Promote Sustainability: Drive Floatplanes, Not Cars

"The automobile is arguably the most destructive technology ever invented by the human species. *Especially when you consider the black stuff that is usually found beneath them, asphalt. Why is it legal to take the toxic waste from oil refineries and spread it all over the earth, so that cars and trucks may roam about freely? When crude oil is put into an oil refinery, by the hundreds of millions of barrels a day, we take the gasoline off the top to run the cars, then the diesel oil to run the trucks and trains. Near the bottom we extract the bunker C crude oil which is used to fire the boilers on big ships as they cross the sea. But in the very bottom, left over, is this black, gooey crud. If you took it to a licensed landfill in a truck they would turn you away at the gate because it's toxic, hazardous, and carcinogenic to boot. It is illegal to bury it, but perfectly legal to load it into huge fleets of trucks and dump it directly onto the earth in a thin layer, killing every living thing. This is the world's largest case of legalized toxic dumping, and we turn a blind eye to it because of our love affair with the automobile and our dependence on the transportation infrastructure it provides."* – Patrick Moore[1],

In the early days of aviation, 80 years ago, floatplanes were viewed by some as the potential future break-through mode of transportation, since they used rivers and lakes as their basic infrastructure. Most cities and towns had been developed along rivers and lakes, because boat transportation had been the principal mode of transportation for several hundred years prior. Imagine our world if Henry Ford had developed floatplanes on the assembly line, rather than the automobile. Imagine our country with floatplane ponds dug every five miles of land surface, with canals connecting the suburban areas to nearby urban centers. And imagine this entire constructed water infrastructure serving not just man's floatplanes, but creating additional habitat for the other birds – ducks, geese, and other waterfowl – along with the added salmon, bass, and trout in the water. It could have been a quite different world, had we pursued travel by air a bit more strenuously in those early days.

That dream of using our lakes and rivers seems far away today, as our country is crisscrossed with 2.5 million miles of paved roads[2], along with the associated additional area of pavement for driveways and parking lots that connect to the roads. Instead of more ponds, lakes, rivers, and wetlands, we are filling in the existing ones at the rate of 58,500 acres per year (90 square miles per year)[3]. To understand the immensity of this choice our country made, try to imagine those 2.5 million miles of roads with today's 137 million cars[4] spread out along them – there would be one every 96 feet of road! That is a lot of cars and a lot of asphalt.

One can question the wisdom of that decision, to use cars as our primary mode of transportation, and consider the benefits to our world, were floatplanes used in lieu of cars. The hypothesis of this paper is that although floatplanes are in the minority, they may be the more environmentally sensitive mode of transportation. When the cost of all of those millions of miles of pavement and parking lots are considered, perhaps we can see a future in which floatplanes are recognized as a "green" alternative transportation mode – along with walking and the bicycle.

It is easy to understand the general concept, that the cost of the asphalt along with the damage it causes could make floatplane travel more advantageous than the auto. To mathematically analyze this concept is less easy. The comparative first costs and operating costs for cars as opposed to floatplanes is a fairly straightforward exercise.

[1] Patrick Moore, *Trees are the Answer*, page 11, essay available at www.greenspirit.com/ -- Moore was a founder of Greenpeace who now strongly advocates relying on the regular cutting of our forests (even clear-cutting at times) as the primary approach to maintaining an environmentally sustainable and renewable North America.
[2] Federal Highway Administration, Table HM12, Year 2001.
[3] U.S. Fish & Wildlife Service, Emergency Wetlands Resources Act of 1986 Report to Congress, 2001.
[4] Federal Highway Administration, Table MV-1, Year 2001.

However it is difficult to determine the costs of the environmental damage from the asphalt. What specific dollar value do we put on the greenery that is lost to his "*toxic waste from oil refineries"* that is *"spread all over the earth in a thin layer, killing every living thing"* as it is poetically described by Patrick Moore.

