Perspectives

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Blue ecology: A cross-cultural approach to reconciling forest-related conflicts

Michael D. Blackstock[1]

Abstract

Fresh water has a unifying role at the ecosystem and human level. Water, without fail, is recognized throughout the globe as crucial to human life. By examining a dispute resolution case study relating to Mt. Ida, near Salmon Arm, B.C., this paper offers a probe of the question "What is water?". An Elder poses three questions about fresh water's role in the forest ecosystem; the answers are sought using the concept of "blue ecology," which interweaves Traditional Ecological Knowledge (TEK) and Western science. The purpose is to reveal cross-cultural assumptions and definitions of fresh water, and to assist in reconciling forest-related conflicts between First Nations and government agencies. Because water is a common interest to all people, blue ecology is proposed as a means towards this reconciliation. The paper presents five guiding principles that should be useful to mediators and forests managers seeking to build co-operative cross-cultural solutions.

KEYWORDS: *blue ecology, blue revolution, conflict resolution, fresh water, First Nations, Mt. Ida, water-based ecology.*

Contact Information

1 Professional Forester and Chartered Mediator of Gitxsan heritage, B.C. Ministry of Forests and Range, 515 Columbia Street, Kamloops, BC V2C 2T7. Email: Michael.Blackstock@gov.bc.ca

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Introduction

In this paper, I present a probe into the question "What is water?". My purpose is to reveal cross-cultural assumptions and definitions of fresh water, thereby helping to reconcile forest-related conflicts between First Nations and government agencies. This approach is my local contribution to the emerging global recognition that fresh water has the potential to become a catalyst for co-operation rather than a source of conflict. Endorsed by the United Nations, this movement is characterized as the *blue revolution* (Hinrichsen *et al.* 1997; Cosgrove 2003). As a mediator and forester, I have come to see the value of foundational research that examines cross-cultural perceptions of forest values such as water. When mediating a dispute, there usually isn't enough time for a detailed exploration of underlying perspectives and values. Since water is such a common part of life, it is easy to assume that we must all have the same perception of water's nature. Assumptions, attitudes, and resulting behaviour can create barriers to resolving conflict and disputes. Our attitude—how closely we choose to hold onto our world views or how we relate to others'—is manifested in our behaviour as participants in conflict resolution.[1]

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Based out of Kamloops, B.C., I work for the Forest Service as the First Nations Relations Manager in the Southern Interior Forest Region. Over the past 9 years, I have heard First Nations' community concerns and conducted research with Elders focussing on their urgent fears about fresh water. I first began to hear the Elders speak about deteriorating water quality and availability while mediating disputes over whether and how tree harvesting should occur. Key players in these disputes were usually Elders, Chief and council, and natural resource professionals from forest companies and government ministries. Foresters showed maps of planned harvesting and presented ideas on how they were going to address site-specific concerns as part of their legal obligation to consult with First Nations. The foresters would then ask for feedback. Over time, I noticed that Elders would start speaking of concerns about water. Typically, foresters would seem a bit puzzled by the apparently tangential stories of the Elders which told of water drying up or of how beaver had left a watershed. The foresters' replies usually explained that they are following the Forest Practices Code (and now the *Forest and Range Practices Act*) and, therefore, *all should be well*. The Elders, however, were not reassured by these words or the Code requirements. It is only now, through the help of Elders, that I am beginning to understand their concern about fresh water. Differences exist between how First Nations people and those trained in Western science (e.g., foresters) perceive fresh water. Miscommunication and misunderstandings over an apparently simple concept such as water can lead to mistrust and potentially to conflict. Each disputing party may assume that the other "understands" rather than probing for the other's perceptions of water and other similar keystone concepts.

My previous ethnographic research with Secwepemc, Syilx, and Nlaka'pamux Elders (see Blackstock 2001b and 2002) found that interweaving cross-cultural perspectives on ecology revealed a consequent need to shift away from the Western truism that water is abiotic toward a sacred and profane respect for water's life-enabling spirit which has a central role in ecosystem function. Here the concept of *water-based ecology* or *blue ecology* emerged that combines both Western science and Traditional Ecological Knowledge (TEK) perspectives on freshwater ecology.[2]

In this paper, I further explore the concept of blue ecology as a proposed theoretical foundation for a cross-cultural, co-operative approach to forest management. I begin with a review of blue ecology, and then focus on a dispute resolution case study of Mt. Ida, which overlooks Salmon Arm, B.C. This case study juxtaposes First Nations and Western science perspectives on fresh water and its management in forested ecosystems by investigating three questions about water relations in trees and ecosystems. The two world views are then compared and contrasted. I examine how these world views can be reconciled using a set of

[1] Conflict between two or more parties is usually long term and based on fundamental value differences. Conflict is chronic. Acute short-term manifestations of conflict are disputes. The First Nations' land claims question is an example of a long-term conflict in British Columbia. A road block set up by a particular First Nation to prevent harvesting of timber on forest land to which they believe they hold Aboriginal title would be an example of a dispute arising from the land-conflict question.

[2] I explore the concept of blue ecology from a poetic point of view in my book *Salmon Run* (2005:24).

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blue ecology principles. My central argument is that an in-depth exploration of cross-cultural ecological values lays the groundwork for reconciling conflicts over how to manage forest lands.

Background

During an interview on October 2, 2000, Nlaka'pamux (Thompson) Elder Millie Michell passed a torch to me. At the age of 86, she was very passionate about water and wanted to share with me her deep concern about the availability of fresh water in sufficient quality and quantity for future generations—she was worried that it was drying up and becoming polluted. A cause, in her mind, was our apathy towards teaching children to respect water. As she spoke in her own language to our interpreter about humanity's lack of respect for water, Michell succumbed to a stroke. Shortly before passing away that day, she had asked me: *Are you going to fix it*? She meant were *we*, the younger generation, going to fix what is happening to the water and earth. Michell's grandparents and parents taught her to respect everything, a value she said we do not teach our children today.

