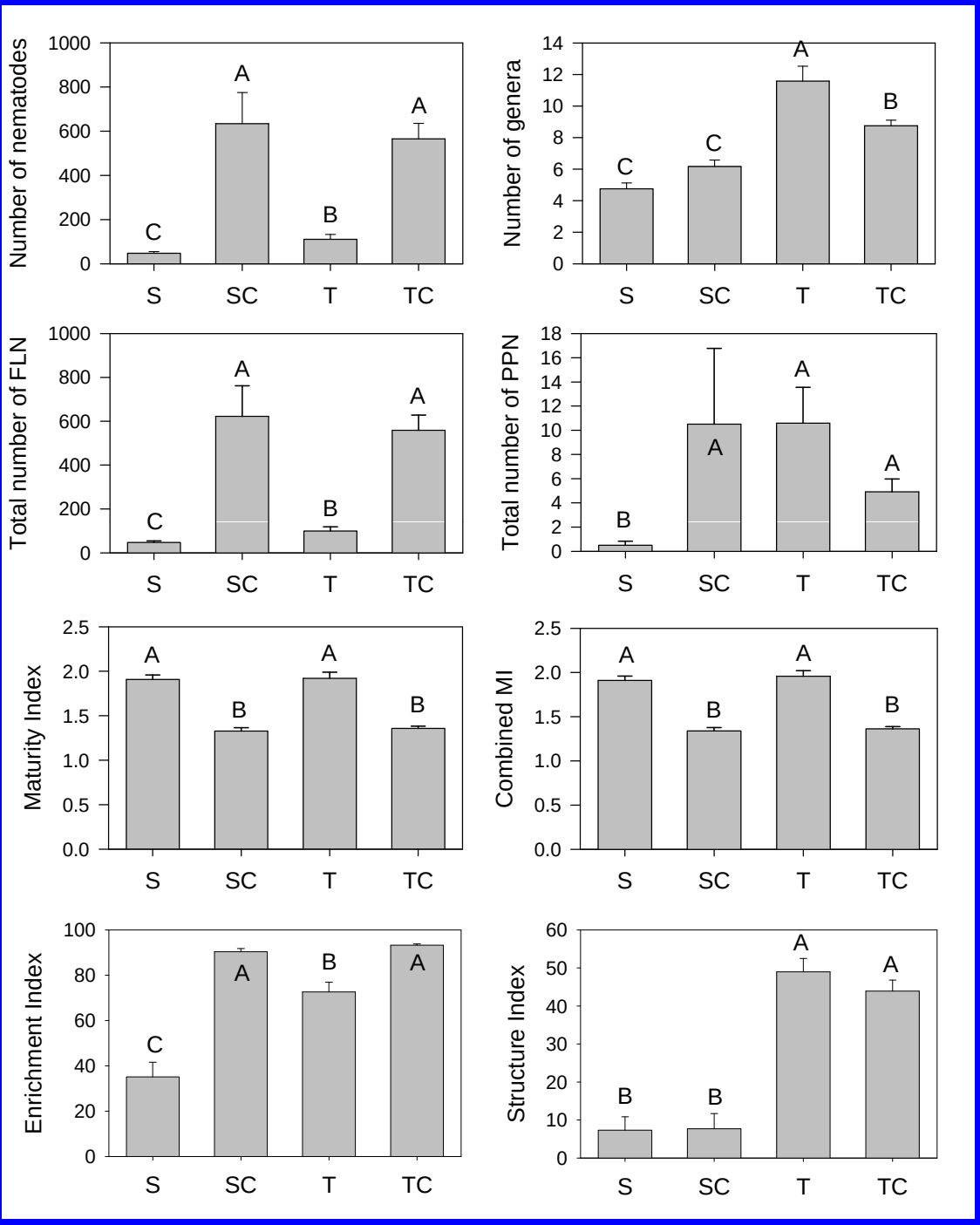
Fungus gnat larva

Role of Nematodes in Nutrient Cycling/Soil Fertility

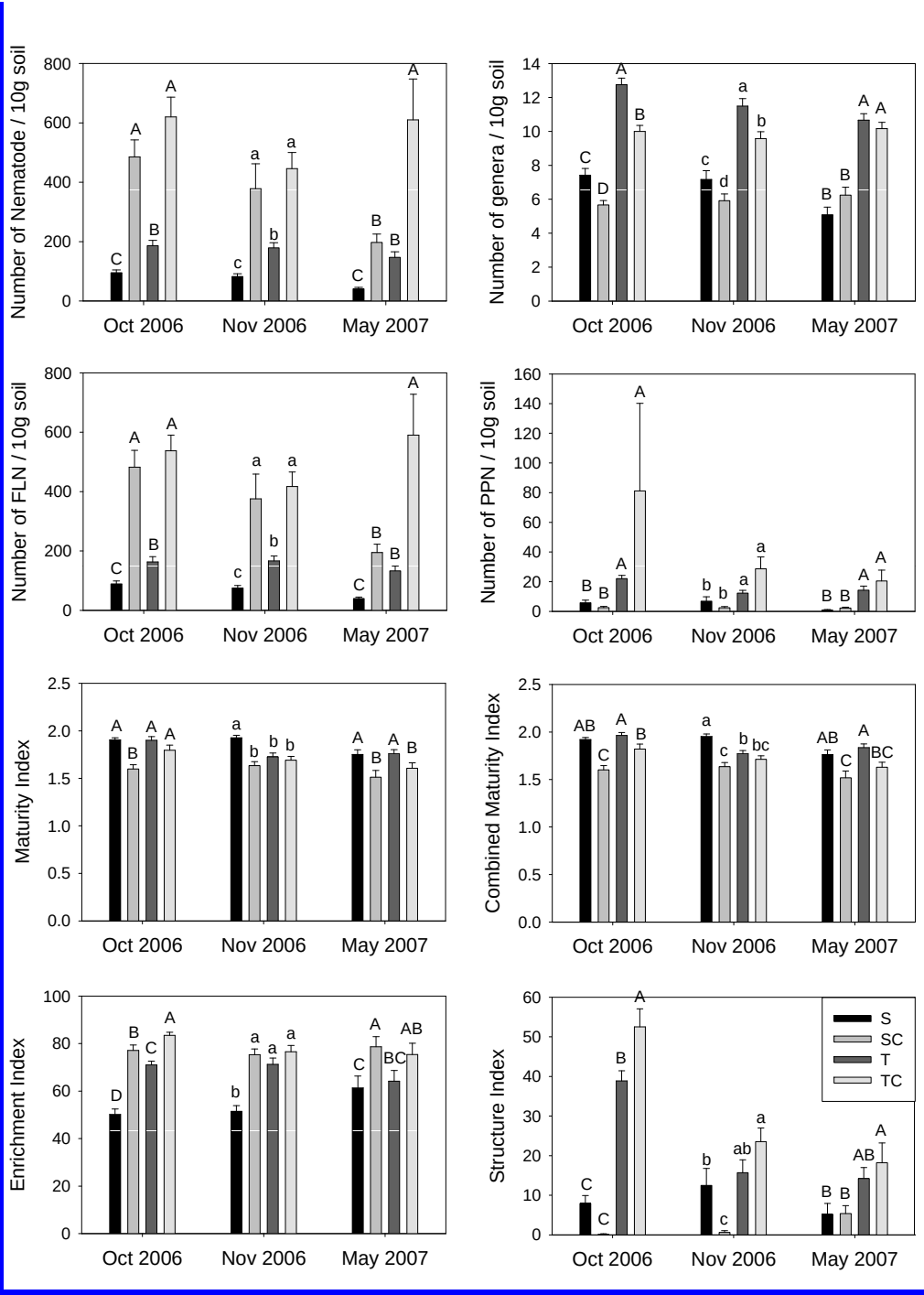




Initial nematode population and genus numbers



Nematodes two months after establishment



Nematodes after one year of turf establishment

Conclusions

>Subsoil has few nematodes and nematode genera

>Compost amendment increased nematode numbers, but not types of nematodes (diversity)

> Compost increased food web enrichment but not structure index two months after turf establishment

- Food web structure index and enrichment index remained low in subsoil even after one year

Fertilizer Application

Major nutrients: NPK

- **N – vegetative growth, color, proteins (AA)**
- **P – root growth and other growth processes**
- **K – physiological processes, disease resistance and water hardiness**

Complete fertilizer: 3:1:2

Fall (Sept) and late fall (Nov) is the best time to apply

Inorganic vs Organic fertilizers

Inorganic fertilizers: synthesized

Organic fertilizers: animal manures or previously living plant or animal parts

-Animal sources: bone meal, blood meal, cow, chicken & horse manure

-Plant sources: seaweed, alfalfa meal, cottonseed meal

-Processed or composted sewage sludge: e.g. Milorganite or ComTil

Fast vs slow release

Organic fertilizers

Product (mg/g)	N	P	K	Ratio
Nature's Touch	167	7	31	24:1:4
Corn Gluten	106	5	6	21:1:1
Ringers Lawn Restore	107	7	62	19:1:9
Cockadoodle DOO	44	14	30	3:1:2
Vigoro	187	6	15	31:1:2
Sweet Peet	20	4	18	5:1:4
Scott's Feather Meal	144	2	2	72:1:1
Scott's Turf Builder	280	11	32	25:1:3

Five ecological principles of lawn ecosystem management

- Nutrient Cycling
- Competition
- Herbivory
- Predation and Parasitism
- Human Intervention

Effect of mowing on weed intensity in lawns

The Competition Principle

Turfgrass plots

- **Endophytic tall fescue**
- **Endohyte-free tall fescue**
- **Endophytic perennial ryegrass**
- **Endophye-free perennial ryegrass**

Methods

- Established in 1999
- Plot dimensions
  - 6.1 x 6.1 m (37.2 m^2)
- Species/cultivars
  - TF cv. Alamo
  - PR cv. Palmer III
- No fertilizer or pesticide applications

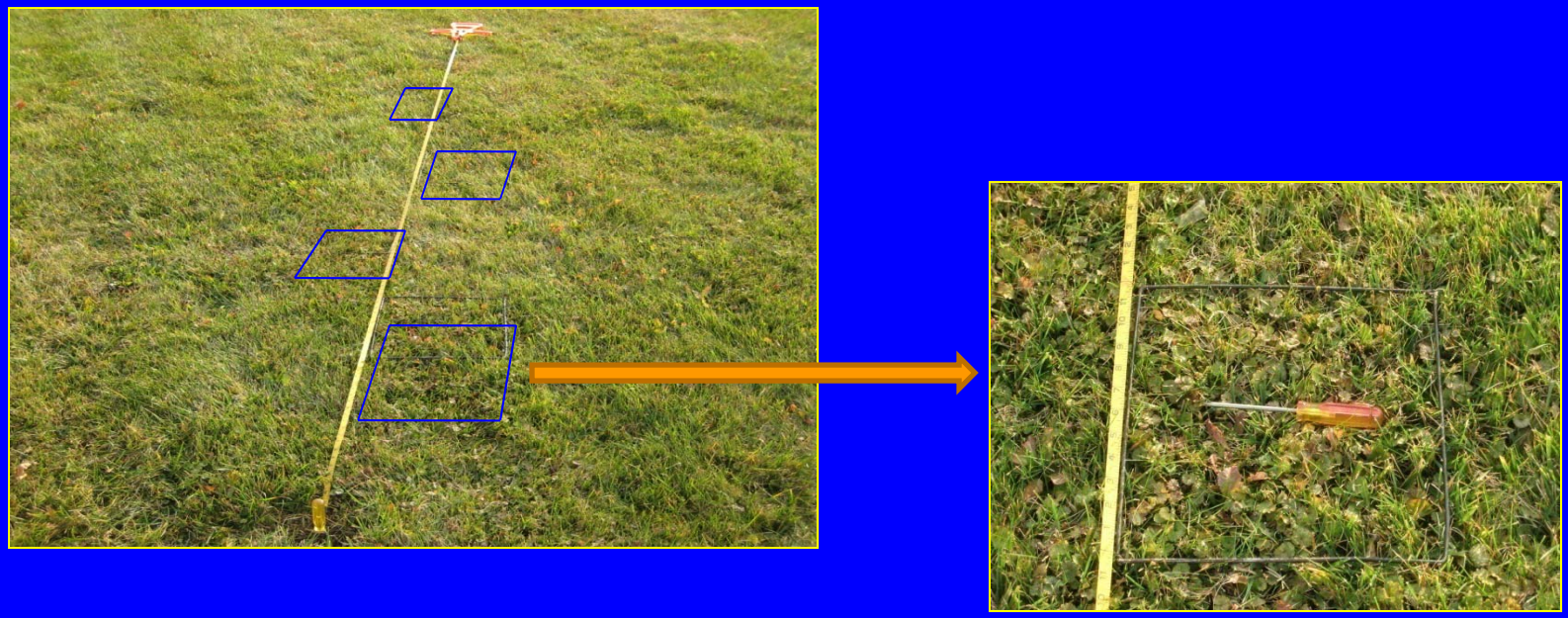
Methods

- **March 2003: main plots divided into 4 sub-plots (4.6 m^2)**

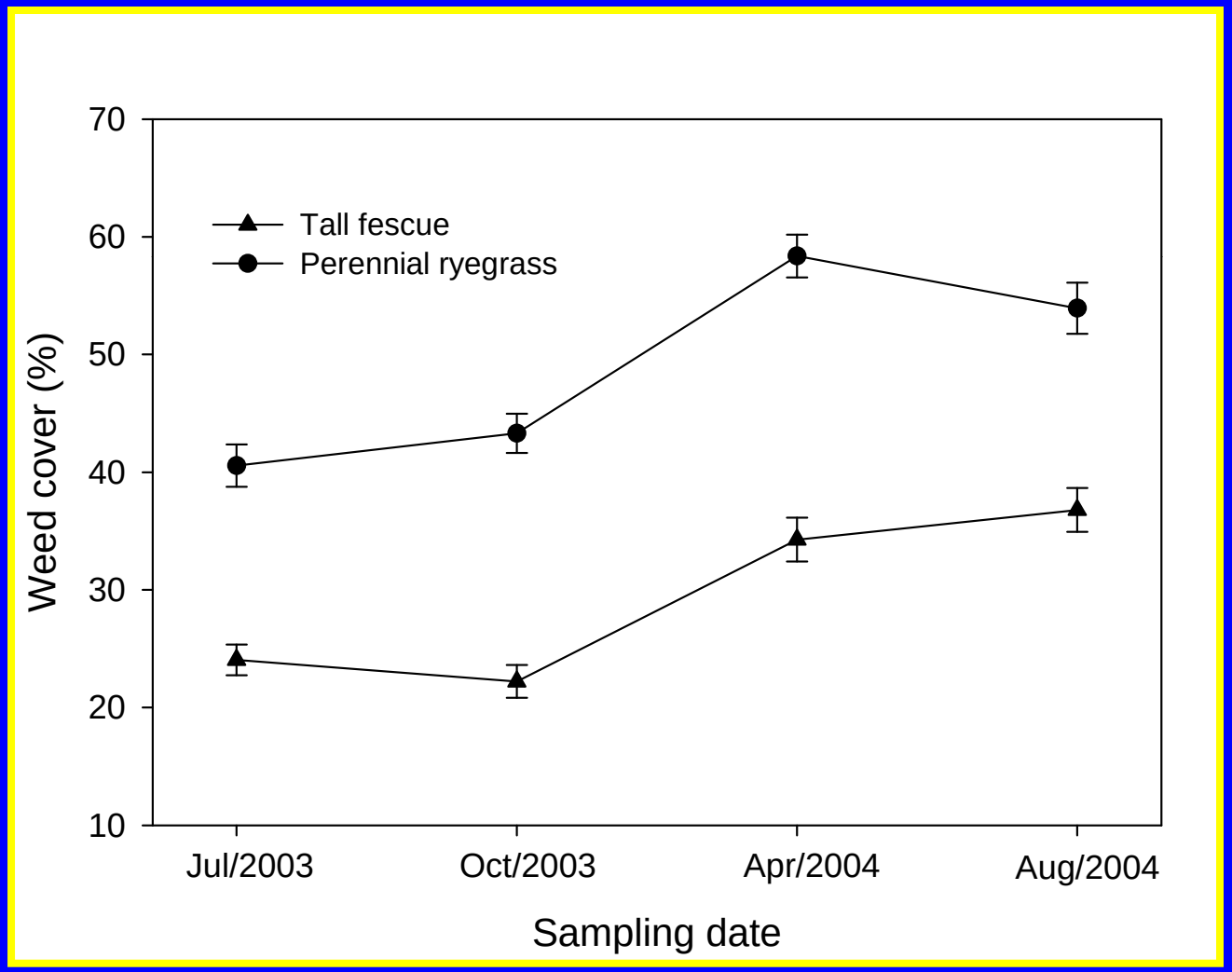
- **4 mowing regimes imposed**
  - **2 inches weekly**
  - **2 inches bi-weekly**
  - **3.5 inches weekly**
  - **3.5 inches bi-weekly**

Methods

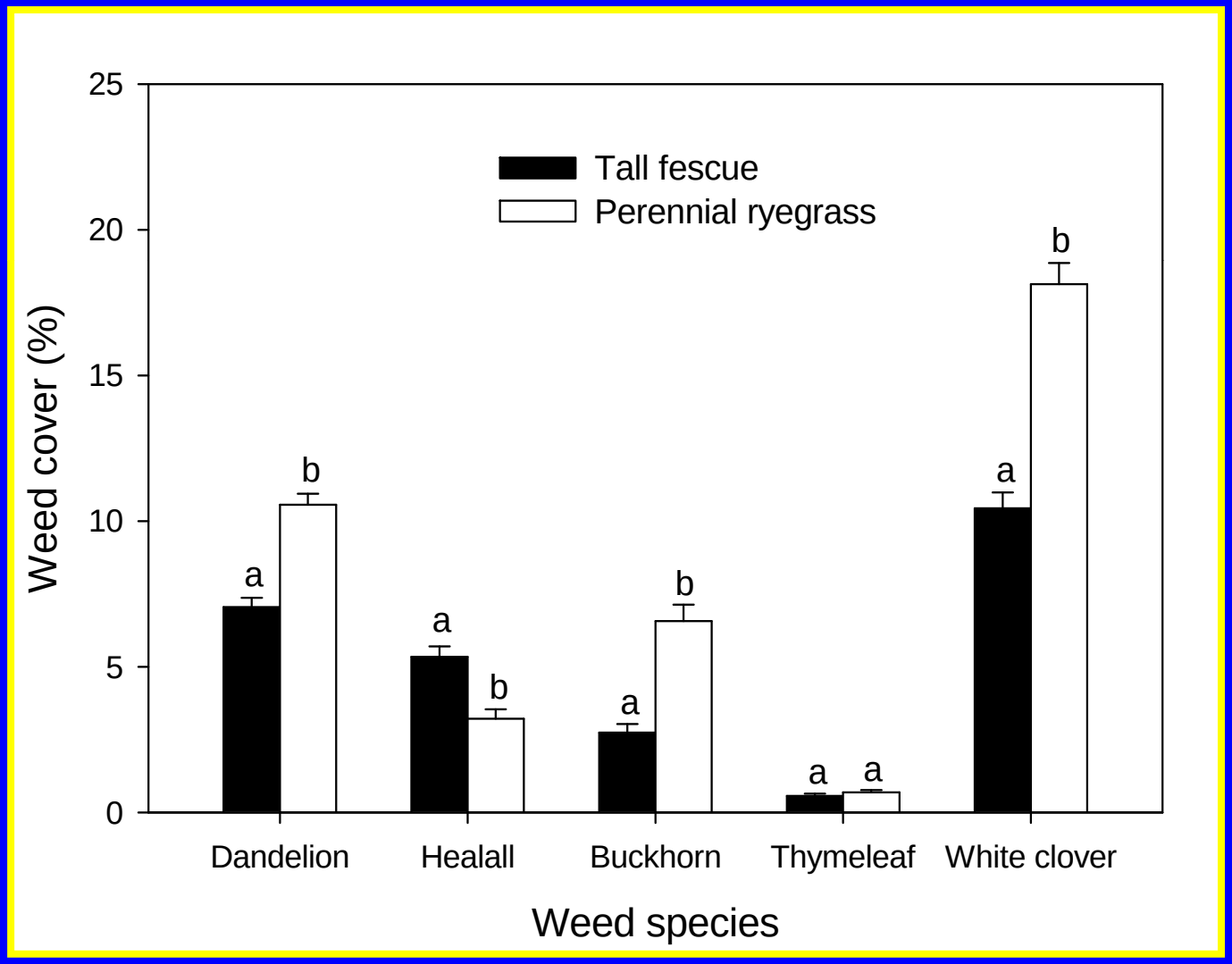
- **Data collected during July 2003, October 2003, April 2004, and August 2004**



