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Insight, part of Special Feature on Sustainability and Resilience in Boreal Regions

Incentive Systems That Support Sustainability: A First Nations Example

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ABSTRACT

Prior to contact with European settlers, the incentive and governance systems used by First Nations peoples of the Northwest coast of North America provided more sustainable use of the fisheries and other resources of that region than did subsequent systems. This paper explores the major reason for that success: the requirements of the potlatch system that chiefs share their income with each other. Because chiefs controlled well-defined territories and subjected each other to review, the potlatch governance system embodied the characteristics of negative feedback, coordination, resiliency, and robustness that political scientist John Dryzek identifies as means to support ecological rationality in the management of ecosystems. This ecological rationality occurs because the sharing of income made chiefs aware of the effects that their actions had on the income of other chiefs. In addition, public discussions that occurred at feasts would allow chiefs to coordinate their actions as needed. The paper concludes with proposals for application of the potlatch system to modern circumstances. Such application means changing the rules for the distribution of income from using ecosystem resources so that all entities share their surplus income with each other. The potlatch system can be applied to modern organizations by noting that chief executive officers are like chiefs, that profit is like surplus income, and that corporations can be viewed as similar to the houses of the traditional Northwest systems. One major change is that profit is no longer privately owned, and must be shared with other organizations that use an ecosystem. Although controls on behavior mandated by state power would be reduced, a modernized potlatch system would still need to operate within a context provided by governments and international agreements.

KEY WORDS: incentive systems, ecological rationality, ecosystem management, sustainability, potlatch, First Nations, American Indians, common-pool resource, Northwest Coast fishery, property rights, watershed ecosystem.

INTRODUCTION

As ecological systems and the social systems that depend on them face crises, investigators have become interested in human-ecosystem interactions that preserve the ability of ecological systems to provide goods and services in perpetuity. Some of the aboriginal peoples in North America, First Nations peoples in Canada and American Indians in the United States, appeared to have had such relationships at contact. This paper uses one of the examples, the residents of the Northwest Coast. In addition, when metal tools became available and population levels recovered from the epidemics, many First Nations peoples continued to use their ecosystems sustainably. For instance, the Menominee Tribe, Taos Pueblo, and Hopi Tribe in the United States, and many Cree First Nations using the boreal forest, have done so. What were the incentive and governance systems that caused members of those societies to make economic decisions that preserved the ability of their ecosystems to continually support people? Might it be that these societies, those that survive, are refugia for ideas that may be useful today?

Not everyone agrees that aboriginal peoples in North America used ecosystems in a sustainable manner. Some cite the purported fact that human immigrants caused Pleistocene extinctions of large mammals. Even if this is true, the extinction process came to an end; few were recorded between 10,000 and 400 years ago. As Callicott (1989*a*) suggests, perhaps a lesson was learned. Others have argued that pre-contact native population sizes and primitive technology would have prevented challenging ecosystem capabilities. Although this may have been true in some locations, recent evidence shows that estimated aboriginal populations and average harvests give total harvests that could have been near river capacity on the Columbia and Fraser Rivers (see Smith 1979, Glavin 1996). In her history of the Canadian coast fisheries, Diane Newell (1993: 45) writes in her summary of the aboriginal system:

"Aboriginal groups developed highly successful fishing and fish-preservation technologies and regionally based systems of resource management and distribution. There is no reason to believe that Indians on the Pacific Coast were perfect conservationists. And because of the tremendous amount of salmon caught for subsistence, trade, and ceremony before contact with Europeans, we can safely assume that the aboriginal salmon fishery, with its highly productive technology, was so large that it may have significantly taxed the resource. But . . . the salmon fishery of aboriginal British Columbia sustained yields for several thousand years. What is striking is the net effect of this system. It assured everyone adequate stocks of fish over the long term. The same cannot be said for the state-regulated industrial fishery that replaced it in the late nineteenth century."

Newell is referring to population numbers that were high prior to the effect of disease. Aboriginal peoples had excellent fishing technology. One should not assert that all aboriginal peoples were good caretakers; counter-examples surely exist. This paper analyzes one region for which the evidence is strong that good caretaking did exist.

If the aboriginal system on the Northwest Coast assured adequate stocks, what incentives caused this to occur? This question does not direct attention to the usual topic: values (Hughes 1983, Callicott 1989*a,b*). If we are interested in modern applications of ideas provided by First Nations, adoption of their value systems as a policy recommendation has some merit. A major characteristic of the modern era is individualization, which includes personal choice of belief systems (Giddens 1990, 1991, Beck 1992, Beck et al. 1994). Thus, implementation of the policy recommendation requires persuasion; a literature of such persuasion has developed (e.g., Suzuki and Knudtson 1992). Suppose that the persuasive project succeeds: two problems (at least) would remain. (1) The group of people who respect nature will need to coordinate their actions. (2) They will also have to control or counteract the actions of those who have not been persuaded. If an effective majority is persuaded that sustainability is needed, then people should act to change incentive systems. What incentive systems should be adopted to accompany the change in values?

