Increasing the Productivity of the North American Water Cycle

by Benjamin Deniston

America does not need a "recovery," but a *new economy*. This means not simply rebuilding what was lost, but *leapfrogging to qualitatively higher levels*. Higher conceptions of economy, including understanding the true role of mankind in managing and improving the biosphere—as by the massive control and direction of water—are demanded in order to solve the continental agricultural and food crises, while improving the overall territory of the West.

To do this effectively, the original 1964 design for a North American Water and Power Alliance (NAWAPA) must be upgraded from the standpoint of a nuclear-thermonuclear economic driver, providing not only *more* desperately needed water, but doing so *faster*, with *less loss*, and with an international commitment to the development of a new nuclear-thermonuclear global economy.

The point is that water is not an object that gets "used up." The newly designed NAWAPA XXI increases the productivity of the existing continental water cycle, by redistributing wasted freshwater and utilizing the unique power of plant life itself.

The original 1960s design would have made significant progress in this regard, but by being based on hydropower, it had a 40–45% loss factor built-in. However, a nuclear-powered NAWAPA XXI changes that.

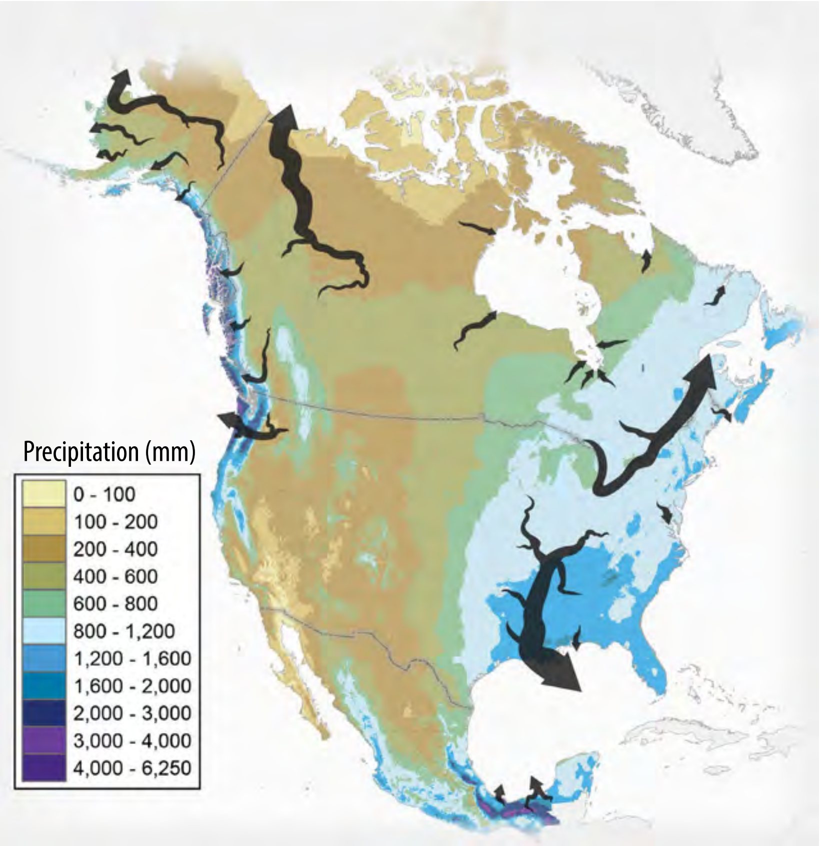
For the original NAWAPA to generate roughly 0.25 GW of electricity through hydropower, one million acre feet (or 1.23 billion tons) of freshwater per year must be released from the system, whereas the same amount of electricity can be generated using nuclear power with 600 million times less "fuel" (by weight), 2 tons of uranium per year – dramatically increasing the efficiency, potential, and size of NAWAPA XXI.

To fully understand the significance of this, it must be recognized that the value of water is never measured in its quantity alone, but defined by its contribution to the growth of the biosphere and the economy.

Why NAWAPA XXI Will Work

There are no isolated water basins on the North American continent (or any continent for that matter). The Earth has a single global hydrological cycle, which can then

Figure 1



NEGI, NR-Can, USGS, North American Environmental Atlas of the Commission for Environmental Cooperation

Precipitation map of North America, with major river runoff overlaid. The thickness of the arrows roughly corresponds to average annual runoff.

be sub-divided into continental components. Any serious discussion of the water issues in a region of North America requires addressing the whole continental system.

