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Seaplane Note: #1

The Enormous Carbon Advantage of Seaplanes

by Aron Faegre

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Abstract: Seaplane basic infrastructure consists simply of the natural system of rivers, lakes, and wetlands that are used also used by other fish, birds, and biological organisms. Automobile infrastructure generally involves removal of wetlands and forests, placement of asphalt, and then long term maintenance of the asphalt and associated highway elements. The operating carbon impact of seaplanes and automobiles are similar. However, when the carbon impact of the infrastructure is included, seaplanes are found to have approximately half the carbon footprint of automobiles.

"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],

Introduction

Seaplanes have a distinct advantage over automobiles in their carbon footprint, in that the infrastructure needed by seaplanes is the same as that needed for wildlife and other biological systems: undisturbed, simple, natural waterways. Thus, what is good for seaplanes is good for fish, ducks, geese, and other biological organisms. Whereas the autos in the United States require the filling of wetlands, and the paving over of the fill – seaplanes need only that the wetlands be left in place!

Highway Infrastructure Carbon Impacts

It is ironic that our nation's paved highway system owes its roots to "mechanical horses" - bicycles. In the 1880's the cycling industry was becoming extremely popular, but it was also a

[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.

very risky activity reserved for only the most athletic[2]. Early cars could power their way through the mud and muck of early roads, as could the horse and buggy rigs, but not the bicycles. The League of American Wheelmen became a national lobby, and pushed for better paved roads. They were successful beyond their wildest dreams.

Our Portland area seaplane pilots might like to know that Macadam Avenue, along the west side of the Willamette River, was the first paved road in Oregon, and this was not an accident of history. Previously known as White House Road, the Multnomah Wheelmen had established it as the first bicycle path in Portland.[3]

Today the United States maintains approximately 2.7 million miles of asphalt road[4] to give auto drivers – and bicyclists – the ability to get where they need to go. To that we must add the supplementary elements: hundreds of thousands of bridges, traffic lights, traffic signs, and streetlights. Then we have to maintain them – we have established elaborate state and city highway departments to keep inspecting this infrastructure to ensure it is safe. Minor repairs due to localized pot holes or damage from accidents, requires ongoing fleets of vehicles and staff. No matter how well they are inspected and taken care of, in the end, asphalt roads are good for 15 to 20 years, bridges for 30 to 60 years, and traffic lights and signs for 10 to 15 years – and then they have to receive major renovation or be replaced from scratch. The cost of this infrastructure, and the carbon footprint of this infrastructure, is immense.

There are roughly 300 million vehicles in the United States – almost more than our human population. In 1928 the phrase was: "A chicken in every pot. And a car in every backyard, to boot." Forget that. Today it's four cars in every backyard!

For purposes of this study, let's talk about the number of cars that are most commonly using the highway system for travel. Let's not include the junkers and extra cars that some of us have – parked in our backyards. We are a highly urbanized society with 80% living in urban areas that have mass transit systems. Given that there are 152 million working adults (16 and older) in the United States, it might be reasonable as a first order estimate to assume half of them own and regularly use cars. For sake of this study we will estimate that there are approximately 75 million autos regularly using the highway system for travel.

A recent study[5] by Vic Roads, the transportation department of Victoria, Australian, estimates that one mile of a one lane width of asphalt road embodies 674,203 pounds (190 metric tones per km) of CO2-e [6]. Simple math then tells us that assuming a 20 year life, 2.7 million miles of average three-lane wide roads reflects an annual carbon impact of 273,052,381,719 pounds of CO2-e. That is 273 billion pounds of CO2-e impact to construct the asphalt for the U.S. road system each year.

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[2] See *The Lost Cyclist*, by David V. Herlihy, 2010 for an interesting history of the bicycle.
[3] See Lake Oswego history blog http://lakeoswegohistory.blogspot.com/2010/07/college-educated-cabbage-mark-twain.html
[4] http://wiki.answers.com/Q/How_many_miles_of_paved_roads_are_there_in_the_US
[5] "Calculating the Carbon Footprint of Road Construction," 2009 National Local Government Asset Mgt & Public Works Engineering Conference April 28, 2009. http://www.mav.asn.au/CA256C320013CB4B/Lookup/amc09maguire/$file/Maguire.pdf
[6] Road construction creates many different types of greenhouse gases. CO2-e is the measure of equivalent CO2 that would result in the same global temperature increase as that of the actual various greenhouse gases.