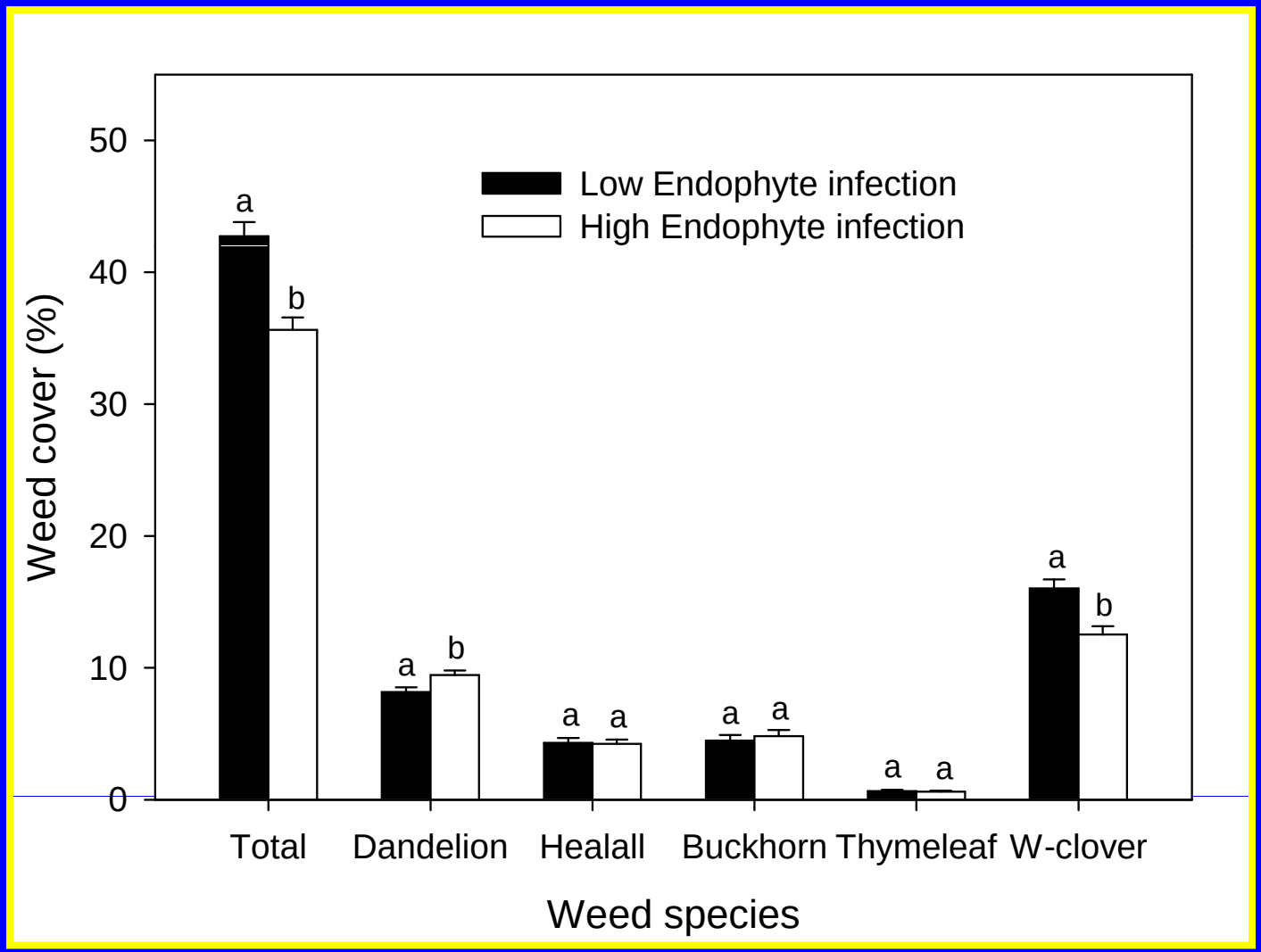
Total weed cover in tall fescue and perennial ryegrass lawns



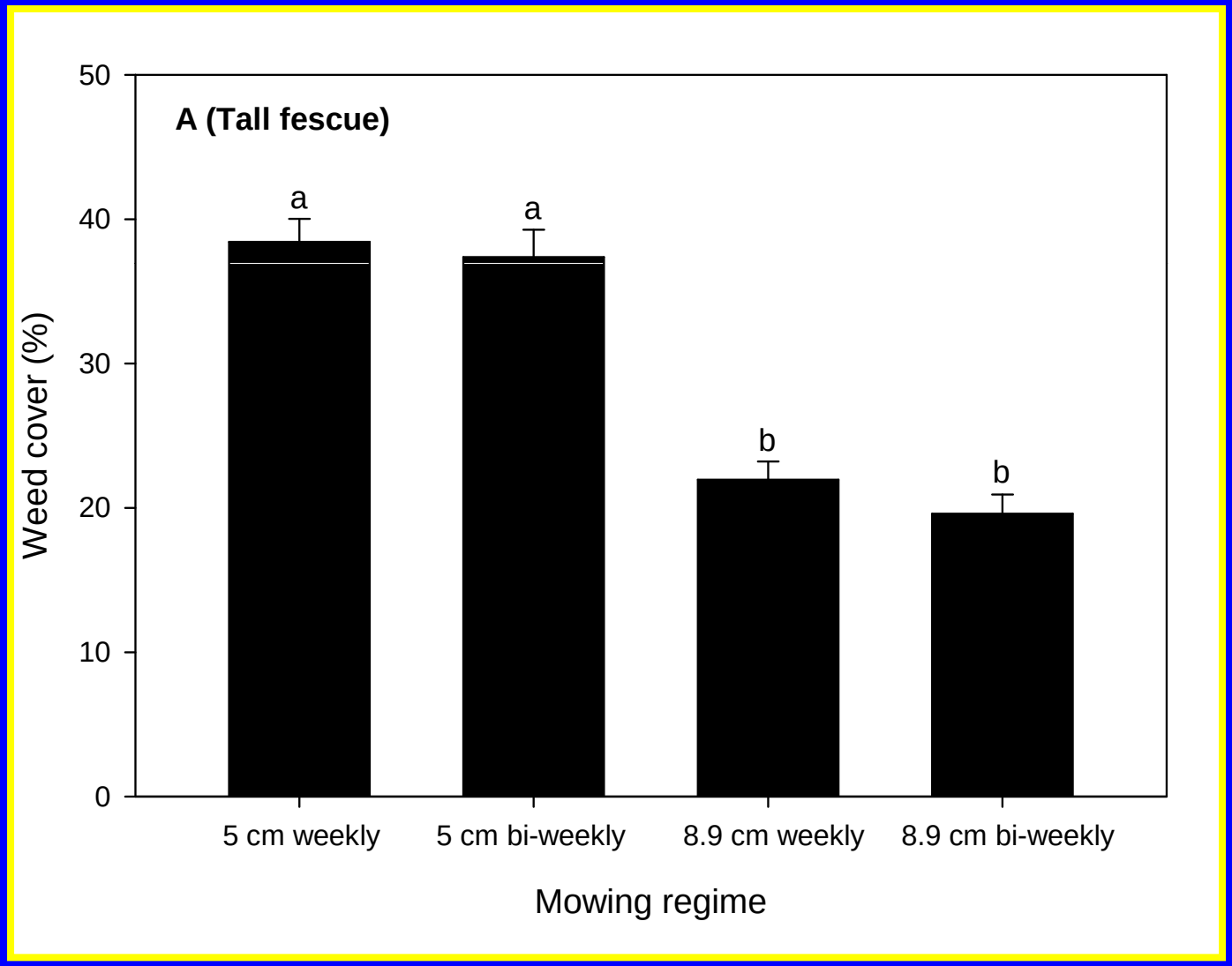
Weed cover by species in tall fescue and perennial ryegrass lawns



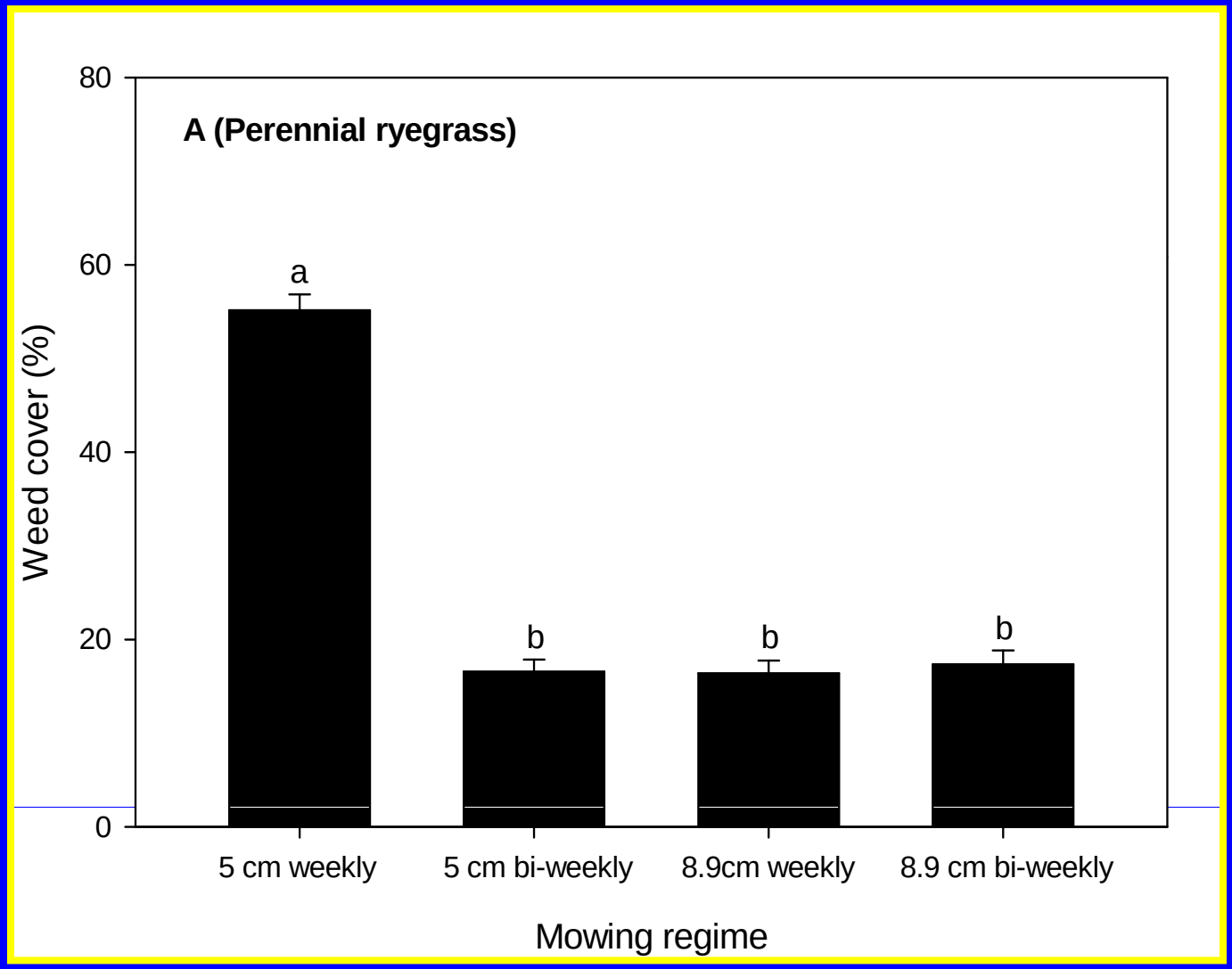
Effect of endophyte on weed cover tall fescue and perennial ryegrass lawns



Effect of mowing regime on total weed cover in tall fescue



Effect of mowing regime on total weed cover in perennial ryegrass



Grewal's five principles of lawn ecosystem management

- Nutrient Cycling
- Competition
- **Herbivory**
- Predation and Parasitism
- Human Intervention

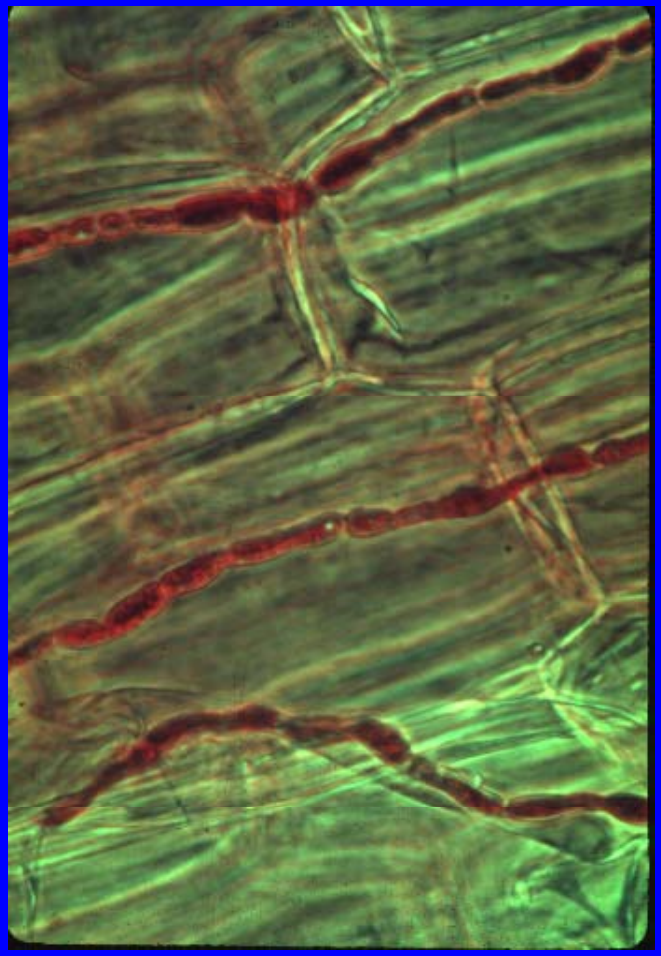
Effect of mowing on grass resistance to insects

Testing the resource allocation hypothesis

Endophyte (*Neotyphodium*) infected grasses

Alkaloids found in endophytic tall fescue and perennial ryegrass

- Indole alkaloids
  - Lolitrem B
- Pyrrolizidine alkaloids
  - Lolines
- Pyrrolopyrazine alkaloids
  - Peramine
- Ergot alkaloids
  - Ergocristine
  - Ergocryptine
  - Erogonvine
  - Ergovaline

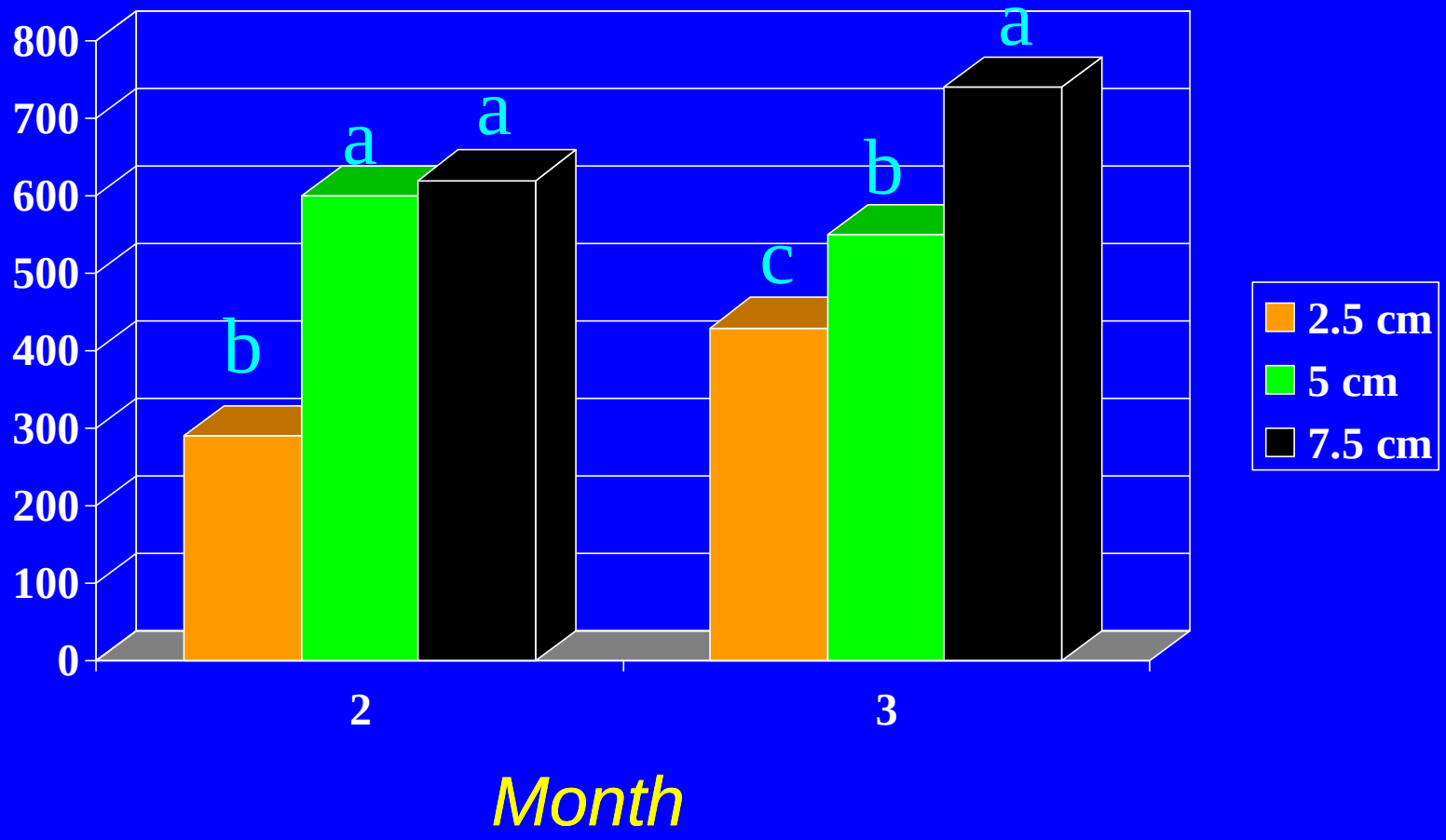


Mowing height affects alkaloid levels in tall fescue

A greenhouse study

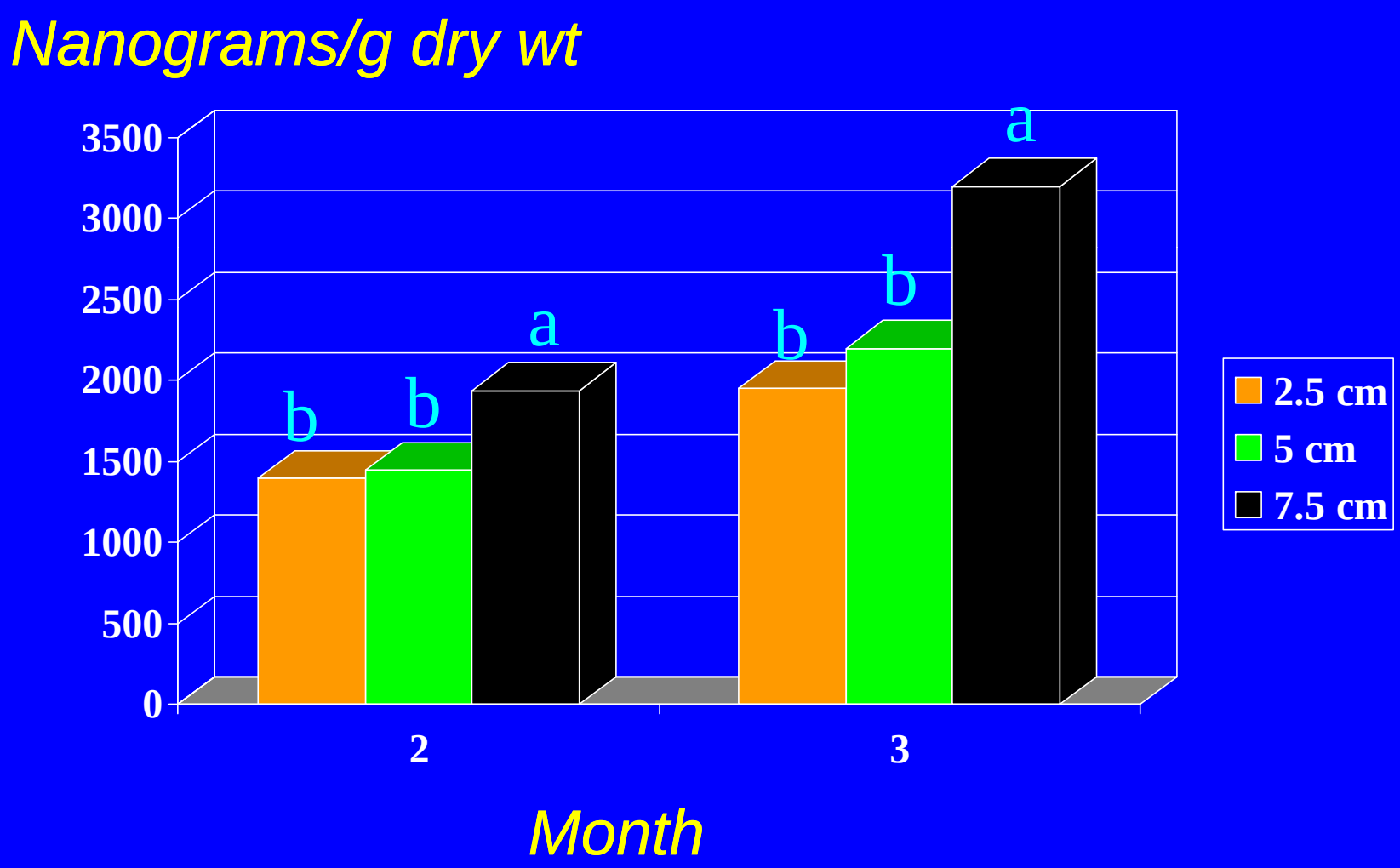
Tall fescue mowing height: Perloline methylether

