Submission to the Independent Planning Committee

A Biodiversity argument
OPPOSING the approval of the Narrabri Gas Project

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We need to be Inventive and Creative
to turn Environmental Grief into Environmental Pride !!
Embrace Climate Change with Renewables and all our best science
to create positive futures for our grandchildren
and the generations to come

Biodiversity

is the term used to describe the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part including diversity within species, between species and of ecosystems. Three levels of biodiversity are discussed – genetic, species and ecosystems diversity. Genetic diversity is all the different genes contained in all individual plants, animals, fungi and micro-organism. It occurs within a species as well as between species.

Timeframes & Scales

Some Timeframes:

Days, Weeks, Months, Seasons, Years, Decades, Generations, Centuries, Millenniums;

Some Scales:

Individuals, Species, Families, Genera, Cohorts, Assemblages, Ecosystems, Landscapes, Continents, Global;

and
All the Interrelationships of these, many of which are unknown!

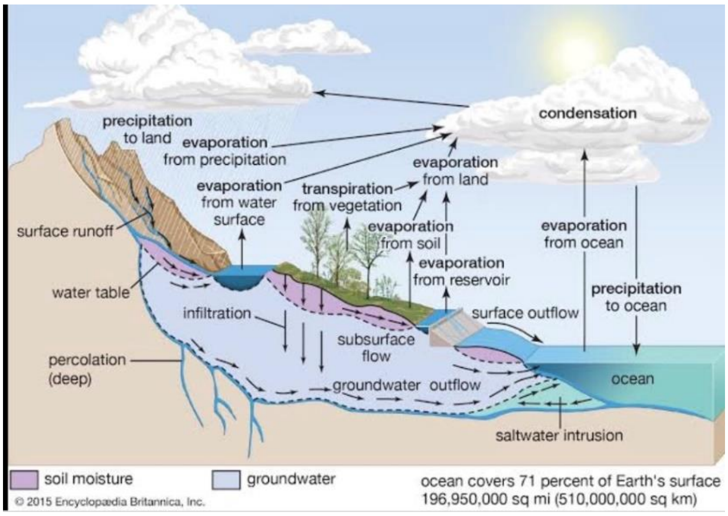
We often use <u>too short a Timeframe</u> and <u>too small a Scale</u>-----
for <u>expedience rather than sustainability</u>!

Some examples of Timeframes applicable to the Pilliga Gas Project -

Climate ---- predicted and progressing to hotter and dryer --- and therefore what are the future implications for the Water Cycle (illustrated below):

- What we do know: Reminders – an absolutely Essential Component is VEGETATION which provides evapo-transpiration- and therefore rainfall – without vegetation there is no rain, nor oxygen to breath.

- What we don't know: The research and subsequent understanding of the relationships between - the surface and groundwater biodiversity (flora & fauna) and ecosystems, is still in its infancy.



The Water Cycle – and the above and below ground linkages for flora & fauna

Tributary Namoi River

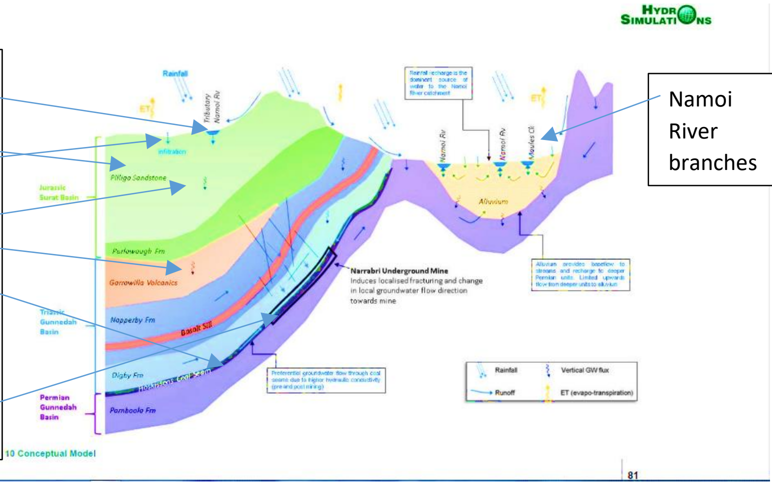
Pilliga Sandstone

Infiltration

Vertical ground water flux

Hodkinson's Coal Seam – Preferential groundwater flow through coal seams due to higher hydraulic conductivity (pre & post mining)

Narrabri Underground Mine



Namoi River branches

Excellent Insight into these relationships ** View "River ecology and groundwater Research"– QUT presentation by Prof. Andrew Boulton, Aquatic Ecologist, UNE, Department of Environmental Science & Ecology, YouTube video Aug. 22, 2013 -
[Research Overview of Interrelationships – patches, altered flow paths, surface waters and groundwater water linkages at multiple scales and Ecosystem Services – and human activity impacts]

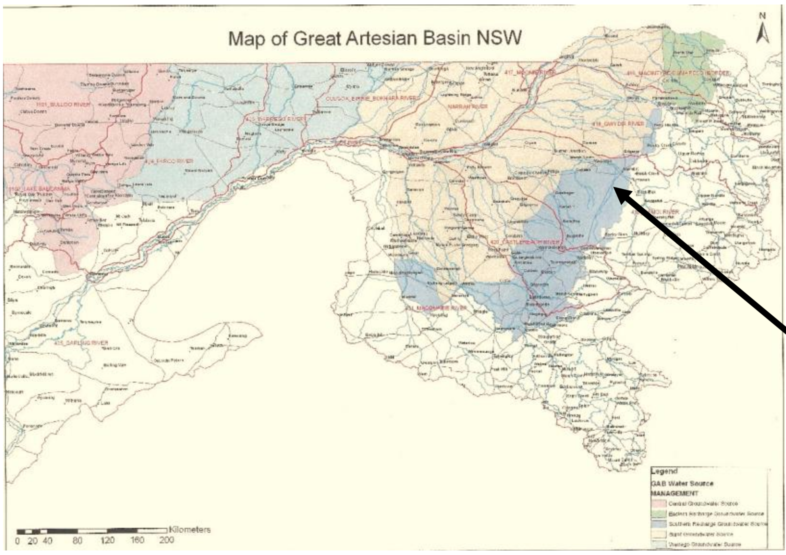
AND Santos proposes drilling 800-1200m. deep x 850 times through these ecosystems and aquafers through Pilliga Sandstone +.

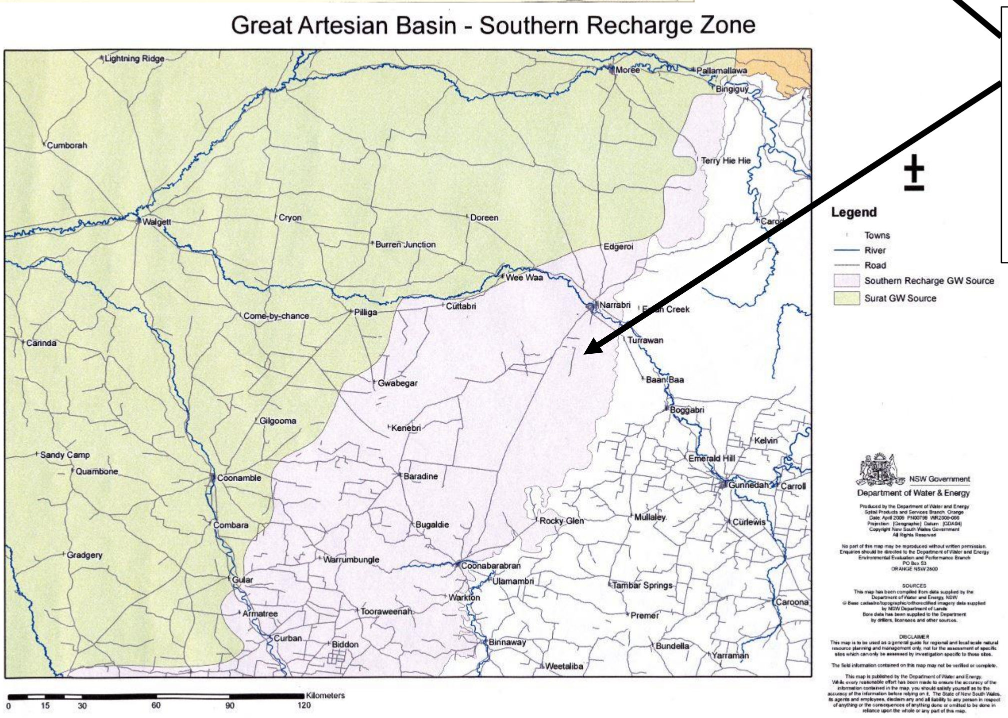
In jeopardy are the little know interrelationships between surface and groundwater biodiversity and thus the functioning of those ecosystems – Why jeopardise precious water?

