Radical Cannabis Ecologies:
A Regenerative Approach to Cannabis Farms in The Emerald Triangle

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A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Landscape Architecture

University of Washington

2023

Committee:

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Program Authorized to Offer Degree:

Department of Landscape Architecture

University of Washington

Abstract

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Over the past 150 years, the forest ecosystems of California's Northwestern Coast have been dramatically altered, first through a century of intensive logging followed by 50 years of illicit cannabis cultivation. Combined, these extractive practices, a warming climate, and agricultural intensification brought by cannabis legalization have put immense pressure on the productive capacities of these landscapes. The emergence of cannabis cultivation as a legal enterprise offers opportunities to radically re-imagine how these sites are situated in the landscape and operate.

This thesis proposal examines how cannabis farms can harness the energy flows and resources of their surrounding physical and biological systems while emphasizing regenerative design strategies within cultivation zones to improve production, mitigate waste, and bolster farm resilience. Using an existing commercial cannabis farm in Kneeland, California as a case study, I develop and investigate an actionable regenerative framework of design strategies that can be adapted to the thousands of similar farms that dot this rugged and remote landscape. In doing so, we can help mend these landscapes and ensure the long-term viability of this homegrown industry.

Radical Cannabis Ecologies

A Regenerative Approach to Cannabis Farms in The Emerald Triangle

By Zachary Myers

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Cover Photo: Shot just as the fog burned off after a summer sunrise, this view is looking directly north over the Mad River Watershed. This drone still shows the vast space and immensity of time that is held in the forests of the North Coast Region.

Preface

Before the passage of California's Proposition 64 (Prop 64) in 2017, a bill that legalized the cultivation and adult consumption of cannabis for medicinal and recreational purposes, most industry knowledge on the subject was clandestine. While many books have been published on the subject of cultivation, and early web forums like *grasscity* allowed users to converse with like-minded green-thumbs around the globe, the majority of knowledge within the industry had been passed down via word of mouth due to the plant's historical illegality. There has never been more of a suitable time for the exploration of this topic as more and more public research about this plant and its social and environmental effects becomes available.

To date, cannabis is still federally classified as a Schedule 1 Drug; therefore there are more rules and regulations required by the U.S. Drug Enforcement Agency (DEA) if a lab or research group is interested in studying the plant. After 2016, Prop 64 gave the state legal authority to form and fund a network of labs at research universities across the state. Medical and pharmacological testing, while still a priority, is one facet of a multitude of societal effects unleashed by legalization that the state has begun to study. A diverse range of public researchers from fields such as sociology, geography, economics, and environmental sciences have produced an ever-increasing body of published work over the past 5 years. In addition, private industry organizations have emerged, producing magazines and reports that focus on the economic impacts and emerging trends at the business level. Still, the research and accompanying body of knowledge are largely incomplete, undocumented, and underfunded. Much of the research is still siloed and the critical eye of a landscape architect is still missing.

The gap from this perspective, coupled with the emergence of a broader scope of cannabis-related research, has played a crucial role in motivating my interest in studying this subject. This research has also aided me in constructing a strong foundation that supports my research and design proposal. Pairing this evaluative research with personal site experience in the region has helped provide me with a fountain of knowledge to draw from. I hope this project will catalyze a new way of seeing, thinking, and valuing these emerging cultural landscapes for readers in the profession and other allied fields.

Acknowledgments

I would like to express my sincere gratitude to my thesis committee members, Ken Yocom and Catherine De Almeida, for their invaluable input and guidance throughout the entire process of this project, which spanned multiple states and countries. Their thoughtful contributions and unwavering support have been instrumental in shaping the direction of my research and site explorations. I'm eternally grateful for their flexibility as I navigated in and out of a multitude of fascinating rabbit holes while formulating the ultimate direction of this research.

Furthermore, I extend my heartfelt thanks to Ron, Rosh, and Neal at Devi Cannabis, as well as Steve, Max, and Brad at Kuda Cannabis, for graciously allowing me to visit their farms and accompany them in their daily operations within these budding new enterprises. Their generosity and willingness to involve me as an eager observer have been truly invaluable.

It was the unwavering support and genuine interest of each of these individuals in this project that have fueled my determination and resilience, especially during challenging times. Their contributions have enriched my academic journey, and I am truly indebted to them for their unwavering support and willingness to share their expertise.

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Introduction

The Emerald Triangle

As we enter this new era, the expansion of cannabis cultivation in Northern California has the potential to not only be an economic boon for the region but also create major ecological problems. This remote and sparsely populated area of the state, known as the Emerald Triangle, is centered around the 3 county region of Humboldt, Mendocino, and Trinity counties and is the largest cannabis-producing region in the United States. In the midst of the economic downturn in the mid-twentieth century, particularly in the commercial timber and fishing sectors, cannabis cultivation emerged as an illicit yet relatively prevalent homegrown agricultural industry. Over the next several decades this specialized form of agriculture effectively filled the economic gap created by the decline in these industries. In 2022, legal cannabis had become the 8th most valuable agricultural crop for California, just behind tomatoes and walnuts, with a wholesale value of $1 billion (Downs et al. 2022).

Much like the transformative impact of Sonoma and Napa counties on the American wine industry, the Emerald Triangle continues to be a key hub of innovation and has long been a primary cultural storehouse of vernacular cannabis production and culture. This has led to an explosion of strain-specific breeding, horticultural experimentation, and a devoted local market that tests and refines each season's output. Cannabis farms can be considered a rich cultural landscape replete with its own agricultural logic and traditions adding yet another branch to California's deep agricultural history. These farms and the people that tend to them are intrinsically linked and a crucial component to the future health of these landscapes.

Legalization and its policy impact on the market for the Emerald Triangle and California are currently being played out. Though cannabis remains illegal at the federal level, individual states have been allowed to pass their own legalization measures. Alongside policy, the infusion of capital and the high cost of compliance has created higher barriers to entry and operation for new and existing operators of cultivation licenses. The Emerald Triangle's long-held monopoly is now waning as the state's market equalizes due to open competition across the state and from other eager municipalities that permit the cultivation and sale of cannabis.

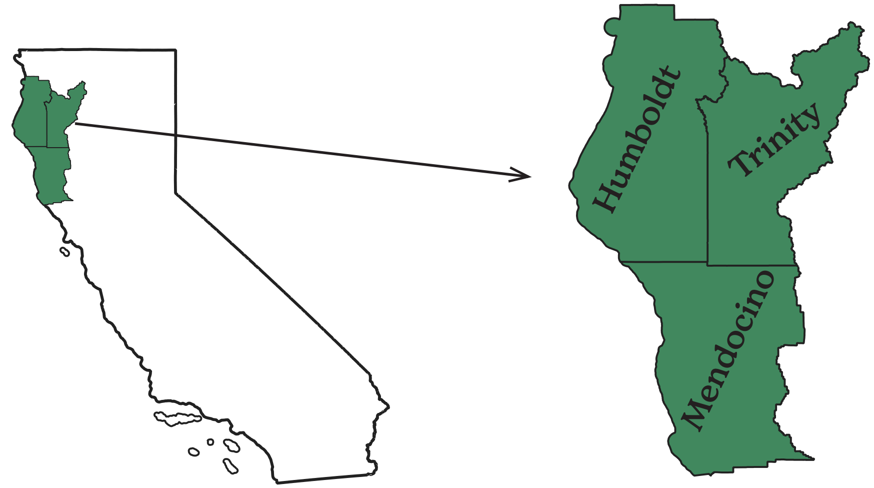


Fig. 1.1 The Emerald Triangle

Given cannabis' economic and cultural importance, it is critical to also examine how these sites can be sustained without depleting the ecosystems they rely on for their success. Cannabis cultivation occurs in remote watersheds with high conservation value and biodiversity (Bauer et al. 2015, Carah et al. 2015). In this region, farms are situated in conjunction with carbon-intensive settlement patterns, deteriorating rural road networks, existing dams and electricity transmission lines, and forests with high fuel loads. Moreover, the landscape has been witnessing longer, drier, and hotter fire seasons in comparison to the recent past. Water, while plentiful during the wet winter season, becomes scarce during the peak of the growing season, requiring farms to draw from wells or creeks on-site during the dry summer months.

These farms must work in tandem with the natural fire-regulated forest and hydrological systems they inhabit to embrace a sustainable approach to both the forest and the farm.

Growers not only have to deal with these complex economic and environmental issues, but they also face cultural stigmas within the region too. Overall, there is a negative perception toward growers by local residents as most farms are seen as a detriment rather than a catalyst in the environment. In a recent survey of over 200 landowners (each of whom owned at least 500 acres) in Humboldt County, a vast majority of respondents believed growers had negative effects on the region specifically in areas of the environment (fig. 1.2) and shared property such as access roads and fences (Valachovic et al. 2019). Combining personal experience and discussions with local residents, disdain for growers come from decades of social distrust and stems from the industry's secrecy during prohibition. However, now legal cultivation is seen as an important economic engine for the region. As jobs continue to cluster in places like the Eureka-Arcata area, the economic hub of the Emerald Triangle, or older ranchers, timberland owners age out and begin to sell their lands, cannabis growers may be the only interested parties in buying and tending to these remote parcels. Cannabis culture and California's North Coast are intertwined with the region's contemporary identity. I believe that the proliferation of cannabis farms and this new landscape typology has the potential to imbue fresh life, meaning, and care into this vast landscape.

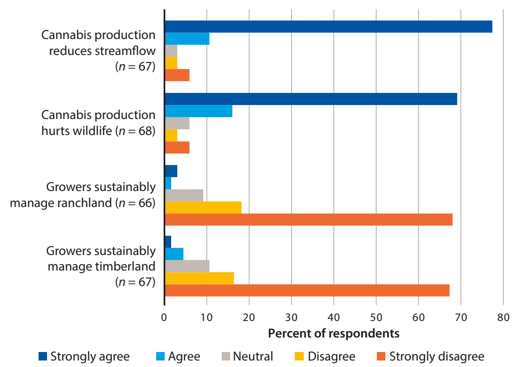


Fig. 1.2 Survey respondents showing negative perceptions toward cannabis growing (From Valachovic 2019)

It is out of these pressing issues that have led me to consider how these cannabis farms can shift from sites of profit and extraction to resilient refuges and reservoirs of production. Furthermore, is it possible to integrate regenerative design strategies in cannabis agriculture to mitigate the effects of climate change while mending their relationship to the surrounding ecological systems that these sites inhabit? To answer these questions I've developed a new approach, one that redefines cultivation practices and prioritizes the health of both cannabis cultivation and the forests they inhabit—a paradigm shift towards embracing *radical cannabis ecologies*.

Cornucopia of Cannabis:
Current Distribution of Humboldt County
& Emerald Triangle Cannabis Farms

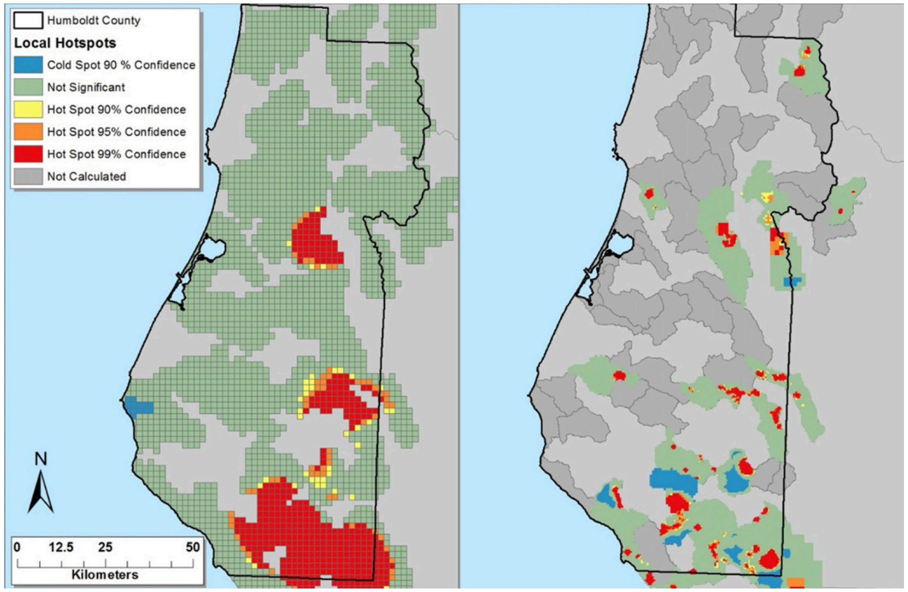


Fig. 1.3 Humboldt County Hotspots of Cultivation at County & Watershed Level (Butsic & Brenner 2016)

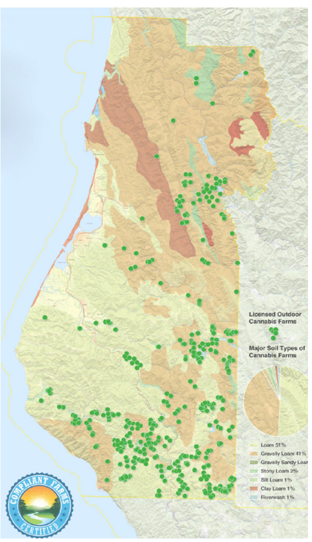


Fig. 1.4 Licensed Outdoor Grows & Soil Type (Holly Hall 2022)

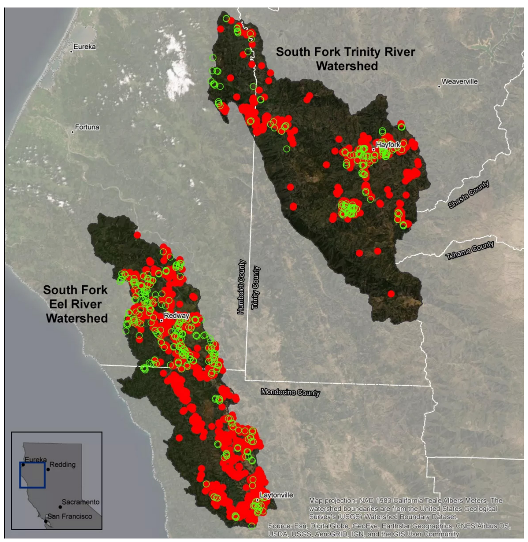


Fig. 1.5 Licensed (Green) & Unlicensed Grows (Red) of the South Fork of the Eel & Trinity River Watersheds (Cannavison 2022)

What is Radical Cannabis Ecologies?

Since the inception of the Save the Redwoods League in 1918, environmental activism has played a primary role in the politics of Northern California. As the 20th century came to a close, environmentalism turned increasingly radical. Groups such as *Earth First!* shifted from PR stunts and the promotion of environmental law toward indirect nonviolent action. These began with sit-ins and strikes and culminated in isolated cases of sabotage and arson at its most extreme (Speece & Sutter 2017). In Northern California, the enemy inevitably meant any logging companies and any government official or office that bent backward for them.

It's out of the flurry of environmental activism, culminating in 1990's Redwood Summer and the work of ecological philosopher and historian Carolyn Merchant that I have chosen to co-opt the word *radical*. The concept helps to define this emerging framework in the long-term management of these cannabis landscapes. I do not intend to repeat the exact actions of these activists or adhere to their every political belief. However, I do believe that *radical actions* can help raise awareness in the public consciousness of these issues. The simple act of protest, whether physical or through media, can help spur change in one's attitude, or over time, garner enough consensus to trigger new political processes that help increase the value or protect what was being fought for in the first place.

Merchant defines *radical ecology* as an ecological philosophy that "confronts the illusion that people are free to exploit nature and to move in society at the expense of others with a new consciousness of our responsibility to the rest of nature and nurture of people " (Merchant 2015). She elaborates on this definition which works to blend social systems (social ecology) and ecology (abiotic and biotic/human and nonhuman) to its fringe. Imagining a world where this new entanglement of systems shifts toward 'new patterns of production, reproduction, and consciousness that will improve the quality of human life and the natural environment (Merchant 2015)."

Radical Ecology was published in 1992, the same year as the ratification of the *UN Framework Convention on Climate Change* (UNFCCC), the first global treaty addressing climate change. Merchant's first definition of *radical ecology* has only become more potent over the past 30 years as the effects of climate change have become well publicized, and phrases such as the *Anthropocene* have increasingly been steeped into society's general conscience. That illusion of exploitation without repercussions that Merchant describes has only become more of a reality in places like Northern California. The promise of a new type of ecological philosophy in her second definition is congruent with the regenerative approach of my proposal. The shift from an exploitative and extractive method of production to one that is reciprocal and regenerative is both required but inherently *radical* compared to the status quo.

The purpose of this thesis is twofold, the term *radical* is used to define a framework that pushes back against the business-as-usual way of producing cannabis by changing the notion of how this industry can operate. *Radical Cannabis Ecologies* is a long-term view of land stewardship that uses principles of agroecology, and sustainable forest management to foster a better reciprocal relationship between the cultivation of cannabis and the health of the people, lands, and energy systems it inhabits and depends on for its survival. It realigns the prevailing and dissonant profit-driven land ethic towards one that responds to the energy flows and systems of the larger landscape. This proposed paradigm shift focuses on mitigating future climatic hazards and promoting forest resilience and site biodiversity. In turn, this approach has the potential to help eliminate polluting practices while ensuring the long-term economic viability and safety of farms across the Emerald Triangle.

Secondly, by restoring the forest and enhancing production, it is my hope that individual resilient site interventions can cascade across the multiple clusters of existing farms in the region helping catalyze positive environmental feedback loops at multiple scales across the region. If successful the industry has the potential to transition from the current mode of production into a new era that can sustain cannabis and its landscapes for countless generations to come.

Extractive Histories

In Northern California, significant changes have occurred in the landscape over the past two centuries. The region saw a surge in land and resource speculation during Westward Expansion, the Gold Rush, and the Timber Boom. Both the Gold and Timber industries followed a similar pattern of rapid resource extraction, leading to depletion and eventual abandonment. This created an opening for cannabis cultivation to take root and flourish.

However, most of these sites remained abandoned until broader cultural changes occurred in California, giving them renewed significance and value. As logging and mining activities declined, a younger generation brought about a shift in the public consciousness. The rise of environmentalism and counterculture prompted many individuals to return to these former timber and mining lands, seeking a more agrarian lifestyle. Concurrently, California society underwent a wave of social liberalization, leading to a more permissive attitude towards personal recreational drug use. This paved the way for the decriminalization and eventual legalization of cannabis. California's vast expanses of uninhabited land, the cultural acceptance of personal drug use, and the progressive cannabis policies implemented by the government all came together to help build the foundation of the Emerald Triangle.

Land of Isolation & Speculation (1775-1900)

The rugged North Coast of California remained relatively unexplored until well into the middle of the 19th century. The first reports of this land happened in 1775 when Spanish explorers touched down off of Trinidad Bay in Humboldt County. Stepping ashore, they didn't find an untouched American arcadia or wilderness but a rich matrix of indigenous tribes that carefully managed a mosaic of ecosystems. The whole state had been densely populated and north of Mexico City, California held the highest densities of people of any area of equal size in North America (Anderson 2005). The Spanish quickly got back on their ships and sailed north and for another 75 years, the region remained relatively independent from outside contact.

Fig. 2.1 Gold Rush Advertisement

Then in 1849, the quiet shores of the North Coast changed forever when gold was found in nearby Weaverville, CA. The event was one of a handful of events that precipitated the California Gold Rush. Soon primarily Euro-American prospectors and settlers came in droves to explore, exploit and extract from the landscape. At first, they came up the Central Valley through Sacramento and Redding but soon an overland route from Weaverville to Humboldt Bay was established in that same year. Within a year, the cities of Union City (later Arcata) and Eureka were incorporated, serving as a port of arrival for boats coming from San Francisco filled with eager souls to hop onto pack trails into Trinity County in search of gold (Keter 2013).

Fig. 2.2 Large Logs at Ryan Slough in 1904

Though the Gold Rush lasted only a few years, its economic impact was immense. Small outposts such as San Francisco and Sacramento became bustling towns, and statehood was established by 1850. As the mines dried up, the federal government deeded millions of acres to the state to encourage settlement. In 1850, the Swamp Land Act was enacted to encourage the sale and reclamation of wet and inundated lands across the western states. For California, it opened over 2 million acres of ambiguously termed 'swamp' lands for purchase at $1.00 an acre and 20% down of up to 640 acres per person (Gates 1975). The Timber Culture Act (1873) and the Desert Land Act (1877) subsequently followed to promote the settlement and development of non-traditional farmland such as rocky forested outcrops, or semi-arid and dry lands devoid of trees.

The most significant bill for those in Northern California that Congress passed during this time was the Timber and Stone Act (1878) which allowed individuals legal means to buy timberland. In *Land and Law in California*, historian Paul Gates writes, "After 1878, nonarable, nonmineral public land could be purchased at the cut-rate price of $2.50 per acre. The claimant merely had to swear that he meant to use his [sic] 160 acres for practical and exclusive use, not speculation or contractual transfer to another party" (Gates 1991). Without broad enforcement, claimants of these 'non-arable lands' routinely consolidated them through legal and illegal means. Not before long all of the claims for Northern California's vast redwood forests were bought up. As the Gold Rush in California waned and shifted northward toward British Columbia and Alaska, a new lucrative industry began to emerge, a century-long timber boom and the beginning of the Redwood Empire.

By the 1880s and 1890s, large timber operators harnessed the new power of the steam engine to mechanize

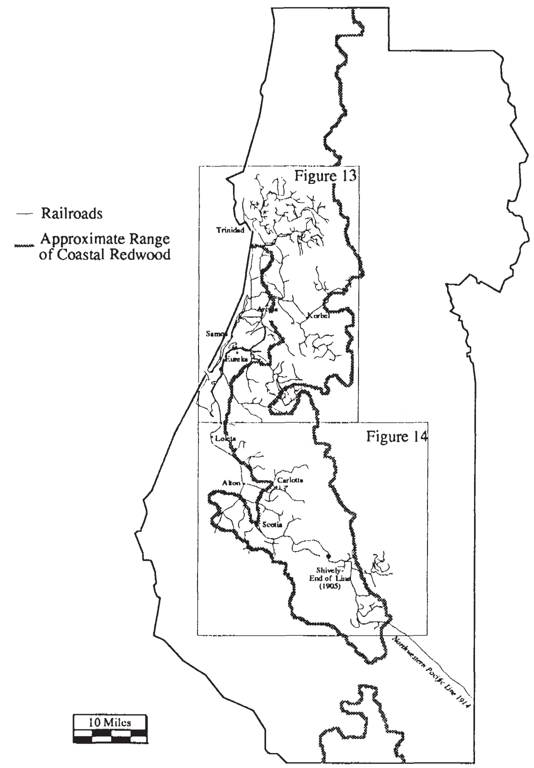


Fig. 2.3 Extent of Humboldt County Railroads 1854-1846 (From Farnsworth 1996)

the harvesting and processing of lumber out of the steep and rugged forest to a network of independent railroad operators (fig. 2.3) into Humboldt Bay and onto ships headed for San Francisco (Farnsworth 1996).

The profitability of these large trees for logging operations was unbelievable at this time. For example, the California Redwood Company, a large vertically integrated operation, the costs of harvest were as follows: “In 1885, lumber was selling at $15 dollars per thousand trees an acre, therefore, producing 30,000 board feet was grossing the mill $450.00 for every $1.25 invested (Melindy 1952).” By 1900, all the redwood timberland on the North Coast had been sold to private landowners, loggers, or ranchers. From the time of the Gold Rush to 1950 nearly half of the original old-growth redwood forest had been cut down (Farmer 2013).

Post WW2: A Well-Oiled Machine

By the middle of the century, the emergence of powerful internal combustion engines led to a new array of machines capable of transforming the landscape. In prior eras, lumber was dictated by its proximity to the existing railcar network connecting to the mills of Humboldt Bay. Powerful construction equipment opened up more remote parcels uncoupling the need for logging to be nearby rail lines or alongside a river. California’s expanding state highway network helped logging companies easily access more timberlands and move them faster to both mill and market. Loggers could immediately begin building access roads and skid roads right off these new routes thus carving further into the interior of Redwood Country. Through the use of modernized dozers, tractors, yarders, and most importantly logging trucks, forested tracts could easily be harvested from multiple collection points, thereby intensifying the extraction process.

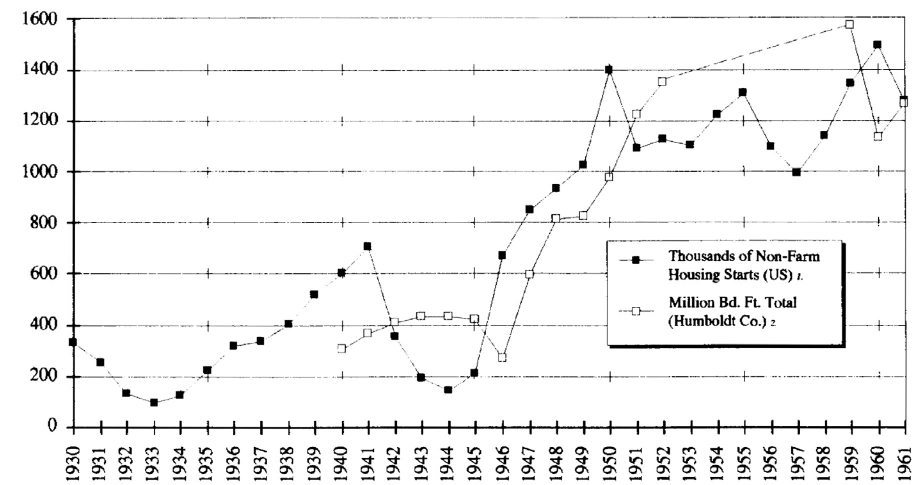


Fig. 2.4 National Housing Starts and Humboldt County Timber Production (From Farnsworth 1996)

Trucking out lumber was cheaper and more efficient than by railroad and soon the old network of logging railroads began to be ripped up and replaced as roads. . Soon logging roads crisscrossed throughout the North Coast on both private and public forest land.

Due to the Post WW2 economic boom, California exploded in demand for lumber (fig. 2.4) to build homes for returning G.I.’s. However, a labor strike froze the harvest and production of redwood in the region for nearly two years from 1946-1948. The importance of the strike was not in the labor issues that those loggers were seeking but in the unintentional impact on the industry as it shifted production to a new harvestable resource, the Douglas-fir (*Pseudotsuga menziesii*).

Gyppo Loggers 1945-1960s

Post-war demand was so high for dimensional lumber that strands of old-growth Douglas-fir became quite marketable in the region. Independent small-scale lumber operations, known as *gyppo logging*, began to crop up as the redwood industry was at a standstill. Loggers from around the country or those that left the redwood mills staked out on their own search for the bounty on the North Coast. In 1946, 19 sawmills owned all the private and harvestable redwood land not preserved or owned by the government. By 1950, 252 sawmills had popped up as Douglas-fir filled the gap in demand (Wilson 2001). From 1940-1948, Douglas-fir went from 11% to more than 60% of the county's total output of linear board feet (Vaux 1955).

Unlike the majority of the redwood forest whose range hugged the long linear fog belt along the coast, Douglas-fir forests tended to be farther inland and less uniform in size and strand. This shifted the geography of logging patterns on the North Coast. Gyppo loggers would purchase temporary harvest permits from independent landowners, based on the current stumpage and potential harvest, and then move on to the next parcel. They typically did not invest in the land they were logging so it was not unusual for them to 'cut and run' which exacerbated land degradation in the region.

