Using Markets to Allocate Water: Implications for New Zealand Farmers

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ABSTRACT

Pending institutional changes in New Zealand will allow much greater flexibility in the procedures currently used by regional governments to allocate water resources. In river catchments where competition among various water uses is high, market-oriented approaches to allocate water may be instituted. Such approaches may have serious implications for farmers, since markets imply that farmers will face the opportunity costs associated with water use.

The Ashburton River in mid Canterbury on South Island faces increased and intense competition between agricultural and in-stream uses of water. We analyse the potential short-run impacts to farmers in the Ashburton River catchment if water allocation takes place via a market mechanism. Using a linear programming model, we estimate supply and demand curves for water for a typical mixed cropping farm in the catchment. We then comment on the estimated value of water to farmers and other relevant issues related to the possibility of using market mechanisms to allocate Ashburton water.

I. INTRODUCTION

Historically, water in New Zealand has not been allocated by markets. Instead, it is allocated by appropriation for beneficial uses. These include primary and secondary industry, local authority public water supplies, fisheries, wildlife habitat, and recreational use. Responsibility for water allocation has resided with local catchment boards, who receive authority from central government.

In a 1990 reorganisation and decentralisation of government functions, catchment boards (along with a myriad of other local specialty boards) were consolidated into 14 regional authorities. For now, these authorities allocate water under the existing 1967 Water and Soil Conservation Act and amendments. This enables the authorities to set minimum stream flows, establish priorities for utilisation of water, to specify the allocation between in-stream and out-of-stream uses, to manage applications for abstractive water rights and discharges into water, and to monitor and enforce abstractions and discharges.

In the near future, however, it is likely that Parliament will enact a new Resource Management Bill. Although responsibility for water allocation will still reside with regional authorities, this bill will provide regional managers with much broader scope in managing water. In particular, the bill replaces the concept of "water right" with "water permit" and promotes an integrated consent procedure for obtaining water permits. The bill places fixed time limits on water permits and allows transfers of permits to occur through a management plan (Miller, 1990). Thus, the bill gives greater flexibility to regional authorities to design and use market mechanisms to manage the use and quality of water.

In the case where a catchment has at present oversubscribed water rights, a regional authority may view favourably the implementation of market mechanisms to allocate water. One example of such a situation is the Ashburton River in Canterbury, where the regional council seeks to complete a water management plan for the river by 1992. Traditionally, the river has been the primary source of stockwater and irrigation water and much of the river has been committed to those uses. But the river also supports anadramous and freshwater fisheries, wildlife habitat, and recreation. Because of the conflicting interests between continued water abstraction and in-stream uses, the management plan must address the balance between development and conservation of the water resource.

In this paper we first provide a brief overview of the water situation in the Ashburton River catchment and identify the types of economic analysis that can contribute to the management plan. Second, we analyse one type of water use in the Ashburton - agriculture - by developing a model that estimates the value of water to farmers in the Ashburton catchment. Third, we discuss the estimated value of water to farmers and other relevant issues related to the possibility of establishing a market to allocate Ashburton water.