Among the candidates are those used by First Nations peoples to organize their use of ecosystems. Many neoclassical and other current economic models presume a private property system, with the courts of a modern state enforcing ownership rules. The state provides other policies that mitigate the effects of decisions within the private property system. External effects are to be controlled with taxes, subsidies, and quantitative controls. The modern state has considerable difficulty in using these tools for controlling external effects. Among the problems are those of information, bureaucratic incentives, log-rolling in legislatures, and enforcement costs. Because First Nations peoples did not utilize modern states, we should not be surprised to discover that their incentive systems did not require state authority.

Their incentive and governance systems did, however, require that groups of people sanction those who did not obey the rules. The rules in the Pacific Northwest had three main characteristics: control of territory was clearly defined, the chiefs ruled as a polyarchy, and the whole society had an elaborate system of exchanging wealth, known as the "potlatch." The requirement to share wealth is a fundamentally important idea for managing ecosystems. When combined with the checks and balances of a polyarchy, sharing income focuses human attention on the interconnections of the ecosystem.

This paper begins with a framework for evaluating incentive systems for their ecological rationality, drawing on work by Dryzek (1987). It next sketches a Northwest Coast incentive and governance model, and asserts that this "potlatch model" addresses ecological rationality. The paper closes with suggestions about how a modernized version of the potlatch model could be constructed through modification of contemporary organizations.

ECOLOGICAL RATIONALITY

Based upon a careful reading of the literature on how ecosystems function, political scientist John Dryzek (1987) has distilled five principles as a way to judge the ability of a human institution or collection of institutions to respond to the needs of good ecosystem management: negative feedback, coordination, robustness, flexibility, and resilience. He has also applied these categories to modern institutions such as the capitalist market and modern bureaucracies (which are found to have low scores). He did not analyze traditional institutions along with modern ones, although he briefly discusses the political organization of hunter-gatherers.

Negative feedback

If the ecosystem is departing from its best method of operation, how are signals about the negative trends processed by the human institutions? Do the negative signals lead to changes in behavior that restore ecosystem functioning to the range desired?

Coordination

Ecosystems have connections, and human institutions need to coordinate decisions to take the connections into account. Coordination within choices occurs if fishery managers avoid the tragedy of the commons. Coordination across choices occurs if waste disposal levels from one ecosystem component do not disrupt or eliminate the function of another part of an ecosystem. Does a particular human institution provide coordination across and within choices, so that ecosystem structure and function are preserved?

Robustness or flexibility

Although coordination and allocation address the issue of selection of an ecosystem state, the idea of robustness addresses the local stability of the state. Conditions in which management of an ecosystem occurs may vary from external effects. Response to the variation can be either robust (in which case the ecosystem management system can handle variation without much modification), or it can be flexible (in which case the management system makes changes to deal with the changed conditions). Response to variation can be fragile, in which case a deviation from one state may not lead to a return to that state, but rather to continued deterioration in ecosystem productivity.

Dryzek argues that robustness and flexibility are substitutes for one another, and that either, in combination with negative feedback and coordination, is a sufficient condition for ecological rationality when systems are behaving normally.

Resilience

If ecosystem functioning has degraded so much that its operation is far out of the normal range in which the above characteristics operate, can the management system implement procedures to restore normal functioning? Dryzek's idea of resilience can be distinguished from that of robustness in this manner: robustness applies to maintenance of ecosystems that are assumed to have a global equilibrium. Resilience applies when an ecosystem is in danger of flipping to a different equilibrium altogether, as during a period of reorganization (Holling et. al. 1995). Dryzek uses resilience to describe such extreme circumstances: what Holling labels ecological resilience. Many ecologists use resilience to refer to a combination of robustness and flexibility: what Holling labels engineering resilience.

A MODEL OF NORTHWEST COAST ECOSYSTEM-COMMUNITY INTERACTION

A model of the Northwest Coast system of managing both fisheries and hunting grounds illustrates the ways in which a native system of resource management can address Dryzek's ecological rationality. The model is based on the literature describing the Kwakiutl, Gitksan, and Wit'suwit'en. The Kwakiutl sources are Walens (1981), Johnsen (1986), and Weinstein (1994); these sources differ from earlier interpretations by Franz Boas. For the Gitksan, this description is based upon Adams (1973), Cove (1982), Copes and Reid (1995), Pinkerton and Weinstein (1995), and Pinkerton (1998). The Wit'suwit'en are described by Mills (1994). Skoda (1987) provides useful maps of the Gitksan and Wit'suwit'en lands. Because each tribe implemented its approach differently, this synthesis distorts each to an extent, but their example provides some principles that can be useful today.

