

THE EFFECT OF SEDIMENT REDUCTION INTO WETLAND ON KUSHIRO WETLAND RESTORATION PROJECT

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ABSTRACT

The Kushiro wetland is the largest wetland in Japan. The wetland area has been decreasing over the last 50 years and that was considered to be the vegetation transition from reed or sedge meadow to alder forest. The major factors of vegetation transition were assumed that sediment intrusion into the wetland had been increasing. Then project for the wetland restoration commenced in 2003 and some practical efforts have been conducted for reduction of sediment intrusion into center of the wetland. One of the most essential efforts of sediment reduction is the Sediment Retention Basin (SRB) in Kuchoro River, a tributary of Kushiro River. SRB is a part of marsh beside the river which is surrounded with low wall made of wooden boards named Artificial Kermi. In 2016, a huge flood occurred in northern Japan. Flood water spread in the SRB and large amount of sediments were deposited. Sediment accumulation observed in sediment traps set on the ground surface resulted in around 6 cm thickness of fine sand at the maximum point in SRB. The effectiveness of SRB in sediment reduction was evaluated using numerical model in comparison between pre- and post-setting SRB. The total amount of sediment passing the point of the SRB was estimated to decrease by 30 - 40% based on the numerical model results.

Keywords: wetland restoration, sediment retention, reed and sedge, alder forest

INTRODUCTION

The Kushiro wetland is located in northern Japan, eastern Hokkaido and is the largest wetland in Japan. It spread in the lower reaches of the Kushiro River and its area is around 250km²(Figure 1). The climate in this area is cool due to the location of northern Japan, and the average annual temperature is around 6 degrees and the annual precipitation is about 1000 mm. The landscape consists of reed and sedge meadow and meandering river and it provides habitats for abundant wildlife including rare species such as Japanese cranes (special natural monument) or Japanese Huchen (largest fresh water fish in Japan).

Although such a valuable wetland environment, a serious problem has occurred at the wetland since several decades ago. The wetland vegetation had been changing gradually. Most of the vegetation in Kushiro wetland had been reed and sedge community originally. However, alder forest had been invading to the wetland and the ratio of reed and sedge meadow area was decreased from 92% in 1947 to 54% in 2004(Figure 2).

The increase of sediment inflow into the wetland was recognized as a key factor influencing the changing wetland vegetation. The land reconstruction was conducted in whole of Japan after World War II. Development of farm land was promoted to increase the food production output with population increase. The unused land adjacent to the wetland had been converted to farmland due to some efforts such as drainage or river channelizing in Kushiro district. These works, combined with deforestation, resulted in increasing sediment yield from the area around the wetland.

It was assumed that the increase in the amount of sediment flowing into the wetland would increase the amount of sediment deposition in the wetland, especially at the marginal area. The transition of habitat for

vegetation due to sedimentation led to alteration of vegetation from reed and sedge meadow to alder forest. In this background, the Kushiro Wetland Restoration Project was commenced in 2003 and its main objective was considered reducing sediment flowing into the central wetland area.

