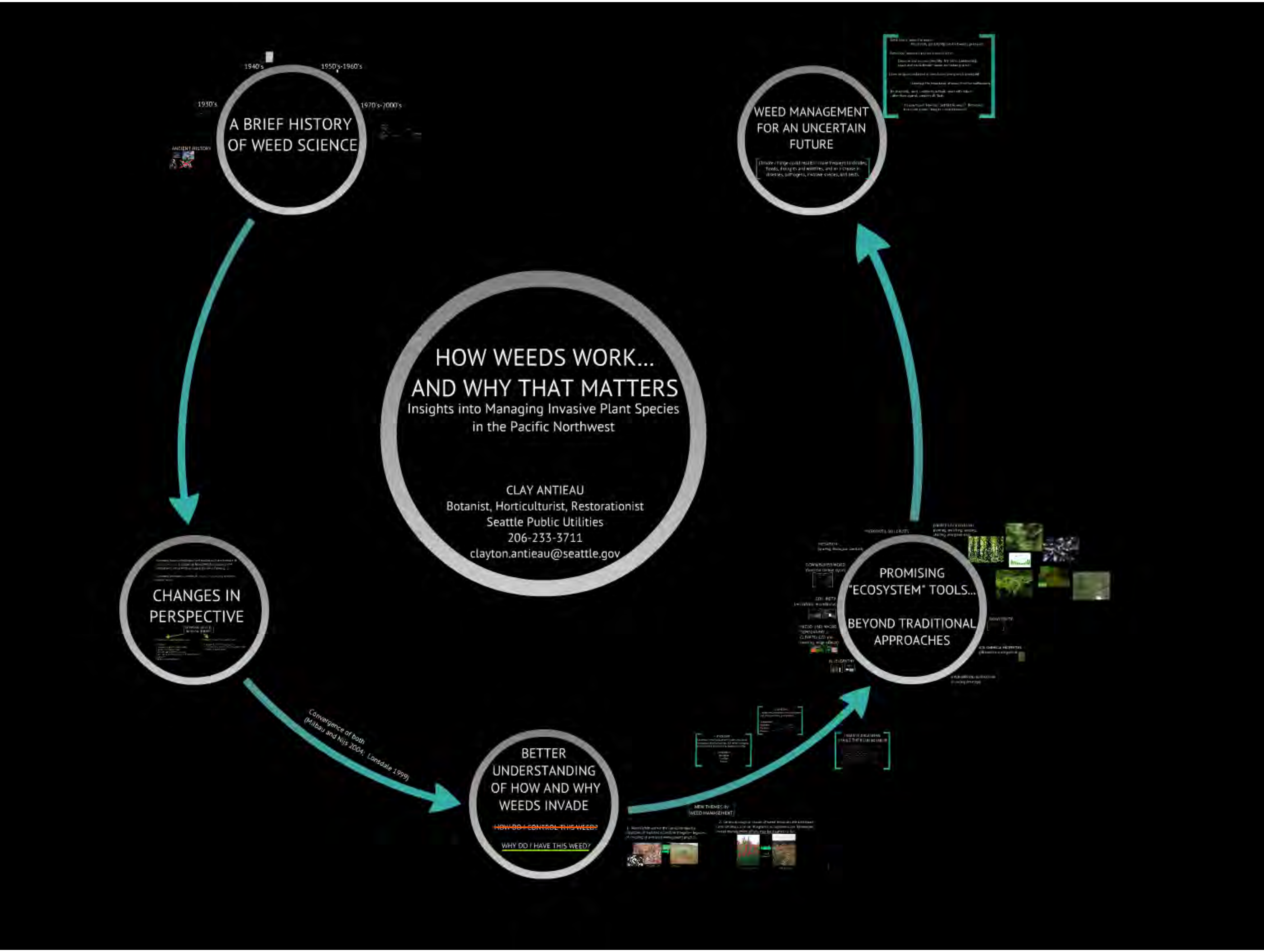
HOW WEEDS WORK...
AND WHY THAT MATTERS
Insights into Managing Invasive Plant Species
in the Pacific Northwest
CLAY ANTIEAU
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A BRIEF HISTORY
OF WEED SCIENCE
1930's
1940's
1950's-1960's
1970's-2000's
CHANGES IN
PERSPECTIVE
Convergence of both
(Milbau and Nijs 2004; Lonsdale 1999)
BETTER
UNDERSTANDING
OF HOW AND WHY
WEEDS INVADE
HOW DO I CONTROL THIS WEED?
WHY DO I HAVE THIS WEED?
NEW THEMES IN
WEED MANAGEMENT
PROMISING
"ECOSYSTEM" TOOLS...
BEYOND TRADITIONAL
APPROACHES
WEED MANAGEMENT
FOR AN UNCERTAIN
FUTURE

HOW WEEDS WORK… AND WHY THAT MATTERS

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A BRIEF HISTORY OF WEED SCIENCE

1940's

1950's-1960's

1930's

1970's-20

HOW DO I CONTROL THIS WEED?

