

The Forgotten Casualty:

The Impact of WWII on Guam's Environment

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War in the Pacific National Historical Park

As a biologist at a war park, I am frequently asked about the environmental impact of WWII on Guam. When I was first asked this question, I found it very hard to answer honestly – I did not know of any studies that had looked at it on Guam. Over the past 5 years, I have had an opportunity to further investigate this topic, and this presentation will examine some of my findings



For this talk, I am going to focus on the environmental impacts on Guam resulting from military actions surrounding and following the Liberation of Guam. I focus on this period, because this is the time during which actual military combat occurred on the island. I will cover the activities that occurred from July 1944 and end with the conclusion of the war in August of 1945.

When people think of the effect of war on the environment, they almost always immediately conjure up images of ecological armageddon. High explosive like this must cause extensive long-term ecological damage.

Agent Orange in Vietnam



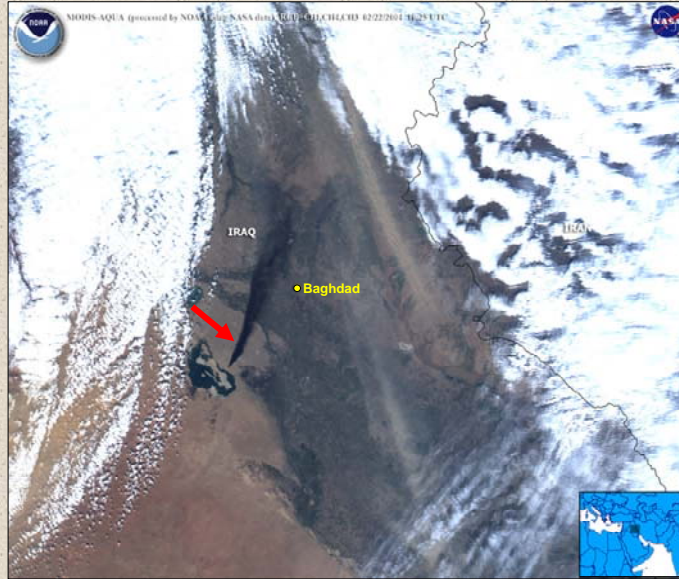
And what about things like agent orange in Vietnam. Surely this has caused permanent damage not only to human health, but to the environment

Oil Fires In Kuwait (1991)



During the First and Second Gulf War, we witnessed massive oil fires. In 1991, over 4 million barrels of oil were spilled in the Kuwaiti desert. That's 16 times what was spilled in the Exxon Valdez accident.

Oil Fires In Iraq



Some of these fires were so extensive, that smoke from the burning wells could be seen in satellite imagery.

What is the Environmental Effect?



So what were the long-term environmental consequences of such actions? It will probably surprise you, but the data available suggests that the environmental impacts of the wartime activities are not as severe as we might imagine. In fact, war may be better for the environment than most people think

Environmental damage is difficult to assess

- Data are anecdotal, grossly unreliable, & incomplete

I say this with some hesitation, because environmental damage, especially damage resulting military action is difficult to assess. In fact, studies of the environmental effects have been done for only few conflicts. What we have learned to this point is that assessing the damage of conflict is very difficult. And there are several reasons for this. First, data are anecdotal, grossly unreliable and generally incomplete.

First Gulf War (1991)

Initial Post-War Assessment	Revise Post-War Assessment
11 million barrels spilled	4 million barrels spilled
Predicted well fires would burn for decades	Last well capped 6 Nov. 1991
Air Quality (AQ) would be affected globally	Cannot separate AQ effects from pre-war industrial effects.
Predicted decimated shrimp fishery	Shrimp fishery was at pre-war levels in 1998

Kosovo Conflict (1999)

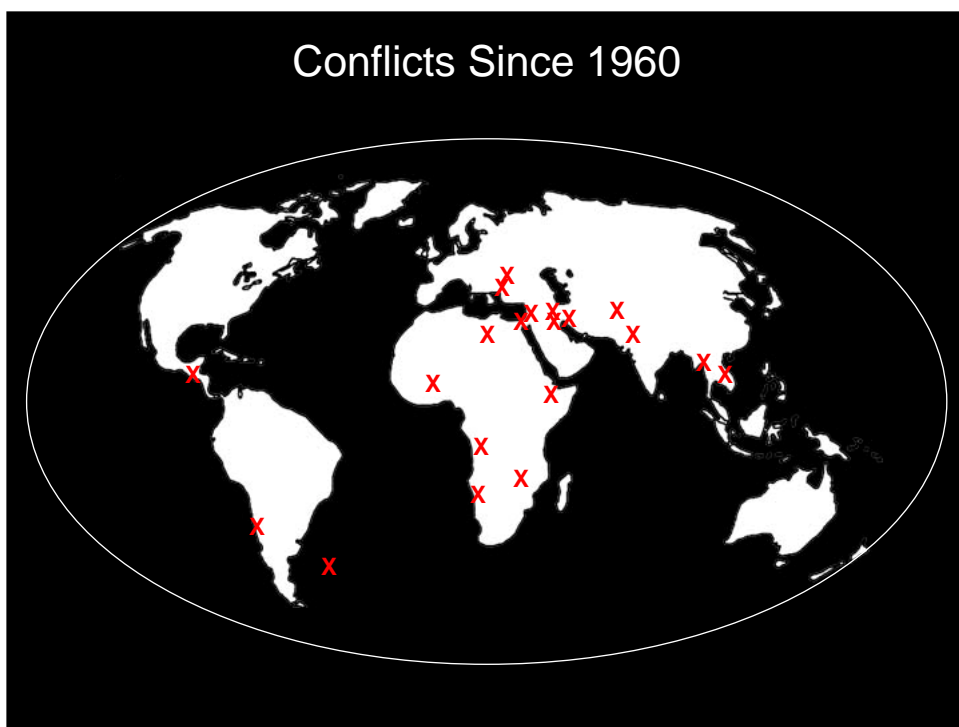
Initial Post-War Assessment	Revise Post-War Assessment
Depleted uranium would impact drinking water	Uranium in drinking water lower than some bottled waters.
AQ severely damaged	AQ improved over pre-War as a result of Industrial shut down.