Nanograms/g dry wt



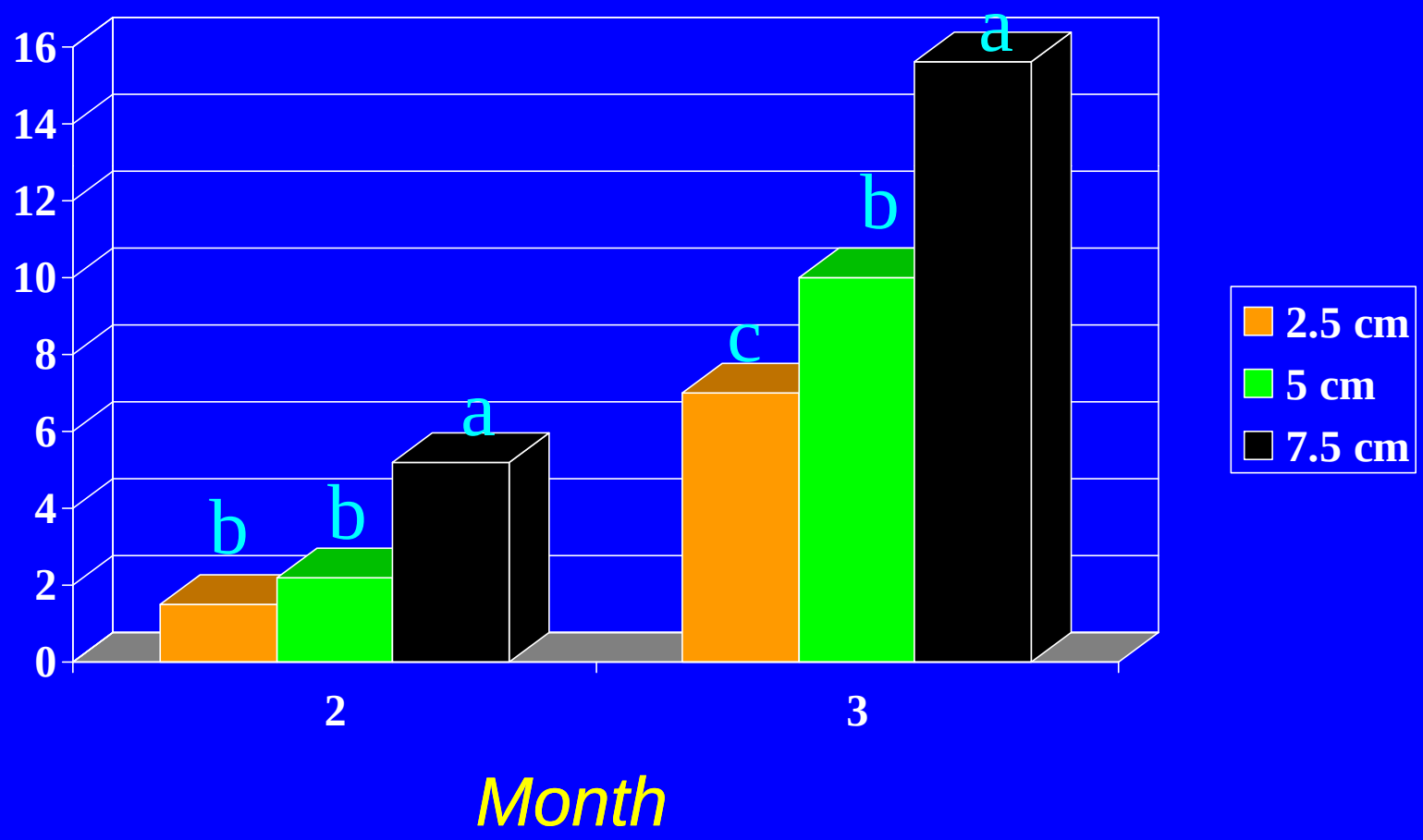
Month

Tall fescue mowing height: Ergonovine



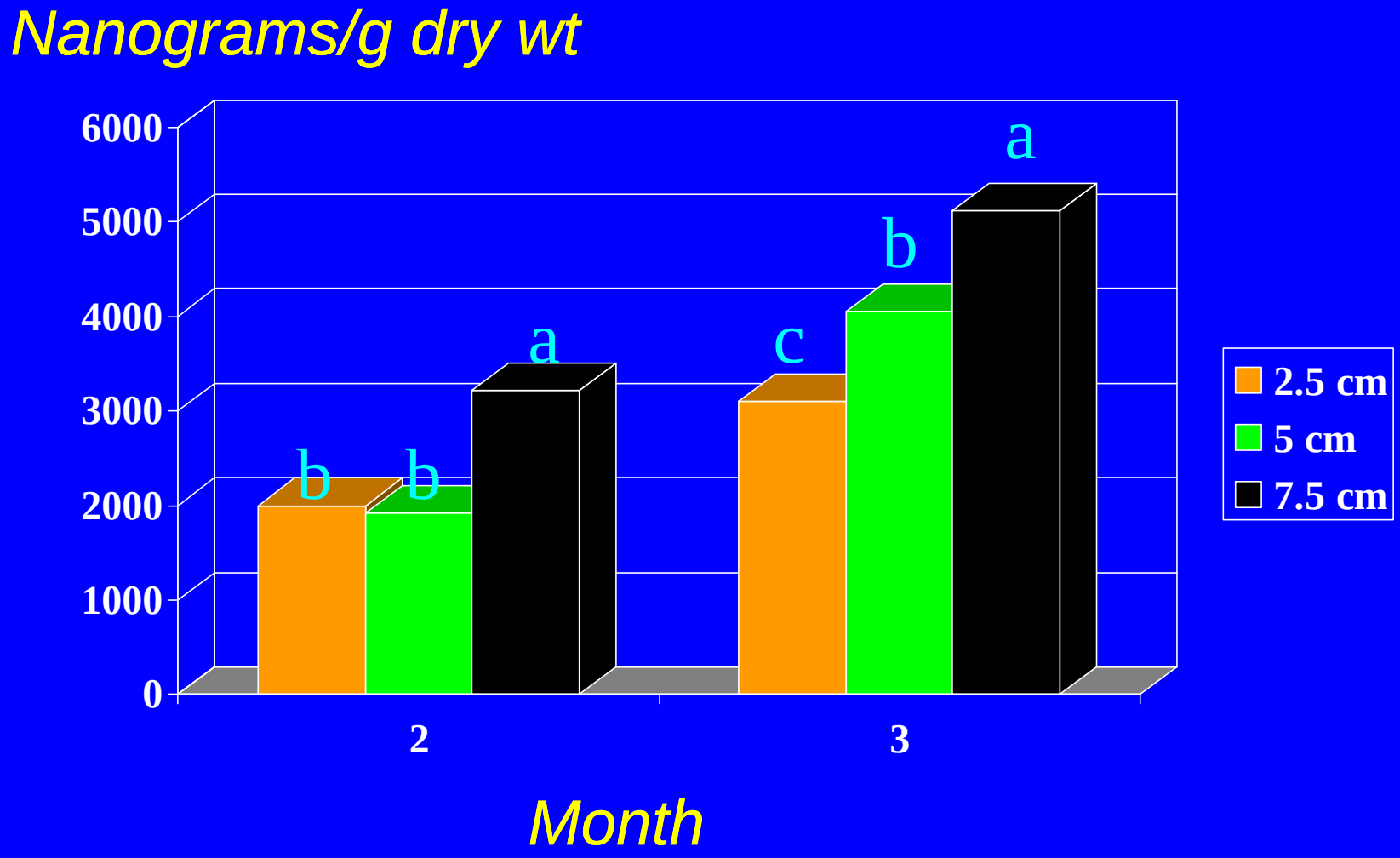
Tall fescue mowing height:
Ergocriptine

Nanograms/g dry wt

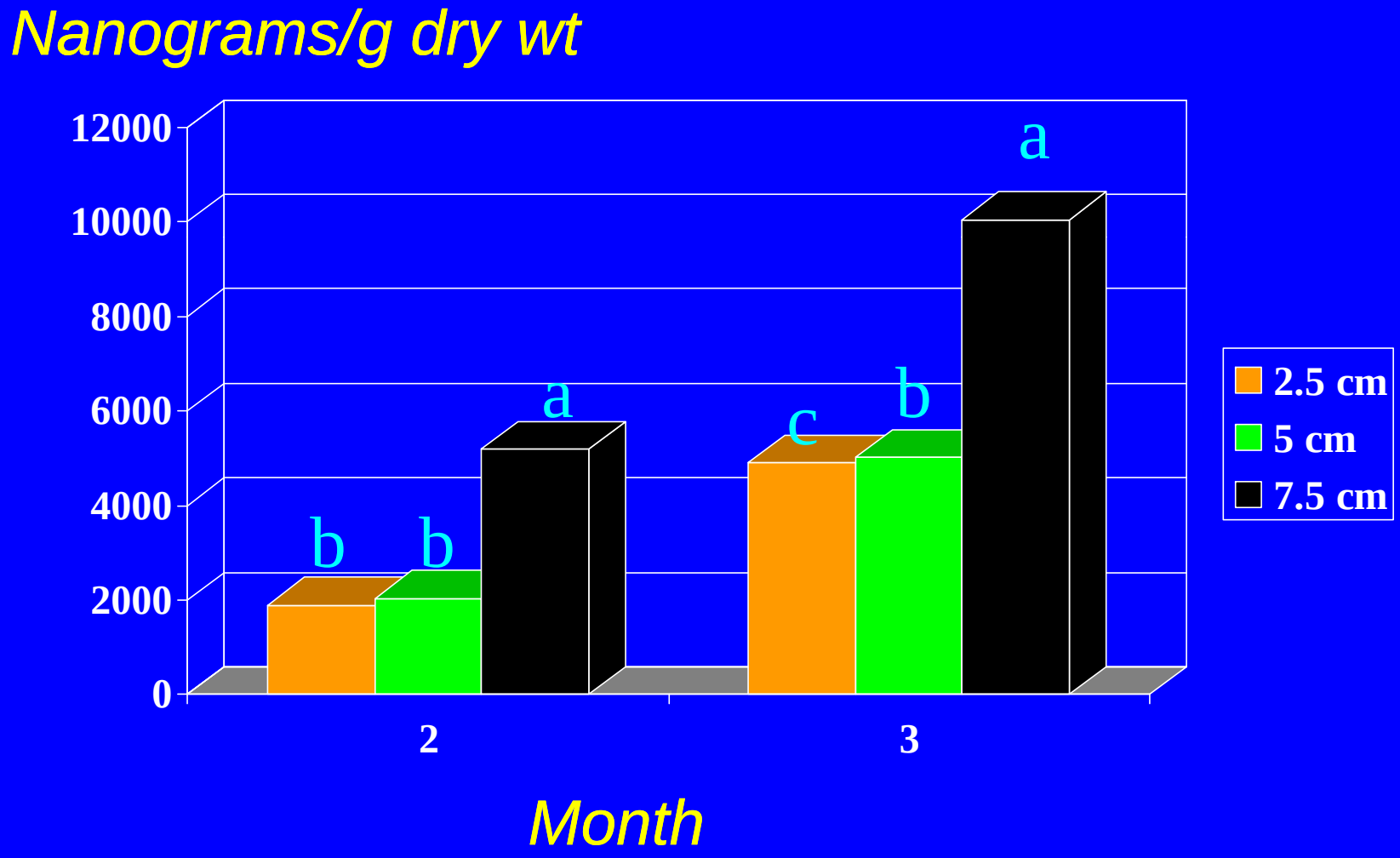


Month

Tall fescue mowing height: Ergocristine



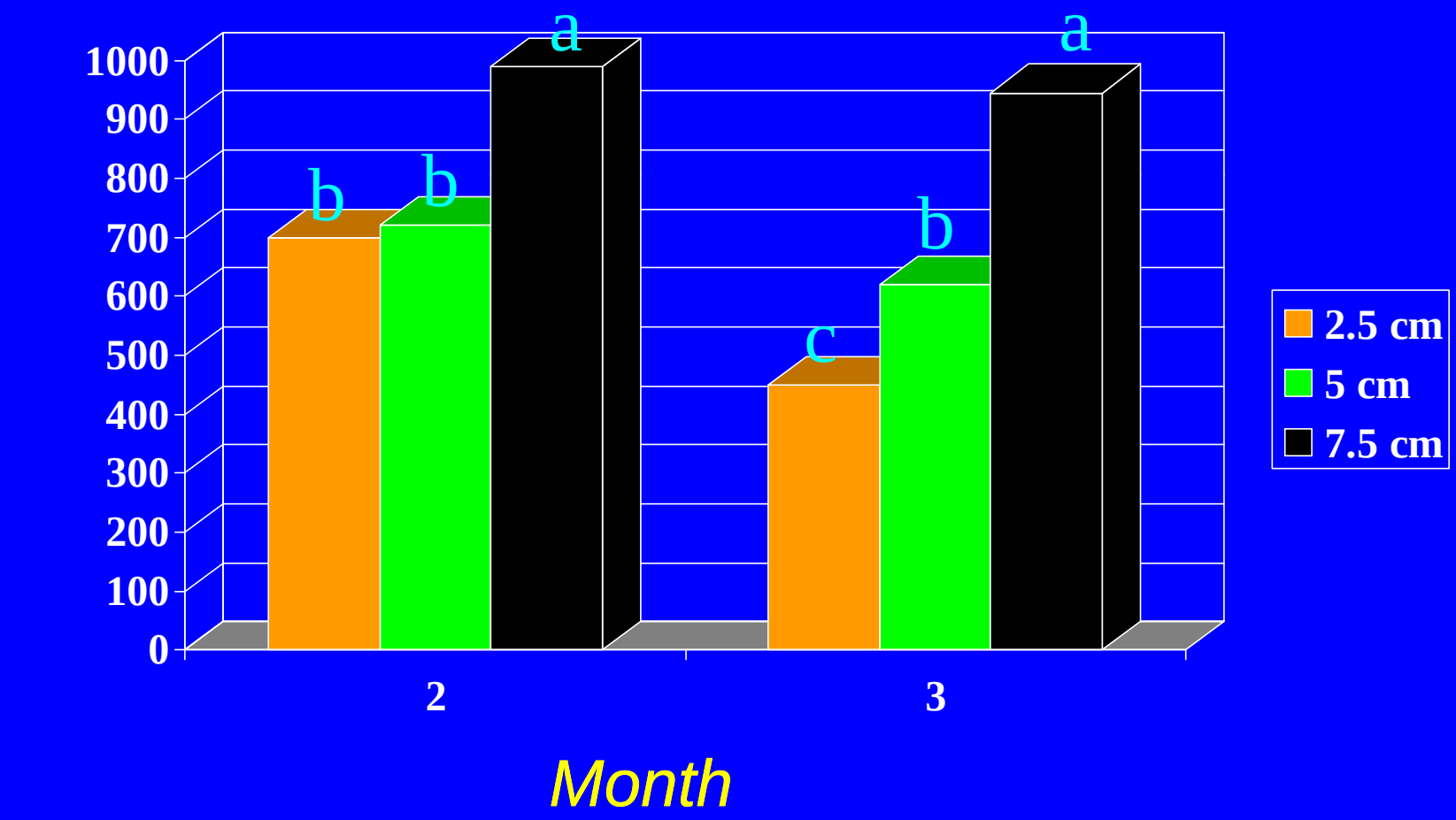
Tall fescue mowing height:
Unknown C



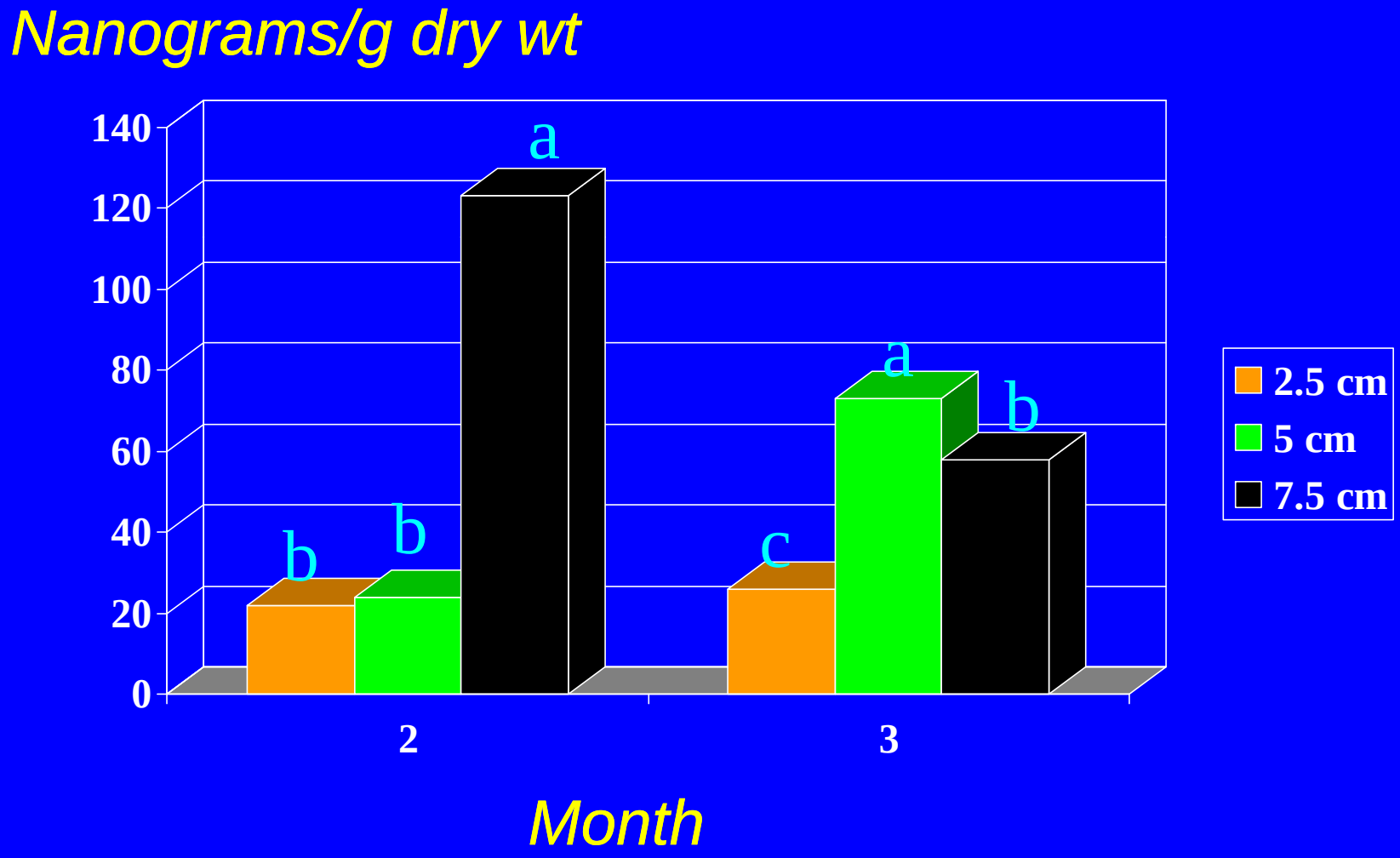
Mowing height affects alkaloid levels in perennial ryegrass

A greenhouse study

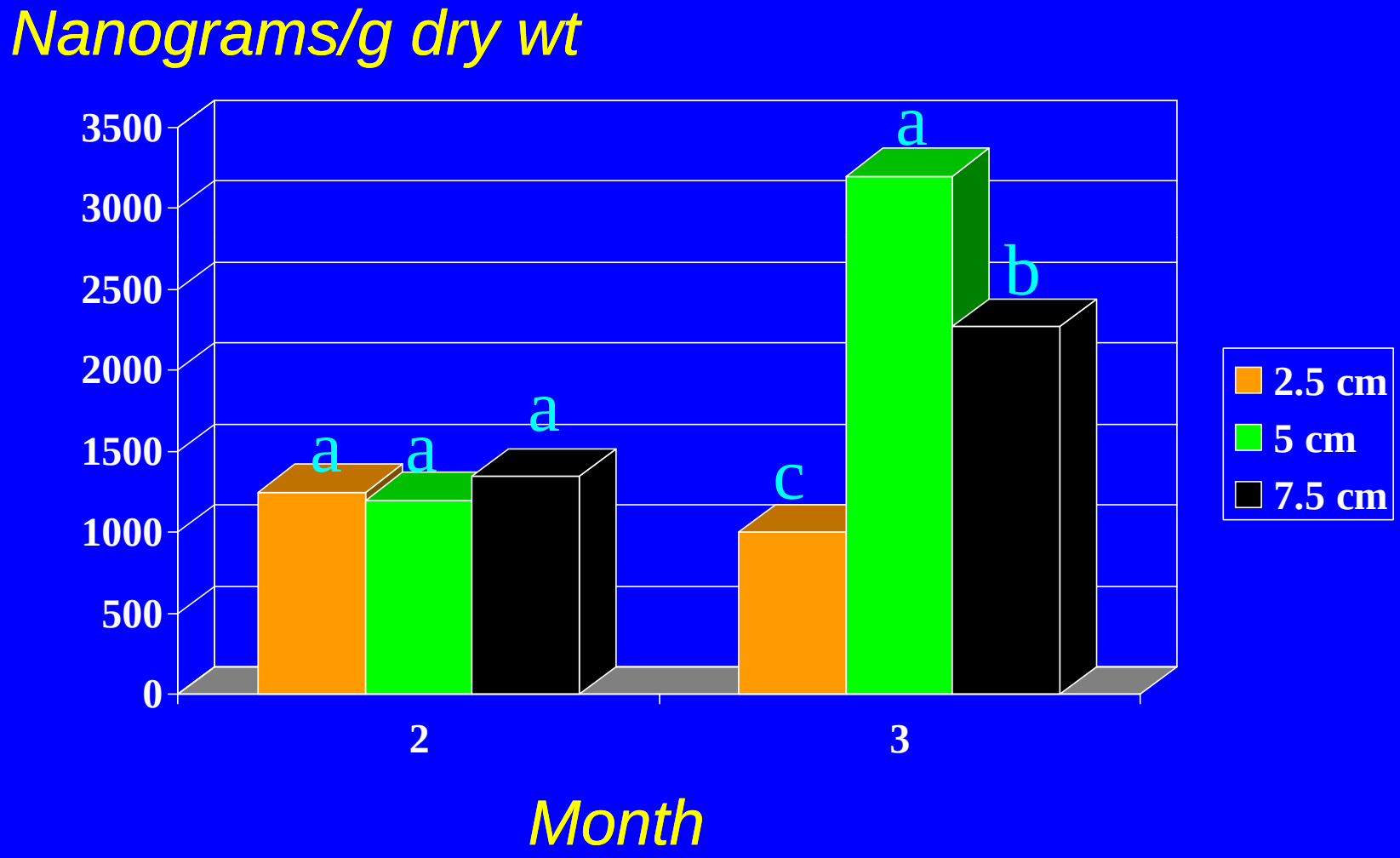
Perennial ryegrass mowing height: Perloline methylether