No one seems to have estimated the CO2-e impact of the bridges, traffic lights, traffic signs, and streetlights, but it would seem reasonable as a first estimate, to double the asphalt construction cost to account for these other costs. This would put the total CO2-e impact of the highway system at something of the order of 546 billion pounds of CO2-e.

Dividing this total by 75 million cars results in an average of 7,281 pounds of CO2-e impact each year, for each car.

To this we need to add the loss in sequestered carbon, that the roads create by loss of forest and wetlands that the road replaced. The roads' impact area at 2.7 million miles represents in round numbers at least 32 million acres of impact area. It is reasonable for a managed forest to long term recover and store 8,000 pounds per acre per year (4 tons per acre per year). If 50% of the highway area could be retained in managed forest or other sequestering biology, this would represent an additional 261 billion pounds of CO2-e per year. Dividing by the 75 million autos, we get a cost to the autos of 3,491 pounds of CO2-e per auto per year.

Remembering the quote at the top of this article, and that asphalt is a toxic material, it should be expected that there will also – someday – be an environmental cost to clean up the asphalt material we have spread around the land. There will be a carbon footprint to that effort too. We will not attempt to add that in for sake of creating a conservative analysis. A future analysis should add the carbon cost to that cleanup to this analysis, as it may double the impact once again.

So, in round numbers, not including future toxic cleanup costs, your car represents a total of approximately 10,772 pounds of CO2-e per year for the infrastructure that simply allows it to function as part of a transportation system.

So, no matter whether you drive a Toyota Prius or a Ford F150, your vehicle has an approximate eleven thousand pound carbon footprint, just for infrastructure, each year.

Now we turn to the seaplane: How many pounds of carbon per year are required for seaplane infrastructure per year?

Zero zilch zip … nada.

Auto vs. Seaplane Fuel Carbon Impacts

Now let's go to the direct operating carbon footprint – the fuel consumption.

Seaplanes basically use the same kind of engine as cars. Gasoline, carburetor, pistons, valves, magnetos, spark plugs, and a drive shaft. The difference for the seaplane is that there is a propeller on the end of the drive shaft, in lieu of a transmission and gears to the wheels. Medium sized four seat seaplanes burn 7 to 10 gallons per hour and fly 115 mph. Smaller two seaters burn 3 to 5 gallons per hour at 90 mph. That works out to 12 to 16 miles per gallon for medium sized seaplanes and 20 to 30 miles per gallon for the smaller seaplanes. But seaplanes fly a

more direct route to their destination. For example the highway drive from Portland to Diablo, Washington on Ross Lake is 305 miles and Mapquest suggests it will take 5 hours and 40 minutes to get there. By seaplane it is more like 250 miles – thus only 82% of the distance travel by car. The flight takes around two hours and 15 minutes.

Another example would be a trip from Portland to Waldo Lake which is approximately 185 automobile miles with a drive time of approximately 3 hours and 10 minutes. By seaplane it is more of a 145 mile trip – only 78% of the highway miles and it takes around 1 hour 15 minutes.

If we factor in that seaplanes take an average trip length that is 80% of highway miles (they travel in a straighter line), the effective seaplane gas efficiency, when compared to autos, climbs by 25%, to 15 to 20 mpg for medium sized seaplanes and 25 to 37 mpg for smaller seaplanes. So in practice, medium sized seaplanes have similar fuel efficiency per mile traveled, to that of an SUV or pickup truck and small seaplanes similar to that of a hybrid.

The lesson from this is: you can get to the lake with a pickup truck or SUV, carrying your two kayaks on the roof rack. Or you can get to the lake with a seaplane, with your two pontoons under your vehicle. The carbon footprint from fuel usage is approximately the same.

Many environmental organizations have on line calculators to help one figure out how much CO2-e is produced by use of autos. Carbon offset seller Terrapass[7] has a carbon calculator which suggests approximately one pound of carbon impact is created per mile for a SUV or pickup truck. Or when driving a Prius hybrid one gets 35 to 40 mpg which reduces these numbers by 50%, thus producing somewhere around 0.5 pounds CO2-e per mile.

Summary of Auto vs. Seaplane Carbon Footprint

The wrap up here is obvious.

- Four seat seaplanes have a carbon footprint of approximately 1 pound/mile. Travel 12,000 miles and the total annual carbon impact is 12,000 pounds of CO2-e.

- Two seat seaplanes have a carbon footprint of approximately 0.6 pound/mile. Travel 12,000 miles and the total annual carbon impact is 7,200 pounds of CO2-e.