For example, in the First Gulf War, initial assessments made by the world community at the end of the conflict painted a dire ecological situation. Much of the data proved to be very unreliable, and many of the predictions proved to be false. The same was found for the Kosovo Conflict, where environmental concerns raised at the end of the conflict, proved to be grossly overstated or flat out wrong when more intensive investigations were conducted.

Environmental damage is difficult to assess

- Data are anecdotal, grossly unreliable, & incomplete
- Assessments are difficult, complex and costly
- Assessment often economically driven

But in addition to poor data, ecological assessments are just difficult to conduct. They are complex and costly. Assessments are therefore economically driven. Not surprisingly, the best studied conflicts are ones that involved the US, and have been conducted with an underlying agenda to assign blame or to leverage economic compensation. There have been dozens of wars fought in the last 50 years, most of them not involving the US in any way, and little or no study of their impact has ever been conducted.



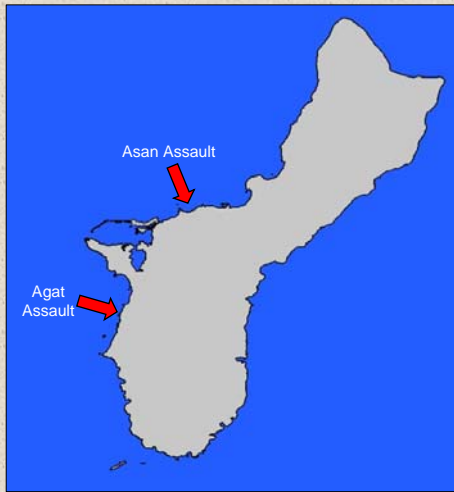
Nearly all of our data on the environmental impacts of war come from recent conflicts, starting with Vietnam. If we look at conflicts since 1960, we see an important pattern that is relevant to my current topic. With only the exception of the Falklands War, these conflicts have been on continental areas. When considering the effects of WWII on Guam, we must realize that the conflict occurred on a small island. Guam is just a tiny dot on this map, so small it doesn't even show up. This is significant because island ecosystems are inherently different from continental ones. In many respects they are more fragile, and whereas conflicts on large continental land masses may have little long-term environmental impacts, conflicts on small fragile island ecosystems may be more significant.

Island Ecosystems

- Cover a small land area
- Endemic species restricted to single or few islands
- Disconnected from potential source populations

Island ecosystems are more fragile than continental systems for a variety of reasons. First, they cover a small area, and any conflict has the potential to engulf the entire ecosystem as opposed to just a small piece of it. Second, islands tend to have a high rate of endemism, or a high number of species that are found exclusively on a single island or on just a few islands. If these species are lost, they are gone forever. Finally, island ecosystems, especially terrestrial ones, tend to be isolated, making recolonization from other sources difficult. The ocean is a very effective barrier to dispersal for many species of plants and animals.

The Liberation of Guam



July 5, 1944 – Naval bombardment begins

July 21, 1944 – Amphibious landings at
Agat and Asan

August 10, 1944 – Guam secured

Before we get into the meat of this investigation, I want to make sure everyone is on the same page regarding the liberation of Guam. The liberation of Guam occurred in three distinct phases. Starting on July 5, the Navy began an extensive 16 day bombardment of the island to “soften up” the Japanese forces. This was the longest such bombardment to occur at this point in the war. On July 21st, the first soldiers came across the reef flats at Asan and Agat. Combat continued on land until the island was declared secure on August 10, 1944. After this time, Guam became a strategic base of operations for the rest of the war.

How does it damage? Let me count the ways.

Intentional Direct Damage

When nature is the target.

Incidental Damage

When nature is damaged collaterally

Indirect Damage

When nature is damaged in non-combat war activity

After Lanier-Graham (1993)

Environmental damage from war occurs in different ways. Sometimes the environment is the focus of a combat activity, such as defoliation efforts during Vietnam. This is Intentional Direct Damage. Other times, nature just happens to get in the way, and is collateral damage. This is Incidental Damage. These first two are the ones most people think about when they think of war damage on the environment. A third category is Indirect Damage. This damage category is a little harder to grasp, but may be the most severe. This is damage caused by non-combat related activities during war and includes activities like waste disposal, development of military facilities and environmental impacts from refugees.

When nature is the victim

Intentional Direct Damage



So let's take these order

Intentional Direct Damage

The environment is the intended target of a combat action

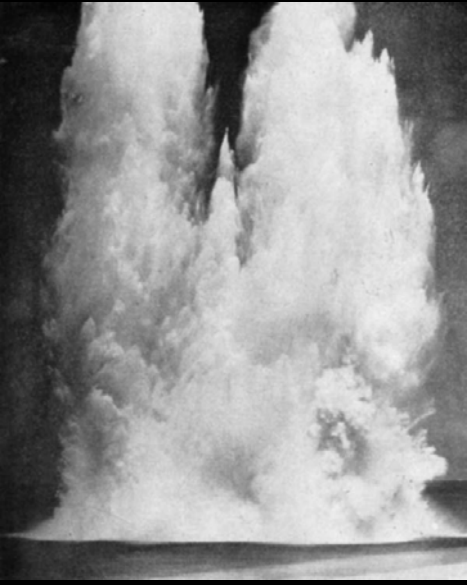
- Crop Destruction
- Defoliation
- Cave Modification & Demolition

Intentional Direct Damage is when nature is the intended target of a combat action. This type of damage historically has been carried out on cultivated lands. Armies would destroy the crops and poison the wells of area. In more modern warfare, this type of damage has become more prevalent, starting with Vietnam, when large quantities of herbicide were sprayed over the jungles. Prior to Vietnam, this type of activity was generally not conducted and as result of US actions in Vietnam, an amendment prohibiting environmental damage was added to the Geneva Convention. A final example of intentional direct damage is cave modification and demolition, and this example is probably the most relevant to my topic.