Start with the entire continental input and output of freshwater (e.g., rainfall and river runoff), and compare the resulting amount of plant growth. For the most accurate representation, the values should be examined in per-area terms, and the rising productivity for the continental system will be seen in the increasing photosynthetic activity per unit of water input. This becomes a reciprocal process, as the development of more plant life (enabled by the water) will then drive an even greater increase in the rate of re-utilization of the water while it remains on land.

This reveals the secret beauty of NAWAPA. Currently, a huge density of precipitation falls along the coastal region of Alaska and British Columbia, which very quickly rushes back into the Pacific Ocean to become saltwater—losing any potential to be productive. Another massive input of precious freshwater flows north into the Arctic Ocean through the Yukon and Mackenzie basins, featuring two of the longest and largest rivers of the continent (with the Yukon and Mackenzie rivers together matching the flow of the mighty Mississippi).[1] (See Figure 1.)

This intense concentration of coastal precipitation is a peculiar consequence of the relationship between the geography of North America, and the Coriolis-driven wind patterns in the northern latitudes (the "anti–trade winds" or the "Westerlies"). The northern west-to-east wind pattern carries with it evaporation from the Pacific Ocean, bringing an immense store of water vapor. However, instead of this moisture delivering its benefits across the land mass (as is done in the west-to-east delivery of Atlantic moisture across similar latitudes in Eurasia), this Pacific moisture hits the massive block of North America's western coastal mountain ranges, pushing the moist air to higher altitudes where it condenses and much of it falls on the Pacific side of the mountains, running back into the ocean before it can get much work done.

This is a terrible waste of all the work the Sun had to do to evaporate all that ocean water, producing the freshwater needed for the survival of life on land.

Compare this unfortunate scenario with South America, where there is also a major mountain range along the western coast, but, being at a lower latitude, the Coriolis-driven winds flow in the opposite direction (the "trade winds" running from east-to-west). (See Figure 2.)

Figure 2

North and South America, with the coastal mountain ranges and moisture-carrying wind patterns indicated.

This results in the exact opposite effect, preventing the water from leaving the landmass. When combined with the power of the Amazon rainforest, this water ranks among the highest rates of productive use *and re-use* (through repeated cycles of evaporation, transpiration, and rainfall) of any continental water system on the entire globe.

In the unfortunate situation of North America, despite the major block of the coastal mountain ranges, some of the water in the northern regions does make it farther inland (over the continental divide), but only to then flow north, into the Arctic Ocean. The biospheric productivity of this northern territory is not limited by any shortage of water, but by lack of sunlight and the resulting frigid cold. For example Canada's Mackenzie basin has a -10°C mean annual temperature, with widespread permafrost in the north (where the land transitions to tundra), and nutrient-poor forest soils in the south.

Contrast this with the lower half of western North America. In the southwestern United States, where there is significant farming, agriculture, industry, population centers, and the potential for much, much more, the amount of freshwater runoff available is very small, ten times less than the north—only 91 million acre feet per year (113 km^3), compared with the 1,220 million acre feet per year (1,494 km^3) of the northern basins (see box: The Great Western Discrepancy).[2]

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[1] Also take note that Canada's Yukon and Northwest Territories have populations of 34,000 and 41,500, and population densities of 0.07/km^2 and 0.04/km^2, respectively. Alaska almost appears like an urban center in comparison, with its population of 731,500 and population density of 0.49/km^2.

[2] Unless otherwise noted, the freshwater runoff figures in this article are from John D. Milliman and Katherine L. Farnsworth, *River Discharge to the Coastal Ocean: A Global Synthesis*, May 2013.

The Great Western Discrepancy

The entire North American continent suffers from the lack of productivity created by the "Great Western Discrepancy."

In the north, there is excessive rainfall and runoff found in the Mackenzie, Yukon, Fraser, and Columbia River basins, plus the Pacific Seaboard, from Bristol Bay, Alaska down to about the northern border of California (42°N latitude).

In the south there is relatively little water throughout the remainder of the Pacific Seaboard down to the Tropic of Cancer (at just about the southern tip of Baja California Sur), and in the Rio Grande and Colorado River basins, along with the landlocked Great Basin.

