The Hidden Life of Trees Study Guide

The Hidden Life of Trees by Peter Wohlleben

BOOKRAGS

Contents

Summary

The following version of this book was used to create this guide: Wohlleben, Peter. The Hidden Life of Trees. Random House, 2016. First edition.

The original has been translated from German by Jane Billinghurst.

Peter Wohlleben shares his experiences from decades of observing the forest. He often noticed peculiar things, which he then investigated. Thus he learned of unknown workings of trees, of the organisms that co-exist with trees, and the whole forest. He writes of both his observations and the properties and processes that he looked into. Often, Wohlleben begins with an anecdote and explores from there but, even once he has reached quite some depth in a biological phenomenon, he has not broken from his story-telling style. And thus he shares insights into biological processes that are indeed unknown to many, but that may also not be regarded as significant enough to consider at length. Wohlleben shows how minute factors come together and that, thus, even seemingly futile elements are important.

His primary purpose in the book is to reveal that trees have more complex capabilities than most people are aware of. This begins with communication between them and extends to regulating the climate around them, ‘learning’ from experience, exchanging nutrients, complex defense processes, transporting water into landlocked countries, ‘telling time,’ ‘making decisions,’ migrating, activating genes or thickening cell walls to adapt to their environment, and cleaning air. Many of these capabilities are introduced by an example of when Wohlleben observed the characteristic in a forest, and they are often explored throughout a chapter. His writing is almost flow-of-consciousness in its progression of ideas, including many tangents and not having a linearly structured scheme of organization.

Wohlleben explains that trees can use gases carried by the wind as well as chemical signals through fungal networks to communicate danger to each other. The trees can grow more leaves to increase humidity and temperature, change the acidity of soil by adding their decaying matter to it, increase the nutrients available to the roots in cooperation with fungi, and thicken clouds above them by releasing volatile compounds. He found that they will use less water for the rest of their lives after suffering a shortage one year and reports that their shrub cousins can learn that a part of their surroundings is harmless. As well as that they are capable of sending each other nutrients through an underground connection of their roots, sometimes bridged by fungi. He writes of trees’ reaction to an insect nibbling on a leaf – sending bitter or toxic substances there to deter the critter. Trees also take preventative action by releasing compounds into the air that ward off their feasting friends. Additionally, they are capable of thickening their bark and drowning a bug or fungus moving into its outer layers. The reader learns that rain is only capable of travelling further than 400 kilometers inland from an ocean due to forests. They hear of leafy giants counting the number of warm days to assure that their leaves will survive, waiting until the daylight time has reached thirteen hours. The masses of

needles and leaves growing bare millimeters filter particulates and gases toxic to humans.

Another major point Wohlleben illustrates is the interconnectedness of trees and in fact all parts of the forest. He also shows that this can be generalized further onto the interconnectedness of all the parts of any ecosystem, with the Earth being the biggest ecosystem that we can describe effectively.

He tells of the “wood wide web” (the underground root and fungus system that can exchange nutrients and information), scent-based communication, pioneers making fields habitable for other trees to move in, species that feed and protect the trees (fungi, woodpeckers, cardinal beetles), the development of an ecosystem’s constellation, the organisms that feed off trees, the organisms that live in trees, the subsurface life that makes soil what it is, the sub-habitats in trees, animals helping tree reproduction, plants that live on trees (some parasitic, some not).

Wohlleben shows that trees support each other in various ways. They adjust their microclimate and other elements of their habitat together, share nutrients, warn each other of attacks, sometimes help out through a coincidence. And Wohlleben also demonstrates that this works at another level, as trees are supported by and support the other organisms in the forest. He points out to the reader that this system actually functions at every level, and is a key element to all life.

Introductions and Chapters 1-6

Summary

Foreword and Introductions

Tim Flannery introduces some of Wohlleben's main points, comparing to fairytales and wonderland. Flannery includes that many people misunderstand trees, some of their processes are much slower than ours, trees communicate via electrical impulses and smells, and the trees in a forest care for each other.

Wohlleben introduces the English edition by explaining that he has cared for beeches and oaks for much of his life. He encourages the reader to explore the forests and trees around them for themselves. He gives an example from the Anglophonic world, describing how the disappearance of wolves from Yellowstone National Park impacted the whole ecosystem. Dozens of organisms suffered from the change. After 70 years, the wolves returned, and the ecosystem is now falling back into place.

In the original introduction, Wohlleben explains that he began working as a commercial forester, comparing his work to that of a butcher. He gave some guided tours and taught survival training, and the perspectives of the visitors to his forest gave him a very different perspective. He began to observe the forest intently, learned a lot walking around it, and gave up commercial forestry. Since then he has advocated for the preservation of the forest and founded an arboreal graveyard.

Chapter 1

Wohlleben describes his inspection of a tree trunk in the forest he manages. The center died hundreds of years ago, but it is still alive at its outermost edges. He explains that trees can support each other by exchanging nutrients through their roots or underground fungal networks. In fact, this is the rule rather than a special case, and is worth it as each tree receives significant protection from wind and heat from its neighbors. Two trees can have different levels of connectivity, and Wohlleben describes that 'friends' can be observed in the fact that they are careful to leave enough space for the other's branches to grow. Planted forests cannot establish such friendships because the trees' roots are so badly damaged and the trees are harvested after as little as 100 years.

Chapter 2

Trees can communicate with each other and the plants and animals around them. Acacias in the African savannah keep giraffes from eating them by moving toxic substances into their leaves and releasing ethylene gas. The wind carries the gas to other trees who also distribute toxins, and the giraffes learn to leave them alone. Beeches, spruce, and oaks send out an electrical signal when a caterpillar bites into them to then spread defensive compounds. Leaves can release scents when there is an

issue at the roots. Also, trees respond to feasting insects by producing bitter, toxic liquids that kill or deter them and pheromones that attract predators specific to an insect species. Dr. Simard, a forest ecology researcher at the University of British Columbia, has found that roots can send warning signals - chemical through fungal networks, or electrical. These fungi can spread very far, though the messages move slowly compared to the ones in human bodies. In forests trees, shrubs, and grasses all communicate when there is a danger, but the plants in farm fields are no longer able to because of selective breeding. Blossoms also attract bees with their smell and appearance. Furthermore Dr. Gagliano, professor of evolutionary biology at the University of Western Australia, has found that seedlings orient their tips towards other seedlings when they produce sounds.

Chapter 3

Trees in industrial forests are grown far apart so they have more space, light, and water. This works well for their shortened lives but has ill effects in other cases. Students at RWTH Aachen University discovered that all trees in a natural beech forest had the same photosynthesis rate for each leaf. Wohlleben explains that they all have different growing conditions and growth rates so they are exchanging sugar through their roots to even out the sugar levels.

For the root network, it is beneficial for trees to grow close together. And foresters who fell trees to make space around selected ones, weaken their support system. Even the healthiest trees need others around them to maintain the right climate and help in events like an insect attack. Wohlleben used to strip bark from trees to kill them and observed that some were supported so intensely that they are still alive now.

Chapter 4

Deciduous trees can ‘decide’ whether they should bloom in a particular year or not. They all bloom at the same time and will skip a year to reduce boar and deer populations. The animals eat their seeds, which means that less seedlings can grow. To avoid inbreeding, the spruce’s male and female blossoms open on different days, allowing more foreign pollen to reach the females. Bird cherries grow tiny tubes to the ovary after a bee puts pollen on them, they test the genes of the pollen and block the tube if the genes are the same as their own. Some species, like the willow, have trees of just one gender. Willows use insects for pollination, so to ensure that they go to the male before the female tree, the male flowers are bright yellow while the female ones are a less noticeable green.

Chapter 5

Wohlleben discusses energy distribution, focusing in on the intensive reproduction process. Some trees (like beeches and oaks) are left quite vulnerable after growing seeds and blossoms, and then have few leaves left to photosynthesize as well. At this moment, when trees cannot defend themselves, insects such as weevils lay their eggs in the leaves and eat huge amounts. A beech that was already struggling can be killed

by this. Though, unexpectedly, the weaker trees are especially likely to blossom, perhaps because they want to try and propagate before dying.

Beech and oak seeds sprout right when the sunlight reaches them in spring, preventing boar and deer from eating them. Other species' seeds can wait several years for the best possible conditions but risk being eaten. Statistically, every tree raises one offspring to replace itself but a beech can produce 1.8 million beechnuts and a poplar over a billion. Seeds are eaten or broken down by fungi and bacteria, seedlings die and decompose before growing to a full tree.

Chapter 6

Young beeches only receive 3% of sunlight through the thick adult canopy, so they grow quite slowly. Their age can be counted by the wrinkles on their branches, and Wohlleben was surprised when he determined a tree with a diameter of a third of an inch to be about 80 years old. Recent research has shown that trees can live much longer if they begin growing slowly. It makes the wood denser, more flexible, more resistant to fungi, and better at repairing itself. Once a nearby 'mother tree' falls down, which may take a few hundred years, the 'children' begin to grow upwards rapidly. Their photosynthesis rates increase dramatically and their leaves adapt to this. The fastest ones block the light of the others, which return to the soil. Deer eat the newly sweet leaves, and honeysuckle tries to conquer the trunk. After a few more centuries of waiting, another grown tree falls and the offspring can reach the top of the canopy.

