Biodiversity salvage

...is the collection, preservation and documentation of species, populations and genetic resources that are likely to vanish in the near future

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QVMAG webpage: http://www.qvmag.tas.gov.au/?articleID=570
Publications: http://www.qvmag.tas.gov.au/?articleID=571

Websites:
Millipedes of Australia: http://www.polydesmida.info/millipedesofaustralia/
Tasmanian Multipedes: http://www.polydesmida.info/tasmanianmultipedes
Spatial data basics for Tasmania: http://www.utas.edu.au/spatial/locations/index.html

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[PDF version of blog at http://biodiversitysalvage.blogspot.com/]

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(1) Introducing salvage

There's a biodiversity crisis. Species are disappearing all over the Earth, and for a lot of different reasons: habitat loss, climate change, competition with invasive species, etc. No amount of protesting or political lobbying is going to stop this loss. What to do?

Most people would answer, "Save what we can." I agree, and I support all the biologists and others who are working to create more nature reserves, get better off-reserve conservation, reduce pollution, fight introduced species, etc etc.

But what about the losers? What about the species, communities and genetic variations that we're losing now, and will be losing in coming years?

An appropriate and responsible strategy is to salvage what we can as specimens for museums and herbaria, and as genetic material in genebanks. Biodiversity salvage of this kind has a couple of things going for it that some other conservation strategies don't. In the first place, all the necessary methods are already well-known and well-used, and the necessary infrastructure (museums, herbaria, genebanks) already exists.
Second, although salvagers might disagree on what needs salvaging first (which microbes, plants or animals), there's not much doubt about where to start salvaging. The places where biodiversity is vanishing fastest are obvious on a global scale on satellite images. On a local scale, prioritising salvage spots is very simple: go first to those habitats which are about to be destroyed, which are furthest from protected areas and which are furthest from previous biological sampling.

The aim of biodiversity salvage is not to create Noah's Arks. That's what reserves do, and zoos and botanical gardens. Biodiversity salvage is more like the archaeological surveys that are done in old cities before a new road or building is constructed. The aim is not to stop the development, but simply to recover some of the historical heritage before it’s destroyed. The aim of biodiversity salvage is not to stop the new farm, housing estate, industrial site or ocean outfall, but simply to recover some of Earth's natural heritage before it disappears.

It worries me that something this obvious has to be proposed as something new. I've struggled, though, to find earlier calls for salvage. The clearest one I know of comes from the Australian zoologist W. Baldwin Spencer, writing more than 80 years ago:

> *...the land and fresh-water fauna is disappearing rapidly, and unless we now make an organized effort it will be too late to study it effectually, and future generations will wonder what manner of people we were not to leave behind us some adequate record of the marvellously interesting forms of animal life which we had succeeded in exterminating...*(p. 121)

> Spencer, W.B. 1921. The necessity for an immediate and co-ordinated investigation into the land and fresh-water fauna of Australia and Tasmania. *The Victorian Naturalist* 37(10): 120-122.

I'd be interested to hear from readers who know of others who've argued for salvage. The most recent article I know of is my own, also on zoological salvage:

> Mesibov, R. 2004. Spare a thought for the losers. *Australian Zoologist* 32(4): 505-507.

I can email a PDF copy on request.

(2) Goals of sampling

People sample biodiversity broadly (many different taxa) in all sorts of places for all sorts of reasons.

Most of the All Taxon Biodiversity Inventory (ATBI) projects I know about are in parks and wilderness areas. The aim is to discover the richness of life in such places, which many people see as the future of Nature.

Outside reserves, Nature isn't thought to have much of a chance, what with the gradual worldwide intensification of agriculture, industrial use and residential development. The world outside reserves is believed to be species-poor. The species that live in intensively settled places are thought to be a small, particularly resilient subsample of the world's biota. City A will have much the same species list as nearby City B, and the list will include many cosmopolitan species.

Boring! By contrast, an ATBI in a national park will turn up large numbers of species new to science. Exciting! It's like reading the passenger list for Noah's Ark. These species will be saved (we hope). An ATBI shows us what the world was like before we ruined it: a rich stew of biodiversity.

