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A Trip up the South Snake River in 1863.

Walter W. De Lacy

In August, 1863, I was at Virginia City (then called Varina, after Jeff Davis' wife), engaged, as were thousands of others, in hunting for gold, and like many others, unsuccessfully. I had already been on "stampedes" in various directions, which had led to nothing, when I heard that a party were assembling somewhere on the Beaverhead river, for the purpose of ascending the South branch of Snake river to its head. One of the men had been part of the way up, and described it as a gold country.

I had always thought that there must be deposits of gold on the Upper Snake river, as I knew that the "color" had been found below; and as the country was unknown, distant, and dangerous, it possessed all the elements which combine, in the eye of a frontiersman, "to lend enchantment to the view." I therefore resolved to go.

I was pretty well fixed for such a trip. I had two good horses, enough provisions to last for about forty days, good arms, and about ten dollars in gold dust. I had a partner, who had come up with me from Walla Walla, the year previous. We had brought up a pack-train loaded with flour, to Bannack, and, during our absence in the Bitter Root, had been swindled out of the proceeds by an old fellow living there, to whom we had intrusted it, and who was afterward shot by some man on whom he had practiced his tricks, and who very modestly never made himself

Note - This article must have been written by Capt. De Lacy between 1874 - 1876. - Ows note date of publication of this book.

auctioneer at Bannack. The guide of the party was Hillerman, usually known as the "Great American Pie-biter," and who was afterward banished by the Vigilants, for supposed complicity in the murder of the German, for which George Ives was hung.

He said that he had been part of the way up the South Snake, with another man; that the other man had accidentally shot himself, and died, and that he returned; that the "color" could be found almost everywhere, and he believed that there was plenty of gold above.

There were about twenty-seven men present, almost all of whom had but recently arrived from Colorado and California, and were totally ignorant of the country where we were going. The only information any of us had (except Hillerman) was derived from a small map which I had brought with me from Walla Walla, and which gave some idea of the headwaters of the Snake, Madison, and Yellowstone, as far as then known, but was very incorrect in many particulars, as was afterward found out.

On the 7th, a meeting was held, at which I was elected captain, being nominated to that dignity by Moore, and utterly unknown to anybody else. In these kinds of elections, as in politics, it is frequently a great point in your favor that no one knows anything about you. It was also resolved at the same meeting that we should commence our journey the next day.

August 8th, we made a start and went up Blacktail Deer creek, over a nearly level country, to its head, where we camped. Here we were joined by another party, headed by Major Brookie and Judge Lewis, which raised our number to forty-two. We also commenced setting a guard tonight, which was thenceforward continued, until we returned to Virginia City.

known. He was evidently one of those who "do good by stealth, and blush to find it fame."

My partner was now in the Deer Lodge valley, engaged in building a "shanty," in a place where no one would ever go, where he expected to keep a hotel, if he could find any one to trust him for the "grub." I sent him my blessing, as the only remittance I could make, and the earnest request to take care of himself, which he did, I have no doubt, solely on my account.

I left Virginia City on the 3d of August, and camped that evening on Ramshorn Gulch, where I found Pete Daly, who had just put up a little cabin, and was living there with his wife and two step-daughters. He has been there ever since, I believe.

The next day I went over to the Beaverhead river. I was alone, and met with only one incident worth noticing. As my pack-horse, who was an independent animal, and had notions of his own, declined being driven, I was compelled to drag him, and, for that purpose, had taken a hitch with the lariat around the horn of the saddle. The pack becoming disarranged, I dismounted to fix it, and while doing this, my riding-horse commenced capering around, and in some way got the rope across the lock of the gun, and caused it to go off directly toward me, the ball passing just over my head. There is always some consolation in the worst misfortunes, however, and when I got over my scare, I felt very thankful that he had not fired the other barrel at me, which was loaded with buckshot.

On the 6th, I, with several others whom I had joined on the road, came up with the main party, which was camped on the Beaverhead river, near the mouth of Blacktail Deer creek. There were only two men whom I knew. One was a young man named Moore, who had been an

On the 9th, we crossed the divide to Red Rock creek, and, on the 10th, made a long march to Dry creek, in consequence of the grass having been burnt on the greater part of the day's march. One of the men killed a porcupine, which is the only one I have ever seen in this country.

On the 11th, we met some wagons going to Virginia City from Salt Lake, with flour, bacon, etc., and some of the men purchased a few stores from them.

On the 12th, we reached Camas creek, early in the day, and camped, as the grass was good and water plenty, to rest our animals, and let them have a good feed.

For several days past, the country had been scant of both, and burnt over in many places. We had now entered the basaltic formation which characterizes Snake river, and extends all the way to its mouth. The country, since leaving the divide, had been of an uninteresting character, and is now well known. We had been for the last three days traveling on the Salt Lake road.

August 13th, we resumed our journey, and, passing Market Lake, soon arrived at the main Snake river, and ascended it toward the Forks, which were represented to be about fifteen miles distant. We camped on the river, where there was good feed. During the day we met with a small band of Snake Indians, among whom I recognized "Baby," a young Indian who had been brought up by Bob Dempsey, and whom I had seen with him at Bannack. He had on a cavalry saber, of which he seemed to be very proud.

On the 14th, early in the day, we reached the two volcanic buttes, which stand at the junction of the North and South forks, and, going to the north of them, forded the North fork (which we found quite wide and deep), and camped on a large island at the mouth of a stream coming

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in from the east, and which is now called Moody creek, on Dr. Hayden's map. One of our men, named Kelly, had strayed off by himself, and as we found a band of Indians at the Forks, we were unwilling to leave him behind. As soon as we camped, men were detailed to hunt for him. He was finally discovered several miles below, and brought to camp late in the day.

The Indians were Snakes, who had been up the North fork hunting and fishing, and had only recently come down. They had their women and children with them, and were apparently very friendly. The squaws were digging roots which resembled small potatoes. They seemed to have but few arms or horses, and to be very poor. They were camped some distance above us, and some of the men came to us during the day, and tried to trade for ammunition and tobacco, but with poor success. It was funny, on this occasion, to see and hear the expedients resorted to by both parties to make themselves intelligible to each other. Some tried broken Spanish and Indian words which they had picked up in California and Colorado, and some invented a sign language, which was a brilliant effort of ingenuity, but utterly incomprehensible to our copper-colored friends. At last, one of the men who had been absent returned, and it was found that he could speak a few words of Snake, and matters went much better. At dark, they were all ordered out of camp, and sentries posted for the night. Some of them wanted to remain, but were told that we did not want them to do so, and all finally retired. I was very anxious to prevent any collision between the parties, as, if the Indians should become hostile, it would be in their power to interrupt or prevent our journey. Some of the men who had joined us on the march were bad characters. Among them was Jack Gallagher, afterward executed by the Vigi-

lants. These men, during the night, attempted to get up a party to attack the Indians, and take their horses. They met with no encouragement, however, from the others, who were respectable men, and were compelled to desist.

As we were now, as it were, on the threshold of our journey, and entering an unknown country, we resolved to make but one march in the day, as a general rule, and to camp early, so as to give time each day to look around at the country and prospect. When appearances were very favorable, we were to stop for one or more days, and make more extended researches. This programme was substantially adhered to throughout the expedition.

I made it a practice to keep a journal of each day's march, accompanied by rough sketches of the country. [I had no instruments except a small pocket-compass, and as I had to do my own packing and cooking, lead my pack-horse, and generally direct the party during the march, my opportunities for making any very accurate or extended obs servations were very limited. There was not a telescope, and hardly a watch, in the whole party.]

On the 15th, we ascended the right bank of the South Snake river, our course being generally southeast, passing through a narrow valley, and making about fifteen miles. We camped on the river, in good grass. We passed a group of hot springs to-day, being the point marked on Dr. Hayden's map as Camp Reunion.

On the 16th, our journey was a very rough one, as we had entered a basaltic cañon, where the trail passed over many rough points of broken rock. At one place we had to ford the river around one of these. Here I noticed conglomerate rock overlaid by basalt. After a toilsome march, we finally camped near the mouth of a small stream with a thick undergrowth of willows on it. There was no tim-

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ber of any size on the river, which was about one hundred yards wide, and very crooked and swift. We seemed to be in a limestone formation here, which above, on the stream, changed to basalt.

On the 17th and 18th, we traveled about twenty miles, over a very rough basaltic country, camping in small valleys on the river. We could see very little of the surrounding country, on account of a dense haze or smoke, such as is often found in this region at this season of the year.

