

IDENTIFYING AND VALUING THE FUNCTIONS OF FLOODPLAINS

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Abstract

The unique characteristics of floodplains, such as low relief terrain, proximity to waterways, and nutrient rich soil, have enabled rural and urban development to thrive. This has resulted in widespread degradation of floodplain functions and the ecosystem services they provide.

De Groot *et al.* (2002) identified 23 functions provided by natural ecosystems across four categories: regulation, habitat, production and culture. A subset of these are considered essential functions of floodplains e.g. floodwater storage and conveyance, groundwater recharge, soil retention and habitat support.

These functions provide a range of biocentric and anthropocentric services. The ability of a particular function to provide these services depends on the presence and condition of particular floodplain processes and structures.

In order to value the services provided by floodplain functions at the site level, key ecological processes and ecosystem structures that enable the functions to occur must be identified and appropriate measures and metrics developed.

This paper presents a priority set of floodplain functions for valuation; the role of the floodplain, services provided and approaches to valuation for each function; and key threats to these functions.

Key words

Floodplain processes and structures, floodplain functions, valuation, threats.

Introduction

The unique characteristics of floodplains, such as low relief terrain, proximity to waterways, and nutrient rich soil, have enabled rural and urban development to thrive. However, early settlers became increasingly aware of flood risks and responded by building levees to protect crops, buildings and infrastructure. This resulted in widespread degradation of floodplain functions and the ecosystem services they provide.

In recent years, there has been increasing recognition of the ecological significance of floodplains, the interdependence between the health of the river and the floodplain, and the role periodic flooding plays in maintaining these connections. For example, the natural function of floodplains to convey and store floodwaters is a major consideration for floodplain managers when assessing encroachments on the floodplain by new developments.

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In order to value the services provided by floodplain functions at the site level, key ecological processes and ecosystem structures that enable the functions to occur must be identified and appropriate measures and metrics developed.

This paper considers the ecological processes and ecosystem structures of floodplains to:

- identify a set of floodplain functions
- present approaches to valuation for each function based on the role of the floodplain and the services it provides (including worked examples)
- identify a list of key threats to these functions.

Ecological Processes and Ecosystem Structures of Floodplains

Floodplains are fluvial depositional environments formed over long periods from sediments transported by rivers in flood. The rate of floodplain formation is dependent on the prevailing flow regime in the river and the nature of sediment delivery from the upper catchment (Roberts *et al.* 2000).

These ecological processes, in turn, determine to a considerable extent:

- the shape and features of the floodplain. The morphology of floodplains is intimately linked with the form and behaviour of the river channels that shape them (Charlton 2007). The key processes that create floodplain features are:
 - lateral accretion from sediment deposition in the channel. This is how floodplains are formed on meandering rivers. The outer bend erodes and sediment is deposited on the inside bend. Through this process of erosion and deposition, the channel gradually moves sideways across the landscape (Gould and Morris 2005).
 - vertical accretion from floodwater deposition. When a particular flood event exceeds the capacity of a waterway, floodwaters overtop the banks and deposit sediment on the floodplain.
- the depth and composition of soils. Sediment deposition on floodplains enables soils to be virtually 'ready-made', consisting of loose and often fertile organic material which can immediately carry plant life (Costermans 1989). The establishment of vegetation on the floodplain furthers the growth of floodplains by aiding deposition and preventing erosion (Morisawa 1968).
- the type and density of vegetation. The array of plants on floodplains includes species that are adapted to dry, almost terrestrial, conditions, to aquatic conditions, and to the various intermediate conditions (Roberts *et al.* 2000). These plants can be grouped under different communities based on factors such as floristic composition, structure and important environmental determinants.
- the richness and diversity of wildlife habitats. Floodplains include both aquatic and terrestrial habitats, making them highly productive and diverse ecosystems, often supporting large and diverse populations of plants and animals. For example:

- floodwaters retain and replenish wetlands, supporting the flora and fauna of floodplains and river systems
- following inundation, some floodplains become very important breeding areas (and their proximity to water promotes significant roosting and nesting areas at other times)
- floodplains with geomorphic features that retain water (e.g. billabongs) have several patches where surface water is prolonged, providing habitat for fish and birds (e.g. piscivores)
- underlying aquifers provide an alternative water source for deep-rooted species such as most floodplain trees and some shrubs.