Climate---- predicted and progressing to hotter and dryer --- and therefore what are the future implications for the Great Artesian Basin (illustrated below):

- What we do know:
  The Pilliga Gas Project area is located within the important Southern Recharge area of the Great Artesian Basin (GAB) & it requires '000s of years recharge time frame

- What we don't know:
  What will be the impacts of water extraction associated with CSG well establishment and processing, and, what time frames will be required for GAB recharging with reduced inputs in a hotter dryer future due to Climate Change - and therefore the implications for above and below ground biodiversity (both flora & fauna) and those ecosystems dependent upon spring and other water sources.





Pilliga Project area & GAB Recharge Zone

Biodiversity - Flora & Fauna: arboreal, terrestrial, below ground - **Time & Scale**

The factors indicating the health, diversity and functioning of terrestrial biodiversity and ecosystems are ---- the Size, the Structure, the Composition, the Condition and the Connectivity –- of areas of native vegetation.

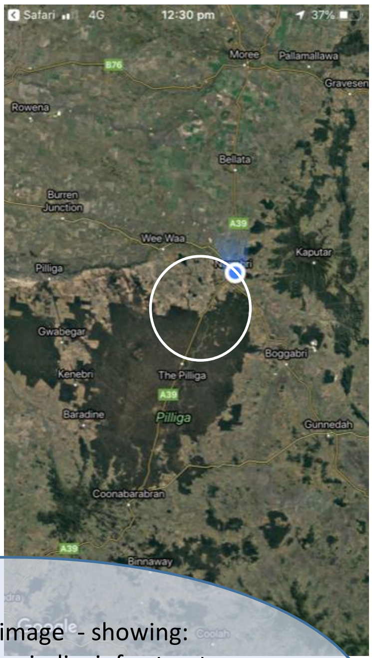
What we do know: The Significance of the Pilliga Forests:

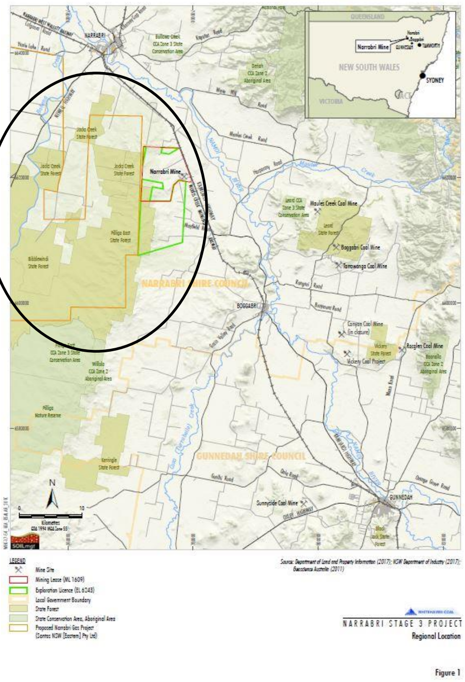
- located in Pilliga Outwash Province;
- is a major component of Brigalow Belt South Bioregion;
- recognised as a national Biodiversity Hotspot (Dept. of Sustainability, Environment, Water, Populations and Communities website);
- largest remaining un-fragmented block of temperate dry forest & woodland in eastern Australia - half a million hectares;
- critical north to south & west to east Climate Change linkage - flora & fauna movement with increasing temperatures and decreasing rainfall;
- globally significant Bird Area (Birds Australia);
- provides critical haven for flora & fauna reproduction and existence (including migratory birds);
- home to –
  - 1. Critically Endangered Ecological Community (Commonwealth EPBC Act 1999);
  - 3. Endangered plant Sp. (NSW TSC Act 1995 - 3; Commonwealth -1)
  - 4. Vulnerable plant Sp. (NSW -4, Commonwealth -4;
  - 1. Critically Endangered Vertebrate Sp. (NSW & Commonwealth);
  - 2. Endangered Vertebrate Sp. (NSW -1; Commonwealth -1);
  - 22. Vulnerable Vertebrate Sp. (NSW -22, Commonwealth -5);
  - + 17 additional Threatened species (NSW TSC Act 1995);
  - + many declining Sp. & stressed communities due to bushfires.

With the catastrophic destruction of massive areas of native flora and its associated devastated fauna, caused by the 2019/2020 bushfires across eastern Australia (including the nearby Mount Kaputar National Park), and the increasing threat of Global Warming, **retaining the integrity of this largest remaining un-fragmented area of temperate dry forest and woodland is absolutely imperative.**

Biodiversity- Flora & Fauna? **Scale & Time**

The Pilliga Gas Project area current & proposed :





Current Google image - showing:
1. Current CSG Bibblewindi + infrastructure of <30 wells;
2. Surface waterways – will be destroyed by proposed 850 Santos CSG wells & infrastructure

According to the Assessment Report:
Santos proposes to develop the Narrabri Gas Project on around 1,000 hectares of a larger 95,000- hectare site in the Pilliga State Forest and on adjoining grazing land ... (p. iii)

The project would consist of about **900 gas wells,** each pair occupying approx. one hectare, **plus numerous other sites** for processing facilities **= approx. 1000 hectares.** However, all sites would be interconnected by roads, gas lines and water lines. Hence the 60,000 hectares of State Forest hosting the project, shown on the photograph above, **would be totally dissected**. This has already commenced, photograph on right & next