On the 19th, we entered a large valley, mostly covered with sage-bush, and extending along the river. On the opposite side, we could see a large valley, supposed to be that of Salt river; but nothing could be made out distinctly, on account of the smoke. We were now apparently in a white limestone formation, extending far to the northward. Shortly before camping we had passed hot springs on both sides of the river. Our course this day had been easterly, and we could see that the river was beginning to turn to the north.

On the 20th, after going about four miles, we came to the lower end of the cañon of the South Snake, and changed our course from east to northeast and north. We now commenced traveling up the cañon by a trail, about one hundred feet above the river, which was very narrow and difficult, and had apparently been very little used for a number of years. The other side seemed to be impassable. The rocks came steeply down to the river on both sides. It was full of rapids, and very swift. This is what is called "Mad river" in Irving's "Astoria," and is the place where the Canadians had a hard time in going over in 1812 or 1813. It is not near as bad, however, as many parts of Salmon river, which were passed by the boats of the Northern Pacific Railroad survey, in 1872.

We went through the cañon with much difficulty, leading our horses, and moving slowly. One of the pack-animals and a horse fell off, and were severely hurt. We made about eight miles, and camped in a very poor place, but got through the most of the cañon by dark.

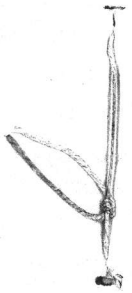
We made a late start on the 21st, as we had to get in the horse and mule which had been hurt, and we made a rule to leave no stragglers behind without looking after them. We were in an Indian country, admirably fitted for their warfare, were not pressed for time, and intended to give an enemy no advantage. If the same rule had been adopted and adhered to on other expeditions in the past, there would have been fewer massacres and other disasters to chronicle. Our route to-day was much smoother than yesterday, and we had a good camp in a small bottom, with cottonwood groves on the bank of the river. The geological formation changed from limestone to sandstone, and we were now altogether out of the basaltic region. We came about ten miles this day.

On the 22d, after going about three miles, as the river was now coming from the north, and the left bank seemed to be more open than the right, where we were, we crossed over, and found a good trail on that side. Our guide, Hillerman, had now got beyond the country which he knew, and was of no further use in that capacity. We went on for five or six miles more, through a comparatively open country, when we unexpectedly came upon a large fork coming in from the east, where we camped, and resolved to stop for a day and prospect. This was the largest tributary that we had yet seen, and is the one called "Hoback's river," on Dr. Hayden's map, named by him (and very properly, too) after one of the early mountaineers, who guided a party through to Snake river, down this stream.

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We found an old trail on this stream, and spent the next day in prospecting, the men going off in parties in different directions—some up stream, some across the river, and others north and south. Judge Lewis' party left us, and pushed ahead. In the evening, every one returned, and nothing had been found except the "color," which is abundant everywhere in this region. Those who had been forward reported that the country became more open. At the mouth of this stream was slate, with traces of lignite.

On the 24th, we kept up the main river, which turned in a northwesterly direction. At one place the stream was divided into a number of channels, with cottonwood on its banks. After about three miles of rough, undulating ground, we entered a prairie country, and in about eight miles further, camped on a stream coming in from the northeast, and having plenty of cottonwood and willows on its banks. As usual, some of the men went out to hunt, and others to prospect, but brought in neither gold nor game. Up to this time, and for a long time after, we saw nothing larger than rabbits. Judge Lewis' party rejoined us this evening.

The weather was remarkably warm and pleasant. A large plain extended before us, most of which was covered with sage-brush. Here, for the first time, we found the "winged ant," which rose up in swarms, and covered men and horses all over. It was the first time that I ever saw them, but I have been well accustomed to them since.

This day, for the first time, we could see the white, outlying spurs of the Teton range, on the other side of the river. The atmosphere, however, was very smoky, and it was difficult to see anything very distinctly.

As we were now in a very open country, where our party could be easily seen by Indians, we were very watchful of

our stock. Our exploring parties had not, however, seen any recent signs of their presence.

On the 25th, our course being still northward, we passed between two buttes, and entered a large and extensive prairie, which was evidently the one known to the old trappers as "Jackson's Hole." In former days it was a great resort of hunters, and also of the Blackfeet, and the two parties frequently came into collision here. The valley is a large and extensive one, stretches for miles on both sides of the river, is surrounded by mountains covered with timber, and is well watered. It is one of the most picturesque basins in the mountains. It is covered with fine grass; the soil is deep in many places, and it is capable of settlement, and will, in the future, be covered with bands of cattle and sheep. As we advanced, I noticed large quantities of wild flax growing. After traveling for several miles, we came to a large stream, bordered by cottonwood, which, at first, we supposed to be the main stream—crossed it, and stopped to noon. Whilst doing so, some of the men went out, and discovered that the main stream was still to the west of us. We also prospected on the banks of the stream, and found a large number of "colors" to the pan, and I have always been sorry that we did not stop for a day or two and prospect the stream at its head. We, however, went forward in the evening.

This stream that we were on received the name of "Gros Ventres creek," from Captain Reynolds, U. S. A., who passed here in 1860; and he doubtless obtained it from Captain James Bridger, who was his guide, and to whom this whole country was perfectly familiar.

The first one who mentioned this valley in print, as far as I know, was the Rev. Samuel Parker, a Presbyterian missionary, who passed through here in 1835, with Captain

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Bridger, and a party of trappers, and a band of Nez Perces, who were on their return across the mountains to Lapwai, on the Clearwater. The most cordial relations always subsisted at this time between the white men and the Nez Perces. Mr. Parker was now traveling with the latter, and went over the mountains first to "Pierre's Hole," a very large prairie or basin between the North and South forks, and which was celebrated in early days as the scene of a great battle, between the mountain men headed by Sublette and aided by the Nez Perces, fought against the Blackfeet. Mr. Parker then parted with Bridger, who went north, and continued his journey to the Pacific coast.

Among the Indians who were with the missionary at this time was "Lawyer," the present aged chief of the Nez Perces, who told me so many years ago. He was also in the battle of Pierre's Hole, and received a ball in the thigh, which was never extracted, and in the course of years occasioned a very ugly running sore. In 1856, Lawyer, with his band, was again the ally of the whites in the fight which the Washington Territory volunteer and Indian employes under Governor Stevens had with the hostile Indians in the Walla Walla valley, and went down with Governor Stevens (to whom I was then adjutant) to Portland to try and have the ball extracted. I believe the surgeons advised against its being done, and he is, I think, still living. Among those who were in this last fight was our esteemed fellow-citizen of Missoula, Mr. Worden, of the firm of Higgins & Worden, who was then in the Indian service.

Captain Wyeth, who founded Ft. Hall, had some men killed in this valley, and Captain Bonneville, Sublette, and the Northwest fur-traders all passed through here frequently. Many adventures which took place here are narrated in Irving's "Astoria" and "Captain Bonneville's Adventures."

In the evening we took a northwest course toward the river, passing over a plain, part of which was covered by the largest and thickest sage-brush that I have ever seen. We were obliged to continue a long way up the stream, as the banks were high and there was no ford. We were lucky enough at last to find a small flat where there was enough grass and camped, having come about eighteen miles during the day. We were obliged to herd our animals during the night, as there was not room to take them out, and had a stampede in consequence, but succeeded in getting them all back without much trouble. Two of our men were missing when we camped.

Opposite our camp to the west and north could be seen the high mountains of the Teton range, and a branch well wooded came from the west, which, I think, was the outlet of "Jenny's" lake, as named by Dr. Hayden.

August 26th. One of our missing men came in this morning and we went on, sending some men back to look for the other. Shortly after starting we found that we could not follow the river, as it had formed a kind of cañon in cutting a way for itself through a high plateau, and therefore we ascended this table-land and passed over it in a northeast direction for about six miles, when we again descended into the valley of the river, which opened out again into a plain, and camped on the main stream, having made about ten miles. We camped only to wait for the missing man, who came up in the evening with his friends, who had gone after him. The river was divided into several channels where we were, and on the opposite side was a high plateau.

The next day (27th) we had gone about five miles in a northeasterly direction when we came to another large valley, through which ran a stream coming from the east. On reaching it we could see to the north other streams coming

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from the mountains, which appeared to be closing in all around the valley and were thickly wooded. To the north and west we could see the white rugged peaks of the Three Tetons, and it was very evident that we must be approaching Jackson's lake. The country about us was an open prairie, and the stream was no doubt what Dr. Hayden calls the Buffalo fork of Snake river.

