Name: David Klein
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Location of Interview: Home of David Klein in Fairbanks, Alaska
Interviewer: Karen Brewster

Brief Summary of Interview: Mr. Klein is talking about various students he had while working for the Cooperative Wildlife Unit at the University of Alaska Fairbanks, and what projects they worked on and accomplishments they have had since graduating. He also talks about caribou and muskoxen, and the differences of each concerning migration and defense against predators.

KAREN BREWSTER: We should now be on, except I can't hear anything.

DAVID KLEIN: Well, I'm not talking.

KAREN BREWSTER: Oh, now, I can hear.

DAVID KLEIN: Okay.

KAREN BREWSTER: There you go. It helps if I turn the volume up, too. Today is July 17, 2014, and it's Karen Brewster and Dave Klein continuing on the Dave Klein story.

DAVID KLEIN: Okay. Good.

KAREN BREWSTER: And I said before we started the recording, last time we'd been talking about the Cooperative Wildlife Unit and your work there and running it, and sort of the more administrative, logistics side of it. So now I thought maybe we'd talk about the research and the science part and working with students.

DAVID KLEIN: Yeah, sounds good. And maybe we'll start by me acknowledging a certain amount of humility that when I started in, just like anybody starting in as a professor, beginning professor at a university where you're dealing with students, you don't have the experience and you don't have as broad a knowledge about areas outside of your specific research area. Like my specific research area for my PhD thesis was deer ecology in southeast Alaska. And so I was well informed about deer ecology in the rest of the United States and even the rest of the world because I had -- all northern areas where deer occur. I'd worked in Denmark later on with deer ecology, and I understood deer ecology. But I didn't understand the areas that other students wanted to focus on for master's degree, because you couldn't expect them all to be working on deer ecology, especially at Fairbanks when the deer is in southeast Alaska or Prince William Sound and not up here.

KAREN BREWSTER: So you didn't know that much about caribou or moose or muskox at the time you started?

DAVID KLEIN: I knew a lot about other members of the deer family, and there were moose down there and I knew about caribou, because I had worked as a graduate student in the Interior with mountain sheep.

KAREN BREWSTER: I was going to say, you'd worked with the mountain sheep.

DAVID KLEIN: And mountain goats for master's thesis. So I'd learned a lot but they weren't the focus of my attention. So I knew a lot but I was – you know, normally if you're going to take on students in an area that they want to work with -- and frankly when I began, yeah, up here I wanted to work primarily with the big ungulates and that included caribou, moose, and then the mountain dwelling ones, which was a favorite of mine, but not so much accessible for students at the University of Alaska Fairbanks. The moose would be natural and caribou, because they're accessible and hunted by people here and you can get up there with -- into the Tanana Hills where there's caribou. But students came and some applied for graduate study. In those days, Alaska wasn't – the University was -- it's had a new program in graduate studies, before that it was all undergraduate. It was a little like, you know, we used to joke Podunk U University because it was undergraduate. And the research institutes thought they were aloof to the academic situation. And they were slow to get around and connect with it and have faculty that would have split appointments. Biology and Wildlife, fortunately we got started off better because wildlife management is an applied ecology. And they had – it was agriculture and land resource management that had to have it, they had funding for that through the land grant university system. So the Co-op Unit here, when it was established in 1950, it was like, it could function well here because we have this basic biology coursework already relating to agriculture. And then it was Agriculture and School of Mines initially before it became a University of Alaska. And as a university it should be broader, and it was the research institutes were coming in the physical sciences mainly, but then they were -- about that time the first – the Institute of Arctic Biology was created, focused heavy on physiological research and the cold adaptation in humans as well as in animals. And so the stage was set to put more emphasis on the native species of animals and that opened the door for ecology. And so I was lucky in the timing to come that, and then it was an environment that required me to become a broader ecologist and take on students that came and were admitted because they had good academic grades. And when they come, we'd see what funding was available. And if they had a specific focus, well -- And they had a stipend that was general and open-ended, then they could have more choice of what they wanted to work on for their thesis project. It was initially only master's, not PhD's. So one of the first students I had was one who was really committed to understanding vegetation and blueberries. And I had good botanical training, but nothing to understand the community relationships of blueberries, but this student was -- He came from the University of -- a smaller college in Vermont that was -- had a lot of focus on botany and had good background. And so I took him on and was -- I don't think I was his major professor but I was on his -- Yeah, I think I was his major

