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Restored fen vegetation following in situ well pad disturbances

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In the Oil Sands region of Alberta, Canada, vast areas of the boreal forest, including pristine northern peatlands, are under pressure by an extensive infrastructure of the oil and gas industry for bitumen production. Disturbances include a wide net of access roads, pipelines, processing facilities and thousands of in situ oil and gas well pads. Well pads are platforms of 1 to 4 m compacted mineral fill, sized 1 to 4 ha, supporting in situ oil and gas scheme wells for bitumen production. As of November 2021, there were more than 42 500 active wells in Alberta, each with a lifespan of about 20 years. Once well pads are no longer in use, peatland restoration is obligatory. The restoration aim is the reestablishment of important peatland functions, such as wildlife habitat, water storage and filtration, peat accumulation, and carbon sequestration.

Our research focuses on the development of characteristic fen vegetation in restored peatlands following disturbances by in situ oil sands well pads in the Peace River and Cold Lake Oil Sands regions in Alberta. We aimed to evaluate different restoration techniques, including 1) the complete removal (CR) of a well pad's mineral fill and spontaneous revegetation via natural ingress 2) the partial removal (PR) of the mineral fill to the water table level (PR0) and spontaneous revegetation, and 3) the PR of the mineral fill to 15 cm above the water table level (PR15) and 4 to 6 cm above the water table level (5 cm), and planting of specific fen species seedlings (*Carex aquatilis, Larix laricina*, and *Salix lutea*). We assessed the return of plant species and community diversity, biochemical quality of the substrate and ecohydrology of the restored peatlands (CR, PR0, PR15, PR5), an unrestored control area, and 28 reference wetland areas (REF), including a marsh, fens, and bogs.

Ten years post-restoration, the CR had developed into a shallow open water area with a larger than 80 cm water table and floating moss carpets along the edges. In PR, the levelling of the mineral fill reconnected the surface to the adjacent undisturbed fens and resulted in a surface-near water table and highest peatland plant species diversity. We observed a total plant cover of 57% in the restored areas, compared to 68% in REF. In the restored areas 61% of the vegetation, with an average of 35 species, comprise characteristic peatland species, compared to 100% in the

REF, where an average of 64 species were observed. Across all restored areas, a close hydrologic connection to the adjacent peatland with a water table close to the surface resulted in plant communities similar to reference fens and with the highest peatland plant species diversity among restored areas.