I halted the men at the creek as they came up, and when all had arrived I suggested to them that we should go on to the next water, pick out a good camp, and remain some days and prospect the different streams which were in sight. This was agreed to, and we went forward about three miles to the next creek, near the outlet of Lake Jackson, as we afterward found out, and established ourselves where wood, water, and grass were abundant.

After unpacking and staking the animals out, another meeting was called in order to decide upon our future action. It was decided to build a "corral," to put the horses in at night that should be left in camp, and that four parties should be formed; one to remain in camp as a guard, and three others to prospect the streams in sight.

The men were then detailed for the different expeditions, and it was suggested, that as there was a strong probability of finding good "diggings," we should adopt some mining laws for them.

We therefore organized ourselves into a "miners' meeting," and, after appointing a chairman, etc., one of the members moved, and another seconded the motion, that the following regulations should be adopted:

1. That every person present should be regarded as a discoverer, in each and every gulch found by any party or member of a party.

2. That each member, as discoverer, should be entitled

to five claims of two hundred feet each along the gulch—viz., a discovery claim, and a pre-emption claim in the main gulch, a bar claim, a hill claim, and a patch claim. (I never knew exactly what a patch claim was, but I think that it meant all that you could grab, after you got the other four claims.)

These liberal and disinterested regulations were voted in the affirmative with gratifying unanimity, and the chairman was just about to put the question to the meeting whether there was any more business before it, when a big, burly Scotchman named Brown, who had apparently been turning the subject over in his mind, jumped up, and inquired with great earnestness, "But, Mr. Chairman, what shall we do with the rest of it."

This question was received with roars of laughter, and the meeting thus good humoredly dissolved, and each one set about preparing for the next day's trip.

Brown was a character in his way. He had been engaged in "hand-sawing" lumber at Virginia City, and he had packed his whip-saw with him, on a horse, all through the journey, so as to be ready for a job in case new mines were struck.

On the 28th, the three parties started, each up a different stream, leaving a few men with me to guard the horses and the corral, which had been built the previous evening. I do not go anywhere, as I was unwell.

On the 30th, two parties returned, having been up, as they reported, to the head of the streams that they set out to explore. They reported that they found plenty of gravel, but no pay, and that the rocks were all sandstone. The third party came in the next day, having been up the Buffalo fork for twenty miles, and then had crossed over to another stream and came down that. They reported the

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same as the others. One party had seen a small stratum of coal on one of the streams. The Buffalo fork headed in a cañon, and the formation everywhere found was sandstone and conglomerate. They had also seen Jackson's lake, which they reported as being near us.

The men were now completely discouraged, and a large number determined to return by the way that we had come. On the 1st of September, therefore, most of those who had come out with Judge Lewis and Major Brookie, and several of my own men, started on the back track. The rest of us, about twenty-seven in number, resolved to try and reach Virginia City by going north. I knew that we could not miss it, and that we would pass through a new and unexplored country.

As the party had broken up I resigned my position of captain, but no one was elected to fill my place. A few days afterward, on the march, I was unanimously requested to resume the position, which I did, and thus continued to the end.

It was evident, from the looks of things ahead, that we were about to enter a wooded and mountain country, with narrow defiles; but I was in hopes that we would strike large prairies on the other side of the mountains.

On the 2d of September, we crossed the stream that we were camped on, and soon came in sight of Lake Jackson, and the white and rugged spurs of the Three Tetons coming down into the lake on the opposite side. Our course was north and northwest, and lay at first along the lake, but afterward through timber and small prairies out of sight of it. On one of the latter, which had a small lake in it, we stopped to noon.

After dinner we struck a trail running northwest, and once more came in sight of the lake, but soon lost it again.

In the evening we camped on a large prairie, on the left bank of a large stream flowing into the head of the lake, and not far from it. We had made about eighteen miles this day.

As some of the men who stopped behind had found encouraging prospects, it was resolved to stop here a day and try the country around. This was done, but without any favorable result. Fresh horse-tracks had been seen, however, and the mountains ahead seemed to be on fire. We might, therefore, expect to find Indians. I will, however, add that we never saw any.

On the 4th, we continued up the valley, or rather cañon, of the stream, going in a northerly direction. It was very narrow, with steep and heavily wooded mountains on either side, and an occasional small prairie in the bottom. We had a difficult day's journey, crossing from side to side, passing through fallen timber and points of wild and steep hillsides, often stopping to adjust the packs. In the evening we camped on the same stream, near the mouth of a small branch coming from the east, where there were hot springs.

We had not traveled more than three miles next day (September 5th), when we came to the forks of the stream that we had been ascending. One branch came from the northeast and the other from the north, and there were hot springs with cones four or five feet high near the junction. Neither of the streams were large, and it was thought that we would soon reach the divide. It being impracticable to go up either branch, on account of fallen timber, we commenced climbing up the mountain side to the west, where the timber was more open, and after ascending about one thousand feet with much difficulty, reached a large open prairie, apparently on the summit,

where there were two small lakes, of a beautiful blue, and small streams flowing in opposite directions. I judged that one of them ran into the North Snake. Here we stopped for dinner.

Here another split of the party took place. Some of the men had noticed veins of quartz, as they supposed, down below, and resolved to return and examine them. This left me about thirteen men to go forward with.

Our friend Brown had been completely disgusted, during the last few days, with his whip-saw, owing to the number of times every day that he had to stop to adjust the pack in going through the woods, and now left that useful implement leaning against a tree, with the remark that "he had packed the damned thing far enough."

On starting, we kept a northerly course and passed over low undulating ridges, covered with open pine timber. The rocks, where exposed, seemed to be a vitrified sandstone. We killed two deer this evening, which was the first large game shot on the trip. After traveling several miles, we saw an opening beneath us which looked like a valley, and descending the mountain, which was very steep and high, reached a small stream flowing northeasterly, just about dark, and camped where there was plenty of grass, wood, and water.

In the morning (6th), we descended the stream for about five miles, and to the great surprise of us all, came to the bank of a large lake. We were all lost in conjectures as to what it could be. Some thought that it must be the Yellowstone Lake, and others that it must flow into the Madison or Gallatin. We finally resolved to go around the southern end, which was not very far from us apparently, and then go around the other side. We then traveled along the lake shore for some three or four miles, when we came to

the outlet of the lake, a large stream flowing *south* into Snake river. Instead of going around the *head*, as we had thought to do, we had been going around the foot.

One thing puzzled me. The outflowing stream was much larger than either of the forks of the South Snake that we had left before. I afterward found out, however, that it flowed into another lake, now called Lewis Lake, from one of the men who went back at our noon halt.

This party which left us, had returned to the forks, and not finding the quartz, as they expected, ascended the stream coming from the north. They encountered a fire in the woods which gave them some trouble, and found some very high falls in the stream. They passed Lake Lewis, and came to the foot of the large lake, where they found our old camp. Here they went up the west side of the lake to its head, and there found a large number of hot springs, some of which were geysers, which they saw in action, spouting up the water to a great height, and thence went over to the South fork of the Fire Hole river, where they again saw our camps, and thence down the Madison river to Virginia City. These facts I obtained afterward at Bannack City, from Mr. Charles Ream, one of the party, and it was thus established conclusively that the large lake was the head of the South Snake, and I was enabled to correct the course of the Madison river, and connect my surveys with it.

The lake which we had now discovered, was the lake afterward called "De Lacy's Lake" on the United States Surveyor-General's maps of the Territory, and afterward renamed "Shoshone Lake" by Dr. Hayden, and the lake below it was the one called by him "Lewis Lake."

To return to our own party. We camped at the mouth of the lake, and prospected and hunted for the rest of the

when I perceived that the country opened out into a large basin, through which the main river ran. To the southwest I could see a large gap toward which it flowed, and the main range of the Rocky Mountains seemed still to be to the north of me. The distance, the timber and a cañon which was at the end of this basin, hid the real course of the Madison from me, and I had no glass with which to assist my sight. I had no great time for observation, as it again began to rain heavily, and I returned to camp.