professor. Yeah, because there wasn't anybody else on campus to do it. And it was fun. He was a nice guy and joked about he got into blueberries because his mom used to make wonderful blueberry pies. And he turned out to be leader after he went on and did a PhD, after he did his master's, and he was a top-notch student. And Steve Young is his name. And I think it's Steve Young, if I remember correctly. And he went back to Vermont and became a faculty member back there. At Middlebury, I think it was. And he became a leader in working with Arctic vegetation. Published widely and came back to Alaska as a professor and did field research with people here at the university, and wrote publications that explained a lot of the early understanding of plant ecology in the Arctic. So, I never realized he would go there and it made me feel good to know that this student did so well. And at the same time, it forced me to draw heavily on the botany I'd had as an undergraduate student, and to build and strengthen that. And it was the same with other studies. I had students working on caribou and caribou ecology, and, yeah, that was close enough to my deer ecology work that I felt confident about that. And then I had a student who wanted to work on sea lions. And he was Finland, no Sweden. He had a few language problems when he came, but he had excellent grades and he was one of those once you meet him, motivated young people. And so got him a project that was funded partly by the state, when they had responsibility before statehood. No, it was after statehood. But they were still doing research on marine mammals. And so they -- he worked on a big sea lion colony down off of Montague Island on the outside of Prince William Sound. And it was great. And then subsequently, we had another student that -- because once we did some preliminary studies there, another student wanted to do it. And he happened to be closely related to a -- he wasn't married yet, but his girlfriend, who was also in our program, and she wanted to work with seabirds. And they were there, so they could work together. By this time, we didn't want to send a student out by themselves in a remote place, so they went together and both of them did masters. I wasn't the advisor for the gal that -- I was on her committee that was working with the seabirds, but another faculty member was. We had one then that was working with birds. And I was advisor for the one working with seabirds -- or with marine mammals. And he was a pretty good photographer, but he was studying animal behavior. So he had these photos but he -- for his thesis he wanted -- he really wanted an illustrator that could show -- take the 35-millimeter slides of limited quality and redo this. So I went to my neighbor, Bill Berry, the artist, who was a fabulous illustrator, wildlife illustrator. He had big files on – called him. And he said, well, he's not a marine mammal guy, but he would study up on them. And he did. And he used these slides and he produced these fabulous pictures that were just so excellent. I have a couple of the line drawings showing female young behavior, mating behavior, and again it was, you know, a way to draw on other, but I was lucky that there were people that could help out. And we had to raise money to cover Bill Berry's cost, but Bill would have done it without pay at all. But he did excellent copies, and they were excellent for use in the thesis. In those days, for a thesis we had to produce things -- the student had to produce things themselves, one way or another, and do all of the figures and bar graphs, and things. There's nothing like that available. And computers weren't even that useful for that purpose. So we had a drafting room, and I had good drafting experience as an undergraduate student and loved to do it. So I frequently would help them. I did for my own thesis, my master's thesis. And had to photograph them myself. We didn't have money to have -- hire that done when you're a student. And