HISTORY

"In the beginning, there were no weeds."

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Alden Crafts (1897-1990): “father of weed science” transforms technology of weed control into a science; World's first textbook on weed control (1942).

- Circa 1900: "weeds" recognized as a category of plant
- Before 1700: folks hand-planted/weeded crops
- Late 1700's: mulches and crude cultivation
- 1730: Jethro Tull invents seed drill, allowing use of hoe [eliminated darnel (Lolium sp.)]
- Early 1800’s: seed cleaning eliminates corncockle (Agrostemma githago), a major crop seed contaminant and poisonous in all parts (githagin, agrostemmic acid).

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1930's

- Salt (20 tons/A), sodium chlorate (1000 lbs/A), carbon disulfide (320 gal/A)
- Copper sulfate, iron sulfate
- Sulfuric acid: onions, cereals, and potatoes
- 1932: 1st synthesized organic (dinitrophenols, e.g. 2,4-DNP; slightly selective; diet pills)
- Mechanization (tractor power)
- Weed seed laws passed to keep crop seed clean

- LOW-TOXICITY
- NON-SELECTIVE
- HIGH RATES

- LOW-TOXICITY
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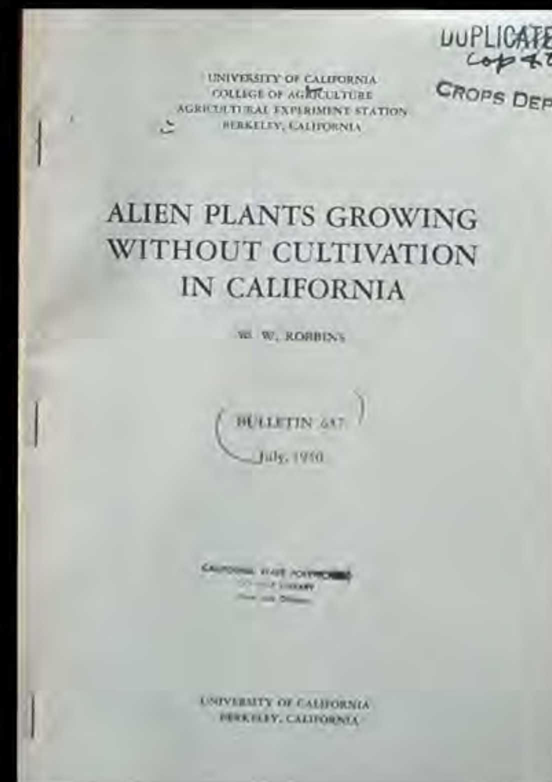
- HIGH RATES

- Chemical and drug companies screen stockpiles for efficacy
- 1941: 2,4-Dichlorophenoxyacetic acid (2,4-D) developed during WWII as PGR; commercialized by Sherwin- Williams; MCPA in Britain; phenoxys often contaminated with dioxins
- Selective against broadleaf weeds, low rates, low relative toxicity to humans
- Need for specialists to develop programs for local conditions (e.g., Land Grant institutions and Cooperative Extension Service)
- Aldo Leopold (1943): “to live in harmony with [all] plants is, or should be, the ideal of good agriculture”



- HIGH-TOXICITY
- HIGH SELECTIVITY
- LOW DOSE

1940's

- HIGH-TOXICITY
- HIGH SELECTIVITY
- LOW DOSE

- 1950: first non-phenoxy herbicide: monuron (urea)


UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

BULLETIN 573 MARCH, 1952

A New Chemical for Weed Control in Strawberries

D. D. Hemphill

- 1954: WSSA first meeting
- 1955: triazines
- 1958 Delaney Clause (FFDCA) stipulates zero-tolerance for herbicide residues in food
- Concerns turn toward drift and crop safety

- 1970’s: sulfonylurea herbicides appear (oz/A) (amino acid synthesis inhibitors; DuPont 1975)
- 1974: glyphosate first registered in U.S.
- Contamination of water food, soils, genomes; worker safety
- Socio-economic constraints (population; development; new chemical development)
- 1990’s: EPA begins mandatory herbicide registration under Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
- 1996 : Food Quality Protection Act
- 2000's: Genetically Engineered Organisms (GMO) appear, leading to herbicide-resistant crops (HRC)

HOW DO I CONTROL THIS WEED?