In the morning (11th), we made a late start, owing to rain, and crossed the cañon to the basin, where the men agreed with me that it seemed as if the main river turned toward the south, and it was concluded that we would go to the head of the two small streams which we saw in the basin, cross the range, and continue on until we struck waters flowing north. We knew that we would thus reach the three forks of the Missouri, and we were indifferent where we went, as one of the men remarked, or how long we were out, as long as our stores lasted, as we came to see the country and prospect it.

We crossed the first stream with difficulty, owing to the numerous beaver dams, and continued northerly to the head of the second one, where we camped at the foot of the range, in a small valley, where there was good grass. We came about twelve miles this day.

The next day we ascended the mountain, by a spur, which was rough and heavily timbered, for three miles, and came to the summit of the range, where we halted to observe the country. Directly to the south we could see the peaks of the Three Tetons. The basin which we had quit lay beneath us, but we were yet unable to decide the question whether the main river ran north or south, as

day, but without any success. The lake seemed to be about ten or twelve miles long, running northwest and southeast, and to be surrounded by low and thickly wooded hills which came down to the water's edge. There was a point projecting into the lake on the west side, which hid a large part of the lake from us, although we did not know it then.

On the next day (7th), we went up the eastern side, near the water, passing through scrubby pines, without underbrush. There were many game trails made by the wood buffalo, whose tracks appeared numerous and fresh. We did not see any, and finally, at noon, stopped on a small prairie, for dinner. In the evening we left the lake altogether, and took a northerly course, hoping to cross the divide to some other stream. Our course lay through timber, and over and around fallen logs, but the ground, though undulating, was not rocky, and we found many game trails leading in our direction. Whenever we could obtain a glimpse of the outside world, we could see high ranges of mountains on every side. We kept on till late, without finding any place to camp, but just at dark arrived at a small dry prairie, where we camped. There was a damp place in the center, where, by digging about three feet, we soon obtained water for both ourselves and animals. As soon as the camp-fires were lit, thousands of black lizzards came forth from the woods, and the whole country was alive with them, doubtless attracted by the light. They made their way directly toward the fires, and rushed right into them by dozens, and burned up. There seemed to be no end to their number. After supper I sat down on a log and watched them. I noticed that many would get right into the hot ashes and take some time to scratch, and doubtless suffer great pain. As I am naturally kind-

(probably salamanders —)

hearted, I just got a crooked stick, and whenever I saw one of them come up and balance himself on his fore paws, looking for a good opening for a young lizzard, I raked him right into the flame, and saved him any further trouble. They continued to annoy us all night, getting into our blankets, and making themselves generally unpleasant until morning.

It rained heavily during the night and also during the next day, and we remained here, as we now had plenty of water and grass.

On the 9th, we continued our journey, and after traveling three miles, descended the mountain side into an open country. In another mile we reached the head of a small stream, the water of which was hot, and soon entered a valley or basin, through which the stream meandered, and which was occupied on every side by hot springs. They were so thick and close that we had to dismount and lead our horses, winding in and out between them as we best could. The ground sounded hollow beneath our feet, and we were in great fear of breaking through, and proceeded with great caution. The water of these springs was intensely hot, of a beautiful ultramarine blue, some boiling up in the middle, and many of them of very large size, being at least twenty feet in diameter and as deep. There were hundreds of these springs, and in the distance we could see and hear others, which would eject a column of steam with a loud noise. These were probably geysers, and the boys called them "steamboat springs." No one in the company had ever seen or heard of anything like this region, and we were all delighted with what we saw. This was what was afterward called the "Lower Geyser Basin" of the Madison, by Prof. Hayden.

We thus went on for several miles, stopping occasionally

to admire the beauty, variety, and grandeur of the sight, and at length came to a large stream flowing northerly, near the banks of which were scattering hot springs, and some of which had been hot once, but had now cooled apparently, the water being tepid and muddy, with a strong smell of sulphur.

We "nooned" on the left bank of this stream, and then continued our way north, crossing the river again, by a deep ford, in about three miles, and camped for the evening on the edge of a small prairie, near where a large fork came in from the southeast. On the left bank of the south fork was a high, perpendicular wall of rock, and we could see the smoke of hot springs up the east fork.

We had great discussions in the evening as to where we were, some thinking we were on the North Snake river, and others that we were on the Madison. The map which I had, represented the North Snake river as running around and heading to the northeast of the South Snake, and these streams seemed to run that way. In reality, we were at the forks of the Fire Hole river, a branch of the Madison.

In the morning (September 10th), we continued our journey down the main river, crossing the east fork just above the junction. The weather looked stormy and threatening. The main river was about fifty yards wide, its valley very narrow, with high, rocky hills on either side, covered with pine, and the general course westerly. After traveling about five miles, rain came down heavily, and we were forced to go into camp on the river, and at the head of what appeared to be a cañon.

In the evening, during an interval of calm, I went forward on the trail across the mountain to explore. In about one and a half miles I came to the foot of the cañon,

when I perceived that the country opened out into a large basin, through which the main river ran. To the southwest I could see a large gap toward which it flowed, and the main range of the Rocky Mountains seemed still to be to the north of me. The distance, the timber and a cañon which was at the end of this basin, hid the real course of the Madison from me, and I had no glass with which to assist my sight. I had no great time for observation, as it again began to rain heavily, and I returned to camp.

In the morning (11th), we made a late start, owing to rain, and crossed the cañon to the basin, where the men agreed with me that it seemed as if the main river turned toward the south, and it was concluded that we would go to the head of the two small streams which we saw in the basin, cross the range, and continue on until we struck waters flowing north. We knew that we would thus reach the three forks of the Missouri, and we were indifferent where we went, as one of the men remarked, or how long we were out, as long as our stores lasted, as we came to see the country and prospect it.

We crossed the first stream with difficulty, owing to the numerous beaver dams, and continued northerly to the head of the second one, where we camped at the foot of the range, in a small valley, where there was good grass. We came about twelve miles this day.

The next day we ascended the mountain, by a spur, which was rough and heavily timbered, for three miles, and came to the summit of the range, where we halted to observe the country. Directly to the south we could see the peaks of the Three Tetons. The basin which we had quit lay beneath us, but we were yet unable to decide the question whether the main river ran north or south, as

we still could see a large opening south, and another stream coming from or going north, while the dense timber hid a great deal from our view.

We then commenced descending the north side of the mountain, which was accomplished with difficulty, over rocks and timber, and leading our horses nearly all the way, and found a stream at the foot of the divide flowing west of north, where we encamped early, in order to prospect and look around. Several men went out, but found neither gold nor game.

September 13, 1863. We went down the narrow valley some four miles, when, finding that the main stream turned suddenly southwest, we ascended a branch coming from the northeast, up which ran a large Indian trail, and in about three miles came to a very low divide—so low that we could hardly perceive that we were passing one—and entered a small basin, where we were evidently on the waters of a different stream from any which we had hitherto followed. Here we stopped to rest for a couple of hours.

There had been Indians at this place within a month. They were evidently afraid of having their horses stolen, as they had built a corral, and where the lodges had been pitched, stakes had been driven, by which the best horses had been tied by the feet, so as to have some to pursue thieves, in case the horses were run off. These Indians had not come by the trail which we had followed, but from the opposite direction, and were probably Crows. After dinner, we went down the valley of the main river, which was very narrow, with steep mountain sides, for several miles. We passed a large branch coming from the southeast, and camped on a small creek, having made about twenty-two miles this day. We saw many elks, and

one was killed near camp, so that we all had plenty of meat.

On the 14th, as the men were anxious to try the ground, and some to go back a short distance and prospect, we moved a short distance to the main stream where there was a grove of willows, which would protect us from the wind, which was blowing violently, and there we spent the day. As usual, the "color" of gold was found everywhere, but nothing that would pay.

The mountains around us were composed of stratified and metamorphic rocks, very much tilted up, and dipping to the north. The stream was about thirty yards wide, and ran a little to the west of north. Just below our camp were two square inclosures, made of rails, and about five feet high. They were arranged across the mouth of the defile, which was very narrow at this point, and were very old, as the wood was much decayed. They looked very much as if they had been made by white men. I was unable to make out what they were, unless they were graves; but this hardly seemed likely, as most of the trappers who were killed in this region, in early days (and their number was great), were "buried by the wolves," as they used to say. It is probable, as they had remained undisturbed for so many years, that they were made by the Indians. When the mines at Alder Gulch were discovered, I saw a similar inclosure on the mountain side, and near it the bones of a horse.

