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Tasmania

Aquatic Ecology of Rivers in the Jordan Catchment

A report forming part of the requirements for State of Rivers reporting

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The Department of Primary Industries, Water and Environment

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The Water Resources Division provides a focus for water management and water development in Tasmania through a diverse range of functions including the design of policy and regulatory frameworks to ensure sustainable use of the surface water and groundwater resources; monitoring, assessment and reporting on the condition of the State's freshwater resources; facilitation of infrastructure development projects to ensure the efficient and sustainable supply of water; and implementation of the *Water Management Act 1999*, related legislation and the State Water Development Plan.

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GLOSSARY

Anadromous refers to fishes which migrate from saltwater to freshwater to spawn

Diadromous refers to fishes that migrate freely between freshwater and saltwater in either direction.

Macroinvertebrate animals without a backbone which can be seen with the naked eye. In rivers, common macroinvertebrates include insects, crustaceans, worms and snails.

Riparian of or on the river bank

1. Introduction

This report deals with aspects of the aquatic ecology of the Jordan River and associated tributaries. It provides a brief overview of the freshwater fish fauna found in the catchment and some detail of the habitat requirements and potential threats to particular native fish species in the Jordan catchment. The main focus of this report details work carried out in the Jordan catchment in 1999 using AUSRIVAS (**Aus**tralian **Riv**er **A**ssessment **S**ystem) to assess river health using macroinvertebrates as a bio-indicator. These models are comprehensive in their development and allow a relatively rapid assessment of riverine health of specific sites along the river and its tributaries. Sites in the Jordan catchment were examined in respect to potential impacts of water quality and habitat degradation on aquatic macroinvertebrate communities.

The Jordan catchment occupies an area of approximately 124,600 hectares (North, 1999) and the river is the outflow of Lake Tiberias. From Lake Tiberias, it flows in a northwesterly direction until Burnt Log Gully where it then flows in a southerly direction for about 80 km through Melton Mowbray, Broadmarsh and Brighton to enter the Derwent Estuary near Bridgewater (Fig. 1a). The Jordan River is classified by Hughes (1988) as a Group 2 river in terms of hydrology. This group includes rivers in the drier regions of the southeast of the state and the hydrological characteristics of these rivers are comparable with semi arid rivers of mainland Australia. Rivers in this group are characterised by low mean annual runoff, low annual rainfall and the greatest variability in terms of monthly flows.

The Jordan catchment is characterised by an upper catchment that consists predominantly of native forest and a lower catchment that has a long history of agricultural use (North, 1999). In the lower reaches, North (1999) found that the riverbanks of the Jordan River and major tributaries are substantially degraded with few sections retaining intact native riparian vegetation with the extent of weed infestation, notably willows posing a significant management problem. The riparian vegetation of the middle to lower reaches of the catchment consists mainly of crack willow (*Salix fragilis*) and gorse (*Ulex europaeus*) with some remnant native vegetation. Many sections of the river are cleared of riparian vegetation with pasture grass adjacent to the riverbanks.

Askey Doran (1993) surveyed the Jordan River and identified 2 significant aquatic plant communities:

1. *Isolepis fluitans – Ranunculus amphitrichus* aquatic herbland

This community is widespread in the Southern Midlands and is commonly found in water up to a metre in depth, mainly in pools, but also in slow flowing water usually on a substrate of silt or a silt /rock matrix (Askey Doran, 1993). Askey Doran (1993) outlined the key management issue for this community as exposure to adjacent agricultural practices, which may result in increased nutrient sediment and water inputs.

2. *Potamogeton tricarinatus –Triglochin procera – Isolepis fluitans* aquatic herbfeild.

This community was found in areas adjacent to disturbed and /or grazing land in water depths up to 0.5m predominantly in slow flowing pools. The community is widespread and Askey Doran (1993) suggests that this community may be an artifact of the surrounding land use. However he stresses that native species still occur as the dominants and as such are important components in a largely altered landscape. Grazing, fire and exotic plant species all place pressures on this community.

2. Freshwater Fish

There have been no recent surveys of the fish communities of the Jordan River. A survey was carried out in 1976 by Lake and Bennison (1977), and surveys have been carried out by the Inland Fisheries Commission on a sporadic basis (Stuart Chilcott, Inland Fisheries Service, personal communication). There are 8 freshwater fish species found in the Jordan Catchment (Table 1), three of which are introduced species. Most of these species are common and have a Tasmania-wide distribution, although some native fish species are perceived to be rare in the Jordan River.

Table 1: Freshwater fish of the Jordan Catchment

Life History: M = migrates to and from sea or estuary, NM = freshwater only

Habitat: R = rivers, L = lake, W = wetlands

Common Name	Scientific Name	Life History	Habitat
Native Fish			
Short-finned eel	*Anguilla australis*	M	R/L/W
Jollytail	*Galaxias maculatus*	M	R/L
Spotted galaxias	*Galaxias truttaceus*	M	R/L
Tasmanian smelt	*Retropinna tasmanica*	M	R
Sandy flathead	*Pseudaphritis urvillii*	M	R
Introduced Fish			
Tench	*Tinca tinca*	NM	R/L/W
Redfin	*Perca fluviatalis*	NM	R/L/W
Brown Trout	*Salmo trutta*	M	R/L

Taken from Lake and Bennison (1977)

Salmo trutta Linnaeus (Brown Trout) is an introduced species and was introduced to Tasmania in 1864 where it is now common in most of the states lakes and rivers. This species forms the basis of an extensive state recreational fishery and is common in the Jordan River. Anecdotal evidence suggests that the trout fishery in the Jordan River has declined over the last 20 years and this may be attributable to the decline in instream habitat for this species over this period. Some ecologists have suggested that this species has had a deleterious effect on native fish populations particularly galaxiid species (Tilzey, 1976; Jackson, 1981) which may account for the decline of galaxiid populations in the Jordan catchment.