the students we were funding, weren't supported enough to cover that. So it encouraged them to learn all these other skills. When you do those, you begin to better understand your data. How can you present it in a way that it would be useful? So then, I -- you know -- and I carried an advisory load larger than any of the other faculty because I had this funding for my salary from the Fish and Wildlife Service and I only had to teach one graduate level course per year, which freed me up to be an advisor as well as raising funds for the students for their research. And the research on things like muskoxen and caribou, and including an occasional one on deer in southeast or mountain sheep, then I had the expertise and I could take them on as major professor. And others, if there was nobody around, like studying blue grouse in Southeast, well, I was the only one around or someone in Agriculture and Land Resource Management. A student applied there and they wanted to study recreation. And so they, technically, they could cover that but they didn't have a faculty member suitable and I had already worked on projects that were related to -- Arctic Refuge, for example, appreciation of use of the refuge for hiking and viewing wildlife, etc. So it was close enough to recreation that I was the only one around to be advisor. And for this one -- another one in agriculture, they came to me because they had -- it was a study of grazing of domestic cattle on natural Alpine vegetation. And I was the only one that had experience in studies in relationship to mountain sheep and mountain goat. They came to me and technically I didn't have to -- I was connected -- the Unit was connected to the biology and wildlife department administratively, so it was up to me if -- I could say, "No, I can't do this. I'm fully booked on other things." But I felt that they were hard up and my primary concern was that the Unit served the university and was closely connected to one department, but it was the university and education of young people. And so I took on this student to do this study. And it was near Palmer, where these animals were grazed by a farmer there on a mountain in the summertime. And they wanted to know which plants were good for them. And we already knew that some of the plants were toxic to cattle, and how they would -- how these cattle would react to all this. Well, the student was excellent, and I only had to spend a little time down there with him when he got started and I realized he worked pretty well by himself. Plus there was -- one of his committee members was with the agricultural experimental station, Mitchell, and he was good all around, but with domestic crops. So he was a good member of the committee and provided moral support when I couldn't get down there at times. And the student did a top-notch job. Learned that the cows are put out there as plants start to grow, they learn themselves which plants to avoid eating. They taste them but they don't eat too much if they're toxic to give them problems. So they're almost like wildlife that has to do the same thing. And so if they're young animals, they learn it and when they're out there. And animals on that native vegetation did much better than they would on a pasture with only one or two plant types, grasses to feed on. So there's different quality vegetation, but they could be selective feeders and select for the best quality plants, which they tended to do, which wildlife does also. So, you know, related to work that I'd done with wildlife, but it was great to have this cross over into a really applied agriculture, but related to wildlife.

And then another one by a student who wanted to -- yeah, it was like recreation again. And he was a student who wanted to work with young people, but environmental education. But, you know, public use of lands, but particularly young people. And he was from California and he was fairly dedicated. He had thought things out well and had a

good academic record and he – he -- we didn't have a degree in agriculture, but they did have one in agriculture and land resource management. But they didn't have anybody at the time on the faculty that could handle it. It was mostly forestry or agriculture faculty. And so I took this guy on and he worked in the Yukon-Charley (Rivers National Preserve). We got Park Service funding right after the Alaska National Interest Lands Conservation Act, to work in the Yukon-Charley National Park. And to access there -- and part of this was the Yukon River in that area. So he and I did a canoe trip with a homemade canoe I had. And we camped out. And I could tell this guy was going to be an outstanding guy. He was really interested in raptors and peregrines. And when we got where they were nesting, you know, he was in glory and he could – taking good notes and everything. So he did a top-notch degree. And he later, with another graduate student of mine, started ABR (Alaska Biological Research). Bob Ritchie.

KAREN BREWSTER: So that was Bob Ritchie?

DAVID KLEIN: That was Bob Ritchie. And Jim Curatello [sp?] did a master's with me on the – on the [inaudible@20:19] caribou calving range study of caribou. And so, the two of them started it and then later he married a woman and they moved back east, sold out his interest and Bob Ritchie developed the ABR, which went on hiring mostly our graduates to work there and still do. And has a wonderful reputation for being very objective, good science and working for oil industry and state and federal governments and a lot of work up on the North Slope, but not necessarily there and just outstanding. We doing okay?

KAREN BREWSTER: Yeah, I was just checking one of the settings. We're good.