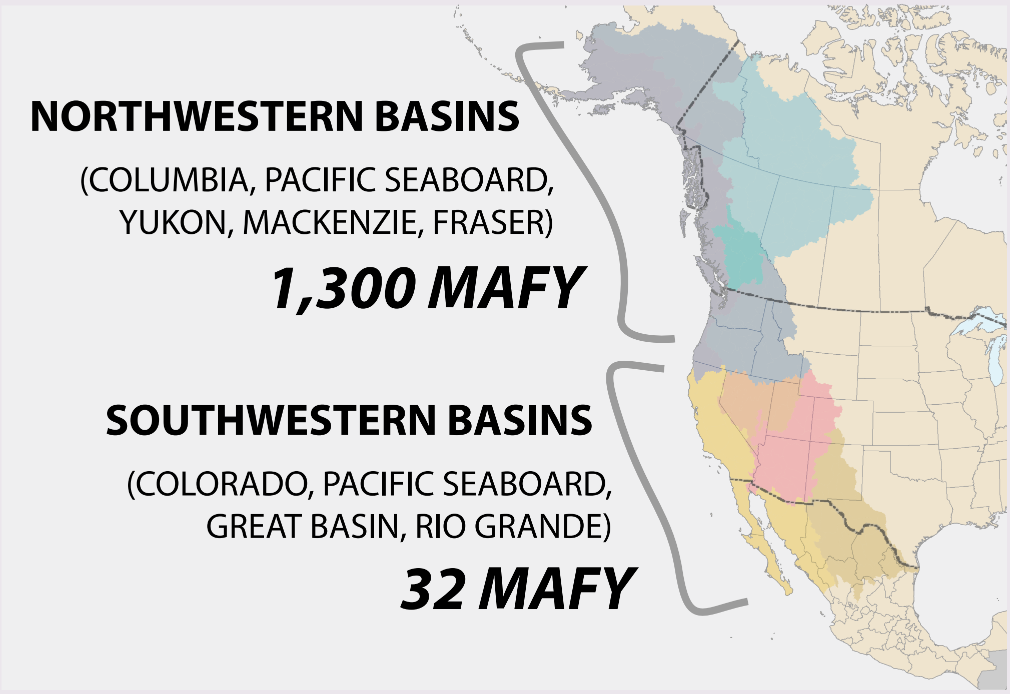
The precipitation into these basins, and the freshwater runoff leaving them, provides the water input and output of the two areas, and the comparison is improved when the values are considered relative to the size of the basin areas—showing that the northwest runoff per area is an order of magnitude higher than the southwest. Comparing these values against the average for the entire continent further illustrates the point, with the Northwest being about a factor of 2.5 times above the continental average, and the Southwest being about a factor of 3.5 times below the continental average, when considered in per-square-kilometer terms, as seen in Table 1.

Table 1

	Runoff (MAFY)	Area (Million km^2)	AFY/km^2
Northwestern Basins	1,220	4.42	276
Southwestern Basins	91	3.11	29
North America	2,554	23.1	110

This defines the physical framework for determining how the entire continental system can be improved by NAWAPA XXI.

The general question is the following: given the average continental yearly freshwater input-output cycle (i.e., the net annual continental hydrological flux), how productive is the water?



Division of the Northwestern water basins from the Southwestern

The total freshwater runoff for each set of basins is provided in million acre feet per year (MAFY), and the averaged acre feet per year (AFY) per square kilometer is provided. The total runoff values are what would leave each basin, assuming no withdrawals for other purposes; for example, the value used here for the Colorado is 16.2 MAFY, which corresponds to how much precipitation the basin receives, even through the actual amount that currently runs into the ocean is only 0.2 MAFY, since most of the river is used along the way for agricultural and economic activity.

In the Southwest, stretching from California to Texas, the climate is excellent, and the soils are fertile, but the limiting factor is the lack of water. The water challenges extend as far north as the Canadian Prarie Provinces, and south to Mexico, where entire regions of agricultural land are being lost, towns are running dry, and finite groundwater stores are being depleted, threatening an imminent and deadly food and water crisis.

Taken together, this north-south disparity in the West lowers the productivity of the water cycle of the entire continent.