Analysis

Throughout this book, Wohlleben presents his own process of learning. His starting point is the teaching of commercial forestry that he completed in 1987, and the book explains his realizations during his many years of experience, observation, and enquiry in his work thereafter. The order is not chronological but rather organized by topics.

Wohlleben's writing includes many colloquialisms (like off kilter, earmark, and death knell) which make it very conversational. He also includes some symbolic imagery, and his voice is marked clearly by his personal perspective. In translating, Jane Billinghurst seems to have made an effort to maintain his voice and the other personal characteristics of his work. There are many idioms and Anglophonic expressions in the book, so Billinghurst either found equivalents for Wohlleben's German idioms and expressions or found other suitable ones in English. There are also elements of the text that have seen greater adaptation, such as temperatures given in Fahrenheit or national parks being used to explain conservation (national parks are not as common in Germany as in the U.S., there are more conservation areas but they are set up differently).

One could say that Wohlleben personifies the trees he discusses, though there is a deeper issue at the heart of the matter. One of the major aims of the book seems to be to demonstrate to the reader the similarity between trees and people. He states that he

thinks people would understand trees better if they saw that they are not so different. Though trees do not have emotions and thoughts in the exact way that humans do, he is trying to show that they have something similar. But he also stops to admit that there is no evidence of them making conscious decisions or carrying out resolved actions. Wohlleben seems to want to spread understanding of trees and thereby help to improve the state of their lives where they are not being treated well. Such changes would, by his explanation of the interdependence of organisms, have a positive ripple effect.

Additionally, Wohlleben seems to want to show and explain intricate workings and complexity, stunningly multi-faceted systems – that, actually, can be found everywhere in nature. Perhaps he reverts to comparing to humans often because that makes it easy for a human reader to understand.

Through exploring the similarity between trees and humans, he also brings the reader to a deeper philosophical question of free will. Why shouldn't trees have the same level of free will as humans or humans the same level as trees – why do we regard trees' behavior as a coerced result of situation but humans' as decision-based? Perhaps, though he never says it, Wohlleben also believes that people would understand humanity better by realizing the similarities between people and trees.

While Wohlleben sometimes looks at a function of a tree and concludes that it is person-like, can 'think,' or something similar, he does the reverse at other times. He may begin with the assumption that trees can 'think' and continue by using that as a lens to look at the tree, drawing all sorts of conclusions. While these inquiries are often very interesting, he never states that they are simply speculations. And within these passages, he is clearly choosing to present only the details that are in line with his assumptions.

Vocabulary

chlorophyll, vestiges, humus, fungal, coniferous, pheromones, procreate, savannah, toxins, larvae, tannins, arboreal, dissemination, hyphae, sate, olfactory, microclimate, bereft, malaise, desiccated, wrought, deciduous, mast year, windfall, hiatus, stigma, catkin, expend, off kilter, earmark, knell, embryonic, dormant, node, compartmentalize, cohort

Chapters 7-12

Summary

Chapter 7

Wohlleben describes the ideal appearance for a tree as having a straight trunk and strong branches starting only higher up, forming a symmetrical crown. He explains that trees of this shape have more stability. If wind or other forces tear at the crown, the impact is felt down the whole trunk and at the roots. Asymmetries or weak spots could lead to the tree cracking. A forked tree, especially with a V-shape rather than a U-shape, ends up with its two forks swaying in different directions and breaks more easily. Trees on slopes can be pushed down by moving snow or soil as they grow, so their lower parts end up curved and the top grows straight. Also, on the edge of deciduous forests, there are more angled trees because they try to reach the sunlight. They may have shorter lives for this but can photosynthesize more.

Chapter 8

Trees store up water in the winter, when there is lots of rain and they take a break from growing. This can last until summer, but if it stops raining then Wohlleben saw that spruce dry out and crack along the trunk. However, trees learn from such an experience and ration their water in the future. Wohlleben saw that spruce, though accustomed to abundant rain, learned to live more frugally on a dry slope in “his” forest and became more resistant to dry weather.

Some trees lean on their neighbors and if one is felled or falls, the other gets micro-tears where it bends. It strengthens those spots until it stands sturdily alone. Dr. Monica Gagliano also showed that plants can learn in an experiment where water was dripped on mimosas (which close their leaves when touched). The mimosas learned that there was no harm being done by the water and so remained open after some time, even after a few weeks. Trunks have been found to vibrate when the water flow has stopped and produce ultrasonic sounds, Wohlleben compares this to the vibration of vocal cords and says that it seems like the trees are screaming.

Chapter 9

Fungi have characteristics of both animals and plants, they do not photosynthesize and their cells are made of a material not found in plants. Fungi are the largest living organisms known on Earth, with a thousand-year-old one covering 120 acres in Switzerland and a 2400-year-old one sprawling 2000 acres in Oregon. Trees use mycelium, the fungus’ underground portion to extend their root network and access more water and nutrients. Fungi grow into and around the roots, and send them supplies from far-away soil and other trees. The fungi are fed by the trees, and in return the mushrooms filter out pollutants such as heavy metals and defend the tree against

bacteria and harmful fungi. Fungal networks can join trees of different species, supporting the diversity of the forest. There are also many other species that help trees, such as woodpeckers which keep bark beetles from killing spruce.

Chapter 10

Water is transported from the soil to the leaves in several ways. Capillary action, the same as when liquid in a cup stands slightly higher at the edge, is one factor. The water pipes in trees are only 0.02 inches or even less in diameter, and this can account for water rising to three feet. Transpiration, the leaves and needles releasing water vapor, is another factor. The suction created pulls water through the tree. Osmosis also plays a role, as water flows into cells with higher sugar concentrations. However, these factors together are not sufficient to explain the amount of water being transported by trees. So researchers are investigating more possibilities. They have noticed strange noises in trees, perhaps from small carbon dioxide bubbles in the trees' tubes which may lead to an explanation.

Chapter 11

Tree bark is similar to human skin in that it protects the insides of the tree, lets gas and vapor in and out, ages, and regenerates. To grow wider every year, old bark is shed and new layers come in. Beeches and silver firs renew their bark at a faster rate, so their bark is smooth for longer whereas pines renew more slowly and their bark cracks. The age can also be observed at the top of the crown, where branches begin to slow their growth making deciduous ones curve and coniferous ones grow sideways. Old trees grow in width more than in height, and eventually they shrink too. At some point, fungi may enter through moist breaks in the bark and grow large half-circles around the trunk. They move far inside the tree too, and eventually the tree becomes so damaged that it snaps.

Chapter 12

Wohlleben has seen many oaks struggling to survive among beeches. If beeches grow close to oaks, they block out most of the sunlight because they are taller. The oaks begin to grow leaves close to the ground to try and rake in some more light, but the effort of growing the leaves is greater than the energy they are able to get from it. They often cannot get enough light and die. However, oaks contain tannins that prevent them from being attacked by fungi and insects; and they can replace fallen branches. Both of these make them more storm-resistant and let them survive better than beeches in open areas.

Analysis

Wohlleben's writing is based heavily in anecdotes. Many chapters begin with a short story from his life, which he uses as a starting point in order to explain a function or characteristic of trees (or other organisms, as he actually explores biological phenomena in general, as opposed to just trees). Many of the pieces of information are

surprising or little-known. In fact, he prioritizes how interesting the information is over the comprehensiveness or sequential progression of the book. The reading feels a bit jumpy at times, both within chapters and between them.

Wohlleben largely uses a story-telling style, even for very conceptual matters. As he progresses from anecdotes to technical details, he still uses the same style and tells of microscopic occurrences as a story as well. The book is written to entertain - his tone is conversational and he uses many exclamations and humor. He often uses familiar concepts as analogies or metaphors to explain the biology concisely, e.g. “This connection makes fungi something like the forest Internet” (51).

Wohlleben explains well-known and lesser known biological facts and systems, often giving background information for the reader to better understand something, but not reliably so. Like the book’s progression, his decisions here seem sporadic, but it seems to be the sacrifice in order to maintain fascinating exploration.

The book is written for a casual reader with some interest in the scientific background of Wohlleben’s observations. Thereby Wohlleben is at a difficult intersection of wanting to explain his findings and convey their legitimacy, but he is also careful not to have too many technical details so as not to evict any reader who does not care for these elements. Engaging his reader sometimes prevents him from keeping his writing completely scientifically accurate.

His writing is not always strictly logical, perhaps simply because he does not give all the relevant information. He tends to present conclusions without a full explanation of how he arrived at them. For example, in Chapter 3 he shares that students at RWTH Aachen University found that all the trees in a forest photosynthesized at the same rate, producing the same amount of sugar per leaf. He explains that all the trees grow in unique locations with different growing conditions, so he expected them to photosynthesize at different rates. However, he concludes at this point that the trees must be equalizing their differences by exchanging sugar through their roots, which is not at all necessitated or supported by what he has said. What if a tree with poorer growing conditions simply has less leaves than another? Or the trees achieve the equal rates via some other process. Wohlleben gives no explanation or evidence to clarify.

Wohlleben is not careful to differentiate between causation and correlation. And he gives evidence to support his claims for some things, and even has an appendix of sources, but also leaves many statements unsupported. He also often does not state the level of specificity or generality of his assertions, for example, clarifying if he made an observation in “his” forest, if this is something that has been observed in many places, or if it is such a widely observed characteristic that it is accepted as universal.