DAVID KLEIN: Okay. So that was sort of the diversity. And then at first, there were only males that were applying for graduate studies in wildlife and also taking any wildlife courses usually because the general attitude was, "Oh, females -- the field isn't where females should be." I mean, there's no special restrooms for women and things like that. It was rather, you know, living in the dark ages so to speak in terms of gender equality. And the faculty was primarily male. And, yeah, we had top-notch students and wonderful male graduates that I'm proud of. And then gradually an occasional woman applied and had good -- and she wanted to get into the field and she was -- she did a project that was funded partly through the wildlife unit and her major advisor was Fred Dean. I was on her committee. And she ended up, I shouldn't say that, she was employed -- she had worked in the national park as a volunteer for a while, and then she got hired by the national park and she became in charge. Sandy Kogel. She took responsibility for the dog mushing and the dogs there and trained them. And worked until she retired in that position.

KAREN BREWSTER: That was at Denali?

DAVID KLEIN: Denali. And she was just known for doing a wonderful job. Not only taking care of the dogs. And they use the dogs for patrol work in the winter, but also she was so good with tourists that come and see the dogs and had dogs. You could separate

the ones that weren't too friendly from the others and the tourists could appreciate details of dog mushing and understand how they were used in the past more than present, etc., etc. And so that started -- she was the first that I recall, female grad student to get her master's degree through our program and with connections with the Wildlife Unit.

KAREN BREWSTER: Do you remember about what year that might have been?

DAVID KLEIN: I would have to look up her thesis in the library to do that. Or Fred Dean, I could get it from Fred Dean.

KAREN BREWSTER: I can look it up then.

DAVID KLEIN: And then -- and Fred Dean could answer that question too if you couldn't. Then there were -- So what I can say is that, you know, I was still carrying on caribou research and sometimes it would be tied closely to the student's project. They'd be dealing with something like say insects harassment to caribou during the insect period. And that would be a part of what I was looking at in terms of summer habitat and the movements of the caribou in relation to insects. And I had one Canadian student who worked with the Porcupine Caribou herd, which was part in Alaska and part in Canada, so most of the work was in Canada. But we had a good understanding with the immigration service, or custom service, so we were able to work across the border. So one of her committee members was from Canada, was with the Canadian Wildlife Service, and the others were here on the faculty. Bob White, who was good on physiology and physiological ecology. And I was her major advisor. And that was good because we essentially were interested in the ecosystems that the caribou were -- the Porcupine Herd caribou used, which some were in Canada and some were in the U.S. And the predators also, and Canadian and some were American. And another study we had was on -- this was also a Canadian from Ontario, who did a master's study on migration in the spring to the calving ground, which was -- it's a winter project and her focus was on snow conditions and how that affected their movements through the Brooks Range to the calving grounds, where once they got there they had to be there in time to have their calves and then take advantage of optimal snow conditions to be very patchy. So you had some winter forage like lichens still available, but also green plants just starting, and patchy landscape made -- with snow and bare ground, made it a cryptic environment for predators. It was hard to see the caribou unless they were standing on a snow patch. And if they moved between snow patches it was hard to see them from a distance for wolves. There weren't very many wolves there but wolves at the time of calving -- I mean bears at the time of calving were a major predator. They were just out of hibernation and they were killing newborn calves that couldn't run fast enough to get away from -- in the first week of birth, after that they could outrun if the moms were alert enough and they were grouped up by that time and they'd tried to stay out of close range with the bears so they couldn't charge and get calves. But there were a lot of calves and the strategy of caribou coming together to have their young, even though at giving birth the females separated for about five days and had their calves separate from other cows so they could imprint on one another. The imprint smells and calls, vocalizations, which are very low. The calf's call is a little bit louder if it gets up and looking for its mom. And