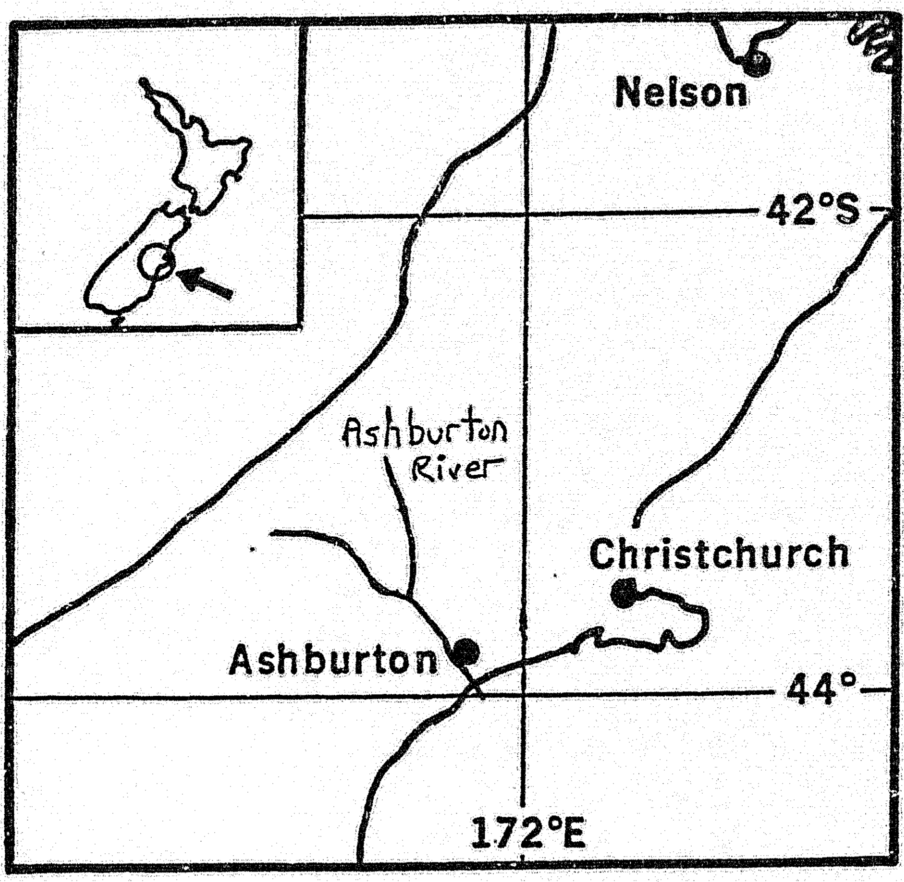
II. WATER AND THE ASHBURTON RIVER CATCHMENT

The Ashburton River flows from its origins in the Winterslaw and Moorhouse ranges in two branches that meet a short distance above the town of Ashburton. The South Branch of the river is the main branch and flows through two gorges before emerging onto the Canterbury plains. Here, the width of the river bed increases and the river wanders over a stony shingle bed enroute to the sea. For most of the distance across the Canterbury plains, the river flows in a braided channel. Figure 1 shows the location of the Ashburton.

High stream flows, caused by melt of the winter snow pack, occur from September through December. Low stream flows occur from mid-February to mid-April. At a point about midway between the river source and mouth, high stream flows run about 18 cubic metres per second and low stream flows run about 6 cubic metres per second. At the town of Ashburton, near the mouth of the river, high stream flows run about 40 cubic metres per second and low stream flows run about 10 cubic metres per second (Scarf, 1983).

Water of the Ashburton River is used for municipal supplies and effluent disposal, stockwater and irrigation, wildlife and fisheries, and recreation. Municipal water supplies (primarily for the towns of Ashburton - population about 17,000 - and Methven - population about 1500) use about .3 cubic metres per second of river water. Authorised stockwater withdrawals account for nearly 10 cubic metres per second of flow, but actual withdrawals account for about 4 cubic metres per second of water. Authorised irrigation withdrawals

Figure 1. The Ashburton River Catchment



total about 9.5 cubic metres per second. About 7 cubic metres per second of this amount is water diverted from the South Ashburton into the Rangitata Diversion Race syphon, which serves irrigators in both the Ashburton and Rakaia River catchments. During the summer, when the stream flows are insufficient to sustain that level of abstraction, the intake into the Rangitate Diversion Race is restricted to allow 1 to 2 cubic metres per second of flow to remain in the river (Scarf, 1983). Irrigation development from the Ashburton occurred rapidly during the 1970s and 1980s such that the water resources of the Ashburton have been severely taxed.

The Ashburton River has historically been an important recreational fishery, supporting primarily salmon, trout, whitebait, and flounder. Although the river attracts both local and [illegible] anglers, the fish resource has declined in the last ten years (Hughey, 19[illegible]). To flourish, migratory fish such as salmon require a continuous surface flow from headwaters to the mouth. This has been a problem in the Ashburton for two reasons: extended periods of artificially-induced low stream flows and periodic closure of the river mouth, particularly during the summer months. This occurs when tide and wave action move beach sediments into the mouth and when the river stream flows are insufficient to scour out this beach material.