In the big picture of WWII, however, this type of damage was relatively rare and very focused. But it did occur.



Prior to the amphibious landing, the military had to deal with getting onto the beaches. That meant getting by the coral reefs, which were a significant challenge. The help them out...



Navy Underwater Demolition Teams

- Reef approach “improvements”
- 200 foot hole in the Agat Reef

Four Navy Underwater Demolitions Teams made numerous “reef approach improvements”. While I’ve no direct documentation for Guam, on other islands this entailed blowing up large coral heads. There is documentation that a demolition team blew a 200 foot hole in the Agat reef to help the landing.



Once on land, the military did make use of fire on small, but intentional, scale to clear brush.



But perhaps the most intentional damage was to the island's caves. Prior to the US invasion, the Japanese dug and modified natural caves for a variety of military uses.

Some caves were only moderately modified, but in other instances caves were heavily modified, such as this cave that was used for fuel storage. The heavy use of caves created numerous challenges for the US forces, and over the course of the war they developed a variety of cave clearing tactics. If they could get a tank into position, they would point the main gun into the cave and fire. They would then fill the cave with jellied gasoline better known to us now as napalm. This technique was perfected during the invasions of Guam and Tinian.



If that didn't work, they request demolition teams who would seal the caves.

You can imagine that these activities were not good for the cave or the animals that used them. Caves are very delicate natural environments and any activity in a cave can adversely impact them. Even small changes in humidity and light can destroy a cave community. Caves are usually home to unique species that are specially adapted for survival in this environment. It's been estimated that there are over 60,000 cave species in the world, but only 10% are known. A very large percentage are endemic, many to only a single cave. So you can see how any impact to a cave can be disastrous.

Cave Animals Impacted by WWII

Pacific Sheath-tailed Bat
(*Emballonura semicaudata*)



Island Swiftlet
(*Aerodramus vanikorensis*)

Unfortunately, on Guam, I have not been able to locate any baseline data on cave species prior to WWII. We do know that cave activities during WWI contributed to the extirpation of the Pacific Sheath-tailed bat, and also adversely impacted the Island swiftlet that uses caves for nesting.

Coral Reef Impacts on Guam Resulting from WWII

Intentional Direct Damage

- Dynamited reef channels and coral heads

So to summarize the Intentional Direct Damage to Guam's natural environment. For coral reefs, the military dynamited coral heads and blew a 200 ft hole in the Agat reef.

Terrestrial Impacts on Guam Resulting from WWII

Intentional Direct Damage

- Cave modifications and destruction

On land, the Japanese army made extensive modifications of the islands caves and the US military cleared caves using very destructive techniques.

Ecological Impacts on Guam from WWII

Coral Reefs

	Severity of damage	Amount	Recovery Potential	Overall Impact
Direct	<i>High</i>	<i>Limited</i>	<i>Low</i>	<i>Low</i>

Terrestrial

	Severity of damage	Amount	Recovery Potential	Overall Impact
Direct	<i>Moderate-High</i>	<i>Limited</i>	<i>Moderate</i>	<i>Moderate</i>

As we really don't have any hard data on these impacts, we can try to put these damages into a subjective high, medium, low scale. So for direct damage to coral reefs, the severity of the damage is quite high, they actually blew up the reef. The spatial extent, or amount, of this activity was very limited, however, restricted to only a few locations near the invasion beaches. Reefs are able to recovery, but it is a very slow process; corals often grow on the order of millimeters per year. A two hundred foot hole will probably never recover fully. When all of these factors are considered, I would say the effect of Intentional Direct damage on Guam's coral reefs was probably low, primary because the very limited nature. We can also examine the terrestrial impacts in the same way, and because of the damage to Guam's cave environments, this is probably moderate overall

Bombs and Tanks and Foxholes

Incidental Damage



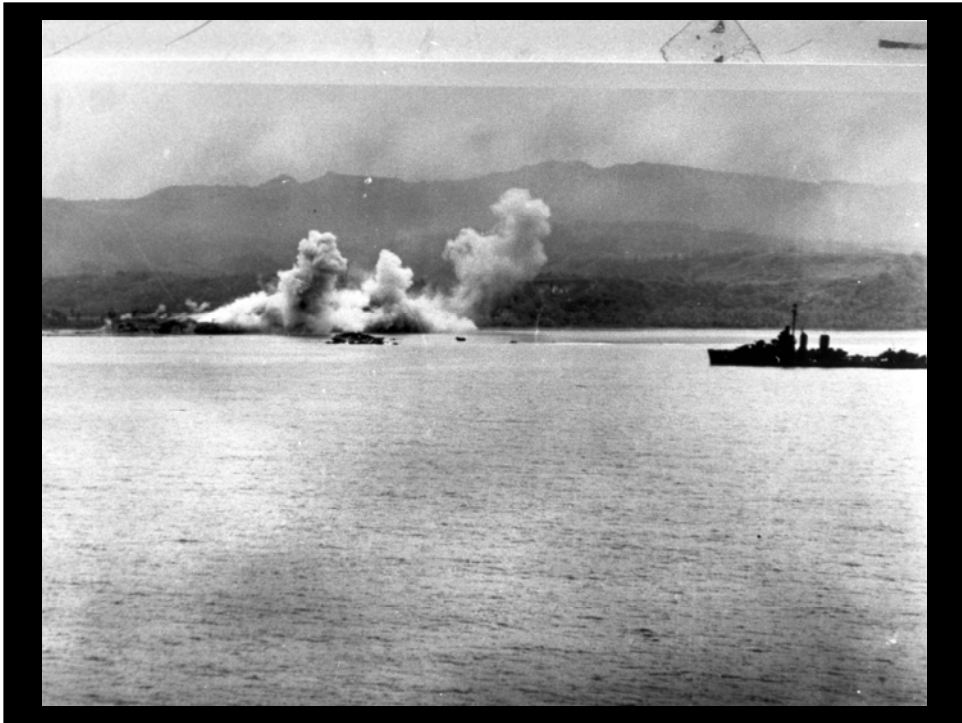
I will look at incidental damage next.