after that five-day period and they go regroup again, then each cow and each calf know one another. And they get mixed up if they're all running from a predator or swimming across a river and some calves get swept downstream. The moms gather up with the calves again and the calves rush around and some cows will reject calves that aren't theirs that want to nurse badly because they're hungry, but the mom knows its own calf by smell and to a limited extent by vocalization. So they learn to identify one another. That's all crucial adaptation of the caribou, very unique to caribou. And they use this group strategy to avoid predators as much as possible and be able to have somebody watching while others are feeding. And in the summer, feeding is all important, that's when food quality is high. Moms got to eat more and process it rapidly so they have to eat the highest quality, new growth vegetation. No longer lichens. So eating and processing that so they can produce milk to feed this rapidly growing calf. Calves grow faster than any other large herbivore. And its adaptation for the short summer, but high quality feeding and the milk that a cow produces had the highest butterfat of any of the deer family. Much higher than even muskoxen, too.

KAREN BREWSTER: So you're saying that the caribou calves grow the fastest, have the fastest growth rate?

DAVID KLEIN: Right.

KAREN BREWSTER: Of any -- even moose or --

DAVID KLEIN: Yeah.

KAREN BREWSTER: -- deer?

DAVID KLEIN: They all -- And moose have a fairly fast growth rate, but they have to grow faster because they have to -- they're up on this summer range then they have to go on a long migration, many of them, most of the big herds, to the winter range. And they have to be strong enough to do that and have started to build up reserves to get them through the winter. But they still will be nursing, the cow a little bit. But they have to go through this rapid transition. Once they're born, they're dependent totally on the milk of the mom. But within a few days, once they're up and can follow their mom around, they start nibbling on green plants but they have to nurse several times a day. And the rumen, at first when they're young, is more like a non-ruminant, so it has a special groove that they can just shunt this milk down so it isn't going into the fermentation process because the milk is so easily absorbed – and digested and absorbed. Where if it goes into the rumen, there's all these microorganisms that are adapted to fermenting and the vegetation, it will take any of the milk and turn it into amino acids which the microorganisms will use. And then as those microorganisms' populations turn over and go down to the rest of the gut, it becomes available again but it has to go through the whole physiological process of converting it back into amino acids that go to muscles, primarily muscle growth. But some fat is more readily assimilated without this. But there's not a high fat content in green vegetation.

KAREN BREWSTER: So the milk of the calf, it sort of, it goes down a different -- ?

DAVID KLEIN: It's called rumen reticulum, which is kind of a groove that's muscular and it kind of goes and makes like a tube, so there might be some leakage but not significant. And it goes down, and then it goes directly into the mid-gut and then the hind-gut. And the mid-gut is like your small intestine of humans. We don't have a rumen.

KAREN BREWSTER: So it kind of bypasses the first stomach and goes to the second stomach?

DAVID KLEIN: Yeah.

KAREN BREWSTER: Okay. That's interesting.

DAVID KLEIN: And so it -- that period -- A lot of people think the greatest stress on the female is coming through the winter in the last period, the trimester, in her pregnancy is when this is the greatest demand because the fetus is getting large now. And so she has to draw on her reserves, as well as feeding, but she's on winter forage then. Lichens, which are high in carbohydrates, but not very high in nitrogen. But they're picking other things and eating other things to get any green vegetation they can find under the snow, which is important because at that time of the year it has some nitrogen in the form of -- that can be -- help to produce this -- use in the development of the fetus, which is getting good sized. But the female is going into winter continues to put on weight up until it gets really extreme conditions and then it can draw on this for her own well-being, but then they're still going on feeding heavily on lichens high in carbohydrates because there's a big energy demand for movement to be selective in feeding. And digging through the snow to get the food there's a lot of -- a big cost there. They don't move as much when they're on winter range as they do in migration, but they still have to migrate back to the calving grounds then to winter. And so it is -- the biggest physiological demand on the female is during peak lactation, which is right in the first ten days or two weeks after calving. And gradually it goes down as the calf learns to eat and the rumen becomes functional, but still it's growing so damn fast that it's very dependent upon the nursing of the milk. So high production continues of milk by the female until probably, up there in the Arctic, about into early August. And then the calf's rumen is well developed and it's feeding on the same thing the mom is, staying with the mom and is still nursing only maybe once or twice a day and the mom is not producing as much milk. She starts reducing it because she has to wean off the calf almost completely to rebuild her body condition in time. And she has to come into estrus if she's going to breed again that year, even though her calf will stay with her going through the first winter while she's -- if she's bred then she's starting the development of the fetus again. Breeding is usually in October. And so that she's still putting on weight, but she changes her diet somewhat and starts feeding more on food that has a higher carbohydrate and can be converted into fat and goes in fat reserves both under the skin, but it's mostly only in the back part of their body because most of the fat is internal along with the body organs scattered out internally because they don't want to have too much fat under the skin because if they run, they get -- they'll overheat because they can't cool very fast if the fat isn't well vascularized so it – unless