A completely different attitude guides a BioBlitz. Here the aim is to record as many species as possible in 24 hours, and the target areas, for practical reasons, are in cities, towns or near-urban wastelands. Local residents help with the sampling, and get an appreciation of how much life there can be in a weedy lot.

BioBlitzes typically yield unexpectedly long species lists. Some of the records are for genuine relicts, species persisting in tiny, isolated remnants of their former ranges. Other records are for vagrants which seem to be using the remnants as an archipelago of habitat islands. One island isn't enough for survival, but a group of islands can mean persistence.

A third reason for broadly sampling biodiversity (and I'm nowhere near the end of the list of possible reasons, but I'll stop shortly) is to compare two or more areas in order to test a hypothesis.

The areas might be experiment vs. control, burned vs. unburned, logged vs. unlogged, etc. The sampling might also be in a series of target areas of increasing size, in yet another valiant attempt by ecologists to draw a definitive species-area curve.

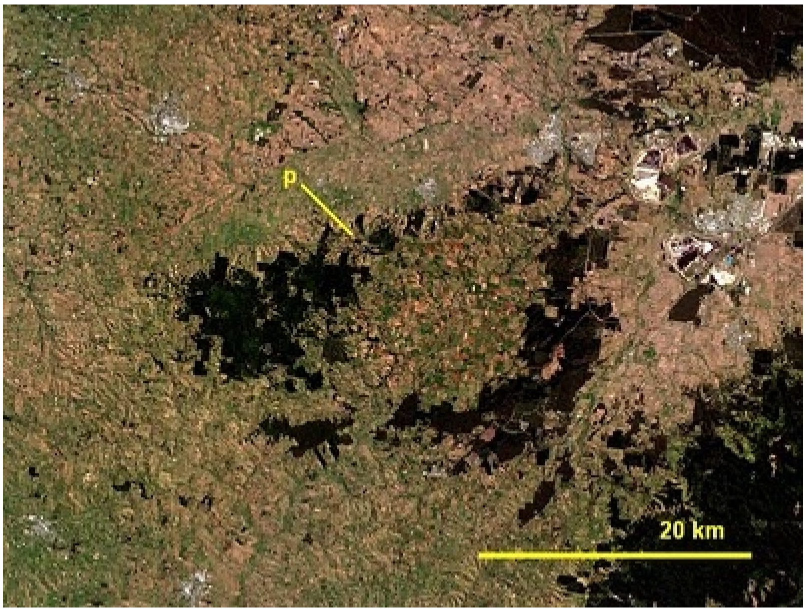
Comparison sampling differs from ATBIs and BioBlitzes in that the collections typically aren't thoroughly sorted to species level, and the specimens often don't wind up properly curated in museums and herbaria. Too often they sit neglected on the premises of the university or company that carried out the sampling. After a few years, when no one can remember what the codes mean on the sample labels, the specimens get thrown out during a grand day of tidying.

Salvage sampling is different from the above. It's done in a place which is on the To Be Destroyed list, or on the list of places which are Largely Destroyed And Someone Is Coming Next Week To Finish The Job. It might be a remnant of native grassland on a pastoral property which has just been bought by a cropping company or by plantation foresters. It might be an unappealing patch of scrub on the edge of town, now for sale in a booming real estate market. It might be the last forested ridge in a subtropical landscape under pressure from slash-and-burn cash-croppers.

The aim of salvage sampling is to get into museums, herbaria and genebanks whatever is about to be lost. And there *will* be loss. Biodiversity varies at all spatial scales. No two places have the same biota, and for many groups of organisms, every place has genetically unique forms. In landscapes largely converted from their pre-human condition, the chances are good that salvage sites will have species found nowhere else.

Finding and documenting these before they disappear is the job of biodiversity salvage.