I shared Millie Michell's story with Olivia Sam, a Nlaka'pamux youth. Sam reflected on a Native North American parable in an essay that she wrote for me, which began as follows:

> *We didn't inherit the land from our ancestors, instead we borrow it from our grandchildren. This saying came to me one day while I was thinking about life and to me it interprets how I feel as a First Nation's youth. I believe that it is important for people to take care of our Earth Mother as if it were our own child. It is vital that we take care of our natural resources such as water. Water is the substance to all life and without water all forms of life would cease to exist. Water creates and sustains all life; this is what our Elders say.*

Water is all around us in an ordinary sense; its ubiquity tends to promote ambivalence. But what is water? How would a First Nations Elder or a Western scientist answer this question? The dying words of an Elder and the insight of an Aboriginal youth prompted me to explore this deceptively simple question in two previous *BC Journal of Ecosystems and Management* papers (see Blackstock 2001b, 2002). Through the use of ethnographic research methods and interviews with three highly respected Elders from the Southern Interior of British Columbia who shared their traditional ecological knowledge, I documented First Nations' concerns and perspectives about water (Blackstock 2001b). The Elders' emphasis on the spiritual importance of water contrasted greatly with Western science's emphasis on water's unique physical and chemical properties.[3] This fundamental difference raises questions about Western science's approach to freshwater ecosystem management and study. The Elders were also very concerned about whether enough clean drinking water would exist for future generations. In a subsequent paper (Blackstock 2002), I highlighted the Elders' vision of the relationships between water, land, and animals and encouraged a shift towards *water-based* ecosystem management, proposing to repair the definition of forest ecosystems in a way that interweaves First Nations' philosophy with Western science's ecosystem-based management approach.

Water's ubiquity tends to promote ambivalence. But what is water? How would a First Nations Elder or a Western scientist answer this question?

[3] A further example of water spirituality can be gleaned from an Elder in my own nation. During the Delgamuukw court case, Gitxsan Chief Mary Mackenzie shared her knowledge of how the Gitxsan *halayt* (shaman or healer) gained power and learned their songs from the waterfall:

> *Songs have to be used by these halayts so they . . . have to put together their own songs in words. Now, to get . . . those songs . . . they're taken out where there's a waterfall and they stay there for some time. And this person would go to this waterfall and sit by this waterfall by the hours and . . . hear the echo of the waterfall . . . [T]hey listen to that and they say little by little there's words coming out from that waterfall . . . [T]hey have to remember what these words are and what they mean so that it forms into a song . . . this is how they make up their songs . . . sitting by the waterfall . . . It takes a long time. It could [take] months and weeks to gather all these songs . . . to use when they start performing on the person that they [are] going to cure.*
> (Mackenzie 1987:390–391)

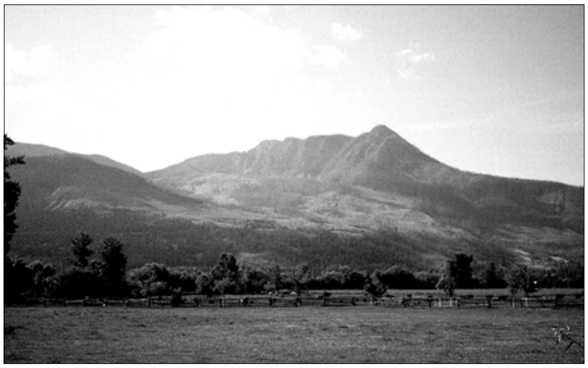

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FIGURE 1. Mt. Ida (Kela7scen), near Salmon Arm, B.C.

Mt. Ida (Kela7scen) Case Study

During the summer of 1998, the Silver Creek forest fire burnt the front face of Mt. Ida, which is adjacent to the town of Salmon Arm, B.C. (Figure 1). The mountain is known as "Kela7scen" to the Secwepemc people, who consider the mountain sacred. *Kela7scen* is the Secwepemc word for volcano. Hot springs emerge from the basaltic fissures on the mountain. The mountain is surrounded by two unconfined aquifers which are classified by the B.C. Ministry of Environment as highly vulnerable (British Columbia Ministry of Environment 2005). This area is in the Interior Cedar–Hemlock (ICH) biogeoclimatic zone. Western redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), and lodgepole pine (*Pinus contorta* var. *latifolia*) are the main conifer species on Mt. Ida along with a diverse representation of other flora, such a birch (*Betula* spp.), soapberry (*Shepherdia canadensis*), and huckleberry (*Vaccinium* spp.). Mt. Ida is a snowmelt-dominated hydrologic regime (i.e., most annual precipitation falls as snow to form a snowpack [Pike and Scherer 2003]).

After the Silver Creek fire was doused, a dispute ignited between the Secwepemc First Nation (specifically, the Adams Lake and Neskonlith bands) and the Ministry of Forests and two forest companies over whether previously approved harvesting should occur. Initially, the bands agreed to a limited harvest of burnt timber from the front face of the mountain, but opposed the harvesting of unburnt trees, an entry that was planned for the backside of the mountain in the same year.

In December 1998, I became involved in the dispute as a mediator. A technical working group, with membership from the bands and the Ministry of Forests, was established to explore solutions. The group struggled and debated, but eventually found innovative ways to modify harvesting plans that would preserve fresh water, honour the sacredness of Mt. Ida, allow time for the mountain to heal, and permit the forest companies to modestly proceed with modified harvesting plans.

The working group, Elders, community, and forest company representatives toured the mountain during the fall of 2000 to view the effects of the fire and harvesting. During the tour, Elder Mary Thomas (Figure 2) became deeply concerned about how the creeks appeared to be drying up and also expressed her desire to let the mountain heal for 5 years. Thomas emerged as a leader in the dispute resolution process by promoting through example her vision to build bridges between the disputing parties and by imparting a respect for the water and the mountain. Her teachings and questions frame this case study of how blue ecology can be used as an alternative ecosystems-based approach to forest management.

Mary Thomas didn't want the birch to be harvested on Mt. Ida, as originally planned. Thomas and her family harvest birch bark to create baskets. During a discussion about Mt. Ida, she talked about her understanding of water and the birch tree. She believed that the birch tree can store a significant amount of water and some of the enriched water returns to the soil:

> *Elders always said that each living plant has some aura, like an electric thing around it. I remember the old people [saying] that in the spring sap starts to go up away from the ground and it collects solar energy.*

Ducks Unlimited Canada

FIGURE 2. Secwepemc Elder Mary Thomas.

> *In the fall, [the sap] goes back [down the tree], the leaves drop, and [energized sap] builds up the soil. The sap goes back in the ground. And it made me [reflect on the Elders' saying about] how much sap really goes back into the soil to enrich it?*
> (Thomas 2000)

Thomas expressed her fear that harvesting trees can reduce the water available in creeks and springs:

> *When that sap comes down . . . [into] the ground . . . other plants feed from it. There is so much sap there . . . no wonder the creeks were filled up. There [was a] certain amount of fluid going into the creeks, it had to come out somewhere and build up our creeks. So why are our creeks drying up now?* (Thomas 2000)

After sharing her story about the birch tree, it occurred to me that underlying her concerns about timber harvesting was her concern for water. Next, Mary Thomas asked me three seemingly simple questions about water relations in trees and ecosystems that probe these interests:

1. How much water is stored in a tree?
2. Does the tree enrich the soil with the sun's energy?
3. What happens to creeks and springs when the trees are harvested?