they're drawing on it or building it. So an animal like a muskoxen, which doesn't run a lot, the moms and adults can have a lot of fat under their skin over their whole body as well as internally, but they don't have to run so much to escape predators. They stand their ground. They don't migrate long distances, and move around as much to be -- And they have a bigger rumen so they can digest poorer quality food than the caribou for their body size. So they can eat poorer quality food, lay down and spend a longer time ruminating and re-chewing it and digesting it. Sorta like how to measure that as a rate of passage of forage through the gut. And you can see that the caribou adapted to feed selectively for high quality forage, but that means they have to move around the landscape a lot. They have to have longer legs and less insulation over some of their body to not overheat if they have to run from predators. Whereas muskoxen can have this thick under-wool in the wintertime, as well as long guard hairs kind to protect it. And that qiviut, the under-wool, is such an excellent insulator that in the winter they can't run very far or they're going to overheat and they can't cool rapidly. If they can't cool rapidly, they're very vulnerable to heat stroke, even in the winter. So they don't run from predators normally, except in the summer, and so they get into a group and then they defend themselves by the -- The adults, both the male and female, have sharp upturn horns and those horns are used for predator defense, mainly wolves. If wolves come, they form a group and all of the young are forced into the -- learn to be in the middle of the group with their -- touching one another, with the adults – the adults on the outside. The wolves run around the -- one of the wolves charges in, one of the adults charges out and tries to hook the wolf with its horn and throw it through the air, and which usually results in ripping open its gut. And that's really lethal for a wolf. So wolves have to learn, mostly when they're killing calves, is that killing muskoxen is when they sneak up close enough when they're feeding and they're somewhat dispersed. And then rush in before the cows can rejoin and they're all rushing together and they can maybe pick off a calf before they get back into the group.

So then, of course, one of the studies we do -- we did up there, which was my main interest area, was how the muskoxen, highly adapted for living in the Arctic, and the caribou highly adapted for living in the Arctic, but their adaptations are different in terms of predator avoidance, energy conservation, and digestion of different quality foods, managing heat stress. In the summer, the muskoxen are -- the caribou shed their winter -- they have under-wool but not very much, but their hairs, the main hairs are bigger and hollow and so they can be raised and lowered, through pilar erection, like on our own arms. And if they get cold, they can be more insulated. So if they're standing still or feeding, they can raise their hairs. If they're running and they want to cool, they can fold them down and then they will lose heat more rapidly. But their legs don't have much insulation, so when they lay down in the winter, they're covering the legs with their body. Moose do the same thing. And that has advantages in that they also have -- with their long legs, which muskoxen don't have, they have very short legs for the size of the animal. They're not good runners therefore. They're not very good at digging through deep snow, as their hooves are more like cattle or smaller per body weight much than caribou. Caribou have very broad flexible hooves that when they're walking on them they spread out and they support them in boggy areas or in the winter on snow. They can walk and they don't sink as far in snow and they tend to walk single file if they're migrating through the snow so that only the lead animal breaks trail. Those following, when the

