生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	海狸重塑陸地與溪流生態系統 (Beavers Remodel Land and Stream Ecosystems)
生物系統 LIVING SYSTEM	美洲海狸 (American beaver)
功能類別 FUNCTIONS	#調節水文流動 #Regulate Hydrological Flows #控制侵蝕與沉積 #Control Erosion and Sediment #維持生物多樣性 #Maintain Biodiversity
作用機制標題	海狸築海狸壩改變溪流流動，並創造多樣化的棲息地 (Beaver dams change stream flows and create a patchwork of habitat diversity.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 出處: M. Rehemtulla/QUOI Media Group / Flickr / https://www.flickr.com/photos/quoimedia/5593613789/
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	

前言：

農業活動影響了大多自然生態系統，通常以犧牲其生物多樣性作為代價，因此保護現存的珍稀或受威脅生態系統至關重要，但對退化系統進行重建或復育也可能增強其恢復力，並進一步提升生態系統功能。淡水生態系統與人類生活的基本需求密不可分，但這些生態系統往往因過度開發、污染、物理改變、外來物種入侵或其他因素而退化。這些生態系統還能作為碳匯 (carbon sinks)，並透過增加儲水能力與延緩水釋放來減少洪水風險並緩解水資源短缺。目前已知淡水生態系統至少可以透過人為干預部分恢復，例如：透過重新調整河道曲流 (re-meandering) 或添加大型木質材料 (large woody material) 來改善河流生態，建造池塘，透過填塞排水溝來提高泥炭地的地下水位，透過點源控制減少營養鹽壓力，恢復河岸緩衝帶以降低擴散性營養鹽負荷，或透過操控湖泊中的營養級聯效應 (trophic cascades) 來改善水質。

海狸 (*Castor canadensis* in North America and *C. fiber* in Europe) 被視為生態系統工程師 (ecosystem engineers)，因其在中小型河流中建造水壩與運河，對環境產生了多種影響。

策略：

海狸可以透過建造水壩 (beaver dams) 來改變溪流和濕地環境，這些由木材、石塊和泥土組成的結構不僅攔阻水流，還形成回水區 (backwater areas)，進而強化水文連接性 (hydrological connectivity)，無論是在垂直 (vertical) 或水平方向 (lateral) 上，都對周圍生態系統的生物多樣性 (biodiversity) 產生正面影響。

當水流減緩，回水區會開始積聚沉積物 (sediment) 和有機物質 (organic matter)，同時增加決口洪水 (overbank flow) 的強度、持續時間與發生頻率，進而增加河道穩定性，並促成多叉流河道 (multithread channels) 的形成。這些變化使細顆粒沉積物 (fine sediment) 和有機物質沉積至氾濫平原 (floodplain)，而沿河岸的濕地 (floodplain wetlands) 和高水位區域 (high riparian water tables) 則進一步提供多樣化的棲息地，為水生與陸生生物創造適宜的生存環境。

此外，海狸改造的濕地 (beaver-created or modified wetlands) 會影響當地的光照穿透率 (light penetration)，這通常與樹冠 (canopy) 的移除或洪水影響地下層草本植物 (understorey herbs) 的生長有關，這些變化提升了土壤濕度 (soil moisture)，並進一步影響植物組成 (plant composition)。隨著時間推移，嗜氮植物 (或富氮植物) (nitrophilous plants) 的覆蓋度顯著減少，反映出養分動態 (nutrient dynamics) 的變化，以及養分如何在沉積物或水生植物中累積與儲存的模式。

潛力：

海狸透過改變水文條件、減少侵蝕、促進生物多樣性和改善水質等方式，為溪流和濕地的恢復提供了有效的生態修 A 復方法，這些變化不僅增強了生態系統的穩定性，還提升了濕地的生態服務功能，對長期的生態保護和恢復具有重要意義。

Introduction :

Agricultural activity has impacted most natural ecosystems, often at the expense of their biological and physical diversity. Protecting surviving examples of rare or threatened ecosystems is vital, but re-creation or restoration of degraded systems may also boost resilience and further enhance ecosystem functioning. Freshwaters are inextricably linked to the most fundamental aspects of human life, yet are often overexploited, polluted, physically modified, invaded or otherwise degraded. Additionally, these systems can act as carbon sinks, or, by enhancing storage and slowing release of water, can both attenuate flooding and alleviate water shortages. It is recognised that freshwaters can be at least partially restored through human intervention, for example, by re-meandering or adding large woody material to rivers, creating

ponds, raising the water table on peatlands by ditch blocking, reducing nutrient pressures through point source control, restoring riparian buffer zones to reduce diffuse nutrient loading or manipulating trophic cascades in lakes.
Beaver (*Castor canadensis* in North America and *C. fiber* in Europe) are ecosystem engineers because of the diverse effects created by their construction of dams and canals along small- to medium-sized rivers .