Vocabulary

buffet, betide, permafrost, stockpile, stricken, spore, cambium, ultrasonic, chitin, mycelium, dicey, woodboring, capillary action, transpiration, osmosis, cohesion,

pathogens, regeneration, slough, fastidious, impervious, vascular, cellulose, lignin, cadaver, relegate, permeate, lichen

Chapters 13-18

Summary

Chapter 13

Trees adapt to many characteristics of their environment - light, dark, wet, dry, hot, cold, lacking in nutrients, stormy, and much more. Beeches thrive in moderate Central European conditions, and other species have adapted to extreme conditions to find space.

Spruce are specialized to cold and long winters. Oils in their needles and bark keep them from freezing. They can have masses of snow fall on them without breaking. Their branches can bend downwards when slow lands on them so that they rest on each other. This also makes the tree narrower, which means that less new snow falls on it. And their trunks are very straight.

Yews and hornbeams grow under beeches, so they use little light and grow slowly. Beeches prioritize their roots so they can store nutrients and even grow back after being eaten or knocked over.

Alders can grow in swamps where other tree roots rot because air can travel through their roots.

Chapter 14

Wohlleben informs that a tree is defined as “a woody plant with a trunk from which branches grow” in his dictionary (79). So he suggests that, if there is not one dominant shoot, the plant is a shrub or bush. Although he points out that this dividing line is blurry on both sides. Next he wonders about trees that have been cut down. Are the living remains of the stump in the first chapter truly alive? Are the trees that re-grow from a severed trunk very old or very young? He expresses that, in the case of a tree in Sweden of which some parts are 9550 years old and some younger, the roots are truly that old and that is the most significant part. The roots are the most permanent part of the tree and are also responsible for all its chemical activity. Wohlleben wonders, since he has given several examples of trees learning, if they have such a system as a brain. This would require electrical activity as well as the chemical, which has been observed in trees since the nineteenth century. At the University of Bonn, root tips were investigated for brain-like structures. Researchers there observed that, as roots move forward through the ground, electrical signals are transmitted when the roots encounter an obstacle and they subsequently change direction.

Chapter 15

Soil was created by geological processes such as glaciers grinding rocks into sand and dust, added to by living matter decomposing into humus. Roots then allowed the

stability to keep soil stationary. Erosion is threatening to wipe out cultivated forests, whereas the untouched forests are gaining in soil every year. Wohlleben maintains that the life in the soil is extremely important to the forest, apparently more important than the animals above ground, and that we know less about it than about life in the ocean. Many species are still undiscovered, most of them too small to be seen with a magnifying glass. Beetles mites are one underground species. They eat leaf litter, fungi juices, rotting wood, dead snails, and much more so they are essential to the decomposition process. Many such tiny animals have died out as the tree species in forests were changed around. Wohlleben theorizes that microscopic organisms could be brought back in the feathers of birds. Though in a recent study, a restored forest has not regained its fungal and bacterial support after more than 100 years. Also, in order for these the support systems to spread through forests again, intact forests need to be nearby. Many solutions have already been found to make forest preservation economically feasible – forest graveyards, eco-tourism, and military support are just a few of the possibilities.

Chapter 16

The forest is a ‘carbon dioxide vacuum’ – the carbon dioxide cycles between different parts of the forest without overall gain or loss. Trees take CO2 from the air for photosynthesis which is converted to hydrocarbons that make up their bodies. When a tree dies and the wood is broken down, only a little of the CO2 is released back into the atmosphere (contrary to some assertions that try to argue for the CO2 neutrality of burning wood). As the wood breaks down, it moves deeper and deeper into the soil and becomes humus. Many of today’s forests do not have the chance to do this because trees are logged, which has the additional effect of prompting animals in the ground to consume humus and release carbon into the air. Wohlleben was taught in forestry school that trees grow most quickly until they are 60 to 120 years old. Recent research has refuted that idea and actually found from 700,000 trees around the world that they grow more quickly once they are older.

Chapter 17

Trees maintain the climate that they need in their immediate surroundings. Wohlleben once observed beeches planted in a dry, nutrient-deficient pine patch making the ground capable of holding water again because their rotting leaves reduced its acidity and making their air moister by reducing the wind’s speed with their leaves. On a hot day, water will evaporate from a forest, cooling it, and thereby reducing the evaporation. This “sweating” can be seen when a tree is planted close to a house and leaves water marks on it. During a storm, trees “drink” deeply by angling their branches upward and letting the water run down from the leaves, along their branches, and in a big stream down the trunk. This makes the water hit the ground with more force and seep down to the roots. Conifers are adapted to regions with more rainfall, and the water runs off their umbrella-like branches. They collect 15% less water than deciduous trees and so struggle in the less rainy regions they have been planted in.

Chapter 18

Water is transported from the ocean to land by clouds, but these have spent their rain, at the latest, after 400 miles over land. However, when the rain lands on trees, a lot of it can evaporate again and move further inland. So forests are needed at the coast and all the way into the interior of a continent, for water to be transported further. In Brazil, the Amazonian rain forest is drying out. The terpenes that conifers release to defend against insects, mentioned in Chapter 2, cause moisture in the air to condense on them, making clouds above them thicker than elsewhere.

The forest soil can act as a water reserve, collecting rain water and bubbling it up when it is saturated, creating springs cold enough for freshwater snails. Trees help to stabilize the temperature of small streams. In the winter, their branches are bare and allow more sunlight to filter through. In the summer the leaves reduce the sunlight, ensuring that the water does not get too hot or too cold for the salamander larvae and tadpoles living there. Fallen trees and beavers also create calm water habitats for other organisms.

Analysis

Wohlleben sometimes addresses the reader with a question or a prompt for a thought, and at times ends up sounding like a teacher. He is, of course, sharing knowledge throughout the book. But it is also suited to readers of a wide age range, bearing interest for teenagers as well as retirees. And he seems to fall into a slightly patronizing tone at times.

Wohlleben sometimes exaggerates to the point of inaccuracy. For example, he says “For trees, though, these creatures are probably way more important. A forest would have no problem doing without its larger inhabitants. Deer, wild board, carnivores, and even most birds wouldn’t leave any yawning gaps in the ecosystem. Even if they were all to disappear at once, the forest would simply go on growing without many adverse effects.” This cannot be true, based on an example he gave himself. He shared that the wolves disappearing from Yellowstone had an extremely widespread effect on all the different parts of the park’s ecosystem.

The author explores the structure of trees, their design if you will. He shows how carefully they are suited to their needs, such as the conifer’s reaction to snow. The level of precision of the “engineering” of evolution reminds us that humans have not reached that level in their creations. Thus humans can keep learning from these systems and simultaneously understand the importance of conserving these artifacts.

Wohlleben brings his reader to the forefront of particular veins of biological research. His references and brief summaries of recent research as well as the glossary provide significant starting points into seemingly fascinating new worlds of knowledge. Some of what he shares is only speculation today, yet to be investigated and determined. Many people are skeptical of the kinds of ideas Wohlleben shares, rightly so to some extent as Wohlleben asserts some matters as true after only one study has been done on the subject. Though he also gives insight into many supported recent developments.

Though the book’s title may be a little clichéd, some of the processes Wohlleben explains are truly awakening, such as the role of trees in transferring water inland. That climate affects trees is a given; but that trees affect climate on such a scale is eye-opening. The common perception of the environmental importance of trees is so far removed from this concept, that it makes the reader seriously consider how many other functions trees serve that are vital to environmental functioning but people have never thought of.

Vocabulary

jettison, frugality, depleted, tundra, coppicing, neurological, impenetrable, repository, filaments, substrate, bituminous, detritus, herald , anthracite, peat, accru, rejuvenate, biomass, whippersnapper, exhortation, subservient, stucco

Chapters 19-24

Summary

Chapter 19

Wohlleben argues that the representation of nature as a careful balance of organisms doing things that are good for everybody is false. He says the forest creatures are ruthless and limited by availability. Woodpeckers have flexible beaks and shock-absorbing muscles that let them peck holes into trunks, out of which the trees' blood flows, which the peckers eat. Aphids attach themselves to leaf and needle veins, letting the sap flow through them, filtering out the protein, and expelling the carbohydrates as a sticky liquid. The trees defend themselves against 'sap-suckers' and resulting infections by releasing defensive compounds and forming a thick outer layer of bark. Aphids benefit other organisms though, such as ladybugs, ants, bees, fungi, and bacteria who eat the aphids and their honeydew. Gall midges and wasps lay their eggs inside leaves, the larvae release chemicals that harden the leaf around them (into a gall) letting them feed in safety. Caterpillars and sawflies eat the leaves and needles. The bird cherry secretes nectar that attracts ants, because they will also eat the caterpillars on the tree.

If a bark beetle successfully penetrates a tree to the cambium, it will signal to its kin and they kill the tree, as the beetle tends to choose weakened trees. The tree tries to kill the first beetle because then the others will not follow. Deer flock to clearings where a tree has recently fallen, and try to eat the saplings' leaves before they grow too tall to reach. Male deer pick flexible young trees of rare species to rub their antlers against, they spend a few days shedding the outer skin, killing the tree in the process. Deer typically live in grassy areas, but since they have been displaced from those by humans many now try to survive off of bark in forests.

Chapter 20

Woodpecker holes allow many forest creatures to make nests. Each woodpecker makes several holes, and the family lives distributed across them. Woodpeckers regularly clear the holes of fungi, extending them in the process. The nuthatch makes the entrance smaller using mud when it moves in. Bats move between holes frequently to avoid getting parasites. Owls need to wait for the trunk to crack so the entrance widens, or sometimes until several holes on top of each other rot and merge into one. The trees try to defend themselves against the holes because otherwise they are often attacked by fungi and rot. However the rotting trunk becomes the home of wood ants, fungi, beetles, and other insects. The species diversity supported by the trunk stabilizes the entire forest ecosystem.