Geography

The tribe's land area consists of a watershed with a river leading to the sea. Near the ocean, the river flows through a succession of narrow canyons; each of the canyons contains fishing sites that can be used for different salmon runs. Although the river is too strong in the canyons for a weir to span it, the speed of the river leads many salmon to go upstream along the banks, using eddies for rest. Consequently, fishermen with dip nets can catch many fish. Fish swimming away from the bank or below the nets pass by. The tributaries to the river, however, can be completely barricaded by weirs and traps, allowing precise control of escapement as well as harvest of the entire run. At times, the river is a mixed-stock fishery; the tributaries are always single-stock fisheries.

Hunting and gathering grounds upstream are sources of food and materials. The pattern of the year is for the people to harvest salmon in the summer, at summer villages along the river and its tributaries. Berries are also harvested in the summer. In the winter, people move inland to winter villages, living on dried salmon and berries and upon the results of winter hunts. The forest provides firewood in the winter, as well as wood for houses and canoes.

Property rights and chiefs

The land is divided into territories owned by houses. Villages consist of groups of houses, with a duality principle defining village structure: each village has two sides, and each side has two groupings of houses. A village, therefore, always has an even number of houses. For example, a village of 12 houses would have six on a side, and each side would have a grouping of two houses. Although each side of the village is equal to the other, there is a ranking within the sides, meaning that the higher ranking group provides the chief for the entire side, with the chief of the second group being "second-in-command." In the case of the 12-member village, then, each of the three-house groups has a "head chief" of the group, with two subchiefs. Each chief, whether high or low in rank, has complete authority within the lands of his house. The following rule enforces house ownership: "Any person who harvests from a house's land without the chief's permission can be killed." Even such a justified murder, however, would mobilize the dispute resolution machinery of a tribe (Mills 1994:146). Members of the house have a right to receive permission to hunt. All hunters have to follow rules specified by the relevant chief.

The hunting lands of the village are contiguous. Each house also owns fishing sites that are also controlled by the chief. Some of these sites are not within the hunting lands of the house because they are along the main stem of the river, practically within the lands of other houses.

Feasts: public decision-making, enforcement of decisions, and dispute resolution

A portion of the year (usually the winter) is designated for feasts, which can occur for many reasons, usually having to do with birth, marriage, and death. Although many different things happen at feasts, my interest is in the giving away of property, speeches, and group decisions.

One common event is that a new chief of a house holds a funeral feast for his predecessor. His side of the village hosts the feast, and his house pays the primary expenses of the feast: food for everyone, and gifts for the other side of the village. The higher the rank of the house hosting the feast, the greater the amount of gifts that are expected by the guests, and the more villages that are invited. Several years after the funeral, the new chief will hold another feast, to raise a totem pole in his predecessor's honor. Both the funeral and pole-raising feasts require saving up wealth for several years; the wealth comes from the lands of the house through the labor of members of the house, who live from food taken from the lands and the fishing sites. The chief shows his worthiness by generating the surplus required for the feast, and the guests acknowledge his position when they accept the gifts.

During the feast, guests are invited to speak, and any public business that needs attention can be placed before the assembly. Sides take turn speaking, there is no limit placed on the time for any speaker, and any decision is reached by consensus of the chiefs present. If no consensus is reached, the matter will be postponed to another feast. If other villages need to be involved, a feast will be scheduled to invite them to discuss the matter. The feasts are a system of peer monitoring (Arnott and Stiglitz 1991).

Intertemporal considerations: reincarnation

Houses are assumed to last forever, with people occupying leadership positions in the houses during their lifetimes. Most of the tribes believe in reincarnation. The belief is so specific among the Wit'suwit'en that elders determine which children are reincarnated previous chiefs. A chief, therefore, may know who he or she was in a prior life, and may expect to be reincarnated into a position in the tribe, if not in the very house in which the person now resides (Mills 1994:118-119). Other Northwest Coast tribes were also specific in their knowledge of the identities of reincarnated souls (Mills and Slobodin 1994).

A belief in reincarnation can support sustainable use by increasing the weight given to future income. Even in the presence of a belief in reincarnation, chiefs could give lower weight to their own future income, based on uncertainty about the future. One might expect believers in reincarnation, however, to give greater weight to the future than would nonbelievers.

Production equilibrium for a common-pool resource: the fishery

Because each house owns fishing sites along the river, each controls a portion of each run's catch. Each has control of some spawning locations. The runs of salmon that pass one house's fishing sites go to spawning grounds on other houses' territories. Because the harvest from the upstream weirs affects subsequent run sizes, much interdependence exists in salmon production. If the first house is downstream and the second is upstream, near the spawning grounds, then the harvest of the first house in one season affects the harvest of the second house in that season. However, the harvest of the upstream house affects that of the downstream house only in a later year, when the next generation of the particular run returns. Such interdependence in fisheries is often modeled by use of the prisoner's dilemma game. Appendix 1 provides a definition of generosity rules. Appendix 2 provides a proof that sharing the net returns from a fishery removes the prisoner's dilemma by changing the payoff structure of the game.