It is commonly recognized that the long-term environmental costs associated with our activities of modern life, are not included in our current accounting methods. What is the value of a product's environmental cost, such as: loss of habitat, reduction of animal populations, loss of wetlands, loss of species, contamination of ground water, visual pollution, noise pollution, air pollution, future climate change, and so forth. If we think of ourselves as worthy, there are also environmental costs to ourselves as well, such as: increased "stress", loss of open space, loss of recreational opportunities, and so forth. To initiate the analysis in this paper, we will assume a kind of "minimal environmental impact case" that the environmental un-funded costs of creating a material (for example, air and water pollution from extracting and refining a gallon of gas) is equal to 12.5% of the initial cash cost to purchase the material (i.e. if the gas costs $1.00 a gallon at the pump, we add 12.5% of that, which equals $0.125), and that likewise the environmental un-funded clean-up costs of using a material (for example, air and water pollution from burning the gas) is equal to 12.5% of the initial cash cost of the material. Thus, there is an added $0.25 of environmental cost for every dollar of material cost. The long-term accounting assumption is that the un-funded dollar cost will come due some day – so we will include this 25% environmental cost with the other costs, to determine the overall sustainability of auto travel vs. floatplane travel.

Once we have laid out this "minimal environmental impact case" approach for including environmental costs, we will perform a "sensitivity analysis" of the data and adjust the environmental costs to greater and lesser amounts to see how that affects the comparative costs between floatplane and automobile. In doing so, we will look at the range of environmental costs from zero percent, to as much as 200 percent.

In looking at the costs of each transportation mode we will include

- ✓ vehicle direct costs and associated maintenance, operations, and environmental costs, and
- ✓ infrastructure costs and associated maintenance, operations, and environmental costs.

We will not include the costs or impacts of inside storage of the vehicles (garages or hangars), storage and transportation of infrastructure construction materials, policing of the vehicles (highway patrol or FAA controllers), and a myriad of other related costs that <u>could</u> be considered. We view the highway system primarily driven by our love and obsession with the automobile. This study has not factored in the joint use of roads by trucks, in part, because had we maintained water-borne transportation as the primary mode, the efficiency of ships and boats would have paid off handsomely in reduced use of petroleum and highway pollution over trucks[5]. Likewise, this study has not included any credit to the floatplane mode, for the added water bodies that would have developed as part of their use, and their associated creation of new and added wildlife habitat, new recreation areas, and the many other benefits that would likely have resulted. In fact, this study will be a very rough, first order analysis only, to see if there is any merit to the idea that aircraft, especially floatplanes, might prove less costly when looking at the larger picture which includes their required infrastructure and associated potential environmental impacts.

<u>Vehicle Costs</u>

Vehicle costs include initial, maintenance, and operational costs. Cars and floatplanes weigh about the same and both use gasoline engines. So one could say their use of materials for construction – along with the associated environmental costs of mining those materials and later disposing of the same materials – is similar. However, floatplanes, as an assemblage of materials, are recycled and reused at a much higher rate than are autos. Most floatplanes range from twenty to fifty years old, yet are well maintained. A good-as-new[6] four seat floatplane costs approximately $60,000 in comparison to a new four seat auto costing approximately $15,000. The aviation industry is structured around re-using and maintaining its vehicles for 50 years use, rather than disposing of them in 15 years as is so common in the auto industry. For comparison purposes, we'll have both vehicles travel 11,766 miles per year[7] which is the average of all cars in the US during 2001.

Since the airplane can travel "as the crow flies" rather than having to follow the twists and turns of the highway, which must follow the contours of the land, we will include a cost reduction factor "S" for sinuosity of travel. For example, when going from Portland, Oregon to Nimpo Lake, British Columbia, the floatplane can fly a more direct path. In that example, the flight distance is approximately 550 miles (5hour flight), whereas the driving distance is approximately 800 miles (13 hour drive) – thus the floatplane only has to travel 69% of the distance the car has to travel. For this analysis we will let S for an auto have a value of 100% and for an airplane have an 85% value.