Incidental Damage

The environment is collaterally damaged during combat.

- Explosive detonations
- Entrenchments
- Vehicle and troop movement

To refresh your memory, Incidental Damage is collateral damage to the environment from combat activities. The environment is not the intended target but suffers collateral damage from explosions, entrenching activities and vehicle and troop movement over the landscape



Prior to the invasion, the US military spent 16 days bombing Guam to “soften up” the Japanese defenders.



You can imagine the amount of damage that such an activity would have on Guam's environment, especially in and around the invasions beaches in Agat and Asan. Forests were destroyed and probably burned.



Huge craters were left both on shore and in the water, as can be seen in this aerial from the Agat area.



After 16 days of bombing the military was ready to land. But the Japanese defenders had fortified the beaches with reef obstacles to hamper landing craft. These obstacles came in a variety of forms, from wire cages filled with rocks to pickets made out of palm trees. Prior to the landing, the reefs needed to be cleared of these obstacles. Over the course of 3 nights, nearly 1000 obstacles were blown up on the Asan and Agat reef flats by Navy Underwater Demolition Teams.

Dynamite Damage to Corals



Many of you are probably aware of the effects of dynamite on the marine environment. One stick of dynamite can destroy a large area of coral, not to mention many fish and other marine animals. Most of the fragments you see in these picture will probably die, and depending on the species of coral, it could take decades for them to recover. At least a thousand of these explosions occurred in Asan and Agat.



In any combat action, you need to move your army. Moving thousands of soldiers and heavy equipment across the landscape will cause damage. Until Orote could be secured, all troops, equipment and supplies came across the reef flats.



The tracks left on the reef can be seen in aerial photographs taken following the liberation.



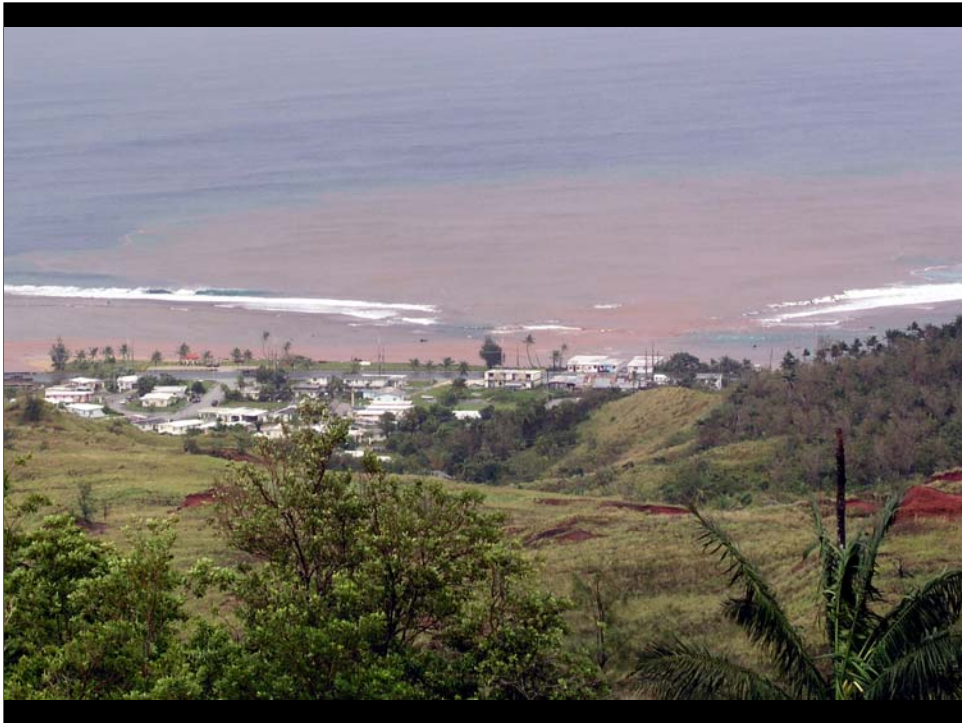
But these activities would also cause damage on the land where roads developed where equipment and troops moved.



In addition to vehicles, troops needed to do a lot of defensive entrenching. Evidence of trenches and foxholes can still be found on the landscape today and are protected by the National Park Service (included on the List of Classified Structures).



All of this activity. The bombing, the vehicles and troops had an incredible effect on the landscape around the invasion beaches. This photo was taken from the ridgeline above Adelup looking toward Asan Point. You can see the level of de-vegetation and destruction, which would have a significant environmental impact. As a result of no vegetation, the erosion off this landscape must have been incredible, especially during the wetseason (July-December on Guam).



On a vegetated landscape in Asan, sediment plumes like this are common after a storm. The waters off the invasion beaches must have bled red with dirt after the invasion, which would have adversely impacted not only the land, but also the coral reefs

Sediments Kill Reefs



Sediments kill reefs, and can quickly turn a reef that looks like this into one that looks like the one on the left, into one that looks like the reef on the right. But did this happen on Guam? Probably not. From research conducted at the park, we have seen that vegetation has an incredible ability to resprout, and by the end of the wet season, Asan would have been green with grass once again. The erosion rate would have dropped and while the erosion and sedimentation was incredibly severe, it was of a short duration.