Improvements in even smaller but powerful logging equipment like gas and electric chain saws allowed gyppo logging crews to be smaller and more nimble. By the 1950s logging by truck emerged as the most cost-effective method of transport prompting gyppo mills to relocate farther inland (fig. 2.5 & 2.6). As a result, mill development shifted away from Humboldt Bay toward the southern part of the county in emerging logging towns such as Garberville, Alderpoint, and Bridgeville. It was a boom time for the region, lumber in Humboldt County was the largest source of tax revenue in the state of California and the county was the second-largest producer of lumber in the United States (Wilson 2001).

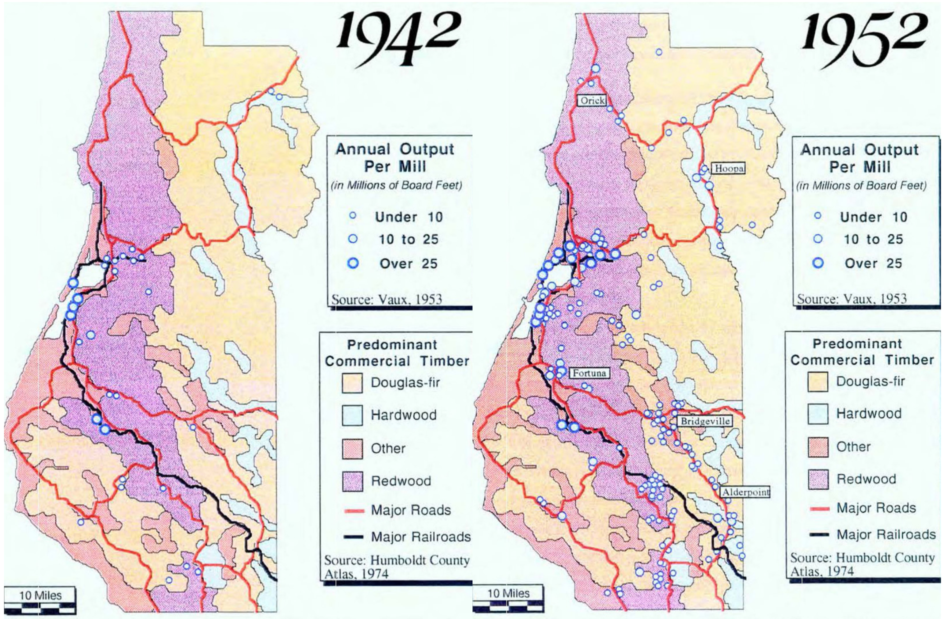


Fig. 2.5 & 2.6 Humboldt County Lumber Mills 1942 & 1952 (From Farnsworth 1996)

Fig. 2.7 Inundated Lumber at Scotia Lumber Company after the 1955 Flood

Fig. 2.8 The Town of Holmes Flat Flooded from a Surging Eel River during the 1964 Flood

End of the Boom Years

The party didn't last long, first in December of 1955 then again in 1964, a 100-year flood repeatedly hit the region causing massive flooding throughout North Coast. Mills that were too close to the river's edge were submerged or partially swept away. Smaller mills that didn't have money to rebuild, were either shuttered or sold to larger companies like Georgia Pacific. The lumber industry peaked in both terms of employment and linear board feet by 1959 (Farnsworth 1996).

Supplies of mature redwood and Douglas-fir began to dwindle and mill operations pivoted to cheaper and smaller Douglas-fir wood products such as studs, plywood & veneers. Between 1947 and 1967 there was nearly a 53% reduction in the total area of commercial timber for Douglas-fir and a 24% reduction in redwood (fig. 2.9) (Farnsworth 1996). This concurrent depletion of these two dominant tree species in turn diminished the dominance of the North Coast in its role as a supplier of specialty wood products for California and the West. It was out of these depleted logging lands that paved the way for another plant to take hold, not a tree but an annual, *Cannabis indica* and *sativa*.

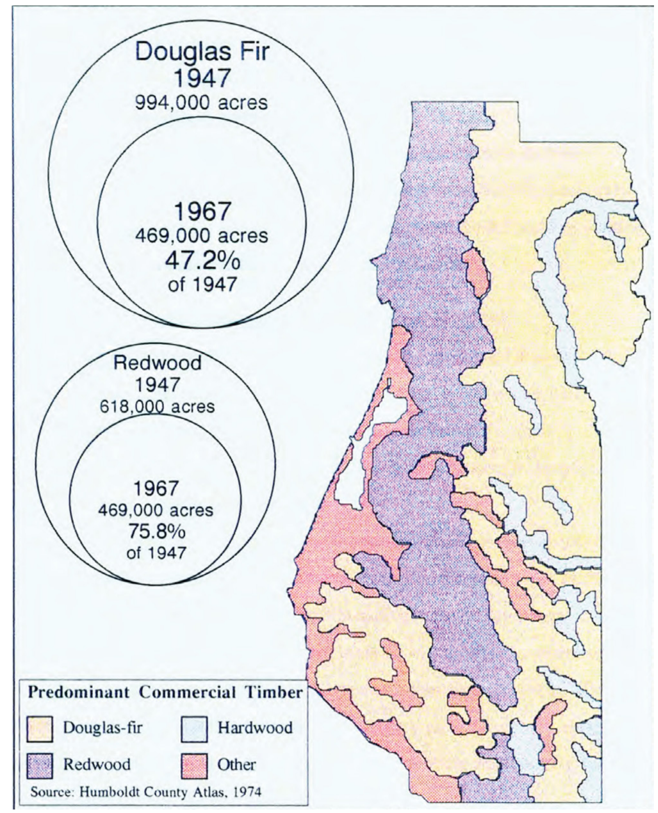
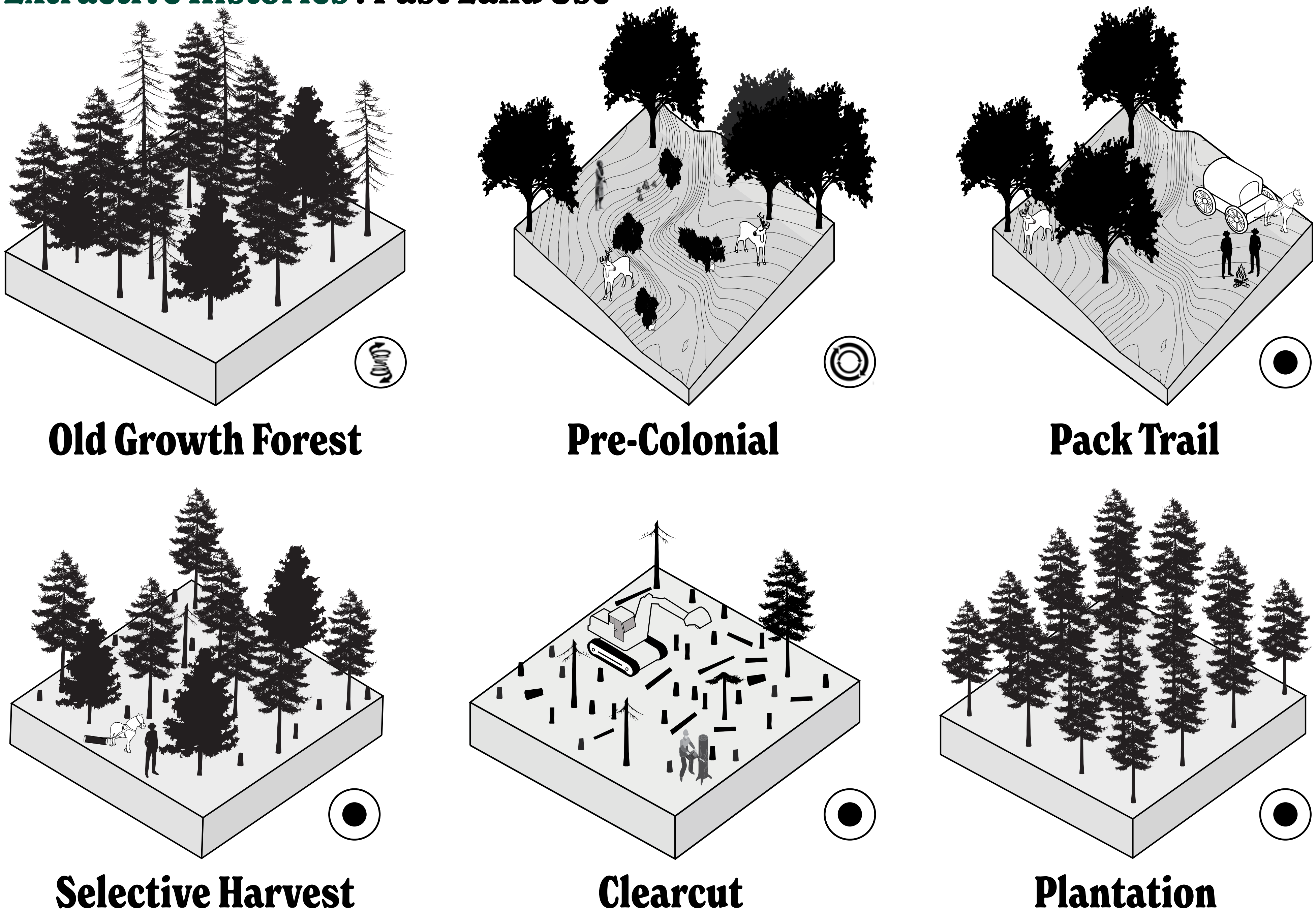


Fig. 2.9 Comparison of Commercial Forest Area Available during 1947 & 1967 (From Farnsworth 1996)

Extractive Histories : Past Land Use



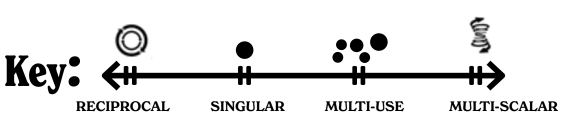


Fig. 2.10 Historical Land Use Typologies Across the Emerald Triangle

Outdoor Recreation and the Modern Environmental Era

As the logging industry depleted the forests, a concerted effort from the federal/state government and local conservation groups worked to create a number of protected natural areas for civilian enjoyment and use. A number of important national forests and parks were established in the region at the time such as Redwood State and National Parks (1968) and Kings Range Conservation Area (1970). These natural lands provided a stark contrast to the boom in population growth that was happening across California, especially in places like the San Francisco Bay Area. From 1950 to 1970, the nine-county SF Bay Area nearly doubled in population going from 2,681,322 to 4,628,322 residents (US Census 2010).

For some, the contrast between this era of economic growth and the undeveloped landscapes of California was incompatible. Books such as Rachel Carson's *Silent Spring* in 1962 exposed the ecological and health problems of releasing too many toxic chemicals, pesticides, and oil into our land, air, and water. Carson's *Spring* caused enough public outcry for Congress to pass the Clean Air Act in 1963. Less than a decade later, in 1970, the National Environmental Policy Act (NEPA) and the EPA were formed. These broad environmental policy measures limited the amount of pollution and environmental impacts local governments, companies, and individuals could emit.

Through the 1960s and 1970s, this dissonance sparked the modern environmental movement of which the San Francisco Bay Area was one of its epicenters. Groups such as the Wilderness Society and the Sierra Club exploded in membership. They mobilized their base to support local conservation initiatives and to encourage governments to pass pro-environment laws. In the region, protest about the destruction and deforestation of North Coast old-growth forests was a common issue.

From Summer of Love to Back-to-the-Land

The proponents of environmentalism were also likely to be involved with the growing counterculture movement happening in the region at the time. At its core, the counterculture movement began as a response to the growing materialistic, technocratic, and capitalistic motives of modern American life. In the Bay Area, counterculture influence culminated in 1966's Summer of Love when thousands of youth and hippies converged on the city. Multiple events such as the Human Be-In and the Trips Festival tied together the arts and politics with psychedelic/spiritual reawakening. In 1967, Timothy Leary at the Human Be-In famously remarked, "Turn on, tune in, drop out". Soon "drop out" they did, out of society and into the forested lands of Northern California. Stemming from these two movements, environmentalism, and the counterculture, a number of freewheeling residents began to contemplate a different kind of pace and lifestyle, one not tethered to the rigors of

Fig. 2.11 Trips Festival Poster

modern life. Groups of people soon began to decamp north from the city, into the former timber and pasture lands of Sonoma, Mendocino, and Humboldt counties. Here in Northern California, there was an explosion of communes and alternative farms trying ways of living and cooperating with land farm from the humdrum pace of city life to the south.

Extractive Bedfellows: Timber and Cannabis on the North Coast

The timber industry had already begun to wane by the 1970s, due to both the shifting geographies of timber production and increased environmental regulations such as 1973's Forest Practices Act. The industry had unsustainably cut both its old-growth redwood and Douglas-fir supply, without any proper selective harvesting practices or re-planting plans. This left many small land owners and operators with loads of depleted timber lands that were decades away from viable second growth. Numerous fairly cheap forested parcels had become a viable financial option for some of these counterculture pioneers and 'back-to-the-landers' as a homestead.

Those who did purchase these parcels quickly began to work the land and practice semi-subsistence agriculture in hopes of creating a closer relationship with nature (Boal 2012). Unless one had access to an inheritance or some other form of wealth, life wasn't always as bucolic on the farm as one would think. Once the money ran out, poverty and hunger were a real possibility for the whole commune. One plant though, cannabis, with its counter-cultural ties, could provide some stability to this lifestyle. The independent spirit of these communal ventures relied heavily on the belief of self-sufficiency and political independence separate from the general populace and cannabis afforded the means to do so. Most sites in Northern California were remote and forested, perfect for the clandestine nature of illegal cannabis cultivation. In addition, mild year-round temps and access to abundant water made cultivation relatively easy and affordable. Physical proximity to San Francisco and access to existing social networks made the sale of cannabis relatively easier to accomplish compared to other communes in the United States.

Since growing cannabis was still a felony, its street price was quite high. According to a 1976 *New York Times* article, a pound of quality cannabis could range from $1000.00 to $1500.00 (Ledbetter 1976). Accounting for inflation that would be equivalent to just under $5,000-$8,000 in today's dollars. Communes and early growers only had to grow a small number of plants to earn a decent return. The allure of easy profits led 'back-to-landers' to set aside their utopian ideals and embrace a modified version of the California Dream. One centered around a cannabis-infused style of Jeffersonian agrarianism that led to the creation of the Emerald Triangle.

In the 1970s in California, a general shift in public opinion favored an increasingly open atmosphere toward decriminalization and legalization. In 1972, the state voted on Prop 19, the first ballot measure in the nation that would legalize the use, possession, and cultivation of cannabis. It failed to pass garnering only a ⅓ of the vote but was important in the shifting perceptions of its use. In 1975, The Moscone Act took effect, reducing the possession of an ounce of cannabis from a felony to a misdemeanor punishable by a $100.00 fine.

This was the opposite of the nation's trajectory, in 1973, President Richard Nixon declared "an all-out global war on the drug menace" and worked with Congress to approve the creation of the Drug Enforcement Agency (DEA), a singular agency that would consolidate and coordinate the government's drug control activities. (dea.gov 2023). At the time 90% of cannabis was being imported into the country from abroad (Brady 2013).

To hinder the supply of cannabis coming from Mexico, the DEA began to spray the herbicide Paraquat on cartel grows down south throughout the mid-1970s. As reports of Paraquat-laced weed began to enter the country, buyers looked to other sources for their product. In 1979, when the government stopped this spraying program it was estimated that 35% of the cannabis the state consumed was grown in California. The Department of Justice that same year publicly recognized that Humboldt, Lake, Del Norte & Mendocino counties had replaced Mexico as the main supplier of cannabis in the state (McClung 1982).

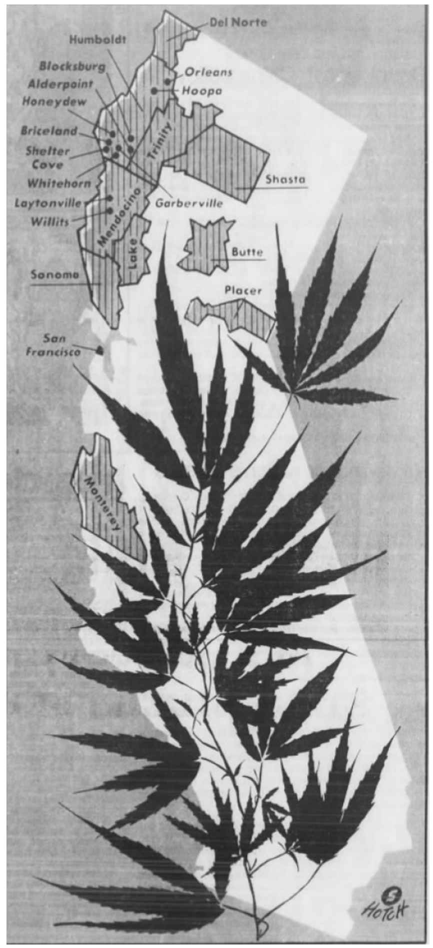


Fig. 2.12 Illustration of the Emerging Emerald Triangle

In Southern Humboldt, Garberville became the de-facto capital of this new cottage industry of domestic cannabis cultivation. "A farmer could make $25,000 to $50,000 (133,000-250,000 in 2023 dollars) on a typically yearly harvest growing no more than 50 plants" (Carlsen 1979). Logging around Garberville, once boasted 40 sawmills within a 25-mile radius, as of 1979, only two remained. Plentiful clear-cut land, ideal climatic conditions for growing cannabis, and the growing domestic demand for homegrown cannabis doubled land prices in 3 years from 1976-1979 (Carlsen 1979).

By the early 1980s, the cannabis industry in Northern California had become worth over a billion dollars and the secret was out. Not only had the *New York Times* and *San Francisco Chronicle* run pieces on this emerging trade but by the end of 1982, national magazines like *People* and *Life* had run profiles on the scene. An increase in media exposure, crime, and the negative optics of this situation in the eyes of the Federal Government culminated in what could be labeled the first domestic drug war.

Fig. 2.13 Life Magazine Cover with Cannabis Feature Article

Top 10 California counties by share of total CAMP eradication, 1984-1995	Average CAMP plants eradicated, 1984-1995	Share of CAMP plants eradicated, 1984-1995
Humboldt	40311	36.8%
Mendocino	28298	25.9%
Trinity	5686	5.2%
Santa Cruz	4887	4.5%
Santa Barbara	4050	3.7%
Butte	4029	3.7%
Sonoma	3105	2.8%
Monterey	2391	2.2%
Shasta	2062	1.9%
San Luis Obispo	2045	1.9%
Lake	1924	1.8%

Table 1. CAMP Eradication Totals 1984-1996 (From Corva 2013)

Top 10 California counties by share of total CAMP eradication, 2005-2009	Average CAMP plants eradicated, 2004-2009	Share of CAMP plants eradicated, 2004-2009
Lake	333505	15.0%
Shasta	286151	12.9%
Mendocino	184192	8.3%
Tulare	153648	6.9%
Fresno	144882	6.5%
Humboldt	109646	4.9%
Los Angeles	91113	4.1%
Riverside	89195	4.0%
Trinity	73294	3.3%
Napa	67719	3.0%
Kern	66957	3.0%

Table 2. CAMP Eradication Totals 2004-2009 (From Corva 2013)

In 1983, a joint task force California's Campaign Against Marijuana Planting (CAMP), was formed of local, state, and federal agencies to monitor and eradicate illegal outdoor plant grows (tables 1 & 2) during the harvest season months between August and October. This kicked off a 20-year campaign and game of cat and mouse whereas eradication efforts grew, so did growers' scale and tactics provoking two main market shifts. Its first impact was the reterritorialization of cannabis growing in the state, as early eradication efforts 1980s were focused around Mendocino and Humboldt. As a result, the geographic extent of the Emerald Triangle pierced deeper into even more remote sections of Northern California and across the state. The second major impact of CAMP and increased enforcement of illegal cannabis cultivation in the state was the stability of prices during the CAMP years. "Prices rose from $4000/lb in the early 1980's and stayed stable until a price decline in the late aughts to as low as $1500/lb in 2009" (K. Jodrey as cited by Corva 2013).

The Medicalization of Cannabis 1996-2016

In 1996, Prop 215, the Compassionate Use Act passed via ballot measure once again shifting the state's legal relationship with the public consumption of the plant. This measure allowed physicians to prescribe cannabis to patients as medication. It also set up a patient-caregiver system where a patient who was prescribed cannabis could legally purchase a product from a local 'caregiver' or grower both of whom could do so without criminal penalty. Slowly an informal network of caregiver growers and medical cannabis patients emerged across the state.

Table 3. Number and changes in cultivation sites, number of plants, and area of cultivation across counties and years (from Butsic 2018)

Year	County	Number of cultivation sites	Percent increase in number of cultivation sites	Mean number of plants per site	Percent increase in mean number of plants per site	Total plants	Percent increase in total plants	Greenhouse area (km^2)	Outdoor area (km^2)	Total area (km^2)	Percent increase in total area	Average cultivation area per farm (m^2)
2012	Humboldt	3783		84.82		320905		0.21	0.79	1.00		654
2016	Humboldt	6656	75%	119.44	40%	795 057	147%	0.6	1.09	1.70	69%	721
2012	Mendocino	4064		53.46		217 270		0.11	0.93	1.05		476
2016	Mendocino	7507	84%	95.75	79%	718 842	230%	0.54	1.70	2.24	112%	633
2012	Total	7847		68.15		534 832		0.33	1.72	2.05		549
2016	Total	14 163	80%	106.99	56%	1515 425	183%	1.15	2.79	3.94	91%	668

It wasn't until SB 420, the Medical Marijuana Program Act passed in 2003 by the state legislature, that provided guidance to local governments on uniform implementation across the state. Most importantly it allowed local municipalities to set their own limits on Prop 215 garden sizes and afforded smaller producers increased legal protections for anyone with one or more Prop 215 cards (Corva 2013). The Humboldt County Board of Supervisors immediately passed the most liberal county limits in the state allowing one caregiver to grow up to 99 plants per patient. This county measure ushered a 'medicinal era' in the Emerald Triangle as new growers flooded the area, and existing growers ramped up production on the premise of these new gray area medical protections leading to an explosion of farms. By 2010, 97% of the state's counties had implemented a medical cannabis program.

As each municipality was dealing with regulating medical cultivation, several directives from the federal government proved to be important for cementing a legal stance for growing in the state. In March of 2009, Attorney General Eric H Holder Jr issued a memo titled *Investigations and Prosecutions in States Authorizing the Medical Use of Marijuana*, it would effectively end Bush-era federal drug raids and prosecutions for growers and distributors in states who had passed medical marijuana laws. In August of 2013, Deputy Attorney General James M. Cole issued another memo that the federal government would not enforce prohibition law in states that "legalized marijuana in some form and ... implemented strong and effective regulatory and enforcement systems to control the cultivation, distribution, sale, and possession of marijuana" (Cole 2013). These memos from the Obama administration reflected a federal shift in the illegality and prosecution of cannabis in the United States.

A year prior, in 2012, Washington and Colorado, were the first states to legalize cannabis cultivation and use, implementing their own system of regulation and compliance. Between the new federal stance on cannabis prosecution, the ending of CAMP in 2012, and the potential legalization of California, a wave of the Green Rush hit the area. More and more growers came into the Emerald Triangle as they faced a reduced risk of seizure, prosecution, and imprisonment for their activities. From 2012-2016 in Mendocino and Humboldt Counties, cannabis farms increased in number by 58%, cannabis plants increased by 183% and the total area under cultivation increased by 91% (table 3) (Butsic 2018).

Legalization

In 2016, the passage of Prop 64 legalized the adult consumption and cultivation of cannabis in California. It had been 2 decades since Prop 215 and the atmosphere amongst outdoor growers in the 'scene' was optimistic but skeptical. On one hand, growers had the chance to become legitimate businesses not having to hide or shield themselves on the farm or around

Fig. 2.14 Anti-Legalization Bumper Sticker

town. On the other hand, being out in the open exposed many to the nuances of legal market forces and the high cost of compliance. Some saw promise with the ability to expand or cash out while others saw it as an attack on their way of life. Grower's relationships with government officials and law enforcement had already been fraught as social mistrust had festered after three decades of raids and eradication efforts. The thorny issue here in the Emerald Triangle was this bustling illegitimate industry had intricately interwoven itself into the region's economy over the past several decades. For municipal leaders, a new era of legal cultivation would finally require growers to adapt to environmental, labor, and health compliance measures common to other legal business enterprises. Secondly, municipalities were now able to tax these services through the legal taxation of a grower's crop and other business tax measures and licenses.

Market Effects: Legal Cannabis in the Golden State

A half-decade into legalization, the Golden State offers a golden opportunity to assess the regulatory issues facing most growers in the Emerald Triangle. The quality of their crop, care of their farm, and viability of the business is being stress-tested in real-time. Farms are now facing 3 core challenges in this new market: a high tax-high regulation atmosphere, a geographic reorganization of cannabis production, and an oversupply of cannabis flower.

Tax & Regulation

Prior to legalization, there were little to no compliance costs required of growers other than making sure your property taxes and related permits were current. In a post-Prop 64 environment, the cost of staying compliant remains quite high for growers of this specialty agricultural industry.

On a federal level, according to IRS XCode 280e and because cannabis is a Schedule 1 drug, taxpayers of legal cannabis businesses cannot claim deductions under the 'ordinary and necessary' standard that applies to most businesses. Growers are affected because they can only deduct costs directly incurred to produce inventory (Lawrence 2022). This means insurance, interest or taxes are not able to be deducted unless they are explicitly related to cannabis cultivation. i.e., fire insurance. When the federal income tax is applied to cannabis businesses, they fail to account for a licensee's profitability. Taxes are assessed against licensees even when they are unprofitable. Both create a market disadvantage for growers compared to traditional businesses.

Moving to the state's tax code, annual license fees remain a large annual cost burden of doing business. In California, these fees are levied by the Department of Cannabis Control. Here are 4 different licensing fees structures below as of 2023:

License Type	Application Fee	Yearly License	Notes
Med Mixed Light 1	$1,555	$13,990	10,001 sq feet to 1 acre of canopy
Med Mixed Light 2	$2,885	$25,970	10,001 to 22,000 sq feet of canopy
Medium Outdoor	$4,945	$44,517	10,001 to 22,000 sq feet of canopy
Large Outdoor	$1,555	$13,990	+1 acre of canopy + additional fees per sq. ft

Table 4. Licensing Fees for 4 common types in California

On top of those, annual fees (table 4), the state had imposed an additional tax on the grower when it sold any cannabis to a wholesaler. Initially, this was $9.25 per ounce in 2018 and was slated to increase to $10.08 by the end of 2022. However, Governor Gavin Newsom has eliminated this wholesale tax to provide financial relief to growers.

The last layer of burden for growers comes at the individual county level which imposes a cultivation tax either based on an annual tax per square foot of canopy or as a percentage of gross receipts. In Humboldt County, the government chose the former and implemented Measure S in 2016. The measure institutes a 3-tiered cultivation tax that was levied from between $1.00 - $3.00 per ft of canopy depending on cultivation type. Due to low wholesale prices across the industry, the Humboldt County Board of Supervisors recently reduced Measure S's fee by 85% in 2020 and subsequently froze it through November 2024. For the 2022 cultivation year, the current delinquency rate of this tax prior to the freeze was 57%, showing that the regulation is making it hard for most growers to stay current on their business costs (Burns 2022).