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[5] "Water transportation is also the most fuel-efficient way to move cargo. One gallon of fuel can move one ton of cargo 514 miles by barge. By contrast, one gallon of fuel can move the same ton of cargo only 202 miles by rail and 50 miles by truck. Barges produce a fraction of the emissions of trucks and trains. Ships and barges also have the lowest number of spills, according to the U.S. Department of Transportation." Page 166, *The Mississippi*, Steven Ambrose & Douglas Brinkley, National Geographic, 2002.

[6] General aviation aircraft are not currently mass-produced to the same extent as autos, and thus have an artificially high initial new cost when compared to an auto. For the purposes of this study, I will use operational statistics from my two vehicles – a Cessna 172 four-seat floatplane, and a Toyota Corolla four-seat car.

[7] Federal Highway Administration, Table VM-1, Year 2001.

$$VehicleCost = \frac{InitialCost}{LifeInYears \times MilesUsedPerYear} \times [(1(cash) + 0.25(environmental)] \times S$$

$$CarCost = \frac{\$15{,}000}{15\,years \times 11{,}766\,miles} \times 1.25 \times 1.0 = \$0.106\,/\,mile$$

$$FloatplaneCost = \frac{\$60{,}000}{50\,years \times 11{,}766\,miles} \times 1.25 \times 0.85 = \$0.108\,/\,mile$$

Thus, vehicle costs per mile for a floatplane are 0.2 cents (or 2%) greater than for a car. The fact that these are so similar, is because of the much longer useful life of the floatplane.

Maintenance costs of aircraft are higher than for cars. By using a constant 2 percent of initial vehicle cost as the annual maintenance cost, this difference will be taken into account. Maintenance costs are mostly labor so environmental associated costs will be assumed to be ignorable as a first order analysis.

$$MainenanceCost = \frac{AnnualCost}{MilesUsedPerYear} \times S$$

$$CarMainenanceCost = \frac{2\% \times \$15{,}000}{11{,}766\,miles} \times 1.0 = \$0.025\,/\,mile$$

$$FloatplaneMainenanceCost = \frac{2\% \times \$60{,}000}{11{,}766\,miles} \times 0.85 = \$0.087\,/\,mile$$

Thus, maintenance costs per mile for a floatplane are 6.2 cents (or 240%) greater than for a car – which is expected.

Both autos and airplanes use gasoline for fuel. The basic cost of gasoline, not including federal, state, and local highway taxes, is currently $1.17 per gallon. Cars burn an average of one gallon per 22 miles[8], whereas small aircraft burn an average of one gallon per 12 miles (10 gallons per hour at 120 mph). Thus, the operational costs, including 25% environmental associated costs are:

$$OperationalCost = \frac{FuelCostPerGallon}{MilesPerGallon} \times [1(cash) + 0.25(environmental)] \times S$$

[8] Federal Highway Administration, Table VM-1, Year 2001.

$$CarOperationalCost = \frac{\$1.17}{22\,mpg} \times 1.25 \times 1.0 = \$0.066\,/\,mile$$

$$FloatplaneOperationalCost = \frac{\$1.17}{12\,mpg} \times 1.25 \times 0.85 = \$0.104\,/\,mile$$

Thus, operational costs per mile for a floatplane are 3.8 cents (or 56%) greater than for a car. The floatplane engine is based on old car engine technology, and could be improved substantially if modern car engine technology were used.

In conclusion, totaling the initial, maintenance, and operational costs, for each vehicle we get:

$$CarTotalCost = 0.106 + 0.025 + 0.066 = \$0.197\,/\,mile$$

$$FloatplaneTotalCost = 0.108 + 0.087 + 0.104 = \$0.299\,/\,mile$$

Thus, a floatplane is more expensive to operate than the car by a factor of 52%, as long as infrastructure costs are ignored. This is where the cost comparison between aircraft and cars often ends. Below, we will add in the infrastructure costs, and find that they are a key element, that can totally reverse the results of the cost analysis.