Perca fluviatalis Linnaeus (Redfin perch) and *Tinca tinca* Linnaeus (Tench) are exotic species and were both introduced to Tasmania in the mid-19th century. Both species inhabit lakes and slow flowing rivers and are abundant in the Jordan River.

Tench are commonly found in sluggish or still waters particularly where there is a muddy bottom and extensive weed growth, and is often found amongst weed or in deep sheltered holes. This species is tolerant of low oxygen levels, warmer water and brackish conditions. Spawning occurs in late spring and early summer, when water temperatures reach 16 ^{o}C. Eggs are small and laid in shallow water, either amongst aquatic plants or on the bottom in clumps and are released in several separate spawnings at about two or three week intervals.

P. fluviatalis is locally abundant in eastern and southern Tasmania and inhabits still and slow flowing waters in especially in dense beds of aquatic vegetation. Spawning occurs in spring with thousands of eggs laid among aquatic plants and submerged logs. This species has been thought to be a predator of native fish species such as pygmy perch (not present in the Jordan) (Faragher & Lintermans, 1997). Populations tend to become very dense and in some localities, redfin have been blamed for the decline of previously healthy trout populations.

Retropinna tasmanica McCulloch (Tasmanian smelt) is endemic to Tasmania. It occurs in the lower reaches of coastal rivers and streams and is locally common in riverine habitats. Little is known of the specific habitat requirements of this species. It is probably anadromous and enters coastal rivers during spring as part of the Tasmanian whitebait run. Spawning probably takes place in the lower reaches of rivers on sandy beds. Once larvae have hatched they go to sea where the majority of growth and development takes place. This species is likely to be extremely rare in the Jordan River as changes in landuse, effects of clearing of riparian vegetation and subsequent willow infestation would have severely degraded the in-stream habitat historically used by this species.

Psuedaphritus urvilli Cuvier and Valenciennes ('Sandy' or 'Freshwater flathead') is primarily an estuarine species that is common in the lower reaches of rivers. This species is widespread and abundant and is usually found on the beds of slower flowing rivers partly buried among rocks and under sunken logs and overhanging banks. Knowledge of spawning patterns is limited although adult fish are thought to migrate from the upper reaches down to the estuaries to spawn during autumn and winter. This species is abundant and populations would be common in the lower reaches of the Jordan River.

Galaxias maculatus Jenyns (common jollytail) and *Galaxias truttaceus* Valenciennes (spotted galaxias) are members of the Family Galaxiidae (one of the largest families in the Australian freshwater fish fauna).

G.truttaceus is widely distributed in Tasmania and landlocked populations also occur in some inland Tasmanian lakes. This species is defined as locally abundant on a statewide basis but its geographical range has probably been impacted by land clearing in some areas (Fulton, 1990). It is found in rivers of low elevation where it inhabits pool habitats, most often in marginal cover, under logs or overhung banks. River populations spawn in autumn and winter and are thought to undertake a downstream spawning migration. Newly hatched larvae are swept to sea and return to rivers as whitebait juveniles during spring as part of whitebait migrations.

G.maculatus is widespread in Tasmania in rivers at low elevations. Fish commonly form schools in still or gently flowing streams. Adults migrate downstream on new or full moons in autumn and spawn amongst terrestrial vegetation on the margins of river estuaries when inundated at high spring tides. The adults mostly die after spawning. The eggs hatch when the water returns and re-inundates the vegetation and the larvae go to sea for the winter and migrate back as juveniles. They re-enter rivers in large schools on rising tides and move upstream into adult habitats to feed and grow. This species is suggested by Fulton (1990) as forming significant food for brown trout and other predatory fishes inhabiting lowland rivers and estuaries during the spring and summer.

Anguilla australis (short finned eel) is native to Tasmania and is widespread and common throughout most of the state, although its distribution is now disrupted by major dams on many rivers (Fulton, 1990). In rivers it is found in slow flowing sections or quiet rocky pools and the species is common in still water habitats in the Jordan River.

It is likely that many native fish species populations have declined in the Jordan River. *T.tinca*, *P.fluviatalis* and *A.australis* would be expected to be the dominant fish species in many reaches. These species are tolerant of degraded instream habitat and flourish in the slow flowing macrophyte dominated reaches of the river. Given large-scale changes in land use, vegetation clearance and willow infestation and associated impacts of these on instream habitats of the Jordan River, *G.maculatus*, *G.truttaceus* and *R.tasmanica* would be expected to be rare. In addition, the construction of dams and weirs can have a significant effect on fish species which have a freshwater and marine stage in their lifecycles by acting as barriers preventing fish from migrating back upstream to their spawning sites (North, 1999). These barriers may also contribute to the decline of these native fish in the Jordan River.

3. Endangered Species

A species is regarded as “endangered” if it is in danger of extinction because long-term survival is unlikely while the factors causing them to be endangered continue operating. At present, no aquatic fauna are listed as endangered in the Jordan catchment (Bryant & Jackson, 1999). Four threatened terrestrial fauna species are known to occupy habitat within the Jordan river catchment area and four others are likely to occur there as suitable habitat is present in the catchment area (North, 1999). According to North (1999), the Green and Gold Frog, which is listed as “vulnerable” could potentially occur in still water habitats in the south of the catchment in areas where there is a good cover of aquatic vegetation.

The Green and Gold frog (*Litoria raniformis*) occurs in localised parts of Tasmania. The species is listed as “vulnerable” under Tasmania’s *Threatened Species Protection Act 1995* and individuals are found in lowland areas, predominantly in the Northeast coastal areas. It is estimated that the range of this species has contracted by over 50% in the last 20 years. Green and Gold frogs live in or near permanent or temporary waterbodies such as streams, swamps, vegetated pools and farm dams (Bryant &Jackson, 1999). The waterbodies are usually dominated by plants such as *Triglochin procera,* or species of juncus and sedge. They spend most of their time on the ground among vegetation or at the edge of water and are rarely seen in open water (Bryant &Jackson, 1999). They are dependent on permanent freshwater for breeding and ideally prefer sites that are shallow with diverse vegetation. Key threats to their habitat include:

- Loss of wetland habitat by drainage and clearance for pasture;
- Weed invasion;
- Pollution, overgrazing and trampling of waterbodies by stock;
- Pollution by pesticides, fertilisers and effluent;
- Collection for use as fish bait.

