Soft-engineering solutions for swamp remediation

- a "how-to" guide

'Save Our Swamps' Program

A Federal, State and Local Government initiative

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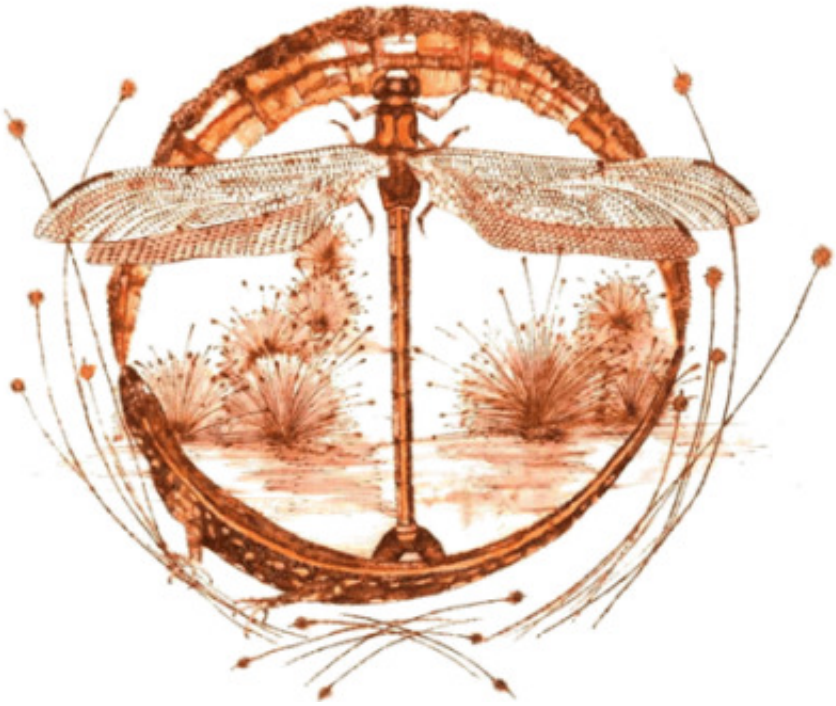

Soft engineering solutions for swamp remediation

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Soft-engineering solutions for swamp remediation - a "how-to" guide

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Blue Mountains Swamp. Photo: S. Duby

Introduction

This '***Soft engineering solutions for swamp remediation'*** manual provides current best practice technical guidelines for the installation of soft engineering swamp rehabilitation devices designed to reinstate the natural hydrology of degraded Temperate Highland Peat Swamps on Sandstone (including Gosford Hanging Swamps on Sandstone) swamp systems and to protect these swamps from ongoing erosion and sedimentation.

Temperate Highland Peat Swamps on Sandstone and Gosford Sandstone Hanging Swamp contain erodible and friable organic peat substrates and are highly sensitive to disturbance and stormwater erosion, resulting in channeling, tunneling, slumping and sedimentation of swamp systems. These changes disrupt the normal hydrology of affected swamp systems, causing the dewatering and desiccation of swamp substrates and the degradation of swamp vegetation.

The '***Soft engineering solutions for swamp remediation'*** manual is a product of the Save Our Swamps (SOS) project which has developed locally responsive soft engineering swamp rehabilitation and rehydration techniques to restore natural swamp hydrology tailored specifically for Temperate Highland Peat Swamps on Sandstone and Gosford Sandstone Hanging Swamp conditions.is seeking to remediate Temperate Highland Peat Swamps on Sandstone and Gosford Sandstone Hanging Swamp on a regional scale.

This manual is the result of the collective experiences of all the councils, land mangers, contractors and community groups who have participated in the SOS project. It seeks to capture the technical knowledge gained as well the lessons learnt through the process of trialing and progressively adapting and modifying the soft engineering swamp restoration techniques over the life of the project.

These swamp rehabilitation guidelines aim to provide:

- **background information** on SOS;
- swamp values;
- a **summary of the current approaches** implemented through this interagency partnership project;
- **technical guidelines on the installation** of soft engineering swamp rehabilitation works designed to reinstate the natural hydrology of degraded Temperate Highland Peat Swamps on Sandstone and Gosford Sandstone Hanging Swamps systems;
- and **representative case studies** from within each of the LGAs.

Save Our Swamps Program

The Save Our Swamps (SOS) project is a 'whole of government' landscape scale approach to the restoration of Temperate Highland Peat Swamps on Sandstone EEC and Gosford Sandstone Hanging Swamps communities across almost their entire range.

It engages all three tiers of government and is funded through both the NSW government's Environmental Trust program and the Commonwealth's 'Caring for Country' (CFoc) program.

The SOS project involves cross council collaboration between Blue Mountains City Council, Lithgow City Council, Gosford City Council and Wingecarribee Shire Council to restore degraded examples of these significant groundwater dependant swamp systems in each local government (LGA) area, which collectively constitutes most of their range. Each individual council is responsible for working on the swamp systems within their LGA while collectively collaborating together on a regional level to share expertise and ideas and to exploit synergies such as economic benefits when ordering materials together and organizing regional scale workshops. The project has a cross tenure approach involving all land managers and stakeholders.

A key objective of the Save our Swamps project has been to develop locally responsive soft engineering swamp rehabilitation and rehydration techniques to restore natural swamp hydrology tailored specifically for Temperate Highland Peat Swamps on Sandstone and Gosford Sandstone Hanging Swamp conditions. This has been achieved by trailing and progressively adapting the innovative swamp rehabilitation and rehydration techniques first pioneered by Roger Good in the alpine bogs and fens of the Australian Alps to the local conditions found in these swamps across their range.

Another key objective has been to progressively build the capacity of agency staff, land managers, local bush regeneration contractors and community volunteers to implement these locally adapted soft engineering swamp rehabilitation and rehydration techniques. The skill transfer process has been achieved through a series of practical workshops, supported by the development of demonstration sites and the production of this swamp remediation manual.

Photo: S.Duby

Above: Save Our Swamps Community workshops and

SOS program engaging local school students with excursions, presentations and hands-on swamp based environmental education activities. The resources are curriculum linked and encourage local schools to learn about their local swamp wetlands

L, R and below. Community information displays and talks.

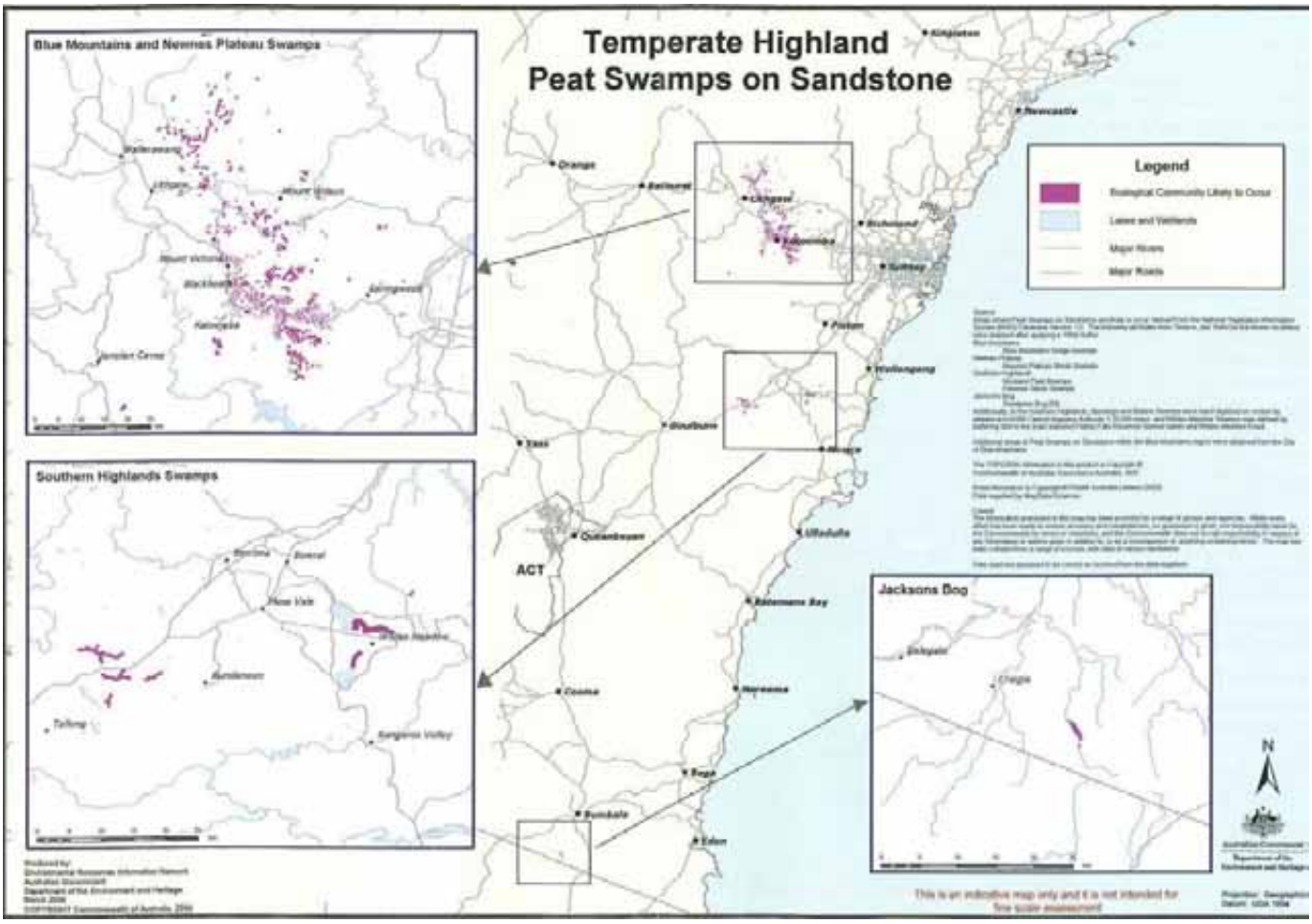
Images to the right. Local Swampcare volunteer groups, skill training, participating and implementing new skills learnt via the SOS program.