Chapter 21

Wohlleben gives more details on the biodiversity supported by trees. A 600 year old, 170 feet tall tree in the Bavarian Forest was found to house 2041 animals of 257 different species. Tree crowns can contain wetlands when rainwater collects at trunk divides. And the dead trunk is as great of a resource to the forest creatures as the living one. Thousands of fungi and insects feed on the trunk, decomposing it. A fifth of all animal and plant species depend on dead wood. A dead trunk can also serve as a cradle for saplings to grow in – called “nurse-log reproduction” (135).

Chapter 22

Do trees hibernate? They store up as much reserve food as possible before the winter, but they cannot get fatter like bears to store extra reserves. Deciduous trees then drain the energy from their leaves, and pull in their chlorophyll as well. When they drop their leaves, they are making themselves less vulnerable to the force of wind and the weight of snow. And they thereby excrete any waste products. Young trees and other plants growing close to the ground continue to photosynthesize later in the fall and begin earlier in the spring than the adult trees, taking advantage of the gap in the canopy. Alders, ash, and elders are exceptions in that they shed their leaves while they are still green. They have the nutrients and energy available to do so. A conifer fills its needles with antifreeze and covers them with wax to protect the water inside. Some conifers drop all their needles, and most drop the oldest ones in order to remove waste.

Chapter 23

Wohlleben looks into how trees can tell when they should shed their leaves and when to grow new ones. The frozen water in the trunk thaws in spring and begins to flow again. Fruit trees seem to count the number of warm days before growing leaves. But the length of the day is also important, and beeches wait until it is light for 13 hours. Trees might be able to sense the amount of light through their buds and in their trunks. The combined knowledge of whether temperatures are increasing or decreasing and days are getting longer or shorter tells the current season.

Chapter 24

Three oaks grow close together by a country road near Wohlleben’s home. They are so close that their canopies have merged, but they change color at different times. One sheds its leaves sooner, ensuring that it can pull in all the energy and chlorophyll before shedding. The others wait, photosynthesizing as long as possible. Because of climate change, it is becoming more difficult to accurately predict when the cold will hit. Another thing Wohlleben has noticed is that some trees ‘decide’ to grow branches low down on their trunks. They can gain a little more energy but risk being attacked by fungi as these branches often die. In the same clearing, some trees will grow branches near their base and others will not.

Analysis

Wohlleben tells of many different instances of interconnectedness, whether it be between trees or between various organisms. He shows the reader that the survival of the forest's inhabitants depends on balance in their giving and taking. Because there are so many organisms in the forest and therefore many more relationships of 'trade,' it is often difficult to observe how and where the giving and taking evens out. But Wohlleben's descriptions include a few examples. He explains in Chapter 19 that the tree gives to woodpeckers, aphids, gall midges, wasps, and deer and we see no immediate benefit for the tree from these creatures. However, we know from previous chapters that the tree is supported for example by fungi, microorganisms in the soil, and humus (which is decomposed organisms). Wohlleben mentions too that ladybugs, ants, bees, fungi, and bacteria benefit from aphids. So one closed loop is that aphids can sap nectar from the tree, sometimes creating an excess which ants can eat. And ants give back to the tree, for example by improving the soil structure. If one wants to understand the cooperation of the entire forest, the web of exchange is very large. But the health of the ecosystem shows that it functions well enough. Taking is limited by availability and restraint, giving occurs voluntarily and involuntarily, and all the organisms seem to create enough balance that it works out.

Wohlleben shows arboreal processes that people don't understand for a great variety of reasons. Some of them are very slow and therefore not recognized, others are simply invisible. For instance, trees create a store of energy reserves before the winter, but it all takes place inside the trunk. Or they release antifreeze and cover their needles in wax, but most people would never observe it. Another example is that we speak at length of the leaves dropping in the fall, comment on their color change and maybe even their texture. But the observations we can make strolling past don't tell us that the tree is actually removing waste from itself at this time too. The author shows that humans' realizations are limited by their needs and perception in life.

To look into perception, a dog for example has its sensory intake focused on smell and sound, with those faculties greater than our own. Our ability to see with detail and color is better than theirs, because we take in more via our eyes. The difference between our perception and trees' is a little more abstract. Many would argue that the comparison is pointless because they believe that trees have no perception whatsoever. Nevertheless, whatever arguments one could have about the word 'perception,' trees clearly respond to their environment. They do not have eyes, but they will grow towards light. They register gases in the air and move towards or away from sound.

These are more processes that we do not notice when we glance at a tree, because our 'perception' is an inherent difference. However, independent of our similarities and differences, Wohlleben wants to help humans gain understanding of trees.

Probably, trying to classify trees' abilities into five senses is too limiting. It seems that their methods of taking in information about the environment (even if only to have an automatic response) can be understood better if we let go of that concept and simply

observe their behavior. Trees can respond to their environment in ways that we are completely incapable of and that cannot easily be classified into any of the senses, such as growing their roots towards water. Wohlleben makes such comparisons several times, perhaps to keep the interest of his reader or to show the similarity between humans and trees, though this one is actually only symbolically true and less so literally. And he does use inverted commas for words such as ‘see’ and ‘hear.’

Vocabulary

arid, taiga, reciprocal, rivulet, denizen, humic, ornithologist, scourge, opportunist, gall, pupate, defoliate, succulent, resinous, phenol, innocuous, mycorrhiza, impetuous, brood, tawny, pummel, recuperate, jettison, nodules, carotene, anthocyanin, germination, foliage, triad, laggard

Chapters 25-30

Summary

Chapter 25

A tree can get sick if it puts too much energy into growing and therefore neglects its self-defense. They have defensive antibiotic compounds and compounds to ward off insects for a large area around them. When a gap opens up in the canopy, many trees seize the opportunity to make a growth spurt but thereby risk an attack by fungi or insects. In Switzerland, some exceptional trees were found to have been attacked by a fungus that killed their cambium, but the roots continued to pump water into the needles and their neighbors must have supplied them with nutrition. A tree can also be injured when a neighbor falls and breaks its bark, leaving it vulnerable. The tree tries to grow new wood over the opening, but a fungus may simultaneously be trying to get a hold. In the outer layers, the tree can fill itself with liquid to kill the fungus. But if the fungus manages to progress further, the wood is too dry for the tree to defend itself.

Chapter 26

Many flowers bloom earlier than trees, using the sunshine coming through the bare tree branches to store energy in their roots and reproduce, all in a two month window. Liverworts and other flowers can be seen to bloom in a colorful explosion in forest clearings. A few plants try to reach the same height as the treetops to get some sunshine. Ivy uses tiny hooks to hold onto bark and grows up trees, taking only sunlight from the tree. Honeysuckle strangles trees, wrapping itself so tightly that the tree is deformed in its growth. Mistletoes grow only at the top of the tree, leeching water and nutrients from the branches. Mosses just use hairs to hold onto the bark and use very little water and nutrients – only as much as they can absorb from the air. They grow where water collects on the tree and actually filter the air. Lichen, a combination of fungi and algae, grow higher on the tree and use even less resources. Thus they grow slowly but can live for hundreds of years.

Chapter 27

Wohlleben looks into the health problems of redwoods imported to Europe and other park trees. The redwoods do not grow as tall but wider instead. They have no support network of neighboring trees and the soil around them is extremely compacted, making it difficult to spread their roots. The containers they are kept in as seedlings are too small, so their roots are constantly cut back. This impairs the roots' abilities in their adult life as well. Because they have access to a lot of light, they grow quickly which puts air bubbles into their wood that make it vulnerable. Because their roots do not go so deep, they are not so stable and would be even less so if they grew taller. Furthermore, the common practice of pruning live branches kills an equal number of roots underground. For city trees in general, a common issue is that they are lavishly watered and cared for

when they are young, but once they have grown it becomes too much work and uses too many resources to care for them at the same level. Sometimes trees grow into underground pipes and are therefore taken down. It was determined that they grow their roots towards loose soil, which they find around the pipes. Trees along roads are missing the space to spread their roots, deal with dry polluted air, are sprayed with dog urine and winter salt, and are missing the support of soil microorganisms, fungi, and other forest aides. So they are more often attacked by insects, such as the oak processionary, and are more prone to losing branches in heavy winds.

Chapter 28

Pioneer species seek open areas, they are adapted to sunlight and grow very quickly. Because many herbivores approach them, they grow thick barks filled with repellant oils. Silver birches are one example, quaking aspens another - named for the way in which their leaves flutter in the wind, allowing them to gather sunlight on both sides. The aspens spread their roots and grow new shoots from them all around, covering up to 100 acres with trunks that are actually all one organism. The pioneers do not live very long, but make it possible for the other species to settle in their shade and thus start new forests. The pioneers reproduce quickly and can start the process anew.