Coral Reef Impacts on Guam Resulting from WWII

Intentional Direct Damage

- Dynamited reef channels and coral heads

Incidental Damage

- Concussion death and damage
- Trampling from equipment and troops
- Chemicals from damaged equipment & munitions
- Sedimentation

So to summarize the incidental damage on the marine environment, concussion and trampling damage, as well as chemical contamination from destroyed equipment and munitions did occur. Also sedimentation would have been severe but of a relatively short duration.

Terrestrial Impacts on Guam Resulting from WWII

Intentional Direct Damage

- Cave modifications and destruction

Incidental Damage

- Concussion death and damage
- Fires
- Erosion from equipment and troops
- Trampling from equipment and troops
- Contaminants from damaged equipment & munitions

On land, the list almost identical. Concussion damage from explosives would have occurred, but also these explosions would have started fires. Erosion and trampling from troops and equipment would have also occurred, and, as in the water, chemical contaminants from equipment and munitions.

Ecological Impacts on Guam from WWII

Coral Reefs

	Severity of damage	Amount	Recovery Potential	Overall Impact
Direct	<i>High</i>	<i>Limited</i>	<i>Low</i>	<i>Low</i>
Incidental	<i>Moderate</i>	<i>Limited</i>	<i>High</i>	<i>Low</i>

Terrestrial

	Severity of damage	Amount	Recovery Potential	Overall Impact
Direct	<i>Moderate-High</i>	<i>Limited</i>	<i>Moderate</i>	<i>Moderate</i>
Incidental	<i>Moderate-High</i>	<i>Limited</i>	<i>High</i>	<i>Low-Moderate</i>

So how does that rate out on our high, medium, low scale?

For coral reefs, we actually see an overall impact that is fairly low. While the damage may have moderately severe, it was very restricted in time and space. While recover may be slow, on the order of decades, it would and did appear to happen

The same assessment could made for the terrestrial environment, but I ranked this a low-moderate, because we have some evidence that soil erosion has significant long-term impacts on Guam's native vegetation. The erosion impacts were certainly severe, but were very limited in scale and duration.

Supply-side Damage

Indirect Damage



The final damage is perhaps the most destructive aspect of war.

Indirect Damage

The environment is damaged by non-combat activity.

- Military support activities (e.g., supply movement)
- Military development to support combat (e.g., roads, buildings)
- Waste disposal
- Refugees

The environment can be damaged by activities that are non-combat related, but critical to the support and supply of troops. This includes things such as damage from moving supplies, construction, and waste disposal. During combat time, waste disposal is often done quickly and without much environmental consideration.

Another important category of Indirect Damage results from refugees, who are forced out their homes and onto the landscape to fend for themselves. The environmental impacts from lack of sewage, food and shelter can be staggering. This last topic is probably a whole talk of its own, and I won't focus on it here.



In the early days of the liberation effort, Americans moved all of their supplies over the reef, including fuel barrels. Barrels like these have been found on the bottom in Agat and presumably were lost overboard with their contents



All of this heavy machinery was constantly moving supplies ashore, causing trampling damage. These supply activities lasted longer and probably involved more personnel and equipment than the initial amphibious assault. Consequently, damage resulting from supply movement would have been greater.



These supplies eventually wound in field supply depots. You can see a Japanese one here, but the Americans probably had similar ones. How much of this fuel wound up spilled?



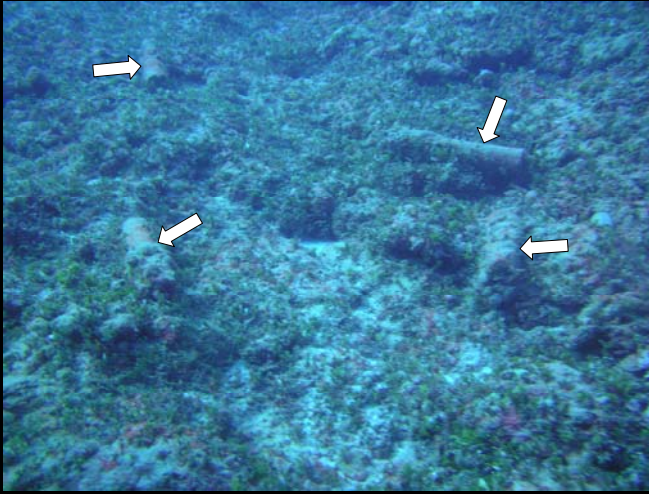
All of the bombing and combat created a significant solid waste problem. Hundreds of pieces of equipment and not mention hundreds of destroyed buildings needed to be disposed of quickly.



Photo by Bonnie Pelner

Much of it wound up on the bottom, like this jeep. And while people argue that things like this make nice artificial habitat, it probably was not cleaned of contaminants like oil and grease before disposal.

Unexploded Ordnance Disposal



Lead
Cadmium
Chromium
Nickel
Copper
Barium
Red phosphorous
White phosphorous
Strontium
Perchlorates
Polyvinyl chloride
Titanium tetrachloride
Hexachloroethane
Hexachlorobenzene
PCBs
Dioxins
Furans
Lead azide
Mercury fulminate
TNT
2,4,6 TNT
Dinitrotoulene
Dinitrobenzene
Tetranitromethane
Aluminum
Ammonium perchlorate

But in addition to equipment, unexploded ordnance and captured enemy ordnance were disposed of in a like manner. An estimated 64 tons of munitions were dumped off the waters of Asan. What is the environmental impact? We don't really know, but shells like these contain many hazardous chemicals, including numerous known carcinogens.