Mary's questions arose from decades of observations of ecological changes on Mt. Ida, teachings from her Elders, and her ethnobotanical research with Dr. Nancy Turner (Turner 2000). Her Elders' intuitive understanding of ecosystems, gleaned from generations of observations and culture-based relationships with forests, may prove to be supported by Western science.

I am not an expert in forest hydrology or plant water relations and consequently I cannot definitively answer Mary's questions; however, I can offer insights into answering these questions using a cross-cultural approach that interweaves the strengths of each knowledge system. Exploration of each question below begins with a science-related primer. My scan of the research literature was guided by the Elders' emphasis on blue ecology and it should be interpreted as a lay synthesis. The reader is encouraged to refer to the cited literature for exact interpretations.

QUESTION 1: How much water is stored in a tree?

The study of water relations in trees is a forest biology topic dedicated to the nature and function of a tree's hydraulic architecture (Aitken and Guy 2005). Water has four functions in plants.

1. As a constituent, it accounts for 80–90% of the fresh weight of most herbaceous plants (approximately 50% of woody plants).
2. As a solvent, it aids in the movement of gases, minerals, and other solutes through and between cells.
3. As a reactant, it is a constituent of hydrolytic processes.
4. As a maintainer of cell turgor, it aids in cell enlargement and growth (Kramer 1983).

The water content of plants fluctuates both seasonally and diurnally. Water storage capacity (WSC) is defined as the quantity of water that can be lost without irreversible wilting (Ewers and Cruiziat 1991). Significant water storage capacity exists in the trunk of conifers (e.g., for *Pseudotsuga menziesii*, 74.8% of the tree's water is stored in the trunk, 19.8% in the roots, 5.2% in the branches, and 0.1% in the leaves). Water coming out of storage in the sapwood represents about 17% of the total daily transpiration stream (Pallardy *et al.* 1994). For short-term or diurnal needs, the available water storage capacity exists in the inner bark (cambium); the sapwood contains water that can be accessed over a longer term (days or weeks) (Ewers and Cruiziat 1991). Water loss through leaf stomata in the transpiration process is a major pathway for the transfer of soil water to the atmosphere, which in turn reduces the volume available for groundwater recharge (O'grady *et al.* 1999). Waring and Schlesinger (1985) estimated that sapwood storage of water may approach 300 t/ha, which is equivalent to the amount of water transpired by the forest in a 5–10 day period.

To determine the actual water content of certain trees, one could use Pallardy *et al.*'s (1994) approximations. The theoretical maximum water content for a 1 m^3 tree is 1000 L. The estimates shown in Table 1 provide a rough guide.

Water stored within trees is significantly less than the amount stored in the soil or transpired by the tree. To understand water relations in trees, however, is to understand the importance of timing. When the plant is under water stress and near the wilting point, where is the available (unbound) water? And at the stand level, where is the available water stored for short-term access by organisms in the ecosystem? Although the amount of water stored in a tree is relatively small compared to the amount transpired each day, the stored water plays an important role when the tree's demand for water is high during transpiration or times of drought. The question of how much water is stored in a tree is important because it

TABLE 1. Estimates (± 25 L) of the amount of water stored in trees (roots, branches, leaves, and trunk) by species for trees found on or near Mt. Ida

	Capacitance		Conductance	
Tree species	**Per tree (L)**[a]	**Per hectare (L)**[b]	**Per tree (L)**[c]	**Diameter (cm)**[d]
Douglas-fir	152[e]	76 111	64	38[f]
			530	134
			16.4–57.3	30–35[g]
Lodgepole pine	220	110 000[h]	25	25
			44	20–26[i]
Redcedar	80	40 000	NA	
Birch	250	125 000	42–70	NA[j]
Aspen	400	200 000	NA	
Cottonwood	500	250 000	51	15[k]
	640	400 000[l]	NA	

[a] Volume of water in litres stored in a *whole* tree (roots, branches, foliage, and stem) with a hypothetical stem volume of 1 m^3.
[b] Number of litres stored per hectare assumes 500 stems per hectare. This number is subject to a number of scaling errors. As a comparative benchmark, a typical in-ground swimming pool (5 m × 9 m) holds about 83 000 L.
[c] Volume of water in litres used by a tree in one day. O'grady *et al*. (1999) assert that a high correlation exists between diameter at breast height and tree water use.
[d] Diameter at breast height.
[e] Based on the studies of David Simpson (Research Scientist, B.C. Ministry of Forests, pers. comm., November, 2002), the sapwood would have 0.11 m^3 of water (for a tree of 0.9 m^3), assuming a 37% moisture content. This figure (0.137 m^3) would represent 75% of the water in a tree, so it was adjusted accordingly.
[f] Averages reported by Wullschleger *et al*. 1998.
[g] Early summer average daily water use by interior Douglas-fir trees in plots A and B is estimated to be 1.08 and 1.59 mm, which is 10 800–15 900 litres per day per hectare (Simpson 2000).
[h] The capacitance for lodgepole pine, redcedar, birch, aspen, and cottonwood was based on the green weight (kg/m^3) and oven dry weight (12%) (kg/m^3) reported by Alden (1995, 1997). A 12% adjustment was made to account for oven-drying; Pallardy *et al.*'s (1994) proportions were then applied to get whole tree water storage.
[i] Averages reported by Wullschleger *et al*. 1998.
[j] Averages reported by Wullschleger *et al*. 1998.
[k] Averages reported by Wullschleger *et al*. 1998. For cottonwood in the 4–5 m height range, they report daily use of 109 L. This data is weak in scope. In general, water use by mature cottonwood is probably higher.
[l] Based on the average initial moisture content of black cottonwood as published by the Northern Hardwood Initiative in Quesnel, B.C. URL: *www.cfquesnel.com.nhi/Content/Section5/5_4.htm*. Pallardy *et al.*'s (1994) proportions were applied to estimate whole tree moisture content.

draws attention to a forest as an interaction of two spirits—the spirit of the tree and of water. I found it curious that the answer was not readily available in the research literature, an observation that may offer insight into the two cultures' differing perspectives of the forest.

QUESTION 2: Does the tree enrich the soil with the sun's energy?

Water sticks or coheres to itself or to substances with which it comes into contact. In combination with water potential gradients, the water surface tension created by cohesion is primarily responsible for the rise of water from the roots to the leaves. The leaves create the lifting action through transpiration, and the cohesive property of water prevents cavitation and enables capillary action (Davis and Day 1961; Aitken and Guy 2005). Capillary rise of water through the soil profile, especially in coarse-textured soils, can occur at rates of about 1 mm per day (10 000 L/ha per day). Water travels through the soil pores to the roots, up the trunk (xylem and sapwood) to the leaves, and then out through the leaf stomata. In saplings and small trees, the mass flow rate of water through the stem is essentially equivalent to the canopy transpiration; however, a considerable lag may occur between fluctuations in transpiration and stem water flux. In the morning, the crown water flux may be greater than the basal water flux. In the afternoon and evening, the converse is true, which indicates a recharge of stem water storage reserves (Wullschleger *et al.* 1998). Water is redistributed within the tree and also passively from the tree back into the soil. This emerging concept is called *hydraulic redistribution* (Brooks *et al.* 2002), or *hydraulic lift* (Richards and Caldwell 1987).