Environmental & Planning Regulations

Complex regulations for both the farm site and the end cannabis product forces a high level of compliance for the grower under guidance from both county and state authorities. Humboldt County is home to one of the most restrictive regulations on commercial cannabis permits in the state. Due to the rural and remote nature of farm sites, especially those located in near ecologically sensitive forest habitats it is difficult and costly to maintain compliance. Some examples of environmental and site requirements for the code are below:

- **Cultivation in Environmentally Sensitive Habitat Area (55.4.5.1.3):**
  Notwithstanding any other provision of the certified LCP, no commercial cannabis activity shall be permitted within one hundred (100) feet, at a minimum, of environmentally sensitive habitat area (ESHA), as defined in Section 313-143 ("Habitat Areas, Environmentally Sensitive"), or wetland, as defined in Section 313-158. In some cases, local coastal land use plans may require setbacks from wetlands and riparian areas to be greater than one hundred (100) feet. In addition, the buffer requirements of the biological resources protections performance standard (Section 313-55.4.12.1.10) shall apply to all commercial cannabis activity.
- **Generator Use (55.4.6.5.4.1):**
  Use of on-site generators to supply up to twenty percent (20%) of

cannabis cultivation-related energy demand may occur as a principally permitted use.

- **Cultivation Setback (55.4.6.4.4.2.1) + (55.4.6.4.4.2.2):**

  Six hundred (600) feet from the boundary of any residentially zoned area.

  Six hundred (600) feet from any residence located on a separately owned parcel.

In addition, the Humboldt Environmental Harm Reduction (HEIR) program, overseen by Planning and Building Department's Code Enforcement Unit (CEU) enforces the country's cannabis laws and has levied millions in fees and fines on over 1200 growers for environmental violations. There is an active class action in proceedings at the time of this publication.

The one state agency with the most environmental oversight for cannabis is the California Water Resources Board. In 2019 they adopted their Cannabis Cultivation Policy - Principles and Guidelines for Cultivation, one of the most rigorous water management requirements in the country for a specific agricultural product. It's a sweeping 40-page policy that regulates water diversion and waste discharge specifically for cannabis cultivation. For example Term # 130 out of #180 regarding winterization states:

> "Cannabis cultivators shall maintain all culverts, drop inlets, trash racks and similar devices to ensure they are not blocked by debris or sediment. The outflow of culverts shall be inspected to ensure erosion is not undermining the culvert. Culverts shall be inspected prior to the onset of fall and winter precipitation and following precipitation events that produce at least 0.5 in/day or 1.0 inch/7 days of precipitation to determine if maintenance or cleaning is required" (CWRB 2019).

This policy will obviously be a net benefit for the environment but with no large financial or tax incentive program for site improvements, the cost of environmental compliance remains high for outdoor growers in the state, especially compared to indoor farms. In addition, illegal growers don't have to face any of these compliance costs and California's black market makes up an estimated 70% of all cannabis sales (St. John and Ylanan 2022). This furthers the need to incentivize compliant growers in some way if the state seeks to build a legitimate statewide industry.

Equalization

Prop 64, included 'local control' provisions that gave each city and county the legal authority to decide whether to allow commercial cannabis activities within their jurisdictions. At its peak, the Emerald Triangle was estimated to have supplied 50-60% of all cannabis consumed in the United States (Butsic 2018). Now, a new statewide market has decentralized the Triangle's monopoly on cultivation and threatened its status as the loci of cultivation in the state. Two effects stemmed from statewide legalization, one is prohibition and the other is liberalization.

Large swathes of the state, typically rural and interior counties chose to ban these cannabis businesses related completely. California as a whole remains more prohibitive than most of the West Coast. Statewide, 38% of CA (or 44% of cities and counties) allows at least one cannabis business type (fig. 2.16). For retail only, 39% of the state allows cannabis retail compared to 67% for Washington and 79% for Oregon respectively (St. John and Ylanan 2022).

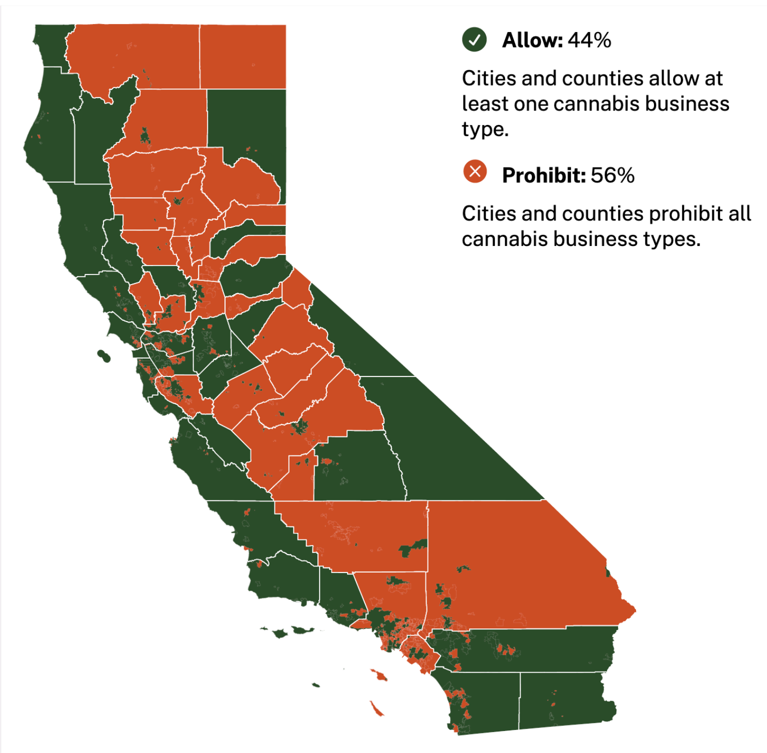


Fig. 2.15 State Map of Where Cannabis Businesses Are Allowed

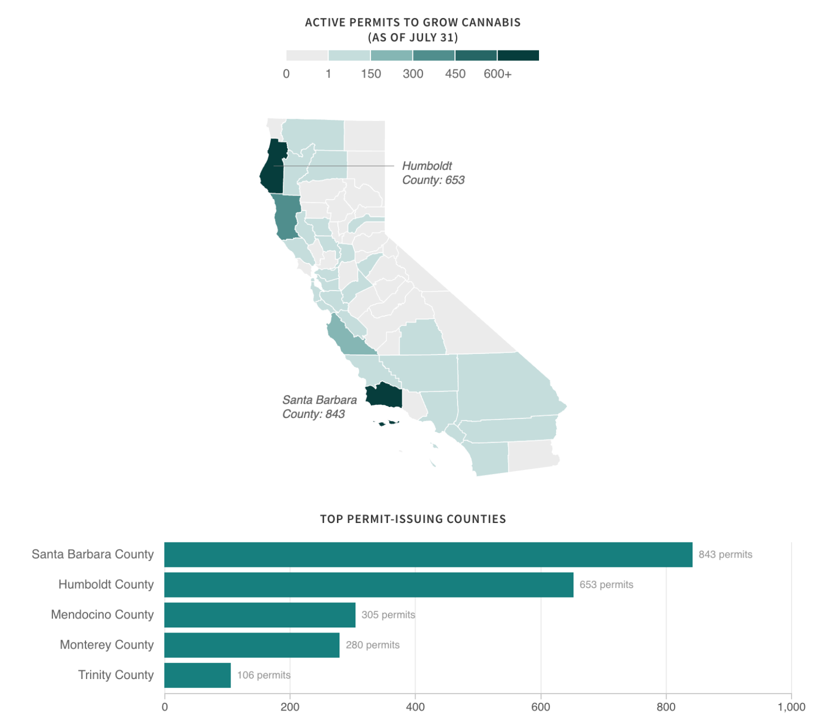


Fig. 2.16 Active Cultivation Permits & Top Permit-Issuing Counties as of 2020

Prohibition is coming at a price, according to a report on tax impacts on the legal market by the Reason Foundation, "As of February 2022, Colorado boasts one legal retailer per 13,838 residents while Oregon boasts one retailer per 6,145 residents. California, by contrast, boasts one legal retailer per 29,282 residents (Lawrence 2022). Overall, this highlights a lack of access growers face getting their product to legal consumers across the state. There are not enough retail establishments compared to the amount of cannabis being produced for the legal market.

On the other side of this coin, there are counties that have chosen to liberalize cannabis cultivation and sales shifting cultivation away from the historic centers of the Emerald Triangle.

Humboldt and Mendocino counties are still dominant but others such as Santa Barbara and Monterey (fig. 2.16) are emerging as large cultivation hubs. Once rich agricultural valleys filled with numerous cut-flowers and spring green farms are now filled with cannabis. Since 2019, the Carpinteria Valley, south of the city of Santa Barbara has been home to the densest outdoor cannabis cultivation facilities in the nation (Mozingo 2019). In addition, these farms are larger in cultivation canopy area and size with fewer county-level environmental regulations than Humboldt County.

As of 2022, the cultivation of cannabis is being pulled southward along the coast and eastward into the existing agricultural hubs of the Central Valley. Most importantly, the location of these growers is hundreds of miles closer to the centers of distribution and consumption like the robust markets of the San Francisco Bay Area and Los Angeles. It will be up to consumer preferences and the quality and marketing of the once-famous “Humboldt Homegrown” that growers will have to rely on to differentiate themselves from other growers in the rest of the state.

Market Isolation:

Humboldt and Mendocino counties has some of the highest numbers of active cultivation permits in the state. However, these locations are about as far from the large urban in-state distribution centers and consumer markets as one can get in California.

In 2019, Humboldt County ranked first statewide in distribution-transport and 4th in distribution licenses (fig. 2.17 & 2.18) (Weaver 2020) . ‘Distribution-Transport licenses’ allow one to self-distribute only what the licensee has cultivated or manufactured. Usually, employees of growers of the farm hold these licenses. A ‘Transport license’ allows any cannabis goods to be transported between licenses usually through a distributor or independently contracted delivery service. Both reflect an added operating cost on top of already high compliance costs for Emerald Triangle farms compared to most growers to the south. This could lead to a decrease in demand for their product, as larger farms located in other parts of the state can offer cheaper cannabis with the same potency. These larger farms would be able to supply retailers and consumers in the more densely populated areas of the state more quickly than farms in the Emerald Triangle.

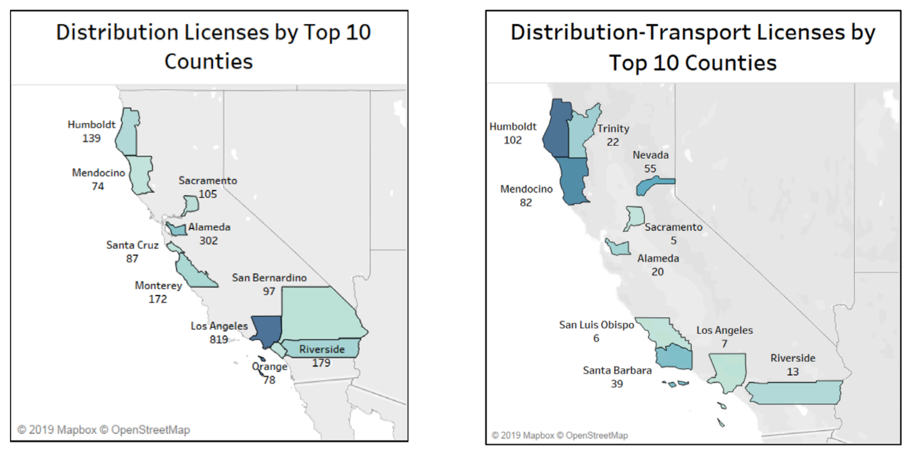


Fig. 2.17 & 2.18 Map of Distribution & Distribution-Transport Licenses by County

Market Isolation Fig. 2.19

Key Distances of Cannabis Distribution from Eureka, CA

To Garberville: **67 mi / 1 hr 10 min**

To Ukiah: **157 mi / 2hr 40 min**

To Santa Rosa: **219 mi / 3hr 45 min**

To San Francisco: **273 mi / 5 hr**

To Los Angeles: **645 mi / 10 hr**

Market Bloat

Even as new cannabis businesses are entering the market, there is an obvious mismatch in the legal market between growers and getting their product to consumers via distribution and retail. Looking at the graph below (fig. 2.18), there has been a slow and steady incline in the number of cultivation licenses active in the state while retail and distribution have remained flat since legalization. Too many growers, growing too much cannabis flower have turned the industry into a buyer's market. In 2022, the California market produced the most amount of legal cannabis ever, growing 577 metric tons (+12% YOY) while its value remained at or around $1 billion dollars (-40% YOY) (Downs et al. 2022). Looking at these numbers show a surplus of legal supply but a lack of legal demand, possibly due to the high retailer-to-population ratio. Legalization across the state has brought wholesale prices, especially for

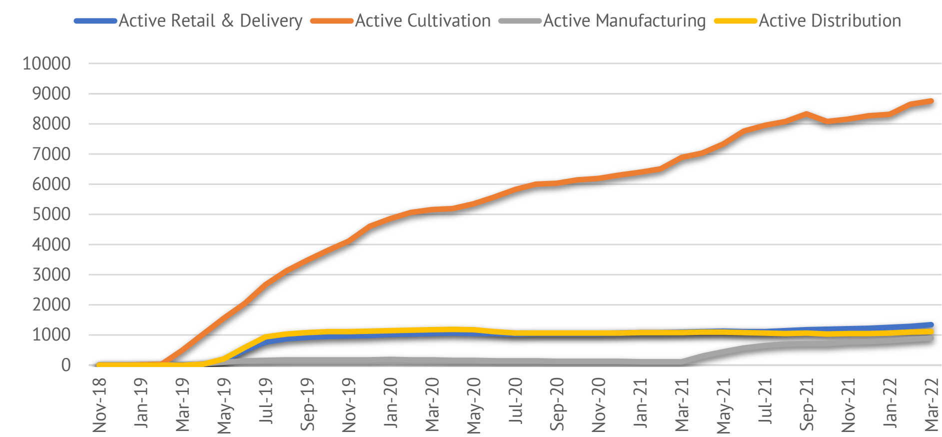


Fig. 2.20 California Active Annual Licenses, By Type (Nov 2018 - March 2022) (From Lawrence 2022)

outdoor, down to or below their cost of production. In just a matter of 5 years, wholesale cannabis has dropped by nearly 50% (fig. 2.20) proving profitability elusive, especially for small growers. In response, Humboldt County has already experienced a rapid decrease in the number of original pre-Prop 64 farms. Since 2017, while newly permitted farms are being built only 40% of legacy farms continue to operate (Black 2022).

High supply at low prices has weakened most farms' ability to keep remain financially solvent. After factoring in fees, taxes, operating costs, environmental compliance, and other expenses, there is very little left to invest in farm development, support workers, and ensure stability for the production of the next year's crop. While the future may appear bleak for most farms, there are opportunities to expand cultivation, explore alternative revenue sources, and seek government assistance through environmental grants. Compliance has become challenging for many growers, and the implications of legalization are still being resolved.

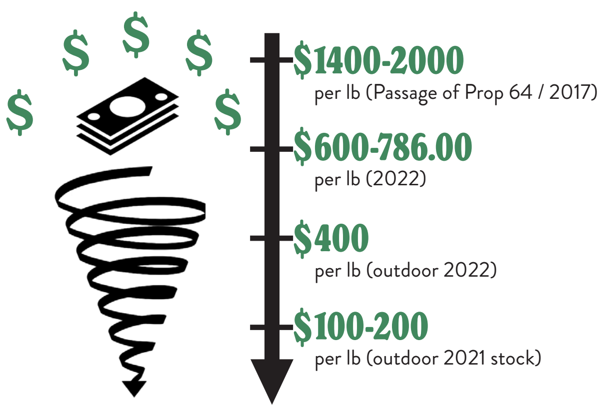


Fig. 2.21 Price Decline of Cannabis

In all, California's unique combination of vast uninhabited land, cultural acceptance of personal drug use, and the gradual wave of cannabis decriminalization and legalization set it apart from other states during that time period.

The Emerald Triangle reflects the unique historical and cultural influences that have shaped the landscapes where these farms are located. Current market effects that stem from legalization add yet another layer of history and influence, which can either support or endanger the future viability of these farms. The interaction of both historical influence and market dynamics also places specific pressures on the surrounding landscapes and ecosystems compared to other farms in the state. To address this, implementing a *radical cannabis ecologies framework* can help restore functionality to the farms, improve their market competitiveness, and enhance resilience against future industry trends and climate conditions. However, first, it is crucial to assess the environmental impact of cannabis farms and anticipate what future climate challenges they face in order to better understand what conditions and practices both the farm and forest require. It is out of this exploration that will inform and guide this framework.

Authors Note

The proposal I've developed in this project does not provide a comprehensive solution to address every possible issue growers may face in an open market, as that is beyond the scope of this project. However, I am taking into account the potential market effects on a farm's future development and incorporating those considerations into my *radical cannabis ecologies framework.*

Cannabis & The Environment

The Douglas-fir / Mixed-Evergreen forests and woodlands of Northern California have been routinely disturbed through fire, indigenous land management, heavy grazing, and logging. Thus creating a complex mosaic of forests, woodland, and grasslands between the coastal forests and the montane slopes of the Coast Range. From the dizzying patchwork of these lands, numerous sunny sites with little marketable timber and poor soils have made it a prime environment for another disturbance, the cultivation of cannabis (*C. indica* & *C. sativa*).

Over the past 25 years, as the state transitioned to a statewide medical cannabis program and the probability of legalization grew, cultivation has become more intense, posing a threat to the forest ecosystems where most farms are located. These cannabis farms directly interact with the natural environment, often extending right to the forest's edge. In comparison other parts of the state (fig. 3.1) are situated in highly modified alluvial valleys and plains with existing agricultural infrastructure or controlled indoor warehouses of urban areas. Even when cultivation is in wildlands, it is usually found in open and flat areas such as shrublands, prairies, or desert. While the Eastern Coast Range and Eastern Northern, and to a lesser extent Southern, Sierra share similarities with the Emerald Triangle, the distribution and quantity of farms are less prevalent and fall outside the scope of this project.

In the Emerald Triangle, it is estimated that there are approximately 10,000 to 15,000 farms of various sizes, both legal and black market. This region stands out not only for its high concentration of farms but also for the unique site conditions and impacts it creates. Moreover, it is more susceptible to disturbances like extreme weather and climate change, distinguishing it from the rest of the state. Converting forests into cannabis farms can have direct environmental effects, including forest fragmentation that leads to habitat loss and changes in hydrology. Additionally, farm development can create hazardous conditions for the farms themselves. Establishing cultivation zones can contribute to increased dead fuel accumulation, soil erosion, and landslides, posing risks to farm workers' safety and the long-term economic viability of the farms.

Anticipated changes in precipitation and temperature will further amplify the already distinct wet-winter, dry-summer conditions that govern this landscape. This, in turn, will lead to negative environmental impacts such as drought, and an increase the prevalence of wildfires, pests, and insects, placing immense pressure on the forest systems and the vital ecosystem services they provide to cannabis farms.

By understanding the underlying ecosystems, analyzing environmental changes due to the conversion of forests into cannabis farms, and considering the potential effects of climate change, these can determine areas of vulnerability, pinpoint intervention possibilities, and provide valuable insights for the development of a *radical cannabis ecologies* framework.

Fig. 3.1: Diverse Landscapes of Cannabis Cultivation in California

Cannabis Farms Across California

The North Coast Bio-Region

The Northern California Coast Ranges start just above the San Francisco Peninsula and run parallel to the Pacific Ocean until they hit the Klamath Mountains around the California-Oregon Border. The mountains create a distinct rain-shadow effect. The west side of the Coast Range is temperate forest, shifting from a foggy and cool Mediterranean climate to a drier and colder continental climate as one travels further east. Dense redwood forest (fig. 3.1) dominates a thin linear fog belt that stretches along the Northern Coast Range closet to the ocean.

In the northern reaches of the Emerald Triangle in northern Humboldt and throughout Del Norte counties, redwood mixes with species one would find in the Pacific Northwest such as Western Hemlock (*Tsuga heterophylla)* and Western Red Cedar (*Thuja plicata*). However, both the redwood and these northern coastal forests (fig. 3.3) are too moist and dark for outdoor cannabis cultivation. Hence, any farms located here are at higher elevations or along the sunny ridges.

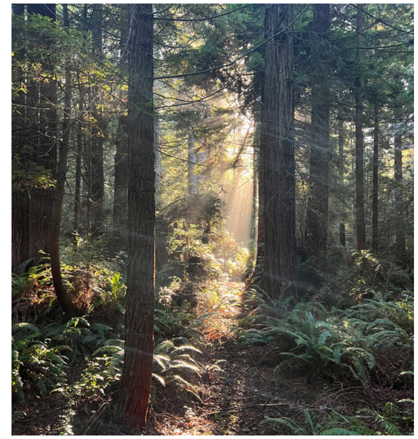
As one moves inland or upland, the redwood forest transitions to a mix of Douglas-fir (*Pseudotsuga menziesii*), Tan Oak (*Notholithocarpus densiflorus*), and Pacific Madrone

Fig. 3.2 Extent of Redwood Forests

Fig. 3.3 Extent of North Coastal Forest

(*Arbutus menziesii*) that comprise the majority of the tree canopy. In sunnier aspects atop ridges or in open canopy, Doug fir will intermix with Coast Live Oak (*Quercus agrifolia*), Canyon Live Oak (*Quercus chrysolepis*), Oregon White Oak (*Quercus garryana*) and California Black Oak (*Quercus kellogii*). California oak-woodlands are found on the drier and sunny ridges on poorer non-sedimentary soils in strands or single specimen trees that are surrounded by coastal and upland prairie grasses. These Douglas-fir / Mixed-Evergreen forests (fig. 3.4) are found throughout the Emerald Triangle and have been the predominant habitat type where growers have chosen to site their farms.

Fig. 3.4 Extent of Douglas-fir / Mixed-Evergreen Forest



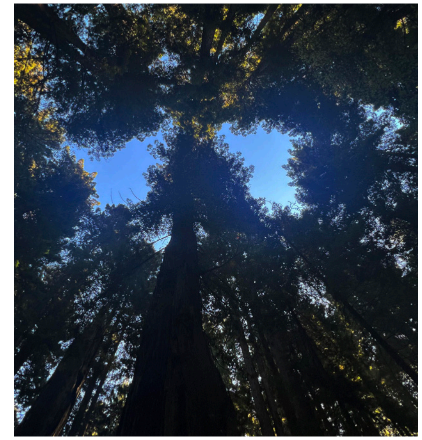


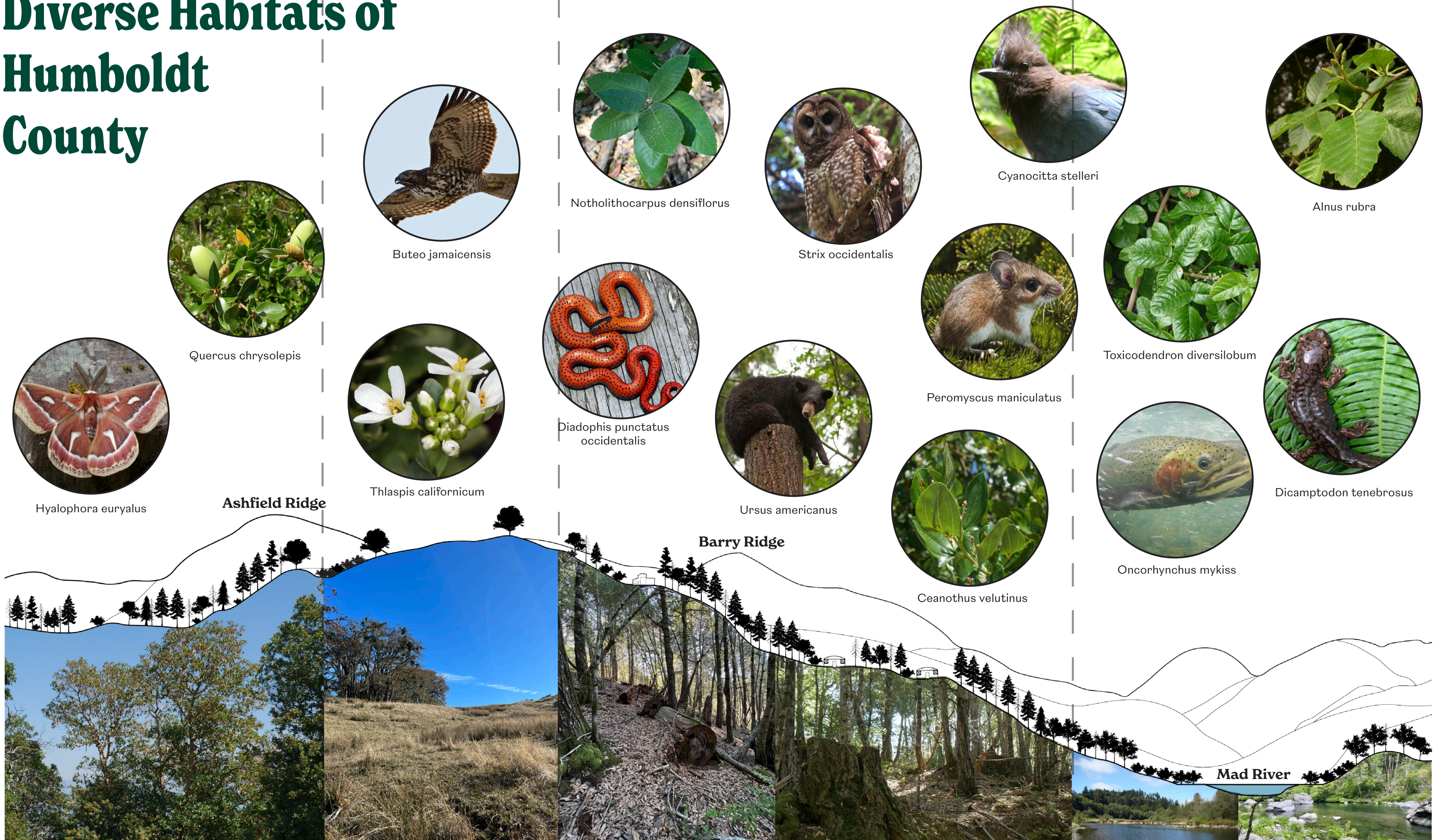
Fig. 3.5 & 3.6 Redwood Forest

Fig. 3.7 Oak Woodland

Fig. 3.8 Douglas-Fir / Mixed-Evergreen Forest

Fig. 3.9 Section of common habitat types and associated species found in or near cannabis farms

Diverse Habitats of Humboldt County



Environmental Effects of Cannabis Agriculture in the Emerald Triangle

When a site is developed in this region, it possesses a shared set of characteristics that directly affect the native ecosystem and create common environmental conditions across all farms. Typically, these sites are remote and located in forested areas, often clustered with other cannabis farms nearby. They are frequently situated within environmentally critical watersheds that hold significant conservation value and support endangered wildlife. The development and ecological disturbances associated with these sites, such as forest fragmentation, changes in hydrology, and habitat disturbance or removal of wildlife, have various impacts on the environment. However, these characteristics also offer opportunities to restore and enhance the environmental conditions that were lost during initial development.