Council, Deerubbin Land Council, Industry and Green Corp workshops and training days.

Temperate Highland Peat Swamps on Sandstone

Temperate Peat swamps on Sandstone are listed as an Endangered Ecological Community (EEC) under the federal Environment Protection and Biodiversity Conservation Act 1999 due to their restricted distribution and their vulnerability to ongoing threats. They are characterized by highly organic sandy loams to mineral peats overlying sandstone at altitude , which supports a unique assemblage of flora. National listing acknowledges that its long term survival is under threat and aims to prevent its further decline through assisting community and land manager efforts in its recovery.

The federally listed Temperate Highland Peat Swamps on Sandstone Endangered Ecological Community (EEC) occurs in the Blue Mountains, Lithgow, Bombala and Wingecarribee Local Government areas. They have a naturally fragmented distribution pattern forming in response to extremely localized conditions which are created by a unique combination of topographic, geological, hydrological and groundwater influences.



Under the NSW Threatened Species Conservation Act 1995 Temperate Highland Peat Swamps on Sandstone are listed under regional ecological community variations including Blue Mountains Swamps, Newnes Plateau Shrub Swamps and Montane Peatlands and Swamps of the New England Tablelands, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and the Australian Alps bioregions.

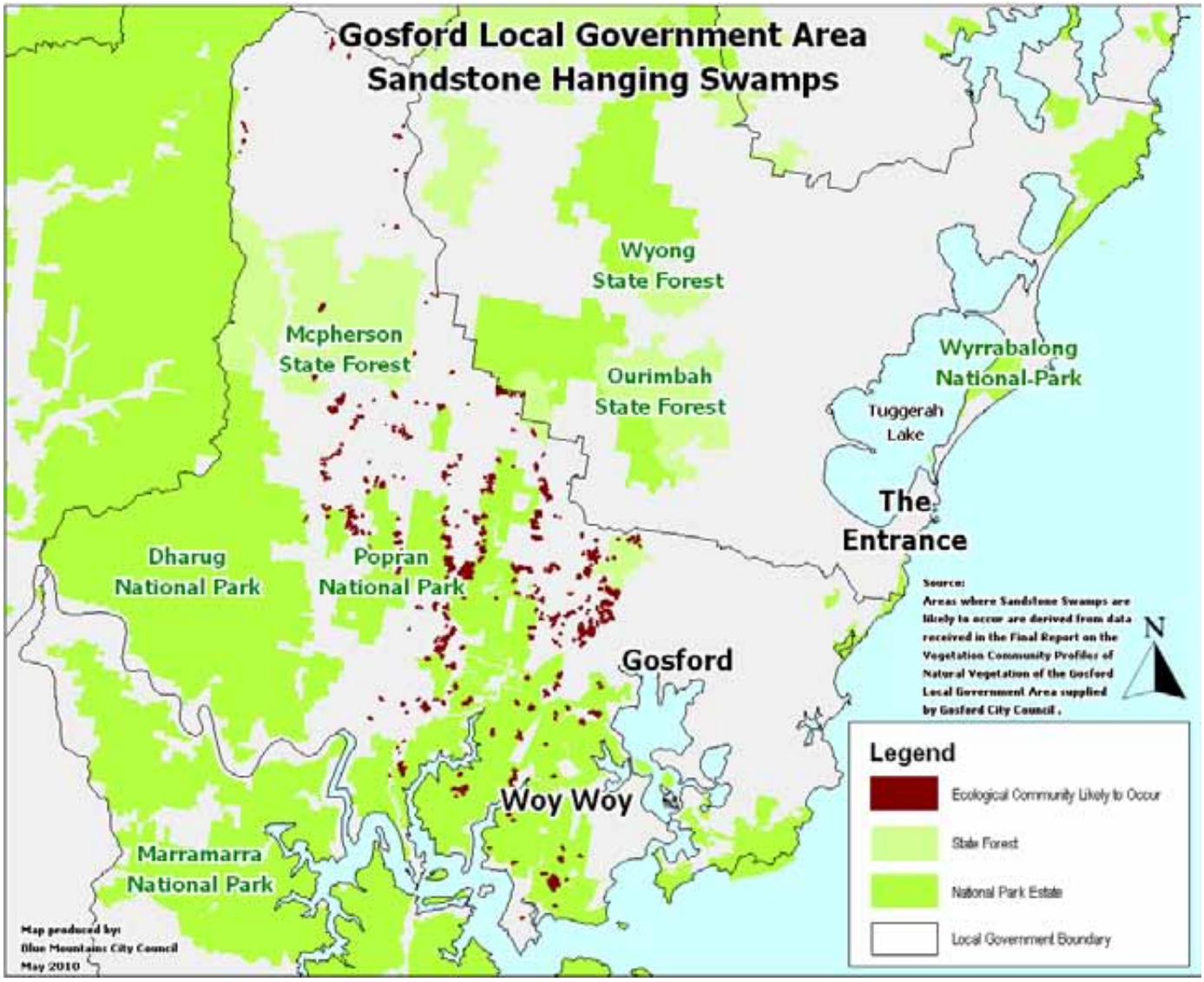
HOTLINKS

Factsheet Federal Government Community Profile Ecological Communities homepage

Gosford Sandstone Hanging Swamps

Gosford Sandstone Hanging Swamps are restricted in distribution, yet display a diverse range of distinct structural and floristic forms related to factors such as water table depth and the type of soil accumulated. Gosford hanging Swamps have been tentatively attributed to one of four recognisable variations, although additional sampling elsewhere in Gosford will enable a better understanding of their relationships.

Some forms of hanging swamp show strong similarities to those occurring on sandstone at higher elevations, such as in the Blue Mountains region. Others appear to be more closely related to the surrounding Exposed Hawkesbury Woodlands. While these swamp systems are not currently listed as endangered ecological communities it is likely that they will be listed in the future given their limited distribution and their vulnerability to degradation.



HOT LINKS

Gosford Sandstone Hanging Swamps Community Profile
Gosford City Council Vegetation Community Mapping
Central Coast Vegetation mapping (community 17 pg 110)

Swamp values

Temperate Highland Peat Swamps on Sandstone and **Gosford Sandstone Hanging Swamps** provide a variety of important hydrological ecosystem services.

The highly organic swamp substrates can hold many times their dry weight in water. As a result they act like giant sponges in the landscape absorbing and holding large amounts of water, which are then gradually released back into the environment, maintaining base flows (dry time flows) to downstream watercourses over extended periods of time. By holding water in the landscape they also moderate peak storm-water flows protecting downstream watercourses from erosive flows.