Chapter 29

Trees can only migrate between generations, and so the transportation of their seeds is key. Some, including poplars and willows, have light seeds covered in hairs that can be blown around by the wind. They can travel far but have less resources and less assurance of survival. Birches, maples, and conifers have wings for their heavier seeds which can travel about a mile. Oaks, chestnuts, and beeches have heavy nuts that rely on being carried by birds or mammals that bury them underground. Migration allows trees to slowly adjust their position to changing climates. They are still slowly moving north, following the retreat of glaciers. Large-leafed beeches did not make it across the Alps quickly enough before the last ice age and thus are not seen anymore in Central Europe. As the other beeches moved north again after the ice age, they encountered land severely altered by humans. A lot of trees had been cleared, taking away their dark childhood sanctuary, and livestock was being herded into forests, eating seedlings. Silver firs are moving back more slowly than other species; they have seeds that are too heavy to be carried far by the wind and too small to be moved by animals. As the climate continues to change now, many species in Central Europe are continuing to move northward.

Chapter 30

Trees cannot adapt genetically at the rate that many other organisms do because they have such long lifespans, but they have other ways of adapting. The seeds respond to external conditions by activating certain genes, spruce as an example adapt to warm weather. Once mature, a tree can “learn,” using less water in future years if it experienced a shortage in its life. It can even add a layer of wax to its leaves and thicken its cell walls to reduce water loss. Trees also have a far greater genetic diversity

than many other organisms, which helps with their slower genetic adaption since they will not be wiped out by one environmental change.

Analysis

We coexist with trees, for some at very close quarters and others further away…with planted trees, forests, parks, or pioneers in a field. We can view the need to understand trees, that Wohlleben highlights, as a result of us needing trees and trees needing us. Their contribution to the air that we breathe, their impact on the fertility of soil, their calming and beautiful presence, and their material use are all significant to us. Our creation of carbon dioxide and deposition of organic materials and minerals into the ground are useful to them. Or we can see how, on a broader scope, we are part of a web like the forest ecosystem, but bigger. The places we live are difficult to analyze as ecosystems because so few humans today live in small self-sufficient communities. We bring in food, materials, sometimes even water from far away. So cities and suburbs are difficult to compare to the comparatively closed webs we see other organisms living in. However, if we look at a broader scope, of the entire ecosystem of the Earth, we can make such a comparison. And, just like Wohlleben demonstrated for a forest ecosystem, there is a dynamic balance as all the organisms take and give. Humans have been doing a lot of work to overcome restrictions on how much they can take, especially in the most recent decades, thus to maintain the balance, they need to do as much that gives to others.

In these chapters, Wohlleben gives detailed information on how people could create better habitats for trees. He shares how the beds along roads and tree plantations can be restructured to let trees live longer healthier lives. And this would result in less maintenance work too. Moreover, he shows that the understanding of trees is what is essential to finding such solutions. And part of that is the knowledge that, in a forest, a huge variety of species are working together to maintain this habitat. Thus, making changes to benefit trees will inadvertently benefit other species too, strengthening the trees' support system.

Vocabulary

phytoncide, protozoa, apportion, sapwood, heartwood, anemone, abstemious, troupe, hemiparasite, jibe, paunch, brazen, backfill, molt, auroch, betulin, interlope, pendulous, interglacial, conquistador, insinuate, gangbuster, imperative, stoic, batten down the hatches, proviso

Chapters 31-36 and Notes

Summary

Chapter 31

Hurricanes often flatten commercial spruce and pine plantations. Natural forests are more resilient, but if there is a wind that suddenly changes direction they may be taken down too. The trees have not developed defensive mechanisms against events so rare. Some branches are struck off by heavy rains because they grow out horizontally and then up rather than out, up, out more, and then down slightly. Though, in some conditions, even the ideally structured branches break. When snow is very wet, it is very heavy. And sometimes it becomes so cold outside while fog hangs in the air, that ice suddenly clings to everything – also creating a lot of weight. Trees with smooth bark are less often harmed by lightning because the water running down their trunks diverts the electricity. The ones with rough bark are often split open when hit by lightning. Forest fires are not so frequently started by lightning, more often by humans. North American forests naturally have some small fires, which regularly burn dry needles and twigs on the ground. When these fires are put out, the kindling accumulates, and the next fire spreads into the crowns of the trees and creates much more damage. Wohlleben observed some trees growing in a flooding area where sheets of ice floating on the water tore the bark from all the trees, leaving marks at the exact same height.

Chapter 32

Trees have recently been imported from far away, as souvenirs by travelers and through commerce. These “immigrants” as Wohlleben refers to them, often thrive when they first arrive because they are not hit by the local pests. They can only do so if they find a place suited to their specific needs in terms of climate, soil, moisture, and supporting organisms. So when people plant foreign trees, it is difficult to tell whether they will fare well or not. The foreign trees mix with the native ones, creating hybrids and sometimes replacing indigenous species. However, the insects and diseases are now being brought from abroad as well, so the foreign trees do not have that much of an advantage. Recent imports to Europe include the Asian long-horned beetle, ash dieback fungus, and giant hogweed. Wohlleben also wants to explain what exactly ‘native’ means, explaining that many people will think of country borders, but that habitats are the key factor. Thus a species is actually native in one part of a country but not in another.

Chapter 33

Trees clean the air around them, their leaves and needles filtering the particles that float by – up to 20,000 tons per year per square mile. The materials include soot, pollen, dust, acids, toxic hydrocarbons, and nitrogen gases. Conifers disinfect the air around them, and all trees put out scent compounds to communicate. Wohlleben encourages

the reader to try walking in a commercial forest and a natural one, to compare how they feel in each. Forests put out a lot of oxygen when the sun is shining, at night and during the winter they actually put out carbon dioxide. When trees are burning their energy reserves, they take in oxygen and put out carbon dioxide, which is why their roots need to be able to breathe. Trees have been found to die when they do not get a break from light or heat, so it seems they need their nightly sleep and some hibernation.

Chapter 34

Wohlleben discusses colors, explaining that he finds the sight of a green forest and blue sky immensely relaxing. For a tree, however, a blue sky signals a sunny day on which a lot of work gets done. Colors appear because different materials absorb different parts of the light spectrum. Sunlight has light of all wavelengths, and chlorophyll absorbs all but the green light. Red leaves cannot absorb as much light, because they are reflecting more of the light and do not have the chlorophyll to help them process it. The shadows in forests are actually slightly green, and that is a part of why saplings under canopies get so little light. Wohlleben concludes that people, and even conservationists, often misunderstand trees. They cannot see many processes occurring that defy their preconceptions. For example, trees are not slow in every respect, they transport water and nutrients at a third of an inch per second up their trunk.

Chapter 35

There are different initiatives in different countries to keep ancient forests intact – ancient woodlands in the U.K., old-growth forests in Australia, leave-no-trace forest preserves in the U.S., and temperate rainforest in Canada. German politicians have so far only agreed to let 5% of forests return to their untouched state. It will take about 500 years for the land under coniferous plantations to return to its natural state. The conifers will have to be left to die, in the next generation deciduous trees will join in, after two generations there will be no more conifers, and then it will take a while for all the supporting organisms to settle back into the area. Deciduous forests that have seen some commercial use will only take about 200 years. There is a common misconception that natural forests contain overgrown shrubbery and are therefore inaccessible to people, but this is not the case. It is actually less likely that a branch or trunk will fall on somebody passing through an old-growth forest than a commercial one, because of their stronger roots and support of each other.

Chapter 36

At the end of the twentieth and beginning of the twenty-first century, people have been making many changes to recognize that animals are not objects, have emotions, and deserve certain rights. Wohlleben sees it is time for us to do the same with trees – harvest paper and wood while letting trees grow in healthy habitats. Königsdorf near Cologne has made an agreement with its forest service, not to use heavy machinery and to preserve ancient trees. In Virginia, there is a Healing Harvest Forest Foundation that cuts trees selectively. In Switzerland, the constitution states that “account [is] to be taken of the dignity of creation when handling animals, plants, and other organisms.”

Wohlleben adds that we should also care about trees for the puzzles and wonders they present to us. Because sometimes they are “the last remaining piece of Nature, right on our doorstep, where adventures are to be experienced and secrets discovered” (245).

Analysis

Wohlleben continues his explanation of why old-growth undisturbed forests are more resilient than commercial ones. He gives examples of cycles and mechanisms that have developed in forests over the ages, explains why they are beneficial to the forest, and why they do not exist in commercial or planted forests. Wohlleben has worked for the last few decades on conserving undisturbed forests and reforming commercial forestry. This considered, his tone is relatively neutral when discussing the comparison of the two types of forests. However, it would not be possible to tell just by reading the book how much bias the information he presents contains. If he is presenting more positive traits of the old-growth forests and more negative traits of the commercial forests, for instance. However, the fact of greater resilience in old-growth forests is supported by many scientists, as a quick internet and literature search indicates. Thus this book can, in a sense, be seen to be distributing recent silviculture findings to the masses. Unfortunately, knowing that commercial forests are not resilient cannot lead to an improvement on its own. For that, methods must be sought out or developed to serve current needs via a different strategy. We cannot suddenly shut down commercial forests because so many other things depend on a supply of wood and paper. Thus the next step is what Wohlleben has been working on for years, but only mentions in passing in this book – supplying wood and paper sustainably. He brings up “selection cutting,” that it is a possibility for material supply, that he has been working on it, and that other groups too are working on its implementation (244). Selection cutting tries to maintain the beneficial characteristics of old-growth forests while cutting some trees from a forest. Wohlleben tells explicitly of the banning of heavy logging machinery which can be replaced by forestry tractors or even animals.

