NESP 1.15 Coastal wetland restoration for blue carbon

Spatial analysis workflow – Peel-Harvey and South West case study, WA

Purpose: To identify the coastal wetland restoration opportunity in the Peel-Harvey and South West study area and manipulation of spatial datasets for input into the following R codes: 1) blue carbon estimates, 2) economic analysis and 3) co-benefits analysis. Spatial analysis conducted in ArcMap 10.8 (ESRI, 2019) for restoration opportunity and carbon abatement, and QGIS (Open-source software, 2002) for co-benefits.

RESTORATION OPPORTUNITY

1. **Delineate study area**
   a. **NRM clusters**
   - Downloaded "NRM sub-cluster shapefile" from https://climatechangeinaustralia.gov.au/en/overview/methodology/nrm-regions/
   - Select by attributes code= "SSWFW" = new layer "NRM_SouthWesternFlatlands"

2. **Pre-European vegetation**
   - Download data from https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006
   - Need a SLIP data account.
   - Vegetation types have different classifications – decide which ones are coastal wetlands in the descriptions in Page 16 of Byrne et al. 2013 (https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/CONSERVATION_SCIENCE_VOL_9.1print_ready_low.pdf).
   - Select attributes by veg_type
     - 3. Woodland: jarrah, marri, wandoo, tuart and flooded gum
     - 6. Low forest: acacia, peppermint, coastal moort, Rottnest pine or mixed tropical forest
     - 9. Low woodland, open low woodland: other species
     - 10. Mangroves: low forest (Kimberley) or thicket (Pilbara) mangroves (Avicennia marina, Rhizophora stylosa, Bruguiera exaristata)
     - 14. Thicket: wattle, casuarina and teatree (Acacia–Allocasuarina–Melaleuca alliance).
     - 29. Short bunch-grass savanna
     - 32. Riverine sedgeland/grassland with trees
     - 33. Sedgeland: (mainly in the South West) Cyperaceae, Restionaceae, Juncaceae
     - 38. Shrub-steppe
     - 51. Salt lake, lagoon, claypan
     - 53. Tidal mud flat
     - Mosaic 101. Medium forest or woodland/Low woodland/Low forest or woodland
     - Mosaic 106. Low woodland/Scrub or thicket
     - Mosaic 107. Scrub-heath/Thicket
     - Mosaic 116. Short bunch-grass savanna/ Grass-steppe
   - "PreClearVeg_Wetland" then clip to Peel-Harvey SW study area "PreClearVeg_Wetland_PeelHarveySW".

3. **Land use mapping**

- Download data from https://catalogue.data.wa.gov.au/dataset/catchment-scale-land-use-mapping-for-western-australia-2018/resource/3c28bef9-04e1-44f7-9866-a80272d9c8cb
- Open data WA_CLUM_August 2018
- Select attributes from Secondary V8 and export data as "WA_cropping_grazing"
    - 3.2 Grazing modified
    - 3.3 Cropping
    - 4.2 Grazing irrigated
    - 4.3 Irrigated cropping
- Clip to Peel-Harvey SW study area "WA_cropping_grazing_intensive_PeelHarveySW".
    - ➢ Cropping is minimal within the restoration sites (495 ha is grazing and 5 ha is cropping).
- Remove cropping and just use grazing - Select attributes from Secondary V8 "WA_grazing"
    - 3.2 Grazing modified
    - 4.2 Grazing irrigated
- Clip to Peel-Harvey SW study area "WA_grazing_PeelHarveySW" using "SW_PeelHarvey_clip".