The permeable highly organic swamp substrates also act as bio-filters. They filter water as it moves through the swamp, removing sediments and binding pollutants and significantly improving the water quality of swamp discharge water subsequently released downstream. By trapping sediments they also prevent sediment build up along watercourses and in downstream water supply dams such as the Farmers Creek Dam in Lithgow and Wingecarribee Reservoir in the Southern Highlands

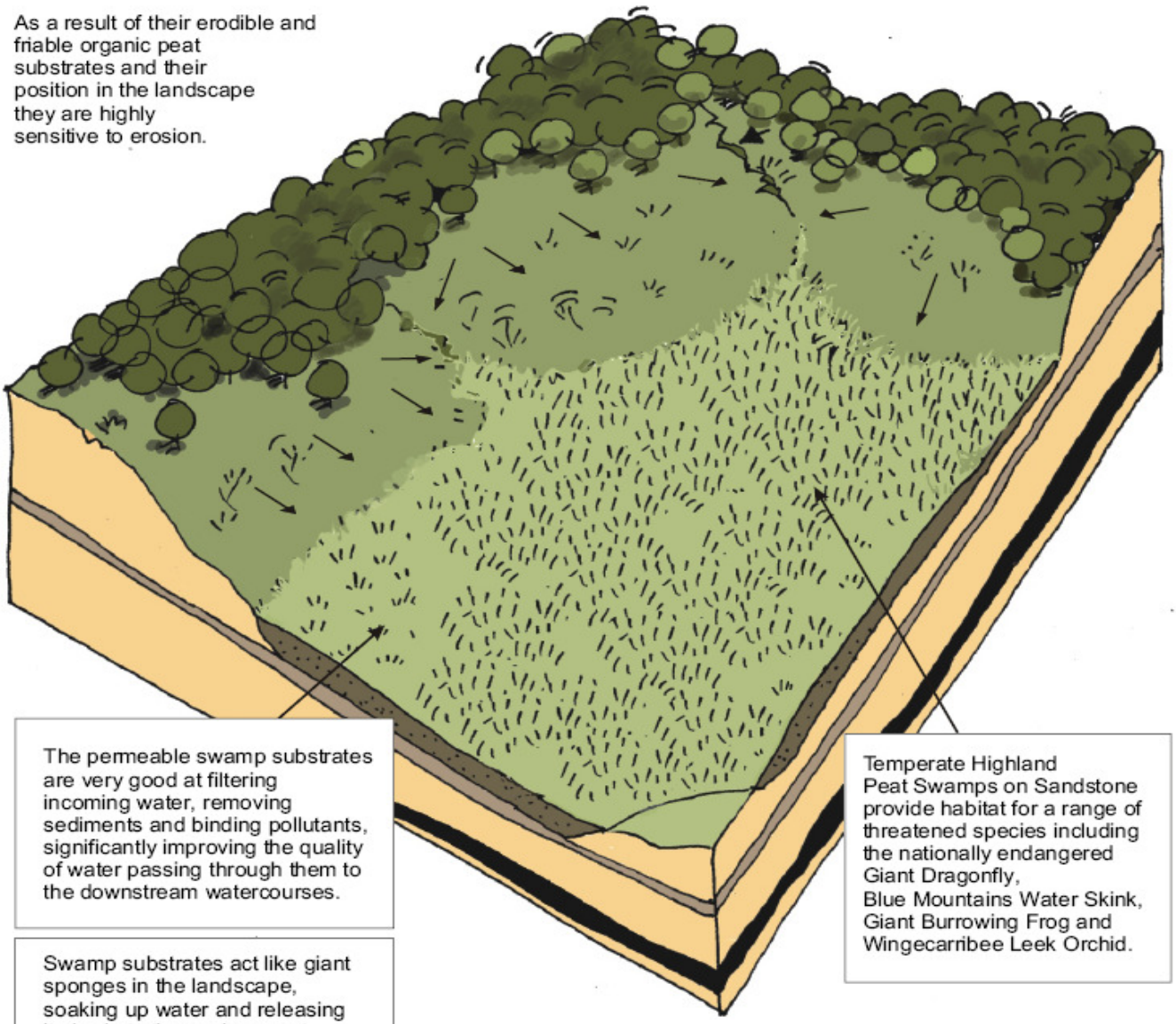
Temperate Highland Peat Swamps support a unique assemblage of flora and provide habitat for a range of threatened species including the nationally endangered Giant Dragonfly, Blue Mountains Water Skink, Giant Burrowing Frog and Wingecarribee Leek Orchid.

Endangered and RoTap Species which utilize swamp habitats:
(L to R) Gentian Orchid, Giant Dragonfly, Blue Mountains Water Skink, and Giant Burrowing frog and *Almaleea incurvata*
(Photos: J.Briggs, X.Sledge, S.Nally M.Chambers)

Peat Swamps

Temperate Highland Peat Swamps on Sandstone EECs occur in the Blue Mountains, Lithgow, Bombala and Wingecarribee Local Government areas.

As a result of their erodible and friable organic peat substrates and their position in the landscape they are highly sensitive to erosion.



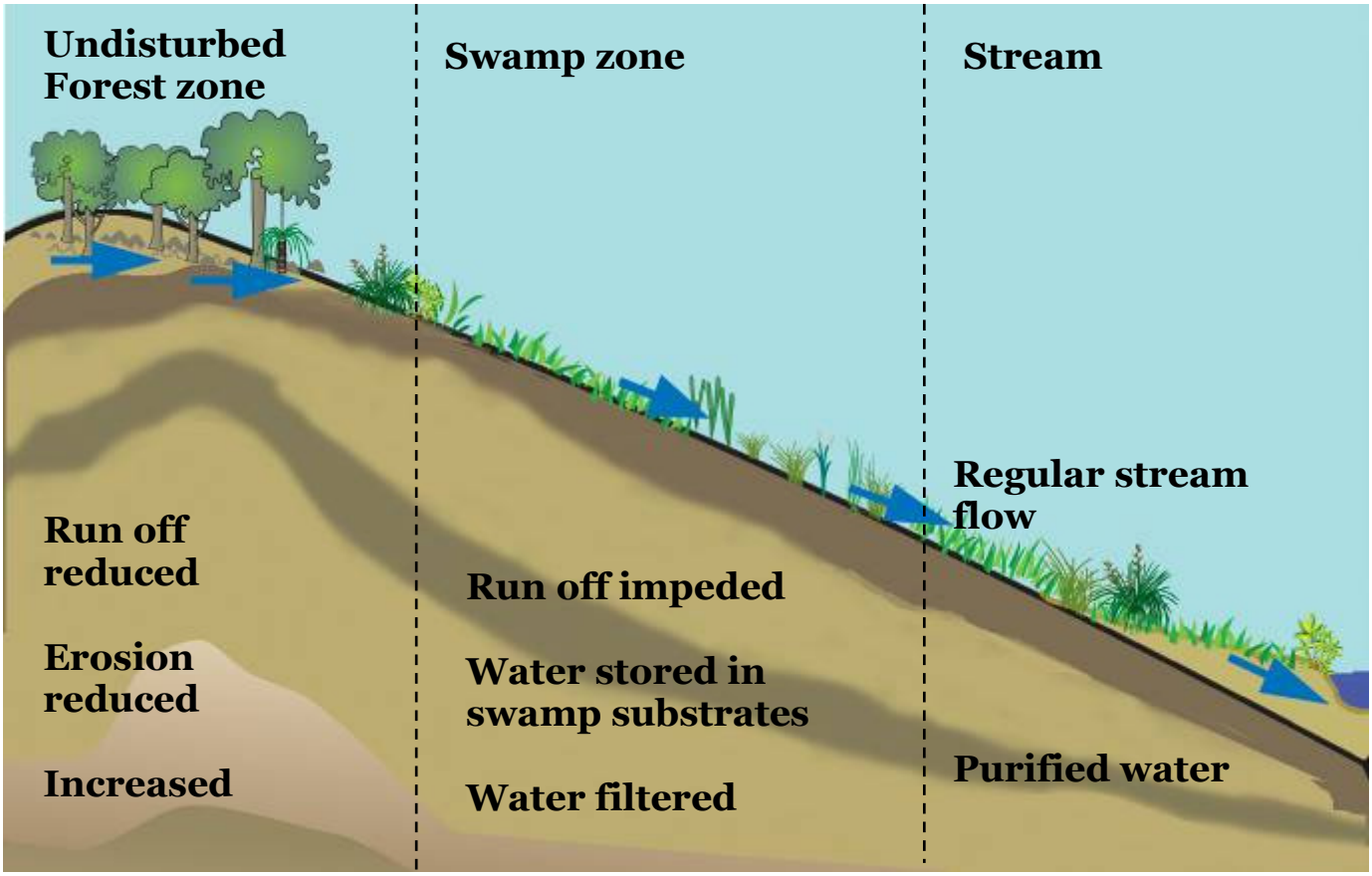
The permeable swamp substrates are very good at filtering incoming water, removing sediments and binding pollutants, significantly improving the quality of water passing through them to the downstream watercourses.

