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Optimal prediction of coastal acid sulfate soil severity using geographic information systems

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Optimal Prediction of Coastal Acid Sulfate Soil Severity using Geographic Information Systems

A thesis submitted in fulfilment of the requirements for the award of the degree

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By

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CERTIFICATION

I, Marcus J. Morgan declare that this thesis, submitted in fulfilment of the requirements for the award of Master of Engineering (Honours), in the Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Marcus J. Morgan

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Abbreviations

ACASS	Actual Coastal Acid Sulfate Soil
AGD	Australia Geodetic Datum
AHD	Australian Height Datum
Al	Aluminium
ALS	Airborne Laser Scan
AMG	Australian Map Grid
ANOVA	Analysis Of Variance
ANS	Australian National Spheroid
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Australian Resource Management Council of Australian and New Zealand
ASRIS	Australian Soil Resource Information System
Cl:SO4	Chloride:Sulfate
CANSIS	Canadian Soil Information System
CASS	Coastal Acid Sulfate Soils
CASSOK	Coastal Acid Sulfate Soils Ordinary Kriging Model
CEC	Cation Exchange Capacity
CIS	Commonwealth of Independent States
CLT	Central Limit Theorem
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EAA	European Environment Agency
EC	Electrical Conductivity
EM	Electromagnetic Survey
ESB	European Soil Bureau
EGII	European Geographic Inform Infrastructure
ESRI	Environmental Systems Research Institute
EU	European Union
EUSIS	European Union Soil Information System
ExAl	Exchangeable Aluminium
Fe	Iron
GCS	Geographic Coordination System
GDA	Geocentric Datum Australia
GIS	Geographic Information Systems
GPI	Global Polynomial Interpolation
GPS	Global Positioning System
GWR	Geographically Weighted Regression
FAO	Food and Agriculture Organization
IDW	Inverse Distance Weighting
ISG	Integrated Survey Grid
KCl	Potassium Chloride
LIDAR	Light Detection And Ranging
LPI	Local Polynomial Interpolation
LRR	Land Resource Region
LRRC	Land Resources Research Centre
LRU	Land Resource Unit
MGA	Map Grid Australia
MLRA	Major Land Resource Area

NASIS	National Soil Information System
NRCS	Natural Resource Conservation Service
NSW	New South Wales
OK	Ordinary Kriging
PCASS	Potential Actual Coastal Acid Sulfate Soil
PCS	Projected Coordination System
pH	$\log_{10}(H^{+})$
RBF	Radial Basis Function
REMS	Reclaimed Water Management System
RMSPE	Root Mean Square Prediction Error
RMSS	Root Mean Squared Standardised
RV	Representative Value
Spocas	Sulfate –
Scr	Sulfur-Chromium Reducible
SAI	Space Applications Institute
SALIS	Soil and Land Information System
SOTER	Soil and Terrain Database
SPADE	Soil Profile Attribute Data Environment
SRADWG	Shoalhaven River Acid Drainage Working Group
SRTW	Self Regulating Tilting Weir
SSIS	Spanish Soil Information System
SSSD	State Soil Survey Database
SSURGO	Soil Survey Geographic database
STATSGO	State Soil Geographic database
SQL	Structured Query Language
TAA	Total (Titratable) Actual Acidity
TF	Thiobacillus Ferroxidans
TPA	Titratable Peroxide Activity
UK	Universal Kriging
USDA	United States Department of Agriculture
UTM	Universal Transverse Mercator
VIF	Variance Inflation Factor

Abstract

Coastal Acid Sulfate Soil (CASS) is a soil-water phenomenon that causes soil and water pollution resulting from the exposure, typically human-initiated, of pyrite to atmospheric and biotic oxygen. Structural deformation of capital works, combined with loss to flora and fauna (biodiversity) resulting from CASS has caused major concern to environmental managers, industries that rely directly on high quality water conditions for day-to-day operations, and landholders who experience characteristic scalding and other associated environmental problems on land adjacent to disturbed areas.

Areas of CASS in Australia have been identified by Department of Natural Resources (DNR) using a combination of expert knowledge, geomorphologic principles and Geographic Information Systems (GIS) known as Acid Sulfate Soil Risk Maps. These maps have been applied by local managers in planning and natural resource management to identify areas showing the highest probability of being severely affected by CASS.

In this project, with the DNR model as a starting point, the aim was to improve the way CASS severity is assessed. This included using five major soil-chemical parameters and/or relationships in a number of geostatistical models. The five parameters included were: Total Actual Acidity (TAA), pH, Chloride to Sulfate ratio ($Cl^{-}:SO_4^{2-}$), Depth to actual CASS layer (Jarosite layer), and Exchangeable Aluminium per cent of total Cation Exchange Capacity. Other parameters such as depth to Potential CASS layer (Pyrite layer) and Sulfur per cent (S%), also have weight but not as significant as the other parameters and were subsequently removed from further detailed analysis.

Ordinary Kriging (OK) was identified as the most suitable geostatistical method to predict CASS severity using the aforementioned soil-chemical principles. The resulting 3-Dimensional model was compared to the 2-Dimensional DNR Risk Maps with similarities in both models validating both approaches in determining severity using different methods. The CASSOK model put a greater emphasis on soil parameters down the soil profile and how they relate to surface elevation across a finite study area (Broughton Creek floodplain, New South Wales).

Applying the new CASSOK model to broader areas of New South Wales will be dependent on available data to input into the model. Using the current DNR risk maps is a broad indication of an area, using CASSOK will give a greater indication of what can be expected 2m below the surface. The ability to create a method that can be applied across the entire state of New South Wales, and then to a national level will be an invaluable resource to land managers in future planning and risk management.

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Soy Terminar! Gracias mi amore.

Dedication

This is dedicated to all the research students that undergo serious difficulties in trying to complete a research document due to reasons out of their control, I understand your grief.