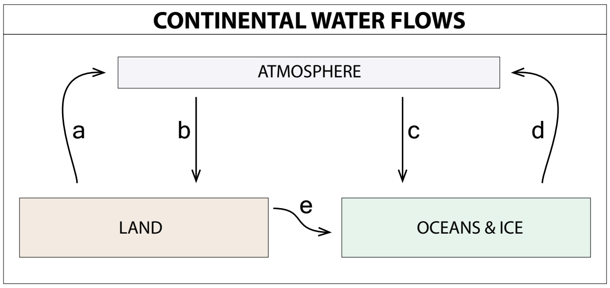
NAWAPA XXI is designed to take a fraction of some of these northern rivers (about 10% of the total runoff, by taking 20% of the runoff from a select set of rivers), and redirect the water south, both down into the Southwest and into northern Mexico, and also southeast, into the drought-prone Canadian Prairie Provinces and to the Great Lakes (where the water level has been steadily falling since the late 1990s), a more equitable distribution that will vastly improve the productivity of the continent as a whole.

Input and the Multiplier Factor

To measure the increased productivity, we have to first know more about the nature of North America's freshwater cycle.

In the most simple terms, Figure 3 illustrates a basic continental hydrological system. Rainfall (***b***) provides a freshwater *input*, while rivers releasing freshwater into the ocean provide an output (***e***).

Figure 3

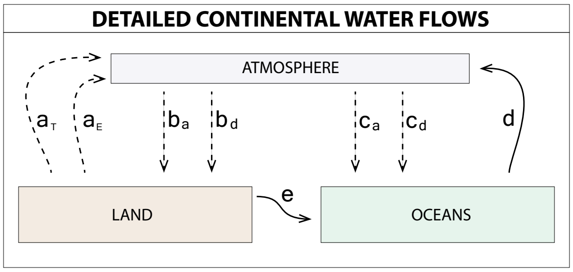


General flows of a continental hydrological cycle.

However, we must note that some of the atmospheric moisture which falls on land as rain *(**b**)* comes from the evaporation of water that was *already* on the land *(**a**)*.

So, to properly define continental freshwater input requires *knowing where the rain actually comes from*. True "input" is only new freshwater that is introduced onto the continental system: evaporated ocean water that then falls as precipitation over the continent. Simply measuring precipitation without investigating the source would lead to double counting when strictly defining input.

Figure 4



*Detailed schematic of a continental water cycle with precipitation subdivided by the source of the moisture (either from **a**, the continent, or **d**, the ocean), and evaporation from land subdivided into general evaporation (**E**) and the transpiration of plants (**T**).*

As seen in Figure 3, actual input is the amount of water evaporated from the ocean (***d***) which falls over the land (***b***). This is indicated in Figure 4 as b_d (a value that is different than simply the total precipitation).

While this may seem like a rather peculiar challenge, a team at Delft University of Technology, Netherlands, has investigated precisely this question.[3] Using new methods for modeling the transfer of water between the atmosphere, oceans, and land, they were able to estimate *where rainfall comes from*.

For example, according to their simulations, on average for the entire globe, only 60% of the rainfall over land would be considered fresh input (originating from moisture that evaporated from the oceans), while the remaining 40% comes from evaporated water *that was already on the land*. However the percentage varies significantly for different landmasses.

For China, they estimate that *only 20%* of its precipitation comes from ocean water, and about 80% comes from the Eurasian landmass. But for North America, the ratio is inverted, with 70% of the precipitation originating from the ocean, and only 30% coming from the land.

This analysis of the different sources of precipitation can be used to define the *rainfall multiplier factor* for any continental water cycle. For water that falls on a particular continent, how many times will it evaporate, and then rain back onto that continent again, before returning to the ocean? For North America the multiplier factor is about 1.45, below the global average.[4]

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[3] See, Rudi van der Ent, Hubert Savenije, et al., "Origin and fate of atmospheric moisture over continents," *Water Resources Research*, September 2010.

[4] Of all the water falling on North America, only 70% is fresh input, while the remaining 30% is input that has been re-cycled or re-utilized (in the form of precipitation). Since 70 is to 100 as 1 is to 1.45, the

Not surprisingly, when discussing this lower multiplier factor for the North American continent, the authors of this study repeatedly point to the role of the Western coastal mountain ranges in blocking moist air from moving inland, correctly noting that this lowers the cycling potential from the very start by causing a large amount of precipitation to immediately return to the Pacific Ocean before it has a chance to evaporate (let alone participate in plant life). For the precipitation (input) that is lucky enough to remain on land long enough to re-enter the air, they note that 60% of the land evaporation from the West returns to the continent again as rain. So while most water falling along the West Coast does not get a chance to evaporate, that which does has a multiplier factor of 1.67 (higher than the continental average of 1.45).