Production equilibrium for a watershed ecosystem hierarchy: forests, game and fish

Interdependence also exists for hunting, because many animals such as deer, moose, and bear have wide ranges. Appendix 3 presents a way to model this interdependence. The model assumes that the cost functions of firms each depend upon the quantities produced by other firms, and shows that a symmetric generosity rule (defined in Appendix 1) causes firms to select production quantities that achieve a social optimum. When cost functions are separable, the firms can reach a mutually acceptable solution by independent action. Each can determine the right level of harvest without previously knowing that of the other firms.

In the more realistic case of nonseparable costs, the model becomes more complicated; individual firms cannot determine their private optima without knowing what the other firms intend to do. To reach a global optimum, some degree of common discussion and agreement is needed. This discussion can happen in the feast hall.

Because the models in Appendix 3 are abstract, in the tradition of economic analysis of externalities, the results are quite general. The quantity of production by one firm raises the costs of production for other firms. Examples from the Northwest Coast could be as follows. Bears depend on berries and fish, among other sources of food; harvest of the bears' food by man could reduce bear populations and increase labor effort in harvesting. Had there been technology for extensive timber cutting, the harvest of trees would have, as it has in modern times, reduced fish populations through effects on rivers and stream habitat. For migratory animals such as moose, harvests on one house's lands would affect total population levels, in a manner similar to the problem with fisheries.

Once the problem of harvest level has been determined, the problem of cheating remains. When each house keeps its own profits, there is a strong incentive to cheat at the social optimum. When each house has to share its profits uniformly with others, Appendix 3 shows that the incentive to cheat is removed.

Let modernity bring a wood fiber market

The pre-contact trade among tribes on the Northwest Coast primarily involved trade in fish and animal products. In the modern era, a market has developed for wood fiber. Excessive or incorrect harvest of trees can damage spawning and rearing portions of streams, lakes, and rivers. This is a one-way interaction, in that there is not a strong feedback: excessive harvest of salmon does not reduce tree production, although the salmon carcasses do contribute nutrients. As long as houses remain interdependent through feasts, the introduction of a market for wood fiber will not necessarily lead to excessive negative effects on salmon production. Houses that cut trees would have to share their wealth with other houses. If the timber harvest were to reduce salmon harvests, it would affect the house on its own fishing sites and would affect the ability of other houses to generate wealth for distribution at feasts.

THE ECOLOGICAL RATIONALITY TEST

If sustainability can be implemented with Dryzek's ecological rationality, a method of managing an ecosystem in a sustainable manner has to provide Dryzek's characteristics.

Negative feedback

The potlatch system provides negative feedback through the signal that a house chief gives to other chiefs with the quantity of goods given away at potlatches. A chief who is unable to maintain adequate gift-giving is subject to scrutiny by the other chiefs. Because these chiefs are themselves experts in fishery management, they can provide good review. (Because a poor harvest may be due to random environmental variation rather than management, expertise may be needed to distinguish the cause.) If a chief is not performing, his right to hold office is in jeopardy. Members of houses also have a way to signal to a chief that his management is not good: they can move to other houses (Weinstein 1994). In many of the house systems, any one individual can select among his or her kinship connections in associating with one or another house. There are two ways, therefore, for a chief who is not managing the resource well to be notified of his difficulties by other people. His direct monitoring of the resource provides a third source of information.

However, income can be generated by unsustainable activities. If a chief, in his desire to have many workers and show his ability, harvests above a sustainable rate, other chiefs have a way to deal with the problem: insisting on a greater distribution of goods at feasts. Penance for excessive harvest is sharing the output, which is the way in which a feast system solves the prisoner's dilemma in fishery management.

Coordination

As shown in Appendices 2 and 3, the sharing of surpluses among the houses addresses the effects of externalities directly. Each chief will be aware of activities by his house that reduce the income of other houses. The other chiefs will inform him of the problem in the feast hall, and he will also have a reduction of potlatch gifts received from other houses.

Robustness or flexibility

A potlatch system has some robustness for a fishery because it reduces competition and encourages restrictions on capacity (as a determinant of fishing effort). This consequence follows from the solution provided to the prisoner's dilemma (Appendix 2). Social robustness exists because the sharing of land rent among the entities means that a crisis in the productivity of what is owned by one house can be weathered by reliance on the production from other houses. If the rules for the distribution of surplus are flexible, the system as a whole may be flexible.