lead animal gets tired -- it's usually females if they're going to the calving ground. The males wait and go to the calving grounds onto the Arctic later. And so when the lead animal gets tired, it just steps aside and starts to feed or maybe lies down. And it doesn't lie down, you know, if they're moving. It would just step aside and the rest of the group moves and it goes in the back of the group and then they've got a packed trail. They go single file through deep snow. So only the lead animal and the first few animals are breaking trail. And they just rotate, the same as you would if you were a group of skiers out when somebody gets tired in front, you just say, "Oh, somebody else want ahead and break trail?" And you take turns. And the caribou do the same thing. So there's not a leader that's leading the group. The animals are going -- and it's females and young animals going together to get to the calving grounds in time to have their young. So it's the motivation of pregnant females to get there in time that keeps them going, but then they have to -- and we haven't figured this out completely yet, they have to navigate to get there. And they go back to the same general area to calve each year. We know that they use a lot of clues, but they must be using other clues in addition, because they don't always go the same route to get to the -- They go the same direction, but they go -- they probably learn repeated routes. And so young animals going with older females, younger ones that haven't given birth yet or the first time, will follow in the direction of the other females that are more inclined. We've learned some work reindeer in Scandinavia that relates to that and when they started they used to herd the animals with reindeer sleds and then with snow machines to get them from the wintering area to the summering area. And sometimes the distance was quite a ways, and you didn't always have the snow melting at the right time. They then started trucking them. Round them up. And they had corrals for rounding up the reindeer. Trucking them from, say the winter range, which was down in lowland areas like in pine forests, into the mountains close to the Norwegian border. And then they'd go into the mountains and it was higher quality forage for summer to be up there where there was a lot of sunlight and lush new green growth because the regular terrains of north facing versus south. North facing was late in the summer, high quality food, but delayed growth early. South facing would be the place to go first and then you moved around east/west and take advantage of all of these on a very local basis. And so when they trucked them, then the next year if they didn't truck them, the animals had a hard time migrating and finding their way as they had in the past. So it's based somewhat on memory even though they might go in the same general direction, but for reindeer it was very important they went to the right place because there were other reindeer herds close by. And there were often other reindeer herder families and they didn't have fences to keep the animals for the -- especially during migration. So they learned that once you start trucking them, you're going to have to keep on doing that if you want to do that. In some cases in Norway, they didn't truck them, they moved them down to the sea and put them on barges sort of and drove across ferries that crossed the wide fjord that they couldn't swim them all across. And then they would get into an area where there was good forage and good grazing.

KAREN BREWSTER: That's interesting that -- I mean, birds migrate these huge distances, and how do they know how to get from, you know, Alaska down to Mexico? And they do it year, after year, after year. It's a similar thing.

