Trade for Nature

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Discussion Paper

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Abstract

Optimal management of biodiversity at the national level, even if achievable, is not necessarily consistent with a global optimum. While the existence of trading relationships allows for the possibility of the use of trade interventions as a means of imposing unilateral solutions, the presence of unidirectional global externalities suggests as an alternative policy the use of international transfers to achieve a co-operative solution. The following paper develops a two-country comparative trade model in which one country contains a biological resource that it exploits for domestic consumption or export while simultaneously converting habitat land for use in other economic activities. The second country does not have any stocks of this resource but values its global conservation. The latter country also produces a consumption good which it is willing to trade for the harvested resource exports of the first country. Trade has a direct effect on conservation of the biological resource through impacts on exports and thus harvesting levels, as well as an indirect effect through substitution of imports for consumption activities that lead to the conversion of habitat. We use this model to explore how national trade policy behaviour distorts the management of a biological resource, and in particular fails to achieve a global or 'cosmopolitan' optimum. We demonstrate the effects of trade policy interventions that influence the terms of trade (TOT), and international transfers that are 'neutral' with respect to the TOT. The possibility of a ‘trade for nature’ agreement, including free trade in exchange for a cosmopolitan stock of the resource, is discussed. It is argued that this is an option when two conditions are fulfilled: Neither free trade nor optimal tariff must be a safe option for any of the countries; and the optimal tariff on the resource products must be positive.

Keywords: Biodiversity, biological resource, cosmopolitan solution, habitat, international transfers, nationalist solution, trade, trade interventions, terms of trade.

1. Introduction

Biodiversity loss is linked to at least two economic processes (Barbier, Burgess and Folke 1994). First, the depletion of stocks can make species vulnerable to extinction. Second, conversion of land through economic activities results in the destruction, degradation and fragmentation of natural habitats, which increase the risk of extinction. Given empirically established relationships between the number of species and the total area in a habitat, recent assessments of global biodiversity have concluded that loss of habitat is the main cause of the present high rates of extinction (UNEP 1995; WCMC 1992). From an economic perspective, the essential issue is not the magnitude of the loss of biodiversity but whether current rates of extinction are optimal - i.e. whether the benefits of greater biodiversity conservation exceed the costs.

In economics there is a well-established theory of optimal management of renewable resources (Clark 1976). However, actual management of biological resources is often far from optimal in most countries. Problems of open access, poorly defined property rights, externalities, and incomplete or distorted markets are some of the many factors leading to excessive depletion of renewable resources and habitat loss. In short, decisions to deplete resources or convert habitat usually do not take into account the social costs of any resulting loss in biodiversity.

Even if optimal management of biodiversity could be achieved at the national level, it may not necessarily be optimal from a global perspective. As noted by Perrings *et al.* (1995), consideration of costs and benefits within countries is only one dimension to the biodiversity management problem: "The critical questions from an economic policy perspective concern the distribution of the benefits of biodiversity conservation as between individual users of biological resources, nation states, regional groupings and the international community." There are several reasons for this. First, some biological resources have the attributes of global public goods. The role of tropical forests as a carbon 'sink' and their potential contribution to the world gene pool are two examples. Second, differences in tastes and wealth across countries may mean that the global costs and benefits of biodiversity conservation are not equally distributed. For example, it is often suggested that individuals in wealthier countries attach higher existence and option values to the international conservation of species and habitats (Bishop 1993). In contrast, since much of the world's biodiversity is thought to be located in tropical countries, a higher burden of the global costs of biodiversity conservation is likely fall on these countries - both in terms of direct costs of conservation and the opportunity costs of foregoing conversion and exploitation of biological resources (Barbier, Burgess and Folke 1994). Thus as argued by Perrings and Pearce (1994), biodiversity loss is unusual with respect to both the range of people affected (i.e. at the international, national and local levels) and the degree to which it encompasses both global reciprocal and unidirectional externalities[1].

A further dimension to the problem is the effects of international trade and agreements on the management of biological diversity. Trade and environment linkages have become increasingly a focus of conceptual and empirical investigations in economics (e.g., see Anderson and Blackhurst 1992; Chichilnisky 1994; Copeland and Taylor 1994; Grossman and Krueger 1993; Krutilla 1991; Lopez 1994; OECD 1994; Schulz 1996; Smith and Espinosa 1996). Equally, the economic implications of international environmental agreements have also been analyzed conceptually (Barrett 1990 and Mäler 1990). The efficacy of trade interventions in improving management of key biological resources has been explored in a number of case studies. For example, Barbier *et al.* (1990) have examined the potential impact on the management of African elephants of the ivory trade ban imposed by the Convention of International Trade in Endangered Species (CITES). The implications of various unilateral and multilateral trade interventions on the incentives for sustainable management of tropical timber resources have also been analysed (Barbier *et al.* 1994). In addition, recent analysis has explored the theoretical and practical limitations to international co-operation in implementing the global Biodiversity Convention (Barrett 1994; Swanson 1995).

In this paper we are concerned with the impacts of trade on optimal management of a biological resource. Our approach is both consistent with and builds on similar conceptual explorations of international biodiversity management issues, especially in the open economy context. Swanson (1994) examines the general habitat conversion and depletion problem faced by developing countries. Barrett (1993) concentrates on the optimal provision of natural habitat for biodiversity conservation versus land conversion for consumption under conditions of long-run economic growth. Rowthorn and Brown (1995) also analyse closed economy habitat-consumption trade-offs, focusing explicitly on the role of discount rates. Rauscher (1990) extends renewable resource models to include trade effects, and Barbier and Rauscher (1994) add stock externalities, import good substitution and the influence of trade policy interventions versus international transfers. Barbier and Schulz (1997) attempt a synthesis analysis, which first combines renewable resource harvesting, habitat-consumption trade-offs and stock externality effects in a closed economy context and then examines the additional influence of trade policies and interventions in an open economy. The following paper adapts and extends the latter model to focus explicitly on how trade policy regimes influence international biodiversity management.

The 1992 United Nations Conference on Environment and Development in Rio de Janeiro stated that "unilateral actions to deal with environmental problems outside the jurisdiction of the importing country should be avoided"; however, referring to forest management, a US interpretative statement explained this as "in certain situations such measures might be effective and appropriate means" (Porter and Brown1996). So far, the newly established World Trade Organisation (WTO) has left the problem unresolved. Although in the past some cases - such as the ‘tuna-dolphin’ dispute between US and Mexico and disagreements concerning the tropical timber trade between European and South East Asian countries - have been raised within the GATT/WTO conflict resolution system, current WTO legislation on using trade policy measures for extra-territorial protection of the environment is still ambiguous (Porter and Brown 1996).

Our primary aim is to explore how national trade policy behaviour distorts the management of a biological resource, and in particular fails to achieve a global or 'cosmopolitan' optimum. We contrast the effects of trade policy interventions (such as tariffs) that directly influence the terms of trade (TOT), and international transfers that only indirectly may alter the terms of trade. We do this within a two-country competitive trade model, where the TOT are set within the model by the offer curves of the two trading partners. By assumption, two products are traded - a harvested renewable resource and a consumption good. However, only one country is the source of the biological resource, the total size of which is determined by both its natural regeneration net of harvesting as well as its overall area of natural habitat. The harvested resource product is either consumed or traded by the first country. In addition, the country also has the choice of either converting the resource's natural habitat to produce the consumption good or importing this good through trade with the second country. The latter in turn produces a substitute for the harvested resource product it imports and the consumption good, which is either consumed domestically or traded. To make the problem interesting we also assume a unidirectional (stock) externality - welfare in the second country is affected by the total stock of biological resources maintained in the first country.

Consequently, the model we develop typifies the standard North-South trade relationships associated with current international biodiversity management problems, albeit with obvious simplifications. The first country's situation closely resembles that of developing countries. Rich in biodiversity, these countries generally exploit their natural wealth for domestic consumption or export, while simultaneously converting habitat land for use in other economic activities. As a part of the third world, its trade policy power is negligible. The second country represents the higher income' countries of the North. Although these countries value the maintenance of biodiversity in the South, they are also willing to trade for natural resource products from developing countries.