Bryant and Jackson (1999) list the following key recommendations for habitat management to protect this species:

- Protection of wetlands by prevention of drainage or the drawing of water for other purposes;
- Consideration of long term protection for frog habitat via the establishment of a wildlife sanctuary or management agreement;
- Prevent clearing of native vegetation buffers;
- Re-establishment of native riparian vegetation;
- Appropriate willow removal (see Bryant & Jackson, 1999);
- Prevention of removal of instream and riparian woody debris;
- Fencing and reduction of stock access and grazing in wetlands;
- Appropriate and ecologically sensitive use of chemicals and fertilisers (see Bryant & Jackson, 1999);
- Appropriate design of culverts, weirs and dams (see Bryant & Jackson, 1999).

4. River Health

Methodology

The Monitoring Riverine Health Initiative (MRHI) was formed in 1993 by the Australian Government to provide a means of assessing the ecological condition of Australia’s river systems. The MRHI in Tasmania commenced in 1994 and the programs primary objectives were to develop predictive models to allow assessment of river health using macroinvertebrates as biological indicators. Over 300 reference sites around Tasmania were sampled in order to build the bioassessment models. Sites visited are either classified as reference or test sites. Reference sites are defined as sites that are least disturbed and are suitable for use in the construction of predictive models. Test sites are those sites defined to be of importance in assessing the condition of a river known or thought to be experiencing an impact from water quality or habitat degradation.

In 1999, 19 test sites were visited on the Jordan River and associated tributaries (Table 2) (Fig. 1a and Fig. 1b). These sites were sampled in two seasons (autumn and spring) and it was originally intended to sample two habitats at each site (riffles and edgewaters). In both seasons at all sites except two, only edgewater habitats were available for sampling. The purpose of the study was to provide a snapshot condition of river health in the Jordan Catchment for these two seasons. The coverage of sites was intended to encompass most sites surveyed in the Water Quality Assessment for this 'State of Rivers' report and corresponding sites in both studies have been assigned the same site number for comparison of aquatic ecological data to water quality data.

The autumn sampling took place from the 3/5/99 to 11/5/99. Of the 19 sites selected, only 15 were sampled, as 4 sites were dry (Table 2). Sampling in spring took place from 27/9/99 to 8/10/99 and of the 19 sites visited, only 16 were sampled as three were dry (Table 2). Riffle habitats are not common on the Jordan River and only two riffle habitats were sampled in autumn and only one riffle habitat was sampled in spring. For the purposes of this report, the river health of riffle habitats will not be discussed further.

As a comprehensive description of sampling protocols is given in CEPA (1994) and extensive discussion of the development of river health models Tasmania is already provided by Oldmeadow *et al*. (1998), a detailed description of both of these procedures will not be given here. Essentially, sampling was carried out by collecting invertebrates from a 10 metre section in either a riffle/edgewater habitat using a kick net. The macroinvertebrates from the net were then emptied into a tray and then picked from the tray for up to an hour. These macroinvertebrates were then identified in the laboratory to family level and the resulting data on macroinvertebrate taxa is then entered into AUSRIVAS.

AUSRIVAS modeling

The biological monitoring package AUSRIVAS (Australian River Assessment System) was used to provide a broad scale picture of the health of sites in the Jordan catchment in spring and autumn 1999. The model AUSRIVAS essentially compares the observed taxonomic composition of the macroinvertebrate community at a site with the expected composition if the site were unimpacted. Each site is classified into four categories based on the ratio of macroinvertebrates "Observed" (or sampled) to the macroinvertebrates "Expected". This ratio is known as the observed / expected score or "O/E". Table 3 presents the categories used and the O/E ratio ranges for each cut off.

Code	Name	Easting	Northing	Autumn 1999 Sampling Date	Rating	Spring 1999 Sampling Date	Rating
J24	Jordan/ Pontville Ford	521800	5273150	11-05-99	B	08-10-99	*
J6	Jordan/ Elderslie Rd	514800	5274100	06-05-99	B	27-09-99	*
J7	Jordan/ Andersons Rd	508950	5279950	06-05-99	B	28-09-99	*
J10	Jordan/ Clifton Vale Rd	507200	5289400	05-05-99	C	28-09-99	B
J11	Jordan/ Mauriceton	510100	5291500	05-05-99	B	28-09-99	A
J15	Jordan/ Apsley	512000	5303000	03-05-99	B	05-10-99	B
J23	Jordan/ Black Bridge	515800	5311900	04-05-99	B	06-10-99	B
J25	Jordan/ Jericho	524100	5208100	03-05-99	B	06-10-99	B
J2	Strathallan Rt/ Tea Tree	526300	5272500	11-05-99	B	27-09-99	B
J3	Tea Tree Rt/ Back Tea Tree Rd	525825	5271300	06-05-99	DRY	27-09-99	DRY
J26	Strathallan Rt/ u/s Golf Course	522600	5273600	11-05-99	B	27-09-99	B
J27	Bagdad Rt. u/s Golf Course	522400	5273850	06-05-99	C	27-09-99	B
J6a	Grahams Ck./ Elderslie Rd	509400	5279400	06-05-99	A	28-09-99	B
J8	Green Valley Rt./ Cockatoo Valley Rd	508600	5281400	06-05-99	C	28-09-99	B
J12	Quoin Rt./ Midlands Hwy	514600	5296650	05-05-99	DRY	05-10-99	DRY
J14	Donnybrook Rt./ Den Rd	511600	5299100	03-05-99	DRY	05-10-99	DRY
J28	Jordan/ Burnt Log Gully	520900	52125800	04-05-99	B	06-10-99	B
J19	Exe Rt./ Exe Sugarloaf	518300	5314700	04-05-99	C	06-10-99	B
J20	Dulverton Rt./ Bowhill Rd	525000	5315555	04-05-99	DRY	06-10-99	DRY

Table 2: List of sites visited in the Jordan catchment including location, date of sampling and river health rating.