Dissection! Fragmentation! Current and projected

Narrabri Gas Field – Soil Constraints Assessment

Current development around Bibblewindi

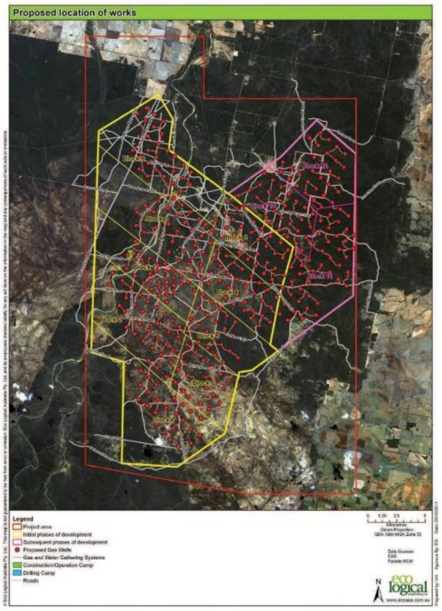


Figure 3: Proposed layout of Project works

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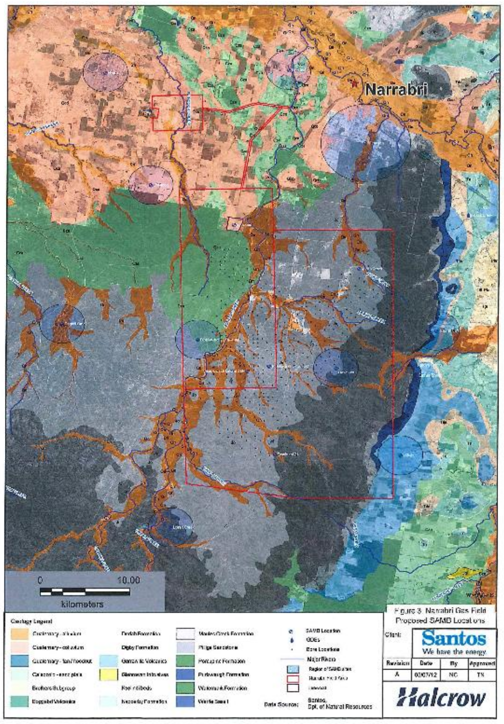
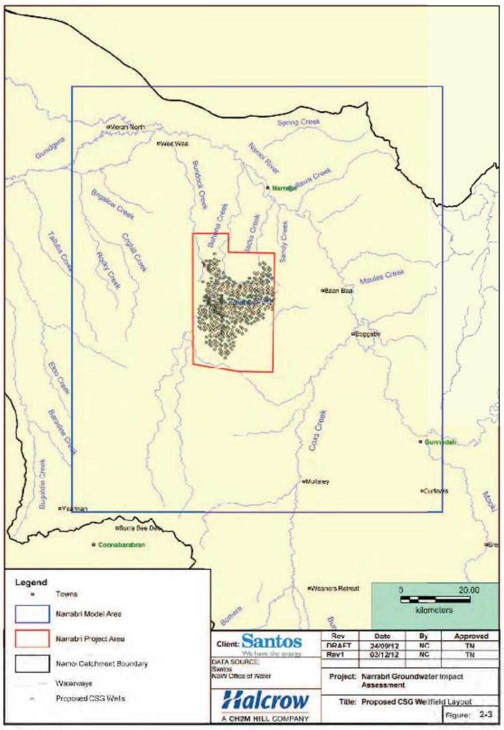
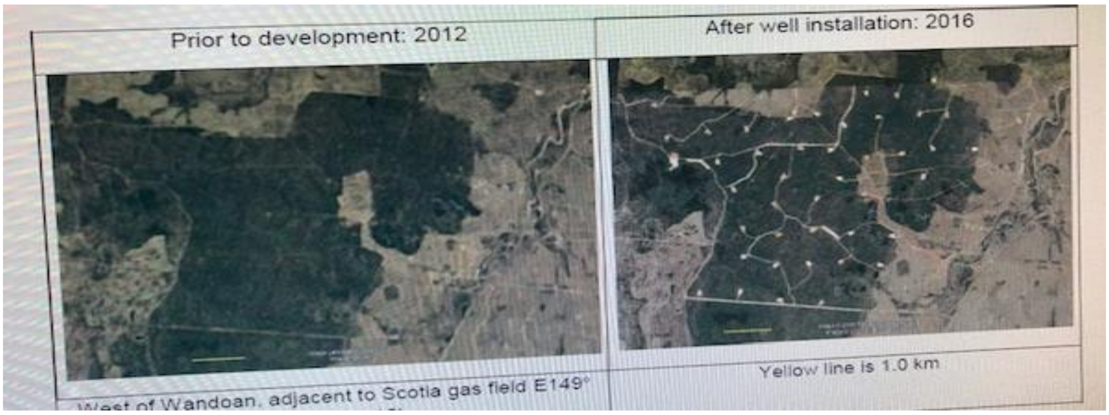




These three images show proposed well sites. Connecting roads, tracks and associated support structures can be imagined – realising the impacts on just the surface water ways and movements.

The reality of what the area would look like before and after development is seen in following pair of photographs taken of the Santos GLNG Project area north of Roma, showing respectively, the intact forest prior to 2012, and the dissected and fragmented area after 2016.



The dissection and fragmentation that typically follows gas field development is shown in the photograph below.

Dissection of State Forest by gas infrastructure near Chinchilla, Queensland 2014

Message from Queensland:

["*The Narrabri project will get the benefit of our Queensland experience*" said Santos CEO, Kevin Gallagher to the ABC.

Objectors to the Narrabri Gas Project have the benefit of the Queensland experience as well. It has shown us the inherent problems this industry cannot overcome.

The Queensland experience has taught us that they have:

- No toxic by-product waste solution
- Destroyed water tables of the Great Artesian Basin
- Risked the health of communities and animals
- Proved that farming and the CSG industry cannot co-exist
- Turned prosperous rural towns into ghost towns
- Fractured communities
- Lied about gas shortages and emission controls
- Not been able to get any Environmental Insurance
- Not overcome the problem of SRB's
- Not complied to worlds best practice"]

Already recognised at Risk in the Pilliga Forests by the Commonwealth and NSW State Governments are:

Endangered Ecological Community:

Critically Endangered : White Box-Yellow Box-Blakely's Red Gum Grassy Woodland & Derived Native Grassland

Threats listed for this community are - Invasion of weeds, removal of timber, loss of understory, groundcover sp., vegetation structure & communities

This is a community consisting of a layered structure - not only a variety of tree species, and an assemblage of shrub species, but a complexity of groundcover species - will be totally decimated by segmentation and structural destruction by Santos' proposed CSG well and infrastructure implementation.

Threatened Individual Plant Species

Of the three individual plant species Listed as **Endangered,** one is a hairless twining plant, two are groundcover species both requiring moisture, the first, a sedge requiring waterholes or creek beds, the other, an annual herb or perennial forb 15-22 cm. high requiring moist sites associated with other ground cover tussock grasses.

The threats listed for these species include: disturbances, changes to flooding patterns, clearing, logging, grazing, forestry activities and track maintenance. Most of these threats will be realised with Santo's Narrabri Gas Project implementation.

Of the five Individual plant species Listed as **Vulnerable**, two are ground orchids, and three are shrubs of various configurations- one up to 4 metres with entwining branches, one slender in a shrubby understory, and the third prostrate with trailing stems.

The threats listed for these species include: clearing, fragmentation, inappropriate fire regimes, road grading of roadsides modification and removal of groundcover grassy components, logging, climate change and degraded vegetation, weeds and feral animals.

Specific threats include: to the tallest shrub, small populations and limited distribution, and for one of the orchids a lack of information related to seed and symbiotic relationship with fungi. This orchid, the Greenhood orchid, pollinated by males of small gnats attracted to flowers by pseudosexual perfume, requires specific habitat of litter accumulation and water runoff.

Flowering of these species is spread across the year, one in winter, one in winter to spring, three in spring, one summer and autumn, and one flowering extensively from autumn to spring.

Threatened Vertebrate Species - showing primary food & shelter resource dependence

Vulnerable, NSW & EPBC Act

- *Koala (Phascolarctos cinereus)*) – dependent upon Eucalypt tree health & connectivity

Vulnerable, EPBA Act:

- South-eastern Long-eared Bat (*Nyctophilus corbeni*)- dependent upon invertebrate fauna, understory & tree hollows
- Large-eared Pied Bat (*Chalinolobus dwyeri*) – dependent upon invertebrate fauna & tree hollows
- Pilliga Mouse (*Pseudomys pilligaensis*) – dependent upon invertebrate fauna, grasses & groundcover
- Swift Parrot (*Lathamus discolor*) – dependent upon Eucalypt flowers & nectar, tree hollows
- Regent Honeyeater (*Anthochaera Phrygia*) – dependent upon nectar Mugga Ironbark, Yellow Box & White Box

Other Threatened Species:

- Black Striped Wallaby (*Macropus dorsals*); dependent upon dense shrubby understory
- Brown Treecreeper (*Climacteris picumnus*); dependent upon invertebrate fauna under bark & tree hollows
- Black-chinned Honeyeater (*Melthreptus gularis*); dependent upon insects & nesting sites in high canopy
- Grey Crowned Babbler (*Pomastomus temporalis*); dependent upon ground litter, group nesting sites in tall upright understory and connectivity – require 12 to breed
- Varied Sittella (*Daphnoesitta chrysoptera*); dependent upon insects under bark, nesting in dead branches in high canopy group roosting, groups of 8 to 10
- Hooded Robin (*Malanodryas cucullata*); dependent upon arthropods mainly insects, ground foraging, tree crevices or hollows
- Speckled Warbler (*Chthonicola sagittata*); dependent upon insects in leaf litter, ground cover for nesting
- Diamond Firetail (*Stagonopleura guttata);* dependent upon ground feeding on ripe fruit, grass seeds, thorny bushy understory, often nest in bottom of birds of prey nests

Important populations of Vulnerable fauna species TSC Act:

- Eastern Pygmy-possum (*Cercartetyus nanus*); dependent upon Eucalypt, bottlebrush nectar & pollen and tree hollows
- Little Pied Bat (*Chalinolobus picatus*); dependent upon mid canopy insects, caves, mines, or houses, possibly tree hollows,
- Eastern Cave Bat (*Vespadelus troughtoni*); dependent upon insects, light caves, mines, overhangs, houses, large spaces for big colonies
- Pale-headed Snake (*Hoplocephalus bitonquatus*); dependent upon tree dwelling vertebrates, frogs, skinks & bats and tree hollows, bark- preferably riparian
- Glossy Black-cockatoo (*Calyptorhynchus lathani*); dependent upon Casuarina sp. Fruit, and large tree hollows
- Turquoise Parrot (*Neophima pulchella*); dependent upon grasses , seeds & sometimes flowers, and tree hollows
- Barking Owl (*Ninax connivens*); dependent upon small/medium mammals, birds, reptiles & insects and very large tree hollows

Table 1. Threatened: Summary - Major Ecosystem resource required by each Listed Sps.

