Field Guides for Inventory and Monitoring of Groundwater-Dependent Ecosystems on National Forests and Grasslands

Christopher Carlson[a], Joseph Gurrieri[b], Leslie Bach[c], and Allison Aldous[c]

[a]USDA Forest Service, Washington, DC
[b]USDA Forest Service, Golden, CO
[c]The Nature Conservancy, Portland, OR

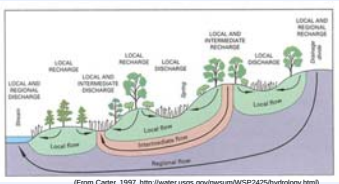
Introduction

Groundwater-dependent ecosystems (GDEs) are located across the landscape in every ecoregion of the United States. Although largely unrecognized, GDEs play an important role for both ecological and human communities. Groundwater-dependent ecosystems support a diversity of species, including a suite of rare biota, and habitats, often serving as critical refugia during extreme climatic conditions. In addition to being ecologically important, GDEs provide key services to society, including high-quality water for human consumption, agriculture, and industry, support for fisheries, and production of specialty commodities.

The Forest Service, in cooperation with The Nature Conservancy, has produced a set of Field Guides for inventory and monitoring of GDEs. These Field Guides will provide the agency with a consistent and scientifically sound approach to characterizing and monitoring groundwater-dependent resources on agency-managed lands. Rigorous field testing at several locations across the US resulted in a user-friendly product and proved that the methodology is applicable in a wide range of different ecological and climatic locations.

What are Groundwater-Dependent Ecosystems?

GDEs are communities of plants, animals, and other organisms whose ***extent*** and ***life processes*** are dependent on **access to** or **discharge of** groundwater.



(From Carter, 1997, http://water.usgs.gov/nwsum/WSP2425/hydrology.html)

Ecologically, all spring, subterranean, and phreatophytic ecosystems depend on groundwater, as do many rivers, wetlands and lakes.

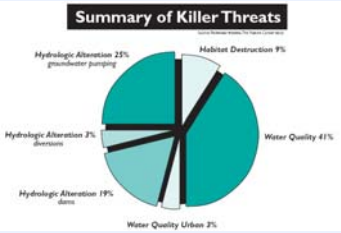
Ecosystem Services from GDEs

Habitat for an array of terrestrial and aquatic species; Refugia for species during periods of environmental stress

Water quality & quantity

Water storage; Recreational activities: hunting, fishing, paddling, birding

Threats to GDEs



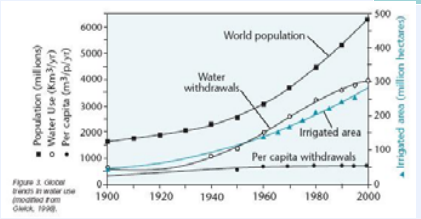
(From Brown et al, 2005, https://rivernetwork.org/files/rv/rv2005v15n3_4.pdf)

A key step to improving the protection of GDEs is to increase scientific understanding and public awareness of their importance and their distribution across the landscape.

Many GDEs are vulnerable to changes in the **quantity and quality of groundwater** and to changes to their **surface environment**:

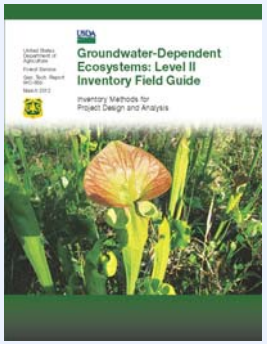
- groundwater extraction
- groundwater contamination
- land uses
- invasive species
- climate change

Role of Groundwater	Ecosystems / Species	Threats
Hydrologic regime	Riparian communities Wetlands Mesic forests	Pumping Roads/ditches Impervious surfaces Land development
Water quality: Chemistry	Calcareous fens Spring snails	Septic systems Fertilizer leaching Pesticides
Water quality: Temperature	Salmonids Endemic lake snails Hot springs	Geothermal energy development Pumping

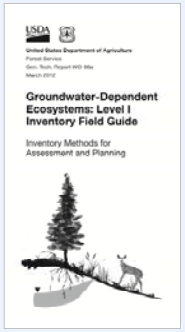


The GDE Field Guides (March 2012)

The new Forest Service Field Guides present options for different levels of intensity of data collection, depending on objectives and priorities, available resources, and spatial and temporal scales of interest.



The **Level I Field Guide**, aimed toward informing land management planning and large scale assessments, primarily describes the GDE type, location, extent, current uses, physiographic and geologic setting, and general ecological conditions.



The **Level II Field Guide**, designed for project-level design and monitoring, captures all Level I information and also includes field methods to inventory and monitor springs, fens and other wetlands, with focus on the measurement of hydrology, soil, geology, and vegetation-related parameters.

GTR-WO-86a (Level I) and GTR-WO-86b (Level II) - http://www.fs.fed.us/geology/groundwater.html

Testing of Field Guide Procedures

Prior to publication, the procedures in the field guides were tested in seven diverse settings across the National Forest System. Lessons learned were identified and the field guides were revised prior to publication.

Some key lessons from the testing:

- GDEs are everywhere
- Many different local or discipline-specific names for GDEs
- Groundwater dependence of many ecosystems is poorly understood across the agency

- GDE work is inherently interdisciplinary (hydrogeology, soils, ecology, botany, etc.)
- Little understanding in general of groundwater-dependent animals, especially invertebrates

Level II Field Methods

In Level II, four basic components (condition, hydrology, vegetation, and soils) are assessed at each GDE. To address local concerns, additional data may be collected on water chemistry, species of concern, and specific management impacts.

Black Hills NF, SD

GDE condition, function, and disturbance are assessed on-site. The following are noted: structures, hydrologic and soil alteration, recreation impacts, impacts of management/land use.

Francis Marion -Sumter NF, SC

Hydrology is assessed using existing information and on-site determination of surface water inputs and outputs, water table depth (in soil auger holes), discharge/flow, flow patterns, and in-situ measurements of pH, EC, DO, and temperature.

White Mountains NF, NH

Vegetation is sampled along transects perpendicular to a longitudinal baseline. Variables recorded: herbaceous species cover in 0.5m² quadrats; woody species cover using line intercept along transects.

White Mountains NF, NH

Soils are sampled along selected vegetation transects by augering to parent material. Variables recorded by horizon): color ; occurrence of redoximorphic features, texture (by hand); if peat, Von Post decomposition class.