On the 15th, we made but a short journey of eight miles, on account of wet weather. During the night the rain turned to snow, and in the morning the ground and surrounding hills were all white. About nine o'clock it cleared up, and we continued down the stream, passing through some narrow cañons, and crossing the river many times. Our general course thus far had been northwest-

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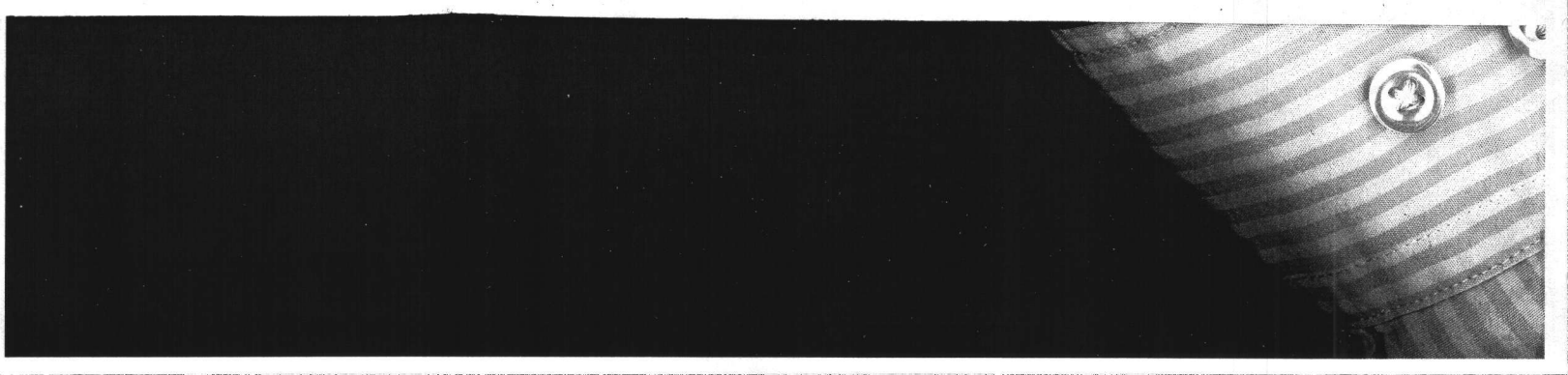
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wardly, but now turned to the north and northeast. We killed a bear to-day, who had come down to take a drink. He ran a little distance, when he saw us, and then stood up to take a look to see what we were, and was shot in that position. He was very old and poor, and covered with vermin. We encountered many bands of elk to-day, who, like the bear, were not accustomed to the sight of men, and would stand within thirty yards of us without fear. Two of them were killed. We also had the excitement of a stampede.

I had a white, bob-tailed cayuse (usually called "Muggins"), who had the peculiarity of having one eye black and the other of a very light blue. When you looked at him, on one side, he had a very obstinate and devilish look, as if he was up to any mischief (and so he was). Looking at him on the other, he seemed a very good-natured, steady, old horse, with a tendency toward religion. He had other peculiarities besides these, amongst which was that when you tried to lead him, he would n't go anywhere if he could help it, and if you let him go loose, you could not catch him under an hour.

This evening, as the wind was cold, and he had been good for a long time, he concluded that the time had come to distinguish himself. He was just before me, and looking round, he cocked his black eye at me, as much as to say, "Look out for squalls," and gave two or three preliminary kicks, which threw off the pack, which he met with his heels, and sent the coffee-pot, frying-pan, a piece of elk, a chunk of bread, and other miscellaneous articles into the air. He then galloped around, scattering the rest of the kit over the prairie, and when he ascertained that there was no more mischief to be done, he let himself be caught, and when I came up, turned his blue eye on me with such an



expression of contrite humility and self-reproach, that I had not the heart to give him the thrashing he richly deserved, and repacked him in silence, and went my way. We soon camped on the right bank of the river, having made about nine miles. Opposite to us was the mouth of a creek. A trail came down this branch, crossed the river, and continued east up another creek a little above us, evidently going over to the Yellowstone river, as we all felt certain now that we were on the Gallatin.

September 17th. To-day we passed through a cañon of granite, crossing the river several times, and having a rough time generally. In the evening we camped on a small flat, having made about fifteen miles, with a northeasterly course generally.

On the 18th, we crossed to the left bank, where we discovered a trail, and in about a mile entered another granite cañon, which was the worst one that we had yet passed. The trail crossed the river many times, the fords were deep, and we had to climb over points of rock at every turn. After a toilsome march of five miles we came to a small flat, partially burnt, where we rested for a while. In the evening we went forward, and passing through another cañon of four miles, came to a long flat on the left bank of the river, where a large creek came in from the left, and the main stream seemed to turn to the northeast, with a short cañon, beyond which we could see a large opening or prairie. There was a large trail going up the creek. The grass was partly burnt also on this flat. As this would seem to indicate that Indians might be near, and the spot was a secluded one, we resolved to camp for the night, and reconnoiter before going any farther, as there was grass enough left for our horses.

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the short cañon mentioned, I came into an open basin, surrounded with mountains, ten or twelve miles wide apparently, and extending north as far as the eye could reach. The stream I was on became a large river, with groves of cottonwood on its banks, and away to the east I could see another river, flowing northwest, which seemed to meet it in the distance. There were no signs of white men, but the grass over the whole country had been burnt. I felt sure that this was the Gallatin valley, of which I had often heard, and that we were now camped on the West Gallatin.

I returned to the boys and told them what I had seen, and it was resolved that we would take the trail up the creek and cross the mountain range to the west of us, prospecting as we went, as there was both granite and quartz where we were.

On the 19th, therefore, we ascended the creek (now known as Spanish creek) for about four miles, and halted for some hours to examine the neighborhood. We then continued on for six miles farther to the foot of the mountain, where we camped. Our course had been generally south of west.

September 20th. We ascended the main divide, passing over an undulating country for about six miles, and came to its western edge, which was very steep. Here we saw beneath us a large river flowing north, and divided into many channels just below us. One of the men in the rear coming up, at once recognized it as the Madison river, and in the distance to the north pointed out the Jefferson. We were just above the head of the lower cañon of the Madison.

Being now absolutely certain of our position, and that we were not far from Virginia City, we turned back to the

last water that we crossed, where we had noticed some outcroppings of quartz, and spent the day there. There was a great deal of red and green quartz here. On the 21st, we went back to the head of Spanish creek, and continued our prospecting, but found nothing.

On the 22d, we made up our minds to go to Virginia City. We crossed the range and descended to the Madison, which we forded above Meadow creek, meeting on the way with two hunters, who gave us the first news of the battle of Gettysburg. We also killed an elk on the mountain, and camped at night near a ranche, on the Madison, not far from what is now known as Slade's gulch.

On the 23d of September, 1863, we ascended the gulch and entered the town of Virginia City, at about three o'clock, and each went his own separate way thereafter.

We had been absent about fifty-one days, and had traveled about five hundred miles.

We had been unsuccessful in our search after the precious metals, but having lived in the country ever since, and seen the developments made within the last twelve years, I am still of the opinion that at some future time, when the country on the North and South Snake rivers becomes settled up, that both gold and silver mines will be found there. The country has since then been traversed by tourists and scientific parties, but the miners have kept nearer the settlements, where they have found enough to occupy them.

The names of those who were on the expedition were as follows:

J. Bryant, S. Brown, A. R. Burr, David Burns, Lewis Casten, W. W. de Lacy, J. C. Davis, F. A. Dodge, John Ferrill, J. H. Ferguson, Geo. Forman, T. J. Farmerlee, Aaron Fickel, S. R. Hillerman, Chas. Heineman, H. H.

Johnson, James Kelly, D. H. Montgomery, H. C. Mewhorter, A. H. Myers, J. B. More, John Morgan, W. H. Orcutt, J. J. Rich, Jos. W. Ray, H. Schall, W. Thompson, Major Brookie, E. P. Lewis, John Bigler, J. Stroup, Richard Tod, Jack Cummings, D. W. Brown, Charles Lamb, E. Whitcomb, A. Comstock, C. Failor, Charles Ream, J. Gallagher, —— Smith, —— Dickie, J. H. Lawrence, E. Sheldon.

Of these, twenty-seven went forward from Jackson's Lake, and about fourteen went forward to West Gallatin with me, after the separation between the two lakes. I have not the names of the last party, which I regret very much.

No exciting incidents occurred during this expedition, but it was, as far as I know, the first one which ascended to the head of the South Snake river, and thence passed over to the head of the Madison and West Gallatin rivers, the geographical results of which were published.