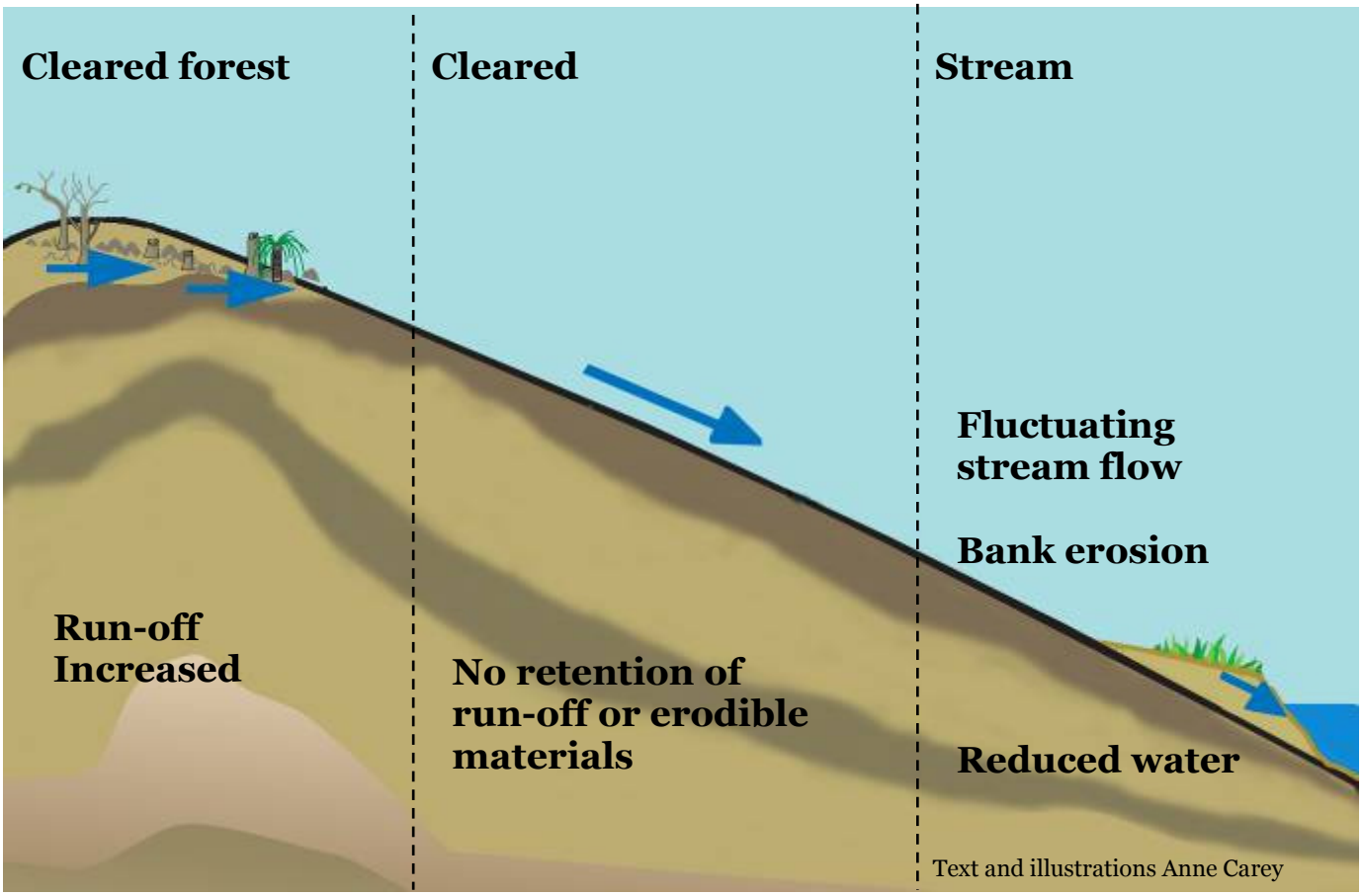
Swamp substrates act like giant sponges in the landscape, soaking up water and releasing it slowly to the environment maintaining the baseflows of creeks.

Temperate Highland Peat Swamps on Sandstone provide habitat for a range of threatened species including the nationally endangered Giant Dragonfly, Blue Mountains Water Skink, Giant Burrowing Frog and Wingecarribee Leek Orchid.

Photo: Lisa Hicks

Ecosystem services provided by swamps





Text and illustrations Anne Carey

Swamp Geomorphology

Both Temperate Highland Peat Swamps on Sandstone and Gosford Sandstone Hanging Swamps have a unique plant community of sedges, shrubs, herbs and ferns. These have been able to form in response to extremely localized conditions which are created by a unique combination of topographic, geological, hydrological and groundwater influences.

In the case of Temperate Highland Peat Swamps on sandstone, these systems are characterized by the deposition of peaty, highly organic substrates over the typical highly erodible and skeletal sandstone soils of the Blue Mountains, Newnes Plateau, Southern Highlands and West Gosford Plateaus

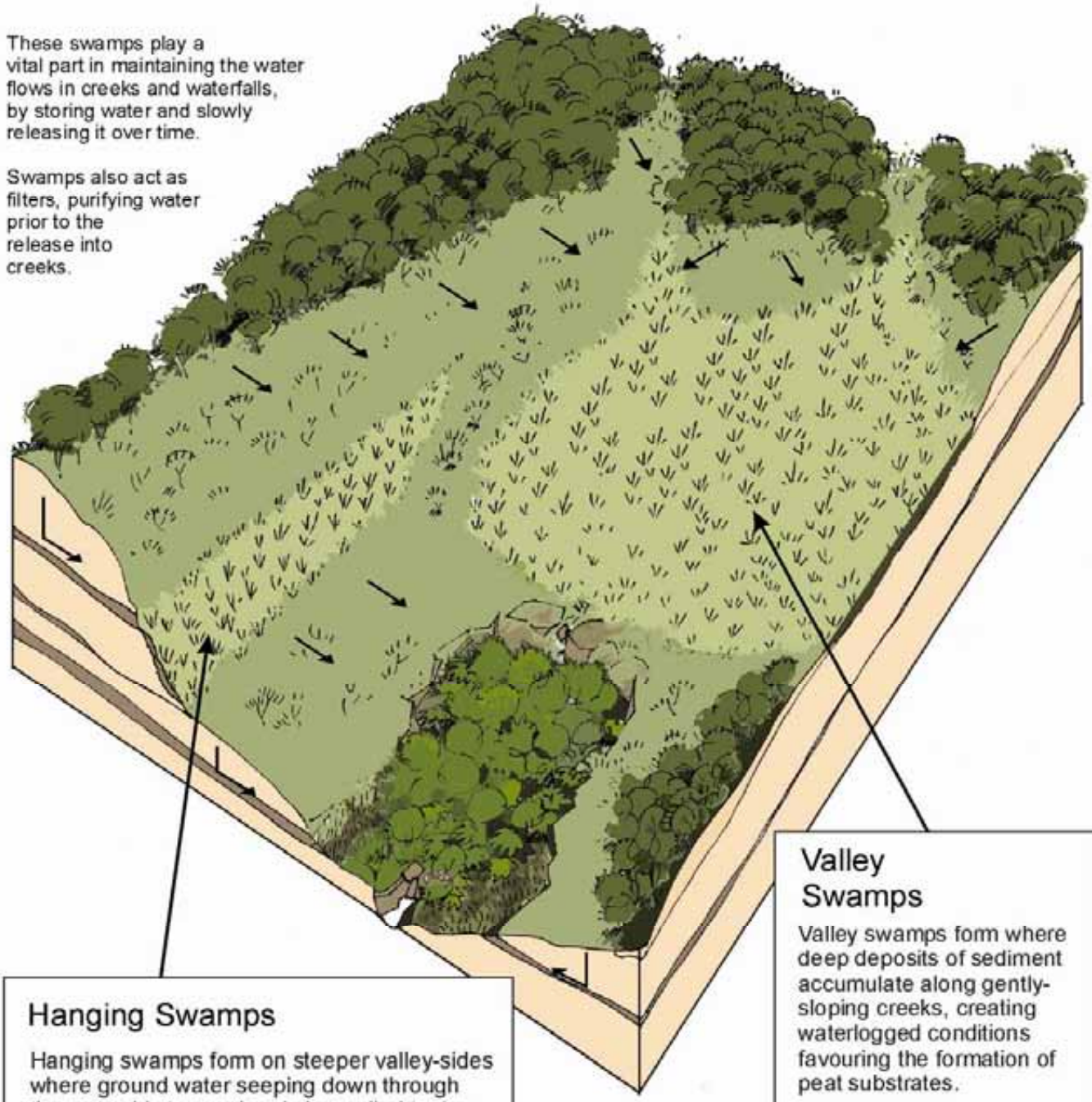
Temperate Highland Peat Swamps exist in two basic morphological forms. They occur as valley fill swamps in the poorly drained headwaters of gently sloping valleys near the top of sandstone plateaus as well as in natural depressions and along watercourses where drainage is impeded.

They can also occur as 'hanging swamps' on steep valley sides where they are fed by groundwater seepage lines associated with claystone, shale and ironstone outcroppings. Gosford Sandstone Hanging Swamps have a very similar geomorphology to this 'hanging swamp' type.

Groundwater dependent swamps

These swamps play a vital part in maintaining the water flows in creeks and waterfalls, by storing water and slowly releasing it over time.

Swamps also act as filters, purifying water prior to the release into creeks.



Valley Swamps

Valley swamps form where deep deposits of sediment accumulate along gently-sloping creeks, creating waterlogged conditions favouring the formation of peat substrates.

Examples are found throughout Newnes Plateau, Southern Highlands, Blue Mountains and Newnes Plateau..