Remoteness

Until 2017, commercial cannabis cultivation in the state was illegal. Sites suitable for illegal cultivation before then had to be clandestine by nature. This meant forested parcels, far away from main roads not visible from any public vantage point. In a 2017 study modeling 1431 grow sites in Humboldt County, researchers found that a parcel's location influences its likelihood of cultivation. "Parcels that are further to the north are less likely to have cultivation sites, as are parcels closer to cities and farther from the ocean. Proximity to roads also significantly reduces the likelihood of cultivation, with a 1% increase in distance to a road increasing the probability of a cultivation site by 2.3% (Butsic et al. 2017)." The study also found that a "parcel's slope is a strong predictor of cultivation site size. Slopes with over 30% had a positive relationship with the number of plants cultivated on a parcel." After Colorado and Washington legalized cannabis, an explosion of illegal and quasi-legal medical farms followed in California. Cultivation then pushed further into remote areas of the region. "Production increased by 40% on steep slopes, sites more than doubled near public lands, and increased by 44% in remote locations far from paved roads (Butsic et al. 2018)."

Timber & Forested Sites

The growth of farms on the North Coast during this time was in part due to the long history of logging that I examined in the previous chapter. A dense matrix of logging roads led to numerous secluded and private forest parcels (fig 3.10 & 3.11) in one of the most sparsely populated regions of the state. Logging continued well into the 20th century, but logging companies and private landowners began to harvest and sell off remote parcels in areas with little or no short-term timber value.

Until 2019 these parcels had been sold to intrepid growers who slowly converted them into cannabis farms . The timber production zone (TPZ) designation allows the harvest of timber and protects the parcel from development through an incentive of a reduced property tax. Before legalization, timber would be harvested and (depending on the county) particular uses like homesteading or agriculture would occur. Most TPZ parcels in the Emerald Triangle grew cannabis while getting a reduced property tax. In Humboldt County, cannabis cultivation has been allowed on forested land whose property had been a site of a grow previously. After this initial conversion after legalization, no timber production zone properties can be converted to commercial cannabis cultivation. Illegal timber conversions and black market farms are still an issue, with the former rising 200% since legalization (McGuire 2018).

During the 2012-2016 era of cannabis expansion "88% of sites were developed in areas of natural vegetation, with forest the most common previous land cover, 41% of the cultivation sites developed on lands that were classified as forest. 27% of cultivation sites were developed on shrublands, and the remaining 20% of sites were developed on grasslands (Butsic et al 2018). As the value of cannabis crops continues to exceed the value of the timber harvest in many places in Northern California, the pressure to convert timberland to cannabis cultivation is still pervasive.

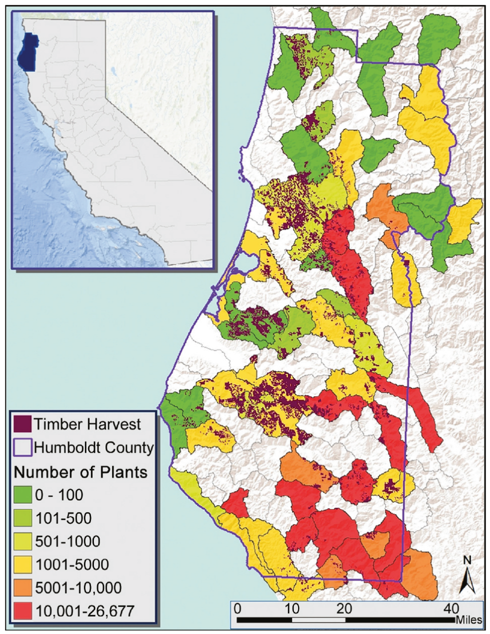


Fig. 3.10 Number of cannabis plants on each watershed and areas of timber harvest from 2000-2013 (from Wang 2017)

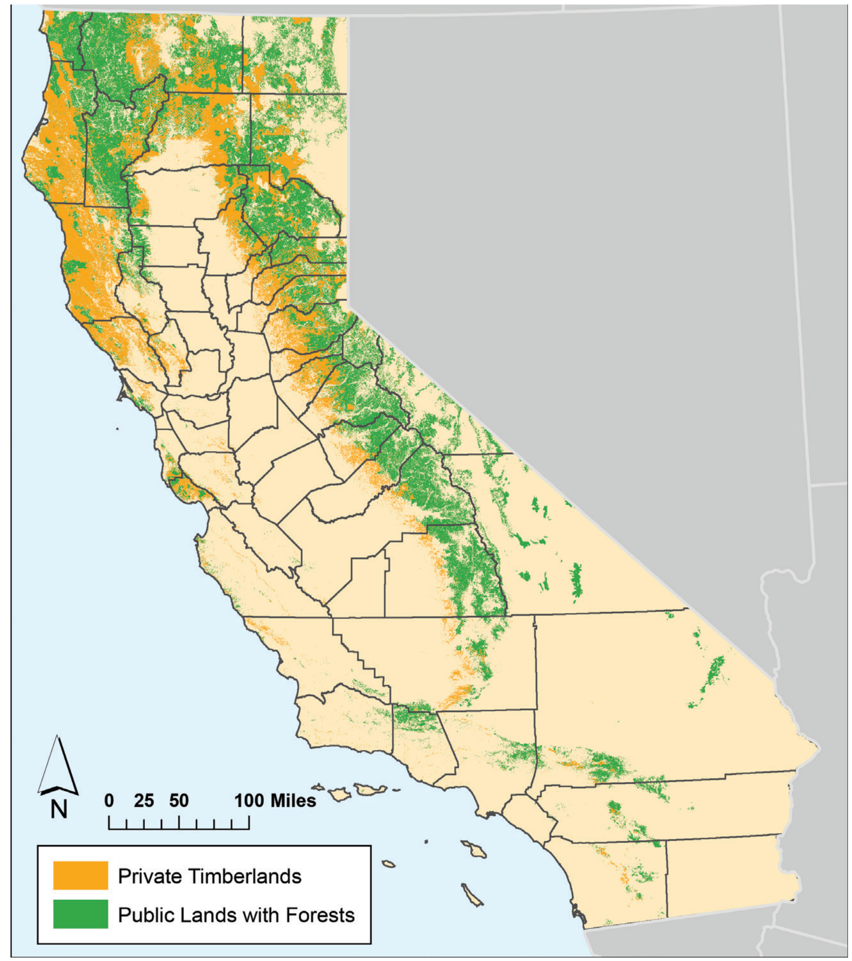


Fig. 3.11 Map of Private and Public Timberlands (2015)

Clustering

Proximity to other cultivation sites positivity increased the chances that cultivation was happening nearby. "Within 100m of a cultivation site, the probability of a parcel having a cultivation site is 4.5%. When there are 200 plants within 100 m of a parcel, the predicted probability jumps to 35.7%, this effect steadily increases through 4600 plants, for which the predicted probability of a parcel having a cultivation site is 66.5% (Butsic 2017)." This clustering effect is common among the Emerald Triangle and the long history of informal business and supply networks may explain its cause. See Figure 3.12 for an example of how this clustering effect played out over the course of 30 years around the Kneeland Site.

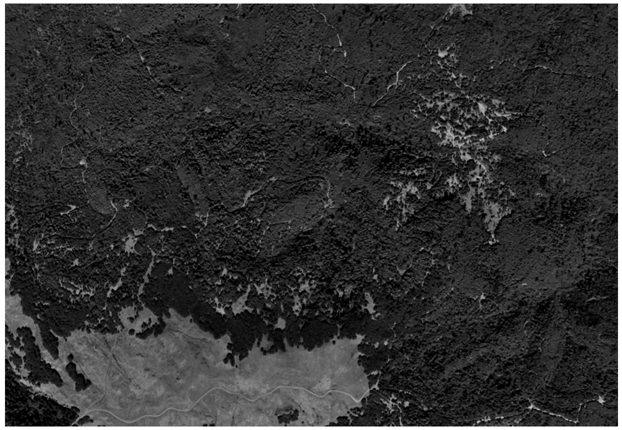
Over the past 4 decades, the slow creation of these vast remote networks of clustered grow sites on steep, forested terrain far from major roads and cities has created ecological issues unique to cannabis cultivation. Issues such as increased forest fragmentation, unsustainable water consumption, high fire risk, and potential loss of biodiversity all put pressure on the viability of this new industry.

Forest Fragmentation

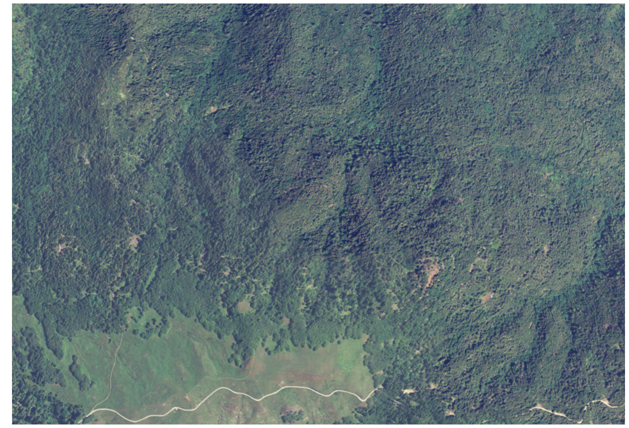
Since this region is heavily forested and sunny naturally prairie land is typically reserved for pasture, many sites require the removal of tree canopy so adequate sunlight is available for full cannabis plant growth. When comparing cannabis cultivation to timber harvest, cannabis' remote and isolated parcel locations create greater core forest area while increasing forest shape patch irregularity and overall complexity. Timber, on the other hand, creates larger overall forest loss and more patch and landscape division but in a small more uniform, and isolated shape. See Figure 3.13 for how the cultivation of cannabis has transformed the forests around the Kneeland site area. In a study area of 208.7 km2 of timber harvest compared to 4.1 km2 of forested cannabis grows " one-quarter of the study's watersheds, cannabis caused greater landscape change than timber harvest, including a >12% increase in forest edge and a >3% core habitat loss in certain watersheds (Wang 2017). In a study area of 208.7 km 2 of timber harvest compared to 4.1 km2 of forested cannabis grows "one-quarter of the study's watersheds, cannabis caused greater landscape change than timber harvest, including a >12% increase in forest edge and a >3% core habitat loss in certain watersheds (Wang 2017). " The main conclusion drawn from this study is that the reduction of the core forest canopy can have significant impacts on animal and insect populations that prefer closed-canopy and shaded forest environments. Forest fragmentation resulting from this reduction can lead to various immediate site problems, including the loss of mature trees, increased soil erosion, and the accumulation of dead fuel, which can pose a fire hazard. However, a positive aspect of this human-induced disturbance is that it creates openings or gaps in the canopy, introducing new environmental conditions that promote the thriving of a greater variety of plant species.

Cannabis Farm Clustering of Kneeland Prairie Ridge

Fig. 3.12
These Google Earth satellite photos depict the transformation of a forest in Humboldt County into a cannabis farm cluster. After timber harvest sometime around 1988, three decades of forest growth occur before the first signs of a farm emerge. The primary logging road becomes the central axis of this cannabis cluster, with new farms progressively emerging farther and farther from the main road before terminating near the Mad River (not shown).



1988



2005

September 2010

September 2011

May 2014

September 2022

Forest Fragmentation of Kneeland Site

May 2010

September 2010

September 2012

May 2014

September 2019

September 2022

Fig. 3.13
As we zoom into the parcel scale of this cluster, we can observe the gradual transformation of the existing forest into a cannabis farm. Each subsequent wave of farm expansion alters the shape of the forest, creating larger and irregular perforations. Consequently, the core forest area diminishes, but the forest edge and shape complexity increase.

Water Use

In addition to forest fragmentation, cannabis agriculture encourages increased consumption of localized water sources to grow the plant. Across the Emerald Triangle, rural and remote grows rarely have access to municipal water systems and therefore rely on water extraction from the environment through springs, streams, and wells. This is unique among other crops in the state and occurs outside of valley and low-elevation areas where farmland is most prevalent. To compound the issue, most farms do have access to larger water conveyance systems, like the California Aqueduct, and operate outside of regulated groundwater basins (Butsic and Brenner 2016). There are 6 common water use types: Subsurface water well, subsurface water diversion, spring diversion, rainwater catchment, water delivery, and municipal water supply.

In a 2019 study of water use in the Emerald Triangle, well use was the most common type of water source with 58.2% of sites relying on them for supply (Fig. 3.14) (Dillis et al. 2019). However, it is important to note the Trinity County numbers show high well water use due to a majority of respondents coming from one watershed. So, when the numbers were adjusted by weight usage was similar to other counties (table 5).

Though the patterns vary by county, it's important to note that most farms needed multiple sources of water to supply the farm. The study also looked at water sources for compliant and non-compliant farms (Fig. 3.15 & 3.16) and found that non-compliant sites were more likely to use surface diversion (39.4%) and spring diversion (36.1%) more commonly than compliant sites (14.9% and 8.6%).

Location	Surface	Spring	Well	Rain	Off-Site
All	21.6%	16.2%	58.2%	12.0%	5.4%
Humboldt	33.1%	23.9%	40.9%	18%	3%
Trinity	20%	11.2%	59.4%	2.6%	14.7%
Mendo/ Sonoma	12.1%	14.1%	73.1%	10.3%	5.8%

Table 5. Water Use in the Emerald Triangle (Adapted from Dillis et al. 2019)

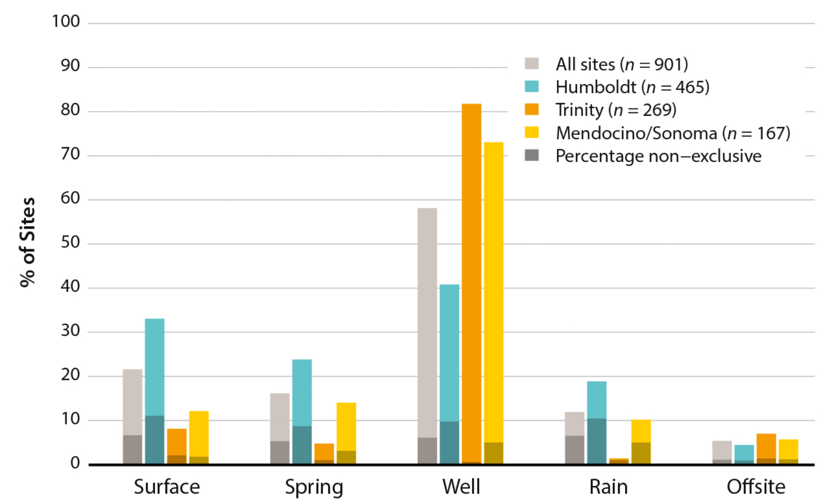


Fig. 3.14 Percentage of sites extracting water from each source, overall and in each county analyzed. Shaded portions of bars depict the percentage of sites using each respective source that also used additional sources (i.e., the percentage exhibiting nonexclusive use). The shaded portion depicting percentage corresponds to the length of each bar individually, rather than the x-axis. (from Dillis et al. 2019)

Based on this data, non-compliant and other black market farms are more likely to use surface diversion and spring diversion to supply water. These two methods directly affect local stream health more than any of the other types.

Water use for permitted cannabis farms across California showed similar results for common water sources. Well-use is the most common with 76% of all farms in the state. Humboldt and Mendocino counties respectively had 53% and 73% well use for

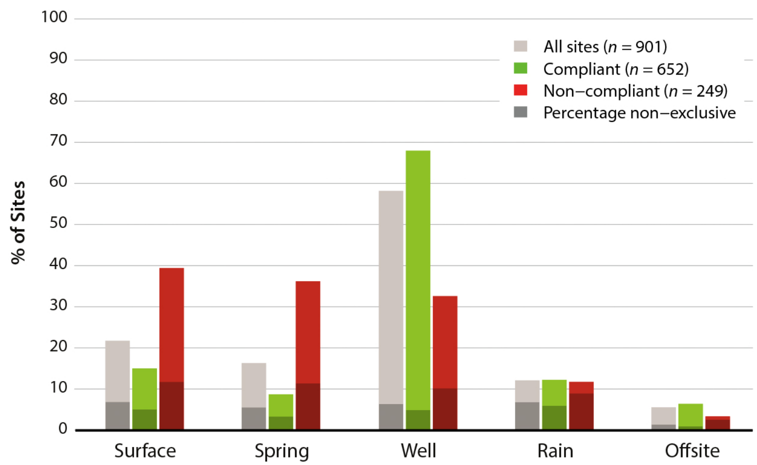


Fig. 3.15 Percentage of sites extracting water from each source, organized according to reported compliance status. Shaded portions of bars depict the percentage of sites using each respective source that also used additional sources (i.e., the percentage exhibiting nonexclusive use). The shaded portion depicting percentage corresponds to the length of each bar individually, rather than the x-axis. (from Dillis et al. 2019)

permitted farms (Dillis et al. 2021). These numbers from counties in the Emerald Triangle differ from other emerging hubs such as the Central Coast, where counties such as Monterey and San Luis Obispo rely exclusively on well water at 98% and 100% respectively. Rural counties such as Humboldt which have permitted and unpermitted grows far from established water infrastructure depend on potentially environmentally detrimental techniques such as spring diversion to supply the farm with water.

Not only is the source of water important for farms and municipalities but how they use it throughout the season can help identify some of the challenges and opportunities to conserve water in the future. California's Mediterranean climate creates a distinct wet and dry season with 75% of annual precipitation falling during the winter months. Cannabis cultivation requires the most water in summer and early fall, the exact opposite of what the

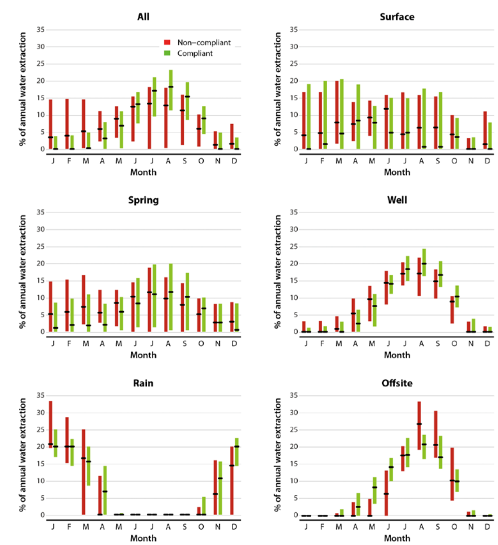


Fig. 3.16 Comparison of relative monthly water extraction for compliant and non compliant sites. Boxes depict the interquartile range, with black lines at median values for each month. Monthly values reflect the sum of water placed in storage and directly applied to plants. (from Dillis et al. 2019)

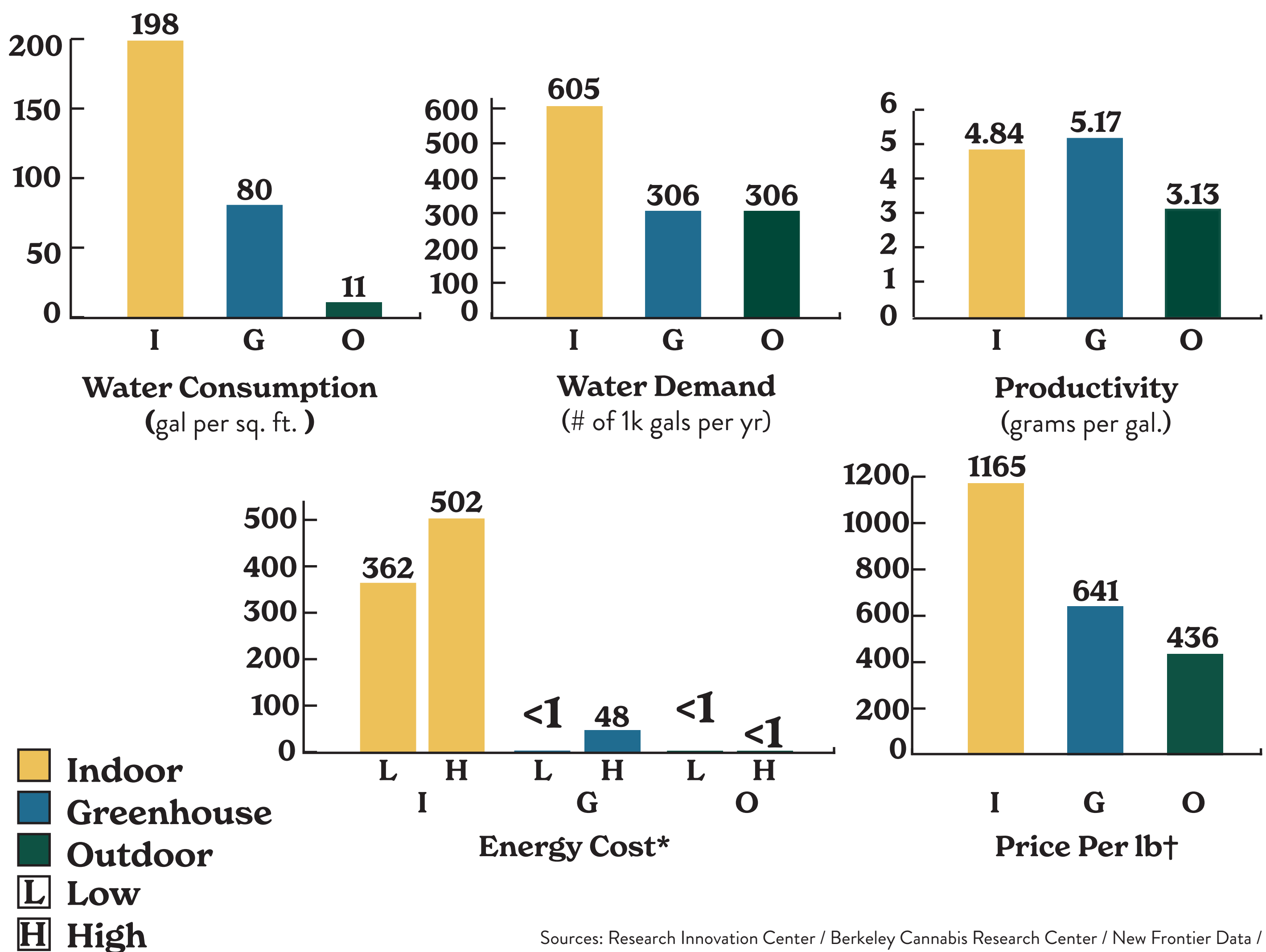
ecosystem provides. With little to no precipitation during the summer months, growers are forced to use not only wells but pull from local springs and creeks to supply their water.

In the 2019 study of the Emerald Triangle, usage (fig 3.16) across all sources peaked in the summer months except for rain catchment which one would expect. Well use peaked in the height of the summer around August then fell throughout the off-season. Spring and surface diversion stayed relatively uniform throughout the year but also fell immediately after harvest season and into the wet season. In the first months of the year spring and surface extraction picked back up, presumably for water storage for the upcoming growing season. Looking across all extraction types, rain and the uses of the large-scale catchment for all that naturally occurring precipitation in the Emerald Triangle seems to be underutilized.

In 2019, the State Water Resources Board established the Cannabis Cultivation Policy, placing restrictive environmental standards to water use and discharge in the state for all farms. Most importantly farms are prohibited from diverting surface water for the duration of the growing season (April - October) Forbearance Period (CSWRCB 2016). For farms seeking to stay compliant and keep their cultivation permit active, water storage is going to be an important infrastructure issue as the industry matures. Another study that modeled water usage from farms that participated in the North Coast Regional Water Control Board Cannabis Program, found that over 81.8% of farms had a negative storage balance (Dillis et al. 2020). Meaning a majority of farms needed to pull water from wells, streams, and springs to meet demand during the growing season. Only farms that had irrigation ponds could meet the storage requirements to completely forbear between April and October. Between these two water usage studies cited only 10-14% of farms had ponds on their property. If no water conservation strategies are employed, extraction without oversight or enforcement has the potential to reduce stream flows (Butsic and Brenner 2016), increase temperatures (Arismendi et al. 2013), and negatively affect aquatic life due to most farms proximity to ecologically sensitive areas. The natural clustering effects of farms as cannabis production intensifies could intensify this issue for particular sub-basins in environmentally critical watersheds throughout the North Coast. Still, cannabis agriculture's scale and total cultivation area across the region and state are small relative to other major crops and residential water use.

When looking across the cultivation industry in the state, greenhouse and outdoor grows demand less water and energy than indoor cultivation (fig. 3.17). Add the North Coast's ample supply of water, it may be the most sustainable place to produce cannabis compared to areas of Southern California with the lack of fresh water and higher energy costs.

Cultivation Comparison



Sources: Research Innovation Center / Berkeley Cannabis Research Center / New Frontier Data / Cannabis Benchmarks
* based on .1813 per Kwh (avg CA commercial rate)
† national average as of Feb 24th

Fig. 3.17 Comparison of Water and Energy Demand for 3 Main Cannabis Cultivation Types

Wildlife

Between increased water usage and forest fragmentation caused by cannabis cultivation, its effect on wildlife is more pronounced when compared to most other cannabis-producing regions in the state. Cultivation in the Emerald Triangle exists right into the forest and stream's edge in some cases.

In a study that analyzed 4428 grows across half of the watersheds in Humboldt County, over 68% of grows were located more than 500m from a developed road. 25% of grows were within 500m and 6% within 100m of Chinook salmon (*Oncorhynchus tshawytscha*) habitat. For Rainbow trout (*Oncorhynchus mykiss irideus*), 19% of grows were within 500m and 4% within 100m (Butsic and Brenner 2016).

If one looks at the map from this study (fig. 3.18) you can see that the areas of high plants per watershed coincide with the middle and upper reaches of environmentally sensitive aquatic habitats such as those on the Van Duzen and Eel River. These rivers contain populations of these endangered and threatened salmonid fish which they use as yearly spawning grounds.

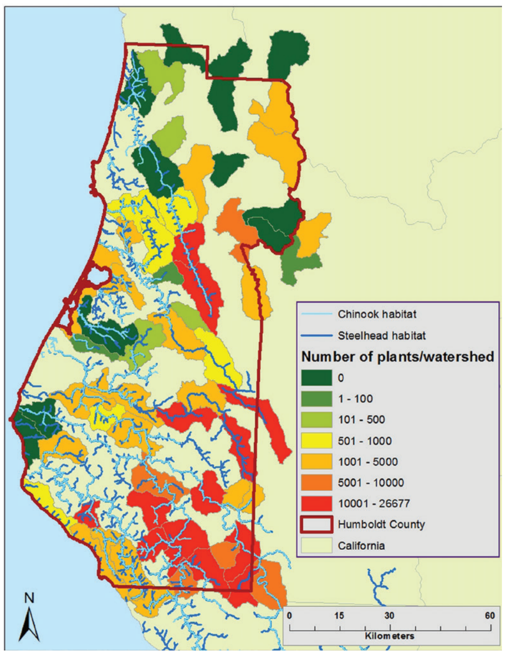


Fig. 3.18 Number of plants per watershed and location of critical habitat for steelhead trout and Chinook Salmon (From Butsic & Brenner 2016)

The images to identify these grows were from 2012-2013, from 2012-2016 across both Humboldt and Mendocino counties, there was a 80%–116% increase in cultivation sites near these environmentally sensitive aquatic habitats (Butsic et al. 2018). When increased water demand for cannabis cultivation exceeds stream flows during low-flow periods it can cause diminished stream flows during critical stages of life for salmonid and other aquatic species. (Bauer et al. 2015). Even groundwater pumping from a well may impact the supply of summer water that can help cool baseline flows in these streams. Larger pumping rates, located near streams with soils that have high hydraulic conductivity are more liable to affect summertime base flows and temps leading to high seasonal mortality of aquatic species.