As a result, the trade in natural resource products from the South for (manufactured) goods from the North has both a direct and indirect influence on biodiversity management. The direct effect is through the impacts of trade on the choice of resource harvesting levels and thus the stock of biological resources. In addition, there is also an indirect effect on the stock of biodiversity because trade allows substitution by imports for consumption activities that lead to the conversion of habitat and thus biodiversity. The North country may influence the terms of trade by using trade policy measures.

Our model includes explicitly these direct and indirect linkages between trade and biological resource management. It therefore allows us to examine the way in which trade interventions affect these linkages and thus optimal rates of resource depletion and habitat conversion. By assuming that the biological resource generates a unidirectional global externality, we can also explore the effects of international compensatory payments, or transfers, in influencing resource management outcomes. We can thus compare the effects of trade interventions and international transfers as alternative policy mechanisms to achieve increased resource conservation.

The basic trade model is developed in the next section. We illustrate the general equilibrium or global optimum in Section 3, and compare in Section 4 this 'cosmopolitan' solution with the partial equilibrium or national optimum, which assumes that each country maximises welfare separately. Sections 5 and 6 analyse and discuss respectively the use of tariffs to achieve national objectives and the effects of trade interventions versus transfers to achieve the cosmopolitan solution or social efficiency. The final section provides some concluding remarks.

2. The Model

For the model, the following variables, functions and parameters are defined:

There are two countries, A and B, with each country assumed to produce two goods. The social discount rate, δ, is the same for both countries.

Country A

S(t) total stock of species biomass - the renewable biological resource

y(t) harvested output of the resource, with producer price p_y

x(t) exports of harvested products from the renewable resource, with world price p_x

c(t) output of other products from converted habitat land, perfect substitutes with imports m

w(S) resource depletion rate, per unit of harvested products from the resource, $w(S) \geq 1$, $w_S \leq 0$

τ unit tax rate on products from the renewable resource

t_a import tariff rate, country A

Country B

z(t) output of complete substitutes to imports of harvested renewable resource products, with producer price p_z

q(t) output of other products, with producer price p_q

m(t) exports of other products, with world price p_m

t_b import tariff rate, country B

We denote $p = p_x/p_m$ for the international terms of trade (TOT) for the products. To simplify the notation, we omit the argument for time-dependent variables, represent the time derivative and growth rates of a variable with a dot, and employ numbered or variable subscripts to indicate the partial derivatives of a function.

Country A harvests the renewable biological resource (i.e. the total species stock, S) at a sustainable long run rate, y, and with positive exports of harvested products, x, from the resource. Net domestic consumption of harvested products is therefore, y-x. The habitat area set aside for the biological resource may be converted and used to produce other consumption goods, c[2]. The exported products from the renewable resource, x, are traded with country B for imports of another consumption good, m. It is assumed that both c and m are perfect substitutes in consumption. Thus total consumption of non-harvested goods in country A is c + m.

The available resource stock and habitat land constitute the restrictions for production in country A. As noted in the introduction, in developing countries a threat to natural habitat is conversion to other economic activities; alternatively, an opportunity cost of increasing the size of the total species stock, S, and thus the habitat area necessary to support this stock is less production of other consumption goods, c, from converted habitat area. We incorporate in our model this conflict in the use of land assuming increased resource stock, S(t), to reduce the production of other products, c. This means that increased stock of the resource requires land, and this restricts production of other consumption goods, c. We assume decreasing marginal productivity in production of c through conversion of natural habitat, hence

$$c = f(S), \qquad f_s < 0,\ f_{ss} < 0. \tag{1}$$

Growth of the renewable resource is assumed to be net of harvesting, i.e.

$$dS/dt = G(S) - w(S)y, \qquad w(S) \geq 1,\ w_S \leq 0 \tag{2}$$

The term G(S) is the regeneration function for the total species stock. G(S) is assumed to display the standard bioeconomic properties; i.e. G is defined over the interval $S(t) \geq 0$, and there exists values $S^{min}<S^{max}$ such that $G(S^{min}) = G(S^{max}) = 0$ and $d^2G(S(t))/dS(t)^2 < 0$. The growth is the biological growth less the harvest rate w(S)y as in equation (2). To introduce costs in the model we assume that some of the harvesting is lost in costs, letting the loss per unit harvest decrease with S, $w(S) \geq 1$, $w_S \leq 0$[3]. Finally we assume that all harvested output, y, is either consumed or exported in exchange for importables, m, and there is a net export of products from the natural resource, x. The utility of consumption in country A is expressed by the utility function U^A in equation (3) below, which is assumed additively separable in terms of its two arguments (the net consumption of both goods, y-x and c+m) and which has the standard properties with respect to its partial derivatives

$$U^A = U^A(y-x; f(S)+m), \qquad U^A_i>0, U^A_{ii} < 0, U^A_{ij}= 0, i \neq j, \quad i,j = 1,2. \tag{3}$$

It is clear from all the above that an increase in consumption and its consequent social benefits must occur as the result of additional harvesting of the renewable biological resource or conversion of natural habitat to other production activities.

Country B produces two goods, one of which, z, is a complete substitute for imports of the harvested renewable resource from country A. Country B is a net exporter of the other good, q, and net domestic consumption of this good is q-m. The production possibility frontier for country B is assumed to be concave and

$$F(q,z) = 0, \quad F_q/F_z>0 \tag{4}$$

All output is by assumption consumed or exported in exchange for importables, and there is a net import of products from the biological resource produced in country A. The utility of consumption in country B is expressed by the utility function U^B in equation (5) below, which is assumed additively separable with the net consumption of both goods (z+x), (q-m) as arguments, and the size of the total species stock, S, in country A as a third argument. U^B is assumed to have the standard properties with respect to its partial derivatives

$$U^B = U^B(z+x; q-m;S), \qquad U^B_i>0, U^B_{ii} < 0, U^B_{ij}= 0, i \neq j, \quad i,j = 1,2,3. \tag{5}$$

The world social optimum is assumed to be the maximum present value of total future welfare in A and B subject to the restrictions (2) and (4). The balance of trade in products is secured through the definitions of consumption in both countries.

$$\text{Max } W = {}_0\int^{\infty} U^A(y-x;\, f(S)+m)e^{-\delta t}dt + {}_0\int^{\infty} U^B(z+x;\, q-m;\, S)e^{-\delta t}dt \qquad (6)$$

$$S(0)>0 \text{ and } \lim_{t\to\infty} S(t)\geq 0,\; S^{max}>S^{min}>0,\; G_1(S^{min})=G_1(S^{max})=0,\; G_{SS}<0,$$

$$U^k_i>0, U^k_{ii}<0,\; U^k_{ij}=0,\; i\neq j, \quad i,j = 1,2,3, \quad k = A,B.$$

The variables x and m are specified in the utility functions to ensure that all goods are consumed. The control variables of the above maximisation problem are y, x, m, q and z.

3. The Cosmopolitan Solution

First, we investigate the conditions for a world optimum in the management of the economies of both countries. Following Meade (1952) we denote this as the *Cosmopolitan Solution*.

The current value Hamiltonian of the problem in equation (6) is

$$H = U^A(y-x,\, f(S)+m) + U^B(z+x,\, q-m,\, S) + \lambda[G(S) - w(S)y] - \theta F(q,z), \qquad (7)$$

where λ is the shadow price of the biological resource stock in country A, and θ is the shadow price of increased production in country B. Assuming an interior solution, the following first order conditions must be satisfied

$$U^A_1 = \lambda w(S) \quad \Rightarrow \quad \lambda = U^A_1/w(S) \qquad (8)$$

$$U^A_1 = U^B_1,\; U^A_2 = U^B_2 \qquad (9)$$

$$\lambda = (\delta - G_S + yw_S)\lambda - U^A_2 f_S - U^B_3 \qquad (10)$$

$$U^B_1/U^B_2 = F_z/F_q \qquad (11)$$

$$dS/dt = G(S) - w(S)y \qquad (2)$$

By combining equations (2), (8) and (10) we obtain

$$y\text{-}x = [1/U^A_{11}][(\delta\text{-}G_S+yw_S\ )U^A_1 - w(S)(U^A_2 f_S + U^B_3)] \tag{12}$$