When the tree is transpiring near midday, it uses deep roots to lift water from the moist soil to where it is needed. Wullschleger *et al.* (1998) assumed that stomatal conductance and transpiration were positively correlated with the hydraulic conductance of the soil–root–leaf pathway. As transpiration slows in the evening, the tree begins to replenish the short- and long-term reserves in the trunk which may have been used to supplement the main flow of water from the roots. Reliance on stored water increases with tree size (Phillips *et al.* 2003). At night, the water efflux (i.e., passive leaking of water from the roots into the rooting zone) typically occurs in the upper layer of denser and younger roots. Trees allocate more resources to root growth during dry periods to overcome soil drying (Eamus 2001).[4] The hydraulic redistribution of water in the upper soil layer demonstrates how deeper roots can have an effect at night as well. Rectification, a property of a barrier that allows flow in one direction and not in the other, increases as the roots age, so the water passes more easily across the cell wall barrier of younger roots to the lower water potential in the dry upper layer of soil. Essentially, the tree not only provides available water to neighbouring plants that is easily accessed for short-term use, but also a water solution that may be nutrient enriched (Caldwell *et al.* 1998; Brooks *et al.* 2002), which confirms it is possible for trees to enrich the soil.

Davis and Day (1961) expressed wonder at the remarkable ability of water to act as a universal chemical solvent; they described the sea from which evolutionary life emerged as *Magna Mater*—the Mother of Life. Naturally occurring water is an aqueous solution of suspended micro-organisms and chemicals, ever flowing, connecting, and serving tissue fluids, blood plasma, and the liquids flowing in cell interiors. Over one half of the world's chemical elements, as well as an abundance of micro- and macro-organisms, are found in rivers, streams, lakes, and oceans. Biologically significant is water's inertness; it can exist as an aqueous solution without being modified itself.

Elders believe that all beings, including trees and water, have a spirit (aura). Plants, as individuals and communities, seem able to self-manage the flow of water, depending on their demands and the availability of water. Therefore, from a TEK perspective, naturally occurring water is biotic. From a scientific perspective, the emerging field of hydraulic redistribution seems to support the Elders' teaching and Mary's belief that a tree can enrich the soil.

QUESTION 3: What happens to creeks and springs when the trees are harvested?

This is a surprisingly complex question requiring a background review of groundwater hydrology, springs, and the sponge effect. These concepts are examined first from a Western science perspective and then from a TEK point of view. Mary Thomas's question is answered in the concluding subsection on "Ecosystem Water Balance and Health."

Western Science

Two thirds of the world's fresh water is found underground (Environment Canada 2000). In the preface of Ralph Heath's *Basic Ground-water Hydrology* (1987), he states that groundwater is one of the United States' (and equally so, Canada's)[5] most valuable resources—yet, surprisingly, the occurrence of groundwater is poorly understood and is the subject of common misconceptions. All water that occurs beneath the land's surface is referred to as *groundwater* (Heath 1987). Groundwater, though difficult to visualize, occurs in the pores between soil particles (silt, sand, and gravel) or in cracks in bedrock much like water is held by a sponge. Rain or snowmelt percolates into the soil in permeable groundwater recharge areas. Excess water percolates down to the water table, the top of the zone of saturation. The most significant function of groundwater is perhaps its gradual discharge into streams, rivers, and springs to maintain streamflows during dry weather. A spring is a "place where a concentrated discharge of ground water flows at the ground surface" (United States Geological Survey 2004).

Visualize the soil layer as consisting of two sponge-like layers—an unsaturated layer on top of a saturated one. The unsaturated layer is further divided into the soil, or rooting zone, and a lower intermediate zone. The saturated layer is divided into the transitional capillary fringe and groundwater (see Heath [1987] for an excellent diagram describing this concept). Groundwater

[4] Inverse flow of water from roots in a recently wetted desert soil to roots in the deeper drier soil allows the deep roots to grow toward a water table. Caldwell *et al.* (1998) called this process "inverse hydraulic lift," and reported roots of Kalahari desert plants reaching a depth of 68 m.

[5] For domestic use, 26% of all Canadians rely on groundwater (Canada Mortgage and Housing Corporation 2000).

moves very slowly at about 1/9000 the rate of river water (Heath 1987). If you were to squeeze the unsaturated sponge, it would feel wet because of a mix of air and water in the pores; however, it would not drip water like the saturated sponge. Starting at the top surface, the unsaturated sponge dries out as water is used by plants and evaporates from the soil.

The water table is a separating line between the unsaturated and saturated zones; the transition between them is called the *capillary fringe*. Simply, the water table is the level of water in a well. An aquifer is a specific kind of saturated sponge that consists of a geologic formation (e.g., sandstone, carbonate rock, basaltic, volcanic, unconsolidated sand and gravel) porous enough to retain, transmit, and yield significant amounts of groundwater when saturated. Heath explained a common misconception about groundwater and aquifers:

> *. . . from our observations, both on the land surface and in caves, we are likely to conclude that groundwater occurs only in underground rivers and 'veins'. We do not see the myriad of openings that exist between the grains of sand and silt, between particles of clay, or even along the fractures in granite* (Heath 1987:1).

Therefore, aquifers are not underground lakes or rivers. Recharge areas with permeable unsaturated soil in forests or grasslands allow water to infiltrate the aquifer. The aquifer, in turn, supplies significant quantities of groundwater to springs and wells through a system of interconnecting pores and fractures within the host formation.

First Nations Traditional Ecological Knowledge

Springs provide very pure water for medicinal plants and localized sources of water for small animals. These waters are used for making medicinal tinctures and may give spiritual power (Blackstock 2001b). Eliade (1958) described the life force of flowing water and springs:

> *By their very nature, springs and rivers display power, life, perpetual renewal; they* are *and they are alive . . . There are a great number of cults and rites connected with various springs, streams and rivers throughout history to correspond to these many different values given to water.* (Eliade 1958:199–200)

Nlaka'pamux Elder Nathan Spinks described a spring located on the Lytton Indian Reserve. Black "pit" snakes mated in the little spring waterfalls. He said the snakes intuited their "liking" of you; consequently, if they don't like you, they would drive you snaky (crazy) (Spinks 2002).

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FIGURE 3. Stat'at'imc Elder Albert Joseph.

