A PEDOGEOMORPHOLOGICAL ANALYSIS OF GOORGANGA WETLANDS TO ASSSIST WITH MANAGING THE AREAS ECOSYSTEMS

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Abstract
Goorganga wetlands are situated east of Proserpine in Central Queensland and cover approximately 19544 ha. These wetlands are nationally recognised as having a vital range of terrestrial and aquatic ecosystems which support numerous animals. There is a need to develop an understanding of how these wetland ecosystems function in order to manage them sustainably. This study has examined the use of soil, geomorphology and vegetation data to map ecosystems in Goorganga wetlands. The 19 pedogeomorphological classes were intersected with the 17 remnant vegetation communities to produce ecosystem units using a GIS. These ecosystem units describe a unique assemblage of soil and vegetation combinations which have inherently distinct ecological functions. One soil was found to have twelve vegetation communities or ecosystem units. The ecosystem units were useful in understanding the complex soil-vegetation relationships in Goorganga wetlands. These units were used to determine the climax and successional ecosystems for each soil. The ecosystem units produced from this process provide information that can be directly translated into management plans. The study found that soil and geomorphology data is useful in mapping the spatial extent of wetlands and their ecosystems.

Additional Keywords: soil mapping, wetlands, ecosystem units, wetland mapping.

Introduction
Wetlands provide environmental services that are vital to a range of terrestrial and marine flora and fauna. Some of the main wetland functions include the sink and source of nutrients (QEPA, 2000), provide habitats for migratory birds and other terrestrial animals (EA, 2001 and Siebentritt and Wilkinson, 2003), and providing some important ecological niches in the interface between the land and marine environment. The ecological values of wetlands make it important to manage them in a way to maximise biodiversity outcomes.

The first step in managing wetlands is an understanding of the natural resources and processes that are present. This information is best gained through mapping natural resources. Most mapping and classification of these inundated lands focus on surface features such as vegetation, surface water, and may use a loose description of landform such as swamps, or plains (Blackman *et al*, 1999 and EA, 2001). The vegetation of wetlands is often a key piece of information that is used to map and describe wetlands. The vegetation present is a reflection of the pedological, geomorphological and hydrological processes at a specific site. The combination of these factors form ecosystems. An ecosystem can be defined as “a dynamic complex of plant, animal, fungal and micro-organism communities and the associated non-living environment interacting as an ecological unit” (CoA, 1993). The ecosystem may be the most appropriate mapping unit for managing wetlands.

The use of the pedological – geomorphological relationships and principles in understanding landscape function has been discussed by Thwaites and Shafer (2000). In this study these pedogeomorphological principles are used with vegetation data to map the ecosystems across Goorganga wetlands as a means of providing data to manage these areas effectively. Goorganga wetlands is a nationally recognised but is not an internationally listed area (Blackman *et al*, 1999 and EA, 2001) and is situated about 9 kilometres south east of Proserpine in Central Queensland and covers 16,851 ha (Blackman *et al.*, 1999).

Methods
This study used current soil and vegetation data for the Goorganga wetland area. The study intersected the digital soil mapping with the remnant regional ecosystem data, assessed the regional ecosystem mapping for the area and compare the wetland classes identified by Blackman *et al* (1999) with the ecosystem units developed from the process.

Soil mapping was conducted at a scale of 1:25,000 using a free survey technique (McDonald *et al.*, 1990). Mapping was assisted with the use 1:25,000 panchromatic air photographs. Soils were described from cores and classified into soil profile classes. Soil profile classes represent unique soil morphological, chemistry and geomorphology properties.

The soil morphology and basic chemistry, including pH and electrical conductivity were described at each site. Top soil and subsoil samples were also collected for the main soils. Subsoil sampling was also undertaken to determine the quantity of pyrite within three of the soil profile classes. Other site information such as drainage, surface relief and estimations on flood depth and frequency were also described. The soil profile classes were termed pedogeomorphological classes to reflect the relationship between soil and geomorphology. The pedogeomorphological relationships were used to define the spatial extent of Goorganga wetlands.

The Queensland Environmental Protection Agency has mapped the vegetation of the Goorganga wetlands at a scale of 1:100,000. The vegetation was placed into regional ecosystems representing broad geological, and geomorphological classes. The remnant regional ecosystems mapping was used as the vegetation data for the study.