Utilising equation (12) , and the conditions (2), (8)-(11), one can find the following system of equations describing necessary conditions in a long run equilibrium where y = x = S = 0. Denoting an asterix (*) for the equilibrium values

$$U^A_1\ (y^*\text{-}x^*) = U^B_1(z^*+x^*)\ ,\ U^A_2(S^*,m^*)= U^B_2(q^*\text{-}m^*) \tag{13}$$

$$U^B_1(z^*+x^*)/\ U^B_2(q^*\text{-}m^*)= F_z(q^*,z^*)/F_q(z^*,q^*) = U^A_1\ (y^*\text{-}x^*)/\ U^A_2(S^*,m^*) \tag{14}$$

$$[\delta\text{-}G_S(S^*)+G(S^*)w_S/w(S^*)] = w(S^*)/U^A_1(y^*\text{-}x^*)[U^A_2(S^*,m^*)f_S(S^*)+ U^B_3(S^*)] \tag{15}$$

$$G(S^*) = w(S^*)y^* \tag{16}$$

Equation (13) sets as an optimum condition for equilibrium in the Cosmopolitan Solution that the marginal valuation of each good for both countries must be equated, and equation (14) is the traditional welfare condition MRS^B=MRT^B. Taken together, and for known S^*, these two equations constitute an optimal trade exchange between country A and country B, while simultaneously determining production in B. Equations (15) and (16) are the conditions for optimal long run equilibrium biodiversity or resource conservation in country A. Note that the equilibrium Cosmopolitan Solution requires that optimal management of the total species stock in country A takes into account the marginal welfare impact on country B of the global stock externality, $U^B_3(S^*)$.

The system of equations (13) - (16) contains five equations which together with equation (4) determine the optimal values of S, y, q, z, m and x. The trade balance is not specified in the optimality conditions. However, the optimal solution determines the trade flows, and implicitly also the international terms of trade. We shall denote a *Globally Efficient Solution* for a situation with international Pareto efficiency. It is easy to demonstrate that a Globally Efficient Solution must fulfil conditions (14) - (16), while equation (13) adds the extra condition required to obtain the maximum welfare defined in equation (6) and thus the Cosmopolitan Solution.

So far we conclude that there exists a set of necessary conditions for optimal management of the renewable biological resource and trade consistent with the Cosmopolitan Solution. The production and consumption patterns in both countries, the world distribution of welfare and the trade flows are all determined in this optimum, and the management of the resource cannot be solved optimally without taking into account the global biodiversity value of the species stock directly into the management scheme.

4. The Nationalist Solution with Free Trade

There exists no world social manager with political power to establish the optimal management regime of the Cosmopolitan Solution. Each country manages their own resources optimally, taking other countries' actions for granted, there is no trade interventions, and this establishes the terms of trade in the world market. Following Meade (1952) we denote this as the *Nationalist Solution with free trade.* We do not investigate the internal markets in each country, since this is well known from international trade theory and bioeconomics.

In our model, the two countries constitute the world market. Each country maximises its own welfare, taking the terms of trade, p^j, for granted. Thus p^A are the terms of trade (TOT) faced by country A, and p^B are the TOT confronting B. However, p is determined in the world market, and in equilibrium with no tariffs

$$p = p^A = p^B = p^0, \tag{17}$$

where p^0 is the equilibrium free trade price. In contrast to the Cosmopolitan Solution, the Nationalist Solution comprises two separate maximization problems for countries A and B.

First, *country B* maximises its own welfare, taking resource restrictions on its own production into consideration and facing the given international terms of trade p^B. In addition, country B observes the biological resource stock S^0 determined by country A but cannot influence this management policy directly, since there is no market for the global non-consumptive biodiversity value of this resource. Thus the welfare maximisation problem of country B is now

$$\text{Max } W^B = {}_0\int^\infty U^B(z+x, q-m, S)e^{-\delta t}dt, \quad U^B_i>0, U^B_{ii}<0 \tag{18}$$

s.t. $S = S^0$

$$F(q,z) = 0 \tag{4}$$

$$p^B x = m. \tag{19}$$

Equation (19) ensures external trade balance as a restriction in the welfare maximisation problem. Since the above is an autonomous problem, maximising W^B is equivalent to maximising U^B of equation (5) with the same restrictions. Maximisation of $U^B(z+x; q-m, S)$ with respect to the control variables z, q and m and the restrictions (4), (19) and $S=S^0$ yields

$$U^B_1(z^0+x^0)/U^B_2(q^0-m^0) = F_z(q^0,z^0)/F_q(q^0,z^0) = p^B. \tag{20}$$

The equations (4), (19) and (20) define the optimal values z^0, x^0, q^0 and m^0 as functions of country B's terms of trade, p^B. The optimal values of these variables are not influenced by the size of S^0. The reason is our assumption of an additively separable welfare function. However, the value of W^B (and thus U^B) does increase with S^0. This is a straightforward open economy result which generates the offer curve $Z^B(x,m)$ for the world market as illustrated in Figure 1, where each value of p^B generates a mix of x and m (and of z and q) which constitutes the national optimum for the trading economy. Z^B is also not influenced by S^0 because of our assumption of an additively separable welfare function.

Figure 1 approximately here

Country A also maximises its own welfare within its resource restrictions, taking its international terms of trade p^A as given. However, this means that country A now ignores the external effect of its biological stock on the welfare of country B. Thus the maximisation problem for country A with control variables y and x and state variable S is

$$\text{Max } W^A = {}_0\int^\infty U^A(y-x; f(S)+m)\, e^{-\delta t}dt \tag{21}$$

$$S(0)>0 \text{ and } \lim t \rightarrow \infty\ S(t)\geq 0,\ S^{max}>S^{min}>0,$$

$$U^A_i>0, U^A_{ii}<0.$$

subject to equation (2) and

$$p^A x = m \tag{22}$$

This yields as necessary conditions in equilibrium

$$U^A_1\,(y^0 - x^0) = p^A U^A_2(S^0,m^0) \tag{23}$$

$$[\delta - G_S(S^0) + G(S^0)w_S/w(S^0)] = U^A_2(S^0,m^0)f_S(S^0)w(S^0)/\,U^A_1(y^0,x^0) \tag{24}$$

$$G(S^0) = w(S^0)y^0. \tag{25}$$

We can substitute from equation (23) in equation (24)

$$[\delta - G_S(S^0) + G(S^0)w_S/w(S^0)] = f_S(S^0)w(S^0)/\,p^A < 0 \tag{24'}$$

The equations (22) - (25) define the optimal values of the variables x^0, m^0, S^0 and y^0 as functions of δ and p^A. For the trade portion of this equilibrium it is possible to denote for country A an offer curve, $Z^A(x,m) = 0$, which demonstrates the optimal mix of exports and imports for different values of p^A. The offer curve Z^A is illustrated in Figure 1. Schulz (1996) demonstrates the shape of Z^A for a fixed value of S. However, in the model of this paper S will vary along the offer curve because it is a function of p^A. The shape of the offer curve for country A therefore deviates from the traditional 'textbook' shape of an offer curve, such as the Z^B curve for country B in Figure 1. Nevertheless, there is a lower bound for p^A caused by our assumption of positive exports of resource products. For each value of p^A, there is one value of x, and the trade balance equation (22) secures a corresponding value for m. Hence, we can derive the shape of the offer curve by finding dx/dp^A and $dm/dp^A = p^A dx/dp^A + x$ within the nationalist model of country A. In the market equilibrium equation (17) must be fulfilled, setting $p^A=p^B=p^0$ in the world market. This is illustrated in the Figure with the equilibrium world price passing through the intersection of the Z^A and Z^B curves.

There are two further complications in determining the shape of the offer curve for the resource based economy A. First, deriving the optimal use of the biological resource as well as the properties of the function $S(p^A)$ along the offer curve involves an evaluation of the net returns to 'holding on to' the natural asset, as indicated by equilibrium conditions (24) and (25) above. Because of the opportunity cost of holding on to land as habitat, c = f(S), the optimal level of species stock will also influence the relative marginal value of domestic consumption of harvested products to imports in equilibrium, as represented by equation (23). Second, the long run equilibrium product flow from the resource asset is by assumption an 'inverted U-shaped' function of the stock. Hence, increased stock may very well yield a lower long run sustainable harvest, which may make the resulting trade effect of improvements in the TOT highly ambiguous. For example, if $S^0 > S^{MSY}$ and $\partial S^0/\partial p^A > 0$, the effect of increased stock as the TOT rises is a long run lower sustainable yield, which means less products supplied for consumption or export. On the other hand the trade effect of an improved TOT should be to make exports of the harvested product more profitable, and internal consumption more expensive.