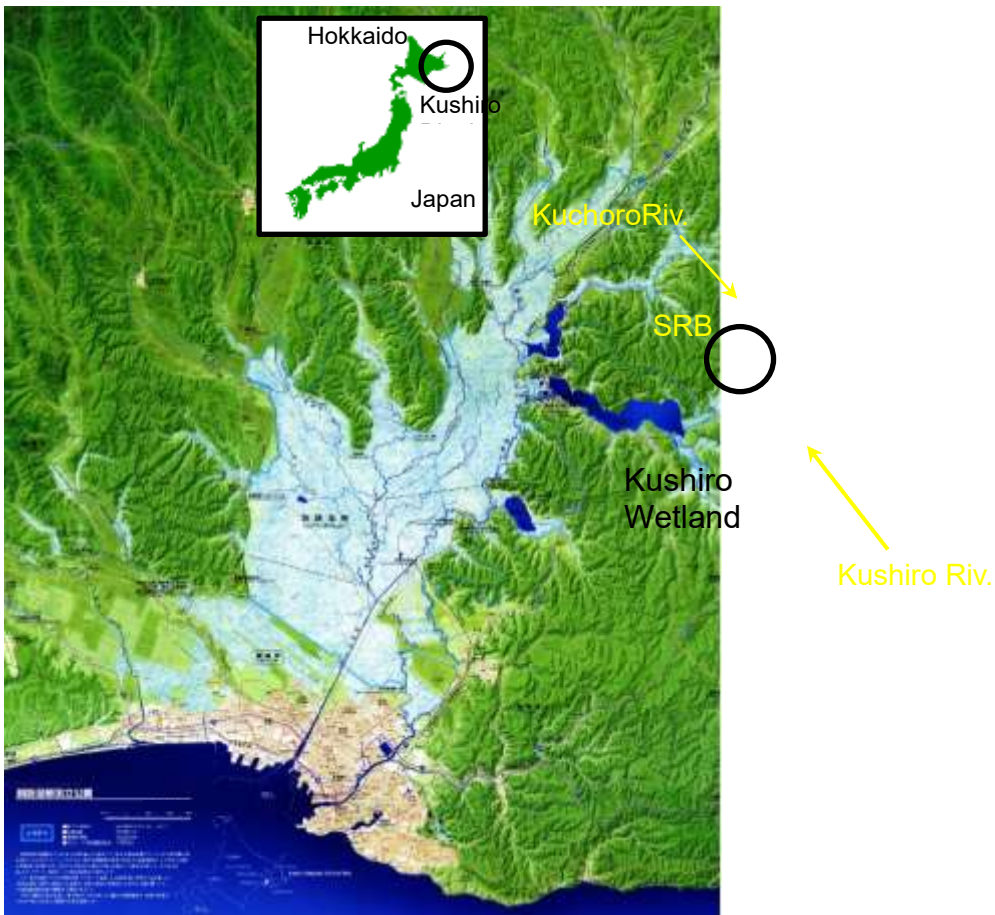


Figure 1. Map of the Kushiro Wetland showing the location in Japan and the position of the SRB at Kuchoro River, the tributary of Kushiro River.

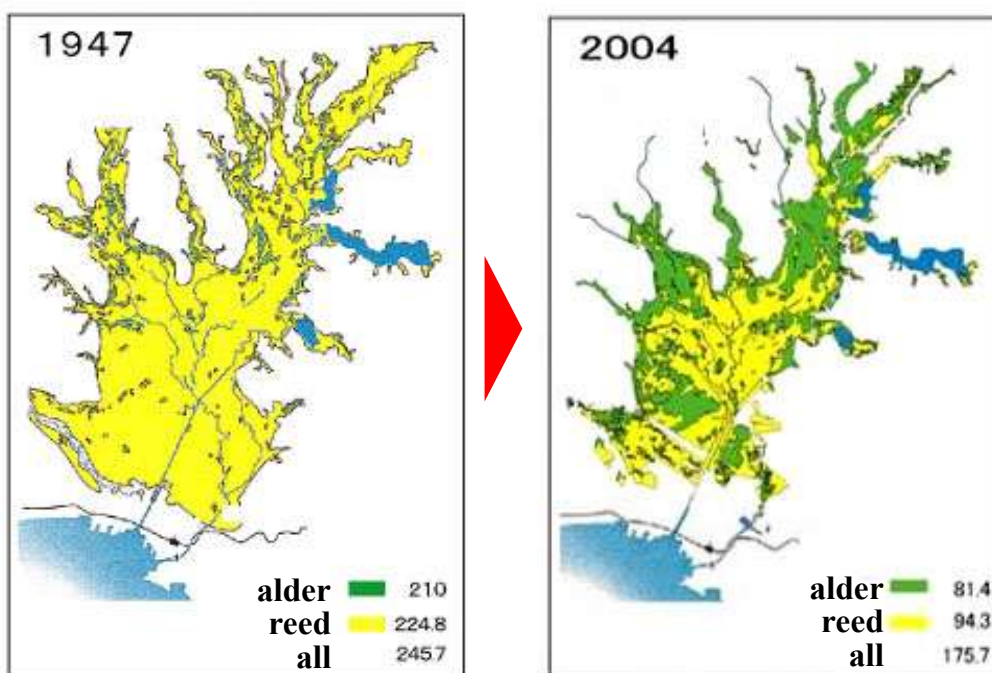


Figure 2. In the early 1900s, whole area of the wetland was covered by reed communities, however, alder trees have been invading the vegetation by 30%. Vegetation alteration triggered the commencement of the wetland

restoration project in Kushiro Wetland.



