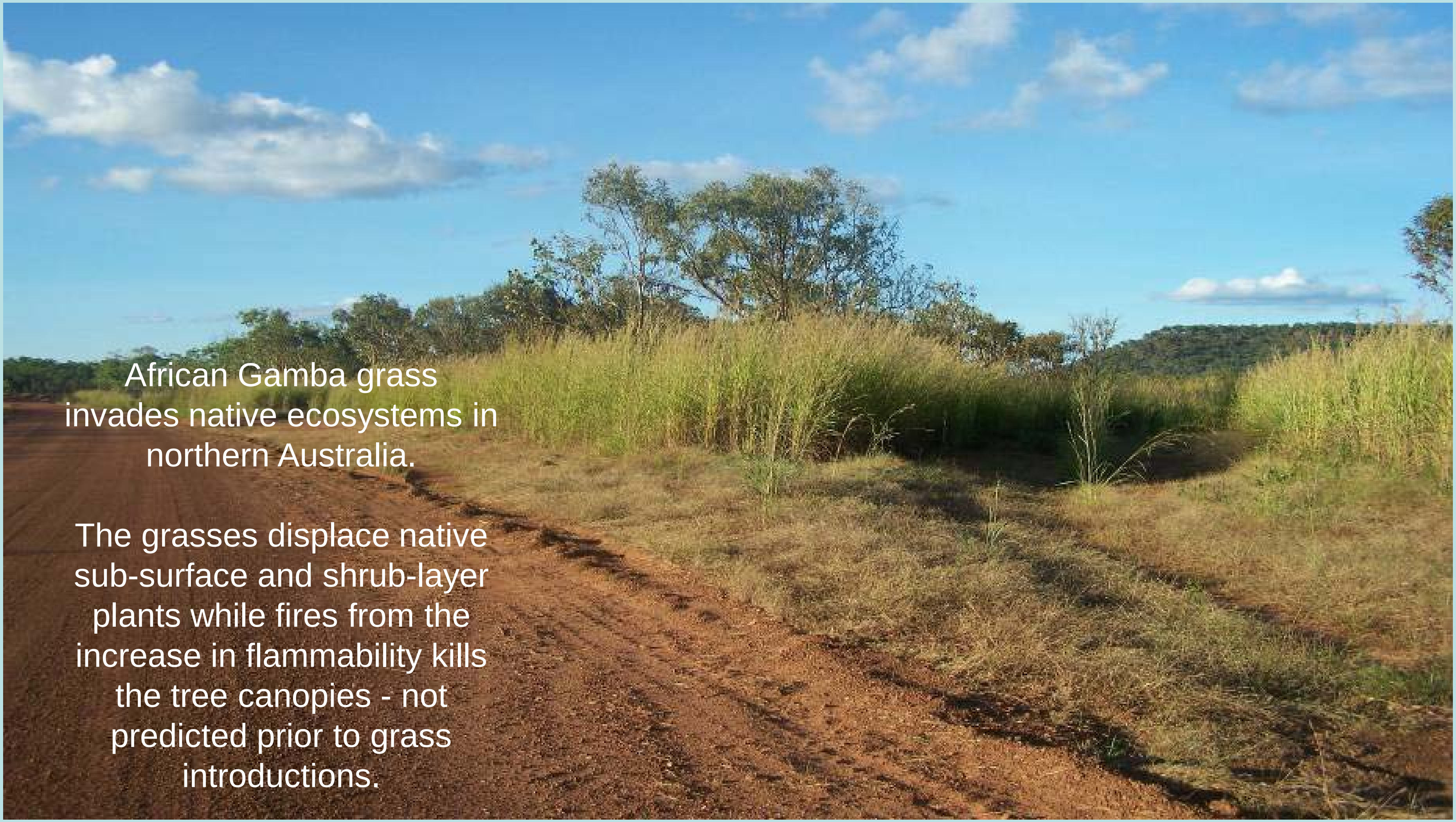
USA Northampton, Massachusetts. *Biological Control for Nature*
3-7 October 2010.

The case for biological control of the exotic African Grasses in Australia and the USA using introduced detritivores

CSIRO



African Grasses were Introduced to increase pasture green biomass and support high stocking rates

They –

- Help sustain seasonal growth of pastures – some are drought tolerant,

- reduce soil erosion, can stabilise pasture nutrients (assisted by dung beetles),

- compete with unwanted species including some toxic weeds

But – there are detrimental impacts of African grasses on rural lands

- Some reduce pasture quality (e.g. love grass), inhibit livestock location or mustering – this can be made impossible (e.g. Gamba grass)

- Many displace mixed grass species with highly flammable mono-covers

- change natural & un-natural fire regimes, increase and change fuel loads; change ‘fire seasons’,

- mono-stands increase fire-adaptation following frequent burning

Fire, invasive grasses and threats to biodiversity

Grass, shrub & sub-surface species suffer most when –

- Weakly flammable understory plants are replaced by highly flammable exotic pastures
- Dead foliage and detritus from the grasses increases the ‘fuel loads’
- Re-growth after burns out-competes indigenous species
- Fire sensitive plants and small animals cannot survive burns or burnt sub-surface remnants
- African grasses + fire = invertebrate extirpations !