Total differentiation of the long-run equilibrium Nationalist Solution for country A with respect to p^A yields the following comparative static results for $\partial S^0/\partial p^A$ and $\partial x^0/\partial p^A$. Since the system is recursive, we first find $\partial S^0/\partial p^A$ from equation (24'), and then we use this result to obtain the other comparative static result

$$\partial S^0/\partial p^A = [-f_S(w(S^0))^2]/\ p^A[\delta p^A w_S + p^A G(S^0) w_{SS} - 2f_S w(S^0) w_S - (w(S^0))^2 f_{SS} - p^A w(S^0) G_{SS}] \quad (26)$$

$$\partial x^0/\partial p^A = [-1/(U^A_{11}+(p^A)^2 U^A_{22}]\{U^A_2(1+\eta_A)+[p^A U^A_{22} f_S - [U^A_{11}/w(S^0)][G_S - w_S G(S^0)/w(S^0)]]\partial S^0/\partial p^A\}. \quad (27)$$

We denote $\eta_A = U^A_{22}c/U^A_2$, and we assume $|\eta_A| < 1$ throughout the discussion[4]. The stock effects of a shift in p^A is found from equation (26). The numerator of equation (26) is positive, but the sign of the denominator is unknown. The two last terms of the denominator are positive, and only if they are outweighed by the first three negative terms will we get the standard bioecomic result that a positive price shift will have a negative effect on the stock size (Clark 1976).

An interesting special case occurs if $w(S)>0$, $w_S=0$, $f_S<0$. Under these conditions, as p^A changes, only the conversion of habitat to produce consumption influences optimal stock management. Since the resource depletion rate is constant, there are no other indirect influences of price changes on S^0 via the intensity or resource exploitation. The effect of a price shift in this special case is depicted in equation (28), denoting w(S) = w

$$\partial S^0 / \partial p^A = (\delta - G_S)/[wf_{SS} + p^A G_{SS}] = wf_S / \{p^A[w\, f_{SS} + p^A G_{SS}]\} > 0. \qquad (28)$$

In comparison with equation (26) of the general solution, under the conditions of the special case, $\partial S^0/\partial p^A$ is unambiguously positive. That is, where the effects of a price change on the optimal stock occur exclusively through influencing the rate - or 'threat' - of habitat conversion, and not through influencing the rate of resource exploitation as well, then an increase in TOT for the resource-based economy may actually lead to a rise in the long-equilibrium stock. This result for the special case helps us to clarify the situations that allow us to sign $\partial S^0/\partial p^A$ under the general solution.

For example, comparing equation (28) with equation (26) indicates that if the influence of a TOT change predominately affects the 'threat' of conversion then this may also lead to $\partial S^0/\partial p^A > 0$ in the general solution. We denote this outcome as the *Conversion Threat* situation, and we see from equation (26) that $\partial S^0/\partial p^A > 0$ if $p^A[\delta w_S + G(S)w_{SS} - w(S)G_{SS}] > w(S)[2f_S w_S + w(S)f_{SS}]$. If this condition holds, then the main effect of a price increase is that it makes it more profitable to keep land for habitat instead of converting it to another use (i.e., to produce c). Note that in this situation the equilibrium stock is usually small, as in the special case depicted in equation (28) where $(\delta - G_S) < 0$ and thus S^0 occurs to the right of the maximum sustainable yield stock level, S^{MSY}.

In conventional bioeconomic models with no conversion threat, the effect of a price increase is to reduce the long run optimal stock due to the increased opportunity costs of maintaining the stock. If this effect dominates in our model and makes $\partial S^0/\partial p^A < 0$ in equation (26), then we denote this outcome as the *Exploitation Threat* situation. Note that from equation (26) and the above discussion, the Exploitation Threat situation is likely to prevail when the equilibrium resource stock is high, as then f_S will be smaller in magnitude, and $(\delta - G_S) < 0$ will approach zero or possibly even be positive.

We conclude that the sign of $\partial S^0/\partial p^A$ essentially reflects the extent to which the conversion constraint becomes sufficiently binding, and thus the extent to which the resource stock effect of a price change in our model deviates from the standard bioeconomic result. The Conversion Threat situation will tend to dominate for a small stock size. Since we are interested in the international concern for the non-consumptive stock values of the biological resource, which is perceived to arise from excessive conversion, it seems reasonable to concentrate on situations with equilibrium $S^0 \leq S^{MSY}$ as the main case, and thus where also the Conversion Threat outcome may prevail.

The sign of $\partial x^0/\partial p^A$ is ambiguous, which confirms the earlier discussion concerning the difficulty of deriving the shape of the offer curve, Z^A, in Figure 1. Determining the effects of a TOT change on the equilibrium level of resource exports will again be influenced not only by the initial equilibrium stock size and its changes but also by the corresponding changes in harvesting yield, exports and own consumption as a result of price changes. Equation (27) includes all these effects, which together influence the sign of $\partial x^0/\partial p^A$. We shall assume that $\partial x^0/\partial p^A$ is positive for low values of p^A, and negative for large values of p^A, as illustrated in Figure 1. For comparison, the offer curve for country A for a constant stock $S^\#$ is illustrated by a dotted line in Figure 1.

Equilibrium in the world market is found when global demand and supply are equated, and this results in a market equilibrium for both countries consisting of the equations (20), (23)-(25) and (17). This is illustrated in Figure 1 where the intersection of Z^A and Z^B at R demonstrates the only terms of trade that constitute a world market equilibrium.

The difference between the Nationalist and the Cosmopolitan Solutions in terms of global welfare is fairly self-evident. Country B faces the same conditions in both outcomes, except that in the Nationalist Solution the country must take $S = S^0$ as given. Equation (24) demonstrates that country A manages the total species stock ignoring the biodiversity value $U^B{}_3$. Hence $S^0 < S^*$, and the Nationalist Solution is less socially efficient than the Cosmopolitan Solution due to this failure to take account of the trans-national positive stock externality. It is also fairly easy to see from conditions (14) - (16) that in comparison the Nationalist Solution is not a Globally Efficient Solution.

The specific trade effects of moving from a Cosmopolitan to a Nationalist Solution are more difficult to determine. Since we always have $S^0 < S^*$ then it follows that $y^0 \neq y^*$, but the actual change in equilibrium harvest levels is ambiguous. We concentrate on small stocks and assume as before that $S^* \leq S^{MSY}$, and $y^0 < y^*$. This suggests that both domestic consumption and exports of harvested output from country A could potentially be lower in the Nationalist versus the Cosmopolitan Solution, but depending on the difference in TOT between the two Solutions and the resulting impact on exports, it is possible that equilibrium x may actually rise. Unfortunately, we do not know the sign of $p^0 - p^*$, where p^* is the implicit terms of trade from equation (13), i.e. $p^* = U^A_1 (y^*-x^*)/ U^A_2(S^*,m^*) = U^B_1(z^*+x^*)/ U^B_2(q^*-m^*)$, while by assumption $p^0 = U^A_1 (y^0-x^0)/ U^A_2(S^0,m^0) = U^B_1(z^0+x^0)/ U^B_2(q^0-m^0)$. Even if $p^0 - p^*$ can be determined, equations (26) and (27) and the subsequent discussion indicate that the impact on S and x of changes in the terms of trade is ambiguous.

So far we conclude that the free trade Nationalist Solution does not generate either maximum world welfare or world social efficiency, and that country B is always worse off under this outcome. We also know that country A is better off in the Nationalist than in the Cosmopolitan Solution. Although it is free to choose $S = S^*$, country A will always decide to set $S^0 < S^*$ and thus convert more species habitat and/or harvest more of the species stock in order to increase its own consumption and welfare. As country B is unable to affect S in the Nationalist Solution, country A no longer has to conserve as much of the resource for B's benefit, and given the opportunity cost of 'holding on' to the resource, country A will conserve less than the Cosmopolitan optimum, S^*.