The pedo-geomorphological digital map was intersected with the remnant vegetation digital map using a GIS, ensuring that the data sets had the same projection and datum. The resulting data intersection described the soil-geomorphology-vegetation relationship. The resultant mapping units are termed ecosystems units and are numbered for interpretation. The development of the ecosystems will allow scrutiny concerning those that are climax and successional communities. The map of Goorganga wetland ecosystems will be produced at a scale of 1:25,000.

The pedo-geomorphological units and ecosystem units are compared with the wetland classification developed by Blackman *et al* (1999). The comparison of wetland class verse the pedogeomorphological units is used to assess how many soils occur within each wetland class and how homogenous these areas are in terms of their ability to support vegetation communities.

Results

Over one hundred and thirty sites were described across the Goorganga wetlands (Hardy, 2000) which were placed into 19 pedogeomorphological classes. The pedo-geomorphological classes cover a range of soils including Vertosols, Hydrosols, Rudosols, Chromosols and Sodosols (Isbell, 1996). The area of each pedo-geomorphological class was calculated and is shown in table 1. The pedogeomorphological class which covered the largest area (4035ha) was “Go” which is a hydrosol (Hydraquentic sulfaquepts, soil survey staff, 1992) with shallow acid sulfate soil layers.

The pedo-geomorphological mapping units show that there is a distinct difference between the Quaternary Proserpine floodplain and the younger Holocene Proserpine floodplain. Using the Quaternary - Holocene boundary, the Goorganga plains wetland is 19544ha in area. The wetland has a maximum width of 12 km and is 19 km in length. If the marine transgression of the coastline commenced 6,500 years ago (Hopely and Thom, 1983), then the coastline has migrated an average of approximately 2 m a year since the sea level rose.

The vegetation supported by the Holocene floodplain is variable. The regional ecosystem data for Goorganga wetlands show that 13405ha contain 17 remnant vegetation communities or regional ecosystems, with the remaining land cleared. The dominant regional ecosystems are mangroves (RE 8.1.1 with 4044ha) native grassland (*Imperata cylindrica)* (RE 8.3.12 with 3356ha), sedgelands (Re 8.3.4 with 2255ha) and Melaleuca forest (RE 8.3.13 with 1234ha).

The intersection of the pedogeomorphological units with the regional ecosystem data yielded 97 ecosystems. Ecosystems with an area less than 5 ha were excluded from the analysis. The intersection has enabled an analysis of the range of vegetation communities within each pedogeomorphological unit (Table 1). The pedogeomorphological units with the most number of ecosystems were the “Go” hydrosol with 12, the “Mg” Hydrosol with 11, and the “Hs” hydrosol with 10. The dominant vegetation communities on the Go pedo-geomorphological unit were sedgelands (RE 8.3.4 with 1153ha), native grass lands (RE 8.3.12 with 1027ha) and Melaleuca forest (RE: 8.3.13a with 585ha). The dominant vegetation communities on the Hs pedo-geomorphological unit were native grass lands (RE 8.3.12 with 1087ha), sedgelands (RE 8.3.4 with 309ha), and Melaleuca forest (RE: 8.3.13a with 165ha).

The intersection of the two data sets also enabled an analysis of the range of soils that occur under each regional ecosystem. The sedgeland vegetation communities (RE 8.3.4) were found to occur over 11 soils, while the native grassland community occurs over 16 soils.

The most common pedogeomorphological class for the Melaleuca forest vegetation community (RE 8.3.13a) was "Go" with 585ha. The analysis shows that a soil may support a range of vegetation communities, however some of these communities may represent successional or regenerating communities.

Table 1. The results of the pedo-geomorphological unit – regional ecosystem data set intersection

Pedogeomor-phological class	US classification (Soil Survey Staff, 1992)	Geology	Total area (ha)	Area cleared (ha)	Number of Regional Ecosystems	Dominant Regional ecosystem	Wetland class
An	psamments	Qr	584	15	7	8.2.6a	A7
An3	psamments	Qr	52	10	6	8.3.13a	A7
Bh	Haplusterts	Qa	2256	1845	8	8.3.12	B4
Bv	Natraqualfs	Qa	216	213	0	8.3.5	
Cm	Aquic ustifluvents	Qa	506	483	2	8.3.12	B4
Cp	Hemists	Qm	148	83	3	8.3.12	
Dn	Aeric humaquepts	Qm	858	339	8	8.3.12	A8
Gi	Histic humaquepts	Qm	316	182	8	8.3.12	B4
Go	Hydraquentic sulfaquepts	Qm	4035	813	12	8.3.4 / 8.3.12	B4
Hs	Histic humaquepts	Qm	2483	456	10	8.3.12 / 8.3.4	B4
Mg	Histosols	Qm	4349	36	11	8.1.1	A9
Mu	Aquic ustifluvents	Qa	47	47	0	8.3.5	B4
My	Aeric humaquepts	Qa	316	214	4	8.3.12	B4
Po	Typic ustifluvents	Qa	479	77	2	8.3.1a	B4
Sa	Natraqualfs	Qa	279	57	3	8.3.12	B4
Sf	Hemists	Qm	736	54	7	8.1.3	A7
St	Oxyaquic ustifluvents	Qa	243	243	0	0	B4
Sw	Fibrists	Qm	1541	294	8	8.3.4	B10
Vc	Haplusterts	Qa	121	98	1	8.3.4	B4
Total		3	19460	6139	97	8	5