I met, after I returned, with members of the party who had left us between the lakes, and gone down the Madison, and from them learned many particulars of the country before unknown, and corrected some errors into which our party had fallen, relative to the head of the Madison.

In 1864–5, I was employed by the first Legislature of Montana to make them a map, for the purpose of laying off the counties, and in this map I embodied the information which I had acquired. This map was lithographed afterward in New York, and sold there and here.

In 1867, I was draftsman in the United States Surveyor-General's office in Helena, and made a map of the Territory, in order to show the public land-surveys for that year, and by order of General Meredith, then Surveyor-General, I named the lake which we had discovered on the

head of South Snake river, "De Lacy's Lake,"—an official name which it has borne ever since in all maps made in that office.

In 1868, I wrote a letter, at the request of Professor Eaton, on the railroad facilities of Montana, and which was published in Professor Raymond's report on the "Mines of the West," in 1869, in which I stated "that the South Snake river heads in a large lake, which flows into Lake Jackson," and "that at the head of the South Snake, and also on the South fork of the Madison, there were hundreds of hot springs, many of which were 'Geysers.'"

In 1870, the Messrs. Colton, of New York, published a map of Montana, drawn by me, containing all the latest information, and have issued several editions of it since.

In 1872, Professor Hayden visited this lake and re-named it "Shoshone Lake," stating that the numerous and outrageous errors in my map, deprived me of any claim to the perpetuation of my name, and insinuating that I claimed to have been, but had not been, in the region.

When I saw this note in his report of 1873, I wrote a short narrative of the trip, and sent it, together with my original note-book and the original map, to Dr. Hayden, by the hands of Mr. Langford, with a request that he would do me justice. He stated to this gentleman that the note had been inserted by one of his assistants, without his knowledge, and that it should not occur again. He had a photographic copy of the map made, and said that he had some idea of writing to some prominent journal in the West on the subject—and there the matter rested. I still remain under a stigma in a published report, such as I never before received, in a long professional career, and, as I think, unjustly, and against which I now protest.

I never claimed that my map was correct in all particu-

lars, or that I had been entirely over the region in question. Outside of the surveys and my own explorations, I was obliged to rely on the reports of others, who had been there hunting or exploring, and these were not always accurate. I put down what I considered the best, hoping to be able to improve the map every year, and make it thoroughly correct finally.

I do claim, however, that I was the first to publish the fact that the South Snake river took its rise in a large lake, north of Lake Jackson, and flowed into it—a fact confirmed by Dr. Hayden's own surveys; and this would authorize me, according to the general rules governing geographers, to name it myself, or for others to give it my name.

In saying this, however, I am perfectly well aware that the fur-traders and trappers were thoroughly acquainted with the country, and visited every portion of it, but their knowledge died with them. I have seen every kind of map which has been published in the last thirty or thirty-five years, and I have never seen one which has a correct representation of this region or of the Yellowstone, while, at the same time, there is enough put down to show that some one had been there, and was acquainted with the main features of the country.

WALTER W. DE LACY,

Active member of the Historical Society of Montana.

Foraging in the 'landscape of fear' and its implications for habitat use and diet quality of elk *Cervus elaphus* and bison *Bison bison*

Lucina Hernández & John W. Laundré

Hernández, L. & Laundré, J.W. 2005: Foraging in the 'landscape of fear' and its implications for habitat use and diet quality of elk Cervus elaphus and bison Bison bison. - Wildl. Biol. 11: 215-220.

In 1995, wolves *Canis lupus* were reintroduced into Yellowstone National Park, USA, where they began to prey on ungulate species. In response to this new predation risk by wolves, we predicted that the two main ungulate species, elk *Cervus elaphus* and bison *Bison bison*, should compensate by reducing their use of riskier open meadows and increasing their use of safer forest. Additionally we predicted that this shift in habitat use would result in reduced diet quality. We tested the first prediction by regressing the number of faecal groups in 10-m^2 sampling plots against distance from forest edges. To test the second prediction, we compared percent faecal nitrogen in elk and bison faeces between areas with and without wolves. We found a significant negative relationship between number of elk faecal groups and distance from forest edge in areas with wolves ($r^2 = 0.65$, $P = 0.001$), but we did not find a relationship between these two factors in areas without wolves. Mean percent faecal nitrogen in elk was significantly lower ($F_{(1,116)} = 13.9$, $P < 0.001$) in areas with wolves (1.7%, SE = 0.09, N = 40) than in wolf-free areas (2.1%, SE = 0.08, N = 80). For bison, we did not find any significant relationship between numbers of faeces and distance from forest edge nor in dietary nitrogen between wolf and wolf-free areas. We concluded that predation pressure from the reintroduced wolves was consistent with our prediction that elk shifted habitat use, thus lowering the quality of their diet. However, a similar change in use pattern and dietary quality of bison in response to wolf presence was not found.

Key words: bison, diet quality, elk, habitat use, predation risk, wolves

Lucina Hernández & John W. Laundré, Instituto de Ecología, A.C., Durango Regional Center, Km 5 Carr. Durango-Mazatlan, 34100, Durango, Durango, México - e-mail addresses: lucina@fauna.edu.mx (Lucina Hernández); john@fauna.edu.mx (John W. Laundré)

Corresponding author: Lucina Hernández

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Predation risk can influence habitat use patterns of a wide spectrum of prey species (e.g. Fraser & Cerri 1982, Edwards 1983, Kotler 1984, Cassini 1991, Kotler et al. 1991, Sweitzer 1996, Hilton et al. 1999). Predators establish a 'landscape of fear' (Laundré et al. 2001) whose topography is determined by the level of predation risk that prey face in different habitat types. When foraging in this landscape, prey will often shift their use from riskier to safer areas to reduce their predation risk (Mech 1977, Edwards 1983, Stephens & Peterson 1984, Altendorf et al. 2001). Because there is often a trade-off between selection of areas for security and areas of high-quality forage, it has been suggested that these habitat shifts result in a poorer diet quality (Edwards 1983, Sweitzer 1996). Based on optimal foraging theory, in the absence of predation risk prey should select the highest quality

habitats when making their foraging decisions (Edwards 1983, Phelan & Baker 1992). Any shift in habitat use in response to predators would, by default, be a change to poorer quality habitat, resulting in decreased diet quality (Edwards 1983).

Some authors have previously reported a shift in habitat use when ungulates are faced with predation pressures from large predators such as wolves *Canis lupus* and pumas *Puma concolor* (Mech 1977, Edwards 1983, Stephens & Peterson 1984, Altendorf et al. 2001), and evidence of reduced diet quality has also been presented (Edwards 1983). However, most of these studies were of long-extant predator-prey systems. Although in these cases, it seems reasonable to assume a cause-and-effect relationship among predation risk, habitat use and diet quality in ungulates, it does not in itself constitute a critical test of this hypothesis.

The reintroduction of wolves into Yellowstone National Park, USA, in 1995 (Bangs & Fritts 1996) presented a unique opportunity to test the hypothesis that predation risk can alter habitat use patterns and consequently lead to poorer quality diets in ungulates. Prior to the release of wolves, the two most abundant ungulate species in the Park, adult elk *Cervus elaphus* and bison *Bison bison*, lived in a relatively predator-free environment. Predation by the only two other large carnivores, puma and grizzly bear *Ursus arctos* was either localized or limited to younger elk (Murphy 1997). Under these conditions, elk and bison could forage freely and grazed extensively in the open sagebrush *Artemisia* spp. communities (Collins & Urness 1983, Frank & McNaughton 1992, Singer & Renkin 1995). Once released, wolves quickly reestablished a landscape of fear in which female elk and bison rapidly responded with higher vigilance levels (Laundré et al. 2001). Additionally, wolves hunt primarily by chasing their prey so that they can attack vulnerable hind quarters, and their prey commonly flee into heavy cover for protection (Mech 1966, Smith et al. 2000, Mech et al. 2001). Consequently, open sagebrush meadows where wolves can readily outrun their prey should present the highest risk areas for elk and bison. Based on the hypothesis above, we would predict that the return of wolves to Yellowstone National Park should cause elk and bison to shift their habitat use closer to the safer forest areas (Mech 1966, Carbyn 1983, Stephens & Peterson 1984). Concurrent with this shift should be a reduction of diet quality as animals move to safer, but poorer quality habitats. If we find such changes, the most likely explanation for them is the increased predation risk from wolves, whereas the lack of these changes would refute the hypothesis.