Now, in this context recall the specifics of the Great Western Discrepancy. In the northwestern basins, 1,220 MAF of water runs off every year, averaging 276 acre-feet of yearly runoff per square kilometer (as compared with the continental average of 110). When considering its scant participation in plant life, and the limited evaporation for inland transport, *this is among the least productive concentrations of precipitation globally*!

NAWAPA XXI's redirection of the northern water inland automatically increases the multiplier effect of the continental water input (again note that water evaporating from the West has a higher multiplier factor than the continental average). NAWAPA XXI's delivery of freshwater throughout the Canadian Prairie Provinces, the 17 western U.S. states, and northern Mexico, will ensure that more of this northwestern water will not only get a chance to be productive, but also to re-enter the atmosphere, increasing the rainfall throughout the Western and Central regions.

The benefits don't end there. The development of more plant life (supported by this new water) provides an additional feedback on the multiplier factor.

The Delft University team did a follow-on study examining a few specific regions which are highly dependent upon land evaporation for their rainfall, such as China. Specifically they studied the effects on rain patterns created by irrigation and plant life changes in the neighboring lands from which the moisture originates. For example, in one case they concluded that irrigation, agriculture, and water management systems in India have led to an increase in rainfall for China.[5]

NAWAPA XXI will take advantage of similar effects for North America.

The Great NAWAPA XXI Forests

While plants use some water directly for photosynthesis, they also release much more water vapor directly into the atmosphere, through a process called *transpiration*. Adding to existing evaporation, plant transpiration can significantly increase the moisture delivered into the atmosphere, meaning the introduction of large amounts of new vegetation can directly affect the water cycle, weather, and even local and regional climates. While all plants reintroduce additional moisture back into the atmosphere, trees and forests are the most effective in this process. For example, a 70-foot-tall sycamore tree can bring 100 gallons of water per hour from its roots to its leaves, 90% of which transpires into the atmosphere. This takes water from the subsurface water table—which would not otherwise evaporate, but would instead follow the underground water table toward streams and rivers—and lifts it into the atmosphere.

Within forests, certain angiosperms, such as oaks, transport water at a much faster rate then their less biologically advanced cousins, the gymnosperms, e.g., pine trees (although it should be noted that oaks are much slower growing than pines, so they would take longer to get going).

A 2012 review of decades of studies on the effects of plant life and forestation on the water cycle notes that, in general, forests release 1.4 to 1.75 times more water per square kilometer into the atmosphere than grass or croplands.[6] The authors note that plant life plays a critical role in strengthening the inland transport of water inland, and promoting more rainfall.

NAWAPA XXI will provide desperately needed water not only for existing farming, municipal, and industrial needs, but for additional economic growth, potentially tripling the agricultural land, for example—and it can also do more. For the multiplier power of plant life to be fully realized, additional water can go toward significant greening of strategic regions as well.

As discussed above, the atmospheric-hydrological system covering much of North America has an overall west-to-east directionality, a characteristic that can be utilized to increase the multiplier factor provided by plant life. For example, consider using NAWAPA XXI water to create dense strips of forest running north-south along the main NAWAPA XXI distribution trunks running from Idaho, through Utah, and into Arizona and Mexico, as well as the western branch from Utah, through Nevada, and along the California-Arizona border. A third north-south strip could follow the Colorado aqueduct, and/or the High Plains ex-

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precipitation value of rainfall over North America is increased by a factor of 1.45.

[5] See, P.W. Keys, R.J. van der Ent, et al., "Analyzing precipitation sheds to understand the vulnerability of rainfall dependent regions," *Biogeosciences*, February 2012.

[6] See, David Ellison, Martyn Futter, and Kevin Bishop, "On the forest cover-water yield debate: from demand to supply-side thinking," *Global Change Biology*, 2012.

tension (see Figure 5).

Figure 5

Map of NAWAPA XXI with four extensions indicated. Three sets of river basins are also identified, the northwest basins (blue) involved in collection, the southwestern basins (red), and the High Plains basins (green).