AGRICULTURAL TOOLS:

- ROW-“CROPPING” OR STRIP-CROPPING
- INTERCROPPING
- ROTATIONS
- COVER or COMPETITION CROPS
- TILLAGE AND CULTIVATION (e.g., disking)
- FALLOW
- HERBICIDES / GMOs
- MOWING/CHAINING
- PREDATION (grazing; biocontrols)
- FIRE

Widespread Herbicide Use

1.2 billion pounds (est.) are used in the U.S. each year

- contaminated surface/ground waters
- herbicide-resistant weeds (e.g., glyphosate)
- altered soil floras
- altered wildlife estrogenic activity
- threats to human health....
- Socio-economic constraints (population; development; new chemical development)

Introduced Organisms/Pests

- escaped biological controls
- escaped seedings of exotic grasses
- GMO issues

Large-scale Habitat Modification

- biodiversity loss
- increased erosion/sedimentation
- flooding/drought....

Intensified Need for Intervention/Subsidy

- more labor
- more money
- more technology

Increasing focus on biological and ecological characteristics of agroecosystems: Ecologically Based WM, Successional WM, Alternative Control Methodologies, Precision Farming….)

Increasing attention to weeds in natural ecosystems and how weeds "work"

CHANGES IN PERSPECTIVE

[OPPOSING IDEAS IN INVASION THEORY]

INVASIVENESS: Species traits drive invasion

Mechanistic:

- tolerate a variety of habitat conditions
- grow and reproduce rapidly
- compete aggressively for resources
- lack natural enemies or pests in the new ecosystem

"Superplants"

"Hydrilla is the Perfect Weed"

INVASIBILITY: Habitat (niche) allows invasion

- Ecosystem as a "sick" superorganism
- "Invasives are a symptom of poor ecosystem health"
- "Open" habitat for weeds

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stem

Convergence of both
(Milbau and Nijs 2004; Lonsdale 1999)

BETTER UNDERSTANDING OF HOW AND WHY WEEDS INVADE

~~HOW DO I CONTROL THIS WEED?~~

WHY DO I HAVE THIS WEED?

1. Weeds of
symptoms of
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OF HOW AND WHY WEEDS INVADE

HOW DO I CONTROL THIS WEED?

WHY DO I HAVE THIS WEED?

NEW THEMES IN WEED MANAGEMENT

2. Unless eco
and understoo
weed manage

t may be

1. Weeds often are not the cause, but may be symptoms of depleted ecosystem integrity-- legacies of on-going or past poor management practice.

Microbiotic Crust

Cheat Grass

IES IN
GEMENT

2. Unless ecological causes of weed invasions are addressed and understood in an integrated, ecosystem-scale framework, weed management efforts may be doomed to fail.

Purple Loosestrife

"weed vacuums"

Reed Canarygrass

A THOUGHT!

Successful weed management is often not about managing individual species, but rather managing characteristics essential to ecosystem integrity:

Composition

Structure

Function

Process

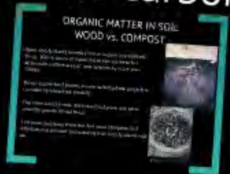
INVASIVE ORGANISMS CHANGE THEIR ENVIRONMENT

Altered Key Ecosystem Processes include:

- nutrient cycling and carbon cycling (Scot's broom; earthworms)
- sediment erosion and deposition rates (spartina)
- disturbance intensities and frequencies (cheat)
- evapotranspiration, water cycling, and hydroperiods (tamarisk; RCG)
- soil chemistry and soil biological processes (Russian knapweed)
- habitat availability for native organisms (RCG)
- primary productivity and germination (ryegrass; fine fescues)
- trophic (food web) interactions/characteristics (earthworms)
- genetic integrity (hawkweeds)
- resistence/resilience to disturbance incl. biological invasions (Scot's broom)
- biodiversity (spotted knapweed; cheat; RCG)

PREDATION
(grazing; biological controls)

OWN/BURIED WOOD
eed the carbon cycle)



SOIL BIOTA
a; microfauna)

- AND MACRO-
RAPHY /
OLOGY (de-
, edge effects)

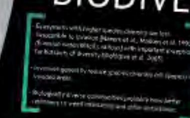
ALLELOPATHY

PROMISING "ECOSYSTEM" TOOLS...

