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

African Gamba grass invades native ecosystems in northern Australia.

The grasses displace native sub-surface and shrub-layer plants while fires from the increase in flammability kills the tree canopies - not predicted prior to grass introductions.
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, Hesperothermes, Nasutitermes*)

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

**Grasslands**: “mallee” moths (Oecophoridae), termites (Isoptera: *Drepanotermes, Lophoterms, 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
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 CONTRIBUTORS TO BIOLOGICAL CONTROL OF AFRICAN GRASSES

Australian cases infer -

• Plant association specificity occurs in Australian detritivores

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

Leichhardt’s Grasshopper

? extinct by 2009 in NT from exotic grass invasions and frequent burning
(D. Rentz pers. comm.)
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.

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