An extensive wetland wildlife habitat is supported by the Ashburton, which provides for a large number of bird species, one of which - the Wrybill Plover - is considered endangered. Habitat ranges from the headwater lakes and their surrounding wetlands to sections of braided river channel with large quantities of clean shingle and shingle islands. Recreation activities in addition to fishing include boating, swimming, bird-watching, and picnicking.

Issues for Economic Analysis

For water allocation, the regional council can base a management plan for the Ashburton River on the economic efficiency of the competing water uses, equity and distribution considerations, or pure ecological factors. In the past, the regional council has drawn on the latter two of these paradigms and based its management plan around specified minimum stream flows and development of regulations for sharing flows above the minimum. This has led to regulations that address technical issues of how and why water can be abstracted.

With regional councils having assumed increased responsibility for water management, the Canterbury Regional Council may seek to place more emphasis on economic efficiency as a criterion for decision making. As such, the council will need two important pieces of information: the value of water to abstractive users (agriculture) and the value of water to in-stream users (fishing, recreation, habitat preservation). Once these values have been estimated, the council can consider alternative allocation schemes that attempt to maximise the value to regional residents of the use of the river water. These estimates of value can also be used as part of a feasibility study for establishing a market to allocate water.

The value of Ashburton River water to agriculture can be estimated by considering the changes in farm activities with and without the river water. Farmers may alter cropping patterns, livestock activities, or change the mix of inputs used, such as labour or irrigation systems. The difference in the returns to land, machinery, management, and other fixed investment costs with and without river water is the value of that water to agriculture.

For in-stream uses of the Ashburton River, a nonmarket valuation approach is needed to estimate the values associated with alternative stream flows. To estimate certain use values, such as salmon fishing, a travel cost approach might be appropriate. To estimate total value of in-stream water, or to segment existence and other nonuse values, a contingent valuation approach would be appropriate.

Besides allocation of existing water in the Ashburton, the regional council may choose to decide if development projects to smooth the stream flows throughout the year are warranted. One option for development includes damming the river near its source in the high country and using the impounded water to regulate stream flows. The council may also choose to decide whether technical improvements for abstractive users, which would decrease the amount of abstraction required, are warranted. In both of these cases, analysis of the economic efficiency of these options would be useful to the council.

III. THE VALUE OF WATER TO FARMERS IN THE ASHBURTON CATCHMENT

Of the nearly 550,000 hectares in the Ashburton River catchment, nearly half is mountains and upland valleys. About half of that is unfarmable. Of the 280,000 hectares of plains, about 200,000 hectares are shallow soils with low holding capacity for water and low natural fertility; 50,000 hectares are free-draining cropping soils along the river banks, and the remaining 30,000 hectares are deep cropping soils with drainage problems. Annual rainfall in the region ranges from about 600 millimetres per year at the coast to about 1000 millimetres per year at the foothills. On average soil moisture deficits can be expected to occur for at least 40 days per year (Ministry of Agriculture and Fisheries, 1984).

Three major irrigation schemes exist in the catchment, with about 70,000 hectares under irrigation. Technically, as much as another 120,000 hectares could be irrigated, but only about 20,000 hectares in close proximity to the river has been identified as a high priority, if water becomes available. Irrigation systems include border-dyke and spray.

In 1989, the Ashburton River catchment housed about 1650 farms. The farming systems employed on these farms vary from straight sheep enterprises to all crop systems, where the entire farm is harvested every year. Crops grown include wheat, barley, peas, oats, grass seed, white clover, linseed, and rapeseed. Fertiliser requirements are not high and crop yields with supplemental irrigation water average only roughly 30 percent higher than yields without water (Ministry of Agriculture and Fisheries, 1989).

To estimate the value of water to a farmer in the Ashburton River catchment, we first specified the nature of representative farms. The primary representative farm is a mixed cropping farm of 179 heactares, with up to 73 hectares allocated to pasture. Representative crops include up to 18.75 hectares of winter wheat, 18.75 hectares of spring wheat, 36.25 hectares of barley, 18.75 hectares of field peas, and 38.75 hectares of ryegrass. We estimated variable costs for farm activities using 1989 data (Ministry of Agriculture and Fisheries, 1989) and average prices over the past five years (Burtt and Fleming, 1990). We estimated production functions for consumptive water use and yield, using agricultural engineering data (Heiler, 1982). Table 1 shows the prices, variable costs, yields, and consumptive water requirements for each crop and livestock activity.