Perennial ryegrass mowing height: Unknown A



Perennial ryegrass mowing height: Ergovaline



Effect of mowing treatments on fall armyworm performance

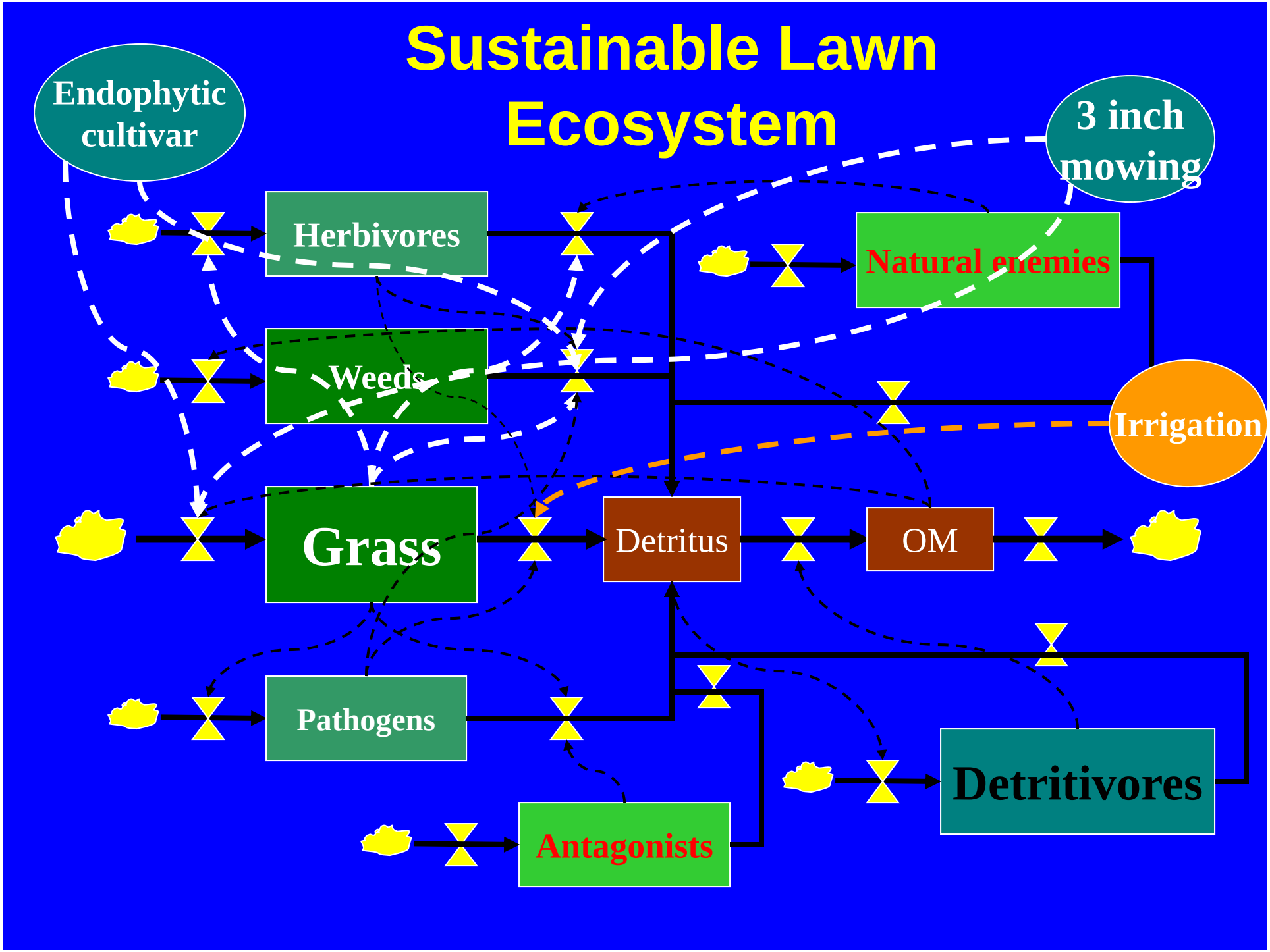
- Mowing height treatments
- Endophyte free or infected plants
- 10 neonate larvae/dish
- Armyworm biomass (dry wt) assessed 6 days later
- 21°C; 16:8 L:D

Grass species selection

- **Tall fescue (improved turf-type cultivars, not Kentucky 31) - Best choice!**
- **Fine fescue**
- **Perennial ryegrass**
- **Kentucky bluegrass**

Why Tall fescue?

- Low maintenance
- Endophytic – built-in insect resistance
- Tolerates low fertility and highly compacted soils
- Tolerates drought and heavy traffic
- Both sun and shade tolerant
- Stays green in the summer due to deep root system
- Does not form thatch


Sustainable Lawn Ecosystem
Endophytic cultivar
3 inch mowing
Herbivores
Natural enemies
Weeds
Irrigation
Grass
Detritus
OM
Pathogens
Detritivores
Antagonists

Interaction between grass-weed competition and herbivory

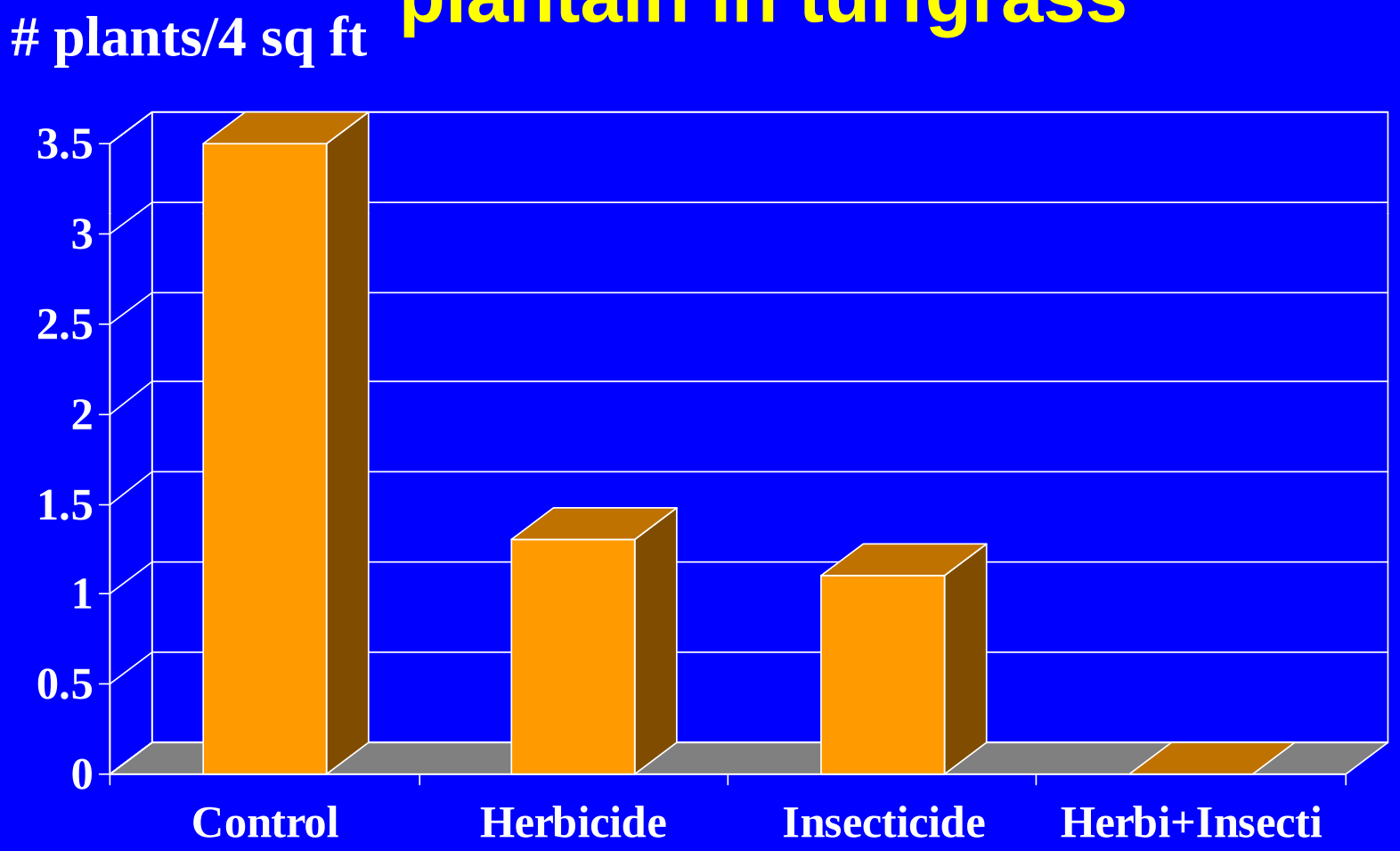
Interactions between weeds and insects

Kentucky blue grass lawn plots

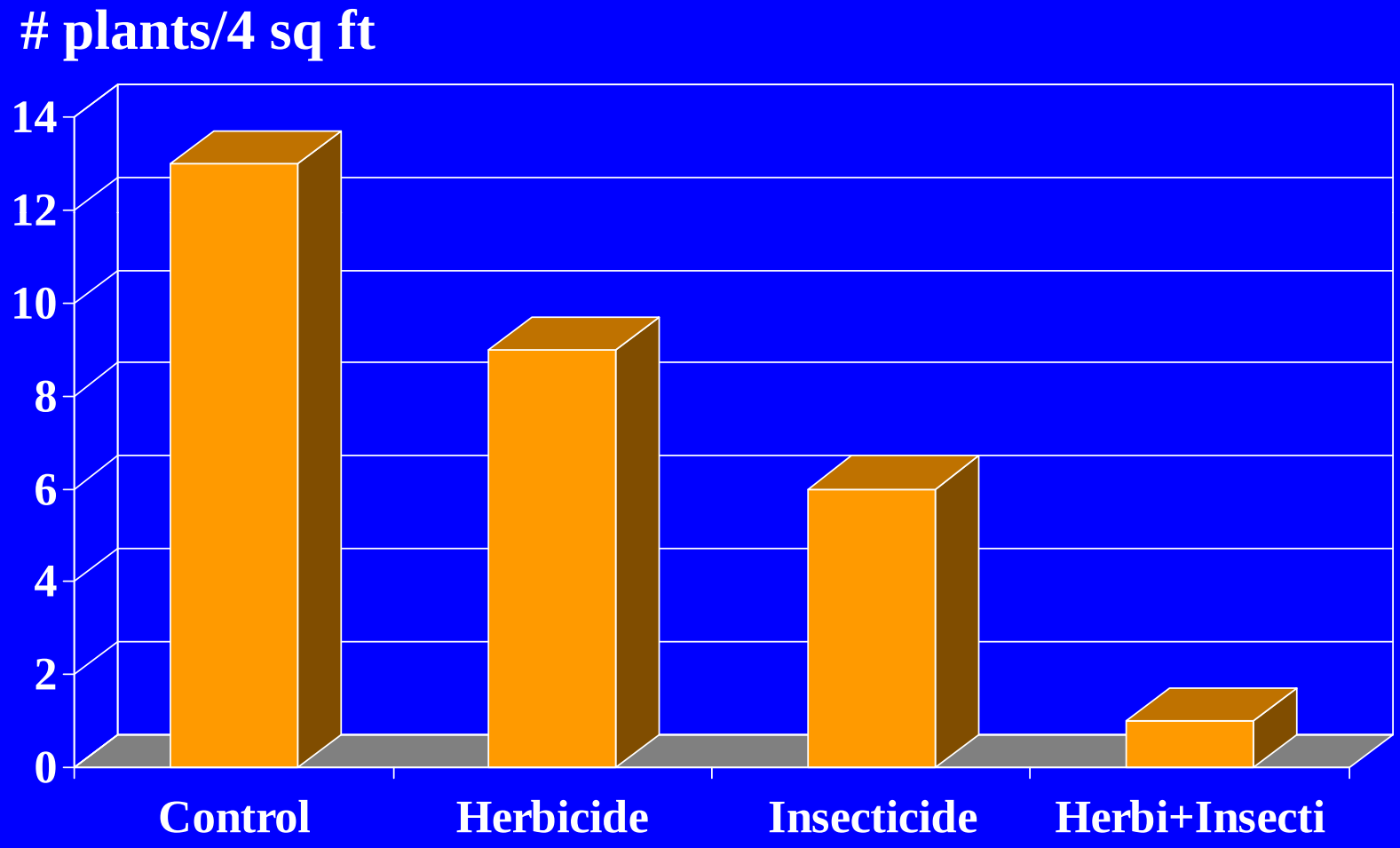
Four treatments:

- **Control (nothing applied)**
- **Herbicide only**
- **Insecticide only**
- **Herbicide plus Insecticide**

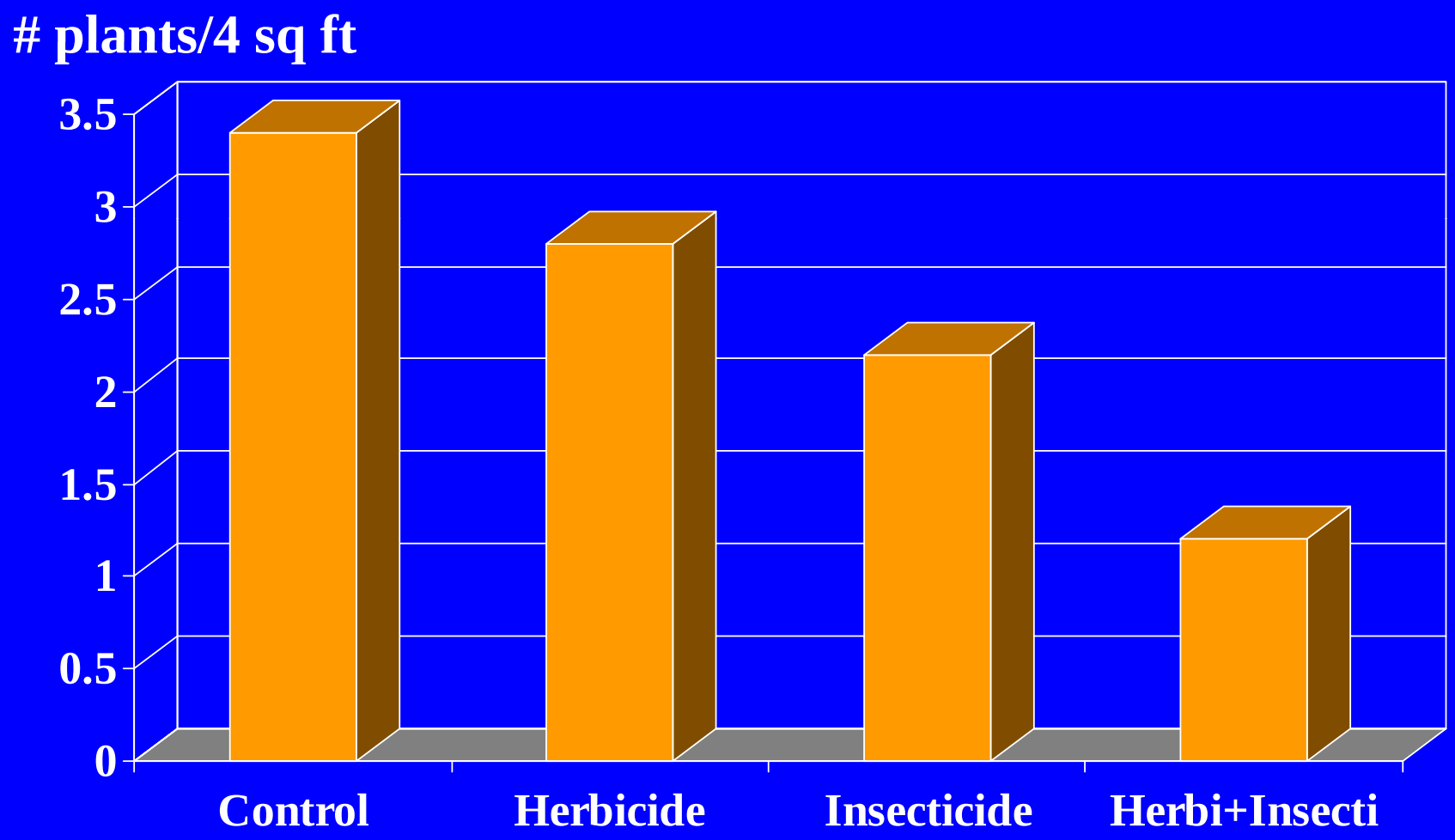
Effect of herbicides (3-way blend), insecticide (imidacloprid), and a combination treatment on buckhorn plantain in turfgrass



Effect of herbicides, insecticides, and a combination treatment on healall population in turfgrass

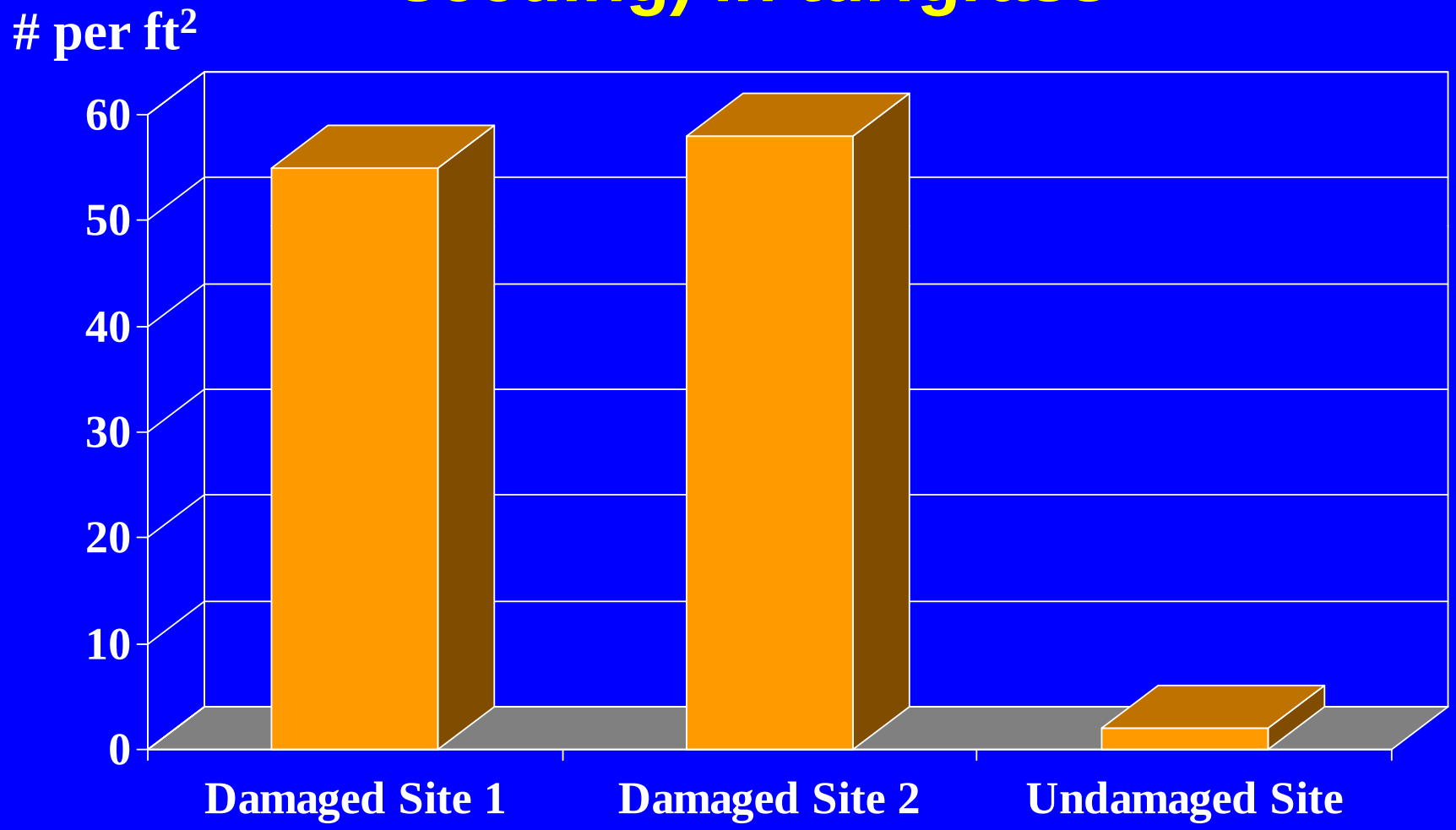


Effect of herbicides, insecticides, and a combination treatment on Oxalis population in turfgrass