Ratings are as follows

Category: '-' - Not sampled

'*' - Outside the experience of the model

A – Equivalent to reference

B - Significantly impaired

C – Severely impaired

Figure 1a River health ratings for sites sampled in Autumn 1999

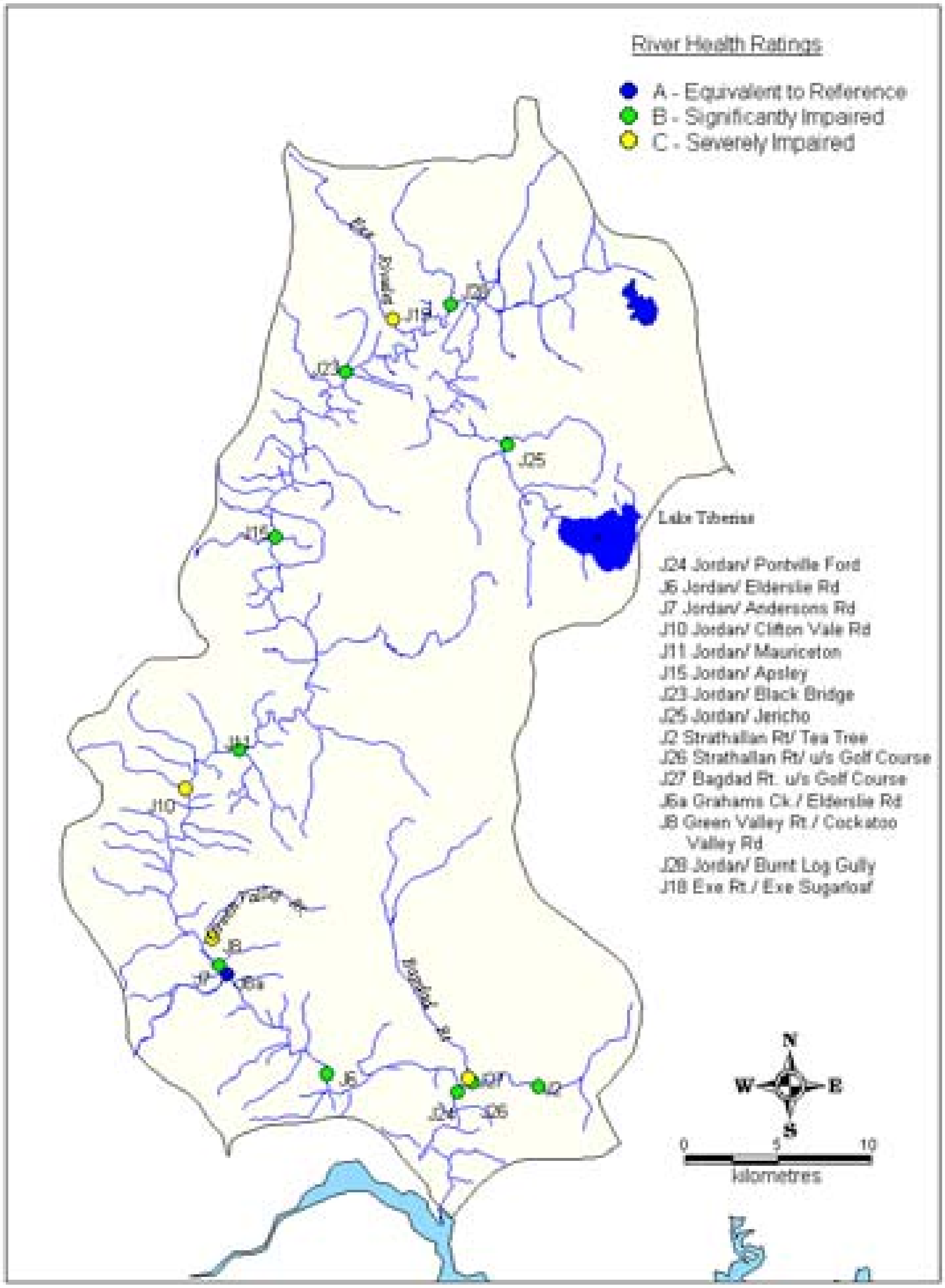

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Figure 1b River health ratings for sites sampled in Spring 1999