Elder Albert Joseph (Figure 3) described a spring located west of Lillooet, B.C., which the Stat'at'imc call "sacred water" or secret spring:

> *It's on this side of Cedar Creek . . . that's a desert up there and the water comes right out of the ground. And it's maybe three feet across and you go down four or five feet and there's no water. It just comes out of that one little hole and the rest is shale. You'd be walking along and the next thing you know it's like a Secret Spring.* (Joseph 2002)

Syilx (Okanagan) Elder Mary Louie believed that Earth Mother filters or cleanses groundwater through the soil by expanding and contracting herself like a sponge. Additionally, the Earth Mother may "push the water away" in retaliation to people who disrespect her or water. Louie believed that we must show respect to water by giving offerings of prayer, coins, or tobacco. The dialogue below provides a glimpse into this complex concept.

> *The water on top is still [quiet or without movement], but underneath you get a fast current, and that current goes all over the place. It's like [blood in] your veins. And when it comes out in the spring time, springs come down. In May, the land goes down [that is, Earth Mother is contracting, or breathing in, causing groundwater to be pushed out onto the earth's surface], but in June or July it comes back up again [that is, Earth Mother is expanding, or breathing out, causing surface water to be sucked back into the earth], then it dries out. The whole*

land goes down; that's why you get the high water—all the springs are running out. The land filters the water . . . and [when] the water goes in the lakes, the mud sucks it down. That's why the water gets polluted. But when the soil starts getting polluted, it can't filter the water anymore. (Louie 2000)

First Nations Focus on Sponge Effect

What are the cumulative effects at all scales of the ecosystem's spongelike functions (e.g., groundwater recharge areas, wetlands, plants, moss, beaver ponds)? Furthermore, what happens if the function of these sponges is impaired, as postulated in Mary Thomas's third question? Based on his observations of the land during his 30 years of experience in forestry and guide outfitting, Elder Albert Joseph suggested that forestry practitioners should be mindful of the sponge effect when contemplating interventions such as harvesting:

They should have knowledge enough to understand how water . . . stays in the forests, through the moss and the swamps and the trees. Like, see if moss will hold water for 4 or 5 months, then the creek will run all summer. So moss is like a sponge. Squeeze a sponge, it's dry; it's the same with moss. That's how a certain amount of water comes out of the hillside, especially on the shady side. And you know those creeks on the mountain, they run almost all summer . . . they were fast-running streams 4 or 5 years ago. And then you burn or log . . . and now the [streams] are all dry, because the moss is all gone. (Joseph 2002)

Joseph has noticed that grizzly bears eat the cambium of spruce and balsam trees in the Paradise Valley, near Lillooet, B.C. He thinks the bears know that the juiciest trees are the ones that grow on wet ground. The bears whack the bark on the base of the tree and then peel the bark down to get at the cambium. For Joseph, other indicators of the existence of springs or seeps include the feel of the spongy ground underfoot, or the way his horses avoid wetter ground because "mud is their worst enemy"; "lots a rabbit tracks" also indicate springs. Joseph remembered a place called Beaver Meadows, near the Paradise Valley, where dams occurred every couple of hundred metres. He thought that the beaver created reservoirs (which could be thought of as saturated sponges) to provide a controlled release of water during the low-flow periods in late summer.

I have heard Elders on numerous occasions worry about the disappearance of beaver from valleys, and the subsequent effects on the local hydrological cycle. Their worries are supported by the research of Olson and Hubert (1994), who outlined the following benefits of beaver activity in an aquatic ecosystem:

- elevated water tables that enhance riparian areas;
- reduced stream velocity;
- improved interception of runoff;
- improved habitat for birds, waterfowl, and animals; and
- improved water availability and storage for summer drought.

Beavers, however, can also be a nuisance to farmers and highway engineers. In addition, the parasite *Giardia* can be transferred via cysts occurring in the beaver's faeces to humans (Olson and Hubert 1994).

Wetlands (i.e., swamps, bogs, muskeg, pothole marshes, and spring-fed seeps on sidehills) are transitional zones between dry uplands and open water. These areas are important sponges created by emerging springs, beavers, and seasonal pooling of precipitation or streams. They are defined as ecosystems dominated by water-loving plants and having saturated soils (Banner and MacKenzie 2000). Wetland environments have had an important role in human affairs around the globe and throughout antiquity. Cattail (*Typha* spp.), bulrush (*Scirpus* spp.), reed (*Phragmites* spp.), and common dogbane (*Apocynum cannabinum*) are important wetland plants used for baskets, mats, sandals, rope, and building construction (Nicholas 1998). Albert Joseph believed that horsetails (*Equisetaceae*) have a purifying or cleansing function in the wetlands. Joseph has noticed that sometimes water, in wetlands or creek edges, has an oily "rainbow" film on the surface, and if you drink it "you will get diarrhoea awfully bad."

Horsetails purify the water too. If you plant some where the water's contaminated, it doesn't take long . . . [in a] few years they purify the water. If you see horsetails out there, you know that the water's good to drink . . . I used to laugh at the Americans for bringin' water up in planes . . . but, ah, you know, that's maybe 20–25 years ago. Now . . . not every creek is pure. When you see that skin on the water, you know you gotta leave that water alone, especially in the spring time [during] the runoff. (Joseph 2002)

Elder Mary Thomas is concerned about the springs and streams drying up on Mt. Ida. She remembered that there used to be lots of water on Kela7scen:

. . . the big burn [on Kela7scen] was a disaster in itself. That's why I asked about the water because I can remember that mountain—there was a lot of

water. We used to have creeks [where] the saddle horses would stop and drink. We would have a nice drink of water up there while gathering material with our parents and all our huckleberries . . . you guys must know that when a place like that has been clear-cut or burned a lot of stumps [are] left. The stumps are going to remain there for at least 2 or 3 years and then start to deteriorate. They rot, they fall, [and then] there's nothing holding back [the water]. The snow is going to melt and it's going to "swish" right out of there . . . it's not going to saturate the mountain. (Thomas 2000)

Ecosystem Water Balance and Health

To answer Mary Thomas's third question, we must think of the integral effects of water relations in plants and the mysteries of groundwater hydrology. Essentially, the resultant question becomes, "How do human interventions, such as tree harvesting and road building, influence the sponge effect? What happens to fresh water in the ecosystem after human intervention?"