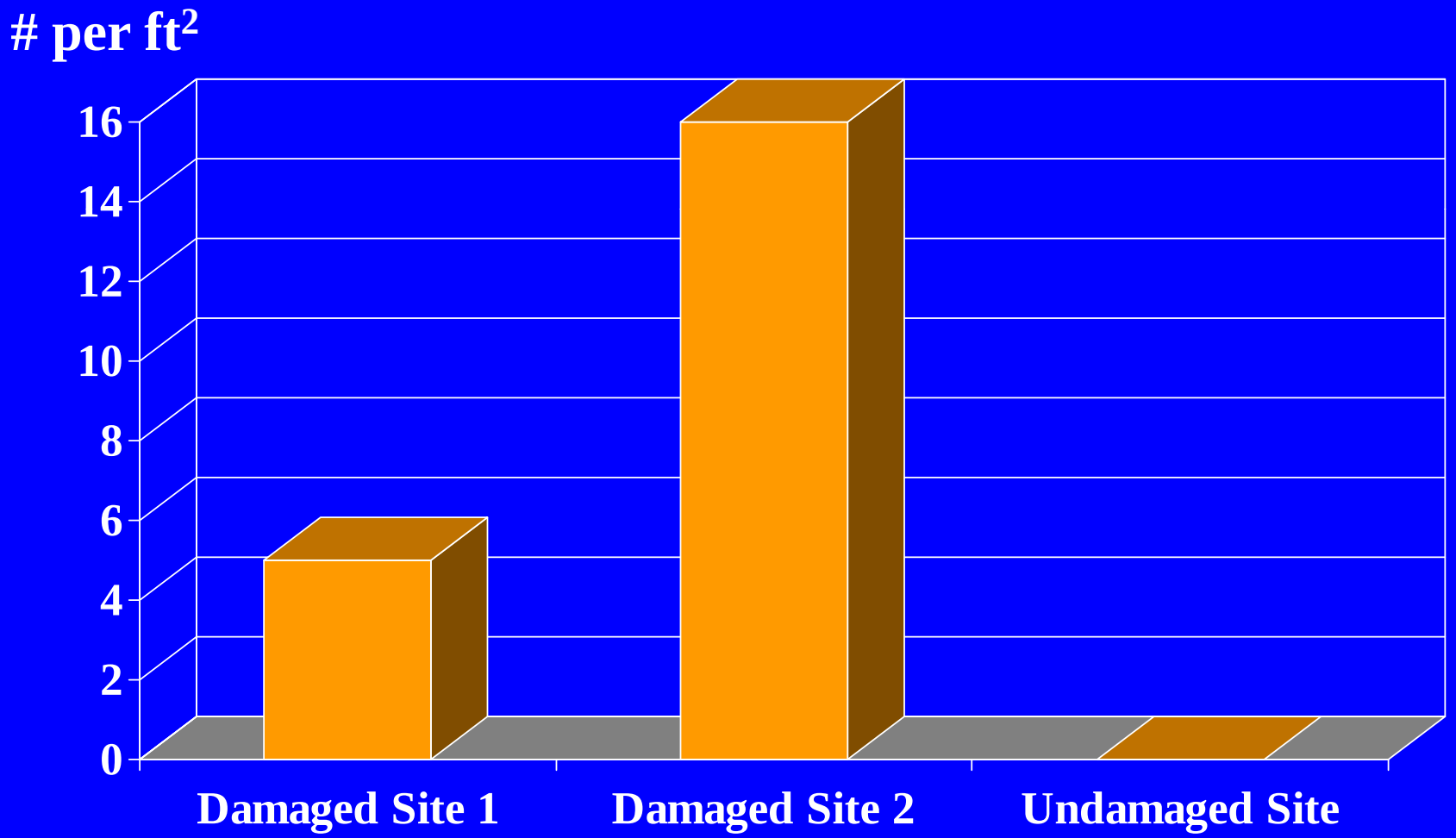


A weed over-seeding study

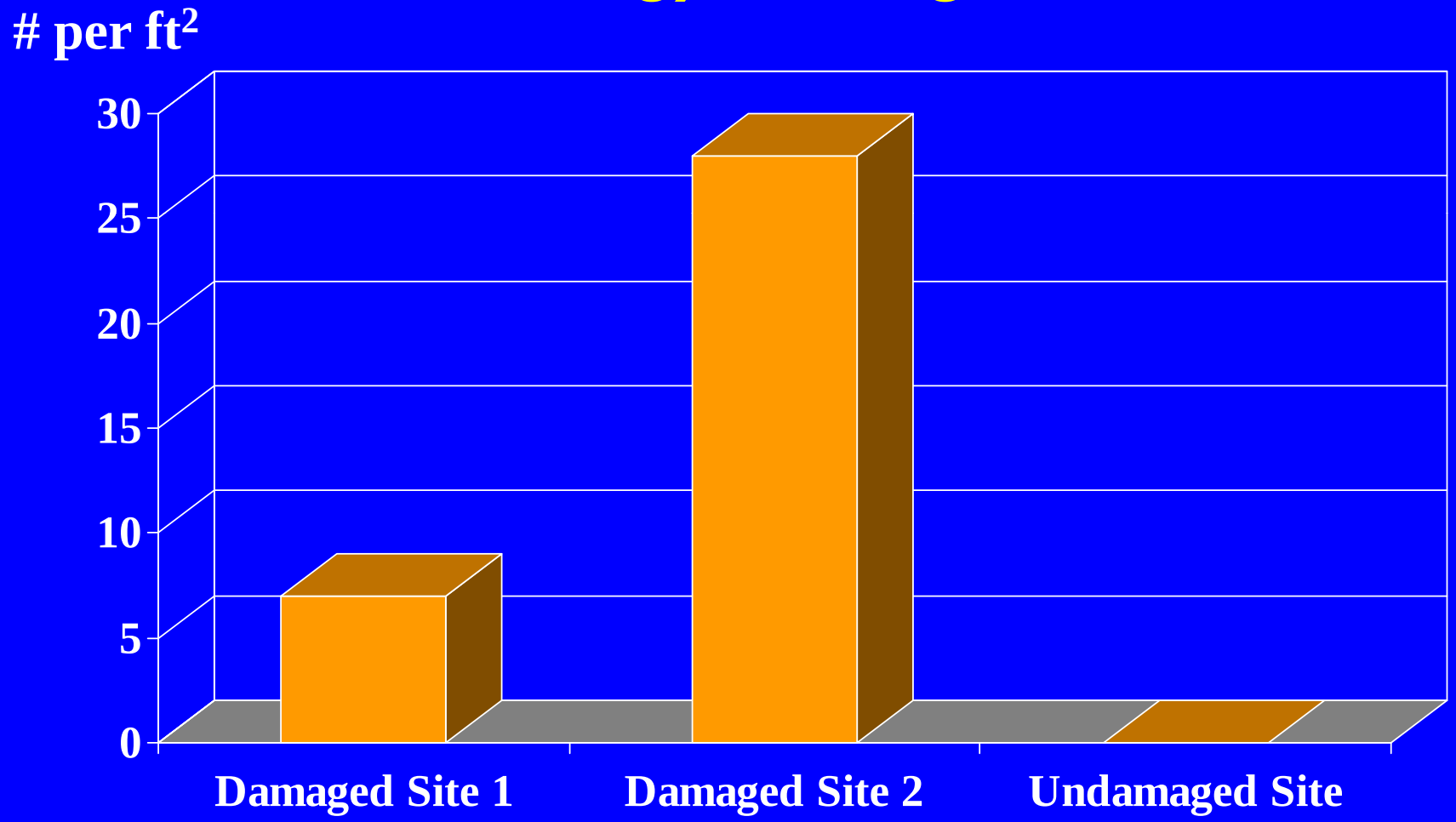
Influence of billbug damage on Black medic invasion (3 month after over seeding) in turfgrass



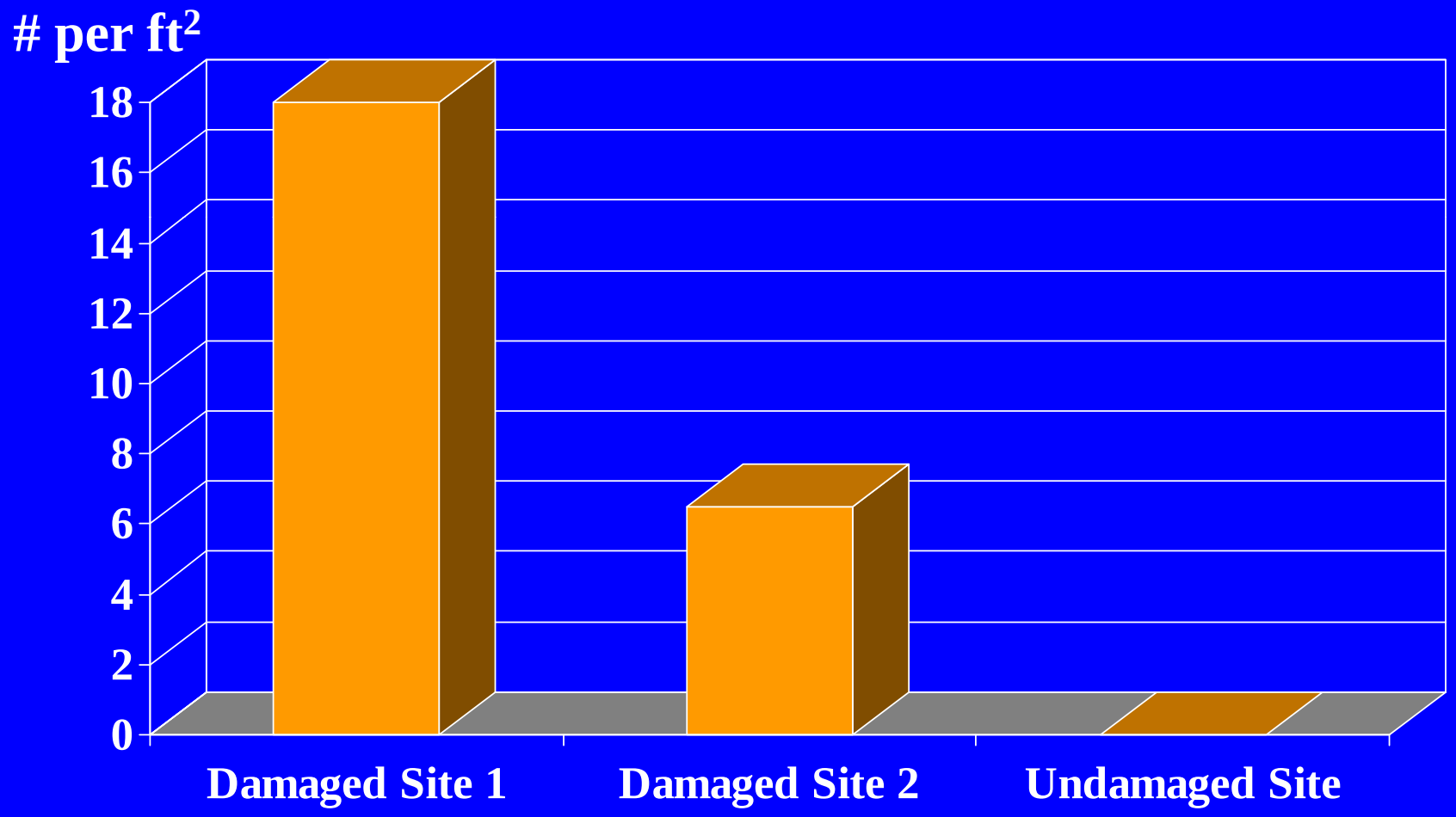
Influence of billbug damage on dandelion invasion (3 month after over seeding) in turfgrass



Influence of billbug damage on crabgrass invasion (3 month after over seeding) in turfgrass



Influence of billbug damage on white clover invasion in turfgrass (one year later)



Are weeds just symptoms of insect infestations?

What a waste of herbicides!

Five ecological principles of lawn ecosystem management

- Nutrient Cycling
- Competition
- Herbivory
- **Predation and Parasitism**
- Human Intervention

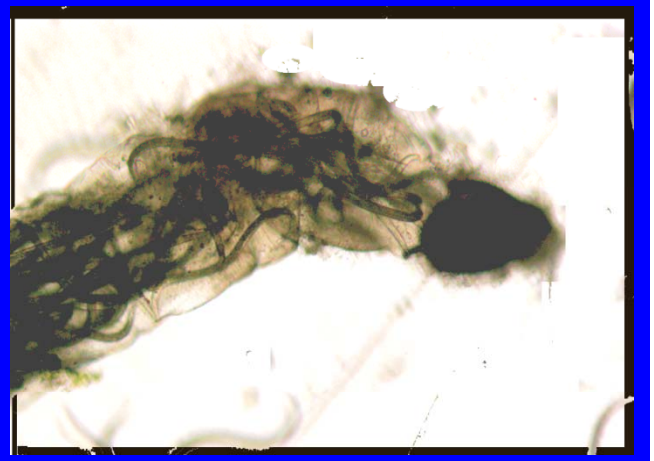
Entomopathogenic Nematodes

Mole cricket

Wax worm

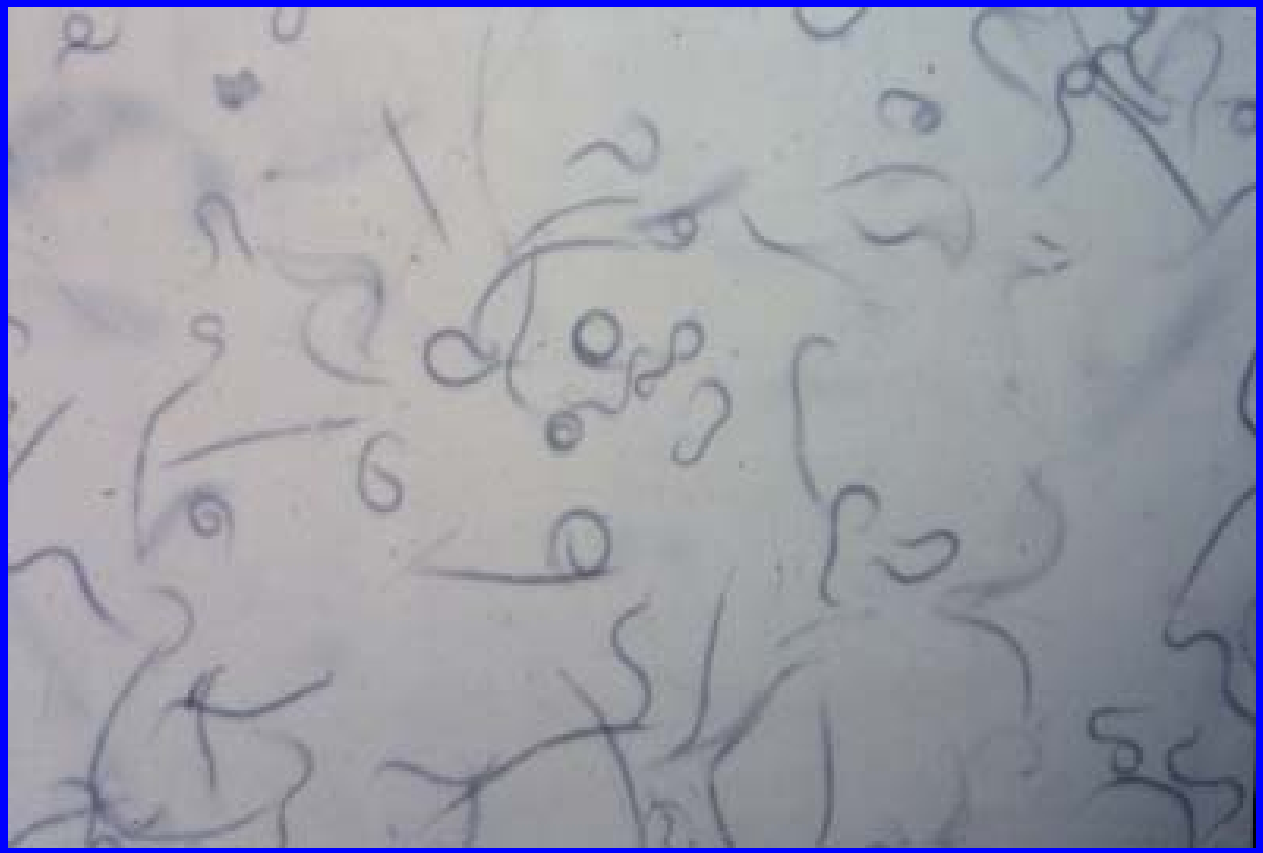
White grub

Beet army worm



Fungus gnat larva

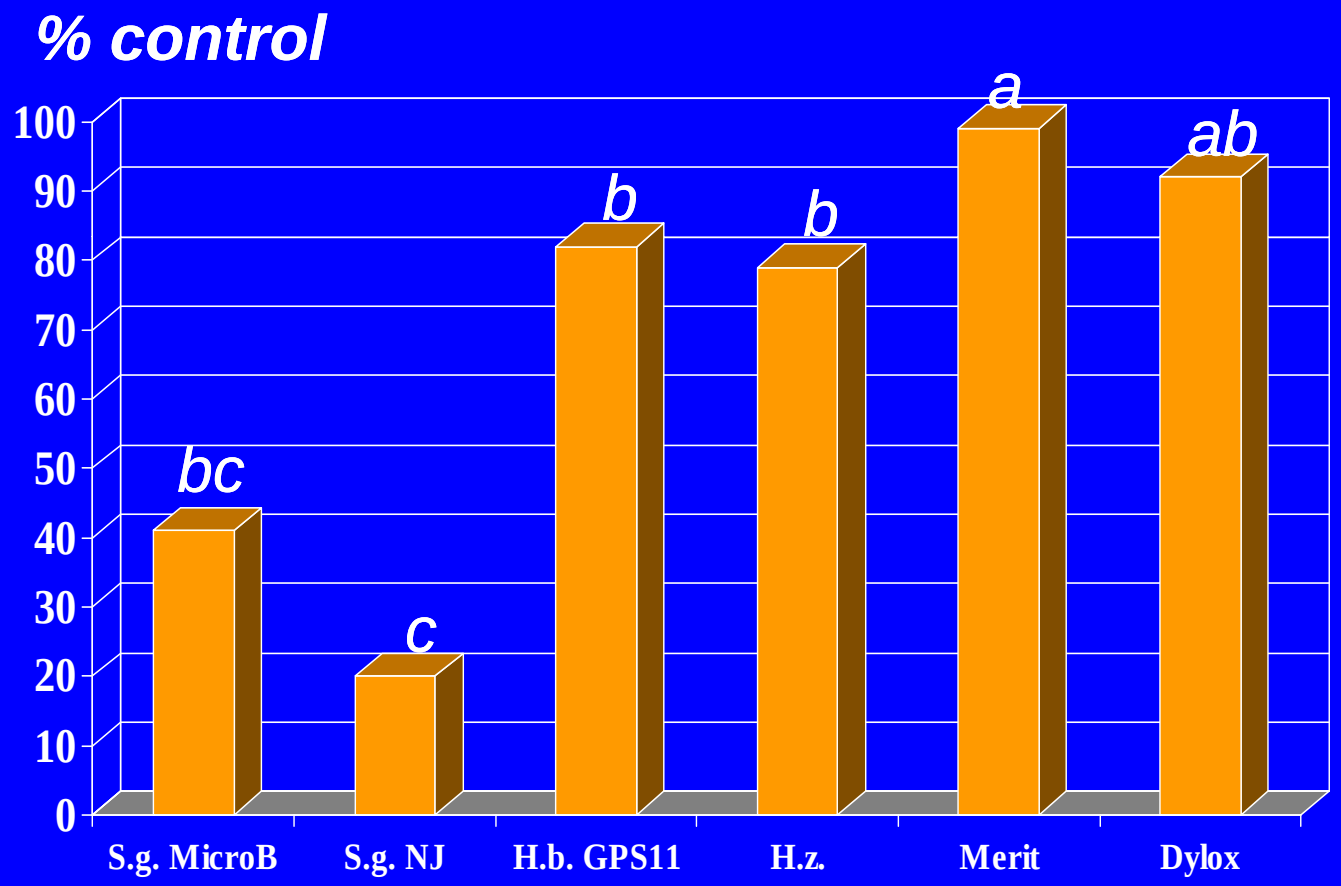
Entomopathogenic nematodes



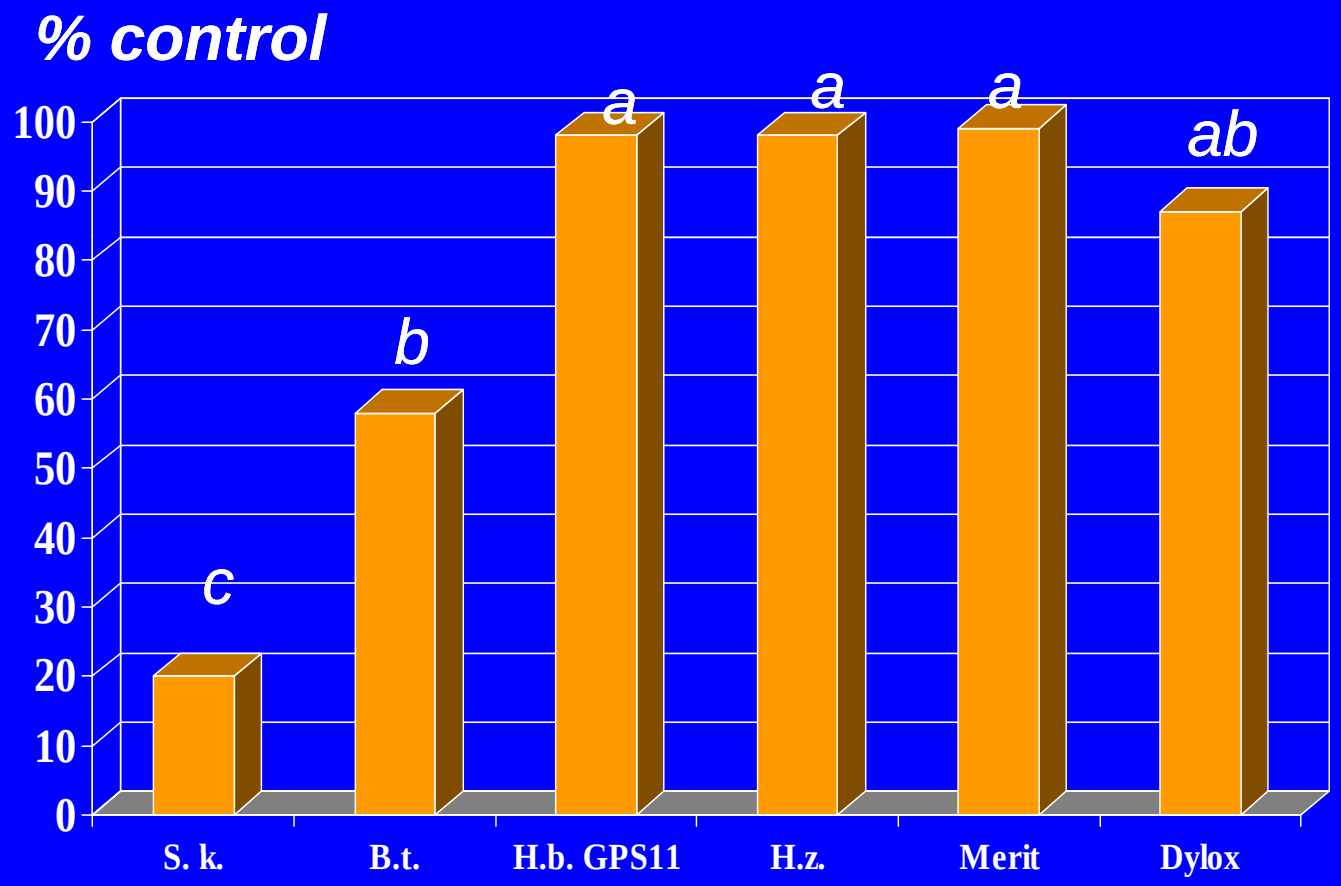

Millenium
Nemasys™
Biopesticide for Fungus Gnat Control
STORE IN REFRIGERATOR (5°C/41°F)
DO NOT FREEZE
DO NOT LEAVE IN BRIGHT SUNLIGHT
USE BEFORE EXPIRATION DATE
READ INSTRUCTIONS BEFORE USE
MicroBio
Mycotech
GUARD
STORAGE
RELEASE


2 58'

Control of Japanese beetle grubs with nematodes in a turf lawn - Fall 2001



Control of Japanese beetle grubs with nematodes in a turf lawn - Fall 2002



Consistency of Control

Treatment	Tests	% control
Hz-X1	8	81 (73-98)%
Hb-GPS11	7	66 (34-97)%
Trichlorfon	7	59 (29-92)%

More Information?
Read this new book!