Threatened Species for the Pilliga Forests	insects	nectar / flowers	fruit	groundcover litter	groundcover grasses	vertebrates	canopy	understory	structure	tree hollows/ bark	Caves	connectivity	ground water/ veg health	Surface Water
Koala														
South-eastern Long-eared Bat														
Large-eared Pied Bat														
Pilliga Mouse														?
Swift Parrot														?
Regent Honeyeater														?
Black-striped Wallaby														?
Brown Treecreeper														?
Black-chinned Honeyeater														?
Grey-crowned Babbler														?
Varied Sittella														?
Hooded Robin														?
Speckled Warbler														?
Diamond Firetail														?
Eastern Pygmy-Possum														?
Little Pied Bat														?
Eastern Cave Bat														?
Pale-headed Snake														?
Glossy Black-cockatoo														
Turquoise Parrot														?
Barking Owl														?
TOTALS 21	13	4	2	5	5	2	3	6	9	11	2	4	3	

Showing : Vegetation Structure and Condition are critical – and partitioning of Landscape Resources occurs

- <u>INSECTS</u> MOST ESSENTIAL RESOURCE <u>- THE DRIVERS OF COMMUNITIES.</u> *** Each Insect Sp. has host plants or preferred habitat – dependant/ inter-dependent upon structure/condition of the assemblage/ community/ ecosystem and weather.
- <u>TREE HOLLOWS SECOND MOST</u> REQUIRED resource *** Prime Real Estate! size, direction, locale.

Impacts – Some examples of SCALE appropriate to this Project

These Threatened species, however, are merely the **"CANARIES IN THE COAL MINE"** – critical indicators of changes in their support systems (ecosystems) that **should alert us** to the need for urgent action to address the **causes**.

What we do know:
Much research has been conducted at the individual and Species scale, not necessarily of all the Listed species, and not necessarily in the Pilliga;

What we know less about or don't know:
Less research has been conducted at the Cohort, Assemblage, Ecosystem, Landscape, Continent and **Global scale.** In other words we know much less about the interrelationships and interdependencies.

In many cases it has required numbers of studies at the individual or species scale, and then further studies of how these may be linked, and again how they may be interlinked! It requires less funding to conduct research of individual Species, however greater funding is required to conduct research of an individual species across communities then landscapes, and greater funding for research of other species and systems related to that species, and more again over long timeframes. Less research has been conducted over greater expanses, or more arid regions that are more difficult to access – disadvantageous to research into community and ecosystem function in the Pilliga.

THE QUESTION OF "OFFSETS"

According to the Assessment Report Biodiversity impacts in the forest would be overcome, (p. v) by
... offsetting any residual biodiversity impacts in accordance with the NSW Biodiversity Offsets Policy for Major Projects 2014 ...

Case studies prepared by the Nature Conservation Council (2016) demonstrated that biodiversity offsetting in NSW is failing to deliver the environmental outcomes governments and policy makers promised. In one Case Study of particular relevance to Narrabri Shire (Boggabri/Maules Creek), biodiversity outcomes were deemed to be "Disastrous".

When Hunter Catchment Management Authority requested access to the register of offsets (to see where they were located) it found there was no register. Subsequent investigations found that the same area was claimed as an offset for multiple (up to four) developments.
In many cases where developers buy land from farmers for offsets, the land being "offsetted" was never going to be cleared and developed by the farmer in any case. In other cases, mine site rehabilitation can be used as an offset credit. To a large extent the Offsets Policy is a fraud and its application to the NGP is likely to leave the Forest's flora and flora depleted.

In answer to a Question put to me by the IPC during my presentation on Tuesday 20th July, - "What do you think of Offsets" - I would like to tell some BIODIVERSITY stories. These stories are not in the main of the Pilliga, due to the paucity of research in the Pilliga, but serve to indicate the complexity and interrelatedness of our biodiversity and ecosystems, and the **critical importance of maintaining whole** Assemblages, Communities, Ecosystems and Landscapes for Local, Regional, Continental and Global sustainability. **One area of vegetation is not able to be Offset with another area of vegetation that may have just Some of the features but possibly None of the interrelatedness. Dissection and Fragmentation depletes and destroys the integrity and function of the "WHOLE".**

Biodiversity Stories:

Insects as Drivers of Communities – components of the "whole" (ecosystems):

As can be seen from Table 1 above, insects as food resources are essential for at least 13 of the 21 Threatened Species in the Pilliga.

1. Observations of Insect abundance and diversity :

Whilst undertaking a project in 1999 for Australian Cotton Research Institute to assess the viability of a Vortex Light Trap to trap and suppress Helicoverpa moth, the predominant cotton plant pest, the sorting and counting of insect trap contents from an array of traps cleared every second night during December and January, showed huge nightly variations both in abundance and species composition. (The Australian Cotton Grower Vol 23 No 2Pg 32) For example huge numbers of black crickets captured one night, not apparent the next night, followed by, for example huge numbers of lady beetles, then dung beetles several nights later.

I also observed intense nocturnal insect activity across cotton fields using night vision binoculars while participating in a small collaborative research project into microbat activity and its impact on Helicoverpa. Helicoverpa along with several other insect species, can hear ranges of ultrasound utilised by microbats during insect foraging. (Australian Cotton Conference Poster, 2000; Australian Bat Society Newsletter No 22 July 2004).

Nocturnal and landscape scale movements are often not observed and therefore not included in decision making. We mostly have no idea what is happening out there at the landscape scale which is influenced by temperature, wind, precipitation, moon cycle, vegetation type, invertebrate migratory and activity patterns – climate change?

2. The Rufous Bettong Story - a Story of what we do know:

I became aware of this story around 1999/2000 when researching and preparing a "An Integrated Fox Management Plan" for the Southern New England Landcare Co-ordinating Committee, and co-ordinating a very large community based environmental exhibition and event at the New England Regional Art Museum in Armidale, NSW, titled "Nova-Anglica – the web of our Endeavours".

Peter Jarman, then Dean of Ecosystem Management Department, University of New England, together with a Technical Assistant, were maintaining a small breeding population of Rufous bettong (*Aepyprymnus rufescens*) within the grounds of UNE in the hope that one day they may be released into a fox-free area of Tablelands native vegetation. Rufous bettong are no longer present across the New England tablelands. This seemingly impossible story opened my eyes to the intricacies and interconnectedness of our biodiversity. In writing this submission and hunting for the source and more recent research, the interrelatedness has become even more astounding.

The characters are: Rufous bettongs, truffle-like fungi, **dung beetles**, mycorrhizae, low nutrient soils, native vegetation both trees and shrubs, vegetation health, vigour and sustainability. At any point in this cyclical story the possible linkage-breakages are apparent.

The Rufous bettong is a small marsupial rat-like kangaroo, about the size of fully grown hare, that stands and jumps on hind legs, has small hand-like forepaws, shelters diurnally from raptor predation in a number of grass nests constructed under low shrubs or in tall grass clumps, **forages and feeds nocturnally on underground indigenous truffle-like fungi** species, the consumed **spores** of which partially germinated within the bettong's digestive system, are **defecated unharmed in dung which is mounted and buried by an indigenous Dung beetle species** that has been attached to the Rufous bettong's fur, germination completed within the soil.