In the last few chapters, the author gives perspective and orientation to the reader. He locates the book’s teachings within today’s situation for forests in several countries. He communicates the overall state of forests today, what is being done, and what can be done to improve the situation. There is minimal undisturbed forest left in the countries he mentions (U.K., Australia, Canada, U.S., Germany), both in comparison to how much there used to be and the entire area of land. The forests have been dwindling for decades and are only now on a slight rise due to conservation projects such as the ones Wohlleben brings up. Thus it seems that he is attempting to make the reader aware of the power they have gained through the knowledge in this book. The reader now understands the significance of undisturbed forest to wildlife habitats, biodiversity, and the survival of all kinds of forests. And this understanding, or perhaps the consideration of it, is so lacking in the general population that many countries are close to losing all their undisturbed forests and therefore losing forever the species unique to that habitat. But the general population’s understanding of what a tree and a forest needs can allow for the advocacy of the management changes that are most

constructive to the survival of the forests. As his example of Königsdorf indicates, it has already been successful in that sense.

Vocabulary

dicey, hoarfrost, understory, inferno, riparian, hardwood, voracious, filament, avian, hydrocarbon, unwittingly, transfused, psyche, metabolic, iridescence, silt, exalted, beset, shorthand, silviculture, leech, irrepressible, mutualistic, scintillation, sessile

Important People

Peter Wohlleben

Wohlleben, the author of the book, is a forester who has cared for a forest in Germany for over 20 years. This forest is in Hümmel, in the Rhineland-Palatinate region. Wohlleben began reforming its forestry practices in 1994 and has continued to this day. He offers guided tours of the forest for people to explore how trees function and co-exist, there is one scheduled in the summer of 2017 that will be based around this book. He also founded a burial ground in the forest, in which the urns are placed under trees. These projects help to fund the conservation of the forest rather than logging, which was the previous source of revenue.

Wohlleben was born in Bonn in 1964 and later moved to Sinzig. He attended the Rottenburg University of Applied Forest Sciences where he received his diploma as a forester, or forest engineer. He began working for the German government, but since he saw that the regulations were harming the ecosystem he made himself independent to be able to conserve the forest.

He has written 15 books about forestry, hunting, and related environmental issues. In 2016, the movie Intelligent Trees was released. It is a documentary about Wohlleben and Suzanne Simard, exploring their discoveries of the communication between trees.

Dr. Suzanne Simard

Suzanne Simard is a Canadian professor of forest ecology, currently teaching and researching at the University of British Columbia. She has done a lot of work on the topic of the communication between trees, which Wohlleben refers to several times. The two have cooperated on a documentary and webseries called Intelligent Trees.

Tim Flannery

Tim Flannery is a fellow at the University of Melbourne, previously having been head of the Australian Climate Commission. He has researched mammalogy, paleontology, environmental science, and global warming. The foreword of the book is written by him.

Dr. Monica Gagliano

Monica Gagliano is a professor of evolutionary biology at the University of Western Australia. Beginning with marine biology, she has recently investigated how plants gain information about their environment. Wohlleben includes some of these findings in Chapter 2 ‘The Language of Trees’ and 8 ‘Tree School.’

Dr. Zoe Lindo

Zoe Lindo is a researcher at McGill University, Montreal, who looked into the moss forming on Sitka spruce over 500 years old. Chapter 8, ‘Trees Aging Gracefully,’ reveals that she discovered algae growing on top of the moss that captured nitrogen, which was available in the soil after rain.

Annette Mihatsch

Annette Mihatsch is a biology researcher at the University of Leipzig. She conducted a study on the carbon dioxide storage capabilities of trees. She works at the German Centre for Integrative Biodiversity Research.

František Baluška

František Baluška is a researcher at the University of Bonn who, with his colleagues, found signaling pathways and other systems and molecules at root tips that suggest they may have brain-like structures. Wohlleben tells of this work in Chapter 14, ‘Tree or not Tree.’

Anastassia Makarieva

Anastassia Makarieva is the scientist who explained the transportation function of forests over large land masses that Wohlleben discusses in Chapter 18, ‘The Forest as Water Pump.’ She is from Saint Petersburg, Russia.

Dr. Martin Gossner

Martin Gossner is a tree researcher who, in 2009, used an insecticide to look into the organisms living in the largest tree in the Bavarian Forest National Park. Wohlleben describes the method, in Chapter 21, as “brutal” since he killed 2,041 animals.

Chief Marilyn Slett

Chief Marilyn Slett is the president of Coastal First Nations, an alliance of aboriginal groups in British Columbia, Canada. In Chapter 35, ‘Set Free,’ Wohlleben quotes her saying, “Our leaders understand our well being is connected to the well being of our lands and waters…If we use our knowledge and our wisdom to look after [them], they will look after us into the future.”

Objects/Places

Germany

Located in central Europe, Germany is a republic with a population of about 82 million (2015). The country's formation is generally traced back to the German territory of the Holy Roman Empire, designated in 962. It has a temperate climate and includes such geographical features as the Alps, the Rhine, Danube, Lake Constance, and the Black Forest. It is about 31% forest and woodland, 35% arable land, 14% pastures, 13% urban, and 3% water.

Hümmel

Hümmel is a small municipality near the western border of Germany where Wohlleben lived and worked for several decades. It is in the state of Rhineland-Palatinate, or Rheinland-Pfalz in German. Its population was 479 in 2015, and its total area is 15.8 km2. Notable monuments in Hümmel include a church built in 1727 and another from 1871, and there is an annual celebration of music and the forest in June.

"His" forest

Wohlleben shares a lot from the beech forest in Hümmel that he has been managing for more than 20 years. He has transitioned it from a lumber production to a conservation area. In order to fund the conservation, he founded a burial ground in the forest, where urns are buried under living trees. Wohlleben eliminated the use of heavy harvester vehicles and pesticides, and the forest has since won several awards for its ecological exemplarity.

Commercial coniferous forests

Wohlleben often brings these up as being one of the most common types of forest found in Germany today. Spruce, pine, and fir have been planted in many regions to harvest wood. Wohlleben points out that they are often put in habitats that they are actually not suited to. They are brought down from mountainous areas into warmer and drier climates.

Old-growth deciduous forests

This is another type of forest that Wohlleben often refers to, another kind commonly found in Germany. Beeches, oaks, and other leafy trees are found coexisting in undisturbed forests in moderate German climates. Many of these forests have been cut

down to be replaced with the conifer plantations, and Wohlleben is trying to preserve them.

RWTH Aachen

Rheinisch-Westfälische Technische Hochschule Aachen is a leading technical university in Germany with a research focus. Several RWTH students conducted thesis research in the Hümmel forest, and Wohlleben includes many of their findings in his book. He seems to have worked with them to some extent, since he knows many details of their work.

Swiss Federal Institute for Forest, Snow, and Landscape Research

The institute is part of a group of Swiss governmental universities and research institutions. It conducts “terrestrial environmental research to provide solutions improving quality of life in a healthy environment,” according to their website. Wohlleben brings it up in Chapter 10, ‘The Mysteries of Moving Water.’

University of Bonn

The University of Bonn is a public research university in North Rhine-Westphalia, Germany. Its institute of Cellular and Molecular Botany has looked into brain-like structures at root tips, which interest Wohlleben. He summarizes this research in Chapter 14, ‘Tree or not Tree.’

TU Munich

The Technical University of Munich is a research university in Bavaria, Germany. Wohlleben refers to tests conducted there that showed that leaves unfurl earlier after a colder winter in Chapter 23, ‘A Sense of Time.’

Bavarian Forest National Park

The Bavarian Forest is in the east of Germany, bordering on the Czech Republic. And the combination of the Czech and German portions of forest form the largest contiguous area of forest in Central Europe. It was established in 1970, and includes spruce, beech, fir, maple, linden, elm, ash, and yew. Wohlleben tells of Martin Gossner researching there in Chapter 21, ‘Mother Ships of Biodiversity.’

Themes

Trees' capabilities

Wohlleben demonstrates that trees have more complex capabilities than most people think. Wohlleben shares abilities of his arboreal friends that are literally difficult to see: some occur inside the tree – like the storage of water for the winter, some are too small. Others happen slowly – such as a branch growing in a different direction to make up for a storm injury, things happen below the ground – like sending chemical messages to other trees through the roots, and sometimes the signs are just too subtle – such as when a layer of wax is added to the leaves and needles to conserve water.

Beyond these factors, there are things people do not realize because of their mindset. For instance, fruit trees wait until there have been a certain number of warm days to begin to grow again. A person must actively be trying to understand the trees to observe such a thing, by noting down data from different years and comparing that to the conditions. Only somebody with the intention of understanding as much detail as Wohlleben or the researchers he incorporates into the book will realize such a thing. Wohlleben also reminds the reader that air moving through a narrow pipe inside a tree and causing vibrations is no different from the process that happens inside humans' air pipes and we call vocalization. Yet we regard one as speech or the purposeful formation of sound and the other as a coincidence, a side-effect. We have, due to our assumption that trees do not think or take intentional action, precluded that this occurrence is meaningless. Wohlleben challenges the reader to question such assumptions and consider the abilities of trees that would thereby be revealed.

Another way one can miss a tree's ability is due to lack of prior knowledge. If one sees a dead insect in a trunk, one might not think much of it. It takes some background knowledge of a beetle's intention and a tree's defense mechanisms to understand that it was perhaps killed by the tree, trying to crawl to the trunk's interior. A lot of the abilities of trees are still being researched right now, so it is not clear yet what they are truly capable of. Thus there is also a promise for discovery to come.