Resilience (far from equilibrium)

If a stock or run falls to extremely low levels, harvest must be suspended in order to save the resource. In a potlatch system, an owner can call upon the gift-giving capacity of neighbors within a scheme in which those neighbors can be assured of return to them when needed. This social insurance aspect of such reciprocity systems is well-recognized; by providing some social resilience, pressure upon a stressed resource stock can be reduced. Arthur Ray (1991) reports on a time when a failure of their salmon runs caused one village to spend an entire winter with another. Within the potlatch system, such generosity by the hosting village created obligations for the other community.

Dryzek (1987:122) argues that "polyarchy" is not good at addressing generalized interest, and among these is long-term resilience of the ecosystem. However, when there is generalized sharing of this type, attention of each of the polyarchs can be focused on the general interest in sustainable use of harvestable resources.

A MODERN IMPLEMENTATION OF THE POTLATCH SYSTEM

How might a potlatch system be implemented today? Although certain characteristics, such as capital punishment for trespass, would not be acceptable, other features might be quite reasonable. This section provides a translation from the language of houses, chiefs, and feasts to modern terms such as CEO, corporation, and profit distribution plans. One would not need to discard all characteristics of modern organizations; a reorganization of relationships might be enough.

In a modern potlatch system, let the major type of organization be a "trust," which is run by a caretaker and which hires employees. A "trust" is a general name for organizations, which can be like modern organizations such as firms, corporations, and nonprofit corporations. They correspond to what in the traditional Northwest Coast systems were called "houses."

The "caretaker" is the chief operating officer of a trust. Such a person might be called a boss, chief executive officer, executive director, chief, or trustee.

The "ecosystem review board" consists of all of the caretakers of the trusts with ownership of components of the ecosystem. The ecosystem review board has the role of a board of directors. In this case, however, the board is not representative of shareholders, because shareholders do not exist in this system. In native systems, this would be the "council of chiefs," and would consist of the governing body for the tribe as a whole.

The trusts each generate a "surplus" after all wages and costs of purchased inputs are deducted from the value of products produced by the trust. This surplus is a combination of what is called profit and rent. Each trust does not fully own its surplus, but it owns a right to a share of other trusts' surplus.

Outside persons and entities. The rights of people in the ecosystem and the rules of ownership and control apply to the ecosystem residents, the trusts, and the employees and their families. Duties to outside governments are to pay taxes to contribute to the overall enforcement and defense system of the government. Other outside entities do not have rights not granted to them by residents of the ecosystem. For instance, the right to purchase land from a house caretaker by an outsider would be subject to compliance with the rules governing the authority of trust caretakers. The caretaker, as manager of a trust, has "control ownership" of the land; he or she does not have "income ownership" (Christman 1994). This lack of income ownership means that sales of land would need the approval of all the other trusts that share in the surplus.

Rules. The right to be the "caretaker" of a "trust" would depend upon completion of an apprenticeship. A caretaker would have to demonstrate knowledge of how to manage the land, reach of river, or run of fish, or else he would lose his position. The caretaker also would have to demonstrate understanding of the rules of ownership and citizenship in this system of governance. Each caretaker, when he or she first obtained control of a "trust,"would be subject to a probation period of significant length: more than a year, but possibly less than five years. The rules for removal of the caretaker during this period would need to be specified, and they would be less stringent than the rules for removing the powers of a caretaker who has passed the probationary period. A major part of judging the quality of a caretaker would be her or his ability to provide a generous share of the surplus from her or his trust. Yet, the generation of surplus would have to be done in a manner meeting the approval of the other caretakers, who would act in their capacity as an ecosystem review board. After completion of the probationary period, certification of full caretaking powers would be given by other caretakers in the ecosystem.

Maintenance of caretaking responsibilities would depend upon annual performance. Some performance measures might be: (1) annual reporting of management outcomes and income earned to all other caretakers; (2) annual submission of investment plans for general caretaker approval; and (3) periodic distribution of a share of the value of products sold or harvested to other caretakers in the system. If the distribution is scheduled to happen annually, then each caretaker would, after receiving the distribution of surplus from the other trusts, make a plan of distribution for the surplus that his or her trust would end up holding. Some of the surplus would be distributed as "bonuses" to the employees of the trust, some would be set aside for investment, some would go to children of employees, and some would augment the retirement income of those employees who have retired. Some would also have to be paid as taxes to the governments with jurisdiction. If the trusts were providing local public services, possibly through the actions of the ecosystem review board, a portion of the surplus would also have to be paid for that. In effect, the surpluses of all of the trust organizations would be pooled and redistributed according to agreed-upon rules and commitments.

The rights of "noncaretakers," the employees of the trusts and their families would also need to be spelled out in a complete specification of this system. There would have to be employment rules, rules for hiring, rules for retirement, and so forth. None of these would necessarily be all that different from current practice, except that a plan to distribute the shared surplus to employees as well as to the trusts themselves might assist in making everyone aware of the ecosystem connections.