BEYOND TRADITIONAL APPROACHES

shading, evergreen-ness

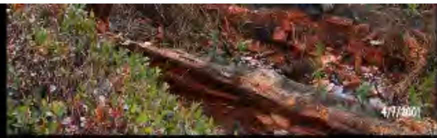
BIODIVERSITY



SOIL CHEMICAL PROPER
(pH/nutrient managemen

HYDROPERIOD ALTERATION

sing Planting Circles



Introduction and "Inoculation" of Down Wood

ALLELOPATHY

ALLELOPATHY

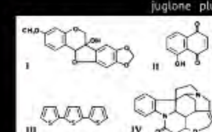
- Some invasive species rely to some extent on allelopathy to enter and expand in recipient ecosystems.
- Some invasives are not allelopathic in their native ecosystems, but can be allelopathic in recipient ecosystems.
- Some native species are allelopathic (sagebrush; pine).
- Allelopathy and resistance to allelopathy are genetically inherited.

ALLELOPATHY

SO, POTENTIAL ECOSYSTEM TOOLS MIGHT INCLUDE:

- Selected or modified plants that make allelochemicals
- Selected or modified plants that resist allelochemicals
- Use of such stock in landscape design and ecological restoration
- Isolated allelochemicals for use as pesticides/herbicides

juglone plumbagin



strychnine

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Russian Knapweed

Garlic Mustard

Perennial Ryegrass

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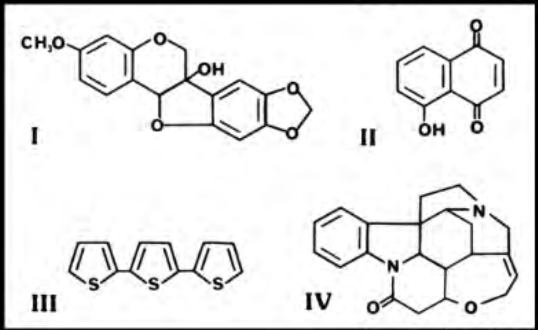
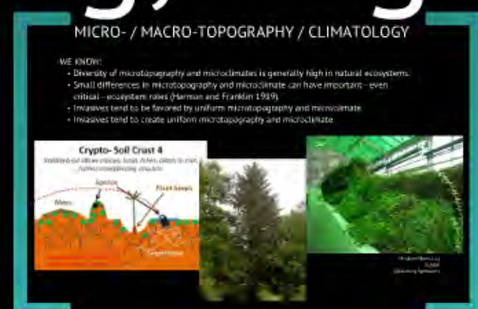
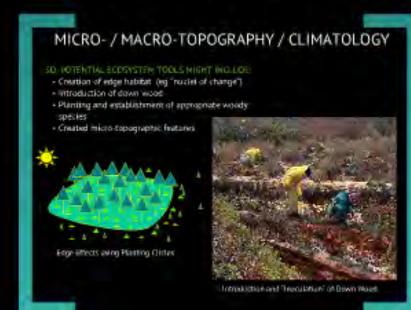


strychnine

Big sagebrush

MICRO- AND MACRO-TOPOGRAPHY / CLIMATOLOGY (de-leveling, edge effects)

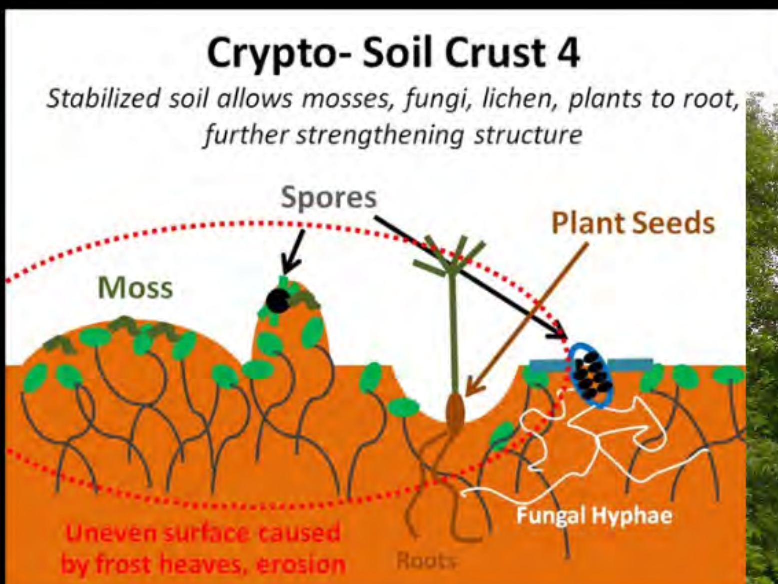




MICRO- / MACRO-TOPOGRAPHY / CLIMATOLOGY

WE KNOW:

- Diversity of microtopography and microclimates is generally high in natural ecosystems.
- Small differences in microtopography and microclimate can have important—even critical—ecosystem roles (Harmon and Franklin 1989).
- Invasives tend to be favored by uniform microtopography and microclimate.
- Invasives tend to create uniform microtopography and microclimate.

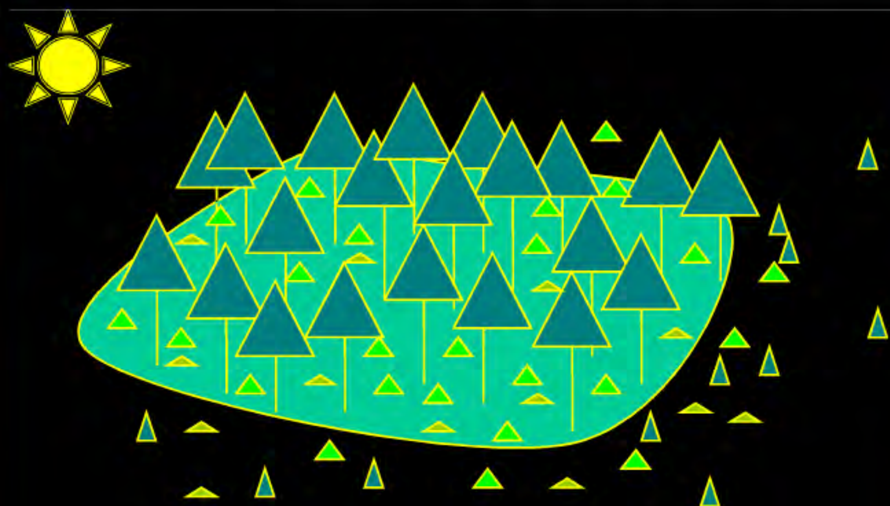


Neukom Nurse Log Exhibit
©Kaleberg Symbionts

MICRO- / MACRO-TOPOGRAPHY / CLIMATOLOGY

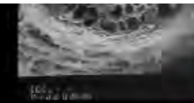
SO, POTENTIAL ECOSYSTEM TOOLS MIGHT INCLUDE:

- Creation of edge habitat (eg "nuclei of change")
- Introduction of down wood
- Planting and establishment of appropriate woody species
- Created micro-topographic features



Edge Effects using Planting Circles

Introduction and "Inoculation" of Down Wood be.



SOIL BIOTA (microflora; microfauna)

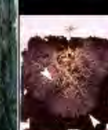
SOIL BIOTA

- Extreme differences in soil biota exist between herbaceous and woody ecosystems (e.g. soils.usda.gov/sqi/concepts/soil_biology/soil_food_web.html; Dr. Elaine Ingham)
- Plants can have very specific requirements for soil biota (mycorrhizal fungi)
- Soil biota changes as vegetation changes
- Native soil pathogens provide some level of resistance and resilience to weed invasion
- Weeds cultivate their own beneficial soil biotas (Centaurea maculosa; Calloway et al. 2004), supporting idea some invasives escape control by native soil pathogens in invaded regions

SOIL BIOTA

SO: POTENTIAL ECOSYSTEM TOOLS MIGHT INCLUDE:

- Addition of large volumes of wood to restart the soil carbon cycle and support development of fungus-dominated soil foodweb; compost
- Innoculations
- Planting and establishment of appropriate woody species
- Anti-fertilization
- Conservation Biological Control (biodiversity inside and outside of crops)