Table 1. Production Data for the Representative Farm

Item	Units	Winter Wheat	Spring Wheat	Barley	Field Peas	Ryegrass Seed	Pasture/ Sheep
Crop Price	$/t	235.73	261.93	183.75	327.50	1125.00	27.18
Yield	t/ha	5.5	5	5	3.2	1.2	14[a]
NIR[b]	mm	128.7	143	143	143	112.5	318[c]
Variable Costs	/ha	834.00	802.00	593.98	648.36	1067.00	31.64

[a] yield = 14 stock units per hectare

[b] NIR = net irrigation requirement = crop consumptive use - precipitation

[c] NIR for pasture plus stock-water requirements

Second, we constructed a linear programming model to investigate the expected response of farmers to changing water supplies and assess the costs to a farmer if water allocation is conducted via a market instead of administratively. This has been a common approach to water valuation in the U.S. (for example, see Whittlesey and Houston, 1984; Hamilton, Whittlesey, and Halverson, 1989). At this point, the model maximises gross returns and thus provides an estimate of the returns to land, capital, and labour and management.

By incrementally reducing the amount of water available to the farmer, we obtain changes in the level of production activities and gross margins. As shown in Tables 2 and 3, as water availability decreases, the model suggests that the farmer will initially shift to dryland pasture and sheep production. As water becomes increasingly scarce, the model shows that the farmer will reduce crop irrigation and select those activities with the highest marginal value product of water use.

By parametrically varying the supply of water available to the farmer, we obtained a demand curve for water. As shown in Figure 2, this curve relates the shadow price of water (which is the average opportunity cost of water across all farm activities) to the quantity of water available. We interpret this as the farmer's willingness to pay for water.

We included a water sales activity to the model, thus giving the farmer the choice between applying water to his crops or selling water in a market. By parametrically varying the price of water in the objective function, we obtained the farmer's supply curve for water. As shown in Figure 3, this curve relates a price for water to the quantity of water that a farmer would be willing to sell. We note that the supply of water a farmer can sell is the net irrigation requirement (that is, the net consumption required for irrigation) and not the amount of water delivered to the farm. A certain percentage of water applied (that which is not consumed by the crops or evaporated) will return to the river. In a market situation, the farmer will not own this water and it cannot be bought or sold.

The estimates of the opportunity cost of water (from the demand curve) should be considered preliminary and probably an upper bound, because the model estimates gross returns and does not separate farm labour from farm

Table 2. Changes in Water Supply and Farmers' Willingness to Pay

Activity		Units	Delivered Water (%) 100	80	60	40	20
Gross Margin		$/ha	366	353	328	278	188
Winter Wheat		ha	19	19	19	19	19
	NIR	%	100	100	100	100	90
Spring Wheat		ha	19	19	19	19	19
	NIR	%	100	100	100	100	77
Barley		ha	36	36	36	17	0
	NIR	%	100	100	100	100	0
Field Peas		ha	19	19	19	19	19
	NIR	%	100	100	100	0	0
Ryegrass		ha	13	39	39	39	39
	NIR	%	100	100	100	100	0
Pasture/Sheep							
	100 % NIR	ha	73	31			
	50 % NIR	ha		16	22		
	Dryland	ha			25	66	73
	Average NIR	%	100	53	50<	0	0
NIR Delivered		mm	37,580	30,064	22,548	15,032	7,516
Shadow Price		$/mm	$0.00	$0.44	$0.81	$1.73	$2.40
Water Delivered		mm	53,685	42,949	32,212	21,474	10,737
Change in Delivery		mm	0	([illegible],736)	(21,474)	(32,211)	(42,948)