EXAMPLES OF FLAMMABLE AFRICAN GRASSES IN AUSTRALIA

	Flammability
• Gamba grass (*Adropogon gayanus* (X)	+++
• Buffel grass (*Cenchrus ciliatus)*	+++
• Love grass (*Eragrostis curvula)*	++
• Panic, Guinea grass (*Panicum maximum)*	+++
• Signal grass (*Brachiaria decumbens)*	++ (seasonal)
• Molasses grass (*Melinis minutiflora)*	+++

Implications for the control of invasive African grasses

- ***Mechanical***: costly & not sustainable; labour intensive, not implemented by local authorities

- ***Chemical***: short-term benefits from small-scale applications, potential polluting and other non-target effects

- ***Fire***: limited use, promotes re-growth of invasive or fire-adapted & flammable species; many non-target & detrimental effects on biodiversity

- ***Biological control***: exploration for agents (herbivores & detritivores) expensive, potential conflicts of interest for pastures *BUT* potentially sustainable

Main problem: African grasses are invasive environmental weeds & their detritus increases "fuel loads"

- In farmlands, forests, grasslands and woodlands: the increasing biomass of exotic plants in ecosystems
- Changes to fire regimes: displacement of weakly flammable ecosystems (e.g. rainforests) with highly flammable introduced grasses
- Increasing threats from the frequency of hot burns
- Threat enhancement from climate change

The relevance of sub-surface leaf litter to environmental weeds and fire

- Exotic grasses develop sub-surface layers of dead leaves ("fuel") affecting ecosystem flammability.

- Invasive shrub-layer exotics (e.g. lantana) also accumulate sub-surface layers but most (e.g. *Ochna*) are not so flammable (except in drought)

- Foliage of woody weeds in Australia tend to be less flammable (e.g. camphor laurel, Chinese elm, privets).

Do Australian sub-surface leaf-litter decomposers contribute to reducing ‘fuel loads’ ?

Major insect groups of detritivores :

Dry eucalypts & woodlands: moths (Oecophoridae; many genera & spp., Tortricidae: Epitymbiini) leaf beetles (Cryptocephalini), Isoptera (*Microcerotermes, Ephelotermes, Hesperotermes, Nasutitermes)*

Rainforests & moist forests: cockroaches (Blattoidea; *Geoscapheus, Cryptocercus*), moths (Oecophoridae: *Barea*)

Grasslands: “mallee” moths (Oecophoridae), termites (Isoptera: *Drepanotermes, Lophotermes, Nasutitermes, Tumulitermes*)

Heathlands: Moths (Oecophoridae & Tortricidae); Isoptera & others but not well documented

AUSTRALIAN DEAD LEAF SHREDDERS

Terrestrial ecosystems:

- Springtails (Collembola), Protura, Diplura,
- Moths: Oecophoridae, Tortricidae, Hepialidae
- Beetles: Clytrinae (*Cryptocephalus*)
- Cockroaches (Blattodea)
- Termites: Isoptera

- Earthworms are not effective in Australian ecosystems

AUSTRALIAN DETRITIVORES IN DEAD LEAF LITTER

Insects –

- decompose leaves: reduce the accumulation, density and flammability

- Bind sub-surface organics with soils and prevent erosion

- re-cycle nutrients (first stage breakdown) and some breakdown surface tension of soil surface layers

- essential for food chains; provide prey for animal insectivores, etc

DEAD LEAF HERBIVORES IN AUSTRALIA – SOME MAJOR DETRITIVORES OF EUCALYPTS

LARVAE OF BEETLES, CRYPTOCEPHALINI (A) and MOTHS, OECOPHORINAE (B)

(A) > 500 species

(B) > 5,000 species

Slides & texts - Marianne Horak

Oecophorid moths - their numbers, identities & niches

- 20% of Australian Lepidoptera species (*ca* total - 22,600 spp., ca 11,000 moths, 400 butterflies described)
- 250 moth genera in Australia
- At least 5,000 moth species occur in Australia
- Ecological (esp.climatic) niches of the oecophorids are *mostly very narrow* (e.g. Eucalypts, Myrtaceae & native grasses)
- Up to 400 species per ecosystem !

Leaf litter Oecophorid moths: winter breeders and the moths are poorly mobile

Oecophorids break down fallen leaves in all Australian eucalypt ecosystems.

Principal nutrient re-cyclers (most of dead leaves)

Important prey for 'small animal' insectivores in Australia and New Zealand

Without these moths, leaf litter & 'fuel' builds up

Oecophorid food, food webs & fire sensitivity

- Majority feed on dead myrtaceous leaves. Larvae break down the whole leaf, the first step in nutrient recycling.
- Most pupate in subsurface litter – few underground
- Most breed in cool winter months – those selected for "cool burns"
- Immature stages are *major food items* for small vertebrates (e.g. birds)
- Survive if some unburnt refuges persist in or near each ecosystem

DETRITIVORES MIGHT BE EFFECTIVE CONTRIBUTERS TO BIOLOGICAL CONTROL OF AFRICAN GRASSES

Australian cases infer -

- Plant association specificity occurs in Australian detritovores

- But - what is known of African detritivores in grasses ?