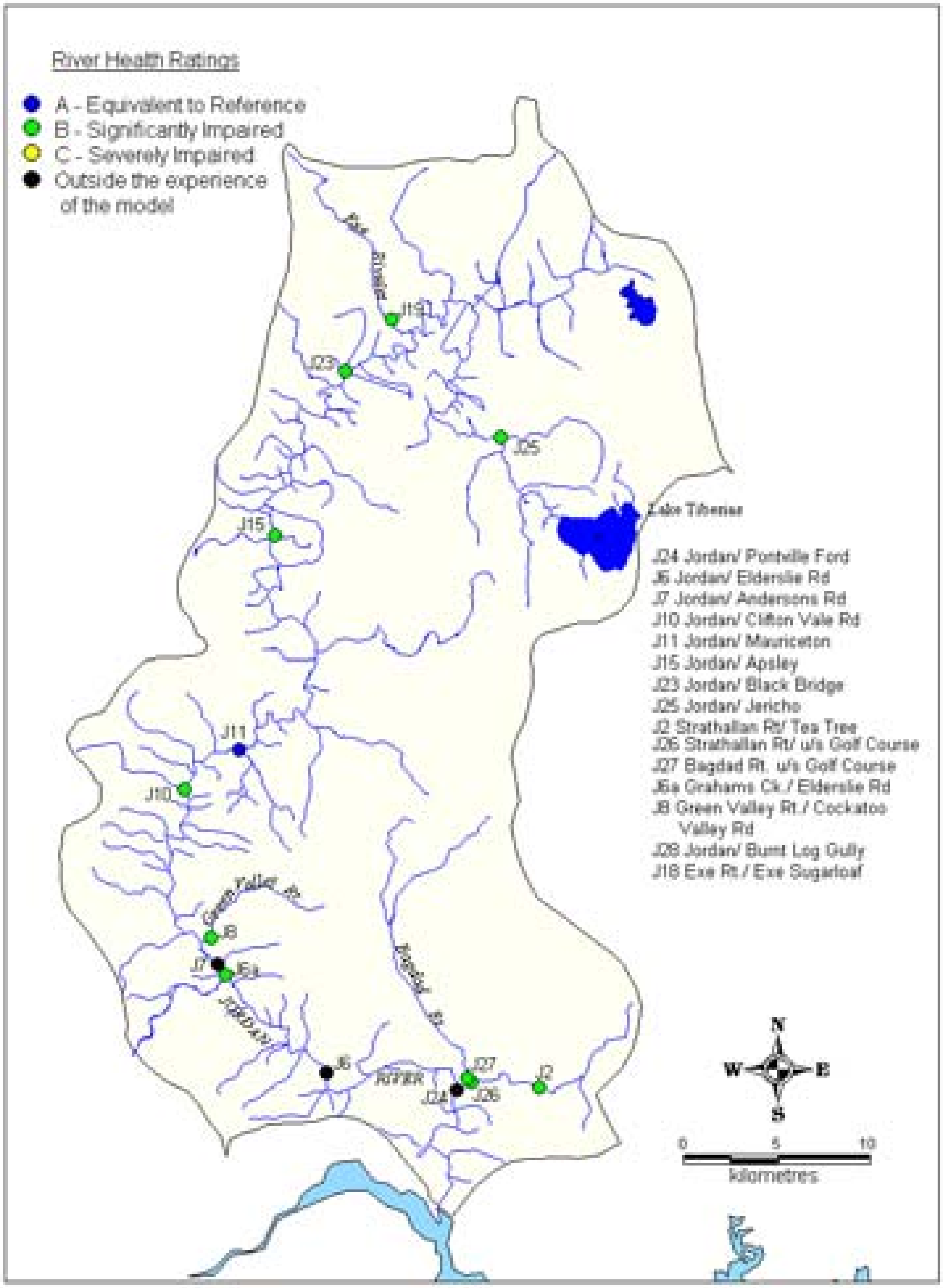

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Table 3: River Health categories and associated O/E scores

Site Status	Class	O/E
Equivalent to Reference	A	> 0.89
Significantly impaired	B	0.70-0.89
Severely impaired	C	0.41-0.69
Impoverished impaired	D	<0.41

The O/E ratio represents the percentage of taxa sampled at a site. From the above table, a site with less than 41 percent of the taxa expected to be present at the site is considered to be severely impaired, and falls within the 'D' band classification. The advantages of these river health models are that not only the presence of an impact but also the magnitude can be determined for a specific site.

A biotic index (SIGNAL, **S**tream **I**nvertebrate **G**rade **N**umber **A**verage **L**evel, (Chessman, 1995)) is incorporated into the model output in the form of a ratio of the observed SIGNAL score (or that sampled) to the expected signal score. The index is based on the sensitivity of macroinvertebrates to common types of pollutants. Each family of macroinvertebrates is assigned a grade according to their tolerance, where the "observed" SIGNAL score is the sum of the grades divided by the number of taxa collected and the "expected" score is the sum of the grades divided by the number of taxa expected. The biotic index is sensitive to water quality and combined with the O/E ratio provides an insight into the nature of the disturbance or impact. OESIGNAL emphasises the effects of water quality on the fauna whereas O/E reflects a wide variety of impacts including habitat degradation as well as reduced water quality.

Identification of Macroinvertebrates

All macroinvertebrates were identified to family level, with the exception of Chironomids which were identified to sub family. A total of 52 families were identified from edgewater habitats in autumn and 51 families in spring. The five most dominant families in edgewater habitats in autumn were Ceinidae (mayflies), sub family Chironominae (midges), Leptoceridae (caddisflies), Planorbidae (freshwater snails) and Coenagrionidae (dragonflies). The five most dominant families in edgewater habitats in spring were Ceinidae, sub family Chironominae, Corixidae (aquatic bugs), Leptoceridae and Baetidae (mayflies). The majority of these taxa are typical of macroinvertebrate communities that inhabit slow flowing or still waters usually in silty habitats or habitats dominated by aquatic macrophytes. Insects were the most dominant, representing around 80% of the total number of taxa collected and accounting for 70% of the total number of individuals collected.

Results

The location of sites visited in the Jordan catchment and associated ratings of river health for autumn and spring are presented in Table 2. These ratings are graphically illustrated by plots of the O/E scores against the ratio of the SIGNAL scores (OESIGNAL) for edgewater habitats in autumn and edgewater habitats in spring and are presented in Figs. 2a and 2b respectively. Maps of river health ratings in each season are presented in Fig. 1a and 1b. The following section interprets river health bands in terms of potential water quality or habitat degradation impacts and relates these health ratings to the riparian and instream habitat characteristics of each site. Sites have been grouped as either mainstream or tributary sites and each site is discussed individually.