However, at the margin U^B_3 may be sufficiently large to make country B willing to pay country A to increase S. This is the basis for international biodiversity negotiations and transfers. As recent analysis has suggested, it is not certain that both countries can reach S^* through an international agreement involving transfers, because their gain by doing so may be lower than the loss for country A (see Barrett 1990 and 1994; Swanson 1995). The alternative may be for one or both countries to try to improve upon the Nationalist Solution by using trade policy interventions to increase national welfare. In the following sections we develop our model further to explore the effects of trade interventions and international transfers as alternative policy mechanisms to achieve increased resource conservation.

5. Nationalist Solution with Optimal Tariffs

The Nationalist Solution in Section 4 makes it feasible for the countries to use tariffs unilaterally to improve national welfare. As long as each country is facing an international market where it is possible to influence the price level this must be one option considered by them. The argument for a tariff within the nationalist model is to extract monopoly profit in the world market (Meade 1952). This is only possible as long as the export supply of the other country is not totally elastic; i.e., the foreign offer curve is not a straight line. This theory is well known in the general case, and even in the case with retaliation (Johnson 1953). However, the effects of trade policy on the optimal stock size of the resource based economy has been shown only for some special cases, and these circumstances indicate some counter-intuitive conclusions (Barbier and Rauscher 1994; Barbier and Schulz 1996; Schulz 1996b). We adapt the offer curve illustration from Figure 1 to indicate the effects of optimal tariffs on our Nationalist Solution.

First, let the resource based economy use tariffs to improve its welfare, while country B takes the price for granted. The internal terms of trade in country A is changed to $p_x/(p_q+t_a)$, and this shifts the offer curve of country A. Since country B will accept any point along its offer curve Z^B, country A can improve its welfare by shifting down its free trade offer curve Z^A. It can do so until one of its trade indifference curves has a tangency with Z^B (see Figure 2, panel A). If the government in country A does this by use of an import tariff, the international terms of trade will be improved for country A from p^0 to p^1. Thus the principal objective of this policy would be to restrict exports to get a better price. However, the relative domestic prices, $p^1{}_A$, for the producers and consumers in A include the tariff rate. Consequently, a change in the internal price ratio will induce substitution in domestic consumption towards the traded good. This triggers a change in the optimal stock size, but still the direction is ambiguous. The result may by chance shift S towards S^*, but there is no guarantee that the policy will yield the optimal long run stock of the Cosmopolitan Solution.

Figure 2 approximately here

Now, let country B use a tariff on imports to increase national welfare, while country A trades according to its offer curve. The right hand panel in Figure 2 illustrates the outcome. The internal terms of trade in country B is shifted to $(p_x+t_b)/p_q$, and this shifts the offer curve of B, Z^B, to the left, and the terms of trade for country B improves from p^0 to p^1. As shown in Figure 2, panel B the effect of the optimal import tariff is to move the trade equilibrium until tangency between Z^A and the highest trade indifference curve of country B is achieved, which occurs at point D. However, Z^A includes the effects of $\partial S^0/\partial p^A$, which suggests that the tariff policy of country B will also influence the resource stock size of country A. This in turn has implications for country B's welfare, as it depends partly on the transboundary externality associated with the size of S.

Thus a tariff introduced by country B has two effects on its welfare. First, the tariff increases welfare due to improved terms of trade and a tariff income. This is the pure 'trade' effect of the policy. Second, the tariff affects the optimal resource stock size for country A, and this influences the welfare of country B as well through the transbounday externality associated with biodiversity. This is the transboundary externality effect of the tariff policy. The latter effect was not included in our offer curve analysis of the Nationalist Solution in Section 4, because under free trade condtions country B could not influence the stock size in country A. Now, however, country B can use trade policy to influence the stock size. If country B has full knowledge of the effects on S of decreased p^A this will influence its trade policy decision.

In the *Exploitation Threat* situation both the trade and the transboundary externality effects of the tariff policy support each other. A tariff both yields the traditional trade gains to B and increases the resource stock held by country A. Hence, the optimal tariff for country B must be positive, and the corresponding stock after the tariff policy is $S^t > S^0$. However, in the Conversion Threat situation a tariff imposed by country B will decrease the stock held by A, and the two objectives of the trade policy have opposite impacts on B's welfare. We can distinguish two possible cases for the Conversion Threat situation. If the income and trade effect of a tariff is strong, this will outweigh the transboundary stock externality effect for country B, and at the optimum B will set a positive tariff and *decrease* the stock, $S^t < S^0$. However, if the positive non-consumptive stock externality to B is extremely large, this will outweigh the possible trade gains from a tariff, and at the optimum B will *subsidize* trade with country A to increase the resource stock. The latter case of course also means a gain for country A, and this situation constitutes the possibility of a global Pareto improvement from either the free trade Nationalist Solution or the unilateral trade policy action of country A. This result is counter-intuitive, as traditional trade theory suggests that if B alone can set an optimal tariff then this should makes country B better off while country A is worse off (Meade 1952)[5]. However, the Conversion Threat situation of our model introduces the possibility that *both* countries could gain from an optimal trade intervention imposed unilaterally by country B - although in this instance country B actually subsidizes the TOT of A and is in turn compensated for any resulting trade losses by the welfare gains arising from increased transboundary biodiversity values.

We conclude that a unilateral trade policy from one of the countries changes the world terms of trade favourably for that country. However, the more interesting case is the choice of optimal tariff policy open to country B. In the Exploitation Threat situation a positive tariff is optimal for country B, while the Conversion Threat situation may trigger a subsidy as B's optimal trade intervention yielding positive net welfare gains for both countries. The latter situation is not as far-fetched as it seems. A study for the International Tropical Timber Organization has concluded that, providing tropical timber exporting countries demonstrate progress towards sustainable management of their production forests, timber products from these countries should have improved access to the markets of large importing countries - particularly as consumers in these countries perceive that they will gain substantially from the greater conservation of tropical forest biodiversity and habitats arising from sustainable harvesting and management practices (Barbier *et al.* 1994).

However, even in the absence of retaliation or sanctions, any unilateral trade policy must be pursued with caution. One cannot be sure that the optimal tariff (or subsidy) will actually move S^0 towards S^* unless we know the values of the parameters in our model. Determining these values for our simple model is complicated enough; determining them for real-world situations is fraught with difficulties. Moreover, any unilateral trade interventions in a world market will never yield the full Cosmopolitan Solution, because the price wedge arising from the unilateral intervention invariably makes the marginal valuation of the traded commodities different in the two countries. To consider ways in which the Nationalist Solution can be modified to achieve the Cosmopolitan Solution, we have to examine the possibility of policy options and interventions at the world market level.

6. Global Policy Options and Interventions

From the analysis of the previous sections it is clear that the complicated interrelationship between trade, bioeconomics and welfare in our model makes it difficult to derive general conclusions concerning the effects of unilateral trade policy interventions. Similar problems confront the analysis of global policy options and interventions. However, it may be possible to discuss the likely effects of global policies based on the analysis and conclusions from Section 4 and 5. In the following discussion, we are assuming that $S < S^{MSY}$. We also assume that, in the absence of a global policy, only country B which is the large country is capable of imposing a unilateral trade intervention.

There are several possible options for 'world market interventions'. It is also feasible to consider interventions that are not related to international trade. Looking at the difference between the Cosmopolitan and the Nationalist Solutions, a major problem is that the transboundary stock externality associated with resource management by country A is ignored. If it is possible to introduce an international subsidy linked to the stock size, then this externality could be internalized. A 'debt for nature' swap between countries A and B may be part of this policy. However, this option is not easy to enforce, and may have limited effectiveness in habitat conservation on a large scale (Hansen 1989). In the following discussion we therefore concentrate on global market interventions to improve global welfare and resource management, as such interventions can be reasonably explored with the aid of our model.

