VIDEO CLIP: Asking Questions and Defining Problems

[TONY:] When I first arrived, there were a few other scientists there. And they had established some form of ballpark figure for the number of animals.

[NARRATOR:] The first aerial survey of the park tallied an incredible total of almost 400,000 large mammals. And curiously, the numbers of certain species were increasing dramatically.

[TONY:] The very first surveys of the buffalo in 1961 counted about 15,000 animals in the park. The next time they did that in 1965, they counted 35,000. For a large mammal, they just don't do that sort of thing!

[TONY (from footage):] The idea is to follow the herd around…

[TONY:] And so I became involved in counting the buffalo from that moment on, year after year, which required doing a lot of flying. Once a year, we had to fly across the whole of the Serengeti and count every single animal that we saw.

Of course these herds are quite big, so we had to take photographs, and then I counted the animals off the photographs.

[NARRATOR:] Tony's counts revealed that buffalo weren't the only ones increasing. Wildebeest populations were skyrocketing too. Tony's PhD project was to figure out why.

He learned that a virus called rinderpest had killed 95% of East Africa's cattle when it first arrived in 1890, and it had periodically decimated Africa's cattle populations ever since.

[TONY:] It turns out that wild animals that were closely related to cattle, like buffalo and wildebeest, they also suffer from this disease.

[NARRATOR:] Tony discovered that a new vaccine to eradicate rinderpest from cattle had also eliminated the virus from the Serengeti's wildlife. The disappearance of rinderpest precisely matched the time when buffalo and wildebeest populations began to explode. This boom was an opportunity for Tony to learn what regulates these animals' numbers, and the entire Serengeti ecosystem.

VIDEO CLIP: Developing and Using Models

[SIMON:] I got myself interested in what's really happening with the wildebeest population. Why has it stabilized? What is limiting the wildebeest population growth?

[NARRATOR:] To consider the factors that might regulate the wildebeest, imagine an ecosystem as a pyramid. At the base of the pyramid are primary producers like plants that get their energy from the sun. Those plants are eaten by herbivores like wildebeest, which are in turn eaten by predators like lions at the top.

[SIMON:] Wildebeest being at the middle of the pyramid, you can think of two things which could be limiting the wildebeest population growth. One would be food because herbivores have to feed on plants, which is at the

bottom of the pyramid. On the other hand, it could be from above, which are predators feeding on the herbivores.

[NARRATOR:] When a population is limited by its food supply, we say that it's regulated from the bottom up. If, however, the population is limited by predators, we say that it's regulated from the top down.

To figure out how the wildebeest population was regulated, Simon and Tony needed, of all things, dead animals. They began examining hundreds of dead wildebeest to determine the most common cause of death — predators or lack of food.

VIDEO CLIP: Planning and Carrying Out Investigations

[NARRATOR:] To figure out how the wildebeest population was regulated, Simon and Tony needed, of all things, dead animals. They began examining hundreds of dead wildebeest to determine the most common cause of death — predators or lack of food.

[SIMON:] Okay, definitely here I see a wildebeest carcass. And if it were hyenas, all the limbs would have been scattered around. So this is predation. Lions, most likely.

Age, you have to look at the tooth wear. Well, there we go. This is adult. And looking at the horn shape, this is a male, an old male.

So some of them will be dying from predation, but also some individuals could be dying out of starvation. For an animal which died from starvation, because of lack of food, the animal starts using its body reserves, stored fat in the body. When conditions are good, most of the fat reserves are stored around the stomach of the animal. But we cannot use that because they are eaten by predators. Scavengers also go for the fat around the belly; everything will be gone.

Because of that, we have to look at what is left behind. Luckily, the very last fat reserves that are used are bone marrow from the long bones. Very few scavengers will go into it. So this is what you'll find most of the time. And I'll crack it open. Yeah, so there we go, and there is the bone marrow. The bone marrow will tell you the condition of the animal at the time of death.

For three years, I recorded not less than 300 carcasses.

In the early years, I would see these type of kills and normally I would think, "Well, for sure, predators, given their numbers, they would be regulating the wildebeest population." So that was my first thought.

But after three years of studying, you look at the data and to my surprise, that was not the case.

During the wet season, when there's lots of food to eat, there were very few deaths which were recorded. And when you look at the bone marrow, it was solid, fatty, and whitish, indicating that the animals died in good health.

But then, during the dry season, we recorded more deaths, and animals were in poor condition, with their bone marrow being translucent and gelatinous.

This research tells us that wildebeest are regulated by availability of food. During the dry season, there's much less food resource for the animals to feed on and that regulates the wildebeest population.