Starting the morning they landed and continuing up to the end of the of the war, Guam was heavily developed by the military. These developments have forever altered the environment of the island. In the year following the Liberation of the island, Camp Asan was built on land that did not exist before the invasion. This entire area was fill placed directly on the coral reef. Those reefs are dead forever.

Camp Asan, 1945



That fill probably came from the cut in the ridge between Asan and Piti that was made to accommodate the newly constructed Marine Drive. Incidentally, Camp Asan was operated as a motor pool during 1945, where they stored and serviced vehicles, an activity that today is not considered an appropriate activity to conduct in the coastal zone.

Apra Harbor, February 1945



Camp Asan is just one example. Perhaps the most severe example is Apra harbor. Compared to present time, the harbor had relatively little deep water in 1940s and had few naval facilities. This aerial was taken in February of 1945.

Apra Harbor, July 1945



Feb. 1945

By July 1945 we can already see numerous changes. The February 1945 shoreline has been overlaid to illustrate the changes in the shoreline. The construction of Victor Warf and the shipyard are underway but not complete. We can then overlay a modern aerial of the harbor

Apra Harbor, Present



Feb. 1945

To make the changes easier to see, keep an eye on the Victor Wharf area, Shipyard, Polaris Point and the Drydock Island (red arrows)

Apra Harbor, July 1945



These features are either under construction or do not exist in July 1945

Apra Harbor, Present



All of this dredging and filling would have destroyed coral reefs and the extensive mangroves that used to fill the harbor. Mangroves are important nursery habitat for many important marine organisms, included commercially important species.

Coral Reef Impacts on Guam Resulting from WWII

Intentional Direct Damage

- Dynamited reef channels and coral heads

Incidental Damage

- Concussion death and damage
- Trampling from equipment and troops
- Chemicals from damaged equipment & munitions
- Sedimentation

Indirect Damage

- Chemicals from equipment and munitions disposal
- Dredge and fill operations
- Introduced species (via ballast water and hull fouling)

So to sum things up one final time. The Indirect damage to coral reef was extensive, starting with chemical impacts from equipment and munitions disposal, not to mention just the physical garbage. But more significant would be the extensive dredge and fill operations. And finally, something we cannot address at all, but may be very significant, what sort of invasive species came in as a result of ballast water or hull fouling? Guam became a hub of activity for the US Military at the end of the war with supply ships routinely coming into and leaving port. We just don't have data on this.

Terrestrial Impacts on Guam Resulting from WWII

Intentional Direct Damage

- Cave modifications and destruction

Incidental Damage

- Concussion death and damage
- Fires
- Erosion from equipment and troops
- Trampling from equipment and troops
- Contaminants from damaged equipment & munitions

Indirect

- Land development for operational headquarters/bases
- Waste disposal
- Introduced species (via support transports)

A similar list impacts of war can be generated for the terrestrial environment. Anderson AFB, Tiyan, and Orote were all built or significantly expanded in those closing days of WWII. Extensive areas of habitat were modified to support the war effort. The disposal of waste was a significant problem. The military operated the Ordot dump, established large landfills on Orote and Anderson AFB. Two of these facilities are now Superfund sites and have potentially significant environmental and human health impacts. And finally, how many invasive species came in during that final year of WWII? I am uncertain. The brown tree snake came in with military supplies, but that occurred somewhere between 1944 and 1953, so it may not have been combat-related introduction, but more on that later.

Ecological Impacts on Guam from WWII

Coral Reefs

	Severity of damage	Amount	Recovery Potential	Overall Impact
Direct	<i>High</i>	<i>Limited</i>	<i>Low</i>	<i>Low</i>
Incidental	<i>Moderate</i>	<i>Limited</i>	<i>High</i>	<i>Low</i>
Indirect	<i>High (?)</i>	<i>Moderate (?)</i>	<i>?</i>	<i>High (?)</i>

Terrestrial

	Severity of damage	Amount	Recovery Potential	Overall Impact
Direct	<i>Moderate-High</i>	<i>Limited</i>	<i>Moderate</i>	<i>Moderate</i>
Incidental	<i>Moderate-High</i>	<i>Limited</i>	<i>High</i>	<i>Low-Moderate</i>
Indirect	<i>High</i>	<i>Widespread</i>	<i>Low</i>	<i>High</i>

So how does this rank on our high, medium and low scale?

I found that Indirect damage has probably had a large impact on Guam's coral reef ecosystem. I put a question mark on these because there are so many unknowns. What invasive species arrived? What are the long-term impacts of contaminants? Again, I just don't know.

When we look at terrestrial impacts, however, we consistently see severe, widespread impacts on Guam's environment.

These results do not seem to compare well with other studies that found the long-term impacts from war time activities were minor. It appears that the environmental impacts on Guam from WWII were greater than the impacts seen in continental areas. This is not surprising, considering that fragile nature of island environments. But having said all of this, how do these impacts fit into the larger picture of environmental damage to the island? As severe as some of these impacts may have been, they are probably minor compared to what we have done to the island outside of the time of war.