Climate and Climate Futures of the Forest Landscapes in the Emerald Triangle

Straddling closely to the coast, the west side of the Coast Range, sharply drains a majority of the region's watersheds immediately into the ocean. This region of California is one of two regions in the state that experiences a water surplus, the other being the Sacramento Valley (Rantz 1968). The eastern side of the Northern Coast Ranges mostly drains into this valley. The North Coast, defined by State Regional Water Quality Board (fig. 3.19), encompasses only 12% of the state's total area but produces 40% of the state's annual run-off (NCRWQCB 2018). The west side of the Coast Range regularly receives anywhere from 3 feet on average (up to nearly 8ft in some places) of rainfall per year, the montane regions only receive 25% of that rainfall and only 5% of that on the eastern side of the Coast Range (Sawyer 2006). As noted earlier, the western side of the Coast Range is a cool Mediterranean climate that creates a distinct seasonal wet winter and dry summer climate where nearly 75% of the rain falls between November and March and little to no precipitation from June through September (OEHHA 2018).

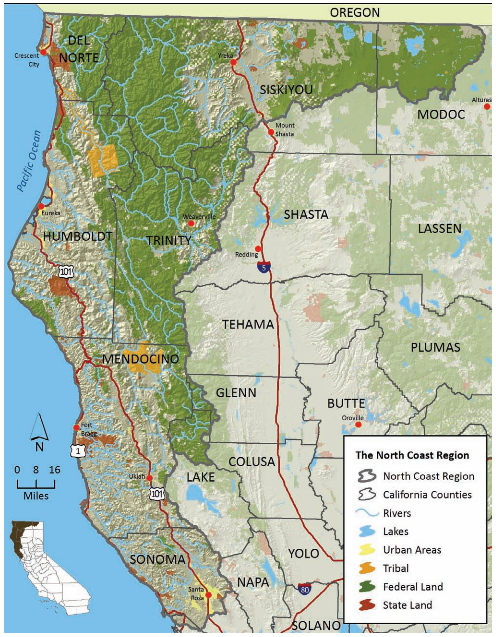


Fig. 3.19 North Coast Region Water Basin

Climate change is predicted to shift these precipitation patterns altering seasonal water availability. This, in turn, will impact the extent and species composition of these forests. These changes will have significant environmental effects, including exposing cannabis farms to higher risks of drought, wildfires, and an increased prevalence of pests and diseases. Over the next century, annual precipitation in Northern California is expected to increase modestly but this distribution will become more variable from year to year leading to more dry years (Pierce et al. 2018). Annually, the wet season (November to March) will become wetter and shorter and the dry season (April to October) will become drier and longer (Swain et al. 2018). Increases in average temperature are also forecasted for these hydrological basins of the North Coast, Northern Coast Range, Northern Interior Coast Range, and Klamath Mountain ecoregions that comprise a majority of the Emerald Triangle (Flint and Flint 2014). They are as follows:

- 4.0–9.7°F increase in the average annual temperature by 2100
- 3.4–8.6°F increase in average winter minimum temperatures by 2100
- 4.0–11.3°F increase in average summer maximum temperatures 2100



Fig. 3.20-22 Cannabis Farms in the Line of Fire

Warmer temperatures will increase the evaporative demand of the region meaning that even in areas with increases of precipitation trees will likely face an increase in climatic water deficit (CWD). Climatic water deficit is defined as the amount of water by which potential evapotranspiration (PET) exceeds evapotranspiration (ACT) (Stephenson 1998). This climatic data variable combines the effects of solar radiation, evapotranspiration, and air temperature on watershed conditions given the available soil moisture derived from precipitation. Increases in annual CWD by 2100 are estimated as follows (Flint and Flint 2014):

- 9–29% increase on the North Coast
- 7–24% increase in the Northern Coast Range
- 5–16% increase in the Northern Interior Coast Range
- 10–32% increase in the Klamath Mountains

An increase in the climatic water deficit, summer temperatures, and lack of summer precipitation will all contribute to more frequent droughts in Northwestern California. Drought years have occurred twice as often over the last two decades compared to the previous century (Diffenbaugh et al. 2015). Severe droughts will happen twice as frequently and a once in a century drought now might occur once every 20 years (Pierce et al. 2018).

Wildfire

With increased drought conditions, temperatures, and less uniform precipitation events in spring and fall, the likelihood of the frequency and intensity of wildfires have increased. Before the 1850s, fire return intervals in these forests were roughly 15-80 years (Van de Water and Safford 2011; Safford and Van de Water 2014). In late summer and early fall, fires were an expected natural event for many vegetation types below six thousand feet elevation outside of deserts (Anderson 2005). The native tribes of Northern California have been actively using low and moderate fire to manage the mosaic of landscapes within these ecosystems for thousands of years. However, since the early 1900s, fire suppression has caused an increase in fire intensity and spread as forests become denser and drier. Increases in temperatures due to anthropogenic activities have caused an increase in fuel aridity that has doubled the Western US forest fire area beyond that expected from natural climate variability alone from 1984-2015 (Abatzoglou and Williams 2016). Looking toward the future in California, the wildfire risk is quite stark, with state-wide increases of up to 77% in mean annual area burned and a 50% increase in the frequency of extremely large fires (>10,000 ha) by 2100 (Westerling 2018).

Wildfire & Cannabis Cultivation:

The impact of wildfire is especially acute in California, where drought, fire suppression, fire-prone vegetation, and broad rural development including areas of the Wild-Urban Interface (WUI) is leading to larger and more frequent wildfires (Keeley and Syphard 2022). Given the low population density of the Emerald Triangle region and the distributed nature of most cannabis cultivation, it's hard to accurately tell how many people and farms are at risk.

The fire severity risk (fig. 3.23) and historical fire regime are highly varied across this topographically diverse region. The cool foggy coast and population center of Eureka-Arcate are at the lowest risk as well as the historical redwood forests of the fog belt. As one travels inland and higher in elevation from the coast, the probability of a fire and its severity increases. It is here in areas of high or very high fire risk where the Douglas-fir/ Mixed-Evergreen forests are located and a majority of the cannabis farms operate.

In a 2022 fire risk study of cannabis farms in the state (fig. 3.24), cannabis was more likely to be at fire risk than any other crop in the state. 986 farms or 36.43% of the total cultivation study area were located in high Fire Hazard Severity Zones (FHSZ) while 788 farms or 24.41% of the cultivation study area were in very high FHSZs (Dillis et al. 2022). As discussed earlier, the growing demand for Douglas-fir wood increased in Northern California, it led to an expansion of logging activities those forest ecosystems. This resulted in a reduction in the size and distribution of large, mature tree stands. Consequently, these fire-suppressed forests became denser and more homogeneous in terms of their structure and composition (Swanson et al. 2011; DellaSala et al. 2014). If plantation planting were implemented after logging, this effect would be intensified, leading to a predominantly even-aged and uniform structure with smaller trees. By replacing structurally complex forest sites with homogeneous plantation conifers, these recovering forests become more vulnerable to disturbances such as fire, pests, and disease.

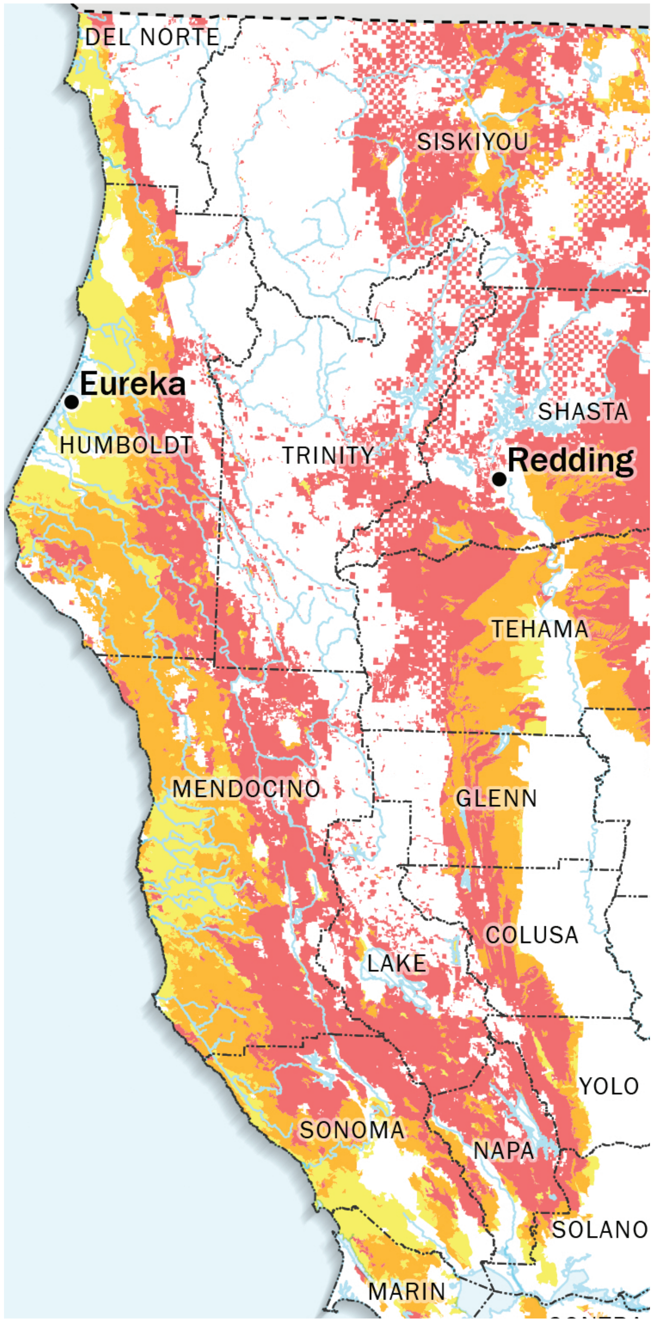


Fig. 3.23 Fire Hazard Zone Map of the North Coast
Yellow: Moderate / Orange: High / Red: Very High

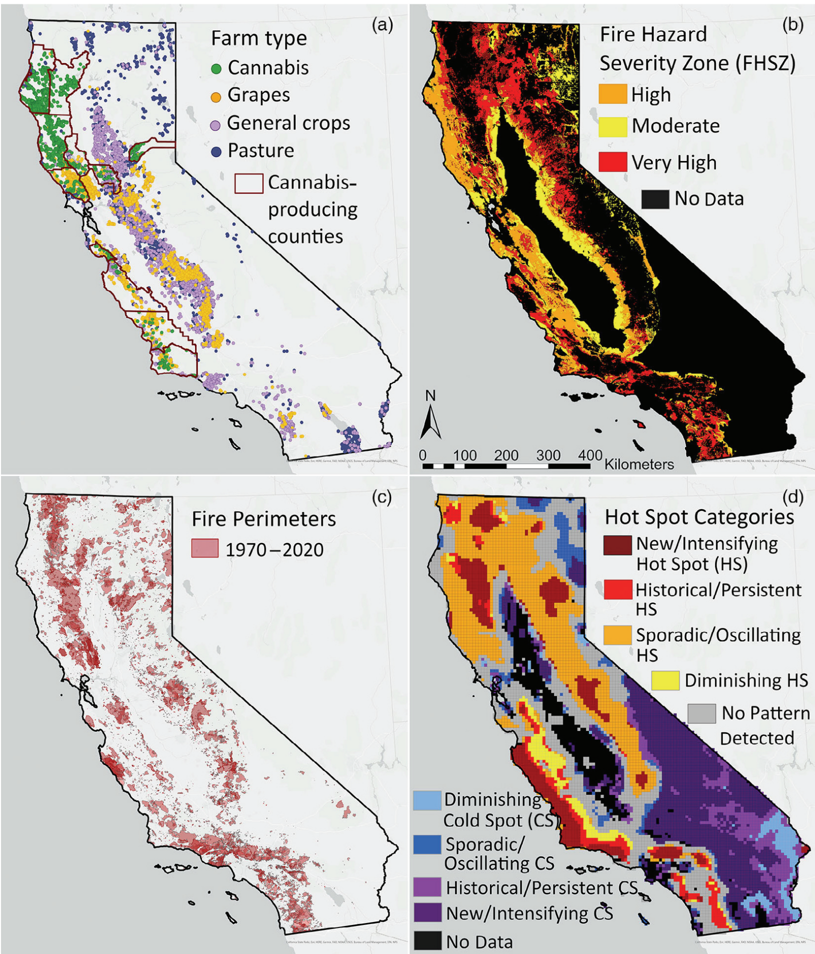


Fig. 3.24 Study area map. (a) Farm types (cannabis, grapes, pasture, and general crops) and cannabis-producing counties (restricted to those comprising at least 1% of Department of Cannabis Control outdoor cannabis licenses). (b) Fire hazard severity zones, as established by the State of California (CAL FIRE). (c) Wildfire perimeters dating back 5 and 50 years. (d) Burn pattern projections from 2020 to 2100 as established by Moanga et al. (2020). (From Dillis et al. 2022)

Furthermore, the succession patterns observed in these re-planted forests following a natural disturbance are less diverse compared to those in forests with a pre-existing complex structure that experiences a natural mixed-severity fire (Swanson et al. 2011; Donato et al. 2012; DellaSala et al. 2014). These outdated post-wildfire management techniques have significant negative implications for cannabis farm sites that are located in previously logged areas, particularly when plantation planting has taken place.

Overall the problem of wildfire has been intensified by a combination of logging effects, deferred fuel reduction, and the introduction of combustible infrastructure such as machinery and flammable liquids in landscapes where the ecological process of fire governs succession. In the long run, this puts the safety of labor and the viability of these farms in jeopardy.

Pests & Pathogens

As temperatures rise and weather patterns become more unpredictable, with warmer temperatures, droughts, and increased winter/spring precipitation, tree populations are increasingly threatened by biotic stressors like insects and pathogens. In this particular forest type, there are two significant threats whose spread may be intensified by climate change. The first is the Doug-fir Bark Beetle (*Dendroctonus pseudotsugae*), which targets the Douglas-fir (*Pseudotsuga menziesii*) tree as its host plant. These beetles typically feed and lay eggs in both standing and fallen trees. When forests experience more frequent disturbances like fire or drought, larger areas become vulnerable to beetle attacks. Trees under drought stress are unable to produce tree resin, which serves as a defense against insects like the bark beetle burrowing into the wood to lay their eggs. This creates a negative feedback loop where the increased availability of food and nesting options leads to more healthy beetles attacking even more trees, resulting in higher tree mortality.

The second major pest, discovered in the 1990s, is the fungus-like plant pathogen, *Phytophthora ramorum*, responsible for Sudden Oak Death. This pathogen can easily travel through contaminated soil or tree material. If it becomes widespread it could drastically reduce the distribution of some of the most iconic oak (*Quercus spp.*) species across California. Since Tan Oak (*Notholithocarpus densiflorus*) is a close genetic relative to oak species, it is susceptible to this pest too. Warmer temperatures, increased winter, and spring precipitation will increase the spore and infection risk across the North Coast and North Coast Range potentially doubling the rate of spread by 2030 (Meentemeyer et al. 2011). If these projections are true, the infection will spread northward and slightly inland. Depending on the intensity of the spread, this disease has the potential to functionally expatriate this key species across a large part of its historic range.

These second-order effects, the expansion of just two pests, from anthropogenic-related climatic shifts may have the potential to alter two of the most important overstory trees in this forest ecosystem. At its most extreme, this would shift the overall species composition into a new uncertain ecological shifting state that looks nothing like the forests that are currently prevalent in this area.

Conclusion

Given the potential environmental challenges that these sites may face, which are compounded by past timber extraction, intensified legal and illegal cannabis cultivation, the future of these sites remains uncertain. Unlike other farms in the state, cannabis farms located in the Emerald Triangle are typically off-grid and self-sufficient, requiring the transportation of all farm necessities except water (unless it is delivered) to and from the site. Remote locations like these farms are more susceptible to disruptions caused by climate change and extreme weather events. If a water source runs dry, a greenhouse is destroyed by fire, or an access road is washed out during a winter storm, it is the responsibility of the farm owner to repair and recover. Moreover, these farms are located farther away from larger metropolitan areas, which means they have limited access to essential services other cannabis farms may benefit from such as reliable water, energy, transportation infrastructure, and emergency services like fire departments and ambulances. By restoring and enhancing the ecosystem functions that were previously degraded, we can also increase resilience and productivity in the disturbed areas of contemporary cannabis farms in the Emerald Triangle. This approach can help mitigate the impacts of an increasingly erratic future of climate-induced weather extremes.

To demonstrate the implementation of the radical cannabis ecologies framework, I will begin by introducing an active legal farm in Humboldt County. This will provide insight into the common layout and operations of a medium-sized cannabis farm. Then, I will outline the key principles of the framework, taking into account the site's history, market effects, environmental systems, and future climate impacts. Finally, I will return to the farm site and illustrate how the core components of this framework can be implemented.

Kneeland as Case Study

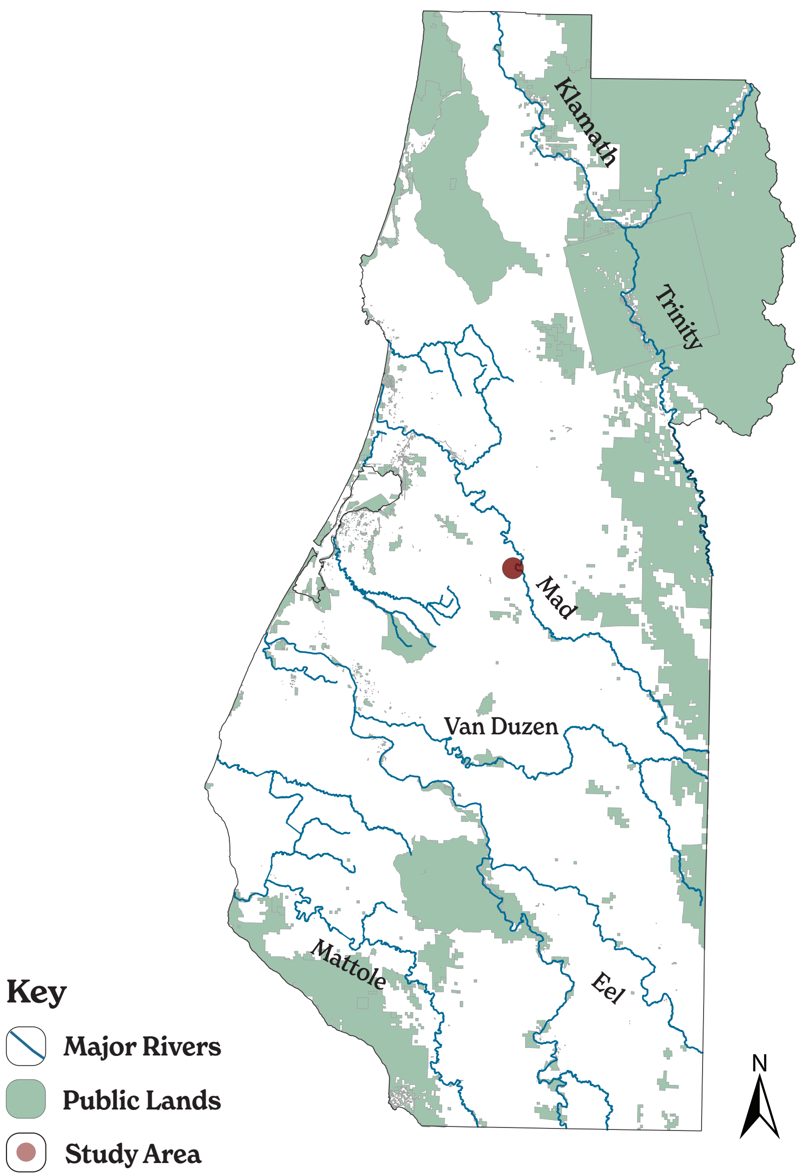


Fig. 4.1: County Context Map

Kneeland Site: A Case Study in Cannabis Agriculture

I have chosen an active legal cannabis farm site in Humboldt County as a case study to test and articulate how *radical cannabis ecologies* can be applied. As the oldest center of cannabis cultivation in the country, the Emerald Triangle provides an excellent setting to study these challenges. By discussing the current and proposed site conditions and fundamental needs of this particular farm, one can better understand cannabis agriculture, the surrounding ecosystems that sustain it, and the issues that they both face.

Kneeland exemplifies various challenges faced by legal cannabis farms in the Emerald Triangle. It is the oldest farm among a cluster of cannabis farms within the Blue Slide Creek Sub-Basin of the Mad River. Being the first parcel near the main road, it has an extensive network of logging roads and secondary skid rows. Its proximity to Kneeland Prairie, which used to be one of the largest indigenously managed prairies in the region, offers insights into how to manage newer cultivated areas in the forest. Furthermore, as a result of its elevation and aspect, if one were to traverse the site and explore the neighboring cluster of farms, one would encounter a diverse range of habitat types in the area. Starting from the sunny open oak woodland savanna at the top, one would descend through second-growth Douglas-fir / Mixed-Evergreen forest and reach a riparian habitat alongside the Mad River.

The Kneeland parcel stands out for its topographic variation compared to other farms in the area. It has numerous terraced cultivation spaces at different elevations that are tied together by freshly disturbed yet unproductive vegetation zones in between. Both the cultivated and disturbed zones meets the forest's edge creating a diverse set of site conditions and aspects compared to the native forest space. Moreover, the farm employs a range of water extraction and storage techniques. The owners use cisterns to gravity-feed the irrigation network, but they haven't fully utilized the land to convey, store, and distribute water across the multiple cultivation areas. The farm's drainage to the Mad River through Blue Slide Creek connects it intricately to the hydrology of one of the county's largest rivers and primary it's drinking water source. Understanding the farm's water usage and management practices has implications for long-term consequences and the actions taken by this farm and similar ones. Its topography, numerous site constraints, and cannabis-influenced environmental conditions provide ample opportunities to explore how my framework can inform design strategies one can apply to other farms in the region.

Showers Pass | **Mule Creek** | **Kneeland** (Neighboring Farm)

Fig. 4.2: Other farms visited in Humboldt County

Fig. 4.3 Site in Relation to Mad River Watershed

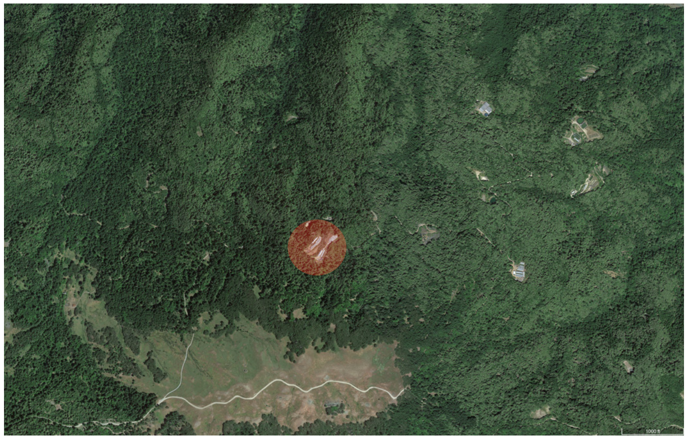


Fig. 4.4 Kneeland Ridge Farm Cluster

Fig. 4.5 Parcel Map of Kneeland Site

Site as Case Study: Drone Mapping as a Way of Seeing

Birdseye View

Fig. 4.6 Birdseye View of Site on Google Earth (2019)

Fig. 4.7 Birdseye View of Site by Drone (2022)

Landscape Change

Lower Area

Fig. 4.8 Nursery & Greenhouse Zone (2020)

Fig. 4.9 Nursery, Expanded Greenhouses & Outdoor Full-Sun Cultivation Zone (2022)

Middle Area

Fig. 4.10 Distributed Vegetation Zone (2020)

Fig. 4.11 New Full-Sun Cultivation Zone (2022)

Upper Area

Fig. 4.12 Disturbed Vegetation Zone (2020)

Fig. 4.13 Newly Cleared Land for Expanded Cultivation Zone (2022)

Drone Map

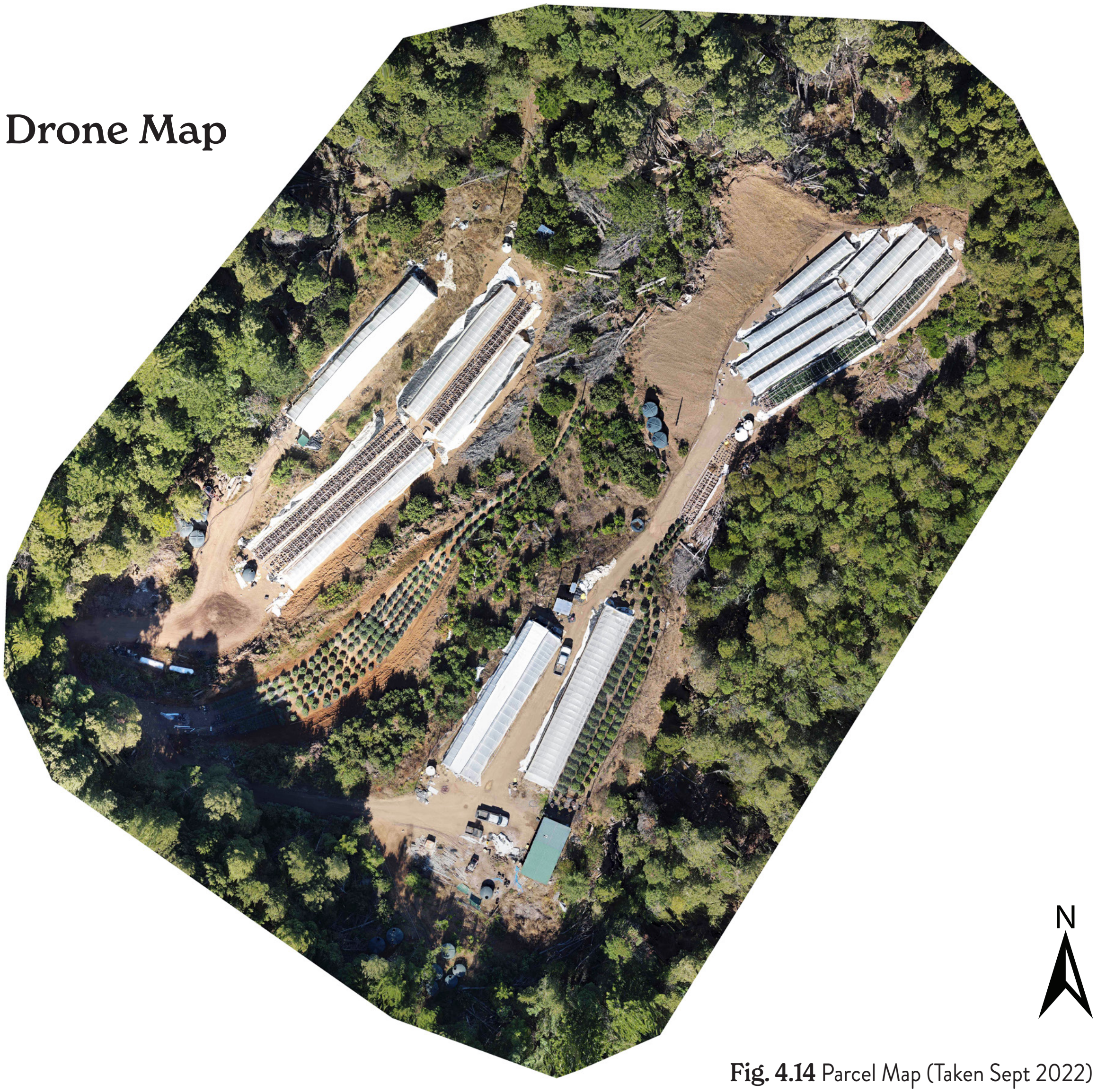


Fig. 4.14 Parcel Map (Taken Sept 2022)

Drone Site Analysis

I arrived in Northern California in the late Summer of 2022, determined to engage in site analysis to better understand the landscape I was working in. In dealing with a site so large, I learned how to fly a small drone as a way of seeing and mapping the land. Taking photos, videos and using an automated flight program, I was able to get real time viewpoints, photography and maps in this rapidly changing landscape. From there I was able to compare my drone photography with previous drone shots that had been done two years prior as a way to understand which locations within the site had been developed upon and what had be left to nature.