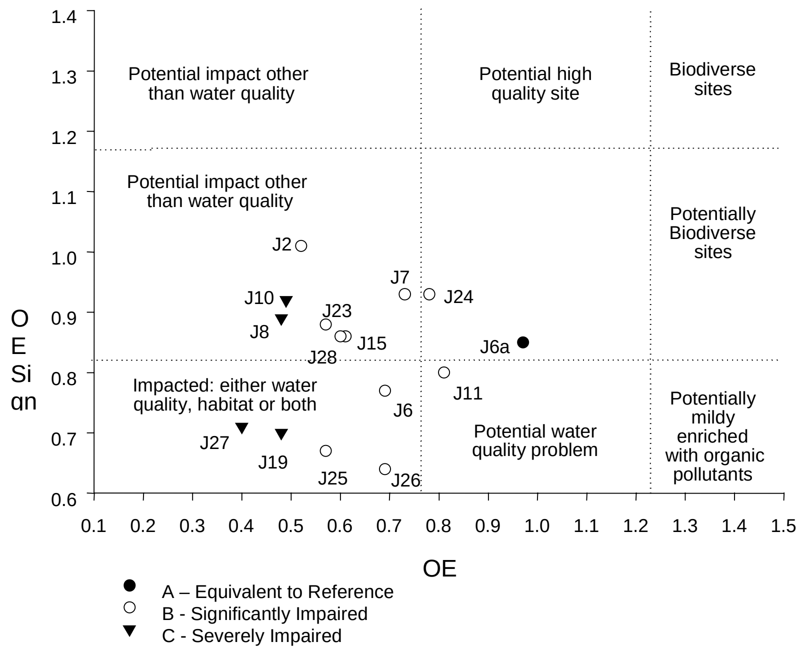

Figure 2a: Plot of O/E50 and OESIGNAL for edgewater habitats in autumn 1999 in the Jordan catchment.

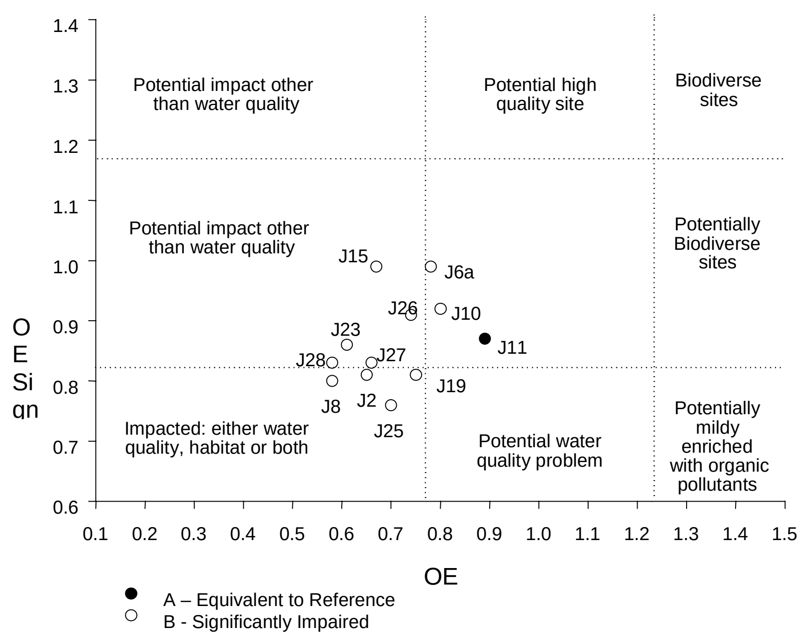

Figure 2b: Plot of O/E50 and OESIGNAL for edgewater habitats in spring 1999 in the Jordan catchment.

Jordan Catchment Tributaries

Six tributary sites were sampled in the autumn and spring of 1999. Only edgewater habitat results are discussed in this section.

Strathallan Rivulet at Tea Tree (J2)

In autumn, the river health at this site was found to be significantly impaired. Its location on both axes in Fig. 2a indicates that the impact on macroinvertebrate communities is by habitat degradation. In spring the site is also significantly impaired although the site is impacted either by water quality, habitat degradation or a combination of both. The riparian and instream habitat at this site is highly degraded. The site is adjacent to a road with little to no riparian vegetation and is subject to periods of low flow in autumn. Potential water quality impacts in both seasons may also contribute to poor river health. High conductivity levels were measured in both autumn (2190 μS/cm) and spring (2140 μS/cm). High Total Nitrogen was measured in autumn (1140 μg/L) and high pH was measured in both seasons (autumn: 8.39, spring: 8.63). The degradation of water quality may be attributable to runoff from the adjacent road during rain events and contribute to the impairment of river health at this site in both seasons.

Strathallan Rivulet upstream of the golf course (J26)

In autumn the river health at this site is rated as significantly impaired by either water quality habitat degradation or both. As the site plots very low on the OESIGNAL axis, the impact is probably more related to water quality. In spring, river health is also significantly impaired, although impacts appear to be related more to habitat degradation. Very high conductivity was measured in this reach on both sampling occasions (>2500 μS/cm) and is likely to contribute to the significant impairment of river health at this site.

Bagdad Rivulet upstream of the golf course (J27)

The river health at this site is severely impaired in autumn by habitat degradation. In spring, river health is rated as significantly impaired by water quality, habitat degradation or both. This site is cleared of woody riparian vegetation and this may lead to increased runoff and sedimentation. Absence of overhead riparian vegetation would also increase light levels through a lack of shading and result in high water temperature in this reach during the summer months. The site is adjacent to the golf course and it is likely that fertilisation and watering of the greens leads to elevated nutrient levels in runoff water. The bore water used for watering course greens was found to be high in nitrogen and phosphorous (unpublished water quality data, MRHI).

Grahams Creek at Elderslie Road (J6a)

In autumn the river health at this site was rated as equivalent to reference, although the location of this site on both axes is close to the boundary of a potential water quality impact (Fig 2a). In spring, river health is rated as significantly impaired. The reasons for this rating is unclear although it is close to the boundary of a potential impact of habitat degradation. The riverbanks at this site are highly eroded and subject to high stock access. The reach is largely cleared although some pockets of crack willow (*S.fragilis*) and hawthorn (*Crataegus monogyna*) were present. The instream habitat is subject to low flows and dense beds of filamentateous algae were found to dominate the stream bed. These factors would result in the loss of taxa intolerant to sedimentation and contribute to the significant impairment of river health found in spring.