A healthy ecosystem is one in which water, of sufficient quality and quantity, is delivered in a functional rhythm.[6] Results of the *Vision for Water and Nature* project suggested that the ecological health or integrity of freshwater ecosystems can be preserved by maintaining:

. . . the hydrological characteristics of catchments, including the natural flow regime, the connection between upstream and downstream sections (including coastal and marine zones), the linkages between groundwater and surface waters, and the close coupling between the rivers and floodplains. (World Conservation Union 2000:50)

Derek Eamus defines ecosystem water balance as the water status, or potential, of vegetation; that is, the water content of the depth of soil (groundwater) and atmosphere which interacts with vegetation (especially the foliar boundary layer). Water balance is simply the accounting of differing rates of input and output. In general, the losses Mary Thomas observed on Mt. Ida may result from several processes, including:

- transpiration from vegetation;
- evaporation from soil, surface water, and wet canopies;
- sublimation (i.e., the process where snow on tree canopies is converted directly to water vapour without first becoming liquid water);
- surface flow out of the ecosystem, such as spring snowmelt and runoff, and rainfall runoff;
- lateral flow through the soil to stream, rivers, and lakes; and
- percolation to 1–2 m below the rooting zone of vegetation (where it is unavailable to vegetation and therefore considered out of the ecosystem) and subsequent groundwater recharge (Eamus 2001).[7]

The field of low-flow hydrology investigates water balance related to seasonal river and creek flow, which generally occurs in summer, but in colder climates may also occur during winter (Smakhtin 2001). British author Johnson (1998) maintains that "diverse and apparently conflicting evidence" surrounds the effects of forestry on low flows; however, these flows seem to depend on the pattern of disturbance in a catchment, intensity of harvesting (e.g., clearcut or selection), and seral stage of the stands (Johnson 1998; Smakhtin 2001). Low flows seem to increase after harvesting because of reduced tree interception and transpiration losses. As vegetation is re-established (i.e., about 6 years after afforestation), low flows begin to decline (Johnson 1998). Smakhtin cautions, however, that:

At the same time, both increase and decrease in low flows are theoretically possible [after deforestation]. For example, reduced evapotranspiration, interception and infiltration rates following deforestation may lead to higher soil moisture storage and increased surface runoff, which in their turn lead to reduced recharge and increased gully erosion. Eventually, this may result in lowering the groundwater table and reduced low flows, which originate from groundwater storage. (Smakhtin 2001:152)

Elders teach, and science confirms, that groundwater and sponge-effect discharges from lakes, marshes, beaver dammed-ponds, mossy seeps, melting snow, or glaciers are the main sources of water during low flows (Smakhtin 2001).

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[6] Naiman *et al.* (1992:129) defined ecologically healthy ecosystems as: ". . . functions affecting biodiversity, productivity, biogeochemical cycles, and evolutionary processes that are adapted to the climatic and geologic conditions in the region . . . Some tangible measurements of ecologically healthy watersheds include water quality and yield, community composition, forest structure, smolt production, wildlife use, and genetic diversity."

[7] Eamus also concluded that the rates of water use along with the changes in groundwater availability and quality (especially salt content) correlate well with ecosystem net primary production. Eamus (2001:63–64) explained that canopy photosynthesis will decrease as the tree adjusts to lower soil water content and higher evaporative demand.

In one of the first comprehensive studies of hydrological pathway disturbance in Canadian boreal forests (similar to, but not the same as, the ICH stands on Mt. Ida), Pomeroy *et al.* commented:

> *Boreal forests are shown to have an important self-control on their hydrological and climatic resources as "water managers." Hydrological pathways and processes in a mature boreal forest are unique and distinctive and can help create the climate and water supply associated with these areas.* (Pomeroy *et al.* 1997:129–132)[8]

They concluded that "basin runoff as measured in streamflow is greater for harvested basins than for undisturbed basins, in both spring and summer" (Pomeroy *et al.* 1997:iii); however, they also emphasized the importance of monitoring water availability as well as the quantity of water in an ecosystem:

> *The combination of higher interception, evaporation and transpiration in forests results in drier soils than cleared areas during most of the growing season. However, much of the excess soil water is stored below the rooting zone of immature species in cleared and regenerating areas and cannot be drawn upon . . . In times of drought mature forests reduce their evapotranspiration demands and runoff losses, conserving soil moisture, while clear-cuts show no such restraint and regenerating sites show limited restraint.* (Pomeroy *et al.* 1997:130)

Hetherington (1987) explains, in his summary of forest management influences, the effects of harvesting on summer stream low flow.

> *Under some circumstances, low flows might be reduced in small streams following logging or fire. After initial increases, flows in West Coast or Eastern Canadian streams could eventually be diminished below pre-disturbance levels by the vigorous transpiration of new streamside deciduous vegetation or reduced fog interception. Even if flows are not reduced, build-up of gravel in streambeds, such as might occur after logging, could result in flow being entirely subsurface. This change in the channel would impair its use by fish. In general, however, the evidence indicates that summer low flows in most of Canada are more likely to increase rather than decrease after removal of the forest cover.* (Hetherington 1987:192)

Regarding snowmelt-dominated regimes, Hetherington makes the following comment:

> *Removal of forest cover by harvesting or fire usually accelerates snowmelt and runoff, and can advance the date at which snowpack disappears . . . Because melt rates are higher in openings than beneath the forest canopy, the acceleration of spring snowmelt from openings may desynchronize runoff to the extent that downstream peak flows are smaller than would occur from a completely forested watershed… The location of openings in forested watersheds is thus critical in determining their influence on snowmelt streamflow* (Hetherington 1987:188, 194–95)

Elders' observations may be related to faster and earlier snowpack melt (a change in peak flow), thus translating into an earlier low flow than they are accustomed to seeing for a potentially longer period. Or, Elders may be observing decreasing peak flows as openings are enlarged over time (because snowpack accumulations have been reported to be less on large openings compared to small openings; e.g., wind across larger openings may increase evaporation [Pike and Scherer 2003]).

Clearly, forest condition is only one of many factors influencing water balance—another is climate. A series of drought years, whether harvesting occurs or not, will result in a "drying up" effect. Additionally, global climate warming may be responsible for declines in river flows, lower lake and wetland levels, and adverse changes in water renewal times (Schindler 2001). Pike and Scherer (2003) postulate that:

> *The belief that timber-harvesting activities dry up streams likely stems from perception rather than physical measurement of changes in streamflow. In some cases, observations of changes in streamflow may actually be observations of changes in stream channel characteristics.* (Pike and Scherer 2003:10)

For instance, road building, water barring, wetland drainage, or site preparation may alter water's course or cause pooling.