Table 3. Changes in Water Price and Farmers' Willingness to Sell

Activity		Units	$0.00	$1.50	$3.00	$3.75
Gross Margin		$/ha	366	470	701	852
Winter Wheat		ha	19	19	19	19
	NIR	%	100	100	50	0
Spring Wheat		ha	19	19	19	19
	NIR	%	100	100	0	0
Barley		ha	36	36	0	0
	NIR	%	100	100	0	0
Field Peas		ha	19	19	19	19
	NIR	%	100	100	0	0
Ryegrass		ha	13	39	39	39
	NIR	%	100	100	0	0
Pasture/Sheep		ha	73	47	73	0
	Average NIR	%	100	0	0	0
NIR Sold		mm	0	20,745	2,942	7,580
NIR Delivered		mm	37,580	16,835	4,638	0
Water Delivered		mm	53,686	24,050	6,626	0
Change in Delivery		mm	0	(29,636)	(47,060)	(53,686)

F'gure 2. Farmers' Willingness to Pay for Water

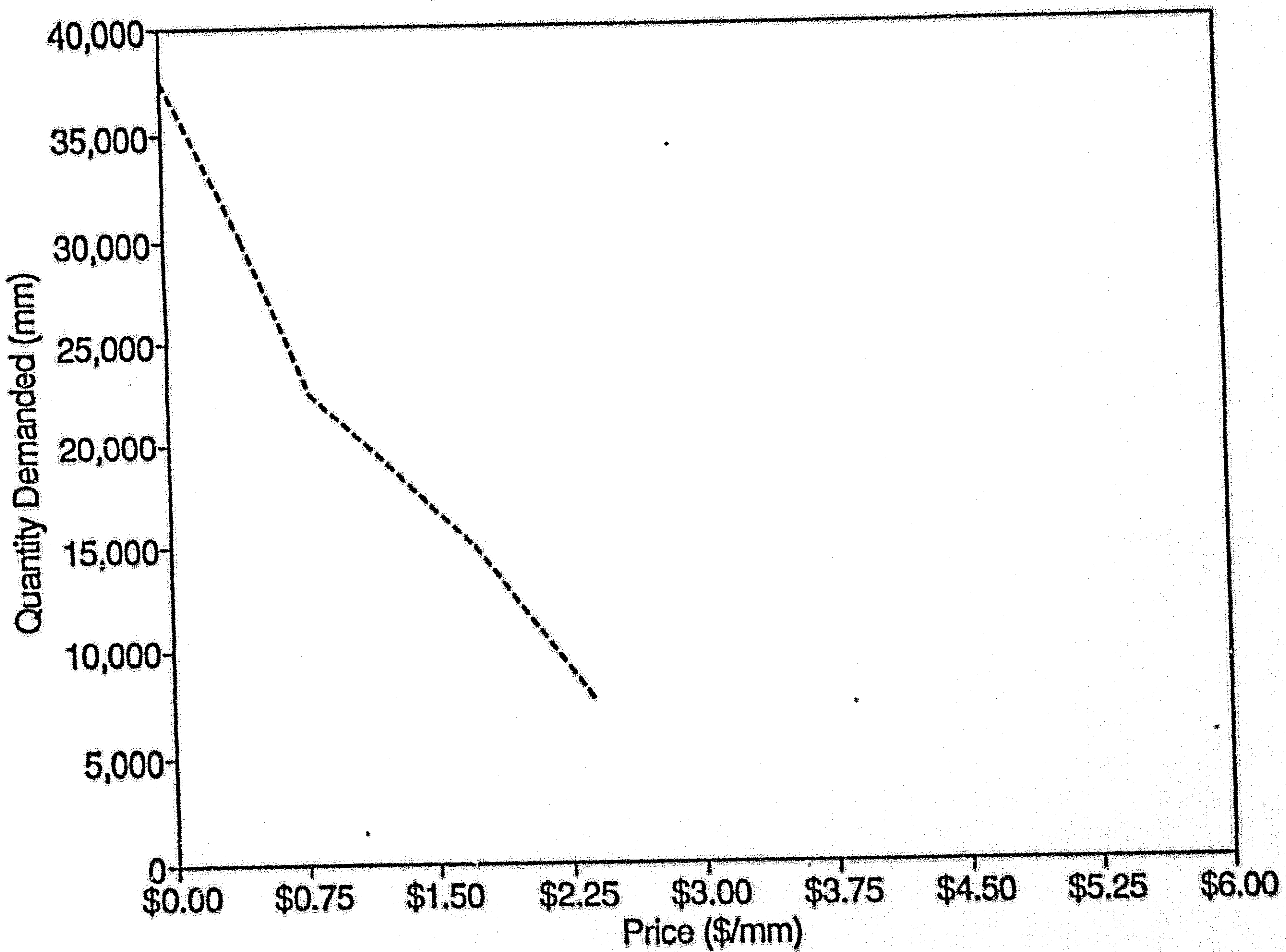
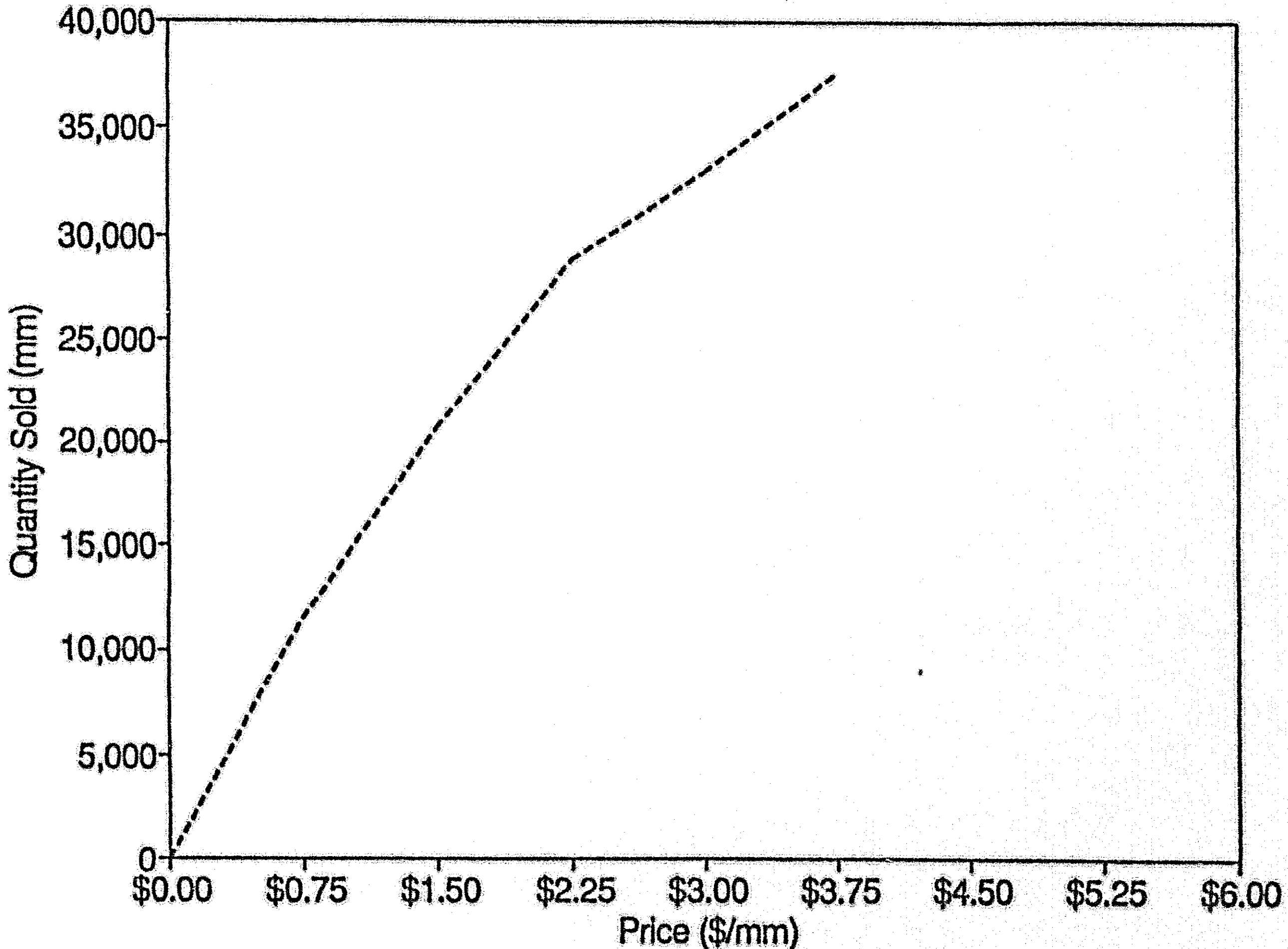