Application to boreal forests

The potlatch model, in its modern form, should be applicable to boreal forests as well as to other ecosystems, because all ecosystems have common-pool resources, externalities, and problems of information among participants. A potlatch system addresses common pools by solving the prisoner's dilemma. It addresses externalities by creating shared surpluses. It addresses information problems by introducing peer monitoring.

Although boreal forests are quite different from coastal river systems, specific externalities can be identified. One major source is the role of fire. Lewis (1982) investigated the use of fire by aboriginal peoples of the boreal forests. The models of this paper describe the management of populations of mammals and fish that are important food sources, and the main tool for management is harvest rate. Fire, however, is an ecological process, not a harvest rate. As applied in small-scale cases, such as a beaver trapline, fire improved the character of harvested resources, probably without externalities. However, the landscape implications of many small fires in spring do address two externalities: the maintenance of meadows and the incidence of catastrophic fire. Meadows had to be burned to prevent encroachment by woody species, for the benefit of wildlife. Areas of the forest with high fuel accumulation had to be burned in the spring to prevent hot summer fires. Both activities were viewed as community activities by the people Lewis interviewed.

To re-institute systems of sharing in boreal forests in Canada, a number of policy changes would be needed. First, the rights of First Nations peoples to territorial control would have to be recognized. Open access to non-native hunters, as documented in Brody (1988), would have to be removed. When modern technologies are applied, such as the construction of hydroelectric dams, the sharing of surplus with natives would also be needed, with a reciprocal sharing by natives of the product of the natural ecosystem with the hydroelectric authorities. Joint governance of the system might be "co-management," but the potlatch model places much control with local leadership and very little with state bureaucracies.

Conclusion

This short paper cannot provide a full discussion of the many complexities of transition from the current system of private property, open access, and bureaucratic control to a system of closed territories managed by trusts under the direction of caretakers who have to share their surplus. The purpose is to show that alternative institutions make some sense, have been used in the past, and may contribute to improved resource management. Whether they are, in fact, adopted in modern circumstances depends on many issues, among which is the intensity of the crises resulting from unsustainable management of ecological and social systems in coming years. Thorough changes such as those suggested here would need a strong impetus; people deciding to change their property and distribution institutions would need to discuss the reasons and come to some mutual agreement about the wisdom of making changes. In addition, such changes would need to be nested in some manner within existing governments and international agreements.

RESPONSES TO THIS ARTICLE

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APPENDICES

Appendix 1. A formal statement of generosity rules. [See erratum.]

Suppose there are *n* firms, each of which generates a surplus S_i, *I* = 1 . . . *n.* A *generosity rule* is a set of weights that describe the distribution of each firm's surplus among the other firms.

v_{ij} = share of S_i that is distributed to firm *j.*

where

$$\sum_{j=1}^{n} v_{ij} = 1$$

The *symmetric generosity rule* occurs when

$$for\ each\ i,j,\ \ v_{ij} = 1/n$$

Walens (1981) reports that the Kwakiutl chief had to have completely empty boxes at the end of a potlatch. In this case, we can define the *Kwakiutl generosity rule,* which occurs when for each *i,j*,

$$v_{ij} = \frac{1}{n\;\;1}\ for\ \ i \neq j\ \ and$$

$$v_{ii} = 0$$

Other generosity rules are of course possible. The pure selfishness, or private profit, rule would be:

$$v_{ii} = 1 \; and \; v_{ij} = 0 \; for \; i \;\; j$$

Appendix 2. Solving the prisoner's dilemma with generosity.

The game of prisoner's dilemma is often presented to illustrate the fundamental puzzle that faces any two or more persons that are harvesting from a common-pool resource (Binmore 1994, Ostrom et al. 1994). Notation varies. There are two players, Player 1 and Player 2. Each has a choice of two strategies: Cooperate or Defect. Their maximum joint payoff occurs when both cooperate. But the payoff structure of the game is set up in such a way that neither player will cooperate unless some condition outside of the game provides inducement to do so.

Let

C = The payoff each receives if both cooperate

D = The payoff each receives if both defect

b = The amount added to *C* that a defector receives if the other player cooperates

a = The reduction in *D* received by the cooperator if the other player defects.

Table 1. Abstract payoff matrix for the prisoner's dilemma.

In abstract form, the payoff matrix for the prisoner's dilemma can be written as follows in Table 1. The first amount in each parenthetical entry is the return to Player One; the second is the return to Player Two.

		Player Two	Player Two
		Cooperate	Defect
Player One	Cooperate	(*C*,*C*)	(*D*-*a*,*C*+*b*)
Player One	Defect	(*C*+*b*, *D*-*a*)	(*D*,*D*)

For *C* = 10, *D* = 5, *a* = 1, and *b* = 2, the prisoner's dilemma payoff matrix is as follows in Table 2:

Table 2. Numerical example matrix for the prisoner's dilemma.