Surrounding Habitat Context

Fig. 4.15 Drone Photo Facing North

Fig. 4.16 Drone Photo Facing East

Fig. 4.17 Drone Photo Viewing North East

Functional & Infrastructural Systems

Functional Systems

A typical cannabis landscape can be divided into 3 functional categories: Cultivation, Circulation, Production & Processing.

Cultivation: spaces where cannabis is actively grown during the year and includes greenhouses, beds, pots, and other outbuildings.

Circulation: includes all the existing roads, footpaths, and outside work areas in and around the farm. They connect the cultivation areas to the processing barn and other infrastructural zones. The main road connects the site to other farms in this growing cluster with access from the main county road.

Production & Processing: The production and processing area is composed mainly of a barn structure and related storage buildings around it. Here is where the cultivation process begins and ends. At the beginning of the growing season, the barn acts as the center of propagation and a space to store and stage materials and supplies for the rest of the season. At the end of the season during harvest, it provides drying and storage space for processed cannabis flowers. The barn area also hosts a majority of the labor facilities on the site. A large centrally heated room includes workspace and meeting spaces for growers and trimmers. In addition, the bathroom and kitchen are located here.

Infrastructural Systems

Interconnecting these three functional space types are 3 main infrastructural systems: Energy, Water, and Waste. Each flows within and between the cultivation and production/processing spaces through circulation paths. These systems also connect through transmission/delivery lines throughout the forest.

Energy: Energy can be categorized into renewable and non-renewable sources. In the context of farms, propane and gasoline are the primary sources of energy. Solar power, a form of renewable energy, is typically used on a small scale to generate electricity for specific functions like operating water pumps for irrigation. Most farms are not connected to the grid. The main source of power for the farm is large commercial diesel generators. The electricity produced by these generators is used to power the barn and charge electric tools such as drills and saws.

During the summer, wall-mounted air conditioning units are used to cool the barn, while a central wood stove provides heating during winter months when the generator is not running. Portable generators are also used in cultivation areas as needed to power small machinery. To transport people and supplies between the barn and cultivation areas, large gas and diesel trucks as well as small ATV vehicles are employed. Both the barn and cultivation areas have containment zones for storing oil and gas-related liquids.

Propane gas has historically been used to heat greenhouses during the cooler early spring and late fall months. However, electric and radiant heating systems are being implemented to heat new greenhouse and nursery areas. Solar power arrays and transmission systems are becoming increasingly common to power greenhouse fans, low-voltage lighting, and electronic heating systems. Still, the amount of battery storage to fully power the farm is cost-prohibitive, and farms rely on commercial diesel generators for the bulk of the farm's energy needs. In-ground power supply lines usually run in tandem with other infrastructure like irrigation lines through the forest or along circulation routes.

Water/Nutrients:
Water systems are vital to the farm's operations. Most water on the farm is obtained from wells, springs, or creeks on the property using a water pump. From the collection point, the water is pumped through a supply line that runs through the forest to a storage point, which is typically a cistern(s) or a water bladder(s). Additionally, a separate potable water supply is directed straight to the barn for on-site workers. Water storage hubs are distributed across the farm, primarily located near the main cultivation areas where greenhouses or outdoor full-sun plant areas are situated. Alongside the water tanks, nutrient tanks are present, where liquid nutrients are mixed with the water for the plants.

From these storage hubs, the main water and nutrient lines directly supply each cultivation area. Within the cultivation area, the water and nutrients are distributed through polyethylene (polyline) pipes, employing drip irrigation or spaghetti wire emitters placed near the root zone of each plant.

Compost tea tanks are also connected to these water systems. Using an aerator, a large tea bag filled with biological amendments and other microbial nutrients combine with the water. The compost tea tanks run on separate lines that run to each area and are hand watered by the farm staff.

Waste: Due to the remote location of these sites all waste and recycling has to collected and hauled off-site by farm staff weekly. Outside of the daily consumptive waste of workers like food packaging most garbage generated on site is material and packaging waste from cultivation activities. These can be everything from used trellis mesh to empty nutrient containers.

Green waste is generated from discarded food scraps and cannabis plant material. These are mixed in with spent soil mixes for compost. If no compost pile is present, the plant material is dried and burned up.

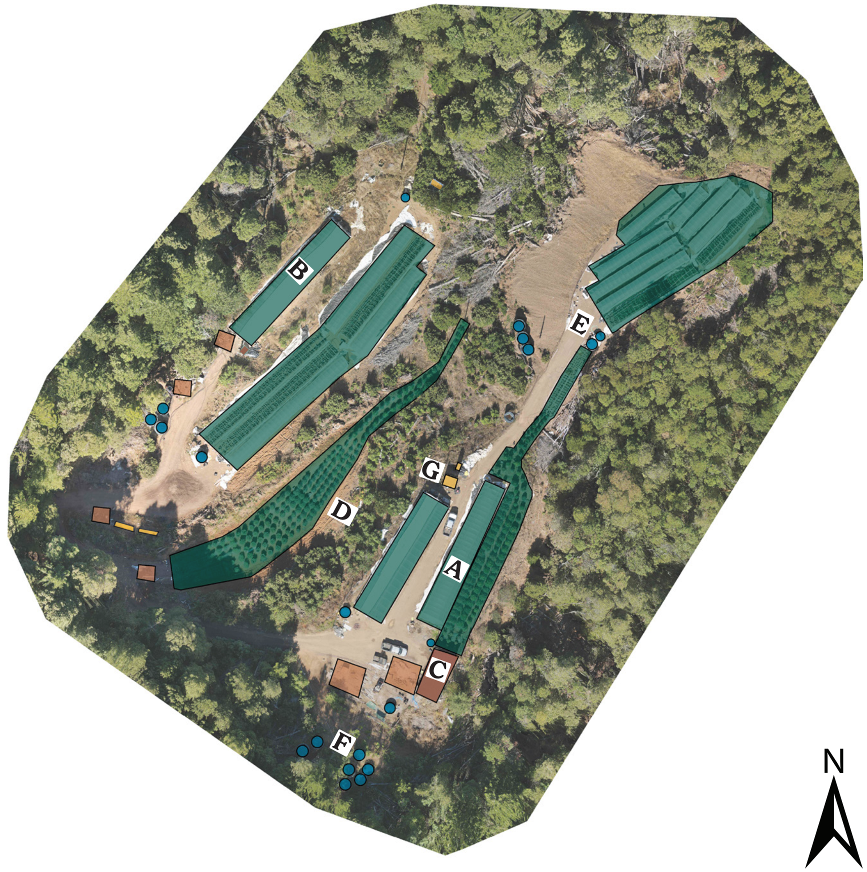
During site redevelopment, construction waste like wood and old ripped plastic coverings of greenhouses are generated. Large waste will be hauled out via a dump trailer. Smaller daily waste is hauled out via garbage bags in the back bed of a farmer's truck.

All human waste is either trucked out via porta-potty companies that service temporary bathrooms unless there is a septic tank on site. Waste is trucked out too but on an annual basis from the property. Most farms are not connected to the sewer or septic systems. Some remote farms use pit toilets or have showers and sinks that drain right into the landscape.

Site as Case Study: Kneeland Existing Conditions Fig. 4.18 & 4.19

A. Greenhouse

B. Nursery



H. Solar Array

G. Disturbed Vegetation

C. Storage Shed

D. Outdoor Cultivation

E. Nutrient Tanks

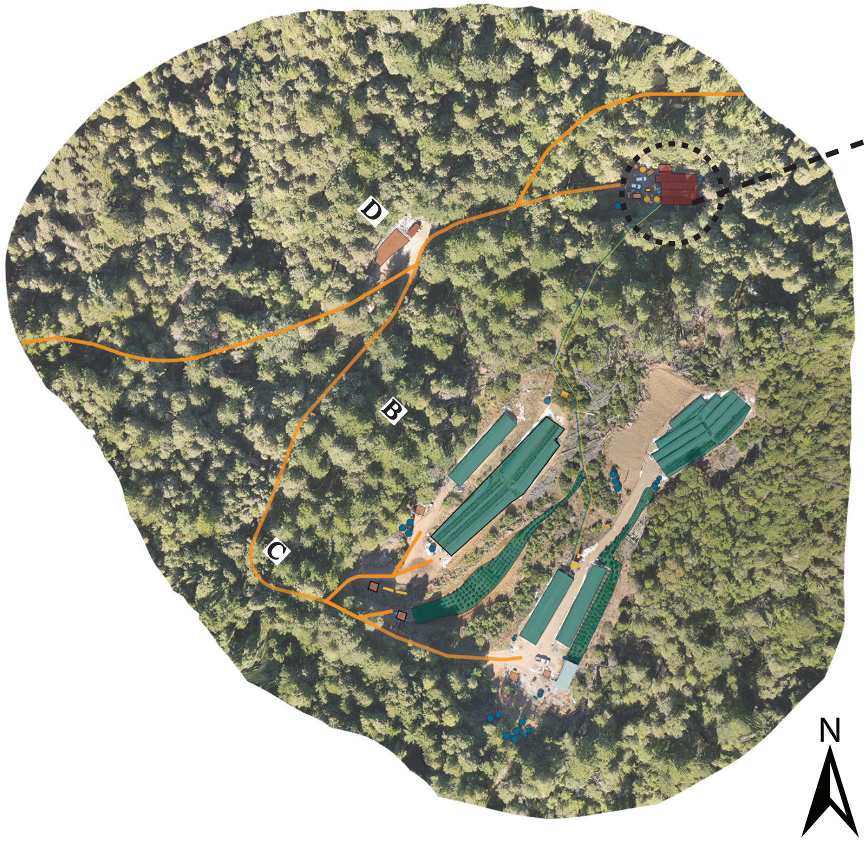
F. Irrigation Tanks

A. Processing Barn

B. Forest

C. Farm Access Road

D. Supply Holding Area



Zoom-In of Barn Area

A & E

E. Barn Energy Hub

Key

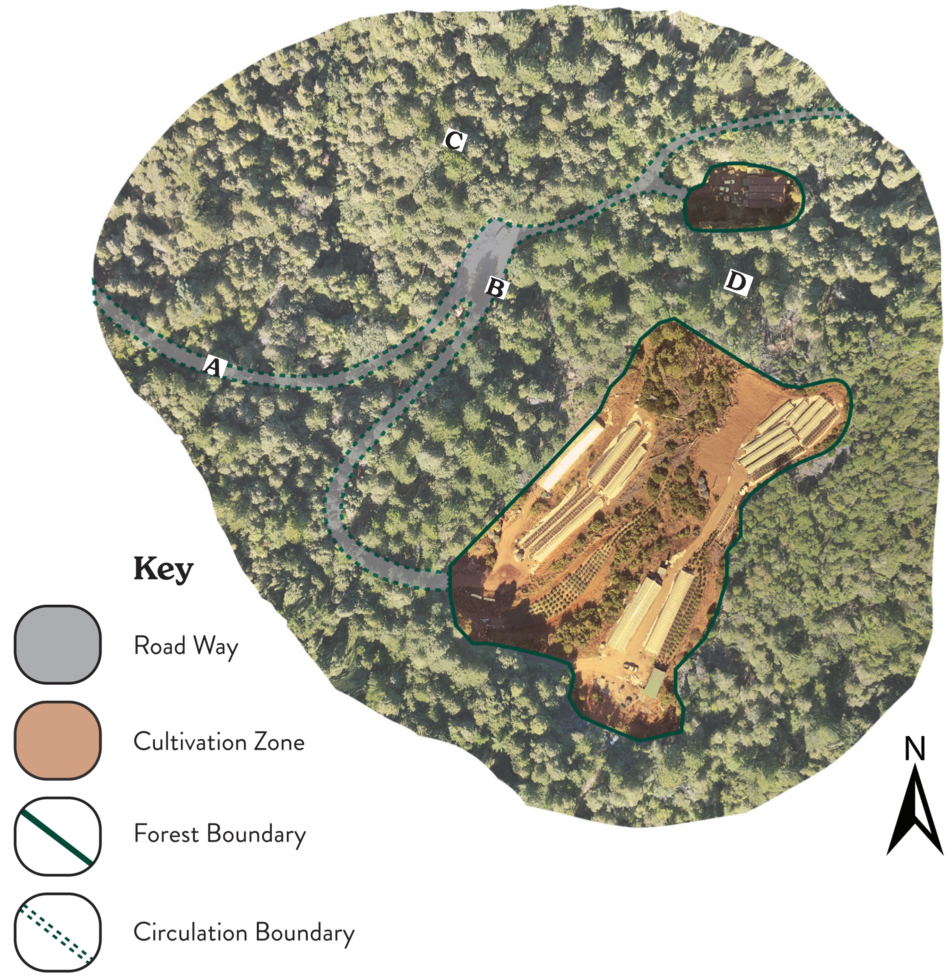
- Cultivation Zones
- Production & Processing
- Circulation
- Irrigation
- Energy
- Waste
- Power Line
- Water line

Timber Traces Fig. 4.20

The legacy of timber production has left noticeable marks on the landscape, primarily through the establishment of logging and skid roads. These roads primarily serve the purpose for vehicles and workers on the property to access each core area of the farm. However, logging roads have detrimental effects on the forest ecosystem in various ways. They lead to the fragmentation of forest areas, disrupt natural hydrological patterns, and contribute to significant surface runoff during winter rains. Despite these negative impacts, logging roads also have some positive aspects. They create sunnier conditions and the roadside swales that direct water to parts of the forest that would not naturally receive precipitation.

Skid roads , roads created to haul logs out of the forest are present but they have not been maintained and are a peculiar feature of cannabis farm sites. Their form is still evident, comprised of sparse vegetation and act as collection areas for ground fuel and leaf duff.

In the forest, old stumps, and fallen trees remain, as a remnant of former logging activities. Dead and decomposing trees such as logs, snags, and stumps provide nesting and foraging space for birds, small mammals, and insects of all kinds. In these types of forests fallen trees comprise up to 20% of the forest floor (Johnston 1994). These spaces have the potential to be hubs for wildlife in the forested zones.



A. Logging Roads

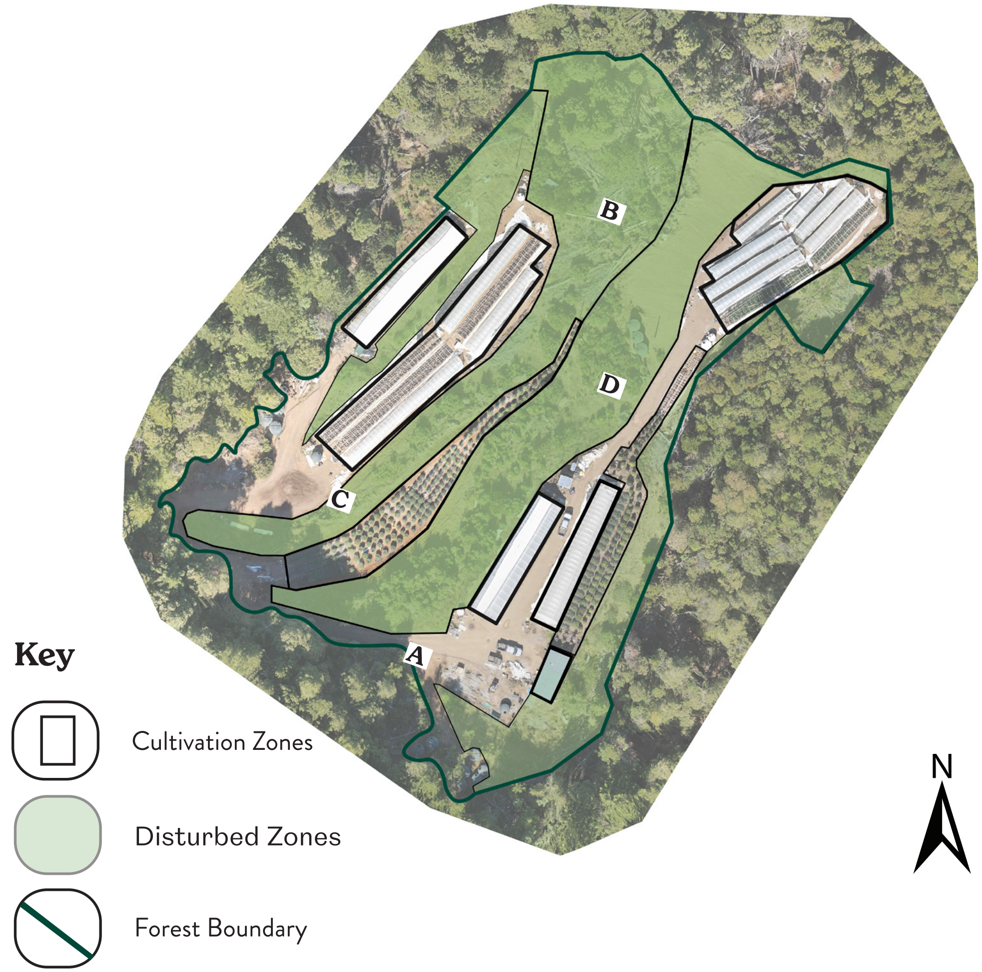
B. Roadside Vegetation

C. Skid Roads

D. Forest Stumps

Cannabis Traces Fig. 4.21

Through the conversion of timberland, cannabis typically creates a perforation in the core of a forest parcel. There are two major landscape conditions that are created when a cannabis farm moves into these forested sites. First, is the creation of a distinct ring of forest edge conditions that define the newly formed boundary between the cultivation area and the existing forest. Here, felled timber is pushed into the forest's edge or stacked into piles nearby. The opening of sunnier edges creates opportunities for plants to expand outside of the shady forest like California Bay Laurel (*Umbellularia californica*) or Canyon Gooseberry (*Ribes menziesii*). Secondly, through the grading of flat land for cultivation, interstitial spaces begin to emerge between these zones. Lands that are too steep for cultivation or a place for landscape detritus such as excess soil or felled trees and are left to their own devices. Quickly these freshly disturbed become taken over by early successional species such as the scrubby tan oak (*Notholithocarpus densiflorus var. densiflorus*), coyote bush (*Baccharis pilularis*), California Lilac (*Ceanothus spp.*) and various grass species.



A. Forest edge

B. Timber Piles

C. Disturbed Slope #1

D. Disturbed Slope #2

Cannabis Agriculture as Productive Landscape

Cannabis flower continues to be the primary agricultural output for both the current prevailing mode of operation for these farms and ones in the future incorporating a *radical cannabis ecologies* framework. Therefore the spatial logic of cannabis cultivation remains a primary factor in the design and order of these farms. To understand the needs of cannabis farms on California's North Coast, one must understand the life cycle of the plant itself and where it is produced in relation to the farm through a typical season.

Cannabis the Plant

Cannabis is an annual herb and goes through its entire life cycle within a typical growing season and flowers in the fall. Cannabis is *dioecious* and each plant requires contact from separate sexual organs of a male and female plant to reproduce. Male plants produce pollen and female plants produce flowers. Unless the farm is trying to produce new seed for a particular strain of flower, therefore needing male pollen, all cannabis plants on site are typically female.

Across the growing season, there are 4 main stages: Germination & Seedling, Vegetative & Flowering, and Processing. Each stage of growth requires a common input including water, light & nutrients to grow. A well-organized grown can get 3 harvests per year.

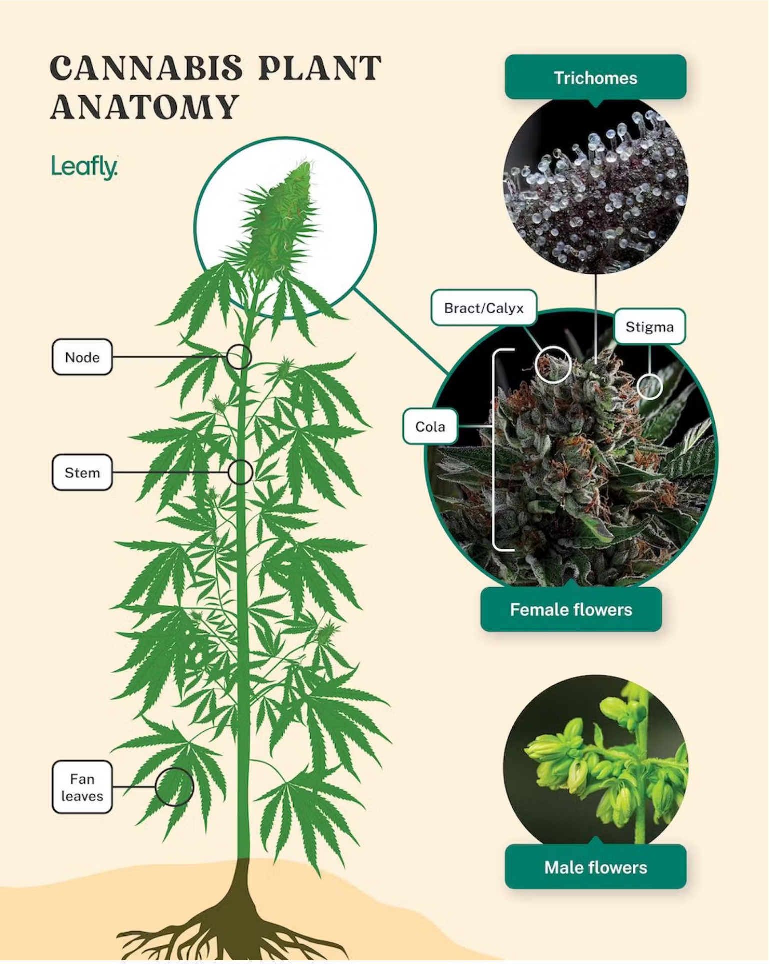


Fig 4.22 Common Parts of a Cannabis Plant

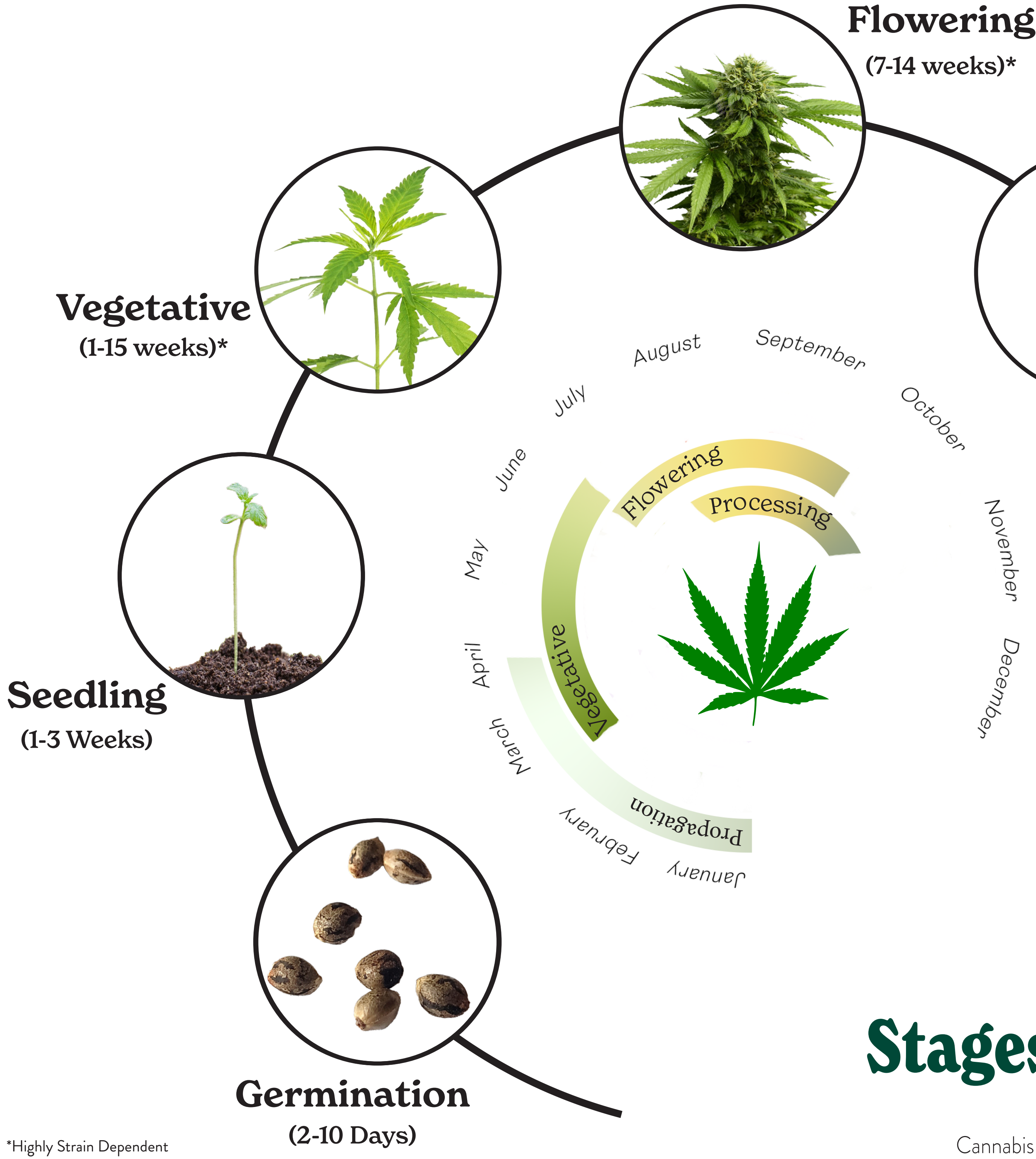


Fig. 4.23 4 stages of cannabis cultivation over a typical season

Stages of Growth

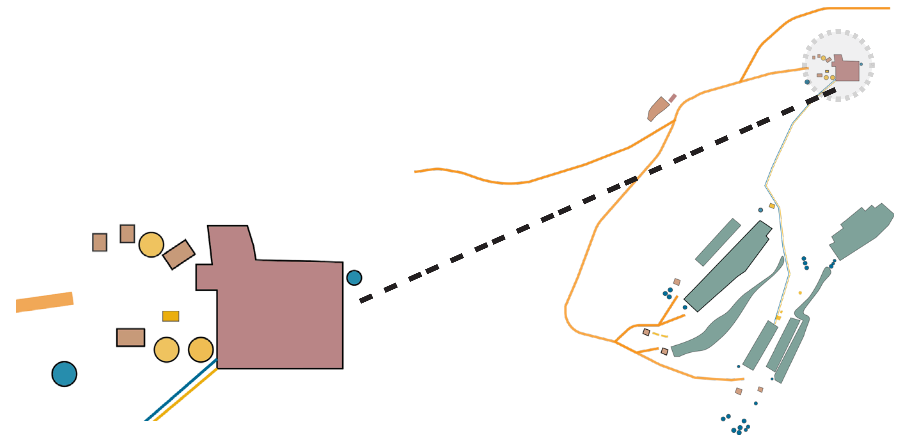
Germination and Seedling Stage Fig 4.24

The season begins in the propagation room at the processing barn. Growers have two options for starting their plants: growing from seeds or producing seedlings (or clones) from existing plants. Cloning involves taking cuttings from plants and rooting them, resulting in a 100% genetic replica of the source plant with the same structure and vigor. Growers can also purchase cuttings from independent cannabis nurseries, bypassing the germination stage and reducing labor costs while ensuring a consistent product. Seeds can have genetic variations, while cuttings provide exact copies of the parent plant.