Infrastructure Costs

Both cars and floatplanes rely on the availability of gas, however, the country's current primary reliance on automobiles just happens to rely on oil to a much greater degree. This is because oil is needed to create and maintain all of the asphalt pavement[9] for 2.5 million of miles of roads along with the thousands of bridges (sadly, cars can't fly over the streams and canyons), and the other highway system elements.

For the analysis of infrastructure costs we will use the Federal Highway Administration's data on costs of all public roads in the United States, which presumably includes all construction and maintenance work. During the year 2001 $118 billion was spent for roads, bridges, and associated highway work[10]. To this is added 15% for federal, state, and local uncovered governmental costs for these programs, such as the collecting and bookkeeping for the taxes. To this is added a factor "P" for private sector infrastructure including private roads, bridges, and driveways that connect to the public system. For this analysis the private investment in roads, "P", will be assumed to be 30% of public expenditure. To all of this is added the 25% environmental costs.

[9] Obviously concrete pavement is used for some highway construction, but it has similar initial, maintenance, and environmental costs that would be included, just as for asphalt.
[10] Federal Highway Administration, Table HF-10, Year 2001; the cost of law enforcement and safety not included.

$$InfrastructCost = \frac{FHWA\cos t \times [1(annual) + 0.15(gov't) + 0.30(private)] \times 1.25(envir)}{137{,}633{,}487\,cars \times 11{,}766\,miles / car} = \$0.132 / mile$$

For the floatplane we must assume some cost for the water infrastructure. For the purpose of this analysis we will provide an allowance of 5% of the road cost. This will be used to maintain the water landing areas, in coordination with the boating community's similar efforts.

$$FloatplaneWaterCost = Allowance = \$0.007 / mile$$

Evaluation: Your Floatplane is Green

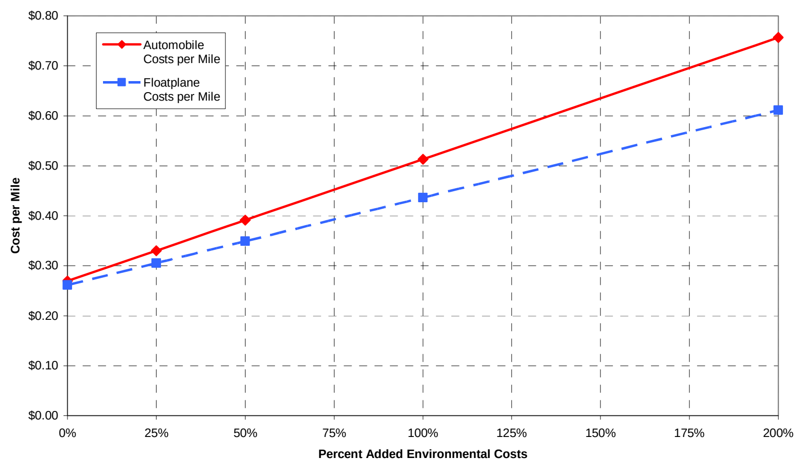
The total vehicle and infrastructure costs for each mode of transportation are as follows:

$$CarModeTotalCost = 0.197 + 0.132 = \$0.329 / mile$$

$$FloatplaneModeTotalCost = 0.299 + 0.007 = \$0.306 / mile$$

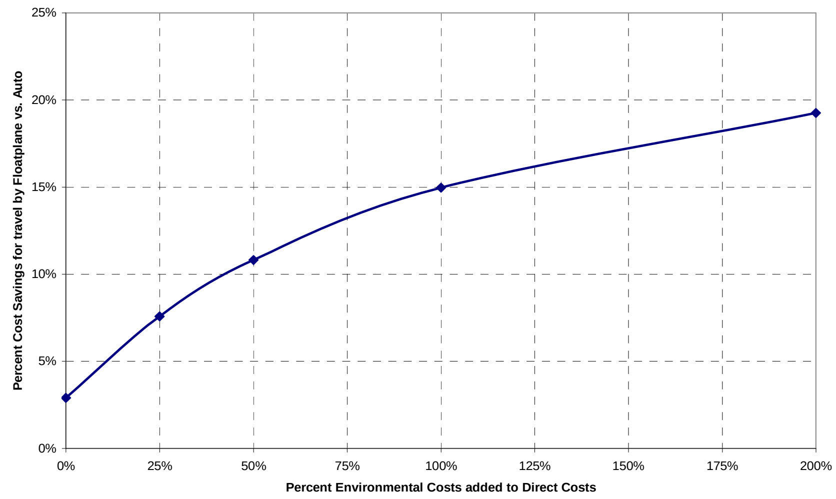
Thus, using a modest 25% environmental cost level, total floatplane costs are approximately 8% less than those of cars. In addition, most aircraft utilize engine technology from the 1960's and would gain much reduced maintenance and operational costs were the technology improved to that of modern car engines. Also, airplane initial costs are high, since they are not currently mass-produced. These factors would make the floatplane total costs much lower than evaluated here, were newer engine technologies and manufacturing efficiencies utilized.

Auto and Floatplane Costs vs. Percent Added Environmental Costs



The chart below shows how the costs per mile for autos and floatplanes changes, for differing environmental percentages of added costs. Note that the above calculations correlate with the 25% added environmental costs point on the graph.

Percent Savings Using Floatplane over Auto vs. Percent Added Environmental Cost

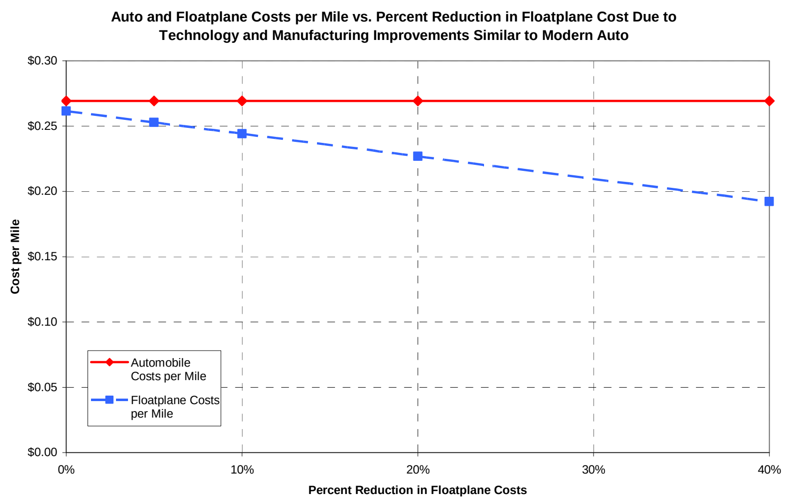


The difference between these costs provides a sensitivity analysis on the effect of the environmental percentage assumptions in this analysis. If the same calculation is performed assuming 0% un-funded environmental costs (in lieu of the 25% assumption), the result is that a floatplane is still a 3% savings over an auto. The infrastructure costs for the auto, when included, make the auto still much more expensive than floatplane! If added environmental costs of 50% are assumed, then the floatplane is a 8% savings over an auto. Added environmental costs of 100% result in a 11% savings. Added environmental costs of 200% result in a 19% savings. The chart below shows these changes in percent savings versus increased environmental costs. The greater the environmental costs that are present, the greater the savings with the floatplane—through the rate of savings is slowly leveling off.