4. Tides

- Data from: Vertical Datum Transformations across the Littoral Zone
- Appendix C, Table 19
- HAT (m above AHD) predictions were obtained for WA and NT.
- Add WA_tides as spatial data layer (add as xy data and export as a shape file WA_Tides_point).
- Selected tide points along the coast of Peel-Harvey SW study area "WA_Tides_point_PHSW"
    - Busselton
    - Bunbury
    - Removed Mandurah because no value for AHD
    - Added in Freemantle
- Spatial join of the tide points with the with the Peel-Harvey SW basins (closest). Exported the table "WA_Tides_point_PHSW_Basins".
    - PeelHarveySW_BlackwoodBasin
    - PeelHarveySW_BusseltonBasin
    - PeelHarveySW_CollieBasin
    - PeelHarveySW_HarveyBasin
    - PeelHarveySW_MurrayBasin
    - PeelHarveySW_PrestonBasin

5. Digital Elevation Model (DEM)

- Download UTM zone 50 at https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/89644
- Import and clip to Peel-Harvey SW study area "DEM_PeelHarveySW"
- Gaps in the data inland.
- Tried with the 30 second DEM but it spent 24 hours building pyramids and was not successful.
- Clipped DEM raster DEM_PeelHarveySW to individual basins within the Peel-Harvey SW.
    - DEM_Preston
    - DEM_Murray

    - DEM_Harvey
    - DEM_Collie
    - DEM_Busselton
    - DEM_Blackwood
- Reclassify values for each basin according to HAT_m_above_AHD value (Arc Toolbox > Spatial Analyst Tools > Reclass > Reclassify). Classify to change values into 4 classes and change break values:
    - 1 (MSL to HAT)
    - 2 (>HAT)
    - No data
        - Note tick box 'change missing values to no data' for 25m DEM, not for 5m DEM
    - Reclass_Blackwood
    - Reclass_Bussellton
    - Reclass_Collie
    - Reclass_Harvey
    - Reclass_Murray
    - Reclass_Preston
- Merge reclassified catchment rasters (Mosaic Rasters) into one raster using for Peel-Harvey SW "ReclassDEM_PeelHarveySW".
- Then create polygon from raster (Arc Toolbox > Conversion tools > from raster to polygon) selecting 'create multipart features' "PolygonDEM_PeelHarveySW".
- Select gridcode 1 (<HAT) "tide5dem_PeelHarveySW".
- Export data to new shapefile "tide5dem_PeelHarveySW".

6. DEM plus sea level rise (SLR)

- Reclassify basin rasters to add in 0.71m SLR.
    - Blackwood River=1.26=SLR_Blackwood
    - Busselton Coast=1.26=SLR_Busselton
    - Preston River=1.38 = SLR_Preston
    - Collie River=1.38=SLR_Collie
    - Harvey River=1.38 =SLR_Harvey
    - Murray River=1.52=SLR_Murray – redo murray
- Merge reclassified catchment rasters (Mosaic Rasters) into one raster using for Peel Harvey SW "SLR_ReclassDEM_PeelHarveySW.tif".
- Then create polygon from raster (Arc Toolbox > Conversion tools > from raster to polygon) selecting 'create multipart features' "SLR_PolygonDEM_PeelHarveySW".
- Select gridcode 1 (<HAT) "SLR_tide5dem_PeelHarveySW". Export data to new shapefile.
- Repeat for 1m SLR.

7. Identify restoration sites

- Intersect land use "WA_cropping_grazing_intensive_PeelHarveySW" with new tidal layer "tide5dem_PeelHarveySW" to get grazing areas that could receive tidal water up to HAT ("tidal_cropping_grazing_intensive_peelharveySW").
- Intersect grazing areas <HAT "tidal_cropping_grazing_intensive_peelharveySW" with preclear regional ecosystem "PreClearVeg_Wetland_PeelHarveySW" to get preclear veg types per polygon "tidal_cropping_grazing_intensive_PreClearVeg"

- Calculate geometry (area_ha) and export as shapefile “PeelHarveySW_rsites_all”.
- Dissolve boundaries and then calculate geometry (area_ha).
- Select sites >1ha and save as PeelHarveySW_rsites_1ha. Export as shapefile.
- Gives 72 sites = PeelHarveySW_rsites_1ha