Truffle-like fungi
There are about 300 truffle-like species documented for Australia with numerous new species awaiting publication which will possibly result in between 1200-2400 species. A very high percentage of these fungi are endemic to Australia. They are found from rainforest to desert, and being **mostly mycorrhizal,** have co-evolved to have a **symbiotic relationship with an indigenous native tree or shrub species.**

Mycorrhizae can be described as symbiotic relationship between a fungus and a plant where both the fungus and the plant benefit from this interaction. The mycelia form symbiotic associations with **plant roots** enabling the creation of a vast connection between the roots of a plant and the soil around them, allowing the fungi via the increased root surface, to increase uptake of nutrients such a nitrogen and phosphorus and water for the plant, whilst acquiring food for itself.

Underground truffle-like fungi cannot make their own food by the process of photosynthesis and therefore need pre-formed organic compounds including some vitamins, and carbohydrates for energy. These are received from the tree, which makes sugar, starch, and other compounds in the leaves, some transported to the rest of the plant including the roots. Being closely associated with the root cells enables the fungal mat of hyphae to sequester various needed compounds.

Unlike other fungi, the truffle-like fungi fruiting bodies are produced underground, the spores are produced internally, the spore bearing tissue generally enclosed within an outer skin- the spores are not forcibly released and rarely are they spread by wind or water. Mature fruiting body typically produce chemical compounds to attract animals to the fruiting bodies, the spores of which are then dispersed by the animal.

Overall **the relationship between plants and mycorrhizal fungi** depend mainly on the availability of nitrogen, phosphorus, carbon and water. Since areas within the environment vary in nutrient and water availability, this can have a major effect on whether or not a mycorrhizal relationship can form between a plant and the fungus.

Field evidence suggests truffle-like fungi form mycorrhizae with trees such as Eucalyptus, Allocasuarina, Leptospermum, Acacia and Northofagus. As described above this leads to increase in the growth of the plant and ultimately greater root growth and overall health and growth. Comparisons between seedlings planted with mycorrhizae and those without, which showed increased growth for those with mycorrhizae.

Santos's CSG drilling, clearing and disturbance for pads, road and track and other distribution infrastructure would impact greatly on the possibility of such continued and future relationships in the Pilliga.

Mammals - most likely co-evolved with endemic truffle-like fungi

At least 30 species of Australian mammal have been found to eat fungi and given the lack of comprehensive studies, there may be more species - the majority of fungi are truffle-like fungi. (Many truffle like fungi have distinctive spores which can be found in droppings and identified). The eating of fungi is well-developed in the rat-kangaroo (includes bettongs and potoroos). For Potoroos and Bettong in general, fungi (mostly truffle-like) constitute at least 30-40% of animal's diets throughout the year, however for Long-footed Potoroo it is 80-90% of the diet.

Dung beetle

More than 480 native Australian **dung beetle** species have been described, many are endemic and are probably adapted to use marsupial dung.

Wright (1997) showed that the **dung beetle species *Onthophagus peramelinus* was associated exclusively with the rufous bettong *Aepyprumnus rufescens***, and Vernes et al. (2001) concluded the dung beetles in their study appeared to partition resources to some degree by selective use of dung by different mammals, and strongly by differentiating between adjacent habitat types.

Summary – Specificity – or finding niches, avoiding competition and resource partitioning

- the **Rufous bettong** forages for and consumes seasonally a **specific** truffle-like fungi species;
- the **specific** truffle-like fungi species, (which underground cannot photosynthesize and is thus reliant on this **specific** mammal species for reproduction via spore consumption and spore distribution), is **specific** to a host tree or shrub species – **specific** Eucalypt species in this instance;
- the **specific** Dung beetle species is **specific** to the Rufous bettong's facies type/composition and is attached to that **specific** mammal species fur;
- this cyclical system is **specifically linked** to a **specific** Eucalypt species, soil type and moisture composition, assemblage, community and ecosystem, bioregion- and landscape.

And this is repeated many times for different mammals, fungi sp., dung beetle sp., vegetation species.

Ecosystem Function: Fox & cat predation and grazing of the understory and groundcover, has resulted in the annexation of the vital Rufous bettong link, breaking tis ycles, reducing possibilities for Eucalupt resilience and health, possibly contributed to Eucalyptus Dieback, and contributed to the deterioration of habitat and ecosystem function – and thus the resultant deterioration of other dependant flora and fauna species across the New England Tablelands.

[**References are many and stretch from 1977 to 2013 – these are some**]

- "Australian Fungi – Truffle-like fungi in Australia" Friends of the Australian Botanical Gardens
- **Danks, M.A. The swamp wallaby (*Wallabia bicolor)*: a generalist browser as a key mycophagist** 2011 PhD Thesis University of New England**.**
- "Mycorrhizae" " Friends of the Australian Botanical Gardens
- "Mycorrhizae" Microbe Wiki 21 Feb 2012
- "Trees and fungi – a productive partnership" 1987/88 Ecos 54 Summer
- Vernes K, Pope L.C, Hill C.J. 2005.Seasonality, dung specificity and competition in dung beetle assemblages in the Australian Wet Tropics, nor-eastern Australia, J. of Tropical Ecology 21;1-8
- Vernes k, Castellano, M & Johnson, C.C. 2001 "Effects of season and fire on the diversity of hypogeous fungi consumesd by tropical mycophagous marsupial" J. of Animal Ecology 70:945-954
- Wright KL 1997 "An examination of the commensal interaction between the Australian native dung beetle, *Onthophagus peramelinus* and the rufous bettong *Aepyprumnus rufescens* B.Sc Honours theses, James Cook University.

A very good article which extensively references previous research:
Coggan, N. 2012."Are native dung beetle species following mammals in the critical weight range towards extinction?" *Proceedings of the Linnean Society of New South Wales* 134, A5-A

Other associated research:

- "Swamp Wallabies on Mt Duval" – wallabies digging up & consuming Australian truffles (New England Tablelands research) ;
  Ass Prof Karl Vernes, University of New England -
- "Swamp wallaby: keystone mycophagist in a fragmented landscape?"
  The Hermon Slade Foundation (NSW,) 2008-06 Karl Vernes
- "Unravelling community interactions between mammals and fungi, and the role of mycophagy in mediating biodiversity and driving ecosystem processes"
  Australian Research Council (Canberra) 2005-01-01 to 2007-12-31|Grant, Karl Vernes *via* Dimensions Wizard
- "Data on the fungal species consumed by mammal species in Australia Data in Brief"
  2017 journal-article, Source: University of New England Australia
- "Redundancy among mammalian fungal dispersers and the importance of declining specialists"
  Fungal Ecology, journal-article, University of New England Australia

The relevance to the Pilliga?

A Pointer to some of what we don't know about Interrelationships in the Pilliga:

Research:
Swamp Wallaby & Black striped Wallaby scat collection to analyse diet and determine truffle consumption North West Plains and Pilliga Forests. Mycophagous (fungus eating) is a component of healthy ecosystems. (North West Plains NSW research)
Ass Prof Karl Vernes, University of New England

> "definite differences in the amount of fungus and the fungal spore diversity across the environmental gradient"

Another story of what we do know:

3. **"Parasitism: A Life of Luxury"**
   by Rob & Steve Davidson, Chapter 6 "Bushland on Farms" 1992

Wingless female Flower wasp (*Hemithynnus hyalinatus*?) – ground dwelling, lays 1 egg per scarab beetle grub in the soil, requires fertilization after laying 1 or 2 eggs, moves to the surface, waits for male attracted by her pheromones, crawls up grass stalk & waits, she cannot fly so male gathers nectar and regurgitates, she is fed whilst copulating in flight. As flight and copulation are energy rich, the nectar source has to be close for the male. Available nectar source is from Blackthorn (*Bursaria spinose)*, which flowers in the appropriate season, was once a widespread thorny understory shrub, but has been removed by graziers as a thorny weed.