Hanging Swamps

Hanging swamps form on steeper valley-sides where ground water seeping down through the ground is trapped and channelled to the surface by horizontal, water-blocking layers of claystone, ironstone and shale.

Hanging swamps develop below these seepage lines in the constantly wet and anaerobic conditions which promotes organic material build up.

Examples are found at Blue Mountains, Gosford (west) and to a limited extent Newnes Plateau.

HOT LINKS

Department of Land and Water Conservation Groundwater Dependant Ecosystems Policy 2002

Department of Environment Climate Change and Water NSW Wetland Policy 2010

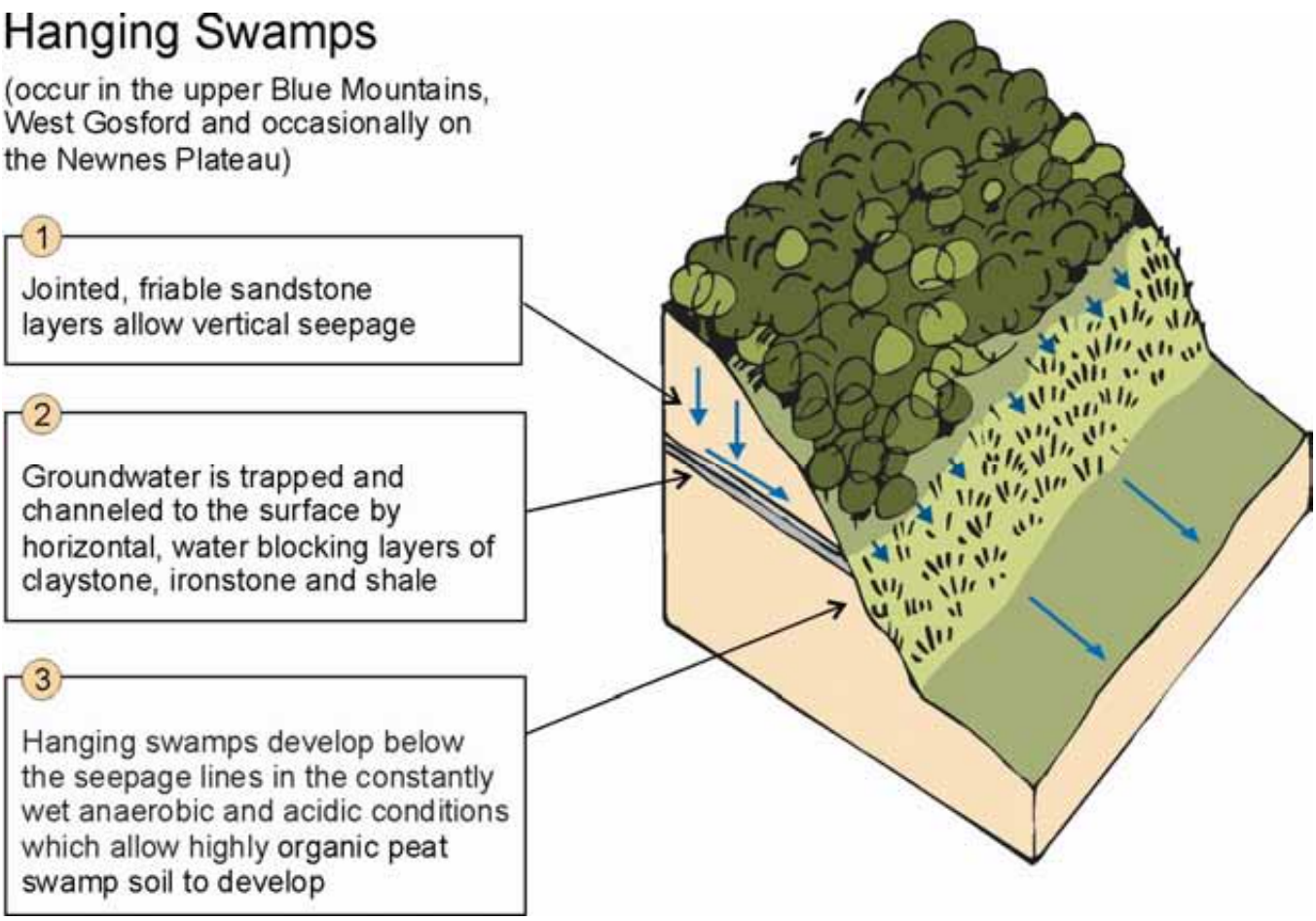
Swamp Geomorphology

Hanging swamps

Hanging swamps occur principally in the Upper Blue Mountains, the West Gosford Plateau and to a more limited extent on the Newnes Plateau.

They are a function of the unique geology of the Upper Blue Mountains and West Gosford plateaus where thick horizontal beds of highly permeable Narrabeen Sandstone are separated by narrow impermeable bands of claystone, shale and ironstone.

Groundwater percolating vertically through cracks in the overlying highly jointed and permeable sandstone layers is forced laterally where it meets an impermeable rock layer. Groundwater is pushed to the surface as groundwater springs or seepage lines when the impermeable layers outcrop on valley sides.

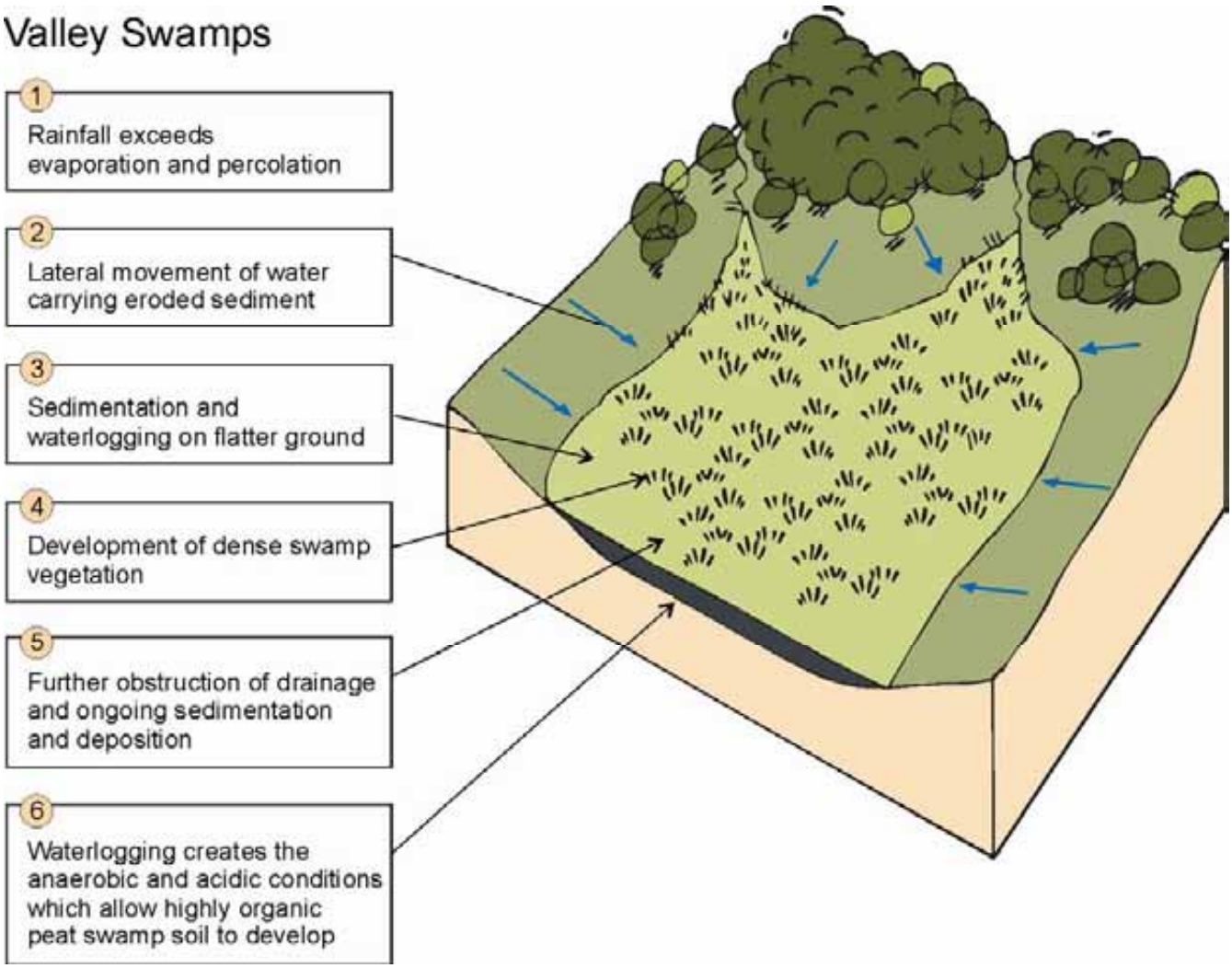


Swamp Geomorphology

Valley fill swamps

Valley-fill swamps develop in poorly drained headwaters, natural depressions and along watercourses of gently sloping valleys near the top of sandstone plateaus. This usually occurs where the significant sediment loads generated from the friable sandstone substrates of the plateaus are encouraged to deposit by the low gradient watercourses and their associated slow flows.