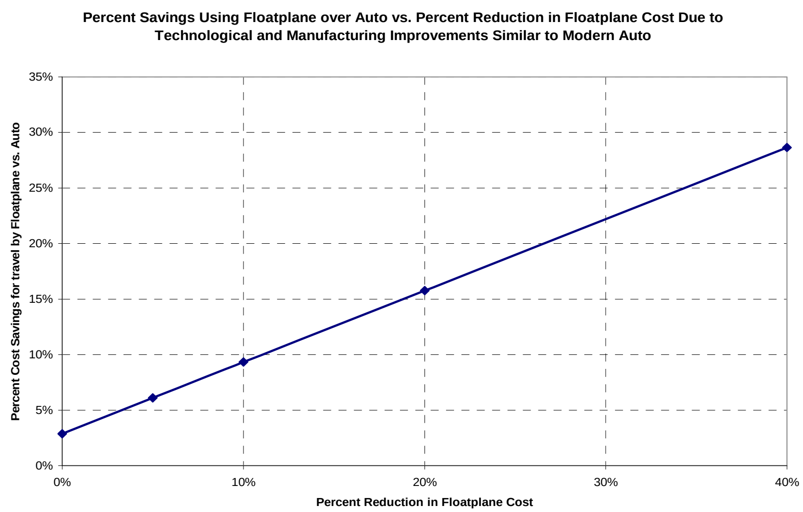
It is interesting to note that we could have performed a similar analysis for land planes, which require paving for the airport runways. In doing so, we would find that the total cost of the land plane mode is between that of cars and floatplanes[11].

[11] Since there are approximately 5,357 public airports, we might find that with an estimated average of 1.5 runways per airport, of 4000 feet length and 75 foot width, with the resultant number doubled to account for taxiways and aprons, there are approximately 0.5% the area of asphalt on airports as compared to roads.

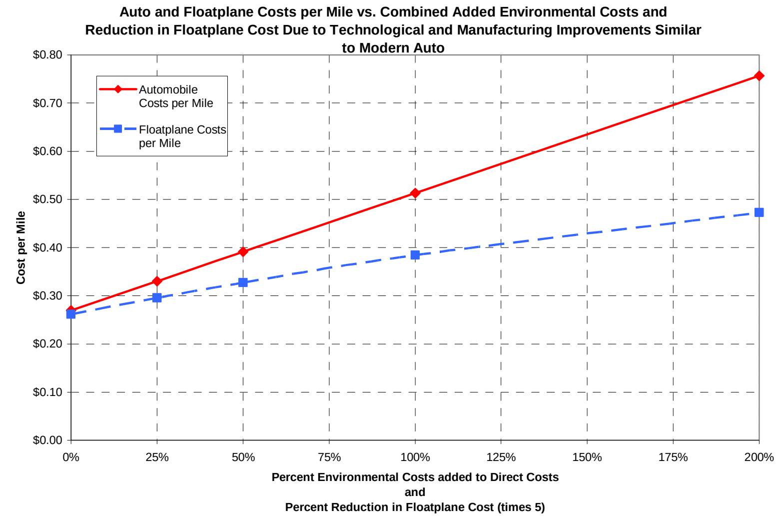
Given that floatplane initial costs would be much less if newer engine technology were used, and if efficiencies of mass production were possible in the manufacturing process, the graphs below show the sensitivity of the initial floatplane cost to the comparison of auto and floatplane per mile costs.



