生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	根嫁接促進生長 (Root Grafting Enhances Growth)
生物系統 LIVING SYSTEM	北美短葉松 *Pinus banksiana* (Jack pine)
功能類別 FUNCTIONS	#獲取、吸收、或過濾液體 #分配液體 #相同物種之間合作 #Capture, Absorb, or Filter Liquids #Distribute Liquids #Cooperate Within the Same Species
作用機制標題	一旦形成嫁接，樹木就能透過土壤下看不見的根系相連網絡，在多個個體之間共享資源 (Once a graft forms, trees can share resources through the connected roots, often among multiple individuals connected by the unseen web beneath the soil.)
生物系統/作用機制 示意圖	   

作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)

介紹

在地面之上，一整片的北美短葉松 (jack pine tree, *Pinus banksiana*) 看似是獨立個體。然而在土壤下，卻揭露出另一個故事。

北美短葉松是一種生長在美國北部及加拿大的耐寒 (hardy) 樹木，在砂質的淺層土壤上茁壯成長，經常是大火後最先回復的樹木種類。北美短葉松普遍長成一整片，有時候穿插在其他樹種之間，例如黑雲杉 (black spruce)。在面對這種環境時，同物種個體間的連結能為它們帶來益處。

策略

當一棵北美短葉松的樹根碰到另一棵北美短葉松的樹根時，它們可能會相互擠壓。根部開始沿著壓力點增生細胞直到它們之間的樹皮破裂為止。

隨著兩株植物的組織互相直接接觸，個別的細胞開始黏合在一起。周圍的組織累積醣分子，形成更牢固的連結。新的細胞發育並最終形成木質部 (xylem) 和韌皮部 (phloem)，木質部的木質導管 (woody vessel) 輸送食物、營養物質和水。

最後形成共享的根系結構，該根系結構通常包含來自兩棵樹的根部物質。一旦形成嫁接，樹木可以通過相連的根系來共享資源，這是多個個體之間，土壤下看不見的相連網路。

儘管嫁接起初會減緩單株樹木的生長，但從長遠來看，它們似乎使群體受益。共有的根系使全部樹木都能夠擁有更有利的生長條件，從而使較虛弱、處於不利條件的樹木得到支持。共有根系使樹椿保持活力，有助於排除潛在的競爭樹種。而且由於整片樹林中可能有多達70%的個體會形成嫁接，它們可額外提供抵抗強風的穩定性。

潛力

在面對著不同挑戰的個體之間建立深入的連結，能在人類、科技裝置還有地下根部系統中，讓有效率的資源和資訊流動。這種「共享經濟」策略提供了一個寶貴的看法，那就是，即使在最初會付出代價，合作能創造更強大、更具彈性的整體系統，為貢獻者和受領者提供最大的利益。

Introduction

Above the surface, jack pines (*Pinus banksiana*) in a stand seem to be independent individuals. A look beneath the soil, however, reveals a different story.

A hardy tree found in the northern U.S. and Canada, jack pine thrives on sandy and thin soil and is often among the first tree species to come back after a fire. It commonly grows in stands, sometimes interspersed with other tree species such as black spruce. But it’s the connections they make with others of their own species that give them an advantage when facing such harsh environments.

Strategy

When one jack pine tree’s roots run into the roots of another, they may press into each other. The roots begin to add cells along the pressure points until the bark between them breaks through.

As the tissues from the two plants contact each other directly, the individual cells start to stick together. The surrounding tissue deposits sugar molecules, creating an even stronger bond. New cells develop and eventually form xylem and phloem, the woody vessels that carry food, nutrients and water.

The result is a shared root structure that often contains root material from both trees. Once a graft forms, trees can share resources through the connected roots, often among multiple individuals connected by the unseen web beneath the soil.

Although grafts initially reduce individual tree growth, in the long run they appear to benefit the stand as a whole. The shared roots allow trees growing in more favorable conditions within the stand to give weaker, disadvantaged trees a boost. They allow stumps to stay alive,

helping to crowd out potentially competing tree species. And because up to 70% of the stand may form grafts, they provide added stability against strong winds.

The Potential

Making deep connections between individuals facing different challenges can allow for the effective flow of resources and information in human and technological settings as well as in underground root systems. This strategy of creating a "sharing economy" offers valuable insights into how, even if they initially come at a cost, collaborations can create a stronger, more resilient overall system to the ultimate benefit of both contributors and recipients.

文獻引用 (REFERENCES)

儘管樹木可以通過根部嫁接形成共享根部系統, 傳統上仍認為樹木是清楚區別的實體 (distinct entity), 根部嫁接是兩條或多條根之間在形態上 (morphological) 的結合。關於自然界中根部嫁接的生態意義瞭解甚少, 但是由於嫁接的樹木可以共享資源和二次代謝化合物 (secondary compound), 因此根嫁接的存在能直接影響相連樹木的生長。傳統的森林生態學概念可能需要修改, 增加相連樹木之間的直接相互作用。

我們以液壓 (hydraulically) 方式開挖了六個30–50-m^2的地塊 (plot)（三個天然林natural stand和三個人工林plantation）。我們測量了每年的徑向生長 (radial growth), 並確定了根部嫁接對樹木徑向生長的影響。

在根部嫁接形成期間, 根部嫁接傾向於減少北美短葉松樹體的徑向生長, 此後生長速率通常會增加。根系嫁接對生長的影響在天然林中更為顯著, 在天然林中發生的嫁接頻率比在人工林中更為頻繁。

根部嫁接在初期是一項耗能巨大的過程, 但在後期並不會有害, 還可能對樹木的生長有益。藉由共有根部系統, 能透過在樹木之間重新分配資源來最大程度地利用資源, 從而促進樹木的生長。

Trees are traditionally considered as distinct entities even though they can share a communal root system through root grafts, which are morphological unions between two or more roots. Little is known regarding the ecological significance of natural root grafting, but because grafted trees can share resources and secondary compounds, growth of linked trees can be affected directly by the presence of root grafts. Traditional forest ecology concepts may have to be revised to include direct interactions between connected trees.

We hydraulically excavated six 30–50‐m2 plots (three natural stands and three plantations). We measured yearly radial growth and determined the influence of root grafting on radial growth of grafted trees.

During periods of root graft formation, root grafting tended to reduce radial growth of jack pine trees, after which growth generally increased. The influence of root grafting on growth was more significant in natural stands, where root grafting was more frequent than in plantations.

Root grafting initially is an energetically costly process but that it is afterward nonprejudicial and maybe beneficial to tree growth. The use of a communal root system allows for a maximum use of resources by redistributing them among trees, leading to increased tree growth.

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生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S)

https://asknature.org/system/conifers?post-type=Biological%20Strategies

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