Identification of Floodplain Functions

The ecological processes and ecosystem structures described above, enable floodplains to perform many functions. De Groot *et al.* (2002) identified 23 functions (under four categories) attributable to natural ecosystems (refer to Table 1).

Table 1 - Functions of natural ecosystems (adapted from de Groot *et al.* [2002])

Regulation functions	Supporting functions *	Production functions	Cultural functions **
gas regulation climate regulation disturbance prevention water regulation water supply soil formation soil retention nutrient regulation waste treatment pollination biological control	refugia function nursery function	food raw materials genetic resources medicinal resources ornamental resources	aesthetic information recreation cultural and artistic information spiritual and historic information science and education

* de Groot *et al.* (2002) refer to Habitat Functions. Others have used the term Carrier Functions.

** de Groot *et al.* (2002) refer to Information Functions.

Floodplains provide many (if not all) of these functions. However, a subset are considered to be key functions of floodplains (refer to Table 2).

Table 2 – Key functions of floodplains

Regulation functions	Supporting functions	Cultural functions
flood storage and conveyance groundwater recharge water filtration soil formation soil retention buffer protection micro-climate regulation greenhouse gas regulation water treatment	bird habitat fish habitat frog habitat floodplain vegetation	aesthetics recreation heritage

Valuation of Floodplain Functions

Services

The functions of floodplains (refer to Table 2) provide a range of both biocentric and anthropocentric services. Biocentric (or biological) services are those that benefit the plants and animals inhabiting the ecosystem (e.g. the provision of groundwater to floodplain vegetation). Anthropocentric services are those that directly benefit humans (e.g. the regulation of water supply quantity and quality).

Many services provided by floodplains have both biocentric and anthropocentric value. For example, Table 3 presents the services provided by the floodplain function – soil formation.

Table 3 - Services provided by soil formation

Anthropocentric	Biocentric
Enhanced soil structure	
Establishment of primary production activities	Establishment of floodplain vegetation communities
Improved soil fertility	
Improved productivity of: <ul style="list-style-type: none"> • horticulture • livestock and dairy • broadacre cropping • timber industries. 	Enhanced biodiversity compared with neighbouring areas

Value Measures

The capacity of a particular floodplain function to provide services depends on its processes and structures (de Groot *et al.* 2002). Therefore, to value the services provided by floodplain functions, the key ecological processes and ecosystems structures that enable the functions to occur must be identified and appropriate measures developed.

The selection of value measures should be based on:

- relevance to floodplain functions and floodplain management
- capability of differentiating between floodplains
- data that is spatially relevant and either accessible or cost effective to collect.

Table 4 presents possible approaches to measure the key functions of floodplains. These measures tend to fall under four categories:

- floodplain connectivity
- floodplain structure and condition (particularly vegetation)
- presence of particular threatened species/communities
- presence of social or cultural features.

A conceptual framework developed for floodplain valuation is detailed in Figure 1 with a worked example provided in Figure 2.

Table 4 – Possible measures for key functions of floodplains

Category	Function	Possible Measure
Regulation	flood storage and conveyance	floodplain connectivity
	groundwater recharge	floodplain topography groundwater use extent of vegetation cover floodplain soil type
	water filtration	extent and condition of wetland vegetation floodplain roughness
	soil formation	floodplain connectivity
	soil retention	percentage of floodplain exposed to water erosion
	buffer protection	width of floodplain vegetation continuity of floodplain vegetation
	micro-climate regulation	extent of vegetation cover
	greenhouse gas regulation	see note 1
	water treatment	see note 2
Supporting	bird habitat	presence of threatened species vegetation quality
	fish habitat	presence of threatened species vegetation quality
	frog habitat	presence of threatened species vegetation quality floodplain connectivity
	floodplain vegetation	vegetation conservation status vegetation condition
Cultural	aesthetics	landscape significance
	recreation	presence of infrastructure e.g. tracks, picnic grounds, sporting grounds, camping areas
	heritage	natural, indigenous and non-indigenous sites

note 1 - All floodplains should be recognised as potentially significant contributors to carbon sequestration and oxygen production.

note 2 - Floodplains that meet specific proximity and topography criteria may be considered as potential waste treatment areas through the development of constructed wetlands.