The Strategy:
Beavers can modify stream and wetland environments by constructing beaver dams, which are structures made of wood, stones, and soil. These dams not only obstruct water flow but also create backwater areas, thereby enhancing hydrological connectivity both vertically and laterally. These changes have a positive impact on the biodiversity of the surrounding ecosystem.
As water flow slows down, backwater areas begin to accumulate sediment and organic matter, while also increasing the intensity, duration, and frequency of overbank flow. This process enhances channel stability and facilitates the formation of multithread channels. These changes promote the deposition of fine sediment and organic matter onto the floodplain, while floodplain wetlands and high riparian water tables further contribute to the development of diverse habitats, creating suitable living conditions for both aquatic and terrestrial species.
Additionally, beaver-created or modified wetlands influence light penetration, often due to canopy removal or the impact of flooding on the growth of understorey herbs. These changes increase soil moisture and further alter plant composition. Over time, the coverage of nitrophilous plants significantly declines, reflecting shifts in nutrient dynamics and changes in how nutrients accumulate and are stored in sediment or aquatic plants.

The Potential:
Beavers provide an effective ecological restoration solution for streams and wetlands through altering hydrological conditions, reducing erosion, promoting biodiversity, and improving water quality. These changes not only enhance the stability of the ecosystem but also improve the ecological services of wetlands, making them of significant importance for long-term ecological conservation and restoration.

文獻引用 (REFERENCES)

“Beaver dams obstruct flow, creating backwater areas that store sediment and organic matter, and enhance the magnitude, duration, and frequency of overbank flow. These changes result in the formation of stable, multithread channels and the deposition of fine sediments and organic matter on floodplains. The creation of wetlands and high water tables in riparian zones also contributes to the establishment of diverse habitats that support a wide range of aquatic and terrestrial species.”
「回水區可以儲存沉積物 (sediment) 和有機物質 (organic matter)，並增加決口洪水 (overbank flow)的強度、持續時間和發生頻率，這些變化使得河道變得更加穩定，並形成了多叉流的河道 (multithread channels)，將細顆粒沉積物 (fine sediment) 和有機物質沉積在氾濫平原 (floodplain) 上，沿河岸的濕地 (floodplain wetlands) 和高水位區域 (high riparian water tables) 有助於建立多樣化的棲息地，為各種水生和陸生物種提供棲息場所。」
(Naiman, et al. 2006)

“Beaver-created or modified wetlands have high or variable light penetration, which is due to either the removal of the tree canopy or the flooding-induced recession of taller understorey

herbs. This creates areas with elevated soil moisture and changes in plant composition, with a significant reduction in nitrophilous plants over time, reflecting a shift in nutrient dynamics and their retention in sediments or aquatic vegetation."
「由海狸創建或改造的濕地 (beaver-created or modified wetlands) 具有較高或變化的光照穿透率 (light penetration)，這是由於樹冠 (canopy) 的去除或洪水引起的較高地下層草本植物 (understorey herbs) 後退所致，這樣的變化創造了具有較高土壤濕度 (soil moisture) 的區域，並改變了植物組成 (plant composition)。隨著時間的推移，嗜氮植物 (nitrophilous plants) 的覆蓋度顯著下降，反映出養分動態 (nutrient dynamics) 的變化以及養分在沉積物 (sediment) 或水生植物中的儲存。」
(Law, et al. 2017)

"Beavers modify habitats by constructing dams from wood, stones, and mud, which not only obstruct flow but also create backwater areas that increase sediment storage. These changes lead to increased hydrological connectivity, both vertically and laterally, promoting greater biodiversity in the surrounding ecosystems."
「海狸透過建造由木材、石塊和泥土組成的水壩 (beaver dams) 來改變棲息地。這些海狸壩不僅能夠阻擋水流，還創造了回水區 (backwater areas)，這些變化增強了水文連接性 (hydrological connectivity)，無論在垂直 (vertical) 還是水平方向 (lateral) 上，都促進了周圍生態系統的生物多樣性 (biodiversity)。」
(Rosell, et al. 2020)

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