Such forests could rapidly accelerate the return of water into the air, as moisture for more rainfall. Additional elements can be considered, including ionization-based weather modification systems, designed to induce existing atmospheric moisture (provided by the trees) to condense and fall as rain.[7]

The Nuclear Driver

Although impressive for its time, the original 1960s NAWAPA design was limited by its hydropower constraints. This resulted in an inherent 40–45% loss factor, in terms of water utilization. Water would have to be collected within the system, only to then be released into the ocean to generate enough power to pump the rest of the water throughout the Southwest. With a higher level of energy-flux density, the power of NAWAPA XXI increases.

Key pump-lift stations in the northern regions raise the elevation of the water to allow it to flow by gravity throughout most of the rest of the system.

To deliver water into the Southwest, a hydropower NAWAPA depended upon collecting around 200 MAFY,[8] and then releasing around 130 MAFY of that collected freshwater into the ocean, solely to generate the power needed to pump the remaining 70 MAFY into the Southwest.

With a series of nuclear power plants to drive the pumping, NAWAPA XXI solves this issue, allowing more water to be delivered to the Southwest.[9] With more water available, critical extensions expand the distribution to new regions, beyond the scope of the original NAWAPA design.

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[7] Or even modulating the systems to keep existing moisture from raining down where it is not desired. See, Benjamin Deniston, “Expanding NAWAPA XXI: Weather Modification To Stop Starvation,” *EIR*, Aug. 9, 2013.”

[8] This number does not include the amount collected and distributed along the Prairie Canal, since that portion of the project on the other side of the continental divide does not have the same pumping requirements. It also does not include the large amount collected in the 1960s design for the purposes of generating excess hydropower.

[9] Recall that only 2 tons of uranium provide the same electricity (needed for pumping) as 1.23 billion tons of freshwater runoff.

Table 2

	North America	Northwest	Southwest	High Plains	Southern Mexico
Area (km^2)	23.1 million	4.4 million	3.1 million	3.3 million	0.42 million
Runoff (AFY)	2,554 million	1,220 million	91 million	238 million	177 million
"Natural" Runoff (AFY/km^2)	110	276	29	73	419
NAWAPA (Hydro) (AFY/km^2)	110	248	52	82	–
Nuclear NAWAPA (AFY/km^2)	110	242	61	82	–
PLHINO & PLHIGON (AFY/km^2)	110	–	39	–	350
Complete Program (AFY/km^2)	**110**	**242**	**71**	**82**	**350**

This table shows the freshwater runoff relative to the size of different land areas, and compares the results of the original NAWAPA, the Nuclear NAWAPA XXI, the PLHINO and PLHIGON, and the complete program (Nuclear NAWAPA XXI, PLHINO and PLHIGON), in these terms.

The High Plains extension provides water to the region of the Ogallala Aquifer, where the agriculture of western Texas, Oklahoma, and Kansas; most of Nebraska; and parts of New Mexico, Colorado, and Wyoming depends upon the overdrawn aquifer.

The California-Oregon (CA-OR) extension provides existing river and water systems in those states with much-needed reinforcements, securing and strengthening the existing capabilities.

Nuclear power can also drive a pair of coastal water projects for Mexico, the PLHINO and PLHIGON, bringing significant additional supplies of water from the *southern regions* of Mexico into the north, connecting into the NAWAPA XXI system.[10]

Thus, higher levels of energy-flux density enable what the original NAWAPA did not. Nuclear systems power the increased productivity and reuse of the entire continental water system, overcoming the arbitrary block of the coastal mountain ranges and bringing the biosphere to levels of activity impossible without man's governing hand.

This more equitable distribution is summarized in Table 2, showing the changing freshwater runoff per area.

This is not just redistribution, and is certainly not simply "using up more water." There is a continuous continental input, but the questions is, "what does the water do?"

Directing more water throughout the water-starved regions of the continent with the nuclear NAWAPA XXI allows for more plant life, more agriculture, and more economic activity generally, dramatically increasing the productivity of the existing continental water cycle.

The key to the future survival of North America is the direct interrelationship among energy-flux density, plant life, and water re-utilization per cycle without changing the actual input.

It is time for man to improve the biosphere in a way only he can do.

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[10] See the discussion of the PLHINO and PLHIGON Mexican water projects in Dennis Small, "Make that Which Is Reasonable, Possible—U.S. and Mexico: Cooperate on Great Water Projects," *EIR*, Dec. 7, 2007.