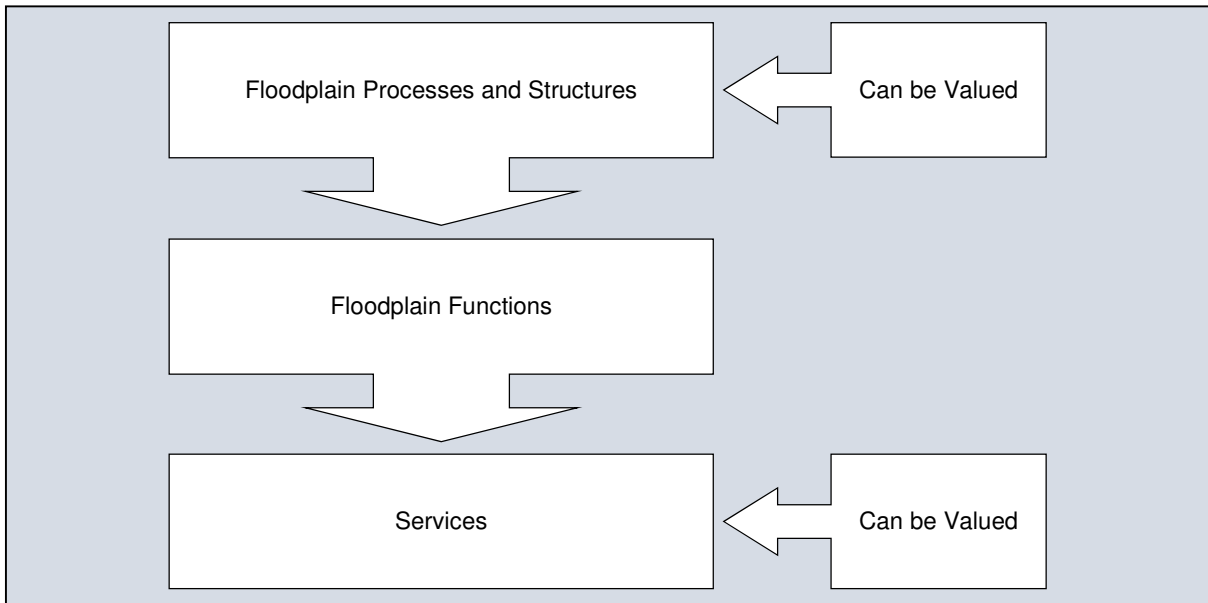


Figure 1 - Conceptual framework for floodplain valuation

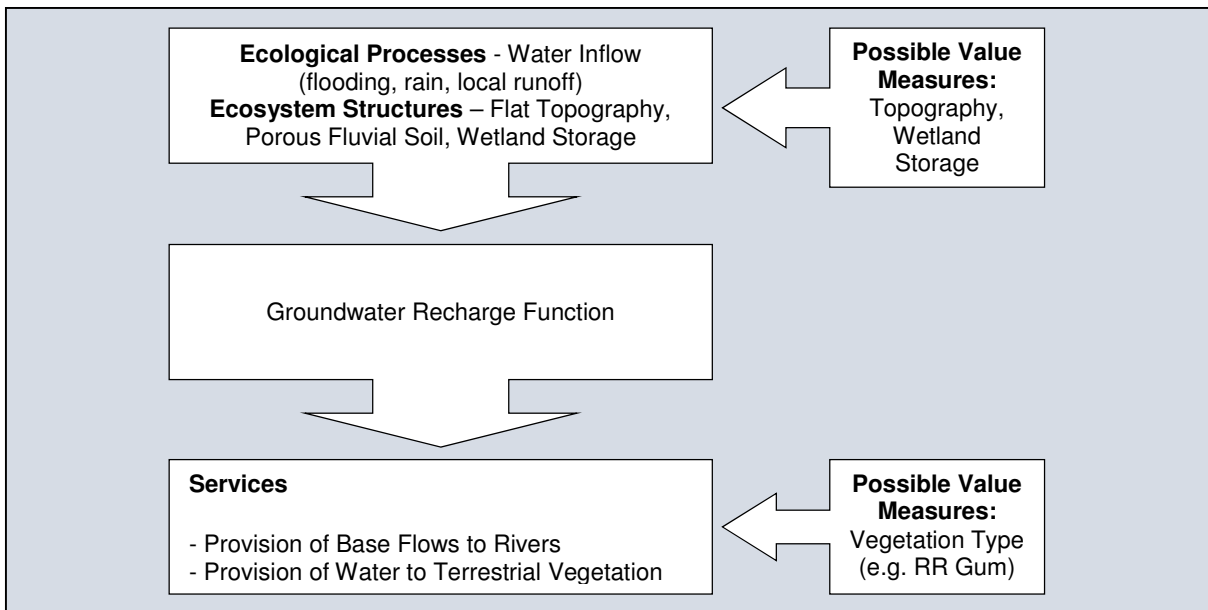


Figure 2 - Example for the groundwater recharge function of floodplains

Example 1 – Valuing Flood Storage and Conveyance

Flooding is a natural phenomenon of every river. Floods occur when flows generated by rainfall overtop the banks of a river, creek or constructed channel, or when the amount of runoff exceeds the capacity of underground drainage systems (Melbourne Water 2007).

Role of Floodplains

Floodplains have a fundamental role in managing the flow of water by providing natural storage areas where floodwaters can be retained and slowly released as stream heights recede (Melbourne Water 2007). This function is considered to be the primary natural function of floodplains (Natural and Beneficial Functions of Floodplains Task Force 2002) and can be described as a balance of inflows, storage and outflows.

Inflows

Roberts *et al.* (2000) and the Natural and Beneficial Functions of Floodplains Task Force (2002) refer to the following floodplain inflows:

- overbank flow i.e. excess stream flow that exceeds the capacity of the channel. River-sourced floodwaters are usually the dominant inflows to floodplains.
- surface runoff from the surrounding catchment. Local runoff can be a significant inflow in areas of high intensity and localised rain events.
- direct rainfall. As for surface runoff, these inflows can be significant in areas of high intensity and localised rain events.
- groundwater discharge. These are generally small for floodplains when compared to other inflow sources.

In general, inflows from surface runoff and direct rainfall occur more frequently than the larger inflows from overbank flows.

Storage

Once water has entered the floodplain, it can be retained in surface or sub-surface storages. Surface storages include wetlands, depressions and billabongs. In addition, the generally flat nature of floodplains can favour local ponding and flood detention (Natural and Beneficial Functions of Floodplains Task Force 2002) after the flood has receded.

The sub-surface storage of floodwater in soils and aquifers is enabled by the permeable nature of fluvial soils which promote infiltration (Natural and Beneficial Functions of Floodplains Task Force 2002).

Outflows

Roberts *et al.* (2000) and the Californian Department of Water Resources (2005) refer to the following floodplain outflows:

- surface outflows e.g. slow discharge back to the river as flood recedes. This is the dominant output following significant flooding of the floodplain.
- evapotranspiration i.e. losses to evaporation and plant water use (determining evapotranspiration losses is difficult due to the complex interaction between factors such as temperature, humidity, wind speed and vegetation).
- groundwater recharge e.g. percolation into aquifers. This is generally determined by the duration of flooding and is rarely the dominant output.