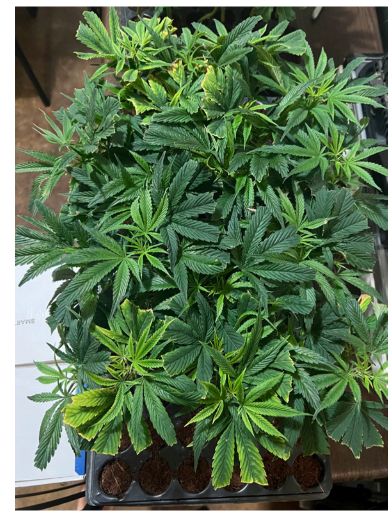
Once seeds or cuttings take root, they are kept in the propagation chamber with consistent light and heat to support the development of the root system and *cotyledons* (the first set of embryonic leaves). Cuttings are grown in small cubes of rockwool or coco fiber with minimal additional nutrients, mainly water and growth hormone.

After 1 or 2 weeks, when the root system has matured and stabilized, the plants are ready for transplant. The small grow cubes are transferred to larger quart or gallon pots filled with a fast-draining coco coir soil blend that includes trace amendments beneficial for early plant growth. Once transplanted, the pots are moved from the propagation spaces to the nursery, initiating the vegetative stage.

Stage 1

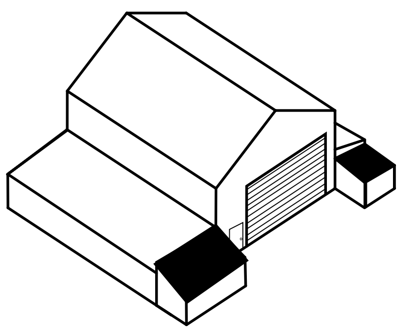


Rack filled with clones for a late summer run



A full tray of clones ready to be transplanted

Zones Required



Processing Barn

Vegetative Stage

Fig 4.25

In the insulated nursery, covered greenhouse and outdoor full-sun pots, plants are provided with a blend of water and liquid nutrients to promote maximum growth. Weaker or smaller plants are removed from rotation by the nursery manager or grower before being planted outside in the cultivation areas.

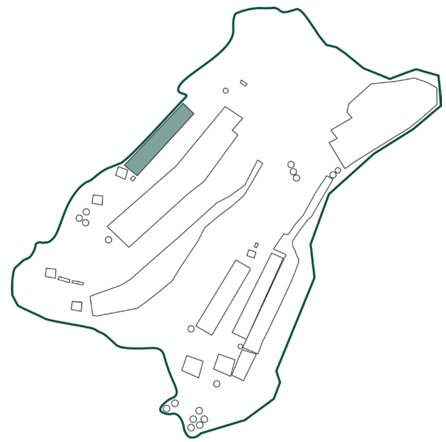
During the early spring, the nursery and propagation areas are active, and larger raised beds or outdoor pots are prepared by removing cover crops or volunteer plants. Additional soil amendments are mixed into the cultivation areas to ensure optimal nutrient uptake by the plants, depending on the richness and age of the soil.

As the nursery reaches its capacity, the oldest plants, typically 1-2 feet tall, are planted in covered greenhouses or outdoor pots. In the vegetative state, plants grow taller and wider, developing new branches and future flower *nodes.*

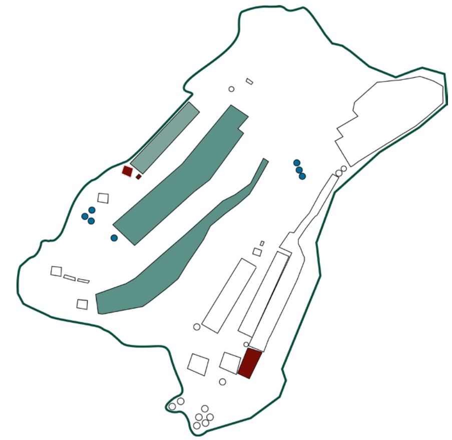
Pruning is essential to guide this growth effectively. By removing interior and low branches, more *auxin*, a plant growth hormone, is directed towards the top of the plant, resulting in a dense and chunky canopy of *colas* (flower buds) by the end of the year. Each plant is trellised with plastic or metal wire mesh to support the branches and prevent breakage due to the weight of the flowers during the flowering period.

Stage 2

Farm Site



Stage 3



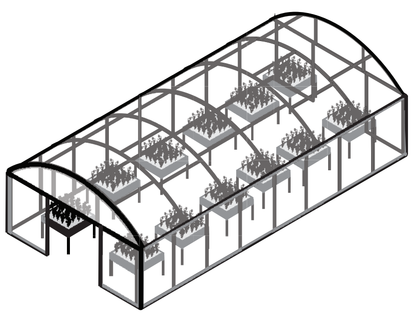
Nursery view with strains grouped together

Outdoor greenhouse freshly planted

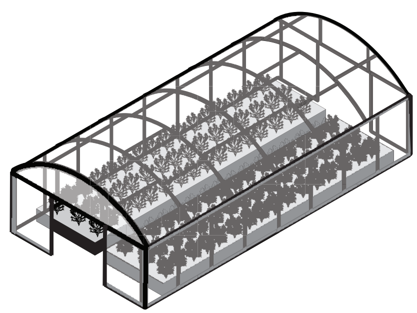
Freshly transplanted plants

Outdoor greenhouse before flowering stage

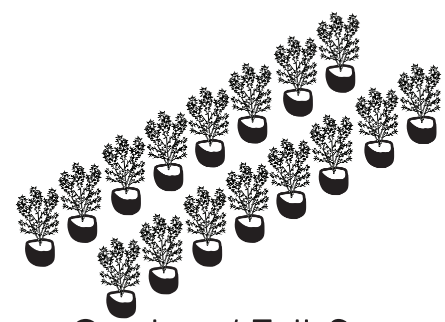
Zones Required



Nursery



Greenhouse



Outdoor / Full-Sun

Flowering Stage

Fig 4.26

After 3 months of vegetative growth, cannabis plants enter the flowering stage. During this time, their focus shifts to developing reproductive organs. To support flower growth, different nutrients are used, and spraying foliar nutrients or pesticides is discouraged to avoid potential harm to the buds. Compost teas are periodically applied to promote more growth.

The flowering period typically lasts 5 to 10 weeks, with the last few weeks being crucial for ripening. *Trichomes*, which contain *terpenes* and *cannabinoids*, become visible. The flower's *calyxes* release glistening *trichomes* that eventually cover the entire plant, while the *stigmas* and *pistils* turn brown. *Trichome* growth can be observed using a magnifying lens, as they transition from a milky to cloudy color, indicating maturity. *Trichomes* continue to develop until the plant is harvested or dies.

In the final weeks of the plant's life, it undergoes a flushing process. Nutrient feeding is stopped, and the plant is given only water until it is ready for harvest.

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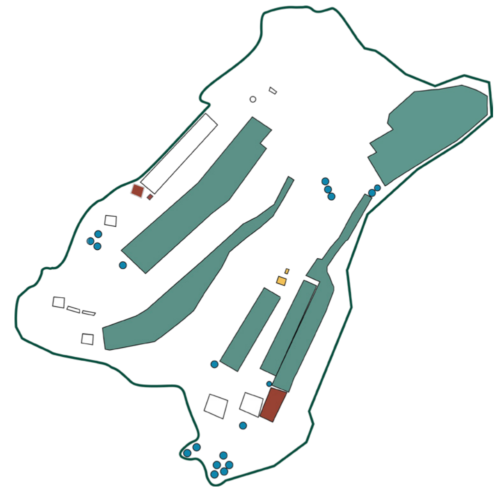
Typical outdoor flowering plant

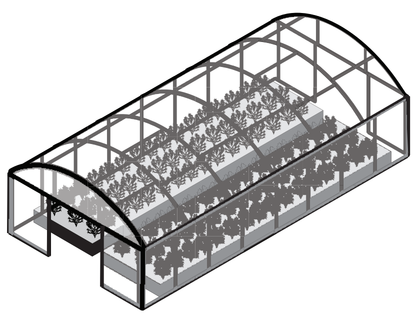
Farm Site



Mature flowering plant with metal trelllis

Outdoor full sun patch with trellis

Zones Required

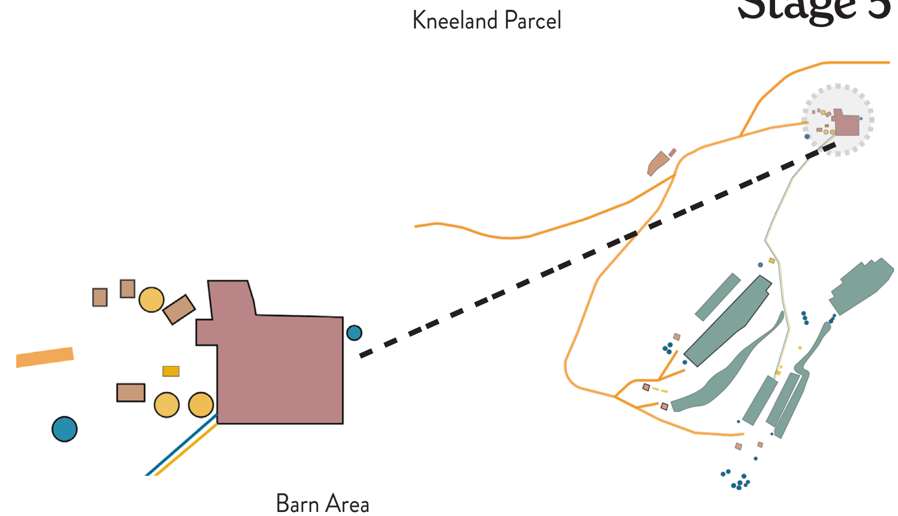


Greenhouse

Outdoor / Full-Sun

Mature flowering greenhouse ready for harvest

Processing Stage Fig 4.27



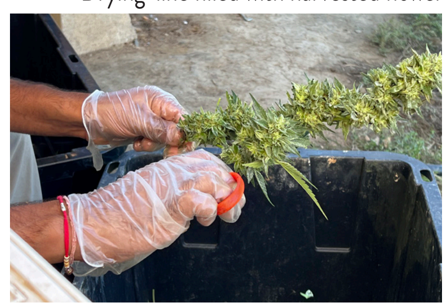
Growers determine the harvest time based on flowering days, appearance, and weather conditions. Increased humidity and moisture during the transition from summer to fall can lead to mold formation, which can quickly ruin an entire crop.

During harvest, growers remove the main branches from the primary stalk and transport them to a processing barn. The branches are hung on wire lines in a controlled environment for drying, which takes about two weeks. Fan leaves are removed, and each branch is hung upside down on a line. Regular checks ensure optimal temperature and humidity while preventing mold or pests. Once enough moisture has evaporated, the branches are trimmed and the flowering buds are placed in plastic-lined totes for further drying. The totes are periodically opened and closed to maintain ideal moisture levels, avoiding sponginess or brittleness.

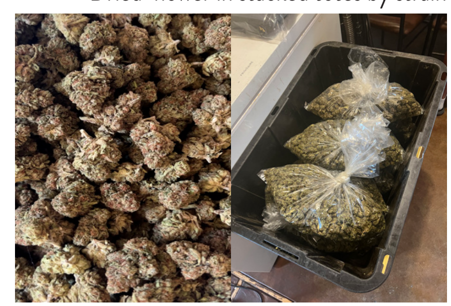
In the final step, the harvested buds in totes are typically given to trimmers who use scissors to shape and remove excess leaves. Trimming machines are sometimes used for larger quantities, but human touch is still necessary for final tidying. The top-quality buds, known as *colas*, are usually hand-trimmed. The trimmed buds are then weighed, packaged in separate plastic bags, and prepared for distribution.

Drying line filled with harvested flower

Dried flower in stacked totes by strain

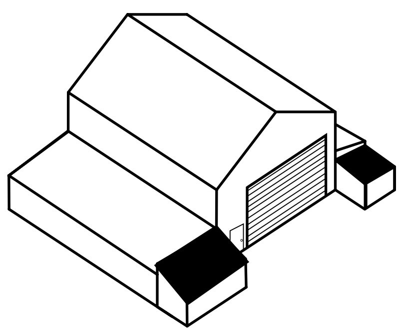


Trimming up a cola stalk



Trimmed and packaged flower

Zones Required



Processing Barn

Conclusion

After exploring the typical site zones required for cannabis agriculture and the common areas present in these landscapes, we can now delve into the components that make up a *radical cannabis ecologies framework*.

Radical Cannabis Ecologies

Over the past half-century, the cultivation of cannabis has rapidly expanded into the North Coast's agricultural frontier, becoming deeply intertwined with the landscape. The rapid growth of farms, driven by demand from distant markets, has led to the large-scale conversion of previously natural habitats, timberlands, and pastures. As mentioned earlier, cannabis farms in this agricultural frontier face specific environmental challenges that stem from the history of exploiting timber and engaging in illegal cannabis cultivation. These cumulative impacts have caused a decline in ecosystem functioning, making them more susceptible to the effects of climate change and jeopardizing the productive capacity of these farms.

Even as the consequences of legalization unfold, one fact remains evident: cannabis cultivation still prioritizes extraction and profit over ecological well-being. Growers are willing to sacrifice trees by clearing them to enhance sunlight exposure or extract water from local sources without considering the potential impact on watersheds. While regulations can steer legal growers towards responsible practices, it is essential to transform the operational methods of all farms, regardless of their legal status.

Radical Cannabis Ecologies Fundamentals

Radical Cannabis Ecologies is a long-term view of land stewardship that uses principles of agroecology, and sustainable forest management to foster a better reciprocal relationship between the cultivation of cannabis and the health of the people, lands, and energy systems it inhabits and depends on for survival. It seeks to repair natural systems while enhancing ecosystem services on-site to improve these farms' productive capacities. In addition, it employs climate adaptive design strategies that can mitigate future environmental impacts to improve the resiliency of these farms.

In *Farmscape: The Design of Productive Landscapes*, landscape architects Phoebe Lickwar and Roxi Thoren argue that one can incorporate agriculture into their spatial compositions in two ways. First, the agricultural realm of a project is ordered on an internal spatial logic that is distinct from or perhaps can inform, the surrounding realms. Second, agriculture is seamlessly integrated into a larger aesthetic vision for design (Lickwar & Thoren 2020). Most farms are currently organized based on the spatial logic of the first type, which is determined by optimizing for cannabis cultivation. However, there is a distinct disconnect between the farm and the forest. To embrace *radical cannabis ecologies* farms must strive toward the second type of agricultural spatial logic, one that is seamlessly integrated not only into the larger aesthetic but also into the functional aspirations of the farm and the larger ecosystems of the forest.

Most contemporary cannabis farm sites can be divided into three main spaces. The first space is dedicated to cannabis production and includes areas for cultivation, circulation, production, and processing, as well as energy, water, and waste management. The second space consists of any "native" habitats such as forests, woodlands, or prairies. Most forest spaces surrounding these sites aren't native or old-growth but rather a patchwork of timber strands in various states of regrowth due to selective logging and plantation practices over the last century. Finally, the third space comprises areas that were previously disturbed due to timber harvesting or the development of cannabis agriculture.

While the first two spaces respectively serve the purposes of cannabis cultivation and passive habitat conservation. It is the third space of a previously disturbed landscape that presents opportunities to expand and connect cultivation with existing native habitats. Thus *radical cannabis ecologies* is a way of operating all three of these spaces in conjunction with one another in an effort to layer functions, build resiliency and increase productivity across the farm and the forest, dissolving the functional boundaries of both.

Currently, farm are sites of intensive cultivation yet the existing forest spaces and disturbed vegetation zones between the cultivated areas remain relatively untouched. Only during the expansion of the farm and its related infrastructures are these spaces acted upon and developed. In the highly productive ecosystem of the Douglas-fir / Mixed-Evergreen forests, these disturbed vegetation zones can be places where sustainable agroecology practices can occur to complement cannabis cultivation needs.

I have set four primary operating goals that these farms should strive for (fig 5.1): mitigating future climate-related risks, enhancing forest resilience and biodiversity, eliminating extractive and polluting processes, and ensuring long-term economic sustainability. To achieve these goals, I will employ 3 main strategies across these farm sites: *building resiliency*, *restoring and enhancing ecosystem function*, and *cultivating productive capacity*.

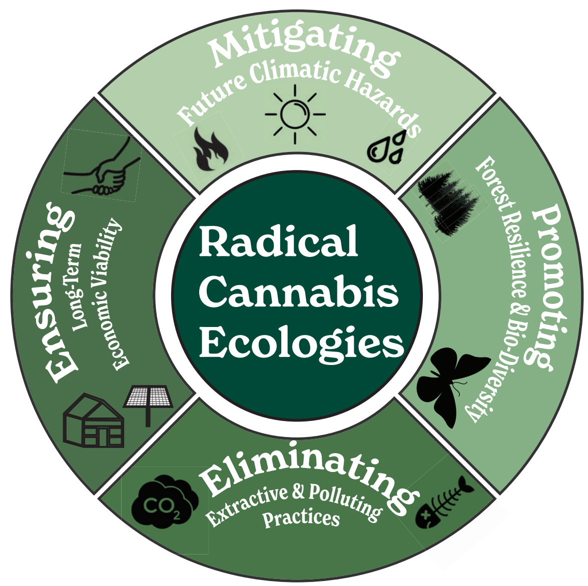


Fig. 5.1: Radical Cannabis Ecologies 4 Primary Operating Goals

Building Resiliency

Historically, these landscapes have been managed solely to maximize timber or cannabis yields, often disregarding their broader functionality beyond extraction. Consequently, these practices establish a singular reinforcing feedback loop, whereby the result is in service of bigger and bigger harvest. This leads to the danger of the gradual depletion of site resources if harvest rates exceed the carrying capacity of a particular site. If this happens the whole site becomes vulnerable when faced with an environmental disturbance. Recovery and restoration are also more difficult to initiate when there are few ecosystem resources for nature to naturally draw upon post-disturbance. Mixed evergreen forests can also naturally withstand disturbances such as prolonged drought and fire due to the ability of these forests to tolerate multiple stressors, resulting in greater natural recruitment across the landscape (Hessberg 2016).

Currently, on most farms, there is a sharp delineation between the farm site and the dynamic forest. The cannabis farm acts independently of the needs and resources given by the forest. To build resiliency in these cannabis farm sites it is essential to develop design interventions that encourage resilience across systems and scales acting on both farm and forest "Resiliency is a measure of the ability of a system to survive and persist within a variable environment... it arises from a rich structure of many feedback loops that can work in different ways to restore a system even after a large perturbation (Meadows 2008)."

When resiliency is employed it helps build multiple feedback loops that enable connectivity, stack functionality, and employ redundancy. If successful, it creates a multi-functional forest-farm ecosystem that benefits through long-term yield while providing clean water, healthy soil, and biodiversity.

Overall the outcomes of this proposed framework align with those found in the climate-resilient development framework proposed by the Intergovernmental Panel on Climate Change (IPCC) in their Sixth Assessment Report (fig. 5.2). By conserving and restoring the forests, woodlands, and grasslands surrounding these farms we can adapt and mitigate against future climate change. In return, farms can secure the provision of cannabis that ensures their livelihoods while providing and maintaining critical ecosystem services throughout the Emerald Triangle.

Building resilience can happen in two ways. The first is to implement design interventions through mitigation strategies that aim to reduce the impact of that disturbance and any harmful outcomes it may bring. The second is anticipatory,

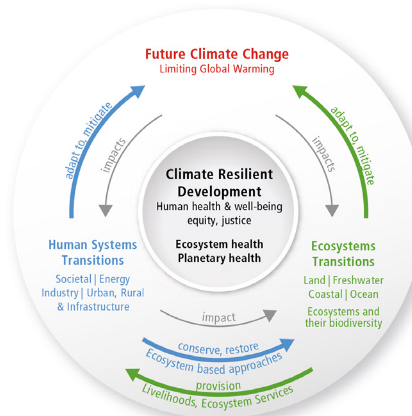


Fig. 5.2: Climate Resilient Development Framework

it looks at the possibilities of all likely future disturbances and deploys adaptive design strategies that can thrive based on a set of these future scenarios.

To be effective growers need to expand their notion of care outside the boundaries of the productive areas and engage with the core forest functions. By restoring and enhancing these systems we can improve the productivity of the farm but also restore broader ecosystem services to these sites to benefit even non-cultivation areas. Ecosystem services (table 7, pg 71) are an activity or function of an ecosystem that provides an external benefit(s). These services are broken down into 4 categories: provisioning, regulating, cultural, and supporting (World Resources Institute 2005). In most contexts, this term is applied specifically in its value and relation to humans. For my framework, an ecosystem service not only benefits humans but extends to the multitude of species that depend on these local ecosystems for their survival. According to the Millenium Ecosystem Assessment (MA), 60% of ecosystem services are deteriorated or already overused (World Resources Institute 2005). It is thus essential that any development on the farm consider how to restore ecosystem services in addition to sustainable cannabis cultivation techniques.

At the core of my framework, I seek to strengthen the overall health and resilience of 4 core forest functions: *fire, water, biodiversity, and productivity.* By proactively engaging with the first 3 core functions (Fire, Water & Biodiversity) we can strengthen the 4th (Productivity) creating a more holistic site (fig. 5.3). Before delving into how these strategies can be implemented across the farm, it is important to first understand some basics of how these core forest functions must be engaged in order to effectively transform these spaces into resilient refuges and reservoirs through *radical cannabis ecologies.*

Fig. 5.3: 4 Core Priority Areas

Radical Cannabis Farmscapes as Resilient Refuge & Reservoir

To guide this framework, I propose transforming these farms into sites that act as resilient refuges and reservoirs. The Klamath-Siskiyou region just north of the geographic center of the Emerald Triangle has been an important refugium of plant and animal species during previous climatic episodes in Earth's long history. Even to this day, the region maintains high-genetic diversity that is able to be more flexible to accommodate changes in overall habitat composition and adaptation to future climatic shifts (Schierenbeck 2017). The Douglas-fir / Mixed-Evergreen forest systems of Northwestern California, as mentioned in the previous chapter, exhibit high diversity resulting from diverse topography, steep temperature, and precipitation gradients, multiple intersecting mountain ranges, and various soil types, leading to significant landscape heterogeneity (Sawyer 2006 ; North et al. 2016). Due to this diversity of landscape, they support many endemic species and cultural keystone species. Varied site conditions also provide multiple smaller sites that can protect species against thermal and drought stress providing protection from wildfire and other such disturbances.

Moreover, while this portion of the state will still face the effects of climate change, its impact will be less intense than areas to the south and inland. The Emerald Triangle, with its temperate climate, large reserves of water, and low population density can serve a dual role as sites of production but also act as both refuge and reservoir, harboring species and resources that may diminish in other portions of the state.

A refuge is a safe place that protects its inhabitants from various dangers or threats. While a reservoir is a place that acts as a container that can hold or supply something. To enable the resiliency afforded by these two strategies, farms need to work with and strengthen the core ecosystem resources and services of the forest, including water, fire, and biodiversity.

Biodiversity

Biodiversity as defined by the Convention on Biological Diversity (CBD), is 'the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (Mori 2013). The more species an ecosystem has the higher its biodiversity. Higher biodiversity is associated with increased ecosystem function (Hooper 2005). It can help build a complex web of interactions amongst species that help regulate a multitude of ecosystem processes. An area of high floristic diversity can provide not only pollen and nectar for pollinators but a diverse range of vegetative structures for nesting or foraging habitats for terrestrial animals. Each species finds its niche creating a tighter-knit system of checks and balances where no one species is able to become too dominant. On these cannabis sites, more biodiversity could allow for better ecosystem regulation specifically in relation to pests and disease. For example, spider mites (*Tetranychidae spp.*) can readily infest and feed off the underside of a cannabis leaf. Healthy farms can deploy a host of natural predators like the native California Lady Bug (*Coccinella californica*) which will eat the mites but don't damage the cannabis plant.

A secondary benefit of higher biodiversity is a larger genetic reserve of species on the site. Each species has evolved its own environmental adaptation through specific physical characteristics or morphological features. Therefore accommodating and designing for higher biodiversity can function as both a reservoir or refuge. A site can function as a reservoir in that if there were a large disturbance that affected the farm site, a larger pool of genetic resources opens up the opportunity for any one species to exploit whatever new shifting ecological state the disturbance had caused. As other environments become too inhospitable, these actively managed human landscapes could lead to more plant recruitment or species migration through the creation of favorable micro-climate sites.

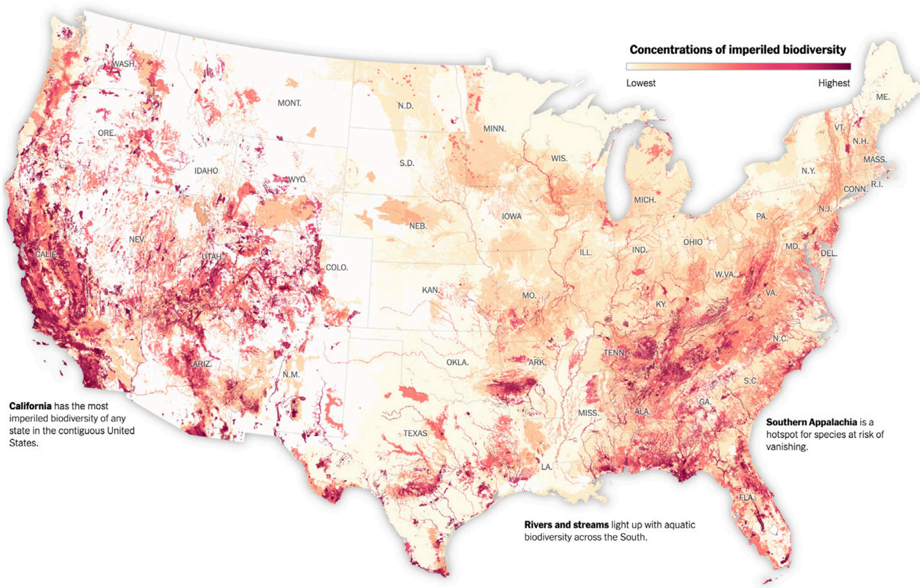


Fig. 5.4: Biodiversity Map of the United States

The importance of the Emerald Triangle as a place of reservoir is especially pertinent when considering its location within the California Floristic Province (CFP) (fig. 5.4). The CFP is a recognized global biodiversity hotspot that includes high levels of endemism of species found nowhere else in the world (Myers 2000). It is the only major hotspot in North America and holds important generic material for a number of plant species and families specifically evolved to handle the Mediterranean climate of California. It is also home to 40% of North America's native bee populations.