Result: increased populations of scarab beetle and defoliation of Eucalypts – a contribution to tree DIEback & deterioration of ecosystem & function across the New England Tablelands.


Wingless Flower wasp
(*Hemithynnus hyalinatus*?


Blackthorn
(*Bursaria spinosa*)

Relevance to the Pilliga? What linkages not yet discovered would the Pilliga Gas Project wells, well infrastructure and activities remove? And what ecosystem function do the plant species already Listed as Endangered and Vulnerable in the Pilliga play?

Just a glimpse into some of what we don't know about interrelationships in Western NSW and the Pilliga –Vegetation Communities resemble some in Pilliga Forests.
A Research Story : (many unnamed parasitoid wasps, and unknown ecosystem functions)

4. **INVERTEBRATE Survey Report in the Bellata-Millie-Gurley Travelling Stock Reserves** (TSRs) for the Border Rivers-Gwydir Catchment Management Authority, 2013
   by Dr Graham Hall –

This Report provides the results of invertebrate sampling from a series of 11 sites identified in the "Fauna Survey Report in the Bellata-Millie-Gurley TSRs" conducted in November 2011.

Table 2 reports the abundance and diversity of wasps recorded at each of the 11 sampled sites. The results indicate that grassland without tree cover (sites 4 and 11) recorded the highest number of wasps, whilst Semi Evergreen Vine Thicket (site 9) recorded the lowest number of wasps. The abundance of wasps at the remainder of the sites was similar.

Wasp diversity was high at all sites, which validated their use as an indicator group for broad surveys. The diversity of wasps at the Grassland sites (sites 4 and 11) was the same (11 taxa and 5 families), whilst greatest diversity was recorded at site 6 (Myall regrowth) with 27 taxa within 7 families. Lowest diversity was recorded at the Bimble Box woodland site (site 8), where only a small number of wasps were collected.

Table 2 Abundance and diversity of wasps collected at 11 different sites (as at June 2013).

Site	Location	Habitat	Wasps	
			Abundance (number)	Diversity
1	14 km W Gurley	Myall regrowth	29	9 taxa; 8 families
2	15 km W Gurley	Grassland	38	11 taxa; 5 families
3	20 km W Gurley	Belah woodland	31	10 taxa; 7 families
4	14 km NW Bellata	Grassland	159	12 taxa; 6 families
5	13 km NW Bellata	Myall woodland	36	15 taxa; 5 families
6	10 km NNW Bellata	Myall regrowth	55	27 taxa; 7 families
7	6 km NW Bellata	Brigalow-Belah open forest	36	13 taxa; 5 families
8	1 km NW Bellata	Bimble Box woodland	21	7 taxa; 7 families
9	8.5 km N Bellata	Semi-Evergreen Vine thicket	18	16 taxa; 7 families
10	8 km N Bellata	Brigalow-Belah open forest	28	16 taxa; 8 families
11	5 km E Bellata	Basalt Grassland	268	11 taxa; 5 families

The results indicate that many of the micro-wasps collected during the study are parasitoids of other insects. However, studies of the interactions between parasitoids and putative hosts are lacking in Australia so definitive statements about the role of specific parasitoids in population control of their hosts would be premature. Nevertheless, the diversity of insect parasitoids amongst the samples from the 11 sites offers the opportunity for further study of the interactions between parasitoids and hosts.

An impediment to this project was the lack of specialist knowledge about the taxonomy, systematics and biology of the captured micro-wasps. Consequently I visited the Australian National Insect Collection, Canberra in April 2013 for discussions and training with Dr John La Salle and Ms Nicole Fisher. This visit and training proved useful in giving me confidence to identify the wasps collected during the project but, because of the lack of taxonomic keys, small size and special preparation techniques for these specimens, progress with identification was slow.

Table 3 Notes on the biology of the taxa

Site	Diversity	Relative abundance of each taxa	Biology of each taxa
1 Myall Regrowth	9 taxa; 8 families	3.6% Braconidae; 3.6% Halictidae; 18.2% Encyrtidae; 39.9% Eulophidae; 3.6% Eupelmidae; 3.6% Eurytomidae; 20.6% Pteromalidae; 6.9% Scelionidae	Braconidae = parasitoids of a wide range of insects. Halictidae = native bees (pollination). Encyrtidae = parasitoids of beetles, flies and spiders. Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Eurytomidae = parasitic and gall formers. Pteromalidae = parasitoids of insects and spiders. Scelionidae = egg parasitoids of insects and spiders.
2 Grassland	11 taxa; 5 families	3.6% Braconidae; 62.5% Eulophidae; 10.5% Eupelmidae; 16.8% Pteromalidae; 6.6% Scelionidae	Braconidae = parasitoids of a wide range of insects. . Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Pteromalidae = parasitoids of insects and spiders. Scelionidae = egg parasitoids of insects and spiders.
3	10 taxa; 7 families	3.1% Braconidae; 3.1% Chalcididae;	Braconidae = parasitoids of a wide range of insects Chalcididae = parasitoids of flies and moths.

Belah Woodland		25% Eulophidae; 12.5% Eupelmidae; 18.8% Halictidae; 25% Pteromalidae; 12.5% Scelionidae	Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Halictidae = native bees (pollination). . Pteromalidae = parasitoids of insects and spiders. Scelionidae = egg parasitoids of insects and spiders.
4 Grassland	12 taxa; 6 families	2.5% Dryinidae; 2.5% Halictidae; 5% Encyrtidae; 47.5% Eulophidae; 12.5% Eupelmidae 27.5% Pteromalidae; 2.5% Scelionidae	Dryinidae = parasitoids of leafhoppers (Bugs). Halictidae = native bees (pollination). Encyrtidae = parasitoids of beetles, flies and spiders. Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Pteromalidae = parasitoids of insects and spiders. Scelionidae = egg parasitoids of insects and spiders.
5 Myall Woodland	15 taxa; 5 families	5.3% Braconidae; 44.8% Eulophidae; 13.8% Eupelmidae; 20.7% Pteromalidae; 17.4% Scelionidae	Braconidae = parasitoids of a wide range of insects Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Pteromalidae = parasitoids of insects and spiders. Scelionidae = egg parasitoids of insects and spiders.
6 Myall regrowth	27 taxa; 7 families	4.3% Chalcididae; 4.3% Encrytidae; 46.8% Eulophidae; 6.4% Eupelmidae; 8.5% Eurytomidae; 14.7% Pteromalidae; 14.9% Scelionidae	Chalcididae = parasitoids of flies and moths. Halictidae = native bees (pollination). Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Eurytomidae = parasitic and gall formers. Pteromalidae = parasitoids of insects and spiders Scelionidae = egg parasitoids of insects and spiders.
7 Brigalow Belah	13 taxa; 5 families	13.6% Braconidae; 4.5% Halictidae; 54.5% Eulophidae; 9.2% Eupelmidae; 18.2% Scelionidae	Braconidae = parasitoids of a wide range of insects. Halictidae = native bees (pollination). Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Scelionidae = egg parasitoids of insects and spiders.
8 Bimble Box	7 taxa; 7 families	11.8% Aphelinidae; 5.9% Braconidae; 5.9% Ceraphronidae 5.9% Encyrtidae; 29.4% Eulophidae; 17.6% Eurytomidae; 23.5% Scelionidae	Aphelinidae = parasitoids of aphids. Braconidae = parasitoids of a wide range of insects. Ceraphronidae = parasitoids of various wasps, flies and bugs. Encyrtidae = parasitoids of beetles, flies and spiders. Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eurytomidae = parasitic and gall formers. Scelionidae = egg parasitoids of insects and spiders.
9 Semi Evergree Vine Thicket	16 taxa; 7 families	5.6% Encrytidae; 39.9% Eulophidae; 16.7% Eupelmidae; 5.6% Scelionidae; 13.3% Torymidae; 5.6% Trichogrammatidae 13.3% Unknown	Encyrtidae = parasitoids of beetles, flies and spiders. Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Scelionidae = egg parasitoids of insects and spiders Torymidae = parasitoids of wasps and flies. Trichogrammatidae = egg parasitoids of many insects.
10 Brigalow Belah Open Forest	16 taxa; 8 families	3.6% Braconidae; 35.7% Eulophidae; 21.4% Eupelmidae; 14.3% Eurytomidae; 3.6% Pteromalidae; 3.6% Scelionidae; 10.7%Trichogrammatidae 7.1% Unknown	Braconidae = parasitoids of a wide range of insects. Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Eurytomidae = parasitic and gall formers. Pteromalidae = parasitoids of insects and spiders. Scelionidae = egg parasitoids of insects and spiders. Trichogrammatidae = egg parasitoids of many insects.
11 Basalt Grassland	11 taxa; 5 families	8.7% Braconidae; 43.5% Eulophidae; 21.7% Eupelmidae; 17.4% Pteromalidae; 8.7% Scelionidae	Braconidae = parasitoids of a wide range of insects. Eulophidae = gall forming or parasitoids of wasps, flies and moths. Eupelmidae = egg and larval parasitoids of a wide range of insects. Pteromalidae = parasitoids of insects and spiders. Scelionidae = egg parasitoids of insects and spiders.