Provision of Services

The floodplain's natural capacity for flood storage and conveyance serves to reduce flood velocities and peak flows in the stream channel (Natural and Beneficial Functions of Floodplains Task Force 2002). This can result in a number of beneficial services as outlined in Table 5.

Table 5 - Services provided by flood storage and conveyance

Anthropocentric	Biocentric
Reduced flood peaks	
Reduced flood damage to downstream public/private infrastructure (number of structures and/or extent of damage) Reduced livestock losses (number) Reduced crop losses (area) Reduced financial cost (level of emergency response during flood event) Reduced financial cost (post flood recovery)	
Reduced flood velocities	
Reduced flood damage to downstream public/private infrastructure (number of structures and/or extent of damage) Reduced financial cost (post flood recovery)	Reduced erosion (and subsequent sedimentation of benthic habitats)

Approaches to Valuation

The frequency, duration and extent of flood events varies among different types of floodplains, depending on their hydrology, geomorphology and amount of floodplain development (Natural and Beneficial Functions of Floodplains Task Force 2002). Based on this insight, the following key ecological processes and ecosystems structures have been identified to value the flood storage and conveyance function:

- floodplain connectivity
- total area of floodplain
- total area of surface storage (wetlands etc.).

However, as storage capacity may be considered valuable regardless of the size of a particular floodplain, the valuation approach adopted for flood storage and conveyance has been simplified to an assessment of floodplain connectivity.

Connectivity between flood waters and the floodplain can be inferred by the presence/absence and degree of impact of the following:

- water regulation and extraction (which reduces the volume of water available to the floodplain)
- channel incision or modification (which reduces the ability of a stream to overtop its banks)
- actions taken to protect property from flooding, mostly by building levees
- infrastructure which cross and disconnect floodplains e.g. roads.

Table 6 proposes how these measures could be interpreted into value.

Table 6 - Valuing floodplain connectivity

High Value	Low Value
Little or no change in flooding magnitude or seasonality AND Stream channel in natural condition AND No levees or other infrastructure exist that disconnect the waterway from the floodplain	Significant reduction in flooding magnitude and seasonality OR Significant increase in stream channel cross-sectional area from natural OR Levees and/or other infrastructure exist that completely disconnect the waterway from the floodplain

Example 2 – Valuing Groundwater Recharge

When rain or snow falls on land, some of it evaporates, some flows to streams and rivers, and some seeps into the soil. Some of the water in the soil is used by plants but some continues to move further down until all the available pores and crevices in the soil and rock are full of water. This is known as the water table and this water is called groundwater (Department of Sustainability and Environment 2009).

This process of water inflow from the surface to groundwater is known as groundwater recharge (Australian Government 2009) and can be divided into two main types:

- diffuse recharge i.e. recharge derived from rainfall or flooding that occurs over large areas
- localised recharge i.e. recharge from rivers, lakes, wetlands and surface depressions (Bureau of Rural Sciences 2007).

Role of Floodplains

The relatively flat recharge areas of floodplains can trap and store surface water for longer, thus making them potentially significant contributors to the transfer of rainfall to groundwater. In addition, the often porous surface material of floodplains (e.g. sand/gravel alluviums) allow rainwater to seep through quickly to groundwater.

When there is a rapid rise in water level in a river (e.g. from a storm event or reservoir release), water can move from the stream into the streambank. The majority of this water returns to the river within a few days or weeks after the river level has dropped.

However, when the water level rise is sufficient to overtop the banks and cause flooding of the floodplain, widespread recharge can occur. This recharged floodwater can take weeks, months or even years to return to the river (dependent on the length of groundwater flow paths).

In addition to the diffuse recharge functions described above, floodplain features such as wetlands can also store floodwaters and local runoff for later substrate discharge.

Provision of Services

Groundwater is an important part of the environment. It flows into rivers and wetlands, often sustaining them during the summer months or in drought. Trees, shrubs and grasses may also rely on groundwater as their key source of water particularly during times of drought (Department of Sustainability and Environment 2009).