- Is biological control of dead leaves a potentially viable option as was for example, biological control of dung ?

Flammable African grasses in Australia

Leichardt's Grasshopper

? extinct by 2009 in NT from exotic grass invasions and frequent burning

(D. Rentz pers. comm.)

Gamba grass invades and displaces northern pastures and invades ecosystems. Prevents live stock observations + poor quality pasture + extremely flammable sinescing leaves and detritus

– David Rentz

Invasion effects and fire in natural ecosystems

- *Light effects*. Most are promoted by human disturbance; animals carry in seeds and germinate with increased entry of light after fires.
- *Edge effects*. Infestations often advance from open edges of roads and tracks; then progress under canopies.
- *Ecosystem displacement*. Sub-surface plants, leaf litter and detritus are replaced by highly flammable African grasses.
- *Fire adaptation*. Frequent burning promotes their rapid growth. Plant communities then become more flammable with each burn
- *Rapid fuel build up*. Fuel reduction burns become ineffective and counter-productive.

Small animals are lost

(vertebrates + invertebrates)

African grasses –

- invade natural ecosystems
- displace sub-surface plants and detritus organisms
- reduce light and indigenous plant recruitment,
- Change or displace refuges; may inhibit animal mobility
- Mono-stands of some species repel native animals

  (e.g. signal grass)

Guinea grass *Panicum maximum* – invasive on east coast, edge effects & under-canopy invasion. Shade adapted, very competitive, highly *flammable,* few green leaf herbivores & detritivores – control difficult

FIRE, SUB-SURFACE PLANTS AND SHRUB LAYERS

- Some *but not all* plants survive being burnt: e.g. regenerate from roots, stems or seeds
- Some plants “benefit” from fires – e.g. seeds germinate and stems regrow, when free of competition

BUT

- Many plants are exterminated if fire frequencies increase (e.g ground orchids
- Animals (including humans) do not survive being burnt. They must escape, find shelters (underground), or recolonise from unburnt refuges
- Fire promotes growth of fire-adapted species - especially the flammable grasses, some native shrubs, trees, & bracken


Heat from hot fires can kill most sub-surface seeds, shrub layer & canopy vegetation, + invertebrates
Buffel grass displaces all indigenous plants and animals and is particularly invasive

WOODLAND INSECTS CANNOT ESCAPE BEING BURNT

On ecosystems:

- Shrub and sub-surface invertebrates are killed by fire unless they can escape (when seasonally active) or shelter underground
- After fires species recovery and reproduction requires re-entry; then adequate food and unburnt habitats – sometimes specialised
- Locally unburnt refuges are essential to protect poorly mobile species
- Cool climate or winter burns have most impacts on the immobile stages
- Frequency of deliberate burning must take account habitat recovery

Leaf litter fuel reduction: a short term strategy but in longer term it promotes growth of flammable grasses

Poorly mobile arthropods ► must have unburnt refuges or shelter underground to survive

Sedentary insect stages cannot cope with fire!

e.g. wasp parasites attacking a moth larva

Molasses grass
Melinis minutiflora –

invasive,
very competitive,
extremely *flammable.*
No known Australian herbivores,
deep build-up of detritus

Makes control difficult
&
eliminates much of the animal and plant biodiversity

An immense depth of detritus develops as growth advances upwards

Infestations of signal grass (and Buffel grass) -
spread from roadsides after fire has opened up a forest to light

Many Hesperid larvae are sub-surface grass feeders ↓

IMPACTS ON INDIGENOUS DETRITIVORES

- Few invertebrate herbivores can adapt to exotics and almost no detritivores
- Few break down dead exotic grass leaves
- Cannot survive the increased biomass of weedy grasses or fuel loads
- Most insect fauna cannot survive broad scale or frequent fires


Signal grass appears insect
repellent and is seasonally
flammable. It permanently
displaces invertebrate ridge and
hilltop habitats within 12 months
of being burnt

INTACT HILLTOPS AND RIDGES ARE ESSENTIAL INVERTEBRATE HABITATS

Invasive grasses, fire and / or drought will kill all animals and understory food plants

The *fiery jewel.* Is a facultative hilltopper

The ant blue
Is an obligatory hilltopper

Many of the rarer 'blues' (e.g. 'ant blue' ↑) must have intact vegetation on hilltops where they can find a mate & essential for genetic mixing

PROSPECTS FOR BIOLOGICAL CONTROL OF AFRICAN GRASSES

- Evidence of specificity of herbivores on monocots appears little different to that for dicots

- The herbivore pests known for grasses (e.g rice) can sometimes be host or species-group specific

- *Foliage* and *stem* feeders are probably the most promising agents

- *Root feeders* of grasses less well known but some are promising (e.g female diaspid scale for Arundo in USA is a rhizome feeder)

- Detritivores of weedy grasses may include potential invertebrate agents available from their native ranges

Acknowledgments:
Marianne Horak
Ted Edwards
Brian Hacker