VIDEO CLIP: Analyzing and Interpreting Data

[NARRATOR:] To understand how other species were regulated, Tony, Simon, and their colleagues used decades of data on the cause of death of many of the Serengeti's mammals.

[TONY:] Well, amazingly, these are the ledgers that I recorded the natural deaths — what caused the death, what ages they were.

In February '72, an old adult here killed by seven hyenas. December of '71…1972…May of 1972…a male, died in the dry season, November 1971, undernutrition…nine hyenas…killed by lion…drowned…hyena…lion, lion…now, here's an interesting one, leopard. We know that because it was found up a tree.

We collected many hundreds of them over the period of time from 1967 to 2000. That's 33 years of data.

[SIMON:] After we collected the data, it was plotted, and here a clear pattern emerged.

Looking at body weight versus proportion of animals being killed, for the smaller herbivores — oribi, impala, topi, and zebra — they mostly died by predation, while larger species — buffalo, giraffe, rhino, hippo, and elephant — most of them were not even touched by predators.

VIDEO CLIP: Using Mathematics and Computational Thinking

[TONY:] We found in the mid-1970s that the buffalo population was finally stabilizing at around 75,000 animals. Meanwhile, the wildebeest population was continuing to climb. And climb at a very fast rate.

[NARRATOR:] Between 1961 and 1973, the wildebeest populations had tripled, reaching 770,000 individuals. Park officials began to worry they were growing out of control.

[TONY:] Some people thought that we needed to do something about it, that we needed to reduce the population because they may have caused damage to the environment. There was a lot of opinion. We decided that we'd let biology follow its natural course and see what happened.

[NARRATOR:] The population continued to grow until 1977 when it peaked at 1.4 million — the largest herd of large herbivores in the world. The big question was, why had they stopped increasing?

VIDEO CLIP: Constructing Explanations and Designing Solutions

[NARRATOR:] In the early 1960s, fires were everywhere in the dry season. Up to 80% of the Serengeti savanna burned each year, killing young trees and preventing the woodlands from regenerating. But by the late 1970s, that figure had dropped dramatically.

So why was there less fire?

Over that very same period, Tony had watched the wildebeest population grow fivefold. Could wildebeest have something to do with the decline in fires?

[TONY:] The test for this was to compare the area burned with the size of the wildebeest population. And surprise, surprise, we found that there was an exact correlation. As the wildebeest population went up, so also the area burned went down.

[NARRATOR:] What was the connection between wildebeest and fire? Fire needs dry grass to burn and spread.

VIDEO CLIP: Engaging in Argument from Evidence

[NARRATOR:] The migratory herds follow a 650-kilometer circuit each year, taking advantage of a massive, temporary food source in the south, then retreating to the north when the southern plains dry out.

Migration gives them access to more food, and since their population is regulated by food, they have become far more numerous than the resident populations.

VIDEO CLIP: Obtaining, Evaluating, and Communicating Information

[TONY:] Before we put the story together in the late '70s, people were working on individual projects: on predators, on trees, on burning, on rainfall, and on the various ungulates, the herbivores. But it was only when we all started talking to each other that we understood that all of these different things were in fact connected. We realized that all of the things that they had been studying actually could be explained, almost entirely, by the changes in the wildebeest population.

[NARRATOR:] Tony and his colleagues had found the engine that drove the Serengeti: a migrating herd of a million living lawn mowers.

[TONY:] This species, the wildebeest, was a keystone in the ecosystem.

[NARRATOR:] When the wildebeest population rebounded, a cascade of unexpected effects rippled through the entire community. Through a web of connections to other species, it was this "keystone species" that made the Serengeti, the Serengeti.

From the very beginning, Tony had an inkling that it would take a lifetime to unravel the Serengeti's secrets.

[TONY:] Given how long I've been around, it's obvious that my time out here is going to come to an end fairly soon. And of course I'll miss it. The Serengeti is a special place. It is just as magical, just as mystical, as when I very first came.

[NARRATOR:] In a quest to learn what makes the Serengeti special, Tony and his colleagues had actually uncovered some of the shared principles that operate in ecosystems around the world.

The species may be different, but the underlying rules are the same. Populations grow quickly at low density and slow down as they reach their carrying capacity. Some populations are regulated from the top down, and others from the bottom up. Migration allows some animals to escape regulation and reach greater numbers. And a keystone species can influence nearly every part of an ecosystem.

Yes, the Serengeti is special. But the unexpected lesson from Africa's greatest wilderness has been that ecosystems everywhere follow the same set of ecological principles. And in that sense, every place is a Serengeti.