(3) Bye bye biogeography



2000 Landsat image of part of west Gippsland, Victoria, Australia. Almost the whole of the area shown was covered in native forest 150 years ago. Now it’s farms (light green and brown), a coal mine (gray on right), and forestry plantations (most of the dark green) established on former pasture. “p” marks the patch with the overlap zone of two native millipede species found only in native vegetation.

Species disappear one locality at a time, erasing piecemeal what used to be the geographic range of the species.

The range is the fundamental unit of species-level biogeography. Knowing where it is can tell you a lot about the habitat preferences of the species, about how the species interacts with other species, and often something about the species’ history as well.

As ranges are erased, so is biogeography. Forty years ago the German zoogeographer Gustaf de Lattin (1913-1968) called for an international effort to document ranges before they vanished:

> *Nature conservation measures, as useful and as necessary as they are for other reasons, do not help here. They can only preserve the threatened habitats and their species point-fashion in small reserves. The original form of the basic element of zoogeography, the natural range, would nevertheless be made unrecognisable...* (p. 447; my translation)
>
> de Lattin, G. 1967. *Grundriss der Zoogeographie*. Stuttgart: Gustav Fischer.

Range-erasing has often frustrated my own, specialist work on millipedes. A group of closely related millipede species is typically distributed mosaic-fashion on the map, with each species occupying its own mosaic “tile”. In relatively undisturbed landscapes, mosaics are complete and can be mapped on a fine scale.

The "tile" boundaries, where two species ranges overlap, can be as narrow as 50 m, but are more usually wider, up to perhaps 5 km. (See my *Tasmanian Multipedes* website for examples of mosaics in the millipede genera *Atrophotergum*, *Dasystigma* and *Gasterogramma*; start at the Checklist page.)

With one millipede genus in the Australian state of Victoria, I struck it lucky. On a farm I sampled a small habitat remnant which preserved the overlap zone between two species otherwise found only in a few other scattered, nearby remnants (see image above). There used to be a mosaic, but it's been almost entirely erased, and one of the two species is now on the verge of extinction.

> Mesibov, R. 2007. The Trafalgar millipede *Lissodesmus johnsi* Mesibov, 2006 (Diplopoda: Polydesmida: Dalodesmidae). *Victorian Naturalist* 124(4): 197-203.

(4a) Salvage near home (overview)

Most people, obviously, live in settled areas, like cities, towns and farming districts.

You might expect that settled areas are the places with the best records for biodiversity sampling: most sites visited, most species recorded. Settled areas are also the places where natural habitats have been most fragmented. But if the fauna and flora of the settled area has already been well sampled, surely there won't be much point in salvaging the local remnants? Surely there won't be many new species to be found, or significant range extensions for known species?

Your expectation may be wrong. Biologists and naturalists like to do their sampling in places where Nature is still going strong. They also prefer to do their collecting and recording on public land, of which there's often a shortage in well-settled areas. These factors mean that the best-sampled places may be parks and reserves well away from urban and farming areas.

I tested this idea in an unpublished study reported anecdotally in my 2004 paper on salvage (see post 1, above). I found that in my home st="on"island of Tasmania, the best-recorded places for invertebrates were in wilderness.

I also looked at forest remnants in settled areas, to see how close they were to invertebrate collecting sites. The analysis was re-done for this blog with slightly different datasets and is detailed in the next post. The most remarkable finding was that six of the 10 remnants furthest from a recorded locality for terrestrial invertebrates were within 25 km of the centre of st="on"Hobart, Tasmania's largest city. All six of these remnants are in private land.

As I said in the 2004 paper, in Tasmania *... the places where the bush is most fragmented and most at risk of further loss and degradation are the places whose invertebrate fauna is least known.* (p. 506)

I'd be interested to see a similar analysis done in other parts of the world.

(4b) Salvage near home (details)

Datasets:

REMVEG (polygon). Remnant forest vegetation of st="on"Tasmania, 1 December 1996 - 31 January 1997. Based on 1:25 000 scale forest mapping; boundary positions typically accurate within 25 m. Remnants are polygons 20-200 hectares in area, totally surrounded by cleared land and separated from larger forest patches by at least 100 m. Some additional patches were added based on advice from experts. Source: Forestry Tasmania.