The ecosystems that require access to groundwater to maintain their health and vigour are known as Groundwater Dependent Ecosystems (GDEs). Eamus (2009) classified GDEs into two types:

- ecosystems reliant on surface availability of groundwater. Swamps, wetlands and rivers are ecosystems that rely on the discharge of groundwater (Eamus 2009). Rivers and streams that flow all year (perennially flowing) are generally groundwater dependent because a significant proportion of their daily flow is derived from groundwater discharging into the river course (Eamus 2009). This flow is known as base flow and can be a large fraction of annual runoff in rivers.
- ecosystems reliant on sub-surface availability of groundwater. These GDEs rely on the availability of groundwater below the surface but within the rooting depth of the vegetation e.g. riparian forests, floodplain eucalypts and plantation forests (Eamus 2009).

Beneficial services provided by groundwater recharge are shown in Table 7.

Table 7 - Services provided by groundwater recharge

Anthropocentric	Biocentric
Provision of base flows to rivers	
Water for primary production (stock water, irrigation) Water for urban supplies (i.e. drinking water) Water for industry Water for recreational pursuits e.g. fishing Attractive river landscapes (strong association between landscape value and presence of water)	Water for aquatic life (animal and plant) Water for other animals with aquatic habitat preferences Discharge of groundwater to rivers and wetlands Maintenance of pools during summer months
Provision of water to terrestrial vegetation	
Water for plantations (commercial, farm forestry, etc.) Attractive rural landscapes	Water for riparian forests Water for eucalypts on the floodplains

Approaches to Valuation

The key factors controlling groundwater recharge (as described by the Department of Sustainability and Environment (2009) and the Bureau of Rural Sciences (2007)) are:

- climate i.e. the amount and intensity of rainfall and evaporation
- recharge bed characteristics, including:
 - topography (in particular the slope of the land surface)
 - land use (particularly use of the groundwater resource)
 - vegetation cover (type and amount)

- soil properties i.e. the ability of the materials to transmit water
- existing soil moisture i.e. residual soil moisture stored in the soil profile from previous rainfall events
- depth to the water table.

Due to the dynamic nature of floodplains, some of these factors can vary significantly over time e.g. existing soil moisture, depth to groundwater, climate. As such, the following ecosystem structures and services were considered more temporally robust for floodplain valuation:

- topography
- groundwater use
- vegetation cover
- soil type.

Approaches to valuing these structures are discussed in the following sections. It should be noted that due to the strong inter-relationships between these factors (e.g. topography and soil type), determining groundwater recharge value may require a metric that links all components.

Topography

As infiltration is directly determined by flood duration (Roberts *et al.* 2000), flatter topographies (which tend to store water for longer periods than steep floodplains) are of greater value to groundwater recharge. Table 8 proposes how topography could be interpreted into value.

Table 8 - Valuing floodplain topography

High Value	Low Value
Relatively flat terrain* with high capacity to retain floodwaters	Relatively steep terrain* with minimal capacity to retain floodwaters i.e. the majority of floodwaters return to the stream once the flood peak has receded

* appropriate floodplain slope intervals to be determined

Groundwater Use

This measure refers to land use activities on the floodplain that can exploit the groundwater resource (e.g. pumping), limiting its potential to provide benefits to GDEs. Table 9 proposes how groundwater use could be interpreted into value.

Table 9 - Valuing floodplain groundwater use

High Value	Low Value
No groundwater extraction occurs on the floodplain	Intensive groundwater pumping operations occur on the floodplain

Vegetation Cover

Underlying aquifers are an alternative water source for deep-rooted species such as most floodplain trees and some shrubs (Roberts *et al.* 2000). If groundwater is found to be within the rooting depth of the vegetation we may reasonably conclude that the vegetation is using that groundwater (Eamus 2009). Therefore the key variables for vegetation cover are type (particularly Eucalypt species) and extent (i.e. proportion of floodplain). Based on these variables, Table 10 proposes how vegetation cover could be interpreted into value.