Thus, after various disturbances, including forest harvesting, significant changes may occur to runoff, stream channel location, rainfall interception, summer

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[8] Pomeroy *et al.* (1997) presented a good diagram of hydrological pathways in a boreal forest (summer and winter). I wonder about the large-scale functional disturbance of hydrological pathway effects resulting from mountain pine beetle damage in conjunction with the associated forest harvesting. For instance, a tree can be viewed as a column of water; wind blowing by the column of water can act as a rudimentary air-conditioner, additional to commonly known shading and evapotranspiration.

low flows, snowfall melt rates, water infiltration into soils, and water availability in plant rooting zones. Most importantly, the ecosystem's sponge effect may be affected, potentially impairing hydrologic self-management abilities. Nevertheless, scientific understanding of ecosystem water balance mechanisms and the relevance of different gains and losses across various sites and climatic conditions is limited (Smakhtin 2001). Because of this multiplicity of factors, it is difficult to measure and assess the Elders' interpretation of the drying up of creeks and springs. No generalizations can be applied to the forests' role in conserving water or regulating streamflow, or consequently to deforestation's effects on low flows (Hetherington 1987; Pike and Scherer 2003).[9] Thus, the answer to Mary's third question could be framed as follows:

> *Western hydrologic research seems to suggest that stream low flow usually increases right after harvesting, and then it begins to decrease again about six years later. However, it is possible that Mary is observing a decrease in water flow in a particular location due to a unique combination of circumstances: season; timing, extent, intensity and type of forest disturbance; drought condition; vigour of riparian vegetation; stream channel or spring disturbance; or local climate change effects.*

Resolution at Mt. Ida

Conflicts over water shortages can be related to stakeholders' perceptions that forest harvesting causes streams to dry up (Pike and Scherer 2003). Consequently, any conflict reconciliation process should respect stakeholders' perceptions, rather than discount them on the basis of generalized research results. This approach should seek to clarify and document Elders' observations; one could seek the following information:

1. specific locations where they observed the drying up of streams, creeks, or springs
2. a description of the extent and intensity of forest disturbance
3. seral stage of the stands
4. any potential stream or spring-bed relocation
5. season or date of observation

The keen interest of Elders in water suggests that forestry professionals should develop a similar awareness and an associated intervention/impact monitoring process.

Mary Thomas was a key member of the Kela7scen technical working group. They considered her questions and implemented solutions to restore water, and therefore ecosystem health, on Mt. Ida by:

- increasing stream buffer widths;
- changing the silvicultural system from clearcut to selection;
- allowing for a healing period (5 years) before harvesting began;
- reducing the rate of harvesting;
- establishing research trials to study the effects of harvesting on traditional plants; and
- preserving the birch trees.

Case Study Teachings

Elder Mary Thomas asked wise questions. What can be learned from them and this case study? First, I compare TEK and Western science perspectives using fresh water as an example. Finally, I discuss how these world views can be reconciled in forest-related conflict by proposing some guiding principles.

Comparing Blue Ecology with Western Science Ecology

If fresh water is the most mistreated and ignored natural resource, then groundwater is the least understood simply because we can't observe its connecting function (Schindler 2001). Water is the lifeblood as it traces through the labyrinth of pathways connecting organisms in the ecosystem. If water is biotic, as proposed here, then the natural conclusion is the one James Lovelock reached in the 1960s—Earth Mother (Gaia) is a living organism and water is her lifeblood (Blackstock 2001a, 2001b, and 2002). In a poignant essay about Gitxsan ecological philosophy, Elder Marie Wilson spoke to this point:

> *These Gitksan (the ancient ones) came to a firm decision that all created life was equal, necessary and a vital part of the interconnected whole that we now call Planet Earth. They believed that this interconnected whole was created to be in perfect balance and must remain so if all parts were to survive in comfort and harmony . . . Thus, we believe that the fish (the silvery swimmer), for instance, have innate knowledge to care for self, innate knowledge that is forever unknown to humans.* (Wilson 1989:10–11)

[9] Further literature is available on this question through the Kamloops Forest Hydrology Abstracts Library (*http://foresthydrology.gov.bc.ca/*).

Water-based ecology, or blue ecology, is based on this philosophical foundation of interconnected wholeness (Blackstock 2002).

Western science's definition of an ecosystem, however, seems to harbour the fundamental difference between the First Nations and Western view of water:

> *Ecosystem: Any unit limited in space that is made up of a biotic community interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure (food chain) and material cycles within the system.* (World Conservation Union 2000:40)

The ecosystem concept, as defined by Klinka *et al.* (1989), divides the landscape into units of relatively uniform climate, soil, plants, animals, and micro-organisms. They characterize the biotic community as composed of a combination of plants (vegetation), animals, and micro-organisms, each of which forms its own community. Their model implicitly acknowledges water's important role through the notion of "hygrotope" and the "soil moisture regime," but it fails to explicitly recognize water as biotic and the central essence of an ecosystem. Water is not explicitly part of the ecosystem definition, rather it is enveloped in the concept of the physical environment—the non-living matter that interacts with the living world.

If one interweaves these two ecological viewpoints, a "blue ecology" definition of a forest ecosystem could read as: "a segment of the landscape, composed of relatively uniform climate, soil, plants, animals, and micro-organisms, *which is a community complexly interconnected through a network of freshwater hydrological systems*." A comparison of these two ecological perspectives is presented in Table 2.

TABLE 2. A comparison of Western science and First Nations' traditional ecological knowledge using fresh water as an example

Characteristic	Western science	Traditional ecological knowledge
Epistemology	– Cause and effect	– Relationship oriented
	– Rely on observations over short term (hundred years)	– Rely on long-term observations (thousands of years) and communication with spirit world
	– Taxonomic	– Integrative
	– Researchers are experts	– Community members are experts
	– Requires empirical proof	– Ancient focus on the prime importance of water
	– Dichotomous (e.g., man vs. nature; mind over matter; abiotic vs. biotic)	– Earth Mother is an interconnected whole, a unifying approach; no dichotomy between living and dead
Definition of ecosystem	– Water is implicit to the definition	– Water is explicit to the definition
Water[a]	– Important, but abiotic; services the biotic world	– Biotic, with spirit and will; the lifeblood of Earth Mother
	– Forest hydrology focus on snowmelt, surface flow, low flow, and soil moisture regime	– Focus on groundwater, springs, and sponge effect
	– A secular hydrological cycle	– A sacred hydrological cycle
	– A resource that provides services to humans	– A living being with which we coexist
Water relations	– Water flux is a focus of water relations in plants	– Water capacitance and the ability of the tree's aura to instill energy from the sun into sap, which is shared underground

[a] Readers are referred to Battiste and Henderson (2000:117–125) for a First Nations perspective on why "Western or Eurocentric thought diverted away from the doctrine of intelligible essences (spiritual forces, life giving energy or having will)." Keith Thomas (1971:50, 80–81) offers a British academic perspective. He examines the Protestant reform of the rituals related to holy water and argued that the Protestants preferred to attribute the magical healing properties of holy springs and wells to "natural means" rather than pagan mystical means.