One possible intervention is a producer tax cum subsidy in country A supported by international transfers from country B. A unit tax τ on products from the resource will decrease the producer price and makes up the same effect as a lower price on the resource management. Contrary to conventional trade theory results, a production quota will not necessarily yield the same results as the bioeconomic conditions of our model would indicate that the long run exploitation rate *increases* with the stock[6]. Within a free trade system it is always possible to reach the Globally Efficient Solution by use of an appropriate production tax cum subsidy, τ. This is seen directly by comparing the free trade conditions, (17), (20), (23)-(25) with the equations (14)-(16). This intervention sets $p = (p_y+\tau)/p_q$, and the relative consumer price is the same for both countries, which is socially efficient[7]. If the tax cum subsidy is set properly we reach $S^0= S^*$. However, such an intervention does not automatically ensure $U^A_i=U^B_i$, which is necessary for the full Cosmopolitan Solution. Usually, the tax cum subsidy must be supported with an international transfer to do this, and we would expect that such a transfer would be from country B to A to account for the transboundary externality associated with greater biodiversity conservation.

This is an important conclusion, since the optimal international transfer not only ensures an efficient market solution through use of a production tax cum subsidy but also simultaneously allows attainment of the full Cosmopolitan Solution. However, optimal design of this policy is only possible if country B works in co-operation with country A. If no international tax cum subsidy agreement is reached, then it may not be possible to improve the free trade market solution through such a policy intervention. Recent experience and difficulties in negotiating international agreements and cooperation on biodiversity conservation and resource management suggest that there are many problems in pursuing this type of global policy intervention (Barbier *et al.* 1994; Barrett 1994; Swanson 1995).

However, alternative trade policy interventions are even less attractive. A world trade tariff cum subsidy on resource based products drives a wedge between the relative commodity prices in the two countries, and therefore cannot be globally efficient. An additional option is to introduce an international transfer to adjust the income distribution between the two countries. This will not internalize the externality in the resource management, and it is not possible to reach a globally efficient outcome in this way. We conclude that international co-operation to implement a resource exploitation tax cum subsidy scheme supplemented by international transfers is a first-best outcome as it could improve global efficiency and even attain the Cosmopolitan Solution, whereas other possible trade policy interventions are second best options.

However, given that the first-best global policy of a production tax cum subsidy may be difficult to implement, it is also instructive to examine other forms of international agreements - such as so-called ‘trade for nature’ deals - that utilize trade incentives to attain global resource management objectives. An important assumption in the following discussion is that the alternative to any global policy is likely to be a trade intervention by the large country to secure its objectives unilaterally. As we shall see, this possibility may actually create the incentives for each country to reach a ‘trade for nature’ agreement in order to avoid its least preferred world market outcome. Since this conclusion is not obvious, it is worth utilizing the results from the analysis of our model to explore why this might be the case.

A key policy lesson from our analysis of Sections 4 and 5 is that the two countries will differ in terms of which world market outcome each would prefer to occur, especially given that in the absence of a global policy country B is capable of imposing a trade intervention unilaterally. Usually the free trade solution is the best available market solution for country A, as it will experience a loss of income if a tariff is imposed by B, whereas the Nationalist Solution with optimal tariff is the best available market solution for country B. Both countries clearly need an incentive to forego their respective preferred outcomes in favour of some kind of mutual agreement over global trade and resource management policy.

Recall, however, that there is one exception to this incentive dilemma: If the Conversion Threat situation prevails, a trade subsidy favouring country A’s exports is sufficient to increase S, and this may be the optimal unilateral policy of country B. If so, the unilateral trade policy of B is an improvement in global efficiency, since both countries are better off. Moreover, although country B will always prefer to have trade policy as an option compared with the free trade situation, the end result could by accident lead to a zero optimal tariff and thus *de facto* free trade. For example, under the Conservation Threat situation, the trade gains from imposition of a positive marginal tariff may be exactly offset by the losses from the decrease in the resource stock held by country B, in which case a zero tariff rate would be optimal. In the following discussion we assume that any optimal tariff imposed by country B would not be equal to zero.

To summarize, the analysis of the previous sections suggests that in the free trade situation $S^0<S^*$, and both countries are facing the same prices. For example, this situation might occur if both countries are part of the WTO, and country B has included country A in a GSP arrangement with no tariff on the resource based products[8]. If country B has introduced an optimal unilateral trade intervention, there would be a positive tariff t_b in the Exploitation Threat situation, and $S^t>S^0$, but we do not know if S^t is larger or smaller than S^*. In this case there is a wedge between the internal price-ratio in the two countries, and the consumer price ratio in B is $(p_y+t_b)/\ p_q>p_y/p_q$. In the Conversion Threat case either country B will set a positive tariff $t_b>0$, and $S^t < S^0$; or its optimal intervention will be a trade subsidy, $t_b<0$, and $S^t > S^0$. However, none of these outcomes are globally efficient, and of course do not satisfy the Cosmopolitan Solution, which additionally requires $U^A_i=U^B_i$.

Given the above likely outcomes in the absence of a global policy agreement, we can now examine the possibile incentives for both countries to implement such an agreement, particularly one that employs trade policy measures to support international regulation of resource management by country A.

We denote a '*trade for nature*' agreement as a deal where country A is secured free trade for its resource products, and in turn the country agrees to maintain $S = S^*$. Compared to the free trade Nationalist Solution this outcome will always be an improvement for country B, since it attains the optimal resource stock, S^*, despite not being able to impose an optimal tariff. However, the welfare of country A declines relative to the pure free trade outcome, as it accepts a larger stock than the free trade choice and gets nothing in exchange. This means that it would not be possible to secure a global 'trade for nature' agreement as long as country A is ensured free trade.

Compared to the Nationalist Solution whereby B chooses an optimal tariff, the 'trade for nature' option is more ambiguous. First, let $t>0$, $S^t \geq S^*$. Under these conditions, country A gains by accepting trade for nature, while country B loses. However, if $t>0$, $S^t<S^*$, then the outcome is more ambiguous. Country B may not be willing to accept free trade as the means to ensure that country A maintains the resource stock as S^*, as B could incur a substantial revenue loss from this action. A 'trade for nature' deal would therefore both add to and deduct from the welfare of B,

and it is uncertain whether there is a net gain. Similarly, country A would gain from the free trade part of the deal, whereas they might lose from keeping a larger resource stock.

In the Conversion Threat situation, country B may still prefer a positive optimal tariff so that $S^t < S^0$. In this situation, country A still prefers free trade but is undecided between the 'trade for nature' and the nationalist solution with the optimal tariff. Country B prefers all other outcomes to free trade, but it is possible that a 'trade for nature' agreement is preferred to a unilateral tariff. We know that $S^t < S^0 < S^*$ in this situation. This means that there will always be some value $S^\#$ of the resource stock such that $S^\# > S^0$, and which would make country A indifferent between free trade and facing an optimal tariff imposed by B resulting in $S^t < S^0$. Similarly, for country B there is a resource stock level $S^\# > S^0$ that would make it indifferent between free trade and the optimal tariff outcome with $S^t < S^0$. Hence, there exists a set of $S_A^\# > S^0$ that country A would accept in exchange for free trade and a set of $S_B^\# > S^0$ for which free trade would be preferred by country B to the optimal tariff outcome. Hence, there is exists the possibility for the countries to make a 'trade for nature' agreement that avoids the worst option for each countries, and which results in free trade and $S^\# > S^0$. If $S^\# = S^*$ then the trade for nature deal will be globally efficient as well.

In the Conversion Threat situation it may also be optimal for country B to set a trade subsidy to increase the resource stock held by country A. If t<0 and $S^0<S^t<S^*$, then we know that B will gain from a 'trade for nature' deal, since this agreement would allow B to forego the trade subsidy for A's exports and yet be able to obtain an even larger stock than S^t. However, in this case country A loses the subsidy, and the increased stock adds further to its welfare loss. Thus, a 'trade for nature' agreement is impossible to reach without supplementary international transfers to country A.

Finally, it is easy to demonstrate that for all the above situations that the 'trade for nature' agreement is socially efficient. First, the biological resource stock in country A is maintained at its optimal level, S^*. Second, prices are equal in all markets. Hence, this outcome fulfills conditions (14) - (16) of the Globally Efficient Solution; however, as noted before, this is not sufficient to ensure the full Cosmopolitan Solution.