Nematodes as Biocontrol Agents

by

Parwinder S. Grewal

Ralf Udo Ehlers

David Shapiro-Ilan

CABI Publishing, December 7, 2005

More Information on Entomopathogenic Nematodes?

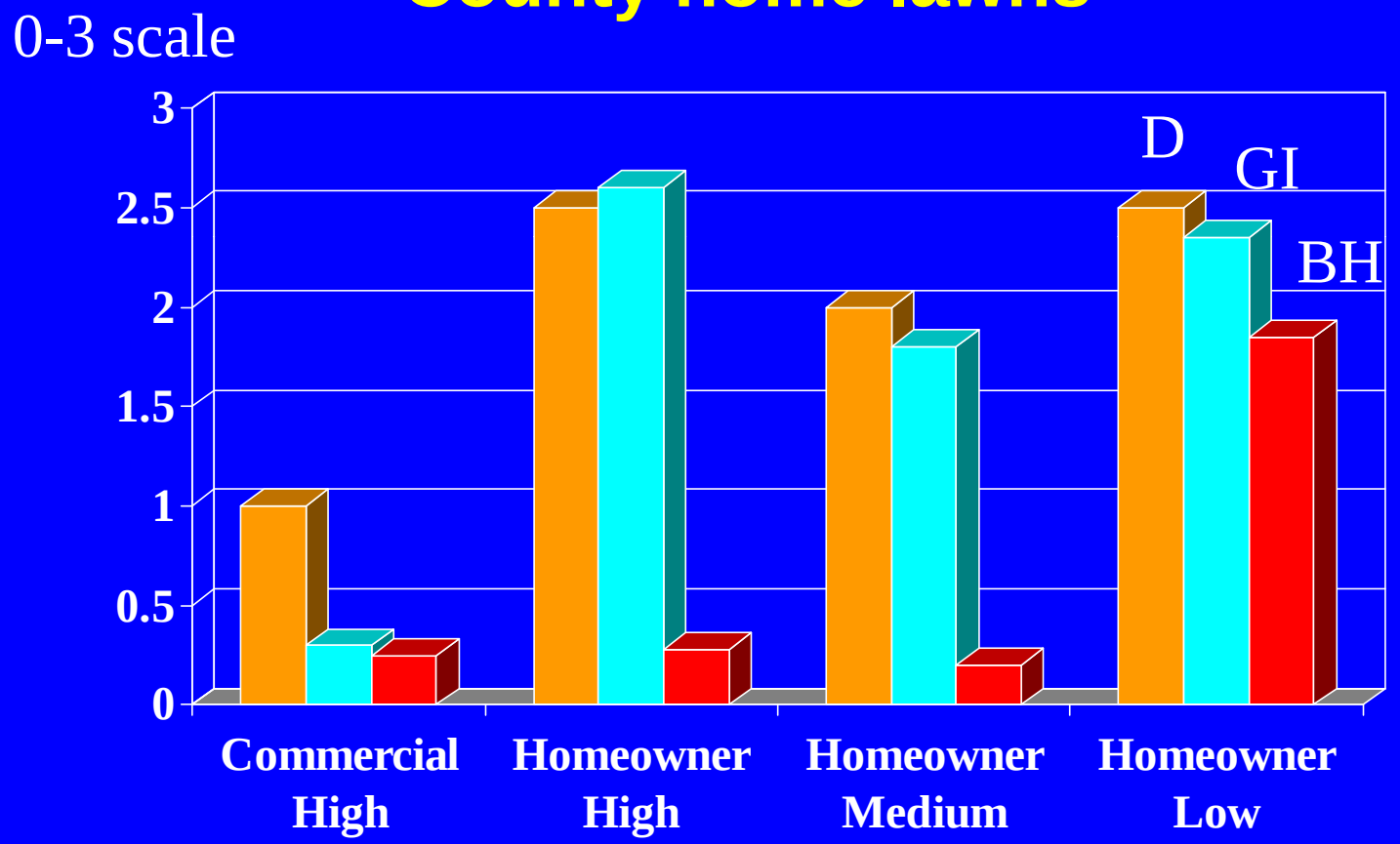
www.oardc.ohio-state.edu/nematodes

Grewal's five principles of lawn ecosystem management

- Nutrient Cycling
- Competition
- Herbivory
- Predation and Parasitism
- Human Intervention

A closer look at lawn management in Wayne County

Effect of management intensity on weed incidence in turfgrass: A survey of Wayne County home lawns



Lawn management study (2004-2006)

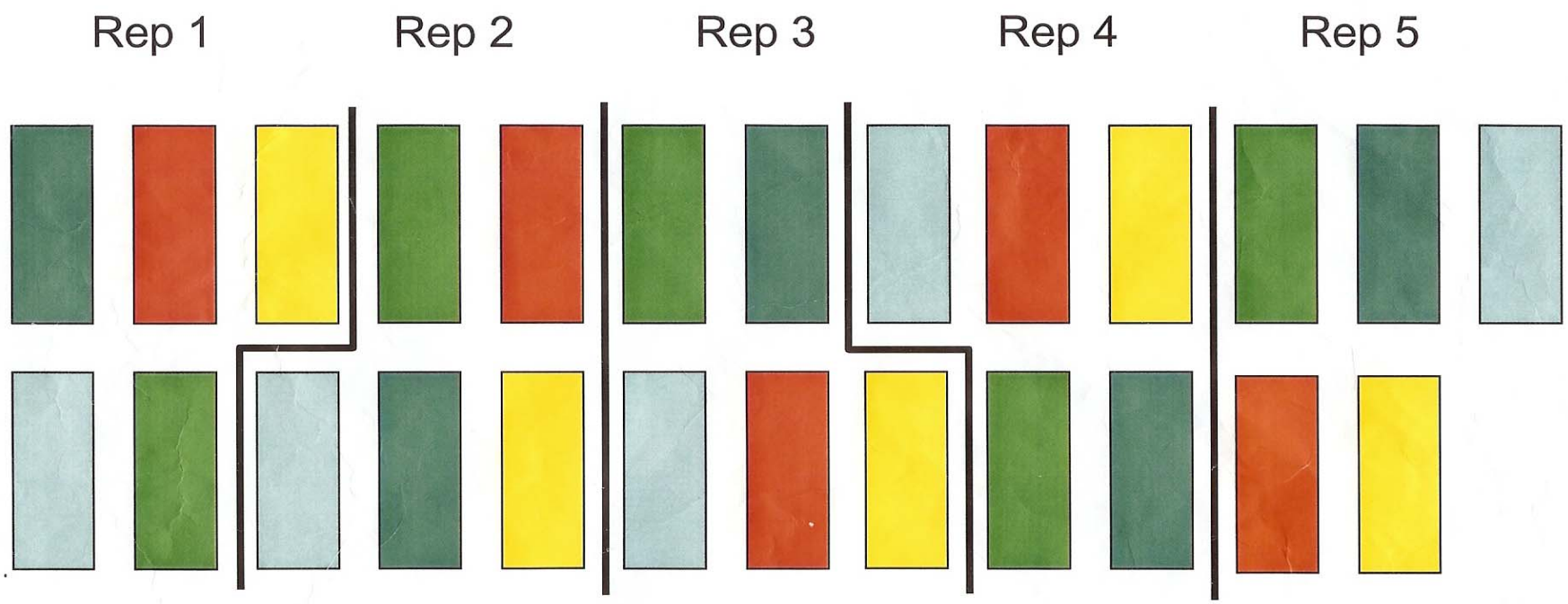
- Established March-April 2004 at OARDC

- Compare 5 management programs:
  - Commercial
  - Consumer
  - Integrated pest management (IPM)
  - Organic
  - Untreated control

Specific objectives

- Determine influence of management program on major insect pests and weeds (Biological)
- Quantify grass stand quality (color and overall appearance) of each program (Aesthetic)
- Quantify and compare basic material costs and time limits associated with each program (Economic)

Field Plot Layout



- Control
- TruGreen Chemlawn
- 4-step
- IPM
- Organic

Plot size 20 x 10 ft
w/ 5 ft alleys
Overall 190 x 50 ft

Green houses

(North)

Commercial lawn care program

Season	Lawn products applied
Early spring	NPK (30-3-3); Triplet; Barricade
Late spring	Triplet; NPK (30-3-3); Merit
Summer	Tri-power; NPK (30-3-3)
Early fall	Triplet; NPK (30-3-3)
Late fall	NPK (30-3-3)

Consumer lawn care program

Season	Lawn products applied
Early spring	TurfBuilder® with Halts® (NPK: 30-0-4)
Late spring	TurfBuilder® with Plus 2® (NPK: 28-3-3)
Summer	TurfBuilder® with Summerguard® (NPK: 28-3-8)
Early fall	TurfBuilder® Lawn Fertilizer (NPK: 29-2-4)
Late fall	TurfBuilder® Winterizer™ (NPK: 22-3-14)

IPM lawn care Program

Season	Lawn products applied
Early spring	TurfBuilder® with Halts™ (NPK: 30-0-4) (2004 only)
Late spring	Triplet (2004 only)
Summer	TurfBuilder® fertilizer (NPK: 29-2-4) (2005)
Early fall	Triplet (2004-2006)
Late fall	TurfBuilder® Winterizer™ (NPK: 22-3-14)

Organic lawn care program

Season	Lawn products applied
Early spring	Ringer® Lawn Restore® (NPK: 10-2-6); Corn gluten meal
Late spring	Ringer® Lawn Restore®
Summer	
Early fall	Ringer® Lawn Restore®; Corn gluten meal; Boron (20 Mule Team® Borax)
Late fall	Ringer® Lawn Restore®

- All lawns mowed weekly at 3.5 inches (8.9 cm)
- Variables recorded during lawn management:
  - Product application time
  - Insect pests and weeds scouting time (IPM)
  - Lawn mowing time
- Variables used in calculating maintenance costs for comparison

Maintenance cost calculation

- **Maintenance cost**

  = Product cost (actual quantity applied) + Labor cost for product application [+ Labor cost for scouting (IPM only)]

  - **Labor cost estimated at $10.00/hr**
  - **Scouting cost estimated at $30.00/hr**
  - **Product cost includes equipment cost (spreader + backpack sprayer)**

Maintenance cost calculation

- Maintenance cost does not include gasoline cost and mowing time
- Adjusted to reflect estimates of maintaining a 5,000 sq. ft. lawn.

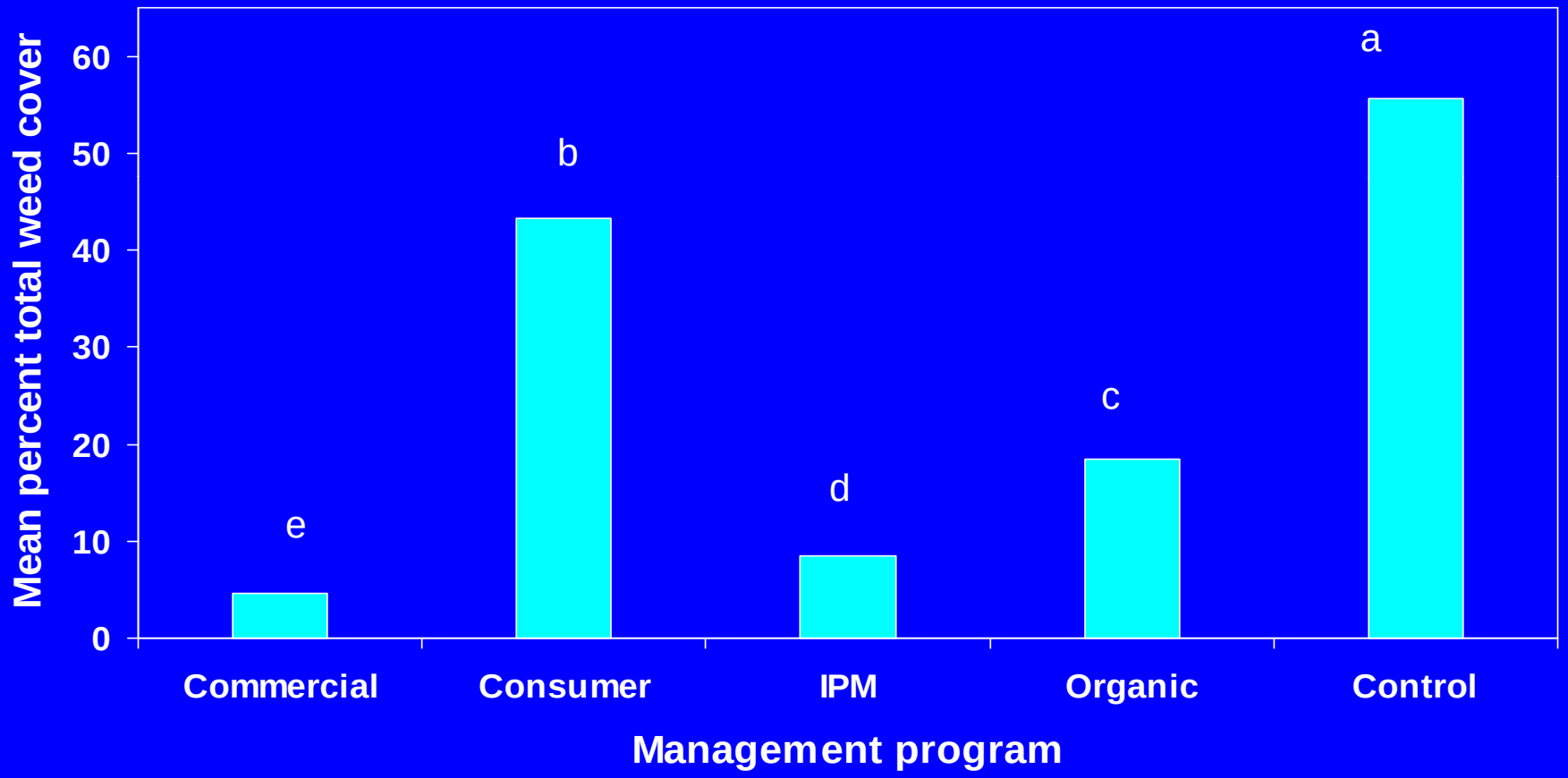
Weed sampling

1.5 ft x 1.5 ft ⇨

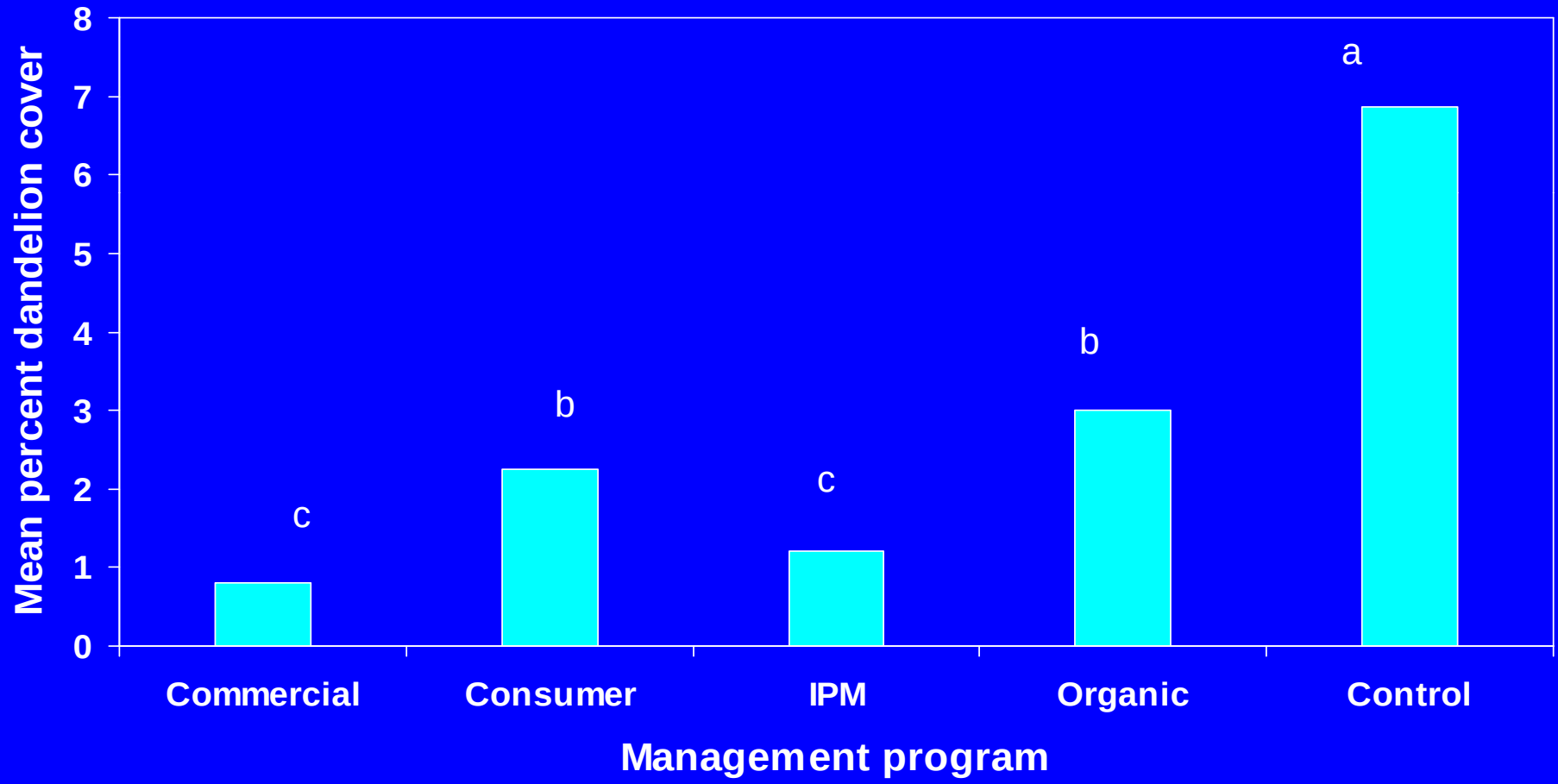
White grubs (JB & MC)

- Turf quality (Aesthetic) rating
  - Quality (color and overall appearance) assessed on a 1-9 score scale
  - 1 = very poor; 9 = excellent
  - Based on the National Turfgrass Evaluation Program (NTEP) assessment