- SUV's and pickups have a carbon footprint of approximately 1 pound/mile, plus 10,772 pounds per year for the highway infrastructure. Travel 12,000 miles and the total annual carbon impact is 22,772 pounds of CO2-e.

- Hybrids have a carbon footprint of approximately 0.5 pounds/mile, plus 10,772 pounds per year for the highway infrastructure. Travel 12,000 miles and the total annual carbon impact is 16,772 pounds of CO2-e.

[7] http://www.terrapass.com/carbon-footprint-calculator/

Thus, four seat seaplanes are 1.9 times more carbon friendly than SUV's and pickups. Two seat seaplanes are 2.3 times more carbon friendly than hybrids. Thus, as a general rule me find that seaplanes have approximately half the carbon footprint of automobiles.

Conclusion

There is a beautiful simplicity and efficiency in the use of seaplanes for travel. The carbon friendly nature of seaplanes as a travel mode should be acknowledged and given preference, where environmental concerns are of interest. This is why seaplanes should be viewed as particularly appropriate as a preferred transportation mode to wilderness and remote land areas. Seaplanes allow access without the need for more roads and parking lots. And in the big picture – the global warming picture – they beat out the automobile in global warming impact because they do not have the extremely carbon costly infrastructure of the automobile: toxic asphalt, cleared forests, and filled wetlands.

Postscript and Apology

Critics will say, "Where did you get these numbers and are they really accurate?" And it is true that the whole discussion of carbon footprint is one charged with disagreement and lack of precision. Obviously there is still debate occurring about whether the earth is even warming. My first career was as a global climate modeler – my first scientific paper, published in the *Applied Journal of Meteorology* in 1972, is titled "An Intransitive Model of the Earth-Atmosphere-Ocean System."

To me there is no question that the earth is warming. And thank God for that. Otherwise Minnesota, Wisconsin, and most of Canada would still be under ice. The earth has been warming for a long time, as it comes out of its most recent ice age. From ice core data we know the earth's climate swings back and forth between warm and cold with some regularity. The oscillations have been shown to be related to time periods of 400 2,500 20,000 100,000 and 500,000 year intervals[8]. Man cannot take credit for most of those swings because we haven't been here that long. Current theories for physical processes that drive these oscillations include:

- orbital changes of the earth's distance to the sun (the further away the sun is, the cooler the earth, the closer the warmer),
- our solar system every 100,000 years "flys" through distant asteroid belts (asteroids hit the earth causing massive fires that create smoke that causes the earth to cool), and
- an oscillation is formed by a precipitation-temperature feedback loop (warmer climates put more water vapor into the air which is transported to the poles to create ice sheets; over time ice sheets reflect more and more of the sun's heat away from the earth causing the earth to cool).

The main point of this study is to point out that unequivocally, the more value one assigns to the

[8] "Cryothermodynamics: the chaotic dynamics of paleoclimate," Michael Ghil, Physica D 77, 1994, pp.130-159.

natural environment, the more CO2-e impact will be calculated from the highway infrastructure. No one will argue that the highway infrastructure has no impact. A more detailed study would need to take into account the CO2-e impacts related to:

- Truck, motorcycle, and bicycle use allocation of highways,
- Parking lots,
- Gravel roads,
- Potential conversion of future roads to concrete,
- Potential conversion of future roads to incorporate permeable pavement,
- Highway drainage impacts on river flows and flooding,
- Highway erosion impacts,
- Docks and minor seaplane infrastructure elements, and
- Average useful life of cars vs. seaplanes,

It would take a much more detailed analysis, which included these factors, to determine whether the "real" carbon footprint of an auto has this estimated 10,000 pounds of infrastructure carbon per year, or whether it is only 1,000 pounds, or whether it might be more like 25,000 pounds.

Personally, I do believe that man is accelerating the earth's warming. So I believe we should attempt to reduce our impact on the environment. Federal land agencies have in recent years been falsely claiming that seaplanes have negative environmental impact on natural resources. It is for this reason that I have made this rough attempt to put seaplanes in a better environmental context, and to show that when including the potential impacts of global warming, it is quite easy to show that – seaplanes have an enormous carbon advantage over conventional highway travel vehicles.

It is a common phrase in the seaplane community:

"Only seaplanes and canoes can visit the wilderness and leave no trace."

Now we must add:

"but only the seaplane arrives with minimum carbon impact."

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