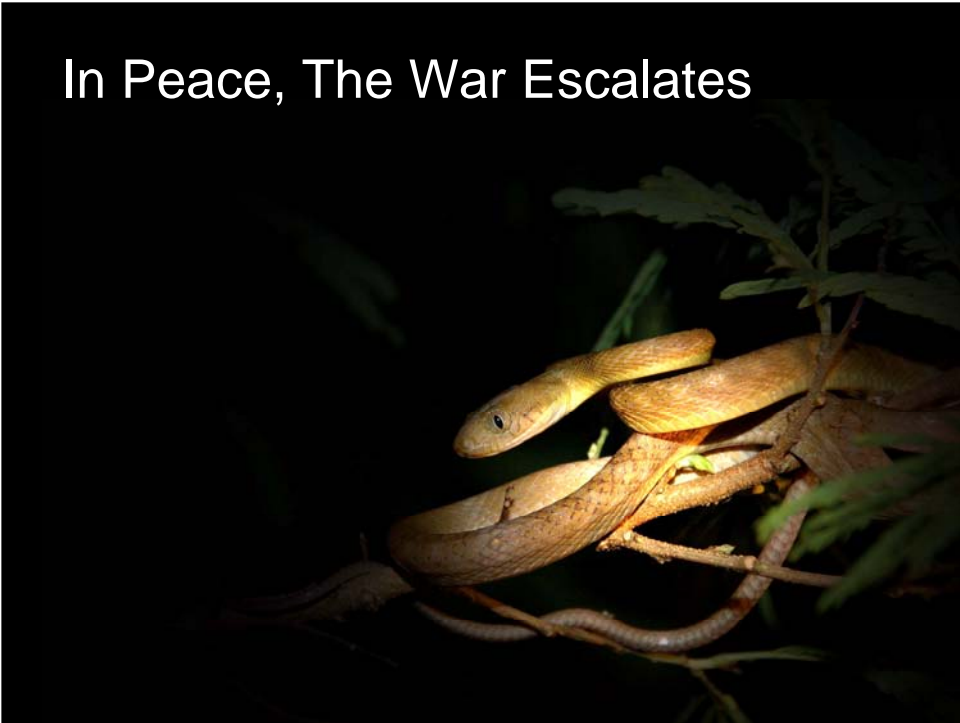
“By far the most damage to the natural environment is wrought not by war, but by peacetime commerce.

The second-most environmentally damaging human activity is *preparing for war.*”

Jurgen Brauer, 2000

Jurgen Brauer, an economist and one of the leading investigators of environmental impacts resulting from war, put it best when he said “By far the most damage to the natural environment is wrought not by war, but by peacetime commerce. The second-most environmentally damaging human activity is preparing for war.”

In Peace, The War Escalates



If true, then it appears that in times of peace, the war on the environment escalates.

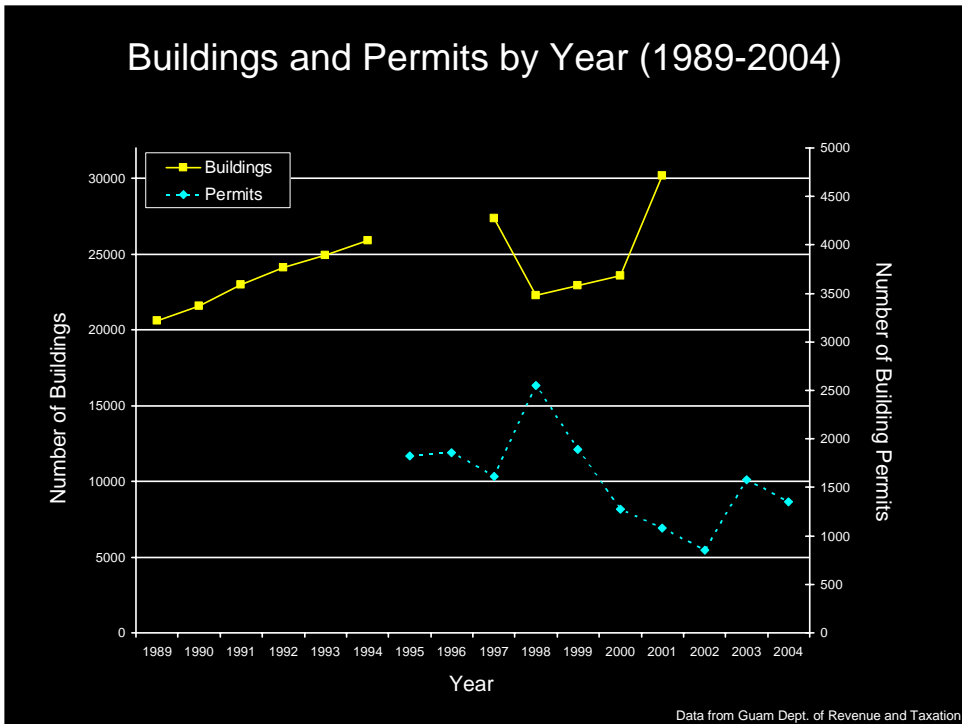


During the closing year of WWII, the military developed large tracks of land on Guam, destroying native habitat in the process. But civilian developments that have occurred since are considerable. This is a picture of central Guam near the end of WWII. Tiyan is in the background and Agana in the foreground. Notice all of this open space.



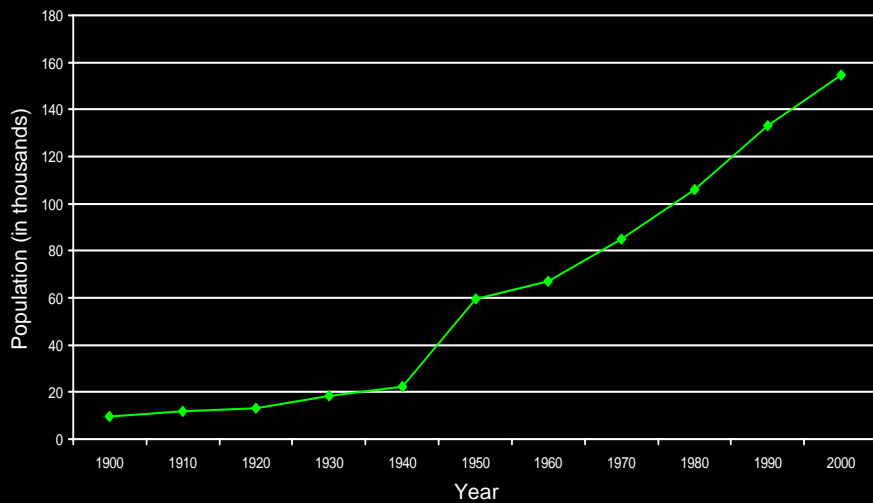
Hagatña, 10 March 2006

Since that time, the civilian development has been considerable and hasn't shown any signs of slowing down. It is ironic that the best pieces of native habitat are now found almost exclusively on military land, and so, in a sense they have been a better environmental stewards than Guam's civilians.