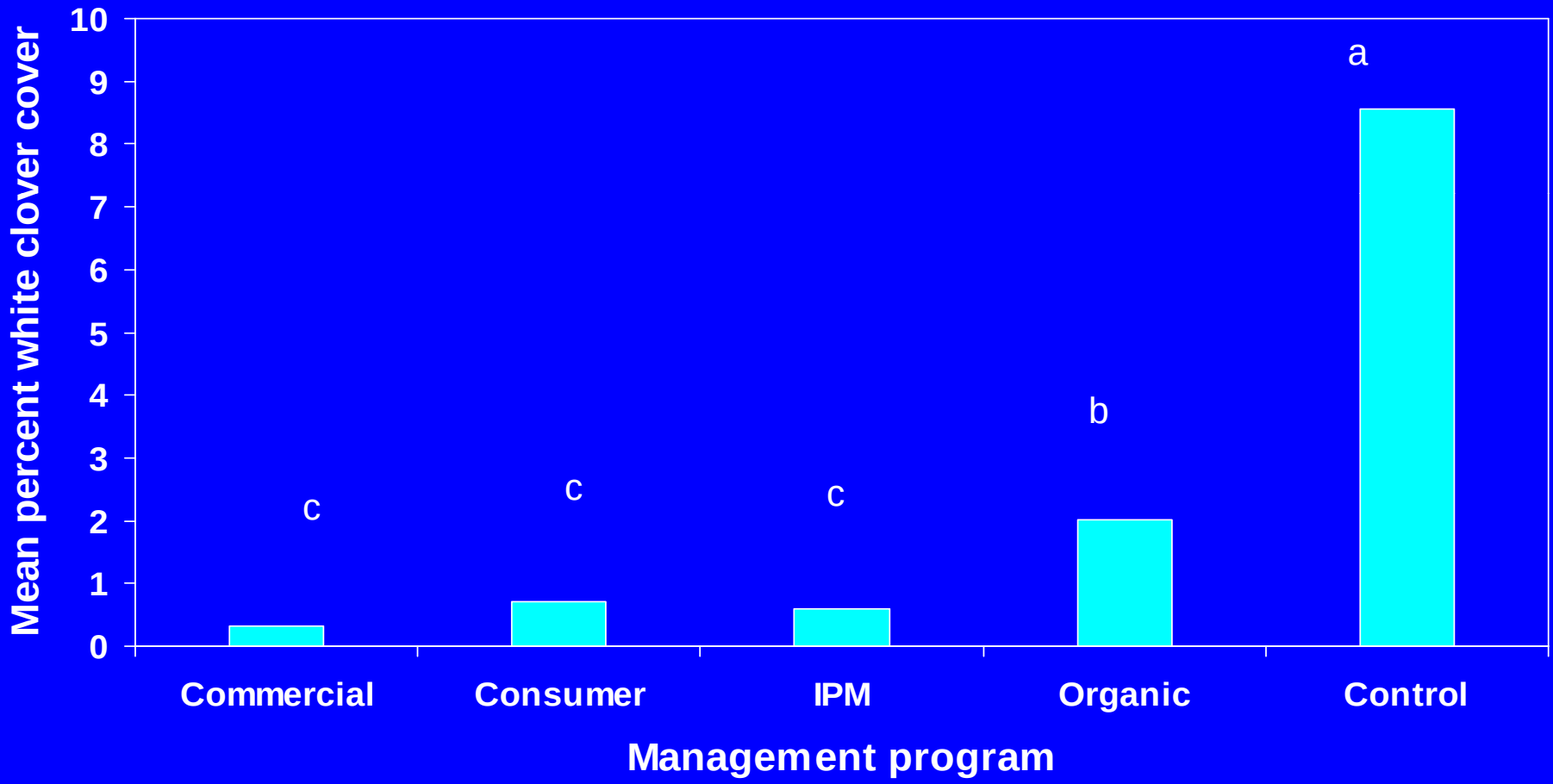
Total weed cover differs significantly with management program



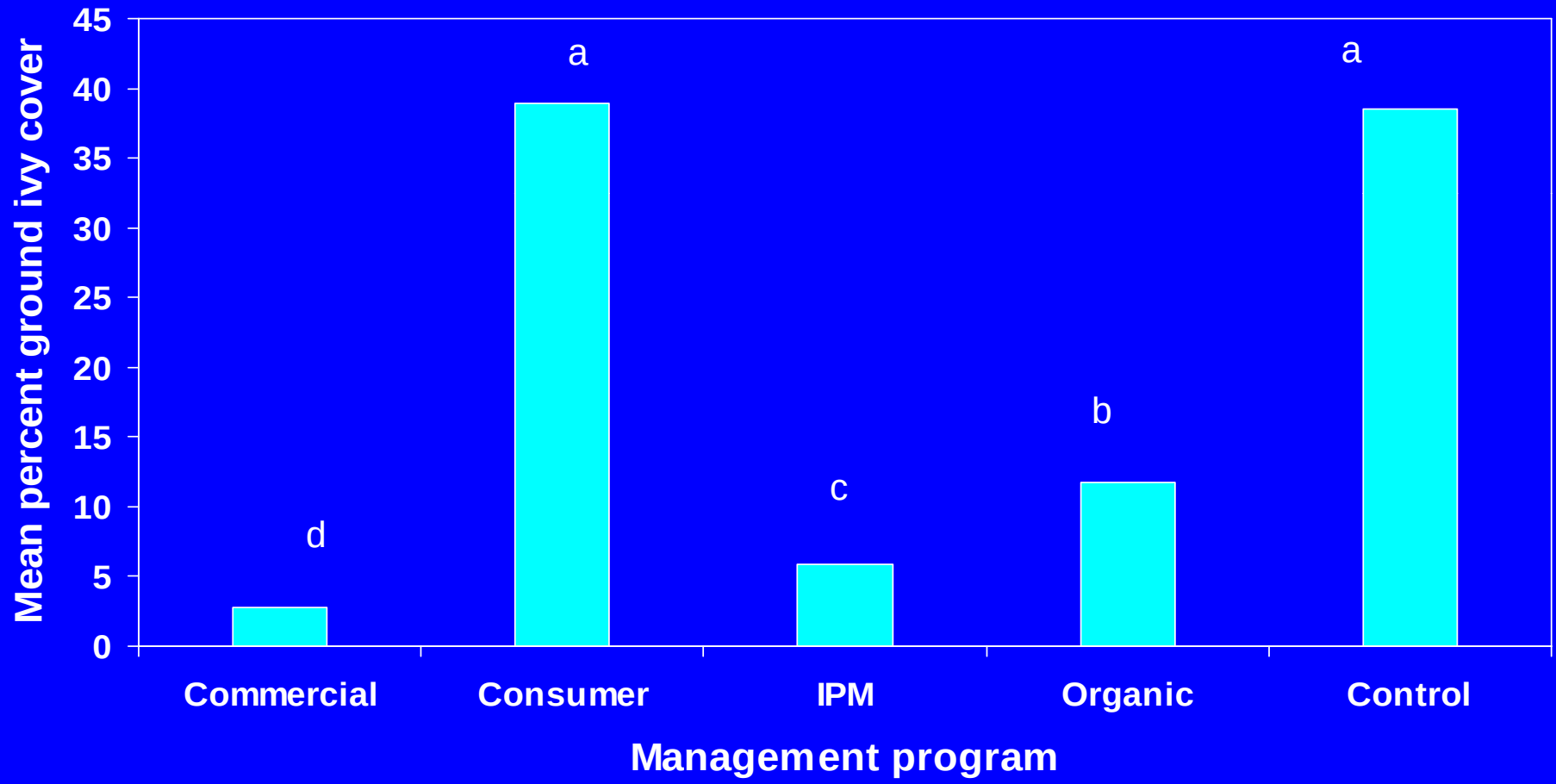
Dandelion cover differs significantly with management program



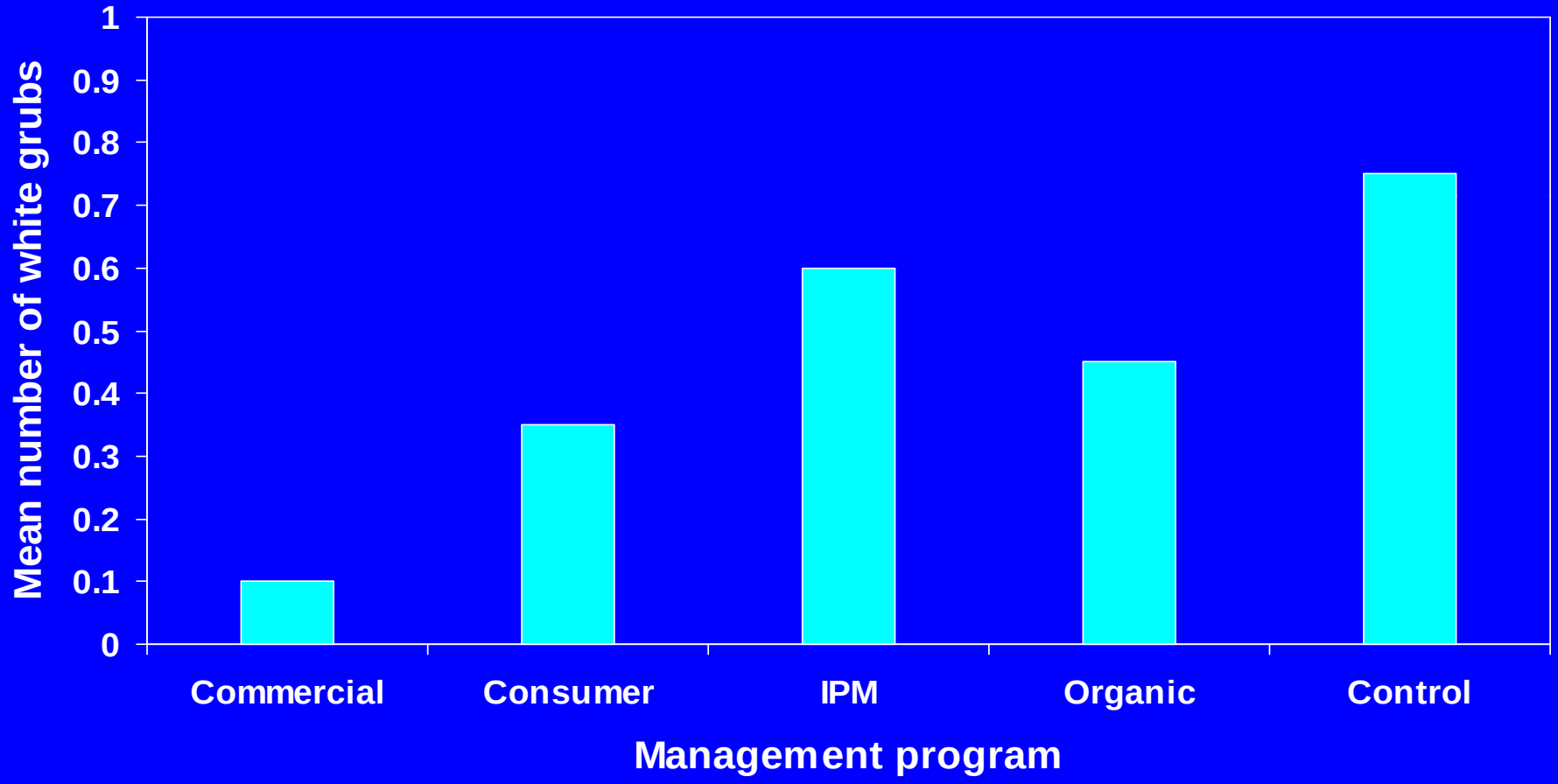
White clover cover differs significantly with management program



Ground ivy cover differs significantly with management program



White grub numbers do not differ with management program



Lawn quality ratings by program

Quality rated on 9-point scale (1 = poor; 9 = excellent)

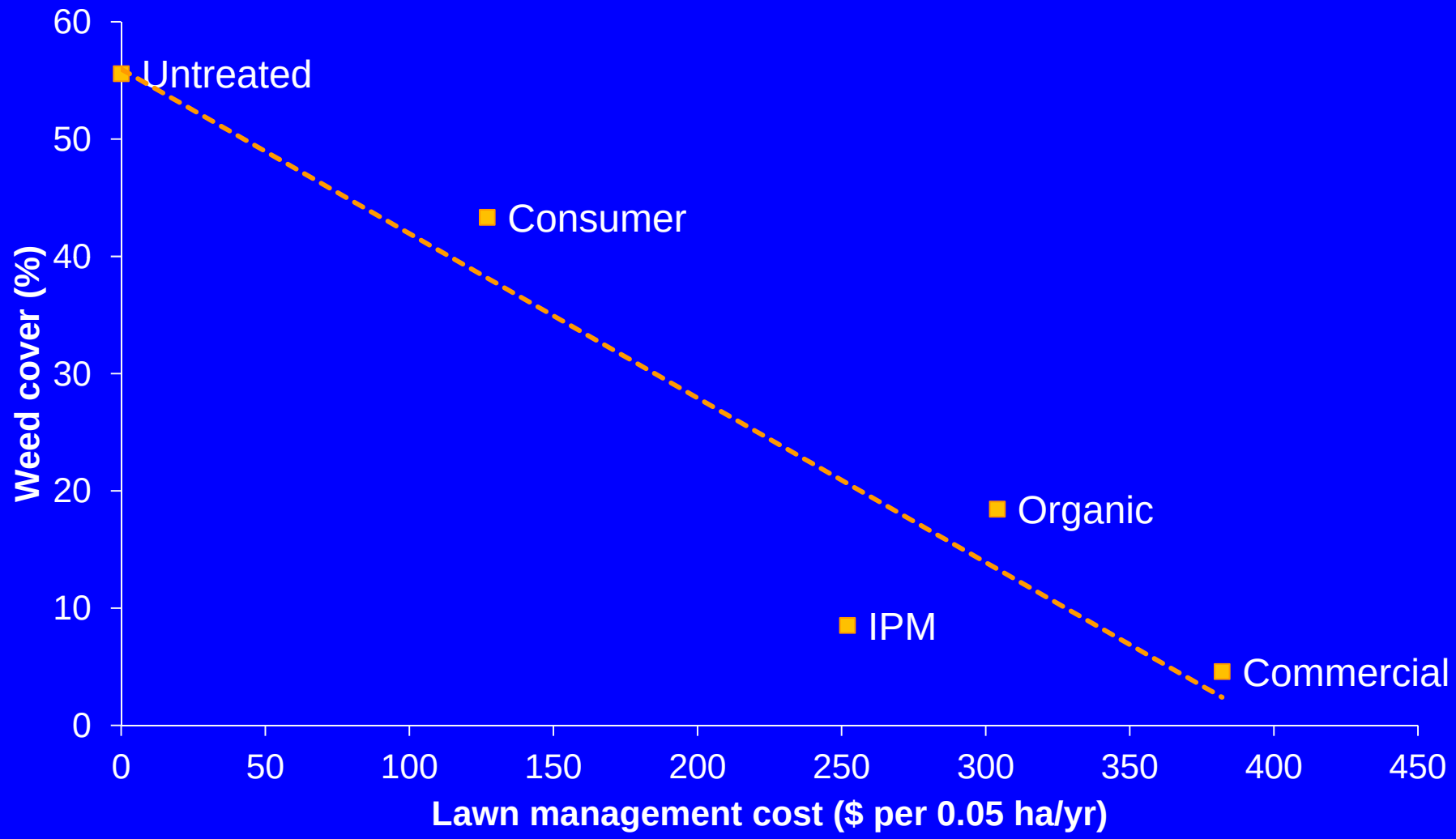
Lawn program	Year 1 (June 2004)	Year 2 (July 2005)	Year 3 (July 2006)	3-Yr mean
Commercial	5.3 ± 0.28a	8.2 ± 0.17a	7.5 ± 0.18a	7.2 ± 0.15a
Consumer	4.1 ± 0.30b	3.9 ± 0.45c	5.7 ± 0.26cd	4.4 ± 0.19d
IPM	5.2 ± 0.23a	6.0 ± 0.56b	6.3 ± 0.23bc	6.1 ± 0.14b
Organic	3.7 ± 0.22b	6.2 ± 0.24b	6.8 ± 0.18b	5.6 ± 0.16c
Untreated	3.4 ± 0.18b	2.9 ± 0.28d	5.5 ± 0.30d	3.8 ± 0.17e

Estimated cost of maintaining a 5,000 sq. ft. lawn per year

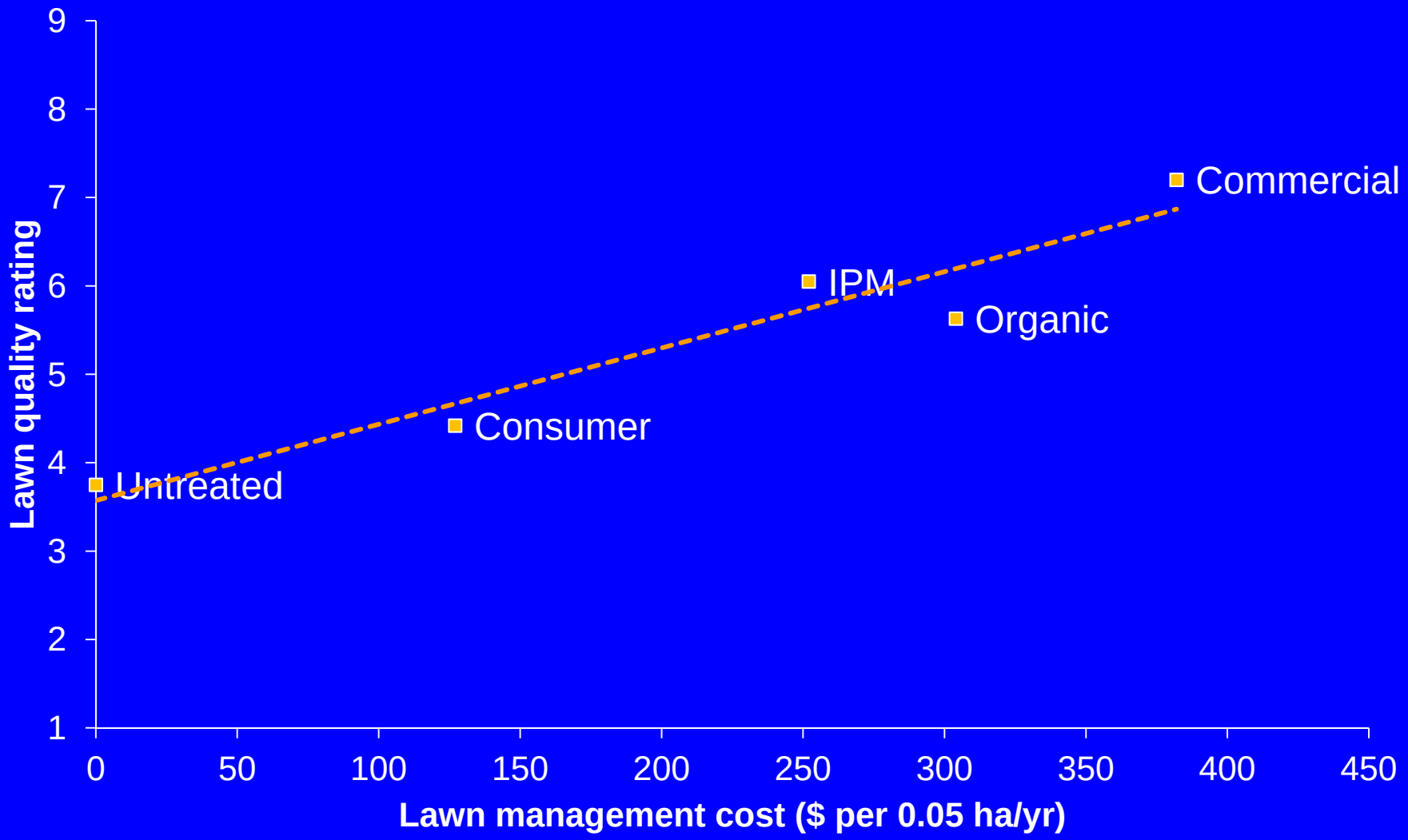
Management program	Maintenance cost* ($)
Commercial	382.40
Consumer	158.04
IPM	331.13
Organic	337.33
Untreated control	0

* Maintenance cost does not include fuel and mowing time

Lawn management program cost Vs weed cover



Lawn management program cost Vs quality



IPM in Commercial Lawn Care

A case study with Buckeye Ecocare, Dayton, Ohio

- **Standard lawn care program**
  - Pesticides applied on calendar basis without treatment thresholds
- **IPM lawn care approach (2005)**
  - Pesticides applied based on pest monitoring and treatment thresholds (5% weed cover or insect damage)

Methods

- **Study began in 2005 with 40 customers**
  - 29 IPM program customers (through a letter)
  - 11 Standard program customers
- **Continued in 2006 with 12 IPM customers**
  - Approx. 40% retention rate

Annual product application schedule

Time of year	IPM program[a]	Standard program
Early spring	NPK fertilizer	NPK fertilizer Barricade
Late spring	NPK fertilizer Trimec Merit	NPK fertilizer Merit
Late summer	NPK fertilizer	NPK fertilizer
Early fall	Trimec	Trimec
Late fall	NPK fertilizer	NPK fertilizer

[a] Herbicides applied to 6 of 29 IPM lawns and insecticides applied to 8 of 29 IPM lawns in 2005. No herbicides or insecticides applied to IPM in 2006.