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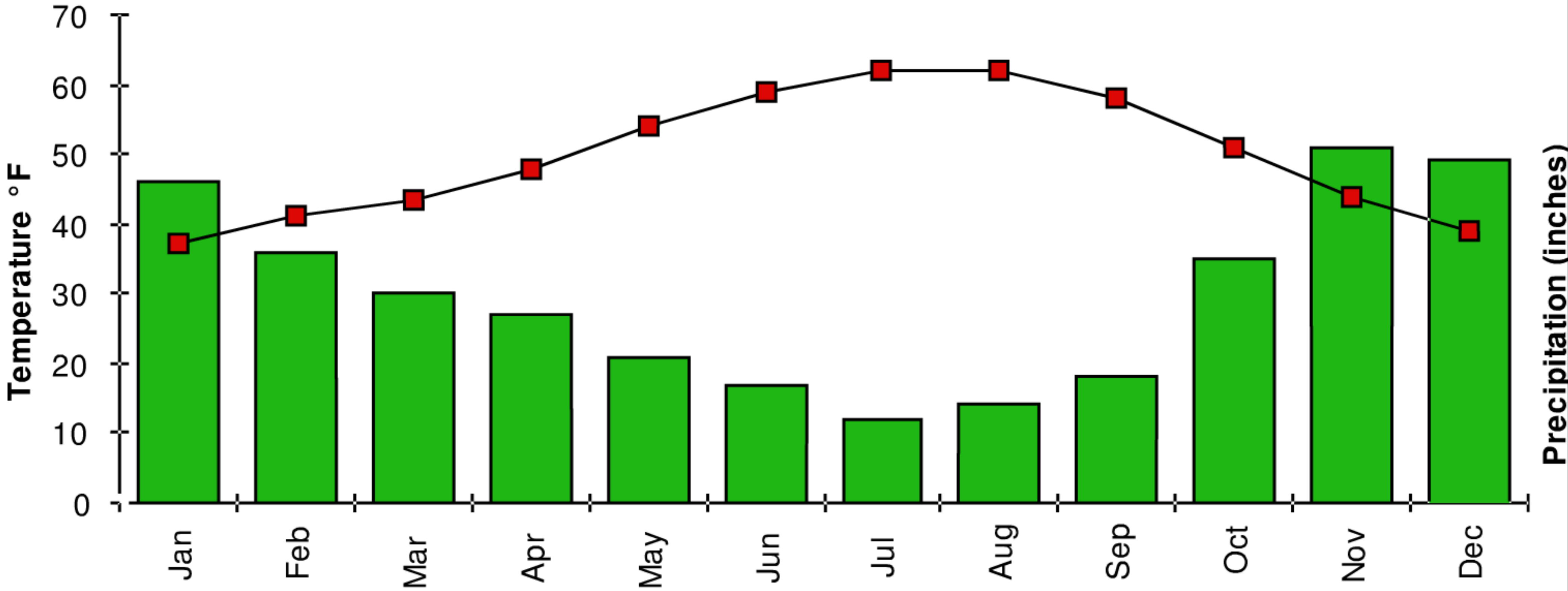
COMPETITIVE EXCLUSION
planting, mulching, seeding, shading, evergreen-ness






Bellingham, WA (1949-1996)




Interlaken Park, Seattle
EVERGREEN UNDERSTORY WEEDS
• ENGLISH IVY (Hedera helix)
• BLACKBERRIES (Rubus spp.)
• VINCA (Vinca spp.)
• GARLIC MUSTARD (Alliaria petiolata)
• CHERRY LAUREL (Prunus laurocerasus)
• PORTUGUESE LAUREL (Prunus lusitanica)
• DAPHNE (Daphne laureola)
• COTONEASTER (Cotoneaster spp.)
• FIRETHORN (Pyracantha coccinea)
• PRIVET (Ligustrum sp.)
• HERB ROBERT (Geranium robertianum)

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BIODIVERSITY

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BIODIVERS

- Ecosystems with higher species diversity are less susceptible to invasion [Naeem et al.; Madsen et al. 1991 (Eurasian watermilfoil); various] with important exceptions for hotspots of diversity (Stohlgren et al. 2003).

- Invasives generally reduce species diversity (all species) in invaded areas.

- Biologically diverse communities probably have better resistance to weed infestation and other disturbance.

WEED MANAGEMENT FOR AN UNCERTAIN FUTURE

Climate change could result in more frequent landslides, floods, droughts and wildfires, and an increase in diseases, pathogens, invasive species, and pests.

Conser
space,

Leave no spac

Be pragmatic
rather than a

It's e
to as

Don’t feed or water the weeds

Weed early, persistently; don’t let weeds go to seed

Remember, wherever you are is an ecosystem

Conserve and increase diversity: life forms (biodiversity), space, and microclimate—above and below ground

Leave no space unplanted or unmulched; evergreen is important

Leverage the importance of wood; feed the soilfoodweb

Be pragmatic, open, creative in outlook…work with nature rather than against; consider all “tools”

It's easy to ask “How do I control this weed?” Remember to ask and answer “Why do I have this weed?”