Interconnectedness

Wohlleben illustrates the interconnectedness of trees and all parts of the forest, purporting that this can be generalized further onto the interconnectedness of all the parts of any ecosystem. He demonstrates that the forest is all give and take in a way that is balanced enough that most members survive. The reciprocity is not always apparent because there are so many organisms linked up in the web of giving and taking. He shows a few loops closing, as for instance the tree gives to the aphid, which gives to ants, which give back to the tree (ants improve the soil conditions for the tree). Thus, via a large web of support, where each organism is an element and the exchanged goods or services are the connections, the forest as a whole and each part

of it remains healthy - with a few exceptions, as some organisms will die in one part of a forest. There is no apparent system of top-down organization, but it seems rather that through each member taking what it needs (but being limited by circumstance or showing restraint) and giving to others (sometimes voluntarily, sometimes because it has no choice) every part of the forest lives on and there is some sort of dynamic balance.

Trees help each other to live - cooperatively create their hospitable habitat, crowdsource and crowdfund food, volunteer for jobs that they are capable of, coincidentally do another a service through an unrelated action, give whatever they can, take whatever they need. And the exact same is true for the trees and their co-inhabitants – fungi, insects, birds, moss, microorganisms, mammals, shrubs, bacteria, and many more. A tree can provide a home for thousands of organisms, and thousands more are needed to keep the soil full of nutrients and structured well. Birds carry the trees' seeds so they can procreate. Mistletoe grows on the top of a tree and lives from its food. The moss growing on a tree creates nitrogen for the soil. And fungi are fed by trees. Take it a few levels further, through bigger and bigger ecosystems and you can see cooperation and interconnection as the basis of all life. This is where Wohlleben's insights melt boundaries and biology blurs into philosophy.

Resilience of undisturbed forests

Wohlleben explains throughout his book that commercial forests are less resilient than the undisturbed kind. He uses examples of properties and mechanisms that have developed in forests over the ages to explain why those properties and mechanisms are beneficial to the forest and why they do not exist in commercial or planted forests. The underground root and fungal networks that have established themselves in older forests cannot grow if trees have been dug up and re-planted because their roots are permanently damaged after this. And they take a while to grow, so if trees are constantly being felled and replaced with new ones, that makes it difficult. Trees in commercial forests are also often placed far apart. This prevents them from sheltering each other from the elements and creating a microclimate between them, as they do when they are closer together.

Some of Wohlleben's arguments along these lines are implicit. Sometimes he simply compares certain properties of the two types of forests, with almost all the features illustrating the advantages of undisturbed forests. He makes a few direct recommendations, including conserving the old-growth forests that still exist today and changing management practices for commercial forests by respecting a species' natural habitat, cutting selectively, diversifying, and using lighter machinery to protect the forest floor. Wohlleben considers this the next frontier, though he only mentions it in passing until going into more depth in the last two chapters. In order for a lasting improvement to be realized, humans' needs from trees need to be serviced in harmony with their growth and well-being. Paper and wood still need to be supplied until better materials are implemented, and thus sustainable forestry practices must be put into place.

In Chapter 27, ‘Street Kids,’ Wohlleben investigates a more extreme case than the cultivated forest – trees along roads and in parks. He shows that these trees are able to maintain even less of the mechanisms that old-growth forest trees rely on. And they are even more vulnerable to the elements, insects, and age than the commercial forests. He presents the park and city trees as though they are further along the same continuum as the commercial forests. In Wohlleben's delivery, humans have interfered with trees’ processes in a similar way but to a greater extent in cities. For instance, park trees are spaced even further apart than commercial ones. And commercial plantations have them further apart than they are in natural forests. Similarly, city trees’ roots are more severely damaged than those of planted ones. The procedure by which an older beech shades a younger one, causing it to grow slowly when it is young and thereby grow stronger is even less functional in the city. The species diversity is also diminished further.

Understanding Trees

Understanding how trees function can help humans to integrate them better into the ecosystems we live in, Wohlleben asserts. Wohlleben has identified some ways in which we can improve the conditions for trees whose lives we have already begun to impact - those growing in cities or the ones whose habitats we are slowly cutting away at. Because the understanding of trees includes the importance of many organisms working together, improving conditions for trees has a ripple effect. Better understanding of trees leads to a better understanding of many parts of the ecosystem, and integrating trees better leads to integrating many elements of the ecosystem better.

Wohlleben identifies our difference in speed as a major contributing factor to our lack of understanding – many of the tree’s processes are so slow that they are not recognized. However, Wohlleben also shows many processes of trees that are just as fast as humans’ but humans do not notice for other reasons. The fact that trees store up reserves before the winter is just not visible to us, because it is happening inside the trunk. The antifreeze released into conifer needles is also hidden and their wax coating very difficult to see. People cannot tell that there are waste products in the leaves when they are dropped in the fall. Our waste appears so different from the way the trees’ looks, smells, etc. And a substance such as resin or latex can be useful to people, so they do not mentally classify it as waste.

Humans are simply limited or biased by their own role in the world, Wohlleben points out. It seems that trees’ methods of taking in information about the environment can be understood better if people can let go of their assumptions and approaches to life in order to simply observe trees’ behavior unbiased. Trees can respond to their environment in ways that humans are completely incapable of and that cannot easily be classified into any of the senses, such as growing their roots towards water. Thus Wohlleben shows that there is actually much to be done yet until humans truly understand trees. Wohlleben prompts the reader to try out observing trees without bias several times. He recommends walking into a forest, letting go of any preconceptions, and just observing what is going on – trying to understand how this system functions.

“Engineering” of evolution

Wohlleben presents the idea that trees have evolved to be able to do things just as impressive and scientific - if not more so, in some cases - than humans.

The structure of trees, or their design, is also explored throughout the book. Wohlleben uses examples to demonstrate that the trees are carefully suited to their needs, such as the conifer’s design for snow. When snow lands on a spruce, its branches can rest on each other due to their shape and flexibility. This makes the spruce narrower, leading to less snow falling on it. Additionally, its perfectly straight trunk leads to the weight being distributed evenly throughout the trunk, which makes it more stable. Another stunning instance is the bird cherry tree’s prevention of inbreeding. When a bee pollinates a stigma, the tree grows a tiny tube to the ovary. However, the genes of the pollen are tested first, and the tube is blocked, stops growing, and withers away if the genes are the same as the tree’s. Humans are now able to test for genes, but only after centuries of scientific research. And it is a very resource-intensive process. The tree’s process is not as resource-intensive and it comes from an organism that we have designated as unconscious and unable to think. Wohlleben invites the reader to reconsider trees’ ability to think. But even if one rejects this notion, the thing that is clear is that this tree has achieved precision and finesse in its structure.

Wohlleben’s repeated attention to careful design in nature makes the reader aware of how far humans have to get to a point of creating things at this level consistently. Wohlleben extends many invitations to marvel at this, such as fungi’s soft and fragile living hyphae extending over acres and transmitting electrical signals, conifers releasing volatile substances into the air above them to increase condensation and thereby gaining precipitation, or hundreds of species living in one tree. Hereby, Wohlleben communicates to the reader that humanity has much to learn yet from trees, plants, all the other organisms on Earth, which also factors into the importance of conserving these. All of humanity’s major engineering breakthroughs have been inspired by other things on the planet, they have been the only things available to observe for millennia.

Via the interconnectedness of all organisms, we can see the Earth as a superorganism, Wohlleben asserts, and we can apply this concept of engineering to that superorganism. Within that framework, the fact that humans are trying to produce the same level of “engineering” is actually just one part of the organism trying to do what another has already achieved.

Styles

Structure

Wohlleben's writing could almost be described as flow of consciousness. He often moves on to another topic due to a detail of the previous one. Moreover, he explores a lot of tangents as well as making many side notes. The structure is based heavily in his anecdotes. Many chapters include - and some begin with - a short story from his life. They are often used as a relatable access point to technical information. On another note, Wohlleben's priority in choosing and organizing the elements of the book seems to be that the information is interesting. For this, he sacrifices a sequential progression and comprehensiveness. The book is loosely organized by topic, in that each chapter addresses an individual topic. The starting point of the chapter is usually clearly defined, and he looks into that more or less depending on the chapter.

To give an example, Chapter 12 begins "When I walk through the forest I manage, I often see oaks in distress" (68). It is anecdotal but also already leading the reader into Wohlleben's investigation of how and why the oaks are in distress. He goes on to describe "Anxious suckers sprouting at the base of the trunk…These spindly tufts of growth ring the tree and usually quickly wither away" (68). Here he is still sharing his experience as a narrative, but that narrative contains further description that gives insight into the oak's distress. Wohlleben then uses a metaphor of "ground-hugging solar panels" to explain the oak's problems further (68). He continues by describing an oak's healthy functioning, then the problems that beeches cause for oaks via a detailed description of how the growth of a beech next to an oak may pan out. Next, he asserts that oaks are very resilient when they are in an open space, throwing in a description of some individuals that managed to grow on rocks in "his forest." And the chapter concludes with a German saying about old oaks and wild boars. This chapter is one of the shortest, so it is easier to have an overview of it. The longer ones have more things thrown in, will take many tangents, and sometimes jump suddenly back to a previous thought. From chapter to chapter, the progression is sometimes clearly linear, with concepts building on each other. But usually it is not, and Wohlleben may create a connection in the first sentence which is often more humorous than serious. Overall, the reading seems to follow Wohlleben's chain of thoughts which can feel jumpy, within the chapters and between them.