Figure 3. The Sediment Retention Basin (SRB) was constructed on the side of flood plain area at Kuchoro River. A large amount of flood water flowed into the SRB and lots of sediment were deposited there on 2016 flooding.



Figure 4. The SRB is the area surrounded low wall made of wooden boards. The wall was named Artificial Kermi, derived from ridge of peat moss in Finland.

Sediment Retention Basinin Kuchoro Site

Sediment reduction efforts have been conducted in some districts of Kushiro Wetland Restoration Project. The Sediment Retention Basin (SRB) is one of the major efforts and was planned on both side of flood plain area at Kuchoro River, the branch of the Kushiro River(Figure 3).

The SRB is the area surrounded with low wall and the objective is to reduce sediment intrusion into the central wetland by impounding inundated flood water and depositing the dissolved sediment in it. The low wall was made of wooden boards named Artificial Kermi(Figure 4). The original kermi is ridge of peat moss mostly found in bogs in Finland.

The first SRB on the left side of the river was completed in 2012. The length of the Kermi is 2.4km and area of the SRB is 27.4ha. Presently, another SRB is being constructed on the right side of the river. The monitoring investigation of left side SRB has been conducted to validate the effect of sedimentation design.

A huge flood occurred in 2016 in northern Japan, especially in Hokkaido, and Kushiro district had large flooding as same as other area. The SRB was inundated for a long period during the flood and lots of sediment were deposited in it.

Table 1. Estimates of Sediment Reduction Ratio

year	period	total sediments in flow m ³	deposited sediments m ³	reduction ratio
2013	7/22-10/10	1,900	240	0.13
2014	8/9-9/2	1,600	120	0.08
2016	8/3-11/18	26,000	2,400	0.09
2017	9/17-10/18	750	5	0.01



Figure 5. Sediment Trap: Square plates were set on the ground surface in the area. Sediments remained on the plate after inundation.(size: 0.22m×0.22m)

Sedimentation Monitoring

Sedimentation monitoring has been conducted from a year after the left side SRB was completed. Field observations were performed on suspended loads in the river channel and deposited sediment on the surface in the SRB.

Suspended loads have been observed at the upstream station of SRB and discharge has been observed simultaneously at the same place during flooding. The concentration of suspended load was converted to the suspended load influx by multiplying the flow discharge.

In the SRB, sediment traps had been set at 21 points on the ground and the thickness of deposited sediment was measured after flooding, and the amount of sediment deposition in the SRB was estimated(Figure 5). The difference between the influx of suspended load at the upstream of the SRB and the amount of sediment deposition in the SRB is the quantity of sediment flowing into the wetland.

Monitoring is important for confirming how much SRB can reduce the amount of sediment flowing into the wetland. The results of sedimentation monitoring on total sediments in flow, deposited sediments and reduction rate are shown in Table 1 for 2013-2017.

It was confirmed from the result of the sediment reduction ratio that approximately 10% of the suspended load was deposited in the SRB. This is the effect of the SRB reducing the amount of sediment inflow to the center of the wetland. Although the reduction rate was significantly lower at 1% in 2017, it is considered that the amount of inundated water from the channel was small because the flood discharge was small and water level didn't rise much.

Evaluation

A simulation model was established to evaluate the sediment reduction effect by comparing the case where the SRB was set or not. The 2D flow was calculated using the shallow water equations, and the sediment transportation was calculated by the advection-diffusion equation of suspended loads.

Calculation results of the 2016 flood are shown in Figure 6. The figure above shows the case with no SRB, and the figure below shows the case with SRB. The result of the case with no SRB showed that much sediment flowed into the wetland area and the case with SRB showed that much sediment deposition occurred. In addition, the annual amount of sediment reduction was estimated utilizing this calculation model. As a result, it was shown that the amount of sediment reduction effect was about 30% by setting the SRB(Figure 7).