To summarize the discussion, a ‘trade for nature’ agreement is always preferred to free trade by country B, but is never preferred to free trade by country A. Nevertheless, both countries may still find it acceptable to agree a ‘trade for nature’ deal because under certain situations it allows each country to avoid its least favourable option. Compared with the optimal tariff regime, trade for nature is preferred by country A if $t>0$ and $S^t \geq S^*$, and for some other situations with $t>0$ as well. The optimal tariff regime is preferred by country B except if $t<0$, $S^t>S^0$, and in some cases if $t>0$, $S^t<S^*$. This means that in the Exploitation Threat situation and $S^t \geq S^*$, a ‘trade for nature’ agreement will ensure that both countries avoid their worst possible option. This may also be the case if $t>0$, $S^t<S^*$ under some Exploitation Threat situations and the Conservation Threat Situation. However, under the Conservation Threat situation where the optimal trade regime is actually a trade subsidy for country A, a ‘trade for nature’ agreement will only succeed if accompanied by additional international transfers between countries B and A.

We conclude that the existence of some risk in the world trade system may be an incentive for both countries to negotiate a ‘trade for nature’ agreement if both parties want to avoid their worst outcome. If under existing world trade rules neither country is sure that it can achieve its preferred first-best solution, then a ‘trade for nature’ deal may be the safe compromise.

Certainly, existing world trade rules appear to be in a state of flux, particularly with respect to trade and environment concerns. World trade is currently dominated by the trade policy rules of the World Trade Organization (WTO). These rules are based on the Most Favoured Nation (MFN) principle, which seeks to avoid bilateral preferential trade arrangements. Ostensibly, the aim of WTO policy is to move the world market system towards free trade; thus, unilateral trade actions are generally ruled out by WTO. This should mean that no unilateral tariff regime is safe from WTO-endorsed sanctions, which ought to mitigate against the type of optimal tariff policy discussed in Section 5. However, many large countries, such as the United States, have established systems of unilateral trade policy interventions that remain largely insulated from WTO rules and sanctions (Bhagwati and Patrick 1991). Moreover, although a unilateral policy decision may be overruled by the WTO, this usually takes some time, and the decisions generally involve political compromises that reflect the strong influence of the major participants the world trade. In addition, there is increasingly a demand for a separate set of rules for trade policy interventions based on environmental reasons (Porter and Brown 1996). These rules both exploit loopholes in the MFN system that allow unilateral trade interventions on environmental grounds and call more generally for national environmental concerns to take precedence over internationl free trade rules.

Thus the current quasi-free trade climate of the world trading system could actually reinforce the conditoins favouring ‘trade for nature’ agreements. Recall from the policy discussion arising from our model that if country A is sure to get a free trade solution, it would be unwilling to accept anything else (except for the situation with optimal trade subsidies). If country B has no threat of an WTO decision on free trade, it will usually prefer a unilateral trade intervention. However, the current world trading system is unlikely to guarantee either of these outcomes. There is a general trend towards free trade, and this makes the nationalist solution with optimal tariffs an unsafe option in the long run. On the other hand, WTO rules are under pressure for unilateral policy interventions, particularly with regard to environmental concerns. This makes free trade vulnerable, especially for countries exporting resource based products. In comparison, a ‘trade for nature’ deal may prove to be a less vulnerable outcome. First it is an international agreement and enforced by the participants. Second, it includes free trade, which makes WTO sanctions less likely. Third, parties to the agreement may face alternative options which could make them worse off, such as free trade for country B and the Nationalist Solution with optimal tariffs for country A.

How realistic are the prospects of a 'trade for nature' agreement? Already, there is evidence that such an approach might work for certain types of resource based products, such as forest products, where trade-related incentives may encourage improved sustainable management of the resource stock. Thus a recent proposal for *country certification* has been suggested to the ITTO and the Intergovernmental Panel on Forests (IPF), which involves an international commitment by both producer and consumer countries to adopt policies and practices towards encouraging sustainable management of production forests and timber products while simultaneously improving international market access of these products (Barbier *et al*. 1994; Barbier 1996). To be effective, country certification would require two broad sets of policy commitments from timber producing and consuming countries respectively.

The first set of policies would require producer countries to undertake substantial reviews of their forest sector policies to determine the implications of their existing domestic forestry policies and regulations on timber-related deforestation and the extent to which their timber export policies may also be affecting deforestation, either directly or through exacerbating problems caused by poor domestic forestry policies and regulations. Producer countries ought to correct those policy distortions that work against sustainable timber production objectives, as such distortions are believed to be at the heart of inefficient and unsustainable forest sector development and timber-related deforestation (Barbier *et al.* 1994; Barbier 1996).

The second set of policies would require a commitment by consumer countries to remove any remaining tariff and non-tariff barriers to timber imports into domestic markets, particularly for those producer countries that demonstrate a commitment to forest sector policy reform. For example, the removal of specific tariff and non-tariff barriers on forest product imports could take place on a case by case basis, depending on demonstrable progress by each exporting country in promoting sustainable forest management policies and forest sector policy reform. This could occur through normal bilateral trade negotiations or through multilateral agreements and organizations. In addition, consumer countries should actively promote, through information and market intelligence campaigns, the use of tropical timber imports from exporting countries that are implementing 'sustainable management' policies. Finally, consumer countries should also undertake a commitment not to resort in the future to developing any ‘new barriers’ through, say, domestic health and environmental regulations, that discourage the imports from participating producer countries.

The country certification arrangement linking trade liberalization of timber products to improved sustainable forest management could serve as a model of the type of 'trade for nature' deal that could be applied to other resource-based trade. However, there are problems with this approach. For example, in the forest products trade, some of the leading importers, such as the United States, the European Union and Japan, are not only major importers as well but also dominant countries in the world trading system generally. Consequently, as long as these large trading regions are able to secure their own unilateral objectives through existing international trade rules, there is little incentive for them to endorse the country certification approach for the timber products trade and sustainable forest management. There are likely to be similar problems confronting 'trade for nature' agreements for other traded resource-based products.

To summarize our discussion in this section, we conclude that as long as the optimal tariff of a large importing country such as B in our model is positive, it is possible to secure an agreement including increased stock and free trade if there is a credible threat of a change to free trade or unilateral trade interventions from country B. However, this outcome is unstable without an international agreement on the matter, since free trade always is better for the resource based country A, whereas an optimal tariff will be preferred generally by country B. In some cases, transfers or an enforcement system must be added to strengthen the incentives for an agreement. As the example of country certification for forest products trade indicates, establishing such an agreement is not easy, unless there is a general perception by all participants that the 'trade for nature' deal reduces uncertainty and instability in a trading system that might otherwise generate what they perceive to be the worst possible outcome.

If the optimal trade intervention from country B is a trade subsidy, there is no reason for a ‘trade for nature’ agreement. Both countries will now prefer the unilateral trade intervention compared with free trade, and there is no reason for country A to insist on any agreement. However, the conditions for this outcome are rather strict: it reflects a situation where the resource stock generates a highly valuable transboundary externality for country B, and by imposing a positive tariff B may trigger more conversion of the resource in country A.

7. Concluding Remarks

We have demonstrated how trade has two different effects on resource management. First there is a direct effect through the influence of exports on the harvesting level and the value of the optimal stock. Second, there is an indirect effect through the influence of imports on the habitat conversion process. Increased profitability in harvesting works to deplete the stock, but the resulting demand for more imports makes habitat conversion less attractive. It is these two counteracting impacts arising from changes in the terms of trade that makes trade interventions difficult to use as a policy option. In addition, the long run management implications of trade interventions differ substantially from short run considerations. While the short run impacts are concerned only with the effects on harvesting, trade policy in the long run also influences the asset valuation of the nature stock. Our model has allowed us to examine several different long run solutions, or outcomes.

Our analysis indicates that it is important to differentiate between the Cosmopolitan Solution of global optimal management and the Nationalist Solution arising from individual countries maximizing their own welfare through trade and resource management strategies. The difference in outcomes turns out to include more than simply ignoring the global public goods nature of the transboundary externality associated with the resource stock. Maximizing national welfare generates an incentive for the large country B to improve its welfare through unilaterally imposing optimally chosen tariffs to ensure both trade and/or resource management gains through influencing the imports of resource based products from country A.