		Player Two	Player Two
		Cooperate	Defect
Player One	Cooperate	(10,10)	(4,12)
Player One	Defect	(12,4)	(5,5)

Using the the numerical example, one can demonstrate the consequence of imposing the *symmetric generosity rule* (defined in Appendix 1). If we interpret each of the payoffs as the surplus received by each player from an economic activity, such as harvesting salmon, then imposition of a symmetric generosity rule changes the payoff matrix to the contents of Table 3:

Table 3. Prisoner's dilemma removed with the symmetric generosity rule.

		Player Two	Player Two
		Cooperate	Defect
Player One	Cooperate	(10,10)	(8,8)
Player One	Defect	(8,8)	(5,5)

In this matrix, the incentive to defect has been removed for each player.

If we apply the *Kwakiutl generosity rule* (defined in Appendix 1) to this two person game, then each player's payoff becomes the payoff of the other player. The new payoff matrix is given in Table 4:

Table 4. Prisoner's dilemma removed with the Kwakiutl generosity rule.

		Player Two	Player Two
		Cooperate	Defect
Player One	Cooperate	(10,10)	(12,4)
Player One	Defect	(4,12)	(5,5)

In this matrix, the incentives also support cooperation by both players. If the values of *a* and *b* are large in comparison to *C* and *D,* then the application of the symmetric generosity rule will generate either the game of chicken or the assurance game. In all cases, the application of a symmetric generosity rule will eliminate the prisoner's dilemma, replacing it with simpler games. The Kwakiutl generosity rule always transforms the prisoner's dilemma into a game with a clear solution.

Because the prisoner's dilemma game captures the essence of many common-pool problems, the generality of the results just given are potentially very great. If this answer is so simple, why have so many commentators not stressed it? The answer is that few commentators realize the possibility of *forced* generosity. Most assume that an agreement to share the outcomes of a game such as the prisoner's dilemma is not *enforceable*. Even if players were to agree before playing the game to divide the returns, there is assumed to be no enforcement mechanism. In a society such as one that requires give-aways, however, the enforcement mechanism is credible.

Appendix 3. Generosity in a continuous partial equilibrium static model of externalities. [See erratum.]

Partial equilibrium models of externalities assume a given set of prices to firms that are interacting with production connectedness (Runge 1981, Varian 1994). Runge formulates a continuous model that reduces to a prisoner's dilemma or an assurance game, depending on the assumptions about cost functions. This appendix reviews his demonstration of the suboptimality of private decisions, and demonstrates the optimality of a solution in which the firms are required to divide their profits among each other.

Runge defines the following problem, Let:

$$q_i = \textit{output of firm } i \;\; (i = 1, 2)$$

$$C_i(q_1, q_2) = \textit{cost function of firm } i$$

$$p = \textit{output price}$$

$$\pi_i = \textit{profit of firm } i$$

Thus,

$$\pi_i = pq_i \;\; C_i(q_{i,q_2})$$

An externality arises if:

$$\frac{C_2}{q_1} \neq 0 \;\; or \;\; \frac{\partial C_1}{q_2} \neq 0$$

A social optimum maximizes joint profit, where

$$\pi_s = \pi_1 + \pi_2$$

Therefore

$$\pi_s = p \cdot (q_1 + q_2) \;\; C_1(q_1, q_2) \;\; C_2(q_1, q_2)$$

The first order conditions are

$$\frac{\partial \pi_s}{\partial q_1} = p \;\; \frac{\partial C_1}{\partial q_1} \;\; \frac{\partial C_2}{\partial q_1} = 0$$

$$\frac{\partial \pi_s}{\partial q_2} = p \;\; \frac{\partial C_1}{\partial q_2} \;\; \frac{\partial C_2}{\partial q_2} = 0$$

The solution to these two equations in two unknowns gives the optimum level of production for each of the two goods.

Now examine a market equilibrium where each firm keeps its profits. The individual firm, for instance firm 1, solves the problem of maximizing its profits,

$$\pi_1 = p \qquad\quad (q_1, q_2)$$

and the first order condition is

$$\frac{\partial \pi_1}{\partial q_1} = p \;\; \frac{\partial C_1}{\partial q_1} = 0$$

which will give a different value of q_1 than the social optimum, because the first order condition omits the term involving the partial derivative of the second firm's cost function.

Now suppose

u = Share of firm 1's profit kept by firm 1

v = Share of firm 2's profit kept by firm 2

Both *u* and *v* can hold a value from zero to one.