8. Select restoration sites that are grazing only

- Intersect land use “WA_cropping_PeelHarveySW” with tidal layer “tide5dem_PeelHarveySW” to get grazing areas that could receive tidal water up to HAT “tidal_cropping_peelharveySW”.
- Intersect grazing areas <HAT “tidal_cropping_peelharveySW” with preclear regional ecosystem “PreClearVeg_Wetland_PeelHarveySW” to get preclear veg types per polygon “tidal_cropping_PreClearVeg”.
- Dissolve boundaries “tidal_cropping_PreClearVeg_Dis”.
- Calculate geometry (restor_ha).
- Select sites >1ha and save as PeelHarveySW_rsites_grazing_1ha. Export as shape file.
- Gives 42 sites = PeelHarveySW_rsites_grazing_1ha.

9. Restoration sites grazing plus SLR

- Intersect land use “WA_grazing_PeelHarveySW” with tidal layer + SLR “SLR_tide5dem_PeelHarveySW” to get grazing areas that could receive tidal water up to HAT under SLR scenario “SLR_tidal_grazing_peelharveySW”.
- Intersect grazing areas <HAT “SLR_tidal_grazing_peelharveySW” with preclear regional ecosystem “PreClearVeg_Wetland_PeelHarveySW” to get preclear veg types per polygon “SLR_tidal_grazing_PreClearVeg”.
- Dissolve boundaries “SLR_tidal_grazing_PreClearVeg_Dis” then calculate geometry (area_ha).
- Select sites >1ha and save as SLR_PeelHarveySW_rsites_grazing_1ha. Export table as excel and sum total ha and number of sites.

CARBON ABATEMENT

10. Soil carbon loss – for baseline emissions

- Download CSIRO baseline map of soil organic carbon (Viscarra-Rossell et al. 2015 from https://data.csiro.au/collection/11088
- Clip floating raster (average map) to “SW_PeelHarvey_clip” (Arc Toolbox > Data Management > Raster > Raster Processing > Clip. Note tick box ‘use input features for clipping’. Save as “SOCavSWPH”
- Convert “SOCavSWPH” to integer using Int = “Int_SOCavSWPH”
- Use zonal statistics by table to get mean SOC per restoration site (Spatial Analyst Tools > Zonal > Zonal Statistics as Table).
    - Input restoration sites layer.
    - Input SOCavFitz as raster.
    - Select Ignore NoData in calculations and get ALL statistics.
    - Grazrsites_PeelSW_SOC

11. **Farm dams – for baseline emissions from ponds and other constructed waterbodies**
    - Download farm dams from https://catalogue.data.wa.gov.au/dataset/farm-dams-of-the-south-west-agricultural-region-of-wa
    - Input data "farm_dams_of_WA"
    - This is polygon data
    - Add field "dam_ha" to layer and calculate geometry in ha.
    - Project spatial reference 1984 to the same as other layers – 1994 = "farm_dams_of_WA_reproject"
    - Layer needed repair – repair geometry tool
    - Clip to SW_PeelHarvey_clip area = "farmdams_PHSW"
    - Intersect with "PeelHarveySW_rsites_1ha" to get dams in each site "PHSW_sites_farmdams".
    - Add field "dam_ha" and calculate geometry (area in hectares).
    - Export table as excel and save as csv "PHSW_sites_farmdams.csv".

12. **Remnant vegetation – for baseline emissions from degraded wetlands**
    - Downloaded remnant vegetation data from https://catalogue.data.wa.gov.au/dataset/swan-coastal-plain-remnant-vegetation-2020
    - Intersected with "PeelHarveySW_rsites_1ha" to get remnant vegetation in each restoration site "PHSW_sites_remnant".
        - Add field "remnant_ha" and calculate geometry attribute.
        - Export table as excel and save as csv "PHSW_sites_remnant.csv".