Table 4 Wasps and their ecosystem function (photographs G Hall)

 Chalcididae = parasitoids of flies and moths	 Eupelmidae = egg and larval parasitoids of a wide range of insects	 Eurytomidae = parasitic and gall formers.
 Pteromalidae = parasitoids of insects and spiders.	 Scelionidae = egg parasitoids of insects and spiders.	 Torymidae = parasitoids of wasps and flies.

Landscape Function & Assemblages: <u>An example of landscape resource partitioning</u> in a landscape just 20km. from Pilliga Gas Project area.

5. Microbat assemblage on 3 cotton properties – seasonal foraging patterns across a production landscape

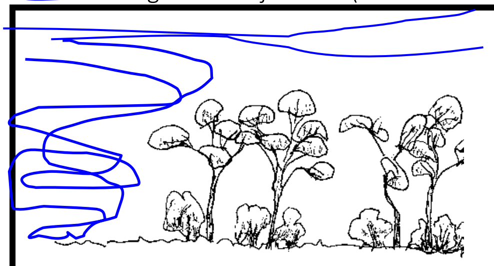
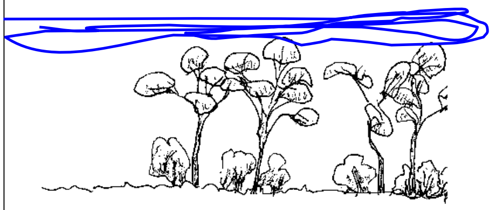
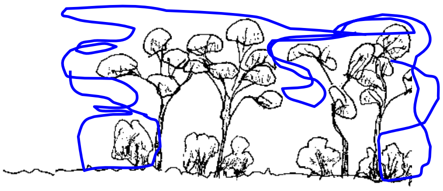
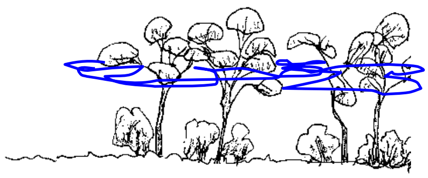
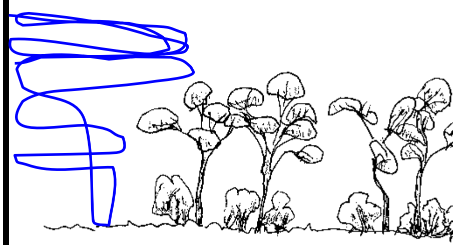
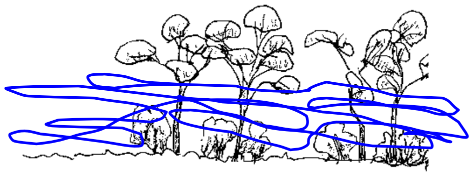
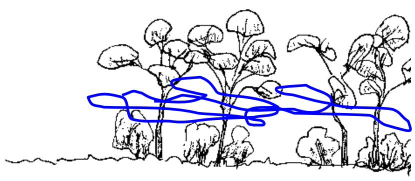
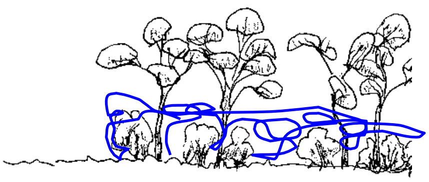
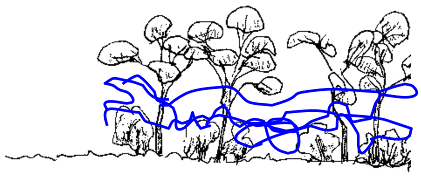
L MacKinnon, MPhil Thesis, 2007 "Microbats in Changing Cotton Production Landscapes – A case study from the Namoi River" .Cotton Research & Development Corporation

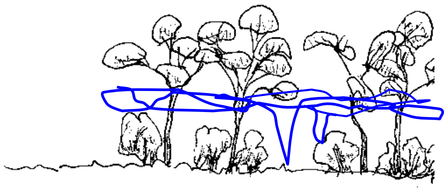
Table 5 below describes the known foraging flight patterns for each species in the assemblage of insectivorous microbats whose ultrasound echolocation calls were recorded with an Annabat recorder.

This seasonally conducted landscape utilisation research showed that different groups of microbat utilised different vegetation assemblages for prey foraging, in different seasons, One of the high flying species White-striped freetailed-bat (*Tadarida australis),* using low far-reaching ultrasound calls, was not present in summer. Other research indicated this species climatically re-locates with variations in temperature – in this case the closest cooler summer climate vegetation is on the Mt Kaputar Range. Another group utilising very high fast ultrasound calls to navigate within the close understory, in autumn was located only in very small patches with understory present. This group although seasonally present, recorded least presence and was the most at risk in this altered landscape. The generalist species were able to optimise the cotton production areas in summer for prey foraging.

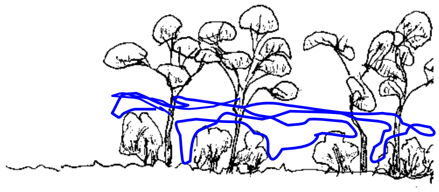
The relevance for the Pilliga Forest? Apart from the Threatened microbat species listed above, a similar assemblage of microbats that are not as yet Listed as Threatened, are most probably present and utilising the variations in vegetation structure and composition in the Pilliga Forests, thus foraging on prey within Pilliga vegetation communities in similar ways – requiring different segments of the landscape in different seasons – utilising parts of the "whole" ecosystem, landscape, and region.

Table 5 Known foraging flight patterns of assemblage of microbats recorded in the Namoi – approximately 30 kms ~~from the Pilliga Gas Project site (MacKinnon~~ MPhil Thesis Microbat in Changing Cotton Landscapes)

		**Known roost preference:** Tree hollows, cracks and overhangs
Tadarida australis (10kHz-13kHz)	*Saccolaimus flaviventris* (17.5kHz-22kHz)	
		Unknown for *Mormopterus* sp. 2 (28.5kHz-31kHz)
Mormopterus sp. 4 (26kHz-29.5kHz)	*Chalinolobus gouldii* (27.5kHz-33kHz)	
		**Known roost preference:** All tree hollows; *C. gouldii* river red gum dead limbs; *M.* sp. 2 tree spouts; *M.* sp. 4 narrow entrances; Others: roof cavities (*S. bal*., *M.* sp. 3 & 4 *M.* sp. 3 water pipes & often with *S. bal.*
Mormpoterus sp. 3 (34.5kHz-35kHz)	*Scotorepens balstoni* (29kHz-34kHz)	
		Unknown for *Chalinolobus picatus* (42kHz-44kHz)
Scotorepens greyii (36.5kHz-40kHz) **?**	*Vespadelus darlingtoni* (41kHz-44kHz)	
		**Known roost preference**: All tree hollows + buildings; Others: *C. morio* +bark, culverts, bridges; *C. picatus* +caves, mines; *S. grey*. + fence posts.
Vespadelus regulus (45kHz-46kHz)	*Vespadelus vulturnus* (46kHz-49kHz)	