To test the hypothesis, we first tested the prediction that elk and bison should decrease their use of open meadow areas and increase their use of areas closer to and along forest edges. Based on the optimal foraging model (MacArthur & Pianka 1966, Charnov 1976, Pyke et al. 1977), our assumption was that before the wolf reintroduction the two species were selecting the highest quality habitats for foraging. Consequently, any shift in area use, by default, should be to poorer quality forage and thus, the second prediction we tested was that diet quality of elk and bison should decline in response to the wolf reintroduction. We tested these two predictions by comparing habitat use patterns and diet quality of elk and bison exposed to wolf predation and animals still living in wolf-free areas within Yellowstone National Park.

Methods

Our study was conducted in Yellowstone National Park which consists of extensive areas of varied forested and open grassland habitat. We collected data on habitat use and diet quality in the same areas where we made our behavioural observations (Laundré et al. 2001). The area exposed to predation by wolves was the Lamar Valley (Fig. 1). Wolf-free areas were selected based on data

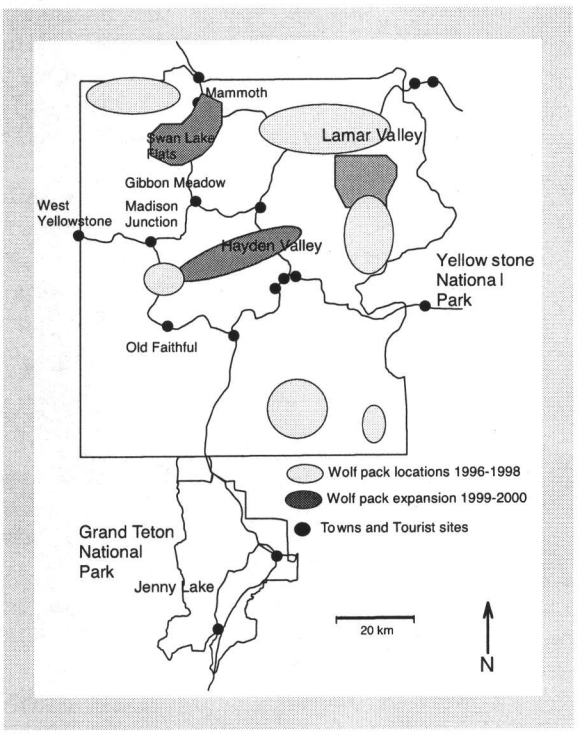


Figure 1. Location of study sites within Yellowstone and Grand Teton National Parks. Areas where wolves occurred during the first three years of the study period (1996-1998;) and their expansion into other areas by 2000 ( ) are indicated.

available on the occurrence of the wolf packs within the Park (J.C. Halfpenny & D. Thompson, unpubl. data). Primary wolf-free areas within Yellowstone National Park were Hayden Valley and Swan Lake Flat (see Fig. 1). During the first year of data collection (1998) we also included data from the Jenny Lake area in Grand Teton National Park, > 100 km south of the Yellowstone study areas. These data provided an external wolf-free control to compare with the Yellowstone data. All the observation areas were similar in that they consisted of large (> 1,000 ha) open meadows boarded by dense coniferous forests. Additionally, wolves began to move into some of the wolf-free areas, and by the end of the study in 2000 they had established themselves in the Hayden Valley area. This enabled us to compare the distribution of elk pellet groups and bison flops in the Hayden Valley before and after wolves arrived.

We tested for habitat shifts by elk and bison by first dividing the length of the forest edges (≈1.5-2.0 km determined from topographic maps) into 50-m intervals and then randomly selecting 10 sample lines in each of the four areas. Sample lines were never closer to each other than 50 m and each extended perpendicular to the forest edge from 50 m within the forest to 500 m into the open meadows. Every 50 m along these lines we established sample points and counted the number of individual animal faecal droppings, pellet groups of elk and flops of bison, within 10-m^2 sample plots placed on these points. If elk and bison shift their habitat use in response to predation risk by wolves, we predicted a negative relationship between densities of elk faecal groups and bison flops and distance from the forest edge in the Lamar Valley and, in the year 2000, the Hayden Valley. We should not, however, see this relationship in Swan Lake Flat, Grand Teton Park, nor, prior to 2000, in the Hayden Valley. To test these predictions, we used a simple linear regression model. The null hypothesis was that the slope of the regression line would not differ from zero.

To test for diet quality changes, we used percent faecal nitrogen (FN) levels. Faecal protein is calculated from FN, and FN is generally considered a reliable indicator of diet quality in grazing ungulates (Leslie & Starkey 1985, Osborn & Jenks 1998, Osborn & Ginnett 2001). We collected elk and bison faecal samples in July of 1998 and 1999 from the 10-m^2 sample plots while we were making the density estimates. From the samples collected, we randomly selected 15-20 samples per year for each species in the three areas of Yellowstone in 1998-2000 and in Grand Teton Park in 1998. The Range Science Nutritional Analysis Laboratory at Colorado State University, Fort Collins analyzed the samples for nitrogen. Laboratory personnel calculated FN in each sample using a LECO CHN - 1000 Carbon Hydrogen Nitrogen Analyzer. To test if diet quality differed between areas with and without wolves, we compared the estimates from the Lamar Valley with the combined estimates from wolf-free areas in Yellowstone (Hayden Valley and Swan Lake Flat combined) and Grand Teton National Park. We used a one-way analysis of variance statistical design with the null hypothesis of no difference in average FN levels among the three areas. As FN was expressed in percents, we arcsine transformed the data before conducting the tests. All statistical tests were run using Sigmastat soft-

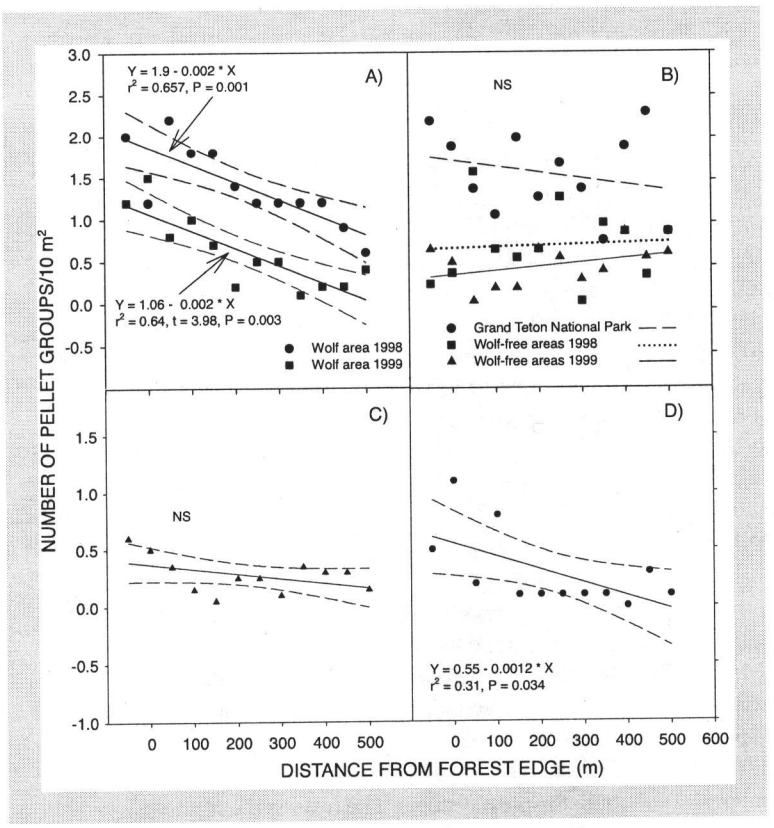


Figure 2. Relationships of mean number of elk pellet groups per 10 m^2 to distance from forest edges for the areas with (A) and without wolves (B), respectively. Data for the Hayden Valley before (C; 1998-1999) and after (D) wolves established themselves in the area are given. Each point is the mean from 10 random transects from the respective areas.

ware (Quinton et al. 1995) with a significance level of $P \leq 0.05$. All means are given ± standard error.