13. **Intersections for data analysis in R – grazing only**
    - Land uses within the HAT:
        - Intersect "tide5dem_PeelHarveySW" with all land uses "PreClearVeg_Wetland_PeelHarveySW" = "tide5dem_preclearwetland_PHSW".
        - Dissolve by veg_type "tide5dem_preclearwetland_Diss".
        - Add field veg_ha and calculate geometry (area in hectares) of each polygon.
        - Export table to excel and save as csv file.
    - Remnant vegetation within restoration sites:
        - Intersect "PeelHarveySW_rsites_grazing_1ha" with "PHSW_sites_remnant" = "PHSWgrazrsites_remnant".
        - Dissolve by FID.
        - Add field "rem_ha" and calculate geometry (area in hectares) of each polygon.
        - Export table to excel. Save as csv file "PHSWgrazrsites_remnant_Dis.csv".
    - Pre-clear vegetation types within restoration sites:
        - Intersect "PeelHarveySW_rsites_grazing_1ha" with "PreClearVeg_Wetland_PeelHarveySW" = "PHSWgrazrsites_preclearveg".
        - Dissolve by FID, area_ha, and veg_type (select create multipart features) as "PHSWgrazrsites_preclearveg_Dis".
        - Add Field (PCveg_ha) and calculate geometry (area in hectares) of each polygon.
        - Export table to excel. Save as csv file "PHSWgrazrsites_preclearveg_Dis.csv".
    - Land use types within restoration sites:
        - Intersect "PeelHarveySW_rsites_grazing_1ha" with "WA_cropping_PeelHarveySW" = "PHSW_grazrsites_landuse".

    - Dissolve by FID, area_ha, and SECONDARY_V8 (select create multipart features) = "PHSW_grazrsites_landuse_Diss".
    - Add Field (Alum_ha) and calculate geometry (area in hectares) of each polygon.
    - Export table to excel. Save as csv file "PHSW_grazrsites_landuse_Diss.csv".
- Tide zones within restoration sites:
    - Intersect "PeelHarveySW_rsites_grazing_1ha" with "tide5dem_PeelHarveySW" = "PHSW_grazrsites_tidal".
    - Dissolve by FID, area_ha, and gridcode = "PHSW_grazrsites_tidal_Diss".
    - Add field "tidal_ha" and calculate geometry (area in hectares) of each polygon.
    - Note = there is no difference in tidal areas in PHSW due to small tides so this is probably redundant.
    - Export table to excel. Save as csv file "PHSW_grazrsites_tidal_Diss.csv".
- Farm dams within restoration sites
    - Intersect "farmdams_PHSW" with "PeelHarveySW_rsites_grazing_1ha" = "PHSW_rsites_farmdams".
    - Dissolve by FID, restor_ha, and FID_farmdam = "PHSW_rsites_farmdams_Dis".
    - Add field dam_ha and calculate geometry (area in hectares) of each polygon.
    - Export table to excel. Save as csv file "PHSW_grazrsites_tidal_Dis.csv".

CO-BENEFITS

14. Cultural heritage

a. Native title

- Download data from https://catalogue.data.wa.gov.au/dataset/native-title-determination-lgate-066
- None in the Peel-Harvey SW study area

b. Cultural heritage database

- Download data from https://www.environment.gov.au/heritage/publications/australian-heritage-database
- None in the Peel-Harvey SW study area

c. Aboriginal Heritage places

- Download data from https://catalogue.data.wa.gov.au/dataset/aboriginal-heritage-places
- Intersect with "PeelHarveySW_rsites_all" to get "rsites_Aboriginal_Heritage".

d. Cultural heritage parties

- Collate information from: https://www.noongar.org.au/noongar-land-estate

e. Leasehold and commonwealth land

- Request data from https://catalogue.data.wa.gov.au/dataset/cadastre-polygon

Instructions for deriving data for other co-benefits in report methods (Hagger et al. 2022) and R code "3_wetland_restoration_cobenefits".