Chalinolobus morio (48.5kHz-51.5khz)

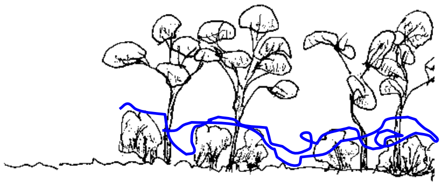


Nyctophilus gouldi (40kHz-67kHz)

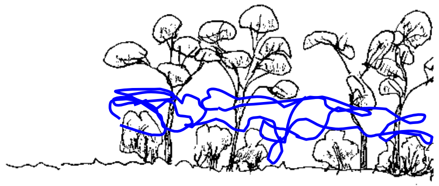
Unknown for

Vespadelus troughtoni

(48kHz-55kHz)



Nyctophilus timoriensis (43kHz-71kHz)
renamed *Nyctophilus corbeni*



Nyctophilus geoffroyi (46kHz-66kHz)

Known roost preference*:*
C. morio *tree hollows, houses, bark, Fairy Martin nests, culverts, bridges;* V. troug. *caves, boulder piles, mines, buildings;*
N. goul. *tree hollows, bark;*
N. tim*. tree hollows, fissures in dead limbs/trees, bark;*
N. geof. *fissures in dead trees, bark, buildings.*

Tree Hollows - A Major Ecosystem Resource

Table 6. Number of tree hollows at three sites, Namoi River (unpublished)
(L. MacKinnon, 2004, Research for "Microbats in Cotton Landscapes in the Namoi" Masters Thesis)

Tree Species	Trees per 2 ha.	Maximum hollows per tree	Average hollows per tree	Total hollows
river red gum (*Eucalyptus camaldulensis*)	19	29	**11**	213
poplar box or **bimble box** (*Eucalyptus populnea*)	23	18	**8**	117
grey box (*Eucalyptus pilligaensis*)	52	+9	**4**	216
dead trees – probably river red gum (*E. camaldulensis*) by proximity to old water course)	5	23	**14**	68 + many fissures

As can be seen in Table 6. differing tree species grow in differing densities and produce differing numbers of tree hollows. It requires 100 to 150 years for Eucalyptus trees to produce hollows. They have to be healthy enough to withstand damage and loss, to recover, heal and produce hollows. Dead trees are incredibly important (ref **Ross L. Goldingay below***)*. As Table 1 above demonstrates tree hollows are the second most critical resource required by Threatened species Listed for the Pilliga, therefore the presence of very Eucalypt and bark producing tree in the Pilliga Gas Project area is critical.

"Characteristics of tree hollows used by Australian birds and bats" - *Ross L. Goldingay*

School of Environmental Science & Management, Southern Cross University, PO Box 157, Lismore, NSW 2480, Australia. Email: ross.goldingay@scu.edu.au

Abstract. Many hundreds of species of wildlife worldwide are dependent on tree hollows (cavities) for their survival. I reviewed the published literature for hollow-using Australian birds and microbats to document their tree-hollow requirements and to guide future research and management. Such information is vital to the conservation of these species. The hollow requirements of only 35 of 114 hollow-using bird species and 15 of 42 hollow-using microbat species were documented in some detail. This overall paucity of information limits the ability to manage for the future requirements of species. However, some generalisations can guide management until further studies are conducted.

Most species used a variety of available tree species, and the extensive use of dead trees probably reflects the high likelihood of these trees containing hollows. Birds (other than large parrots) and bats chose hollow entrances of a size close to body width. Large parrots require large hollows, with a preference for large vertical spouts and trunk hollows. Few birds or bats demonstrated an absolute requirement for high (>10 m) tree hollows, with most (70%) using some hollows with entrances _5m above ground. Temperature has been postulated to influence roost selection among microbats because it enables passive rewarming from torpor and there is some evidence from Australian bats to support this.

Many studies suggest a future shortage of hollow-bearing trees. Currently, artificial hollows appear to be the most likely interim solution to address this. Knowledge of the natural hollow requirements of species can be used to refine artificial-hollow designs.

An increase in research effort is needed to address the many gaps in knowledge that currently exist. Priorities for research include
(1) many additional studies to document the characteristics of the hollow-bearing trees used by species of microbat,
(2) the need to conduct long-term bioregional studies of hollow-bearing tree attrition to help identify where management responses are most needed and
(3) investigating whether fire plays a significant role in the creation of tree hollows of a range of size classes and therefore may have a management use.
Such information has broad relevance because it will provide ecological insight that can be applied to the management of hollow-using birds and bats elsewhere in the world.

Also:

- Cooper CB., Watters, J.R. & Ford, HA. 2002." Impact of Remnant Size and connectivity on response to habitat fragmentation of Brown Tree Creeper, Emu(3) 249-256.
- Gibbons .P and Lindenmayer D. 2002 **"Tree Hollows – and Wildlife Conservation in Australia"**, CSIRO
- **Roost preference of microbat Sp.** – (Linda Lumsden, Brad Law, Andrew Bennett, David Lindenmeyer various papers)

Many studies by Doerr & Doerr on patch size, connectivity and bird landscape movement

THE IMPACTS

Biodiversity Fragmentation and segmentation will mean

- Loss of **all that we don't know yet** – **LACK OF APPLICATION OF THE PRECAUTIONARY PRINCIPLE!**
- Loss of **interrelationships & interdependencies** at various scales and timeframes;
- Loss of **Assemblage, Community and Ecosystem Functioning**;
- Loss of **Threatened Species** and **decline in the health and viability of other species and populations**;
- Loss of **climate change refuge**;
- Loss of **habitat at local, regional, landscape and global scales**;
- Loss and decline of **resources essential to Threatened species – insects and tree hollows**;
- Disruptions & pollution of **surface waterways & water movement & and groundwater ecosystems;**
- Vulnerability to **flares & methane gas flows** – of flora to fire, and fauna by nocturnal attraction to light and chemical poisoning;
- Loss of **future healthy viable populations** and their potential;
- Loss and disturbance of **habitat structure** – tree, shrub and groundcover layers;
- Exposure to **traffic, noise, dust & disturbance**;
- Increase of **Edge-to-Remnant ratio** - advantaging some species and disadvantaging other species; (Noisy Miners; in a microbat assemblage edge foragers versus understory foragers)
- Increase of **weed infestation** – roadways, seed carriage & distribution by edge slashing, vehicular wheel carriage, road traffic, (RTA mapping Johnson's grass & Coolatai along the Newell Highway)
- Increase of **pest infestation** – foxes, cats, pest bird species by track access and fewer dense patches.

In conclusion, the scarcity of knowledge we have, as well as the awareness of knowledge we do not have and can only see glimpses of, **impels** us and the IPC to **apply the Precautionary Principle and Oppose the Approval of the Narrabri Gas Project.**

Leah MacKinnon- 22 Doyle Street, Narrabri

From this in 2013

- to this in 2020, creating wildlife habitat

- 76-year-old **resident of Narrabri area** since 2000
- **lifetime interpreting environmental research** in many locations, situations and methods,
- **Painting Diploma** 1972-76
- 40 year **art practice** much based on environmental interests 1976-2013
- developed **"Catchment-based Urban Storm Water Management Plan"** for Uralla Shire Council, 1999
- established **Landscape Interpretation Centre, NW Queensland**, Gidgee/Mitchell Grass, 1992-96-98
- co-ordinated **"Weedpac", Cotton Co-operative Research Centre,** Narrabri 2000
- **B.of Land Management**, University of Sydney, 2004
- **Masters Phil. "Microbats in Cotton Production Landscapes, Namoi**" Uni of Sydney, 2007,
- **Biodiversity Extension & Implementation, working with farmers, Border Rivers-Gwydir CMA** (Catchment Management Authority), Moree, 2006-2013
- **daughter, son-in-law and grandchildren broad-acre farmers** west of Bellata, north of Pilliga Project area.

"But it's not just about planting trees …." 1/20 1987

"Birds of Prey …" exhibition 1992

"TECs" 2012