Figure 3. Farmers' Willingness to Sell Water



management. Further work will identify and separate the costs of labour, such that the model estimates net returns. Similarly, a model based on net returns will produce a different supply curve. In addition, we will direct further work into further refining the production functions between water consumption and crop yield.

If the representative farm is typical of agriculture in the catchment, these individual demand and supply curves can be summed to obtain aggregate demand and supply curves. Because this farm is not the sole type of representative farm, we have not attempted the aggregation exercise at this point.

IV. A WATER MARKET FOR THE ASHBURTON?

In the previous section, we have examined only one side of a potential market for allocating Ashburton River water - the value of water to farmers. The potential for trade will be determined by comparing the farmers' value of water against the value of water held by in-stream users. A significant difference in magnitudes one way or the other means that trades have the potential to make both types of water users better off.

If that condition exists and if the regional council chooses to use a market mechanism to allocate water in the Ashburton River, issues of property rights will be important for the transition to the market mechanism. At one extreme, farmers initially may be granted permits at current (full) water allocation; in-stream users would have to purchase permits from the farmers to increase stream flows. If this is the case, then the initial potential for trade is determined by the farmers' willingness to sell (that is, their supply curve for water) and the in-stream users' willingness to pay (that is, their demand curve for water). At the other extreme, in-stream users could initially be granted permits for in-stream flow and farmers would face an initial reduction in available water. If this is the case, then the initial potential for trade is determined by the farmers' willingness to pay (that is, their demand curve for water) and the in-stream users' willingness to sell (that is their supply curve for water). The initial allocation will likely fall somewhere between these two extremes and will likely depend in part on the distribution of gains and losses between the two groups of market participants.

Quantitative estimates for both the potential for trade and recommendations on the initial distribution of permits depend on the availability of information on in-stream users' demand and supply for water. We will pursue that through a forthcoming nonmarket valuation study of in-stream users' values.

Water hydrology in the catchment could affect the ability of the regional council to use a market mechanism for water allocation. Farmers currently have the option of using groundwater to replace river water. Under a market mechanism for allocation of river water, farmers will seek to substitute groundwater for river water if the former is less expensive than the latter. If the hydrology between the aquifer and the stream flow is such that there is a high degree of interaction between the two (that is, groundwater pumping affects stream flows), then the council may need to either include groundwater water supplies in the market or otherwise control access to the groundwater.

The regional council will have to consider a host of institutional issues to successfully design and implement a market to allocate water. For example, the current situation in the Ashburton indicates that a permanent water market may be appropriate. Yet, the pending legislation on resource management will restrict permits to a limit of ten years. Under these conditions, an interruptible water market may be appropriate. This is where, say, the actual transfer of water from farm usage to in-stream uses might occur only when stream flows fall below a certain level. But regular annual payments are made from in-stream users to farmers to compensate them for the periodic loss in income when stream flows are low.

Our information on the potential for a water market for the Ashburton River is incomplete, at least until we obtain information from the in-stream users. Assuming that there is a potential for trade and that institutional isues can be satisfactorily addressed, we at this point support the concept of implementing a market mechanism. Although the Ashburton River is a relatively small catchment, the nature of the issues present in many ways will make it an ideal test for a market mechanism. The Canterbury regional council would be able to transfer the knowledge obtained from the Ashburton experience to developing management plans for other, larger catchments.

In general, water is one of the few resources in New Zealand that has usually been allocated by nonmarket mechanisms. This special treatment reflects its crucial role in economic development, particularly in a semi-arid area such as mid Canterbury. In spite of water's special role in the economy, a move towards market mechanisms might prove beneficial. Market mechanisms would likely yield more flexible water use, a voluntary process consistent with a philosophy of free choice, a way to convert water rights into money, and an incentive for efficiency.

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