Table 10 - Valuing floodplain vegetation cover

High Value	Low Value
Floodplain vegetation in natural condition*	Floodplain vegetation extensively modified*

* need to determine appropriate intervals (% cover) to rank value

Soil Type

Whilst all soils are permeable materials with water being free to flow through the interconnected pores between the soil particles (Craig 1989), shallow groundwater recharge is known to be linked to particular soil permeability e.g. sandy soils (Roberts *et al.* 2000). Based on this information, Table 11 proposes how soil type could be interpreted into value.

Table 11 - Valuing floodplain soil type

High Value	Low Value
Highly permeable floodplain soils e.g. gravels, sands	Highly impermeable floodplain soils e.g. clay OR Floodplain surface is impervious e.g. urban housing, roads

Identification of Threats to Floodplain Functions

The IUCN-CMP (2006) defines threats as human activities or processes that have caused, are causing or may cause impacts to assets. Identification of human activities and/or induced processes that create threats is a key step in protecting and enhancing the functions of floodplains.

Based on the IUCN Unified Classifications of Direct Threats, the following key threats have been identified for floodplains:

- residential and commercial development
- agriculture and forestry
- recreational activities
- natural system modifications
- pest plants and animals
- pollution
- severe weather.

Residential and Commercial Development

New urban developments or other non-agricultural land uses can impose substantial footprints on the environment and in particular, the natural functions they provide. For floodplains, these developments include:

- urban, commercial and industrial areas. Development of 'greenfield' sites on floodplains without consideration of ecological processes and ecosystem structure can impact a number of beneficial functions, including:
 - habitat. Urbanisation often replaces natural vegetation, wetlands and depressions with streets, parking lots, houses and drains.
 - flood storage and conveyance. Extensive filling of the floodplain, which is often related to urbanisation, removes the flood storage capacity and blocks the natural conveyance properties of floodplains, which can lead to increased flooding (Natural and Beneficial Functions of Floodplains Task Force 2002).
 - groundwater recharge. The increase in impervious surfaces reduces infiltration and increases runoff.
- recreation areas. Floodplains enable recreational pursuits by providing large, open spaces. However, establishment of these sites can alter the natural habitat of floodplains, particularly if vegetation is removed/simplified or the surface is levelled e.g. to remove shallow, ephemeral wetlands.

Agriculture and Forestry

Inappropriate and/or unsustainable use of floodplain resources can impact on the natural functions of floodplains. Key threat types identified under agriculture and forestry, include:

- cropping and horticulture. Cropping and horticulture can significantly alter the floodplain landscape and consequently, limit the value of floodplain functions. For example, to increase available productive land:
 - native vegetation may be removed, resulting in reduced habitat availability and floodplain roughness
 - wetlands may be drained, resulting in reduced habitat availability, flood storage capacity and groundwater recharge.
- forestry. When properly managed, forestry operations can assist the natural functions of floodplains (e.g. greenhouse gas regulation, micro-climate regulation, buffer protection, water filtration, bird habitat). However, forestry practices such as large scale clear-felling can result in negative impacts to floodplains.
- livestock farming. Livestock farming (particularly dryland grazing) is potentially the least invasive productive use of floodplains. However, activities that lead to overgrazing, soil compaction etc., can result in significant impacts to both the regulation and supporting functions of floodplains.

Recreational Activities

The level of impact recreational activities have on the floodplain environment depends largely upon the characteristics of the floodplain (i.e. vegetation, soils) and the type and intensity of the recreational use (Natural and Beneficial Functions of Floodplains Task Force 2002).

In addition to formal recreation activities provided by golf courses and sporting ovals, floodplains can be utilised for a number of informal pursuits including mountain biking, bird watching, hiking, dog walking etc.

These activities can harmonise with the floodplain if planned and maintained appropriately. However, unstructured and/or inappropriate activities have the potential to alter, destroy and disturb habitats and species.

Natural System Modifications

Threats under this category relate to changes to natural processes and are the result of actions aimed at protecting or enhancing the lives of human.