The deposition of sediment further impedes drainage leading to increasing water-logging and the development of dense swamp vegetation which encourages further sediment deposition, impeded drainage and the accumulation of organic matter until a true valley-fill swamp is formed.



Swamp substrates

Typically forming below seepage lines or in areas of impeded drainage the decomposition of vegetative material under constantly wet, acidic and anaerobic conditions occurs very differently and much more slowly in comparison to the surrounding landscape.

Organic material retains some of its structure even after hundreds, if not thousands, of years and builds into a rich organic substrate. Influxes of sediment after fire and the charcoal layers formed by fire events intersperse between layers of organic deposition as seen in the core below.

SOS and DECCW staff collecting and analysing core samples from groundwater dependant swamps. The above cores come from Long swamp in Lithgow Local Government Area, and images left and right are examples from Asgard Swamp in the Blue Mountains Local Government Area.

Threats and impacts of hydrological changes in swamps

The combination of erodible and friable organic peat substrates in combination with the position of swamps low down in the catchment landscape along drainage lines (or in the case of ‘hanging swamps’ on steep slopes) renders them susceptible to erosion.

This is particularly the case where swamps are subjected to highly concentrated storm-water flows from urbanised and modified catchments. Common erosion patterns that become apparent in these downstream swamps include channeling, tunneling, piping, slumping and sedimentation.

Channeling, creek-bank slumping and incision results in the dewatering of swamps with the subsequent lowering of groundwater levels within swamps and the drying out of swamp substrates.

The desiccation of swamp substrates results in both a reduction in the extent, quality and complexity of the protective swamp vegetation on the surface as well as causing the swamp substrates to become hydrophobic, less cohesive and more erodible.

These changes result in affected swamps becoming prone to further erosion. Desiccated swamp substrates are also vulnerable to burning in the event of a bushfire.

Aerial photograph showing severe swamp desiccation on the Newnes Plateau.

These patterns of erosion can result in the bypassing of the hydrological ecosystem services and functions that swamps perform, including:

- water retention within catchments
- maintenance of baseline water flows in downstream waterbodies and courses
- moderation of peak stormwater flows, and
- water quality improvements through the filtering and capture of nutrients, pollutants and sediment.

Channeling, tunneling, piping, and creekbank slumping can result in the net loss of swamp substrates that have taken hundreds, and in many cases thousands of years to accumulate, which can not be readily replaced.

Erosive processes also cause disturbances which provides invasive weeds with the opportunity to colonize swamp systems. Impervious surfaces such as roads, roofs and driveways may block traditional groundwater recharge points, reducing the supply to seeps and springs that feed swamps.

The delivery of concentrated stormwater to swamps often leads to the development of incised channels that drain water out of them, resulting in dehydration.

Carried by rain and stormwater, sediment may also be deposited in swamps—smothering flora, compromising fauna habitat and disrupting swamp hydrology.

Combined with the nutrient enrichment associated with stormwater, this can provide ideal conditions for weed invasion, further degrading swamp values.

Threats and impacts to ground water dependant swamp systems

The specific threats to Temperate Highland Peat Swamps on Sandstone vary between geographic regions, from swamp to swamp within regions, and with the proximity of swamps to urban, forestry or agricultural land.

Activities that have threatened swamps in the past include flooding, peat mining, and drainage and/or clearing associated with forestry and agriculture.

The main threats to swamps include:

- changed hydrology, weed invasion, erosion and sedimentation e.g. arising from roadworks, tracks, fire and recreational activities (swamps in all regions),
- clearing for, and impacts of, residential development and urban infrastructure,
- impacts arising from forestry and agriculture,
- introduced animals,
- Quarrying and mining.

Observations of impacts in peat communities in Tasmania, ACT, and NSW include the following :

- An increase in either fire frequency or fire intensity is likely to favour fire-tolerant rhizomatous sedges at the expense of *Sphagnum* moss, associated herbs and fire sensitive shrubs. Consequent impacts have included hummocks becoming crusted and hydrophobic, increased acidity, peat-beds drying out and collapsing, and erosion .
- Fire, grazing and logging can lead to increased sedimentation, particularly for peatlands in valley bottoms and topographic depressions. Increased sedimentation can affect substrate organic content and make *Sphagnum* re-establishment less likely.

Swamp systems are dependent on water and highly susceptible to changes in water flow, water table level and structural damage. Changes can affect the condition of the peat substrate, as well as the structure and floristic composition of the swamp vegetation. Changed hydrology may be caused by a wide range of activities within or below the swamps themselves, or in their catchment areas. They include water extraction from aquifers or surface water, damming of swamp water courses, road construction, drainage works, increased hard surfaces in urban areas, clearing and mining.

Water extraction (bores, tapping natural springs and building dams), clearing for residential development and urban infrastructure, mowing and grazing also pose threats to peat swamps.

Introduced animals including cattle, horses, rabbits, foxes, Feral pigs, cats and dogs can cause physical disturbance in peat swamps, grazing and trampling the peat and vegetation, and/or facilitate weed invasion by introducing weed seeds and disturbing the substrate

Swamps located in pine plantation areas may be adversely impacted by encroachment of pines, roads, silvicultural harvesting and burning practices and weed control activities. The impacts may include changed hydrological conditions, erosion, sedimentation and weed invasion.

Altered fire regimes (frequent or high-intensity fire) bushfires may sometimes consume the peaty substrate in localised areas of peat swamps and destroy part or all of the underlying peat that supports the swamp vegetation. Where the peat substrate is burnt, seed banks and subsoil rhizomes of living plants may also be destroyed. Exposure of burnt soils to heavy rainfall may result in significant erosion, and be exacerbated by physical soil disturbance from machinery and vehicles both during activities to manage bushfires such as construction of access tracks and fuel breaks, slashing, mowing and hazard reduction burning

Swamps may be predisposed to impacts associated with anthropogenic Climate change resulting from reduced rainfall and an increased frequency of extreme weather that is likely to increase the chance of summer drought, peat fires and severe erosion events.

Threats to Southern Highland swamps and wetland systems include:

Activities that have threatened peat swamps in the past include peat mining, flooding, and drainage and/or clearing associated with agriculture and forestry.

Small-scale *Peat Mining (historic)* occurred in the eastern part of Wingecarribee Swamp until 1998 following partial collapse of the swamp following heavy rain. As a result about 70% of the swamp sank by 3–4 m and became fragmented by a network of deep fissures reaching to the basal clays, resulting in large areas of exposed peat. Parts can result in serious threat to endangered plants and insects.

Parts of Long Swamp were also mined for peat and peaty sediments for about 10 years. In addition to possible swamp collapse and/or lowering of the swamp's water table, peat extraction can cause stream bank erosion and gullying upstream of the mined area as the streams adjust to the new water level.

Flooding Wildes Meadow Swamp and Wingecarribee Swamp have been partially submerged in water storage reservoirs. In the 1970s the Fitzroy Falls Reservoir partly inundated the southern section of Wildes Meadow Swamp while the western half of Wingecarribee Swamp was submerged by Wingecarribee Reservoir.

Agriculture A number of swamps have been drained for agriculture, mainly for pasture land and to allow cattle and sheep grazing in central and northern parts of the swamp.

Forestry Swamps may suffer adverse impacts from pine plantations such as *Pinus radiata* encroachment, loss of natural vegetation fringing (and hence buffering) the swamps, sedimentation, changed hydrology and adverse impacts from roads, silvicultural burning practices and weed control activities, and weed invasion.

Weed invasion (Pines, Blackberry and other weeds) from adjacent plantations, properties or farmland

Stock grazing Wingecarribee Swamp has been subject to periodic cattle grazing in the past as well as annual burns (usually in late spring) or several fires in a single year.