The wetland classes developed by Blackman *et al* (1999) have been added to the data set for comparison and are also shown in table 1. The relationship of the wetland class and the pedogeomorphological units shows that each wetland class contains a range of soils and vegetation communities. These wetland classes may be too broad to accurately describe and reflect the inherent complexity of the soil-geomorphology-vegetation relationship in Goorganga wetlands.

Discussion

The Proserpine and O'Connell river floodplain is composed of two distinct landscapes, one formed during the Quaternary period and the other formed during the Holocene epoch. The boundary between these two landscapes can be described and mapped by examining the areas geomorphology and soils. The boundary between the Quaternary floodplain and the Holocene floodplain was used to define the spatial extent of Goorganga wetlands.

The soil mapping can be used to describe the history and formation of Goorganga wetlands. When the sea level ceased rising about 6,500 years ago (Hopely and Thom, 1983), it stopped in some places about 2 m below the Quaternary floodplain level. In some areas there is a sharp boundary between the Quaternary floodplain and the lower Holocene floodplain. In other areas, this boundary occurs over tens of metres and is quite diffuse. The Quaternary floodplain is less prone to flooding than the Holocene floodplain, which influences the soil and vegetation communities present.

The examination of the 19 pedo-geomorphological units within Goorganga wetlands gives some indication of their depositional conditions. The patterns of sediment accumulation have had an influence on the geomorphology and distribution and formation of soils across the plains. An examination of the soil mapping of the wetlands show four sets of parallels sand dunes across Goorganga wetlands.

These sand dunes indicate periods of low flow in the Proserpine and O'Connell river systems, where wind blown sand from the near shore area have accumulated and formed dunes. The sand dunes are separated by mostly Vertosol and Hydrosol soils. The soil data shows that there are 4034 ha of Hydrosols with shallow pyritic subsoil layers.

The intersection of the soil and regional ecosystem coverage's provide a data set that can be used to analyse the vegetation – pedogeomorphological relationships across the plains. The 19 pedo-geomorphological units were intersected with the 17 regional ecosystems. The study has found that for some soils, support more than ten vegetation communities (regional ecosystems). The wide range of vegetation which is mapped as occurring on the soils indicate either that the vegetation present is in various stages of succession, or that extremely subtle changes in soil morphology and chemistry are responsible for in some cases dramatic changes in vegetation. The native grassland (*Imperata cylindrica*) regional ecosystem (RE 8.3.12) was found to cover 3356ha and grows on 16 soil types. The soils on which the native grassland grow include hydrosols, sodosols and rudosols (Isbell, 1996). The "Go" hydrosol soil was found to support 12 different regional ecosystems. The vegetation communities which are most widely found on the "Go" soil include sedgeland (Re 8.3.4) with 1153ha, native grass land (RE 8.3.12) with 1027ha and Melaleuca forest (RE 8.3.13a) with 583ha.

The "Go" soil cores described at sites within the Melaleuca forest and those on the sedgeland and grassland were very similar in morphology and chemistry. It therefore appears that the Melaleuca forest represents a climax community on the "Go" hydrosol, while the other vegetation communities represent various stages of vegetation community succession or regeneration. The most likely reason for the large areas of native grasses and sedgeland is recent and historical land clearing and burning. The burning regime used as a management tool is likely to explain the lack of Melaleuca regrowth in the open grasslands.

The use of soil and geomorphological data, together with the relationship between soil properties and vegetation can be used to better understand how ecosystems develop and change with various land management practises. The use of soil data can be used to more accurately assess the likely ecosystems that were present prior to land clearing and the introduction of fire. The use of soil data and regional ecosystem data can provide a more accurate means of mapping and describing wetland ecosystems.

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