Perspective

Wohlleben presents his personal process of learning, with his starting point the teaching of commercial forestry that he completed in 1987. From there the book explains his realizations during his many years of experience, observation, and enquiry in his work thereafter. He learns for instance that conifers have a harder time surviving at lower altitudes than at higher ones, that beeches can restore dry nutrient-deficient soil around

pines, or that commonly employed forestry techniques like stripping bark from a tree are unnecessarily harmful.

The translator, Jane Billinghurst, has tried to make the content clear and understandable while keeping his voice intact. She has translated not only the literal meaning but also tried to find expressions in English equivalent to the German ones. Billinghurst and Wohlleben even changed some things more significantly, past the point of translation, adapting examples and explanations for an American audience (such as giving temperatures in Fahrenheit, or using a relatable example in the U.S. like national parks).

Tone

Considering that Wohlleben has worked for the last few decades on conserving undisturbed forests and reforming commercial forestry, his tone is relatively neutral when discussing forest management practices or the treatment of trees and the environment. For example, he explains in Chapter 16 that “hardly any coal is being formed because forests are constantly being cleared, thanks to modern forest management practices” (94). The information he presents here is not biased and the tone is not persuasive, but the phrase “thanks to” could be interpreted as sarcastic depending on one’s perspective. He goes on to explain the coal-related mechanisms in the soil in a factual tone. The first 34 chapters are a very mildly biased description of how a forest functions, and the bias often comes from Wohlleben simply sharing his personal experiences. The last two chapters clearly state Wohlleben’s opinions, persuasive tone and all.

The book is certainly not written like a textbook, by an anonymous and uninvested scientist, the tone has a personal perspective. As for bias on a wider scale, in terms of content, it would impossible to tell as a reader if he presents more information that supports one view more than another. For example, he could be giving many examples that show the resilience of undisturbed forests and not sharing that commercial forests are resilient in their own way. However, a cursory search indicates that the greater resilience in old-growth forests is supported by many scientists.

Wohlleben’s writing style is conversational, he uses a lot of colloquialisms and symbolic imagery (“off kilter,” “earmark,” “death knell”). And the book is written largely like a story, whether the subject is truly an event or a scientific topic. For example, he says “I’d like to take you back to when soil was first created” (86). This is a typical transition from discussion to technical information and, as one may guess from this fairytale-like introduction, Wohlleben does not abandon his story-telling style when things get technical. He includes exclamations, humor, even some puns so he is clearly trying not to let this be a dry read.

Quotes

But isn't that how evolution works? you ask. The survival of the fittest? Trees would just shake their heads – or rather their crowns. Their well-being depends on their community, and when the supposedly feeble trees disappear, the others lose as well."
-- Wohlleben (chapter 3 paragraph 2)

Importance: This is one of Wohlleben's earlier disclosures of the interconnectedness of the forest ecosystem. He is also highlighting his belief that many people misunderstand trees, and perhaps biological systems in general through his portrayal of what may be intended as the reader.

I could find no other indicator of the tree's age on its tiny trunk, which was no more than a third of an inch in diameter, but when I carefully extrapolated the age of the tree from the age of the branch, I discovered that the tree must have been at least eighty years old, maybe more."
-- Wohlleben (chapter 6 paragraph 1)

Importance: This is an example of Wohlleben's own process of discovery via surprises and investigation.

[The fungus] extends the reach of the tree's own roots as the web grows out toward other trees. Here, it connects with other trees' fungal partners and roots. And so a network is created, and now it's easy for the trees to exchange vital nutrients and even information.
-- Wohlleben (chapter 9 paragraph 1)

Importance: Wohlleben's introduces the deep cooperation and interconnection of the different parts of the forest.

The thick outer layer of the oak's bark is also much more robust than the smooth, thin skin of the beech, and it can take a great deal of punishment. This has given rise to a saying in German, 'Was schert es eine alte Eiche, wenn sich ein Wildschwein in ihr scheuert?' which roughly translates as: 'It's no skin off an old oak's back if a wild boar wants to use its bark as a scratching post.
-- Wohlleben (chapter 12 paragraph 1)

Importance: Wohlleben shares some lesser known pieces of German culture, giving an insight into the Central European view of nature as well. He integrates such elements carefully and also brings in some humor with them.

Of all the plants, trees have the largest surface area covered in leaves. For every square yard of forest, 27 square yards of leaves and needles blanket the crowns.
-- Wohlleben (chapter 18 paragraph 2)

Importance: Wohlleben incorporates many factoids such as this one. They are carefully

chosen and often insightful in relation to the chapter. They also tend towards oversimplification and would be more instructive with information as to, for this example, which area this applies to and what type of trees. If this comes from a coniferous forest in Germany, it is likely irrelevant to a deciduous forest in Greece.

[Ants] get [some sustenance] in the form of caterpillars, and thus they rid the bird cherry of its uninvited guests…but apparently, sometimes…they begin to farm aphids. As I've explained, these creatures tap into the leaves and when the ants stroke the aphids with their antennae, they exude droplets of sugary liquid for them.
-- Wohlleben (chapter 19 paragraph 3)

Importance: This example illustrates how complex the exchange between the forest's different organisms can be. It is extremely challenging, if not impossible, to trace the giving and taking and how they balance out for the whole forest.

[The black woodpecker] uses one [cavity] for the kids, one for sleeping, and the others for a change of scene. Every year, the cavities are renovated, and wood chips at the base of the trees are evidence of this activity.
-- Wohlleben (chapter 20 paragraph 2)

Importance: This is an example of Wohlleben's story-telling style.

In total, a fifth of all animal and plant species – that's about six thousand of the species we know about – depend on dead wood."
-- Wohlleben (chapter 21 paragraph 3)

Importance: He shares surprising facts that illustrate to the reader their misconceptions about biological systems, in a very simplified style.

Per year and square mile of alder forest, these tiny helpers [fungi and bacteria] can extract up to 87 tons of nitrogen from the air and make it available to the roots of their tree friends. That is more than most farmers spread over their fields as fertilizer."
-- Wohlleben (chapter 22 paragraph 1)

Importance: Wohlleben writes in such a way that many different people can enjoy and learn from his book. He includes statistics and facts as well as contextual, experiential information in this example. His phrasing is accessible to reductionist, analytical and nonlinear, holistic thinking. This is another example of the cooperation and interconnectedness of the forest's members.

On the country road between my home village of Hümmel and the next small town in the Ahr valley stand three oaks. They are a commanding presence out in the open fields, and the area is named in their honor.
-- Wohlleben (chapter 24 paragraph 1)

Importance: Wohlleben shares some of the parts of his life that have made the greatest impression on him, on the topic of trees.

Most national parks give in to the clamor of complaint and sell to sawmills the trees they have felled and removed from the forest to combat bark beetle infestations. This is a grave mistake."
-- Wohlleben (chapter 35 paragraph 2)

Importance: Wohlleben shares many insights into procedures that he has found, during his years working as a forester, are not the most effective but are still commonly practiced today. His tone verges on dogmatic at times.

And who knows, perhaps one day the language of trees will eventually be deciphered, giving us the raw material for further amazing stories. Until then, when you take your next walk in the forest, give free rein to your imagination – in many cases, what you imagine is not so far removed from reality, after all!
-- Wohlleben (chapter 36 paragraph 3)

Importance: These are his closing words for the book. The last thing he does is impress again upon the reader the importance of investigating the forest and all he has shared about it for themselves.

Topics for Discussion

Decision-making

Discuss your opinion on Wohlleben's suggestion that trees can make decisions (Chapter 4 and 24). Do you think it is demonstrated by his examples? Do you have other support for its truth or falsity?

Future forestry

Give three advantages of cultivating trees. Give three examples of how undisturbed forests have greater resilience than recently planted ones. Discuss an improved method for forest cultivation for the future.

Bias

Wohlleben advocates for environmental conservation and does communicate his personal vision to some extent in the book (especially in the last chapters). Do you think he succeeds in giving unbiased information? Do you think he should? Do you think that that is possible for him?

Frame of personal experience

Did you feel that the way in which Wohlleben framed the information in his personal experience (telling anecdotes, sharing his thoughts, giving contextual information about his personal life) was effective for a nonfiction subject? Enjoyable? Added depth?

Challenging of view of trees

Which part of your understanding, ideas, and views of trees (or nature in general) was most challenged by the information in this book?

Function of the forest

List all the factors you can remember that impact when a tree sheds its leaves. List all the things that are affected by this change. Share your resulting thoughts on how the forest functions.

Statistics

“In total, a fifth of all animal and plant species – that’s about six thousand of the species we know about – depend on dead wood.” Discuss the power and the limitations of a single statistic in its ability to bring understanding of a deep and multi-faceted over-arching concept, such as biodiversity or conservation in this example.

Representations of nature

Wohlleben presents evidence that nature is an interconnected, cooperating system and also discusses its representation as a fight for survival in which the constituent parts are up against each other. Which do you think is most accurate…perhaps both are true? Support your argument with an explanation and evidence.

Hidden capabilities

A capability of trees that is revealed is drowning an insect that is trying to crawl into its trunk or killing an invading fungus by flooding its outer layers. Discuss in how many ways this capability is “hidden.” As in, explore the title “The Hidden Life of Trees.”

Networks

Compare and contrast the “wood wide web” and the internet. Can you think of other similar networks?