Terrestrial localities (point). Centres of 1 km squares containing locality records for butterflies; carabid, chrysomelid and lucanid beetles; earthworms; geometrid moths; land snails; talitrid amphipod landhoppers; millipedes; and velvet worms. (See below.)

Aquatic localities (point). Centres of 1 km squares containing locality records for caddisflies, dragonflies, parastacid malacostracans and stoneflies. (See below.)

Background:

REMVEG was produced for the 1996 Comprehensive Regional Assessment (CRA) of st="on"Tasmania, a project providing background for the 1997 Regional Forest Agreement (RFA) between the Commonwealth and State governments. Under the RFA, large native forest areas were set aside as reserves and others were earmarked for intensive silvicultural management.

The locality records come from another 1996 RFA project, *Invertebrate Bioregions in* st="on"Tasmania, which was my own work. A detailed project report can still be found online by Googling, although the Commonwealth government now stores all RFA reports in a digital archive. The project database contained 13929 well-located records for 792 native, non-marine Tasmanian invertebrates, mainly from the period 1970-1994. All records were generalised to 1 km grid squares, a spatial "blurring" which reduced the database to 10871 1 km square occurrences.

Analysis in ArcView 3.2 GIS (Environmental Systems Research Institute):

The three datasets were clipped to the main island of Tasmania (excluding Bruny, Maria and Schouten Islands, and all Bass Strait islands). The result was 630 remnants, 2856 terrestrial localities (with up to 115 species per 1 km square) and 1560 aquatic localities (up to 45 species per 1 km square).

The closest terrestrial and aquatic localities to each remnant were found using the Closest Feature function in the AlaskaPak Toolkit for ArcView 3.x (US National Park Service). This function also calculates the separating distance, in this case from the nearest point on the remnant polygon boundary to the centre of the 1 km square locality.

I identified the 10 remnants furthest from a terrestrial or aquatic locality. The 10 furthest-from-terrestrial remnants averaged 9.2 km separation (range 8.7 - 10.1 km), while the 10 furthest-from-aquatic remnants averaged 14.0 km separation (13.2 - 15.6 km).

(5) Some obstacles

Salvage doesn't happen for a variety of reasons. Many field biologists just don't like the idea, or can't see how it fits in with their research. (See http://www.ibcc2007.org/salvage.htm, where I list arguments compiled for an invertebrate biodiversity and conservation conference in December 2007.)

Others are worried that to do salvage is to admit defeat in the battle to Save the Planet. Worse, it might send a message to the destroyers of natural habitats that it's OK, you can wipe the habitats, just stop for a moment so we can salvage specimens, then you can go ahead.

I've recently hit yet another obstacle in my own salvage work: a government bureaucracy. The story is Tasmanian but will probably sound familiar to readers everywhere.

A farmer wanted to raise the level of a dam wall on a stream on his property. More of the land behind the dam would be flooded, and the free-flowing part of the stream would be pushed further upstream.

The farmer applied to the appropriate government agency for approval. The agency consulted the nature conservation bureaucracy, which decided that no species or habitats would be threatened by expanding the dam.

The agency also advertised for public comment. I wrote to propose salvaging terrestrial invertebrates from the area to be flooded. The dam site met all my criteria for priority salvage: it wasn't close to a reserve, it was in an area whose fauna was poorly known and sparsely sampled, and the flooding would happen in the near future. I emphasised in my proposal that the salvage sampling would not interfere with the flooding or stop it happening. I offered to pay sampling costs myself, including sorting and curating of specimens at the museum with which I'm affiliated.

Months of disappointing correspondence followed. In the end, the agency refused to recommend salvage and refused to allow its reasons to be made public.

It’s been suggested to me that the agency was thinking “If we recommend salvage we’re admitting that we’ve approved habitat destruction. We can’t admit that.”

The saddest part of this story is that if I’d ignored the agency and gone straight to the farmer, the specimens would now be in a museum. As I said in my 2004 paper, I’ve been knocking on farmers’ doors for 30 years and never been refused access to private property for bug collecting.