This trend of civilian development is not slowing. We can look at the number of buildings on the island over the past 15 years and see a pretty consistent increase. The number of building permits issued every year is nearly constant, suggesting that this trend will continue.

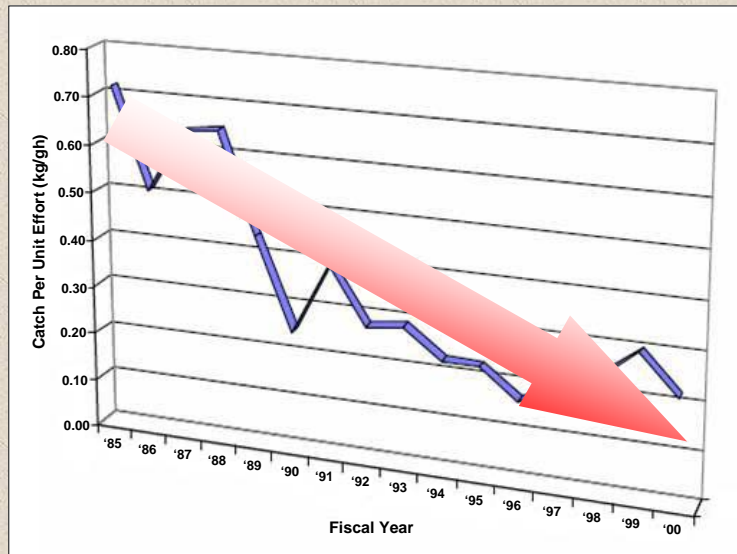
Population of Guam (1900-2000)



Data from U.S. Census Bureau

Of course all of this development is related to population increase. In 1940 there were only about 20,000 people on Guam. Since that time the population of the island has exploded and shows no sign of slowing down. If this trend continues, we will have nearly 225,000 people on the island by the next census in 2010. This population increase also has other impacts, specifically on resource consumption.

Guam's Declining Fisheries



Data from Guam Division of Aquatic and Wildlife Resources

Just as an example, fishery catch has shown a consistent steady decline over the past 20 years. Fish are fewer and smaller, all classic signs of overfishing. During the war fishery resources were probably lightly exploited. Unfortunately, we have no data on this. As has been shown in the Caribbean, declining fish populations can have significant ecological impacts on coral reefs and I imagine that these will become more apparent on Guam's reefs in the coming years.

Peacetime vs. Wartime Invasions

Taxonomic Group	"Peace"	WWII
Plant	34	1(?)
Mammals	8	
Insects	6	
Fish	5	
Molluscs	3	
Reptiles	1	1(?)
Amphibians	1	
Flatworms	1	
Total	60	2(?)

Data from the Global Invasive Species Database

Peace time species introductions are extremely high, and many of these peacetime introductions were done intentional by civilian businesses or the local government. In fact, the two that I've listed under WWII are suspect. Tangantangan may have been introduced by the military during the war, but I cannot find any conclusive documentation.

Peacetime vs. Wartime Invasions

Taxonomic Group	"Peace"	WWII
Plant	34	1(?)
Mammals	8	
Insects	6	
Fish	5	
Molluscs	3	
Reptiles	2	
Amphibians	1	
Flatworms	1	
Total	61	1(?)

Data from the Global Invasive Species Database

The brown tree snake was introduced by the military, but most likely after WWII and is therefore, more likely a peacetime introduction. While I can find no documentation that species were extirpated as direct result of the war effort, peacetime invasions have accounted for considerable biodiversity damage.



The BTS and its effect on Guam's environment really needs no discussion; it is the poster child of bad invasive species.

Ecological Damage from Brown Tree Snake

- 9 of 13 Native Birds Extinct or Extirpated
- 2 of 12 Native Lizards Extinct or Extirpated
- 2 of 3 Native Bats Extirpated

- Effect on insects and plants unknown
- Ecosystem effects unknown

The brown tree snake alone has played a role in the extirpation of at least 13 species and the effect on the other groups and the ecosystem itself are still unknown.

Other Peacetime Invasions

Domestic cat (*Felis catus*)

Flatworm (*Platydemus manokwari*)

Fountain grass (*Pennisetum polystachion*)

But other civilian introductions have been no less damaging to the environment. For example, the domestic cat was the primary reason that the recent Guam rail (*koko*) reintroductions failed. An alien flatworm has been linked to the extinction of at least three land snail species and in reality has probably caused more. Fountain grass is one of the species on island that is driving a grassland conversion and destroying native savanna grasslands by promoting unnatural fire regimes.



Undeniably, WWII changed the face of Guam and its people, but peacetime activities have destroyed more forests, grasslands and coral reefs than any actions committed by American and Japanese forces. For every foxhole or bomb crater, there have been acres of critical forest removed to make room for hotels and homes. For every species unintentionally introduced by the military, untold numbers of plants and animals have been intentionally brought to Guam to landscape island gardens, fill fish ponds, or provide game to hunt. Peacetime road building, pollution and runoff have killed more miles of Guam's reefs than bombs or landing crafts or military bulldozers. Fires set by local people to aid hunting have helped tangantangan spread and replace native limestone forests. Unmanaged hunting for food has help two native bat species toward extinction, and fisheries have been exploited to a point from which they may not recover.

It could be argued that war on the environment abates when war among men begins.



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