Our analysis also shows that there is no easy way to transform the Nationalist Solution into the Cosmopolitan Solution by the use of trade interventions. Two situations have been studied. When the main problem is depletion of the resource stock in country A from harvesting, the Exploitation Threat situation applies, and a lower producer price increases the long run stock. If the main problem is the threat from conversion of habitat land, the Conversion Threat situation, a higher producer price increases the long run stock. Without determining *a priori* which situation prevails in the resource-based country, it is not possible for country B to conclude that its optimal policy should be a tariff or a trade subsidy; moreover, because resource stock and management conditions in countries vary considerably, the correct policy by country B towards one resource-based country may not necessarily be the same for another one.

In determining the incentives for both countries to acquiesce to a global policy or agreement governing trade and resource management, it is also necessary to know how in the absence of such an agreement trade policies of the main trading partners would distort trade patterns and influence the size of the long-run resource stock. In the Exploitation Threat case it seems possible under certain conditions to establish a ‘trade for nature’ agreement, whereby the resource based economy gets free trade in exchange for some regulation of the stock size. Both countries consider this as a second best option, but would agree to it if the alternative was likely to be the worst possible outcome. It seems more difficult to reach a 'trade for nature' deal when we have a Conversion Threat situation, particularly if it turns out to be optimal for country B to impose a trade subsidy, making both countries better off.

In general, our analysis suggests that the main motivation for any 'trade for nature' agreement stems from there being a credible threat from existing trading relationships of a change to free trade or of unilateral trade interventions from country B. However, the 'trade for nature' solution is unstable without an international agreement reinforcing this outcome, as free trade is always preferred by the resource based country A, whereas an optimal tariff will be preferred generally by country B. Obviously, there are additional negotiation costs associated with such an agreement. Given the lack of such deals currently, we conclude that the existing situation of loosely enforced global trading rules and evolving conditions concerning unilateral trade interventions on environmental grounds appears so far to be preferable to reaching an international agreement on trade for nature.

Finally, throughout our policy discussion the role of international transfers has been briefly discussed - mainly as a supplement incentive for securing a 'trade for nature' deal. However, it is important to note that under certain conditions resorting to international transfers on their own may be a better policy option, because the transfers may make the receiving resource based country better off while leaving trade unaffected, and any resulting wealth effect would be easier to evaluate (Barbier and Rauscher 1994). Nevertheless, if there already exists a trade distortion from tariffs, a transfer alone can never obtain a globally efficient outcome nor the full Cosmopolitan Solution.

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Figures

Figure 1. The Offer curves (Z^A and Z^B) and the equilibrium terms of trade, p.

The dotted line indicates Z^A for a constant stock size, $S^{\#}$.

(A) (B)

Figure 2. Optimal tariff set by one of the countries.

Panel A: Country A sets the tariff. Panel B: Country B sets the tariff.
p^0,p^1 = international terms of trade without and with tariff.
p^1_j = Domestic price ratio, country j. Z^j_t = tariff ridden offer curve, country j.

Notes

[1] Following Dasgupta (1982) *unidirectional* (negative) externalities are essentially damages imposed by one agent on another which are uncompensated through markets or through other means. On the other hand, *reciprocal* (negative) externalities are also uncompensated damages but they instead result when agents impose costs on each other through use of a 'common pool' resource. See Mäler (1990) for further extension of this categorisation to international environmental problems.

[2] There are different ways of modelling this trade off between the use of natural habitat to support biological species and the conversion of habitat to other production activities; e.g., see Barbier and Schulz (1997), Barrett (1993 and Rowthorn and Brown (1995). For example, Barbier and Schulz (1997) include in their model an explicit link from the size of the species stock to total habitat area. Although this is a possible extension of the model in this paper, for our results and discussion we need only to define this link as a restriction on production of other consumption goods, c, as shown in equation (1).

[3] Since there is only one product, there is no opportunity cost in production unless we introduce a labour supply. Note that our modeling of costs makes the unit depletion pressure from harvesting a non-increasing function of N, and the MSY is obtained for a larger stock than the one with largest biological growth.

[4] An improvement in the terms of trade results in a price increase for the national resource based economy of country A if $(U^A_2+pxU^A_{22}) = U^A_2(1+ h_A)>0$. This situation is the normal case in the trade sector, and should hold as long as p^A does not exhibit extremely high values. The opposite situation of $|h_j|>1$ corresponds to a backward bending export supply curve, which is the Metzler Paradox situation (see Schulz 1996).

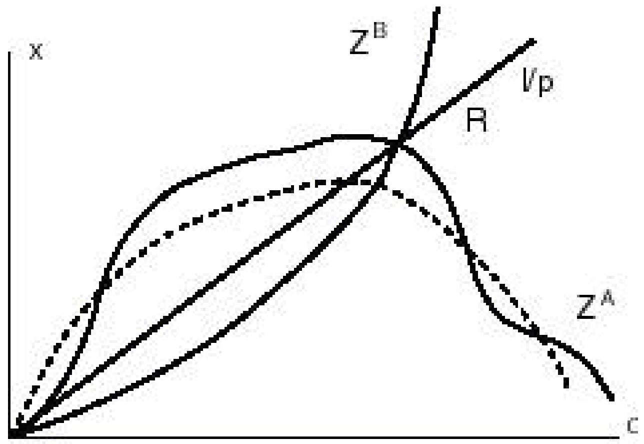
[5] A possible further step is to introduce optimal tariff with retaliation, Johnson (1953). Following his analysis this makes the terms of trade internationally somewhere between the two conclusions in Figure 2, while both countries in the normal case increase the domestic relative price of the imported goods. The situation with tariffs and retaliation must be analysed in a game theoretic setting, and it is beyond the scope of this paper to add this to the bioeconomic dynamics.

[6] The optimal stock is set due to wealth management considerations, and the harvest rate is found as the one which matches the sustainable yield for the optimal stock.

[7] A tax ix needed if $\partial S^0/\partial p^A<0$ (The exploitation threat case), and a subsidy if the threat is from conversion of the habitat.

[8] The General System of Preferences, GSP, is a unilateral tariff reduction executed by industrial countries on imports from developing countries within the GATT/WTO agreements.

Figures



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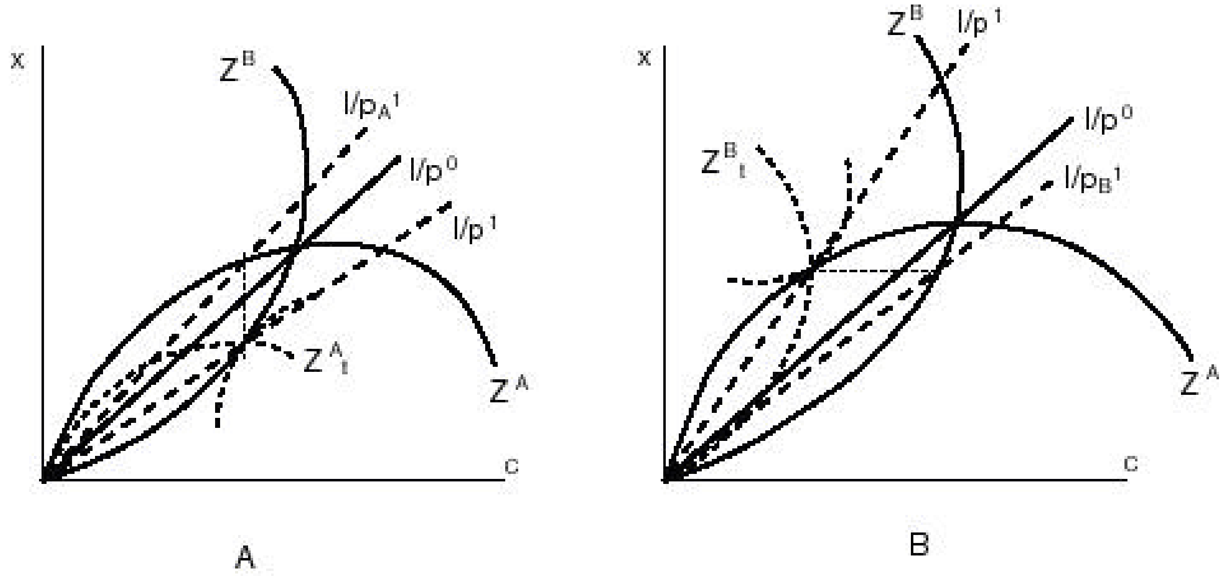
The dotted line indicates Z^A for a constant stock size, $S^{\#}$.



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