Which is another way of saying that governments may be a bigger obstacle to salvage than landowners.

(6) Salvage and ethics

A comment on the TAXACOM discussion list says there's money in biodiversity salvage.

The story is that commercial plant collectors are taking orchids and cacti from land *slated to be 'developed'*. Profits from the sale of the plants are shared with the landowner, who then uses the money to clear the land.

The TAXACOM contributor can't vouch for this story, but if the salvage cart is leading the development horse in this way, anywhere, then there's an ethical complication in promoting biodiversity salvage.

Another ethical concern arises when a biologist knows that specimens or populations to be salvaged are the last of their kind. Most people would hesitate to collect, to avoid having 'blood on their hands' and feeling guilty because they were the reason for a species or variety becoming extinct. They would feel even worse if the development threatening those last survivors never happened - called off at the last minute, the land to be made a reserve instead.

But how likely is this scenario? Imagine a case in which there is enough information about a particular species for biologists to say for certain that the last survivors are threatened by development. Isn't that a solid justification for translocation and off-site conservation?

The reality of species loss is that we’re largely ignorant of the details. We don’t know when, where and how most species are becoming extinct. In coming years we might be able to witness the last days of the last polar bear, but for every iconic mammal or bird there are thousands of invertebrates, plants and fungi which will vanish unrecorded and unknown.

Unless we salvage. As I replied to the orchid/cacti post on TAXACOM:

> *I wouldn't be surprised if there are cases of salvage where none is needed. I'd like to say those are exceptional cases in the context of the vast, worldwide salvage effort. I can't because that effort doesn't exist. That's the problem.*

Update 1: a practical example

Finding where to salvage can be hard. Most biologists have only a limited time available to work in the field, and the number of potentially salvageable sites can be large and widely dispersed.

In the following example, I used a GIS-based protocol to simplify the choice of salvage sites. The principles involved should be applicable to many other salvage projects. For more details and survey results, see

Mesibov, R. 2008. Millipede salvage in southwest Victoria. *Victorian Naturalist* 125(4): 96-103.

1. My salvage target was farmland in southwest Victoria, Australia. The area was largely forest and woodland before European settlement in the mid-19th century, and is now almost all dairy and sheep pasture. The working boundaries of the area were the Eumeralla River and its headwater swamps (W), Hamilton Highway (N), Hopkins River (E) and Princes Highway (S). I created a GIS polygon ('the box') with these boundaries using Victorian Government spatial data. Total area = 2830 sq km.

[For an overview, go to Google Earth (or Google Maps satellite view) and enter 'Hawkesdale, Victoria, Australia', which is more or less at the area's centre. For a ground-level impression, do a 360° Street View on any of the area's roads.]

2. I wanted to salvage woody vegetation remnants in which my target species (millipedes and other litter invertebrates) might still be living. The Australian Government's National Carbon Accounting Scheme (NCAS) produces 'forest' GIS layers as grid data sets, where 'forest' is generously defined as vegetation at least 2 m tall and with 20% or greater projected cover. The 'forest' presence/absence layer I used was based on 2005 Landsat imagery. I converted the NCAS layer from grid to polygon, clipped it to 'the box' and deleted polygons smaller than the 25x25 m grid resolution. 'Forest' area = 105 sq km.

3. The Victorian State government has digitised its oldest aerial photographs and made them publicly available on CD-ROM. I georegistered the 1950-vintage photos covering 'the box' by using junctions and bends in the local road network as landmarks. I then drew polygons around all patches of forest, woodland and scrub >1 ha in the photos, but excluding planted windbreaks. Remnant area in 1950 = 62 sq km.

4. The next step was to create the spatial intersection of the 1950 remnants and 2005 'forest' layers. In other words, I used a GIS tool to define patches which were woody vegetation in both 1950 and 2005. I called this layer 'persistents'. It included native vegetation remnants which had persisted in place for the last half-century, as well as plantations and shelterbelts which had been planted during this period after the original vegetation had been cleared. 'Persistents' = 26 sq km.