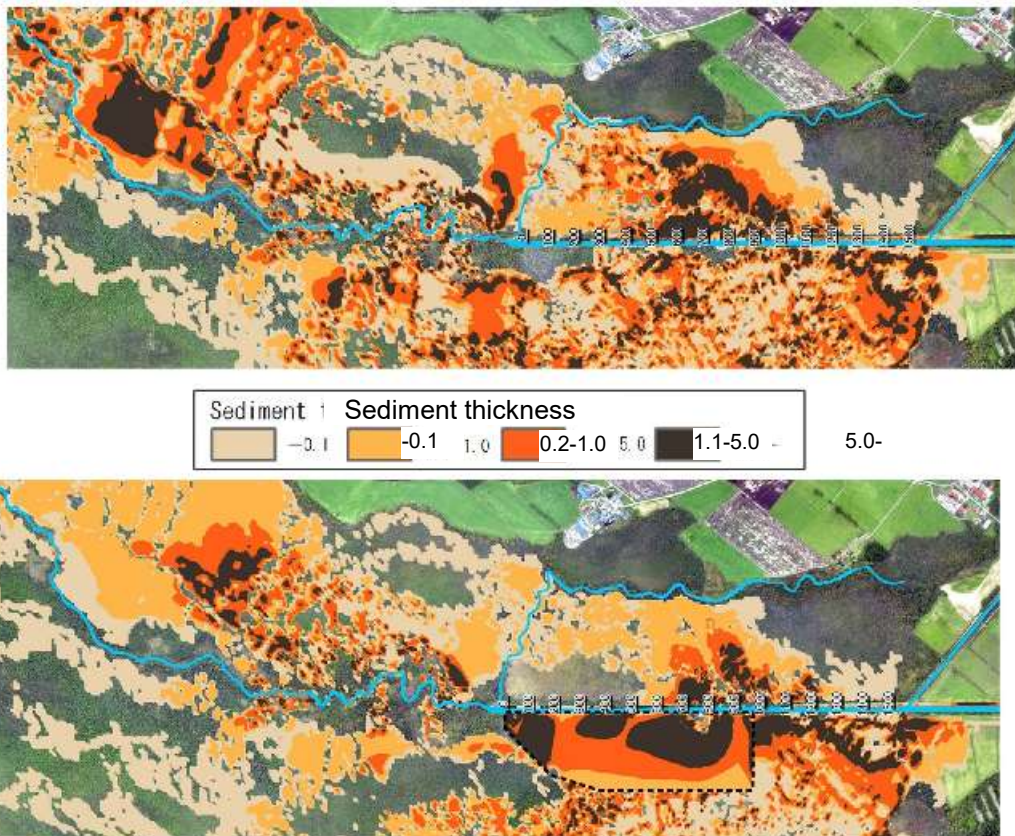


Figure 6. Numerical simulation results of 2016 flood (upper: assuming without SRB, lower: with SRB)

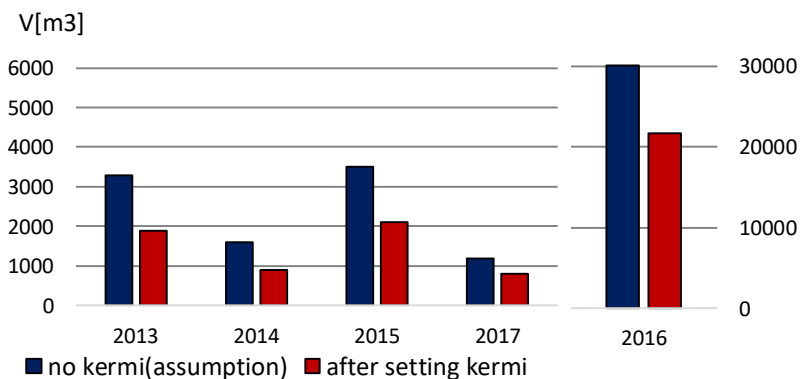


Figure 7. Estimated annual sediment inflow to wetland by numerical simulation

CONCLUSIONS

The effect of Sediment Retention Basin (SRB) set to decrease in sediment intrusion into Kushiro Wetland was validated by field investigation and numerical simulation. Sediment accumulation observed in SRB after flooding and numerical results showed that the sediment inflow to the wetland is reduced by about 30%. We will continue to conduct monitoring investigation and confirm the effects.

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