Methods

- Lawns evaluated in June, August, and September in 2005-2006
  - Insect, weeds, and disease assessments
  - Lawn quality
    - 9-point scale (1 = poor; 9 = excellent)
    - 2 individuals on each evaluation date

Methods

⦿Cost comparison

$$LCPC = AC_h + [LC_m]$$

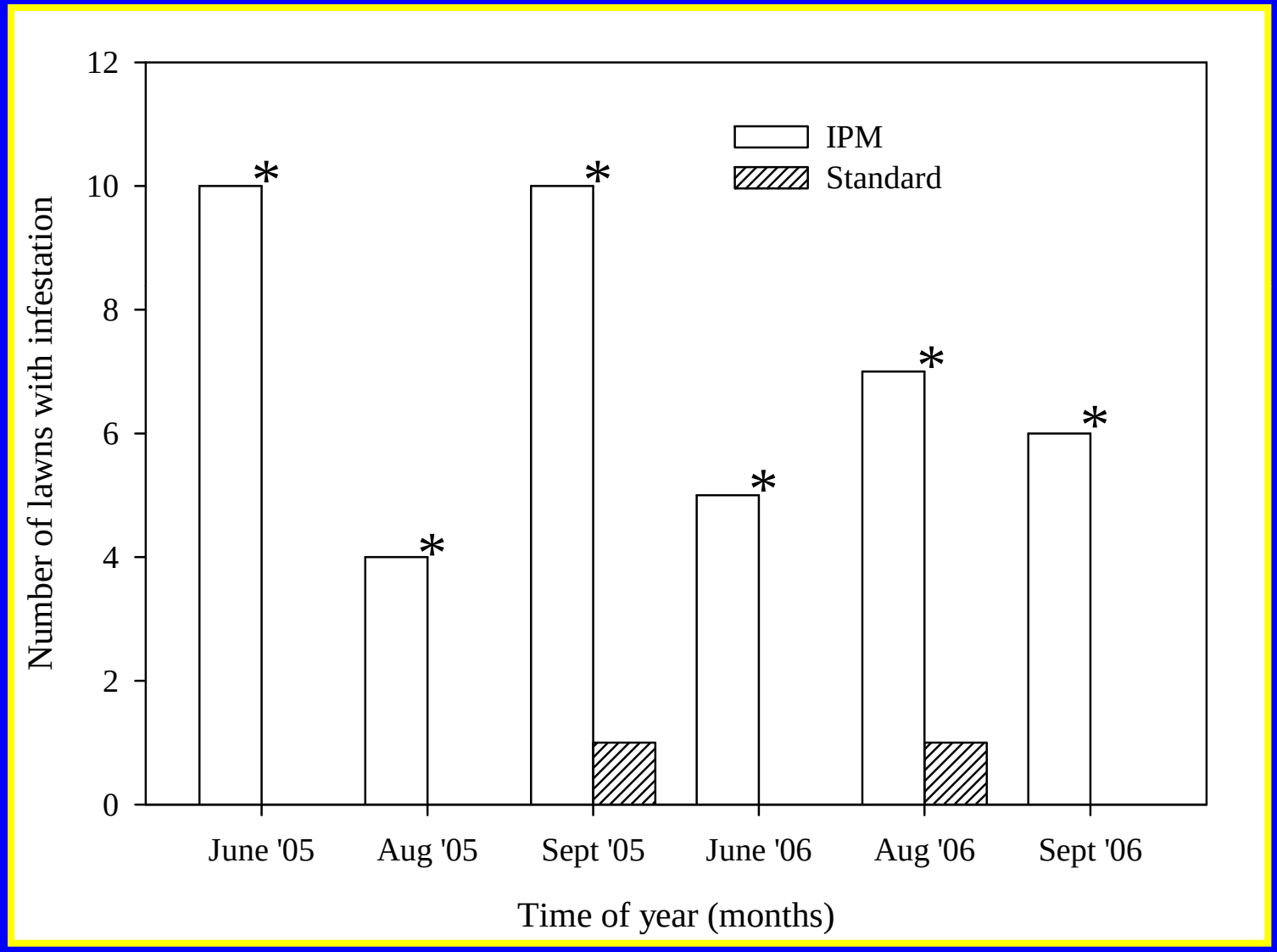
- LCPC – total lawn care program cost
- AC_h – average cost per home owner
- LC_m – labor cost for monitoring (IPM only)

Methods

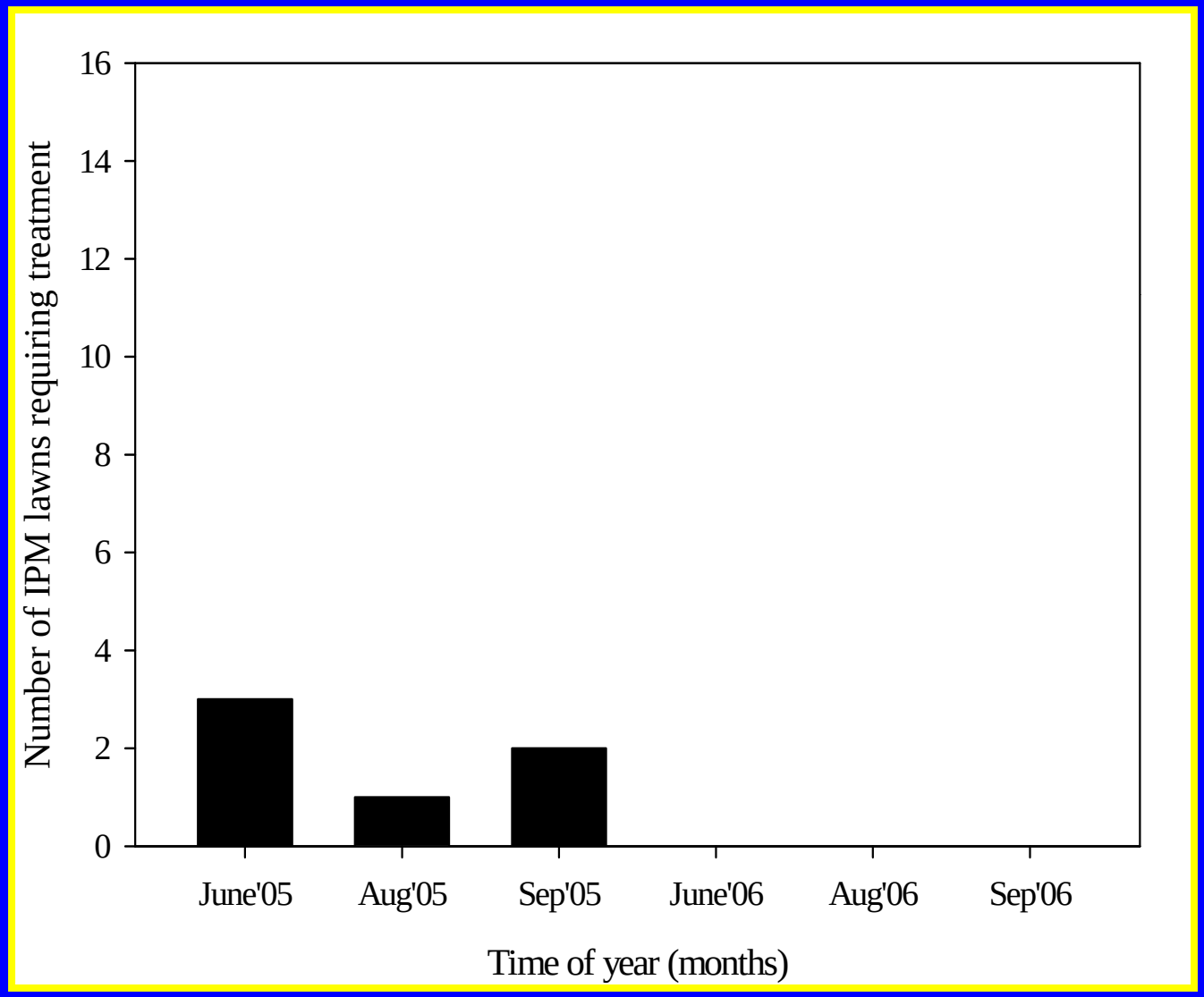
- Conducted telephone interviews at the end of the study to assess the perceptions of the customers about the IPM program

  – Buckeye Ecocare staff

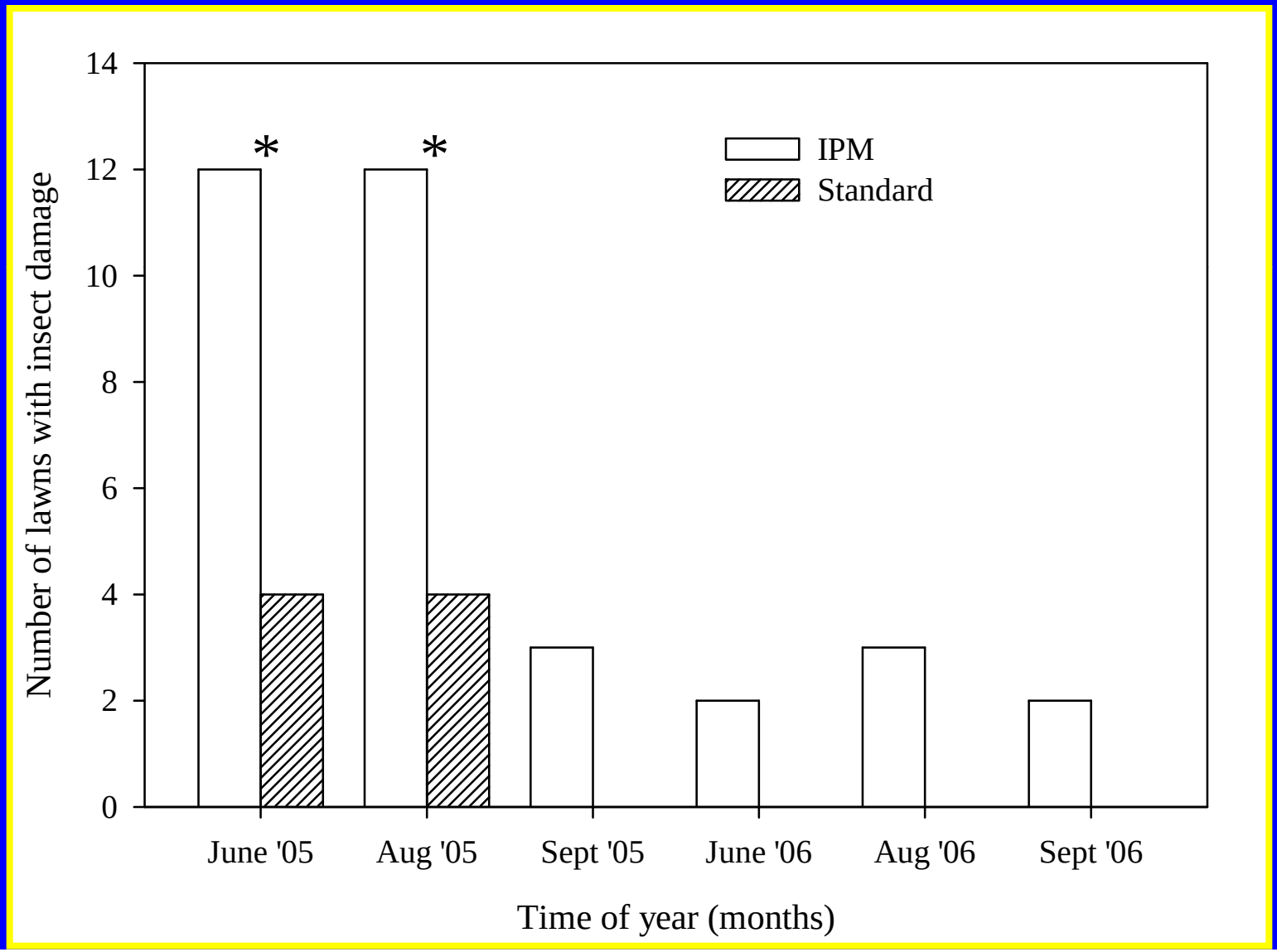
Number of lawns with weed infestation in the IPM and standard program



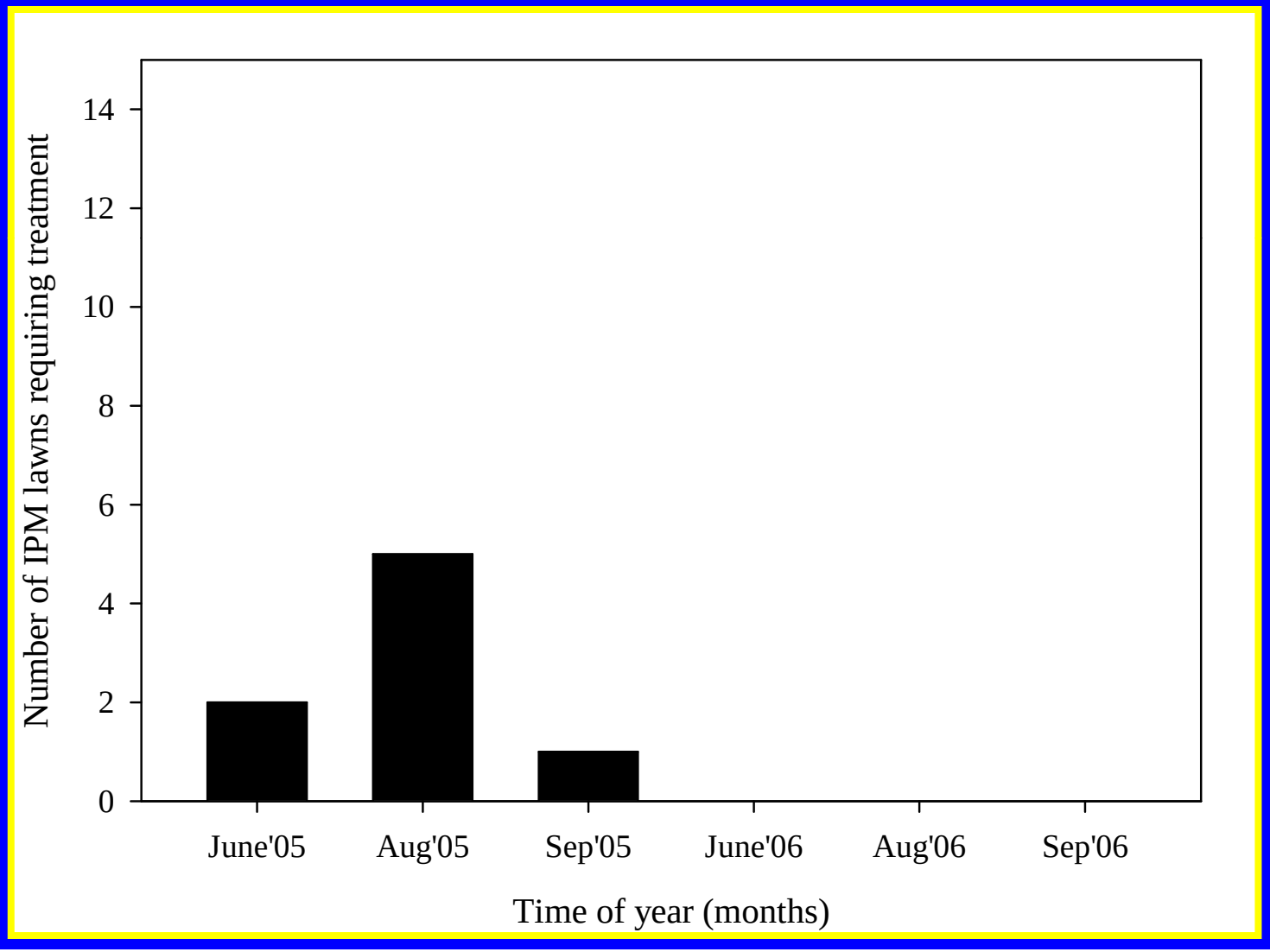
Number of lawns requiring herbicide applications in 2005 and 2006



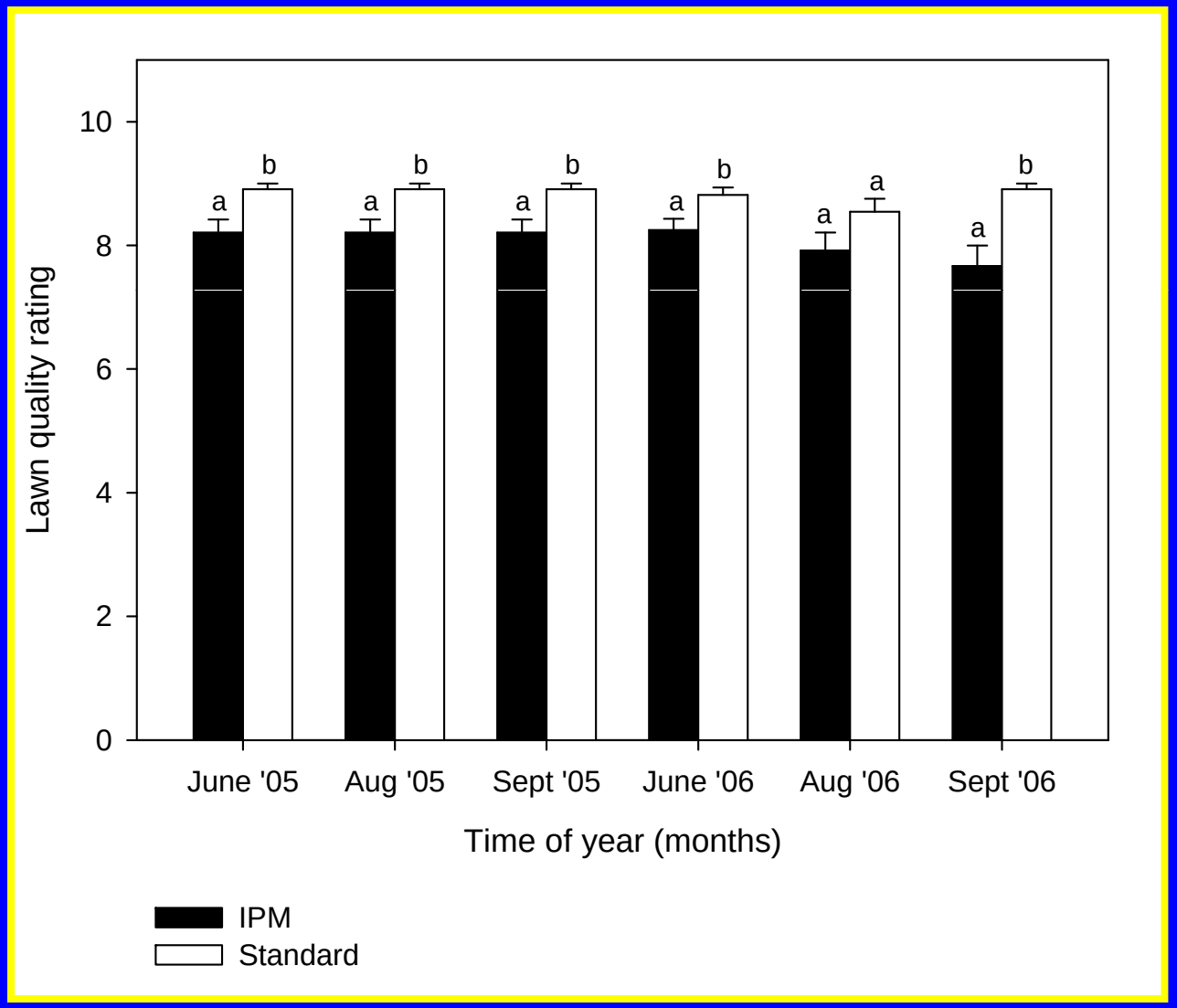
Number of lawns with insect damage in the IPM and standard lawn care programs



Number of lawns requiring insecticide applications in the IPM and standard lawn care programs



Lawn quality in the IPM and standard lawn care programs



Total annual lawn care program cost for the IPM and standard program

Lawn care program	Rate/0.01 ha ($)	Average cost per customer (rate x area)[a] ($)	Cost of monitoring /year[b] ($)	Total estimated lawn care cost/yr ($)
IPM	3.50	259.00	22.50	281.50
Standard	6.19	458.06	0.00	458.06

[a] Average home lawn size was 0.35 acre

[b] Cost of monitoring was estimated at $30.00/h for IPM. Average monitoring time per visit was 15 min. Lawns visited 3 times/yr for an average of 45 min per yr per lawn

Perceptions about IPM lawn care program

- **Telephone response rate – 44.82% (13 of 29)**
  - **7 continued with IPM**
  - **6 did not continue with IPM**

- **Reasons for continuing with IPM in 2006**
  - **Interested in healthy environment**
  - **Liked the idea of "IPM"**
  - **Was satisfied with the IPM program**
  - **Did not cost a thing**
  - **Stayed because of service provider**
  - **Would try anything service provider would recommend**

Perceptions about IPM lawn care program

- **Reasons for not continuing with IPM in 2006**
  - Too many weeds or insect problems (~33%)
  - Expected better results with IPM (~33%)
  - IPM impact is minimal; pleased with lawn care service provider

Acknowledgments

Post-doctoral Associates

Dr. Seppo Salminen

Dr. Doug Richmond

Dr. Sukhbir Grewal

Dr. Ganpati Jagdale

Dr. Elizabeth De Nardo

Collaborators

Dr. John Cardina

Dr. Casey Hoy

Dr. Benjamin Stinner

Dr. Michael Klein

Dr. Tom Blaine

Graduate Students

Alfred Alumai

Corrie Yoder

Mamta Singh

Zhiqiang Cheng

Brian Kunkel

Amr Saeb

M. S. Nahar

Ruisheng An

Li Tan

Shabeg Briar

P. Bussaman

S. Sandhu

Funding

Agency	*Year*	*Amount*	*Project*
NC-IPM	2004	$96,500	IPM
USDA-NRI	2003	$195,000	White grubs
USDA	2002	$145,000	PPNs
USDA-NRI	2000	$170,000	Endophytes
USDA-NRI	2000	$156,000	EPN Longevity
USDA	2000	$144,000	EPNs
USDA	1998	$310,000	EPNs
OARDC	1998	$100,000	Endophytes
OTF	1997-04	$95,000	EPNs/Endo
OLCA	2003-04	$13,000	Mowing/IPM