DAVID KLEIN: There's been a lot of research and it was like bird migration was the missing link. We didn't understand that very well because it's easier to work with something like caribou or reindeer than it is with birds. And so they could -- they did a lot of research, of course, and knew what stimulated them to migrate. And then it was -- they were stimulated to migrate and then you could understand if they had migrated south in the end of summer and then north in the spring. That could be in their genes to want to do that, but how do they get there? It's very complicated. And especially when you deal with -- one of the most extreme cases is birds that -- shorebirds, there's some that nests in the tundra of Alaskan Arctic and then they migrate across the Pacific Ocean in winter and the north coast of Australia. And they've only been able to pin all that down with these little micro-radio transmitters that would transmit to a satellite. So they can plot that bird's route all the way down there. And most, not all of them, some of them stop over regularly and close to Japan or southeast Asia before they go someplace else on Australia. And then there're some species in -- one species that goes – they go – Alaskan's, quite a few species, including some Sandhill cranes, migrate into the Russian far east and then down and winter in Hokkaido and those areas. And so -- But actually, what guides them is a combination of -- they usually wait for favorable winds going in their direction. And so then the cost of migrating is low. They fly usually 10,000 feet or more where there's less dense air. So even airplanes can go faster with a given amount of gas up high and use less gas to fly at high elevations at 30,000 in the case of jetliners. It makes a big difference. And birds don't have a problem. They have some adaptations to deal with this, but when they're flying, their lungs are pumping and they have a lot of air chambers so that they can move a greater volume of air while they're flying. And even though there's less oxygen in the air to get what they need. But they're not using -- they're only using their wings and if they've got a wind behind them -- big birds like cranes and geese, they do minimal amount of flapping. They're gliding. They've got a favorable wind. And they can go a long distance over the ocean without settling down. And they can – you know, they could in the calm ocean, geese could land in the ocean. Of course, seabirds are a bit different because they usually are nesting in the north where the food is more available for them without going into the sea. Where many of them, like albatross are a prime example. They don't come to the land except to have their young. And so then they have to have -- for some, cliffs to nest on, and others islands with no predators and they nest on the land. And then to feed their young, because they have to incubate and the young aren't very -- it takes a long time before they can fly. During that period when they're incubating the young, they can't go very far. But they have to go far enough to get food and bring it back for the -- especially after the young are hatched. And so they have to have rich areas where there's food available close to shore, and that includes say, the Bering Sea, for all of the birds in the Aleutian Islands. The sea birds -- It's different, like geese, for example, are grazers primarily so it's not as big of a problem. Mom can take the young geese if it's nice green grass on land and they graze on that. But there's other birds that -- sea birds, they've got to have food from the sea. Either small things like small shrimp. And the smallest sea birds use very small stuff and they swallow it and then they regurgitate it when they get there. Big birds like puffins and murres, they're catching small fish, so they don't -- Some of them can swallow it, but mostly they're only going a short distance from where they're nesting, and they -- especially puffins because they got these big, powerful beaks, they will have two or three

small fish. And they're big enough so that two or three is enough for a meal for one or two young, which is all they have at a time. So all of these are adapted to the environment in which they have chosen to nest -- selected to nest because of the availability of food. And so sometimes if a population is going down, sea bird population, we can't draw conclusions about why it's going unless we know about the food that's available. And if there's been -- it might be if they're going out to sea a long ways, it might be related to the heavy commercial fishing. Or it may be related to competition for that food by other animals like seals or fish, big fish eating small fish or eating shrimp and small crustaceans like shrimp and krill that the whales use. Big whales are using some of the same food that small seabirds are using, because they're strainers, big whales, whereas the seabirds are – can't -- they're not equipped to do that.

KAREN BREWSTER: Well, all this shows that you've had to expand your knowledge base. Because, as you say, you started by studying deer and mountain sheep and now here you know all this about birds and sea birds and that's all because you had students who were studying it and so you had to learn these things?

DAVID KLEIN: It's not all, but it's partly, in fact it's a major part of the fact that I -- I mean I had the training to think ecologically, but young scientists, we're all pretty much the same, you focus in because of the scientific method works best if you can isolate variables. And you don't think of the whole ecosystem and you're working with deer and you're focusing on the food they eat and maybe predation, and how they behave, and where they go to get -- seasonally migrate. And deer up and down the mountain. So down --the snow covers this wonderful food up high, and it's already the frost is killing the green plants anyway. And then they go down and they have to live on things that were growing down below, which wasn't as good for summer but in the winter, yeah. And so then the snow depth is a critical factor, and in southeast Alaska it's variable from year to year. And so some winters it's -- the snow gets deep, so it's hard for small deer to get through this. Snow condition is all important. If it's moist snow, it's harder for them to get through if it's thick. But if it's rained on and then turns cold, they can walk right on top of it because it freezes up then and then they can reach food they couldn't have reached before. So with those variables and it seems complex, well, it is for that, but then you have to factor in all of the other variables like the competitors, and that might be bears.

[phone rings, end of interview]