***Green Valley Rivulet at Cockatoo Road* (J8)**

In autumn, the macroinvertebrate community at this site was found to be severely impaired by habitat degradation. In spring the river health in this reach is rated as having significantly impaired river health and impacted by water quality, habitat degradation or both. The riparian vegetation at this site is highly modified and dominated by gorse, although there is some remnant riparian native vegetation. The absence of any substantive riparian cover may account for the instream habitat being dominated by dense macrophyte beds. In autumn, high Total Nitrogen levels (2650 μg/L), high conductivity (2270 μS/cm) and low dissolved oxygen (6.3 mg/L) would have a significant impact on river health, accounting for the severe impairment rating of river health in autumn. In spring, conductivity levels (2190 μS/cm) and Total Nitrogen (1960 μg/L) were still high although dissolved oxygen levels are substantially better (10.1 mg/L) than those measured in autumn. This alone may account for the "improvement" in river health to a significant impairment in spring.

***Exe Rivulet at Exe Sugarloaf* (J19)**

In autumn the river health at this site is rated as severely impaired by either water quality habitat degradation or both. This rating "improves" in spring to 'significantly impaired' although the potential impacts are still related to water quality, habitat degradation or a combination of these. This reach is heavily modified by willow infestation and low flow was observed through this reach on both sampling occasions. It is likely that the primary impact upon macroinvertebrate communities at this site is heavy willow infestation. In autumn during low flows, impacts by willows are likely to be more severe, given the large accumulations of leaf litter within the streambed and the rapid breakdown of willow leaves. Moderately high Total Nitrogen levels were measured in autumn (1010 μg/L) and this may be a result of high willow leaf breakdown in this reach. In spring, Total Nitrogen was found to be substantially reduced (257 μg/L). Heavily willow infestation has also been shown to increase sedimentation in rivers leading to decreases in macroinvertebrate diversity (Read & Barmuta, 1999). In both seasons it is likely that both water quality and habitat degradation by willow infestation were responsible for the poor river health rating in this reach.

Jordan River Mainstream

Nine sites were sampled on the Jordan mainstream. It was not possible to obtain river health ratings for three mainstream sites in spring 1999 as they fell outside the experience of the model. This indicates that one of the habitat variables measured at these sites falls outside the predictive capabilities of the model and the site cannot be assessed. However all three sites were visually assessed as being highly disturbed either by clearance of riparian vegetation in one case, willow infestation. Only three riffle habitats were sampled in both seasons (Table 2) but will not be discussed further in this section.

***Jordan River at Clifton Vale Road* (J10)**

In autumn, the river health at this site was rated as severely impaired by habitat degradation. River health in the following spring had "improved" to that of significant impairment although the specific nature of the impact is unclear. The location of the site on both axes (Figure 1a) indicates that the site may be impacted by habitat degradation. Large sections of this reach have little riparian vegetation although isolated pockets of gorse, willow and some blackwood trees (*Acacia dealbata*) are present. In areas not protected by shade, the instream habitat is dominated by dense macrophyte beds.

***Jordan River at Black Bridge* (J23)**

In both seasons, river health at this site was rated as significantly impaired by habitat degradation. The riparian vegetation on this reach ranges from cleared banks to gorse dominated to dense willow infestations. Dense macrophyte beds are common in slower flowing sections of this reach and stock access is extensive on this reach. It is likely that low dissolved oxygen levels (4.5 mg/L) also contribute to impaired river health in autumn in addition to instream habitat degradation.

***Jordan River at Pontville Ford* (J24)**

The river health at this site in autumn is rated as significantly impaired in autumn and this is most likely due to habitat degradation (Figure 1a) although water quality was also found to be extremely degraded. Conductivity was high (1213 μS/cm) and dissolved oxygen was low (4.9 mg/L). These values indicate poor water quality that would eliminate most intolerant taxa. This site could not be assessed in spring as one of the predictor variables required was outside the experience of the model.

***Jordan River at Elderslie Road* (J6)**

In autumn this site was significantly impaired either by water quality, habitat degradation or both. It is likely that both water quality and habitat degradation were contributing to poor river health in this reach. The reach is cleared of riparian vegetation in most sections and dominated by dense isolated stands of willows and gorse with a groundcover of blackberry in other sections. In autumn, water quality measures also indicated that the site was impacted. Conductivity was high (1020 μS/cm) and dissolved oxygen was low (5.4 mg/L). The combination of these two impacts with low flows observed at the time of sampling would result in a loss of intolerant macroinvertebrate taxa in this reach. This site could not be assessed in spring as it was outside the experience of the model.

***Jordan River at Andersons Road* (J7)**

The river health at this site was significantly impaired in autumn by a potential impact other than water quality (i.e. habitat degradation). There is little to no overhead riparian vegetation at this site and the reach is also subject to high stock access. The combination of these two factors was likely to have an impact on the instream environment via increased light levels leading to weed or algal growth, and sedimentation or nutrient addition to the water via stock in the reach. This site was unable to be assessed in spring as it was outside the experience of the model.

***Jordan River at Mauriceton* (J11)**

The river health at this site was significantly impaired in autumn although from the position of the site in Figure 2a, it is unclear whether water quality or habitat degradation was the cause of this impairment. Except for high conductivity (1138 μS/cm), basic water quality measurements at the time of sampling would not appear to be a primary cause of impact. The river health at this site in spring was equivalent to reference. Low flows may be the primary impact accounting for impaired river health in autumn in comparison to spring when flows were not noticeably low.