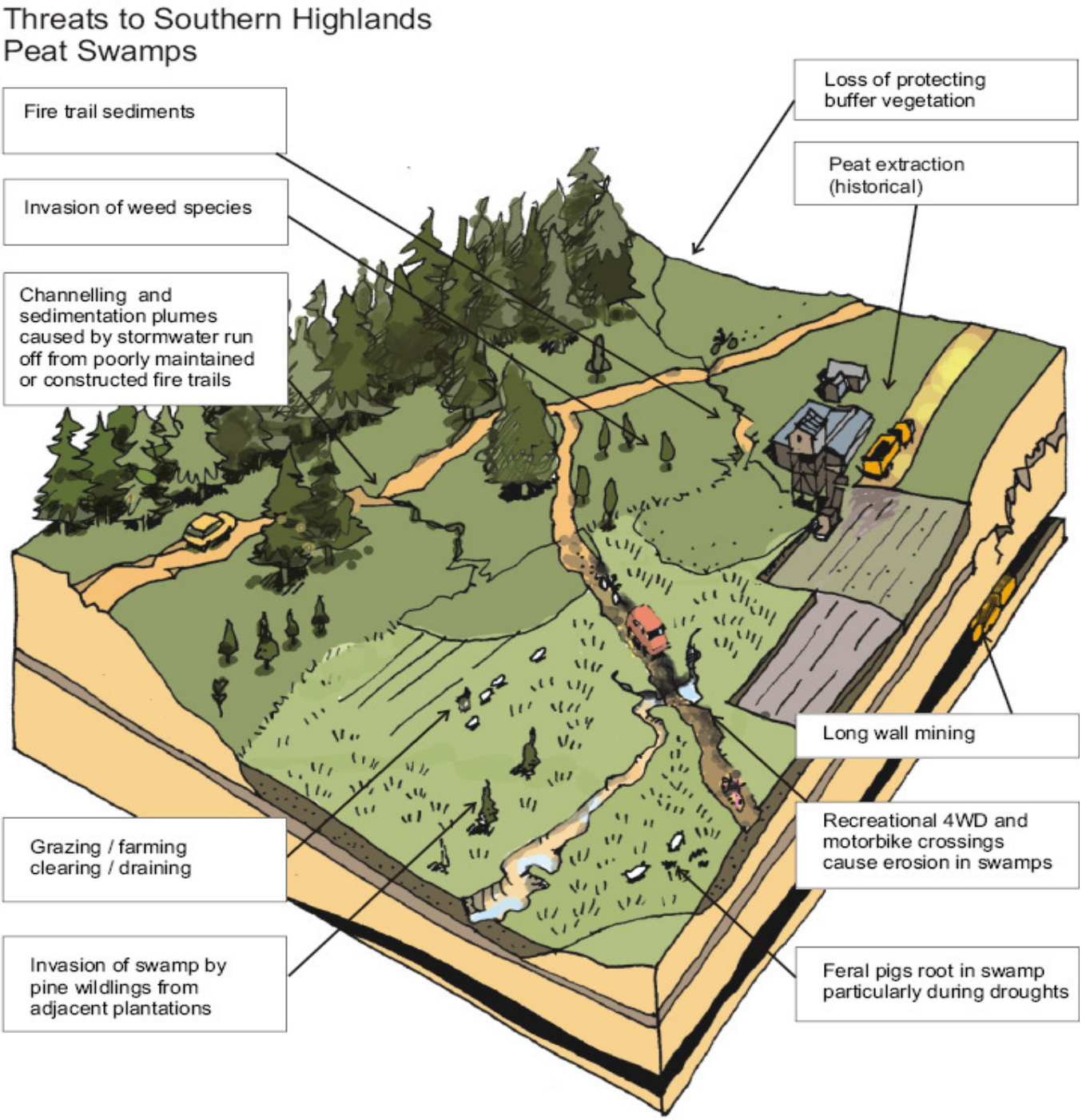
Pollution, cropping and improved pastures in the catchment

Other

Inappropriate management practices in and around swamps and wetlands such as slashing, mowing, land clearing, burning, recreation, draining and infilling

Nutrient discharge from sewage treatment works on Paddy's River in the southern section of a swamp

In 2001, 500 tonnes of sand slurry entered a swamp from an adjacent quarry. The operators were required to clean up the site and undertake a year-long flora study to assess swamp recovery.



Threats to Blue Mountains Swamps predominantly arise from the high urbanization of their catchments and close proximity to urban development including:

Storm-water induced erosion with channelisation, tunneling, , sediment deposition and nutrient enrichment.

Channelisation and tunneling lowers the water table and dehydrates swamp substrates making them hydrophobic and prone to further erosion and weed invasion.

Sediment deposition smothers vegetation, disrupts hydrology and encourages weed invasion.

Fire trails, utilities infrastructure and vehicle tracks and walking trails can generate erosive stormwater flows resulting in sediment washing into swamps

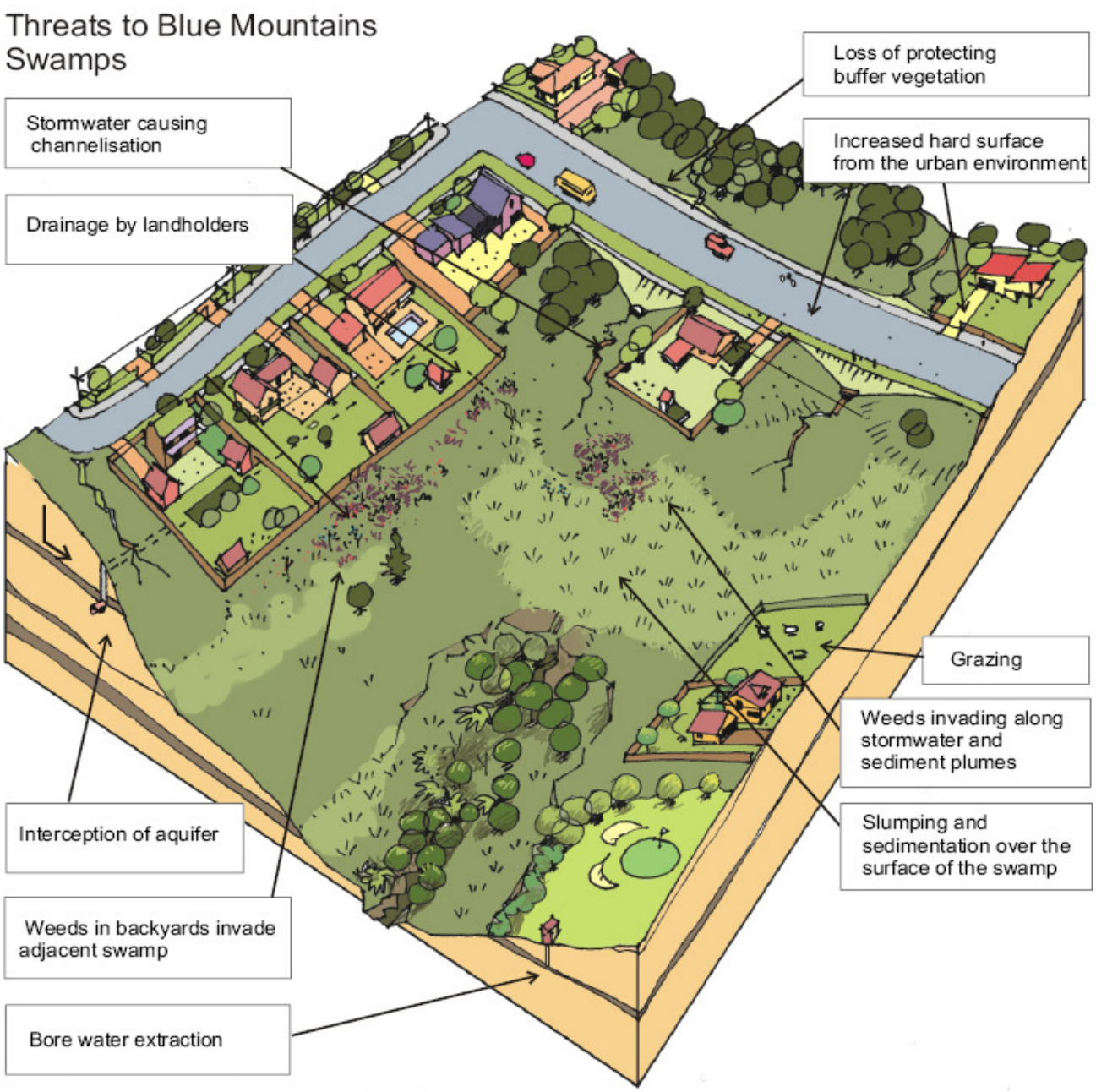
Groundwater extraction (e.g. bores, tapping or damming springs) diverting water that would normally maintain groundwater dependant ecosystems such as swamps. Extraction of water from springs fed by swamps has been proposed for the production of bottled spring water. Proposals to extract groundwater for domestic, industrial or rural use are likely to increase as demand exceeds supply from existing water storages. For more information see "Groundwater" (Blue Mountains Conservation Society brochure).

Outdoor recreational activities such as over-use of walking trails and unauthorised use of tracks and roads by off-road vehicles including trail bikes, result in the compaction of swamp soils, physical damage to vegetation and localised concentration of surface water flows that may result in erosion and sedimentation.

Physical disturbance of soil by walkers or hoofed animals may exacerbate erosion impacts on swamps arising from other causes.