Key threat types identified for floodplains include:

- water storages. The high year-to-year and within-year variability of rivers in most Victorian catchments means that large reservoirs are necessary to even out the fluctuations in river flow to provide a continuous and reliable water supply to towns and farms (Department of Sustainability and Environment 2008). However, these reservoirs can have profound effects on floodplains through reductions in inundation frequency and/or extent which in turn can impact the key ecological process in the development and maintenance of floodplains i.e. natural flood inundation.
- flood control works - channelisation. Channel deepening and straightening can reduce flooding in the immediate area of the channel, but can also aggravate flood heights and velocities, and erosion downstream. Channelisation can also eliminate or reduce floodplain functions by lowering water levels, effectively disconnecting the floodplain from the stream, reducing the retention of water in wetlands, decreasing habitat diversity, and destroying riparian vegetation (Natural and Beneficial Functions of Floodplains Task Force 2002).
- flood control works - levee banking. Levees often have similar impacts on the floodplain as channelisation. Levee systems create drier conditions on the protected floodplain, which may contribute to the loss of wetlands. Levees also typically raise the water surface elevation on the river side during flood conditions, causing further inundation that can lead to soil, vegetation and habitat loss (Natural and Beneficial Functions of Floodplains Task Force 2002).
- stormwater/drainage schemes. Specific works undertaken to contain, detain, convey or treat stormwater include the building and operating of infrastructure such as drains, levees, retarding basins and wetlands. These works, whilst important from a stormwater management perspective, can have significant impacts on floodplain wetlands e.g. conversion of boggy meadows into stormwater quality wetlands; loss of wetlands through drainage; or isolation of wetlands by levee banking.

Pest Plants and Animals

Pest (invasive) plants, or weeds, can pose a serious threat to floodplain biodiversity. They contribute to land and water degradation and can significantly impact native flora and fauna populations.

Pest animals can also pose a serious threat to biodiversity. They contribute to the loss of native animals (through competition for food and habitat, direct predation and the spread of disease) and can significantly disturb native vegetation.

Pollution

Pollution threats to floodplains include:

- urban stormwater. The increased volume of run-off from urban areas carries with it significant pollutant loads such as oils and sediment from roads, fertilizers and pesticides from lawns and golf-course, and organic matter. If these pollutants enter aquatic environments within the floodplain, they can be lethal to fish and other aquatic organisms e.g. by lowering dissolved oxygen or releasing toxins.
- agricultural and forestry effluents. Key pollutants from agriculture and forestry can include biocides (e.g. herbicides, insecticides) and sediments. These pollutants can enter aquatic environments within the floodplain via spray drift or surface runoff.
- gross pollutants. Gross pollutants refer to rubbish and other solid materials (e.g. litter from pedestrians, vehicles, waste collection systems, construction sites) or organic materials (e.g. leaf-fall from trees, lawn clippings). These pollutants can impact the aesthetic appeal of floodplain environments and can also result in fauna fatalities from eating and choking on the material (Environment Protection Authority 2006).

Severe Weather

Two specific climatic events have been identified that can potentially impact floodplain functions:

- droughts. The reduction in wetland and terrestrial inundation can lead to habitat degradation which in turn can result in flora and fauna decline. For example, Bond *et al.* (2008) note that droughts in large floodplain rivers can result in a decline in aquatic biota living in billabongs (from low oxygen levels and high water temperatures) and the death of floodplain vegetation e.g. River Red Gums.
- extreme flood events. Whilst flooding is the key natural process that creates, develops and maintains a floodplain, increases in frequency and severity of extreme flood events (e.g. flash floods) can impact floodplain functions, particularly soil retention (as rapid floods tend to scour rather than replenish).

Concluding Remarks

Human population growth and urban development pose ongoing threats to floodplains, either directly (e.g. occupation, drainage) or indirectly (e.g. stormwater, habitat fragmentation).

By identifying and valuing the natural functions of floodplains (and the range of biocentric and anthropocentric services they provide), floodplain managers can more fully assess and evaluate flood risks and identify opportunities to:

- mitigate flood risks through non-structural measures
- protect and restore floodplains.

Acknowledgements

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