5. The final step was to use recent aerial photos and Google Earth to exclude plantations, shelterbelts and some large gardens (!) from 'persistents'. The pruned 'persistents' = ca 15 sq km.

Now I could begin planning field work. The 1500 ha of target patches were marked on a road map for access planning, and with the help of the local government I contacted all patch landowners in advance for permission to do salvage sampling. (All owners granted me free access.)

The GIS-based protocol had saved me a lot of time, but as I might have suspected from its results, salvage across this farmland area proved to be 'just in time' for some species and far too late for others. Only two blocks of land in the 283,000 ha area still had reasonably diverse faunas. One was ca 1000 ha owned by an Aboriginal corporation (a former Aboriginal reserve), the other was an isolated, 35 ha flora reserve (a former town recreation reserve). The remaining ca 99.5% of the target area either had no habitat for native litter invertebrates or had been taken over by introduced species, to the exclusion of natives.

Update 2: History matters

The remnant looked pretty good: the area was substantial (5 ha+), the vegetation was almost entirely native and the trees were large and healthy. Yet when I started looking for litter fauna, I noticed something odd. There were plenty of mobile native species, i.e. the kind with winged life stages, like ants, termites, cockroaches, flies and winged beetles. However, less mobile groups like land snails and millipedes were either represented by exotic species only, or by exotics and a very limited number of natives.

The first time this happened, I shrugged it off as a quirk of the locality being salvaged. But it happened again and again during salvage sampling trips in eastern Australia. The converse was also true. I found patches of unattractive, weed-infested scrub which had a rich and abundant fauna of native litter invertebrates, and very few exotics. These weren't the kinds of patches that would inspire 'Land for Wildlife' or 'Friends of ...' efforts, but they were keeping alive non-mobile species which had gone extinct in the surrounding farmland.

What was going on?

I think I now have a general answer. Particular places may have their own special stories, but what I'm about to suggest is a plausible (and sometimes testable) explanation for much of settled Australia.

Settlement in the mid-19th century began with a massacre of native species. Forests and woodlands on suitable soils were often completely cleared to create farms. By the turn of the 20th century, most of the remnants in farmed landscapes were on steep and rocky ground, not-yet-drained swampy ground and in small areas surveyed off for public use. These included recreation reserves, cemetery reserves and timber reserves (from which local farmers could take splitting timber, fenceposts and firewood).

These remnants had already been put under pressure by the long 'Federation Drought' of the 1890s, and would be droughted again repeatedly in the 20th century. On-farm remnants were grazed to dust during such droughts, and not only by sheep. For some 80 years until the introduction of myxomatosis in the 1950s, Australia suffered a rabbit plague. Understorey vegetation was eliminated, young trees were killed and the soil was trampled and turned over. Remnants were reduced to scattered old eucalypts standing over bare ground or over stock-transported grasses and weeds.

Litter invertebrate species which had become locally extinct in these degraded remnants could only re-establish if they could fly in from distant, less disturbed patches. Land snails and millipedes couldn't reinvade, because there were kilometres of pasture acting as dispersal barriers.

Time passed, rabbits diminished and new farmland conservation practices allowed forest and woodland to regrow and expand in many places. The old, scattered eucalypts dropped seed and a new forest 'thickened' with quick-growing young eucalypts and with understorey trees (e.g. wattles) established from ground-stored seed. This new habitat looks wonderful, but its litter fauna is depauperate.

The same pattern has been documented by botanists. For a botanical perspective on this view of landscape history, see

> Lunt, I.D. and Spooner, P.G. 2005. Using historical ecology to understand patterns of biodiversity in fragmented agricultural landscapes. *Journal of Biogeography* 32: 1859-1873.

Now, when my wife and I go salvage sampling in rural Australia, we look first for our invertebrate targets in small public reserves. The more degraded and ugly, the better, because 'well-grassed and tidy' means that native species are long gone and the fauna is now dominated by exotics. We also look in exotic pine plantations - but I'll save that for another update.