Many peat swamps are located in, near to or downstream of urban areas. Increased impervious surfaces (such as roads) from urban areas, the delivery of their stormwater and changes they cause to swamp hydrology reduce the recharge to aquifers that support groundwater dependent swamps and reduce their sub-surface flows.

Increased overland flow of water can also result in nutrient enrichment and cause erosion, gullying and the formation of channels within swamps, delivering sediments and weed seeds/propagules into them. impervious sandstone layers can carry effluent from septic absorption trenches to swamps before the wastes are purified, with the resulting nutrient enrichment in the swamps encouraging weed invasion.



Landuse patterns adjacent to and upstream of swamps and expanding urbanization can adversely affect the hydrological integrity and ecological function of swamps. The impacts of erosion are likely to be amplified where swamps occur on steep terrain.

Weed invasion Woody and herbaceous weeds threaten peat swamps on sandstone, although not all swamps are threatened by all the species outlined below.

Woody weeds include *Salix cinerea* (Grey Willow, Pussy Willow), Himalayan Honey-suckle Leycestria formosa), Portuguese Heath (*Erica lusitanica*) *Rubus* spp (Blackberry) and *Ulex europaeus* (Gorse). can be an extremely agressive invasive species in peat swamps. Herbaceous weeds may also be a problem in some swamps. For example, pasture weeds such as grasses, daisies and Creeping Buttercup can be common in both intact and drying areas of swamp, especially in disturbed areas.

Threats to Newnes Plateau Shrub Swamps include:

Forestry Swamps may suffer adverse impacts from pine plantations such as *Pinus radiata* encroachment, loss of natural vegetation fringing (and hence buffering) the swamps, sedimentation, changed hydrology and adverse impacts from roads, silvicultural burning practices and weed control activities, and weed invasion.

Inappropriate management practices in and around swamps and wetlands such as slashing, mowing, land clearing, burning, recreation, draining and infilling

Fire trails, utilities infrastructure and vehicle track overuse by recreational 4WDs and trailbikes. This can result in track proliferation, track degradation, erosion, sedimentation and channelization in swamps. Erosion and channelisation can also affect downstream from swamps and within adjacent swamps.

Mining- On the Newnes Plateau, some peat swamps lie above extractable coal seams that are being mined or are proposed for mining. Longwall mining activities used to extract the coal can cause the land surface to subside and the bedrock to fracture, which can affect the hydrology of the swamps and/or their catchments and facilitate severe and rapid erosion.

Rural residential development and land subdivision adjacent to swamps

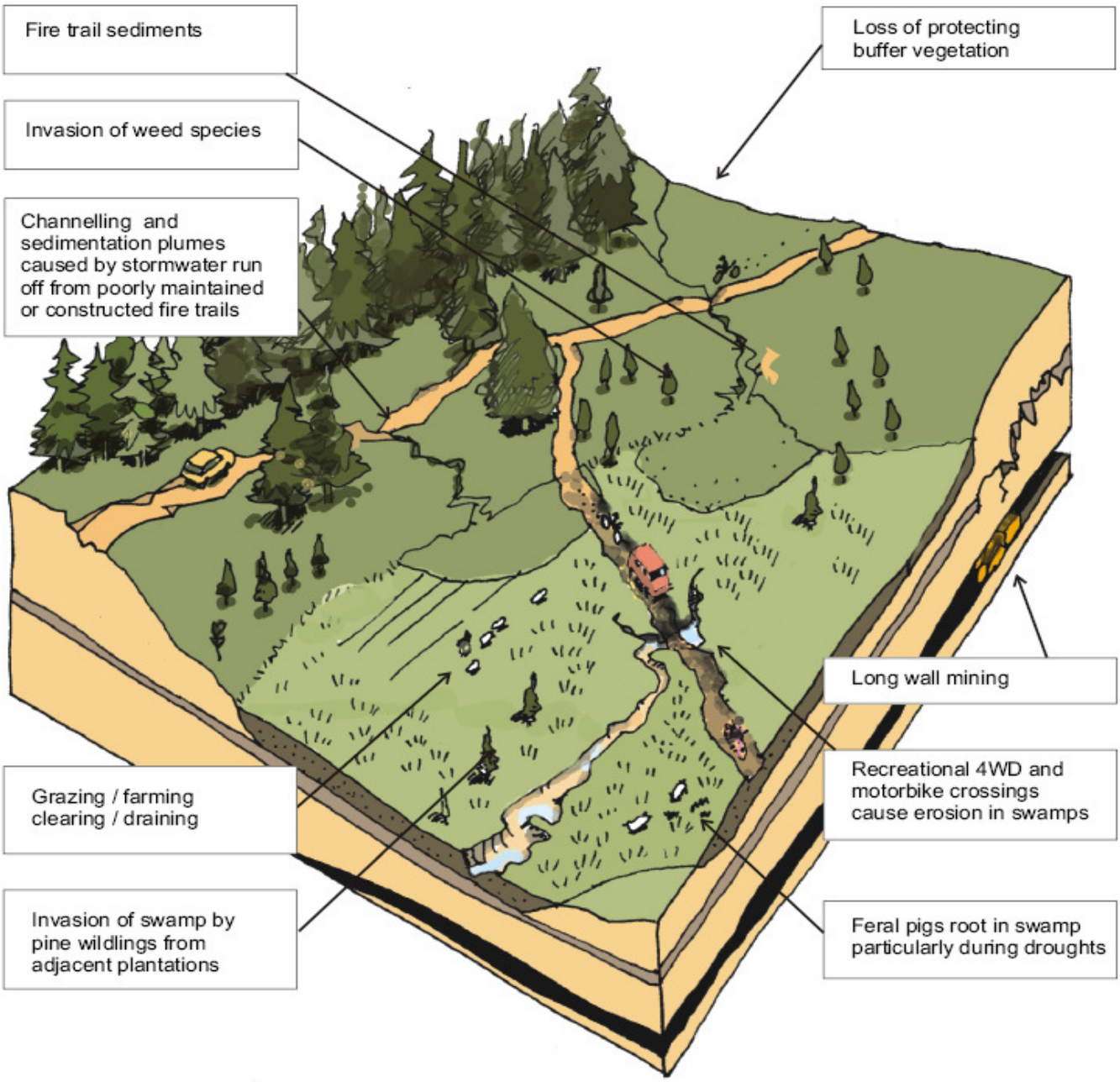
Weed invasion (Pines, Blackberry and other weeds) from adjacent plantations, properties or farmland

Groundwater extraction (e.g. bores, tapping or damming springs) diverting water that may normally maintain groundwater dependant ecosystems

A groundwater bore comprises a hole drilled into the ground to a depth exceeding the water table (the uppermost level of strata that is saturated by groundwater). Water-bearing strata beneath this level (such as rock or sand) is termed an aquifer.

The depth of the water table and aquifers varies considerably from place to place in response to geological and climatic conditions, and can also vary seasonally. A pump system is required to extract groundwater from the aquifer. aquifer extraction and recharge must be balanced on an annual basis. This will ensure that long-term ground water levels and water balance are maintained.

Threats to Newnes Plateau Shrub Swamps



Threats to Gosford Sandstone Hanging Swamps include:

- The expansion of current *development* patterns, such that habitat for specific threatened species is likely to be compromised;
- *Commercial water extraction* of water from springs fed by swamps (e.g. bores, tapping or damming springs). Proposals to utilise swamps to extract groundwater for domestic, industrial or rural use are likely to increase as demand exceeds supply from existing water storages
- *Industrial development* and pressure from land-clearing for agricultural enterprises
- *Extractive industries,* some peat swamps lie above extractable seams that are being mined or are proposed for mining. Longwall mining activities used to extract coal can cause subsidence and bedrock to fracture, which can affect swamp hydrology and/or their catchments and facilitate severe and rapid erosion.

- The invasion of aggressive *weed species* into habitat for threatened plants, or significant communities;
- Inappropriate *Fire* regimes applied to a habitat, such as high frequency fires which exhaust the seed bank of a fire sensitive species, or which dramatically simplify the floristic composition of a community;
- *Grazing/ Mowing* Threats posed to a vegetation community that may dramatically simplify its floristic composition by repeated disturbance;
- The *illegal collection* of plant material by horticultural enthusiasts, normally associated with (but not restricted to) threatened orchid species
- Threats posed by *forestry* operations including loss of habitat through logging, trail construction etc;
- The incursion of *pollutants* into water bodies, normally associated with wetland vegetation types also threatens swamps in this area.



- *Fragmentation* threats posed by the fragmentation of habitat of threatened species or communities, such that disturbance effects associated with edges and small remnants are amplified;
- *Low populations* threats posed by the inherent problems associated with low population numbers, such that single catastrophic impacts may cause local or regional extinction of a species.
- *Rubbish dumping* threats posed by the illegal dumping of rubbish, which may cause the local extinction of plant species, or introduce weed species which will alter the integrity of a community;

Threats to Gosford Sandstone Hanging Swamps