***Jordan River at Apsley* (J15)**

In both seasons the river health at this site was significantly impaired due to habitat degradation. This site is essentially cleared and evidence suggests that it has been subject to willow removal in the past 10 years. Remnant vegetation consists largely of exotic crack willows. The instream habitat has dense macrophyte beds and the entire reach is subject to extensive stock access. In both seasons all of these factors are likely to contribute to poor river health.

***Jordan River at Jericho* (J25)**

The river health at this site was significantly impaired in both seasons and this was either due to an impact of water quality, habitat degradation or both. This site is largely cleared of riparian vegetation with some remnant crack willow (*Salix fragilis*) and poplars (*Populus* spp.). The site is also subject to extensive stock access. All of these factors are likely to cause poor river health.

***Jordan River at Burnt Log Gully* (J28)**

In both seasons the river health at this site was significantly impaired by impacts related to habitat degradation. The riparian and instream habitat at this site is heavily degraded and the riparian zone is largely cleared. In both seasons, dense beds of *Azolla* spp. were floating on the water surface. These aquatic plants are common in stationary and slow moving water that has elevated nutrient levels. The near total coverage of the water surface by this plant prevents light penetration to the river bed and would decrease primary production leading to the loss of intolerant invertebrate families (Dallas & Day, 1993).

Summary

The sites sampled in the Jordan River and associated tributaries indicate that the main river and many of its tributaries are in poor condition in terms of river health. Many of the impacts on macroinvertebrate communities are related to habitat degradation. This is most likely due to widespread stock access, willow infestation at some sites little or no riparian vegetation due to historical vegetation clearance. All of these have the potential to adversely affect stream habitat and water quality leading to a loss of intolerant macroinvertebrate fauna. In many cases sites sampled on the Jordan River are affected by all three impacts.

The majority of sites were found to have degraded water quality at the time of sampling. Many sites had high conductivity and high pH. In autumn, low dissolved oxygen was measured at over half of the sites surveyed. All these water quality parameters can adversely affect macroinvertebrate community composition in rivers leading to poor river health.

There appears to be a slight improvement in river health in spring, as indicated by a shift of severely impaired sites to a significantly impaired rating. This is most likely related to increased flow through the system at this time of year. The poor condition of river health at many sites in autumn may reflect the stress that is experienced by macroinvertebrate communities following the summer period, when natural flow in the system is low, water demand for irrigation is high and water quality is most degraded. This appears to be expressed through the loss of sensitive taxa that are predicted to occur by AUSRIVAS models but unable to tolerate these conditions.

5. Management recommendations

River health at many of the sites surveyed in the study was impacted by a combination of factors relating to agricultural landuse and poor riparian land management. These fall into the following categories:

Willows

Willow infestation is likely to be the principal contributor to instream habitat degradation in the lower reaches of the Jordan River and tributaries. Dense invasions of willows have been shown to have a deleterious effect on aquatic fauna in river reaches through degradation of instream habitat and water quality (Read & Barmuta, 1999). Restoration of native riparian vegetation at sites that are subject to willow invasion is required and involves strategic planning in terms of willow removal and rehabilitation of the riparian zone with native plant species. Appropriate willow management strategies are outlined in (Parker & Bower, 1996) and riparian vegetation rehabilitation guidelines are provided in a suite of state and national documents on riparian vegetation management (Munks, 1996; LWRRDC, 1999; Rutherford *et al*., 2000).

Riparian vegetation protection and rehabilitation

The riparian vegetation of the middle to lower reaches of the Jordan River is severely degraded and this is impacting on the aquatic fauna of the river and tributaries. Rehabilitation and fencing of the riparian zone with endemic plant species to the Jordan catchment is required at all sites surveyed. Over the long term, the rehabilitation of riparian vegetation will provide benefits to the instream environment through shading, food resources to aquatic fauna and a greater diversity of instream habitat (e.g. via input of LWD). Comprehensive plans in regard to revegetation of riparian areas, recommended native plant species for replanting and strategies for revegetation and management priorities are detailed in Hall (1999) and North (1999)

Water use and instream barriers

It is likely that many of the river health problems found in the present study are further aggravated by high water demand during the irrigation season (December to April). Many moderately impaired sites improve to a slightly impaired rating in spring (a period of less water demand and higher flows) and this suggests that river health may be additionally stressed during periods of low flow. Further work is required to determine the impacts of water demand on the aquatic health of the Jordan River and the environmental flow requirements of the Jordan River will ultimately form part of this work. The river health models used in this study are not specifically developed to ascertain the effects of low flow on river health, however the outputs from some sites suggest that low flows in the Jordan catchment are impacting upon river health.

Instream barriers such as dams and weirs are recognised as having large impacts on the distribution of many Tasmanian fish species (Bryant & Jackson, 1999). Although habitat degradation is likely to be the principal factor impacting on habitat suitability for many fish and invertebrate species in the Jordan River, instream structures are likely to prevent movement along the river for fish and therefore restrict the distribution of some native fish species.

Stock Access

Livestock impacts on rivers in a variety of ways. Manure from stock directly deposits phosphorous and nitrogen into the river. Under high light conditions, as is the case in many of the reaches surveyed in the Jordan River catchment, elevated nutrient levels can lead to excessive plant and algal growth. In addition, stock access can increase the erosion of riverbanks and increase the movement of sediment from hill slopes into the river.

At the large majority of the sites visited, river management should be targeted at restoring the riparian vegetation and preventing stock access into these areas. Controlling stock access is the first step in rehabilitation of riverbanks. This involves fencing for stock management and the establishment of off stream watering points for stock. Alternatively a formed access point could be built at a carefully selected section of stream bank. These measures would also assist in the establishment of native vegetation that would not be subject to grazing pressure in an un-managed situation.

Poor river health at many of the sites surveyed in both seasons is attributable to the above impacts. Strategies aimed at reducing these impacts in conjunction with active rehabilitation and restoration of riparian and instream habitats should improve the ecology of the Jordan River over the long term.

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