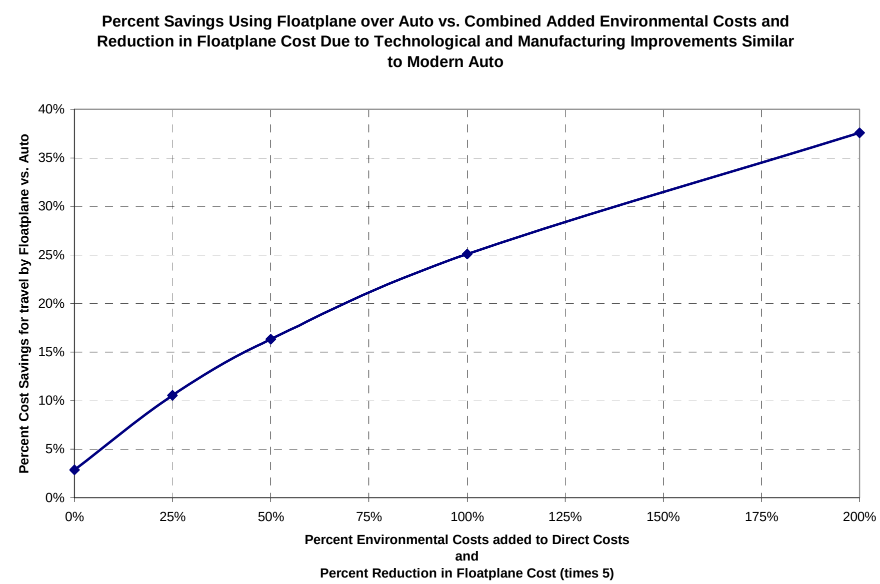
As would be expected, as the cost of the floatplane comes down, there is a decrease in the total cost per mile for the floatplane. This of course makes the floatplane even more desirable from a cost and sustainability standpoint. The graph below shows that the savings in per mile costs is a linear relationship to the savings in initial floatplane cost.



Finally, we can combine the potential increases in environmental costs and reductions in initial floatplane costs, to create a combined scenario. Note that the X Axis percent listed reads the direct value of the environmental added costs, but must be divided by 5 to give the reduction of initial floatplane cost.



And below is the graph of percent savings using the floatplane for these variations.



Conclusion

Given the existing costs of autos and floatplanes, along with their associated infrastructure and maintenance costs, the floatplane currently provides an approximate 3% savings over the auto. When potential environmental costs and/or potential floatplane initial cost reductions are factored into the analysis, the floatplane may provide as much as a 38% savings over auto costs.

It is important for the regulatory powers that be – those who regulate where floatplanes can go – come to recognize this fact, that floatplanes are in many cases preferable to autos, from an environmental and sustainability standpoint. Where a national park (or the Corps of Engineers, or Forest Service, or BLM, or FERC, or a State) prohibits seaplanes in an area, but allows cars – strong consideration should be given to reversing this condition. The floatplane should be rewarded for providing the more efficient and environmentally friendly transportation mode. Every flight in a floatplane is one more disconnection from the grid, the grid of 2.5 million miles of toxic, hazardous, and carcinogenic black tar poured on our magnificent green earth.

Not only are floatplanes enjoyable to fly – but from the sustainability standpoint, floatplanes should in many circumstances be considered the preferred mode of travel.

Epilogue

Were the world of today to be populated primarily by floatplanes, rather than cars, as vehicles, one might wonder whether our rivers would be clogged with these things. Would our local Willamette River need a control tower every five miles to keep the traffic safe? I think the answer requires more imagination than the question suggests. Were the world to have chosen floatplanes over cars, our American culture would have created a great infrastructure of rivers, and ponds and canals—in lieu of so many paved roads and bridges. Ours would be a much wetter world, and thus perhaps a world that would be more attractive, and more full of wildlife!

Americans are not about to give up their cars—the love affair is too strong. So, this analysis is in part hypothetical. However, just as our culture promotes bicycles and energy efficient cars, the floatplane should be added to the list of environmentally friendly vehicles. And where roads are twisty and slow, due to terrain or water bodies, there can be no doubt that the floatplane is, environmentally, the preferred mode of transportation today. Based on the economic analysis above, this is just the hard, cold, – and wet – facts of the situation!

As you fly this summer, talk to the visitors you see. Create good will by picking up other's garbage and flying it out. And whatever you do, as a floatplane pilot, be openly proud of our "green" mode of travel.

Aron Faegre