Results

For elk in the Lamar Valley, where wolves were present, the relationship between pellet group density and distance from the forest edge was significant and negative for 1998 and 1999 (Fig. 2A), and the slope of the regression lines did not differ between years, but the intercept of the regression line was significantly lower in 1999 than in 1998. In the wolf-free areas of Yellowstone in 1998 and 1999 and in Grand Teton Park in 1998, there was no significant relationship between pellet group density and distance from the forest edge (Fig. 2B). In the Hayden Valley there was no relationship between pellet density and distance for the combined data of 1998 and 1999 before the wolves arrived (Fig. 2C). However, in 2000, after wolves had established themselves, we found a significant and negative relationship (Fig. 2D).

For bison, we found no relationship between density of flops and distance from the forest edge in neither the Lamar Valley (wolf area) nor the wolf-free areas in 1998 (Fig. 3A) nor in 1999 (Fig. 3B). For the Hayden Valley, there also was no relationship between flop density and distance from forest edge in any of the three years (1998-2000).

Relative to diets, the FN of elk exposed to wolves in the Lamar valley was significantly lower than in the wolf-free areas of Yellowstone in 1998 and 1999 (Fig. 4A). FN for elk from the Lamar Valley in 1998 was also significantly lower than for elk from Grand Teton National Park (see Fig. 4A). In contrast, there was no difference in FN of elk from the wolf-free areas of Yellowstone Park and Grand Teton Park (see Fig. 4A). Bison FN did not differ between wolf and wolf-free areas of Yellowstone nor from Grand Teton Park (Fig. 4B).

Discussion

Other scientists have attributed shifts in habitat use patterns by ungulates to predation pressure by wolves (Mech 1977, Edwards 1983, Stephens & Peterson 1984), and Edwards (1983) predicted that such shifts could lead to poorer diet quality. However, as mentioned, it can be difficult to confirm such cause-and-effect relationships in long-extant predator-prey systems. The results of our study, however, provide three lines of direct evidence that the reintroduction of wolves caused a shift in habitat use by elk. First, within three years after the release

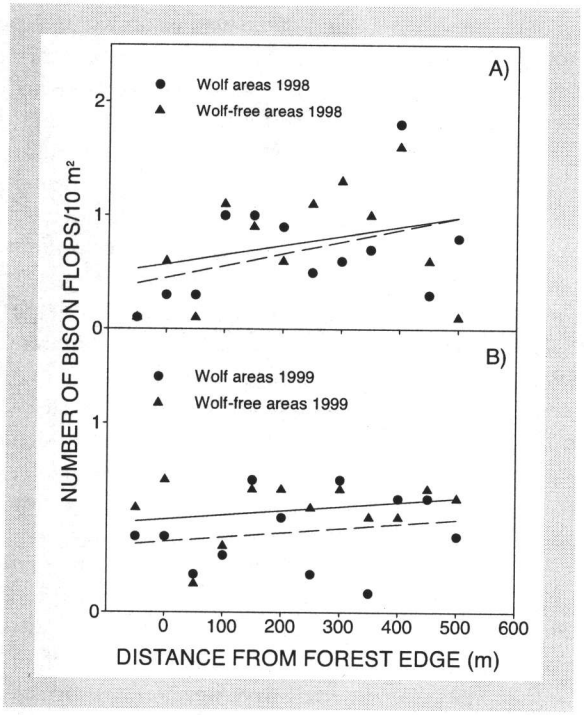


Figure 3. Relationships of mean number of bison flops per 10 m² to distance from forest edges for the areas with and without wolves in 1998 (A) and 1999 (B). Each point is the mean from 10 random transects from the respective areas.

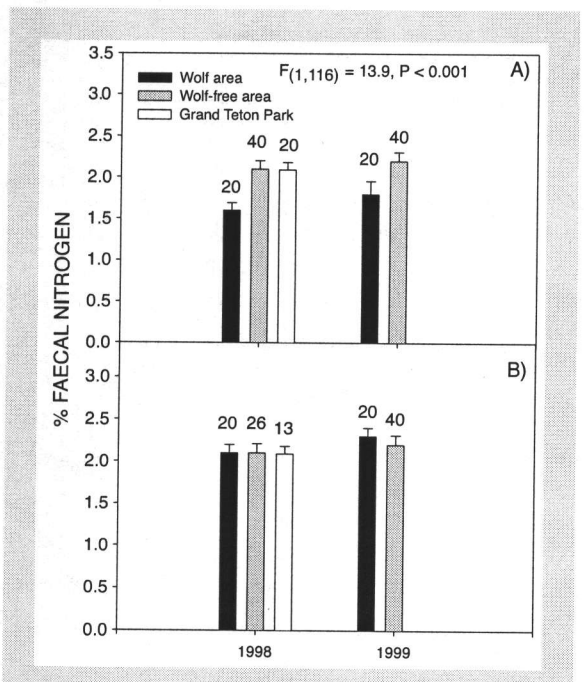


Figure 4. Percent faecal nitrogen for elk (A) and bison (B) from wolf and wolf-free areas for 1998 and 1999. Sample sizes are indicated above the bars.

of wolves, elk in the Lamar Valley were using forest edge areas more than open meadows, although elk preferred open meadow areas before the release (Frank & McNaughton 1992, Singer & Renkin 1995). Second, we did not see this pattern in the wolf-free areas of Yellowstone nor in Grand Teton Park, the latter being > 100 km from the Yellowstone study areas. The results from such diverse areas indicate that elk were using the edge areas more in the Lamar Valley in response to predation pressure from wolves rather than it being an intrinsic use pattern for that area. Third, elk increased their use of forest edges in the Hayden Valley a year after wolves established themselves there, a pattern that we did not find in previous years.

In addition to the shift in habitat use, we also found that elk in the Lamar Valley, as predicted, had poorer quality diets than elk in wolf-free areas only 30 km away. The elk in the area without wolves, meanwhile, had FN levels similar to elk from Grand Teton Park, again > 100 km away. Additionally, the FN levels we found in the Lamar Valley (1.7%) reflect extremely poor dietary nitrogen (DN) intakes (Mould & Robbins 1981, Osborn & Ginnett 2001). It is possible that the poorer diets in the Lamar Valley reflected a lower quality forage normally being available than in other parts of the Park. However, we reject this possibility because Frank & McNaughton (1992) reported percent nitrogen levels of ≈ 2.5% for dominant grasses in the Lamar Valley. This level of DN generally correlates to a FN level of 2.0-2.2% for ungulates (Mould & Robbins 1981, Leslie & Starkey 1985, Osborn & Ginnett 2001). In fact, bison in the Lamar Valley, which did not shift habitat use, maintained FN levels of 2.2% which were equal to FN levels of bison in other areas (see Fig. 4B). All this supports our conclusion that the poor diets of elk in the Lamar Valley are a result of their shifting habitat use in response to the wolves.

In contrast to the data for elk, the data for bison did not support any of our predictions. In some areas, bison are the principal prey of wolves (Carbyn & Trottier 1987). However, in Yellowstone National Park, elk are the main prey of wolves and during our study, wolves did not prey extensively on bison (Smith et al. 2000, Mech et al. 2001). Probably the predation risk to bison was insufficient to cause the predicted shifts in habitat use and a corresponding decline in diet quality. We did notice that vigilance in bison females initially increased in response to wolves but in most cases returned to its original levels (Laundré et al. 2001). This also indicates that predation risk from wolves is still relatively low for bison and would not be a sufficient driving force to cause a habitat shift.

In summary, the data for elk support the cause-and-effect relationships inferred in studies of long-extant predator-prey systems and clearly show that predation risk alone can cause a large ungulate to shift its habitat use to safer areas. Additionally, animals make these shifts at the expense of diet quality. Consequently, predation risk can have a cascading effect on nutritional status of prey individuals; not only does it reduce foraging efficiency of individuals, via increased vigilance, but it further restricts foraging efforts to lower quality areas. Others (e.g. Edwards 1983) have predicted that the subsequent decrease in diet quality should result in a poorer nutritional state, lower survival rates, and lower reproductive success. For elk in Yellowstone, this could mean a reduction in numbers to a more sustainable population size. Additionally, as elk can have a major impact on the open sagebrush community (Singer & Renkin 1995), we originally predicted that their reduced use of this habitat could result in significant changes in the vegetal makeup of this community. Recent work in the Lamar Valley of Yellowstone demonstrating an increase in cottonwood *Populus* spp. recovery supports this prediction (Ripple & Beschta 2003). Consequently, foraging in the landscape of fear can have far reaching impacts on the population level of ungulate prey species (Edwards 1983) and on the diversity of the plant communities that support them.

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