If firm 1's net return is defined by

$$\pi_1^s = u\pi_1 + (1v)\pi_2$$

Then firm 1's maximization problem is to maximize

$$\pi_1^s = u \cdot (pq_1 \;\; C_1(q_1, q_2)) + (1 \;\; v)(pq_2 \;\; C_2(q_1, q_2))$$

The first order condition is

$$\frac{\partial \pi_1^s}{\partial q_1} = up \;\; u\frac{\partial C_1}{\partial q_1} \;\; (1v)\frac{\partial C_2}{\partial q_1} = 0$$

$$or \;\; p = \frac{\partial C_1}{\partial q_1} \;\; \frac{1v}{u} \cdot \frac{\partial C_2}{\partial q_1}$$

Thus, if $u = v = 1/2$, the symmetric generosity rule, then firm 1's first order condition equals the social first order condition.

This example can be generalized to many firms. Let T_j = return to firm *j* after application of forced generosity using the notation of section II above,

Let

$$Q = (q_1, ..., q_n)$$

$$S_i = pq_i \;\; C_i(Q)$$

Then, the return to firm *j* is determined as follows:

$$T_j = \sum_{i=1}^{n} v_{ij} S_i$$

where

v_{ij} = share of S_i that is distributed to firm *j.*

Examining the maximization problem for firm 1

$$T_1 = v_{11}\,[pq_1 \;\; C_1(Q)] + \sum_{i=2}^{n} v_{i1}\,[pq_i \;\; C_i(Q)]$$

The first order condition for the optimum choice of q_1 is

$$\frac{\partial T_1}{\partial q_1} = v_{11}\left(p \;\; \frac{\partial C_1(Q)}{\partial q_1}\right) \;\; \sum_{i=2}^{n} v_{i1}\,\frac{\partial C_i(Q)}{\partial q_1} = 0$$

$$v_{11}\,p = v_{11}\frac{\partial C_1\,(Q)}{\partial q_1} + \sum_{i=2}^{n} v_{i1}\,\frac{\partial C_i(Q)}{\partial q_1}$$

$$p = \frac{\partial C_1\,(Q)}{\partial q_1} + \frac{1}{v_{11}} \sum_{i=2}^{n} v_{i1}\,\frac{\partial C_i(Q)}{\partial q_1}$$

If a symmetric generosity rule applies, then v_{ij} = 1/*n* and

$$p = \frac{\partial C_1\,(Q)}{\partial q_1} + \sum_{i=2}^{n} \frac{\partial C_i(Q)}{\partial q_1}$$

This condition is identical to the condition for social optimality.

Runge points out that if the cost functions are separable, each firm can solve its individual maximization problem without knowing what the other firms have decided. This is true for both the pure private profit case or the symmetric generosity case. Separability means that each cost function is additive:

$$C_i(Q) = \sum_{j=1}^{n} f_{ij}\,(q_j)$$

as a result,

$$\frac{\partial C_i(Q)}{\partial q_j} = \frac{\partial f_{ij}(q_j)}{\partial q_j}$$

$$\frac{\partial^2 C_i(Q)}{\partial q_i \partial q_j} = 0$$

If the cost functions are not separable, then an individual firm cannot determine its point of maximum profit without knowing what other firms are doing in either the pure private profit case or the symmetric generosity case. Non-separability creates a situation in which the need for coordinated action is clear to each firm in either case. Because of the complexity of selecting any equilibrium set of production amounts Q, Runge (1981) does not present a solution. Instead, he points out that the separable case creates a prisoner's dilemma situation, and asserts that in the non-separable case an assurance game results.

To make some headway for Runge's non-separable case, examine incentives to defect from a jointly optimal solution, Q^*, however that solution was adopted. Suppose that through some mechanism (such as a series of public discussions at village feasts), all firms are operating at a socially optimal values $q_1^*,......q_n^*$. **What are the incentives to defect from this social optimum under, first, a pure selfishness rule and, second, a symmetric generosity rule?**

A defection by firm 1 would be an increase dq_1 from q_1^* at the social optimum, since all first partial derivatives are positive,

$$\forall j, \quad \frac{\partial C_1(Q^*)}{\partial q_j} > 0 \ ,$$

it follows that in the selfish case, when v_{ii} = 1 and v_{ij} = 0,

$$p > \frac{\partial C_1(Q^*)}{\partial q_1}$$

and an increase in q_1^* to $q_1^* + dq$ would increase the profit of the first firm. There is a clear incentive to defect.

In the case of symmetric generosity, however, an increase in firm 1's profit is matched by a decrease in the profit of all of the other firms. When $v_{11} = v_{ij} = 1/n$, then there is no incentive to defect, because the condition for a social optimum is that for the first firm, price is equal to the sum of the marginal costs of all of the firms with respect to the output of the first firm:

$$p = \frac{\partial C_1(Q*)}{\partial q_1} + \sum_{i=2}^{n} \frac{\partial C_i(Q*)}{\partial q_1}$$

This same condition applies to all firms. The selected outputs, $Q*$, are stable.

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