2 What are Groundwater Dependent Ecosystems?

There have been many definitions for GDEs given by various authors, but they are all along the same theme, being ecosystems that use groundwater either at some stage of their life cycle or by one generation which is critical to the existence of that species. Demonstration of groundwater *use* does not necessarily equate to groundwater *dependence*. By dependence it is meant that the ecosystem would be significantly altered and even irreversibly degraded if groundwater availability was altered beyond its 'normal' range of fluctuation (Colvin et al. 2003).

Hatton and Evans (1998), in the publication, 'Dependence of Ecosystems on Groundwater and its Significance to Australia', defined groundwater 'for the purposes of identifying ecosystem dependence' as extractable groundwater utilised to a greater or lesser extent, by plants and animals. They noted that the term groundwater should not include transient shallow (soil) water and perched systems including shallow through flow down hillslopes. Hatton and Evans (1998) used vegetation assemblages to classify broad groups of ecosystems that potentially are dependent on groundwater, with dependence being sometimes cryptic or subtle. Most of the current literature refers to GDEs based on an assumption that the groundwater is found in aquifers and able to be abstracted. Colvin et al. (2007) consider the term Aquifer Dependent Ecosystem (ADE), to be more precise; ADE, as used in South Africa, is functionally equivalent to GDE.

Smith et al. (2006) added a time dimension to the term and defined groundwater dependent ecosystems as ecosystems that rely wholly or partially on groundwater to maintain an adequate level of ecosystem function and maintenance of community composition over multiple generations of the longest lived species within the community.

GDE dependence on groundwater is highly variable, ranging from partially and infrequently to continually and wholly dependent. These ecosystems including wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes saline discharges, springs, mangroves, river pools, billabongs and hanging swamps represent complex and important components of biological diversity (Sinclair Knight Merz 2001).

Murray et al. (2003) defined GDEs as requiring the input of groundwater to maintain their current composition and functioning. Removal of groundwater from these ecosystems, or a change in the timing, quantity, quality or distribution of groundwater may influence ecosystems by, for example, changing the availability of water for transpiration by vegetation and the recruitment of seedlings into the adult population. This generally results in changes in associated fauna assemblages.

2.1 Original Classification System from Hatton & Evans (1998)

There are a number of different GDE classifications proposed in Australia. Hatton and Evans (1998) identified four types of GDEs primarily based on geographic setting:

1. **terrestrial vegetation** - vegetation communities and dependent fauna that have seasonal or episodic dependence on groundwater;
2. **river base flow systems** - aquatic and riparian ecosystems that exist in or adjacent to streams that are fed by groundwater base flow;
3. **aquifer and cave ecosystems** - aquatic ecosystems that occupy caves or aquifers;
4. **wetlands** - aquatic communities and fringing vegetation dependent on groundwater fed lakes and wetlands.

2.2 Additional Classes of GDEs

Based on the same approach as Hatton & Evans, Sinclair Knight Merz (2001) identified two additional types of GDEs:

5. **terrestrial fauna** - native animals that directly use groundwater rather than rely on it for habitat;
6. **estuarine and near-shore marine ecosystems** - coastal, estuarine and near-shore marine plant and animal communities whose ecological function has some dependence on discharge of groundwater.

2.3 Alternative GDE Classification System by Eamus et al. (2006)

Eamus et al. (2006) grouped ecosystem types for their GDE classification scheme. They proposed three simple primary classes based upon the type of groundwater reliance. This type of classification is useful for management as it allows GDEs to be separated into readily recognisable ecosystem classes that permit the use of similar techniques and approaches for the identification of GDEs and the assessment of ecological risk. The classes are:

1. aquifer and cave ecosystems, where stygofauna (groundwater-inhabiting organisms) reside *within the groundwater resource*;
2. all ecosystems dependent on the *surface expression of groundwater*;
    - River base flows
    - Wetlands, swamplands
    - Seagrass beds in estuaries
    - Floodplains
    - Mound springs
    - Riparian vegetation
    - Saline discharge to lakes
    - Low lying forests
3. all ecosystems dependent on the *subsurface presence of groundwater*, often accessed via the capillary fringe (non-saturated zone above the water table) when roots penetrate this zone.
    - River Red Gum forests
    - Banskia woodlands
    - Riparian vegetation in the wet/dry tropics

2.4 ADE classification & identification by Colvin et al. (2007)

Colvin et al. (2007) created a new approach to identify Aquifer Dependent Ecosystems (ADEs) based on a combination of aquifer and habitat types in South Africa, or type setting. These specific combinations help structure understanding of these systems and classify them according to the aquifer - ecosystem interface. The actual classes of the GDE habitats was similar to that developed by Hatton and Evans (1998), being:

- terrestrial
- riverine aquatic
- spring
- riparian
- wetland/ seep
- estuarine/coastal
- in-aquifer

The aquifer types in South Africa were categorised into 6 principle types based on lithology. These are as follows;

- Fractured Metasedimentary

- Carbonates
- Unconsolidated sediments
- Dolerite dykes and sills
- Basement complexes and younger granites
- Igneous extrusive