Reconciliation

Water, especially spring water, is a metaphor for healing or reconciliation. It is evident that Western and First Nations perspectives differ on *Magna Mater*. Peter Warshall (2001), through his experience in watershed planning and governance in the United States, believed that springs can bring humans back to the basics of life. He introduces this metaphor as follows:

> *Springs tend to have special waters, healing waters, and healing plants; humans like to gather at them and make special trips or pilgrimages to them . . . Even when not physically at the spring, springs become images of life-giving, reverence, and contentions that encourage humans to meditate on their dreams and what they will accept in life.* (Warshall 2001:56)

The unifying role of water has an influence at the ecosystem and human level. Water, without fail, is recognized throughout the globe as crucial to human life. Humans begin to feel thirst after a loss of only 1% of bodily fluids and risk death if fluid loss nears 10% (Hinrichsen *et al.* 1997). I see opportunity in this unifying human interest to build cross-cultural consensus. Blue ecology, the recognition and interweaving of First Nations perspectives on water with Western ecology, is a piece of the reconciliation process.

Forest policy-makers could reconcile cross-cultural perspectives, for instance, by acknowledging fresh water as a unifying forest value. An exemplar is the British Columbia *Forest and Range Practices Act*. This Act currently identifies 11 forest values (or subjects) to be managed and each is given approximately equal weight. The provincial government could amend the Act to rank water as a primary core value with a unifying role, while the remaining 10 values would play supporting roles. Thus, our first thought when planning human interventions to ecosystems should be: *How will this planned intervention affect the rhythm and quality of water flows*? Thus, the ultimate objective of forest land managers who adopt blue ecology is to produce clean fresh water in a reliable seasonal rhythm. Secondary forest products would include timber and botanical forest products. Forest land-use planning based on blue ecology is further discussed in Blackstock (2001a).

From a conflict-resolution perspective, water is of common interest to people because it is essential to everyday life in a plethora of ways (United Nations 2003). I previously proposed a conflict-resolution process based on trust-building and cross-cultural communication (see Blackstock 2001c). This process recognizes that differences between parties' perspectives on fundamental concepts such as fresh water can aggravate conflict and instill mistrust. For instance, foresters may misinterpret Elders' desires to continually talk about water as a sidetracking strategy rather than a genuine attempt to engage in discussion about forest harvesting. They may prematurely discount claims by Elders that the streams are "drying up." Trudy Govier (1997), a Canadian sociologist and philosopher, emphasized that trust is fundamentally an attitude. Our trusting attitude towards another person or institution reflects our expectations of benign behaviour based on beliefs about the trusted person's motivation, integrity, and competence. Miscommunication can result in the erosion of trust. The trust-based mediation proposal suggests that the preparation stage of a mediation process is critical. It is a chance to build trust by sharing perspectives on keystone world view concepts, and then to commit to respecting these perspectives throughout the mediation.

> *A mediator can reframe conflict by encouraging disputing parties to reflect on and identify their common interest to share and preserve fresh water.*

A mediator can reframe conflict by encouraging disputing parties to reflect on and identify their common interest to share and preserve fresh water, for instance. Blue ecology provides a common ground for mediators to begin the complex process by assisting the disputing parties to understand each other, and then by building and monitoring solutions based on a set of agreed-upon principles. The set of guiding principles introduced here lays an important foundation to reconcile future forest-related conflict.

Guiding Principles of Blue Ecology

In his award-winning treatise entitled *Water*, Marq de Villiers (2000) suggested three fundamental principles for sustainable watershed governance.

1. water should be priced to encourage thrifty use
2. watershed users should return water in as good or better condition
3. unsustainable withdrawals should be prohibited

The discussion in this paper, guided by de Villiers' suggestions, forms the basis for the following five blue ecology principles applicable to natural resource management issues, including but not limited to forest management.

SPIRIT: Water is biotic, with spirit and will. Water is the lifeblood of the ecosystem.

HARMONY: Humans should give back when borrowing fresh water from future generations. Water users should be obligated to maintain water that passes through their area of responsibility in as pristine a state as possible and should be penalized for not doing so. Mary Louie (2000) believed that water should not be owned as property. She emphasized the responsibility to give back to the water by offering gifts and prayer. Most Elders encourage a focus on the importance of groundwater flow.

RESPECT: Unsustainable withdrawals (i.e., when water is withdrawn faster than it is recharged) from water systems should be prohibited. Millie Michell (2000) emphasized the importance of educating children to respect water.

UNITY: Topologically, water is the connector and unifier of the ecosystem and humanity. Water has the potential to build consensus. Local citizens have and demand an important role in water-related conflict resolution (Cosgrove 2003).

BALANCE: Water should be priced to mandate thrifty use. Cairns and Lasserre (2001) outlined a green accounting system for calculating carbon credits for forests and forest products. A similar *blue accounting* system could be devised to account for water credits.[10]

Blue ecology and the associated principles are examples of how a cross-cultural framework can arise as a positive effect from reconciling conflict.[11] Co-operative approaches, acknowledged and interwoven world views, are needed to honour the responsibilities associated with borrowing fresh water from future generations.

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[10] A blue ecology approach has to make financial sense. Although the scope of this paper does not allow for a detailed economic analysis, there are some good references. Refer to J. Stephen Lansing *et al.*'s (1998) excellent paper, "The Value of a River," for an economic analysis of the "free gifts of Nature" within the Skoomish culture context. Also see the United Nations discussion on "virtual water" and the advantages of reframing conflict over sharing water allocations to sharing water benefits (2003:318–319).

[11] Readers are referred to Blackstock and McAllister (2004) for a First Nations' blue ecology perspective on the role of water in British Columbia's grasslands ecosystem, and on a cross-cultural restoration approach.

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Test Your Knowledge . . .

Blue ecology: A cross-cultural approach to reconciling forest-related conflicts

How well can you recall some of the main messages in the preceding perspectives paper? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. How does Western science treat water in the definition of an ecosystem?
   a) as a biotic factor
   b) as a living organism
   c) as an abiotic, or physical factor
2. A new concept called hydraulic redistribution is emerging in the study of water relations in plants. What does this concept mean?
   a) planned human interventions to manage the flow of water throughout the ecosystem
   b) the self-managing ability of plants to store and redistribute water within their own pathways and also to influence the flow in other's pathways
   c) an ecosystem modelling exercise that evaluates the change in flow of water by theoretically redistributing water access in the ecosystem
3. What is the essence of the blue ecology concept?
   a) blue ecology is an epistemological riposte to the deep ecology movement
   b) blue ecology is a First Nations' perspective on how to manage forests which competes with Western science's vision
   c) blue ecology is a cross-cultural ecosystem-based concept in which water has the primary uniting value and function in an ecosystem

ANSWERS

1. C   2. B   3. C