As the southern portion of the state is projected to experience intensified frequency of hotter and drier seasons it will impact the historical range of a number of plant species. Plant species will naturally shift northward and upslope to establish new populations to find cooler locales. However, the change is happening faster than species can respond so cannabis farms have the opportunity to utilize their non-cultivation space to help assist in the migration of these species. Mitigation strategies such as the improvement of long-term vegetation structure or the restoration of habitat can help jump-start the recovery of landscape, faster than it would naturally occur.

Through the active selection and maintenance of species, farms can help preserve endangered or endemic species for future generations. In addition, proactive adaptive management strategies can guide forest competition to provide spaces for plants that are fire and drought-tolerant and better adapted to a drier and more erratic California climate.

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Fire

Fire is a dominant force of disturbance for all forest types and most species tolerate it and require it for regeneration. The high heterogeneity of this region is a result of successive patterns of fire that have created complex multi-layered forest structures that are interspersed amongst open grass and woodlands (Perry et al. 2011) (fig. 5.5). Fire supports the creation of habitat by opening up gaps in the forest, or creating snags and deadwood for animals to nest in. It also pushes plant evolution and diversity because it can both shorten generation longevity and reduces overlap between generations (Pausas and Keeley 2019).

Fig. 5.5: Habitat Mosaics formed by fire near Alderpoint , CA.

Building ecological resilience in forest ecosystems through fire requires three different components: persistence, recovery, and reorganization. Persistence is the ability to tolerate exposure to environmental stress, disturbance, or competitive interactions. Recovery is the ability of populations to establish new individuals from seeds or other propagules following dispersal from the parent plant through reproduction. The final requirement is reorganization where an ecosystem will emerge into a new state after a large disturbance (Falk 2022). Within a resilient ecosystem, each component operates on a distinct level: individuals demonstrate persistence, populations are driven by recovery, and communities shift through re-organization. By encouraging the first two components, cannabis farms can influence and guide the reorganization of the existing plant communities and forest composition located on-site.

Naturally, most Californian plant species show mechanisms of either persistence or recovery. Plants have evolved plant resilience mechanisms over thousands of generations to cope with drought and fire. There are 3 main types of plant structures that work with fire to encourage repopulation and reproduction of these pyrogenetic species: Vegetative structures (foliage, crowns, bark & roots), sprouting structures (epicormic buds, Basal burls, buds at stems, stolons, rhizomes, sprouting roots), and sexual reproduction (fire-stimulated flowering, serotinous cones, seed banks) (table 6).

A forthcoming increase in moisture deficits and an increase in fire frequency will naturally change the composition of these forests. First, reducing moisture will reduce tree vigor and overall forest area. An increase in fire frequency will also reduce forest area and favor species that can colonize quickly after a fire (Hessberg 2016). For instance, in a mixed or high severity fire, there may be a high mortality rate, but fire-resistant hardwoods and shrubs like Quercus, Arctostaphylos, and Ceanothus, which can resprout or rely on fire for reproduction, will thrive and increase their presence in a frequently disturbed landscape. Cannabis farms will require routine active management to anticipate how to work with fire and support forest regeneration while protecting the farm against it.

From an ecological perspective, this will include strategies such as reducing forest areas and fuel load, expanding woodland and grassland areas, and increasing the extent of large trees of fire-resilient species (Hessberg 2016). Growers can begin to experiment in their non-cultivation and forested zones by planting assemblages of California native plants informed by these morphological traits, varied vegetative structures, and reproductive methods. Over time they will be able to reduce density, increase the structural complexity and species composition of these spaces to encourage native plant diversity, restore low-fuel prairie habitats, and open up more woodland. By supporting native pyro-diversity and active forest management cannabis farms can work with the realities of drought and fire to enhance ecosystem services and mitigate impacts.

If all farms in the Emerald Triangle could collaborate to reduce fuel load and create habitats that coexist with fire, we can enhance the reorganization capacities of plant communities at a regional scale, promote landscape heterogeneity, and lower the risk of unnatural megafires.

Plant Structures	Definition	Morphological Fire Response
Foliage	Leaves and Needles	Phenology, moisture level, leaf thickness, shape, area
Crowns	Layer of dead, protective cells around outside of stem, phloem	Crown height and bulk density
Bark	Layer of dead, protective cells around outside of stem, phloem	Bark thickness and density; volatile substances
Roots	Underground structures that absorb water and nutrients, and anchor plant	Amount and duration of heat, depth below surface, concentration and distribution of system
Epicormic buds	Buds in stem capable of sprouting	Fire intensity, fire duration
Basal burls, buds at stems	Woody tissue from which roots and stems originate, often covered with buds	Fire intensity, fire duration
Caudexes, corms, bulbs	Stem base that stores energy may also produce new leaves/stems	Depth and degree of heat from fire
Stolons	Aboveground lateral stems form new plants	Depth and degree of heat from fire
Rhizomes	Below-ground lateral stems form new plants	Depth of heat from fire, soil moisture
Sprouting roots	Roots that have primordial buds capable of sprouting	Magnitude and duration, soil moisture
Fire-stimulated Flowering	Plants that flower or flower more with fire	Sensitive to fire intensity: temperature over threshold kills flowering tissue
Serotinous cones	Cones storing seeds: cones only open with high heat	Temperature of fire, longevity of seeds in relation to fire return interval
Seed Banks	Supply of viable seeds buried in soil	Temperature of fire, longevity of seeds in relation to fire return interval

Table 6: Mechanisms of Plant Resilience (Adapted from Wagtendonk et al. 2018)

Water

Regardless of the time of the year in the Emerald Triangle, no resource is more valuable than water. In the wet season, it's ubiquitous, raining down from the sky, dripping off of tree branches, or flowing along down rivers, especially during the peak spring run-off season. During the dry season, it's still around but its presence is more subdued, either deep inside a well or gently flowing from a spring creek. Though the majority of precipitation is influenced by the Emerald Triangle's position between the Coast Range and the Pacific Ocean, it is the presence of its great forests that help regulate the water cycle and keep the land hospitable for a wide range of biota let alone water-hungry cannabis farms. Forests like those on the North Coast help create low-pressure regions that draw moist air from the ocean that then is sent by prevailing winds bringing precipitation across the coast. At least 40% of precipitation over land across the world originates from evapotranspiration from forests and other vegetation (Ellison et al. 2017). Not only do forests draw moisture but they naturally filter it back into the landscape. The forest's capacity for infiltration is determined by its canopy cover (fig. 5.6) which creates large quantities of groundwater that supply the wells or springs of cannabis farms around the region. Mixed evergreen forests provide natural water collection, filtration, and delivery into streams, wet meadows, and aquifers and enhance flood control by absorbing vast amounts of water during major rain events and then releasing it slowly back into the environment (Ellison 2017).

Preserving tree canopy around cultivation areas is crucial because it creates a cooling effect, which is vital for the successful growth of cannabis. Cannabis, originally from the temperate highlands of Asia, cannot thrive in excessive heat (above 90 degrees Fahrenheit), as it inhibits vegetative and flowering growth. Prolonged high temperatures can lead to heat stress, degradation in flower quality, and even plant death. The Emerald Triangle benefits from its high diurnal temperature variation, combined with nightly humidity and moisture from the ocean, coast, and river valleys. This unique combination sustains the cannabis plants during hot summers. The coordinated hydrological cycle between trees, airborne moisture, and the ocean plays a key role in producing top-quality outdoor cannabis in the US. Therefore, safeguarding the health of the forest is crucial for the long-term ecological well-being of cannabis farms and the broader Emerald Triangle region.

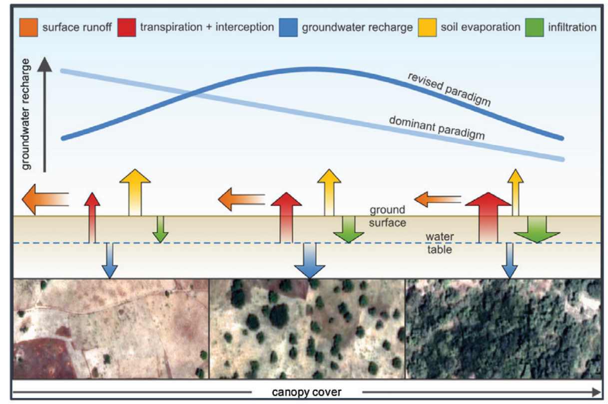


Fig. 5.6: Infiltration and groundwater recharge relative to canopy cover (From Ellison 2017).

Core Forest Systems & Ecosystem Services

	Forest	Biodiversity	Fire	Water
Provisioning	• Food • Fiber • Medicine • Gene & Seed Bank Resources • Ornamental Plants	• Food • Fiber • Medicine • Gene and Seed bank Resources (Crop / Strains - Livestock Breeds - Pollinators) • Ornamental Plants	• Fiber (through re sprouting) • Medicine • Open Space for pastures, agriculture & hunting • Stimulate germination of desirable crops • Ornamental Plants	• Fisheries + Aquaculture • Drinking Water • Flow for Energy
Regulating	• Air Quality • Climate Regulation • Pest/Disease Regulation • Predator/ Prey Dynamics • Carbon Balance	• Air Quality • Climate Regulation • Pest /Disease Regulation • Predator/ Prey Dynamics • Population Regulation • Enhance Flowering and Pollination • Carbon Balance	• Pest Control • Reduce Wildfires • Accelerate Species replacement • Enhance flowering and pollination • Carbon Balance	• Air Quality • Climate Regulation • Pest /Disease Regulation • Purification • Erosion Prevention • Flood Protection • Population Regulation • Carbon Balance
Supporting	• Oxygen Production • Soil Formation/ Retention • Nutrient Cycling • Water Cycling • Bio-Diversity • Habitat Creation • Bio-mass Production	• Nutrient Cycling and Decomposition • Resilience and Resistance to Climate Change • Soil Formation • Taxonomic diversity • Habitat Protection	• Nutrient Cycling and Decomposition • Nitrogen Release • Carbohydrates from underground plant organs • Water Cycling	• Soil Formation / Composition • Water Oxidation • Habitat Creation • Reproduction
Cultural	• Knowledge Systems • Sense of Place • Educational • Cultural Heritage • Recreation • Inspiration (Ecoadapt 2017)	• Charismatic Species • Keystone Species • Educational • Cultural Heritage • Recreation • Tourism • Aesthetic Enjoyment • Inspiration (Mace 2011)	• Knowledge Systems • Educational • Spiritual • Tourism • Hunting (Pausas + Keeley 2019)	• Recreation • Intellectual and aesthetic appreciation • Spiritual and Symbolic Appreciation (Grizzetti 2016)

Table 7

Radical Cannabis Ecologies Priority Systems

Based on a thorough evaluation of the environmental conditions of the farm and ecological systems in the forests surrounding cannabis farms in the Emerald Triangle, I have identified four priority areas (fig. 5.3) for implementing my *radical cannabis ecologies framework*. These priorities are water and earthworks, fire and defensible space, biodiversity and agroforestry, and productivity and energy. Each focus area encompasses design strategies that address cultivation requirements, restore natural systems, and adapt to future climate challenges.

Water & Earthworks

Water is essential for any farm regardless of crop, this need is only intensified in areas of the Emerald Triangle where water consumption for cannabis cultivation is the highest during the summer drought season. As drought periods get longer and more intense, the creation of a natural water system of conveyance and storage for year-round use is needed for these farms to minimize their impact on local water resources. In order to prevent stream diversions and minimize excessive well and spring withdrawals, it is crucial to prioritize the development and integration of earth ponds. By building a large network of lined earth ponds, farms can collect water during the wet season to store for use throughout the growing season. As the California Water Resource Board begins to enforce water forbearance and conservation requirements for legal farms, sustainably capturing rainwater is of absolute importance.

Another key strategy in this area is to create a network of swales that follow the drainage patterns of existing cultivation areas and circulation roads. By collecting and guiding excess run off we can reduce soil erosion and guide water away from critical infrastructures. Additionally, the implementation of a swale and vernal pond system serves a dual purpose and can also provide a native habitat while treating water on-site allowing for natural infiltration back into the soil. Increasing water storage capacity, not only benefits cultivation but also can provide an extra layer of defense if a threat of wildfire nears the property. Water can be used to extinguish or fend off low-intensity fires that may risk the cultivation areas.

Fire & Defensible Space

A combination of active fire management and defensive space to create a protective band of fire and fuel breaks helps reduce fire risk to the farm's cultivation areas and infrastructures while facilitating forest health. Active forest management would require the removal of forest debris and duff that isn't serving a habitat function. Next by removing smaller trees and shrubs and mechanically thinning and limbing up of the remaining trees, one can reduce stand density. Both strategies mitigate the risk of a small surface fire being able to use excess vegetation in the forest as a ladder fuel to spread into the tree canopy leading to a crown fire (a fire that spreads from treetop to treetop).

Farms have two main choices of how to deal with surface fuel (a fire that burns alongside the forest ground). First is through low-intensity prescribed burns during favorable spring and fall conditions when the soils are damp. A low-intensity surface fire would remove a lot of ground fuel in a controlled setting rather than be consumed as feeder fuel in a larger fire. After a fire, the ensuing combustion naturally triggers the decomposition and rejuvenation of the forest floor. This process stimulates the germination of seeds stored below ground, as well as the sprouting of underground plant structures like tuberous bulbs and corms. The manual treatments help to reduce any invasive species and pests and maintain native tree canopy.

An alternative approach is to construct an in-ground pit kiln at a safe distance from large vegetation fuels or farm infrastructure. This kiln can be used to burn collected surface fuel and dead tree material into *biochar* under a highly controlled setting. *Biochar* can serve as a nitrogen-rich fertilizer that can be applied as a top dressing in cultivation or spread across the forest floor, eventually returning nutrients back into the soil.

To provide protection to the farm from fire, a series of fuel and fire breaks can be constructed to reduce the risk of a fire spreading into the farm zone. A fire break removes all fuel load to create a distinct boundary clear of any vegetation so it can prevent the spread of fire from one area to another. These would commonly be used as a long linear boundary protecting the whole farm, 5-10 ft in width. Within the cultivation area, all vegetation would be removed around important structures and infrastructures creating a fire and vegetation-free zone of 10 + feet. Fuel breaks use techniques of thinning and reducing vegetation along a linear path to maintain forest structure and minimize the excessive fuel load needed for a large fire. These fuel breaks would be established alongside a fire break boundary that separates the farm and forest, as well as along circulation routes throughout the farm.

Biodiversity & Agroforestry

At the core of this priority area are two of climate response and adaptation strategies outlined in the 2021 IPCC Report for terrestrial land systems. These strategies include agroforestry, and biodiversity management with ecosystem connectivity. Each of these adaptation strategies is integrated into the site. Agroforestry involves incorporating trees, shrubs, grasses, and other plants to create nesting and foraging spaces for non-human species both outside and alongside the traditional cultivation zones. These techniques serve as a connection, linking functional spaces and habitats across sites.

To enhance the underutilized spaces between the forest and cultivation areas, such as disturbed vegetation zones, roadside edges, and existing forest/cultivation boundaries, various techniques like pollinator strips, deep hedges, field borders, and riparian plantings can be implemented. These techniques contribute to improved pollination services, increased complexity of the food web, and overall biodiversity and ecosystem function.

In the process of creating these agricultural spaces, it is beneficial to use emblematic and resilient plants native to the bio-region. Plants like Arctostaphylos not only attract native insects but also add a sense of place to the farm. Through assisted migration, native plants that are at risk or adapted to future climates can be taken from struggling southern populations and established here, thus transforming these agroforestry spaces into refuges and reservoirs.

By adopting these strategies, both cultivation zones and forested edges can benefit from improved soil productivity, enhanced habitat connectivity, and better water retention. The diverse arrangement of plantings facilitates the storage and cycling of more carbon and nutrients into the plants and soil, strengthening the farm's role as a carbon sink.

Productivity and Energy

Another goal is to minimize the use of carbon-intensive operations and transition to renewable energy sources. Currently, the reliance on diesel generators, large trucks, and machinery throughout the farm lead to it being a carbon source rather than a carbon sink. As California progresses towards phasing out gas-powered tools and generators, implementing small-scale solar power systems becomes crucial. Farm power requirements fluctuate throughout the year. Except for the heating and cooling demands of the processing barn and the gas consumption of occasional landscape grading and site enhancements, distributed solar arrays across the premises can reliably meet the majority of the farm's daily power needs. By supplying renewable energy sources in central areas near the cultivation zones, the dependence on daily generator use and gas consumption can be reduced. Moreover, adopting electric vehicles (EVs) for transporting supplies between farm areas will further decrease daily gas consumption and carbon emissions.

Forest Health and Harvest

As the forests recover to a healthy density, it becomes possible to sell marketable timber as the forest and farm mature. Strategies from each focus area, such as adaptive fire management and agroforestry, can be integrated into a comprehensive and sustainable forest management plan specifically tailored for farms with extensive forest strands. By considering my concept of a reservoir, the diverse range of long-living trees in these forests can allow them to function as a carbon sink. By maintaining and promoting a diverse vegetation structure, these forests can facilitate the accumulation and storage of carbon, enhancing the farm's role in mitigating climate change.

Grower Agency

Human agency plays a crucial role in the success of this framework. The future viability of these farms relies on the active involvement of growers. Their responsibilities will expand beyond cannabis cultivation to include land stewardship. This may involve developing pollinator habitats, engaging in fuel treatment, or planting streamside filter strips. Through these efforts, growers will develop a keen sense of observation and embrace a land ethic inspired by the practices of indigenous tribes predating Euro-American settlers by nearly two centuries.

Conclusion

By adopting a *radical cannabis ecologies framework*, these farms can leverage the surrounding ecosystems, tackle adverse environmental impacts, and proactively address future climate-related challenges. In the next chapter, we will delve into a case study of the Kneeland site, illustrating the practical application of this framework to a representative farm in the Emerald Triangle.

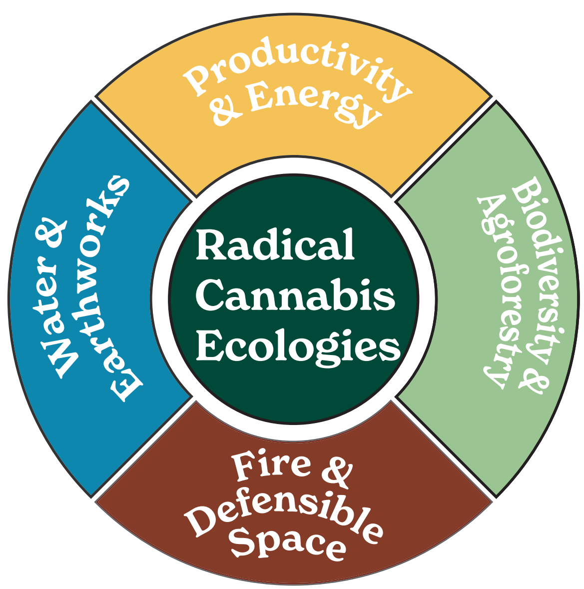
Fig. 5.7 Radical Cannabis Ecologies Key Systems & Site Strategies

Productivity & Energy

- Develop Solar Power System
- Battery Powered Vehicles +Farm Equipment
- Lower Daily Operating Costs
- Use 100% Organic Nutrients + Pesticides

Water & Earthworks

- Expand H2o Storage
- H2o Conservation
- Maintain Water Quality
- Ensure Stream Health



Biodiversity &Agroforestry

- Prioritize Healthy Soil Biome
- Varied Vegetative Structure
- Create Habitat for Fauna
- Expand Native Plant Palette

Fire & Defensible Space

- Encourage Fire-Resistant Planting Design
- Prioritize Labor Safety
- Actively Manage Fuel Load
- Maintain Defensible Space

Kneeland as a Radical Cannabis Landscape

To put the radical cannabis ecologies framework to the test, I have chosen an existing farm site to demonstrate the implementation of my 4 goals through 4 priority areas (fig. 5.7, pg 75). The Kneeland site, with its size, context, and complexity, serves as an ideal case study. It offers valuable insights into effectively addressing the wide range of environmental, climate, and market challenges that most farms will face in the future. After providing an overview of my proposal, I will go into the four main focus areas of my design and explain how I have incorporated them throughout the site. In a conventional farm layout and program, the focus is primarily on the development and management of cultivation zones for growing cannabis. Other areas, such as disturbed vegetation zones and existing forests, often get neglected unless they are directly involved in supporting cannabis production or infrastructure. Circulation routes serve to connect these zones and enable workers to tend to these spaces.

In contrast, a farm that adopts the *radical cannabis ecologies* framework creates a more intricate relationship between the cultivation area and the forest. This fosters the development of diverse layered spaces and habitat types that not only support cannabis cultivation but also contribute to a healthy forest, watershed, and renewable energy system. While the diagrammatic plan may show distinct lines between zones, in reality, there can be spatial or functional overlaps between different areas. For instance, the seasonal vernal ponds in the earth pond and swale system may overlap with each other, and plants that thrive in aquatic environments can also help manage runoff from precipitation.

One of my primary goals in developing this framework is to move from an extractive method of production singularly focused on cannabis to one that is more regenerative. A mode of production that can realign the demands of cultivation more in line with the resources and flows of the existing forest ecosystem.

Overall, a *radical cannabis ecologies system* promotes circular energy, waste, and material flows between the resource systems and productive areas. This enhances efficiency, reduces waste, and provides functional redundancy.

Conventional Cannabis Farm Model

The diagram (fig. 6.1, pg. 78) consists of two rows: the front row represents production spaces commonly found on farms, while the back row represents the resource systems that support these production spaces. The arrows represent the primary flows of energy, waste, and materials between these two types. Currently, there is minimal functional overlap and interaction between the production spaces and resource systems. Most of the arrows flow through these two types and exit the system without being recycled back in. In this context, cannabis flower cultivation generates waste, carbon from plant material, and water as byproducts. However, only water is naturally recycled within the system through the hydrologic cycle, where excess water returns to the groundwater and forest through precipitation infiltration and runoff. Other resources currently lack a closed-loop recycling mechanism.

Radical Cannabis Ecologies Farm Model

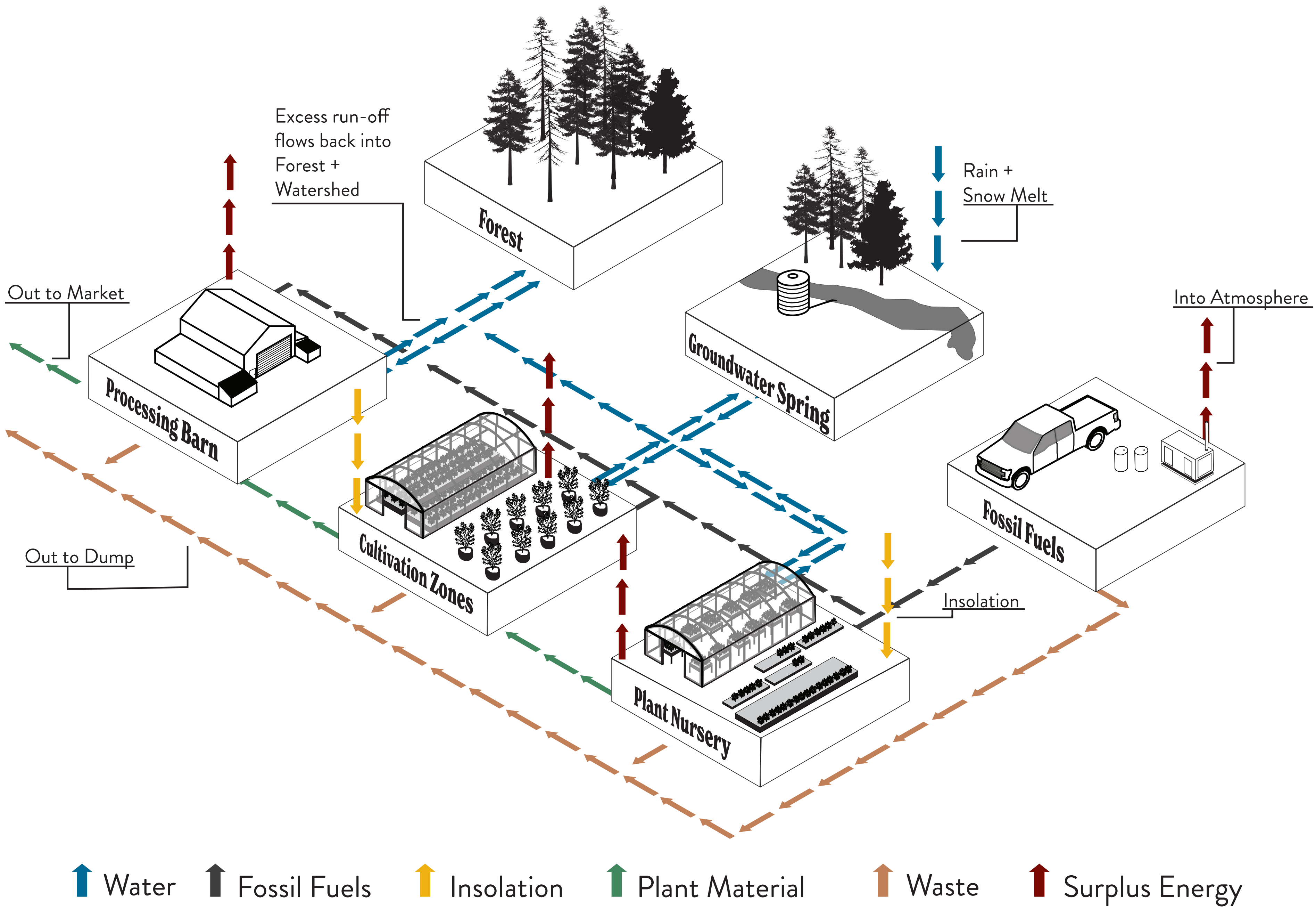
In a radical cannabis ecologies system (fig. 6.2, pg 79), new multi-functional spaces are introduced to complement the existing cannabis production areas and resource systems. These new spaces combine features of both production and resource systems found in conventional farms. Renewable energy sources replace fossil fuels, and three additional spaces are integrated: defensive space, agroforestry, and spring & earth ponds.

While some energy, waste, and materials still exit the system, they do so in lesser amounts with an emphasis on recycling back into the system. Plant material, including cannabis and forest maintenance waste, now returns to the farm system as compost or biochar Instead of being completely discarded. Water is sourced from a new earth pond system, serving both the cultivation areas and the processing barn. These ponds also contribute to the farm's security measures by creating defensible space. Additionally, the water from the ponds supports the water needs of cultivation in the agroforestry spaces.

Overall, a *radical cannabis ecologie*s system promotes circular energy, waste, and material flows between the resource systems and productive areas. This enhances efficiency, reduces waste, and provides functional redundancy.

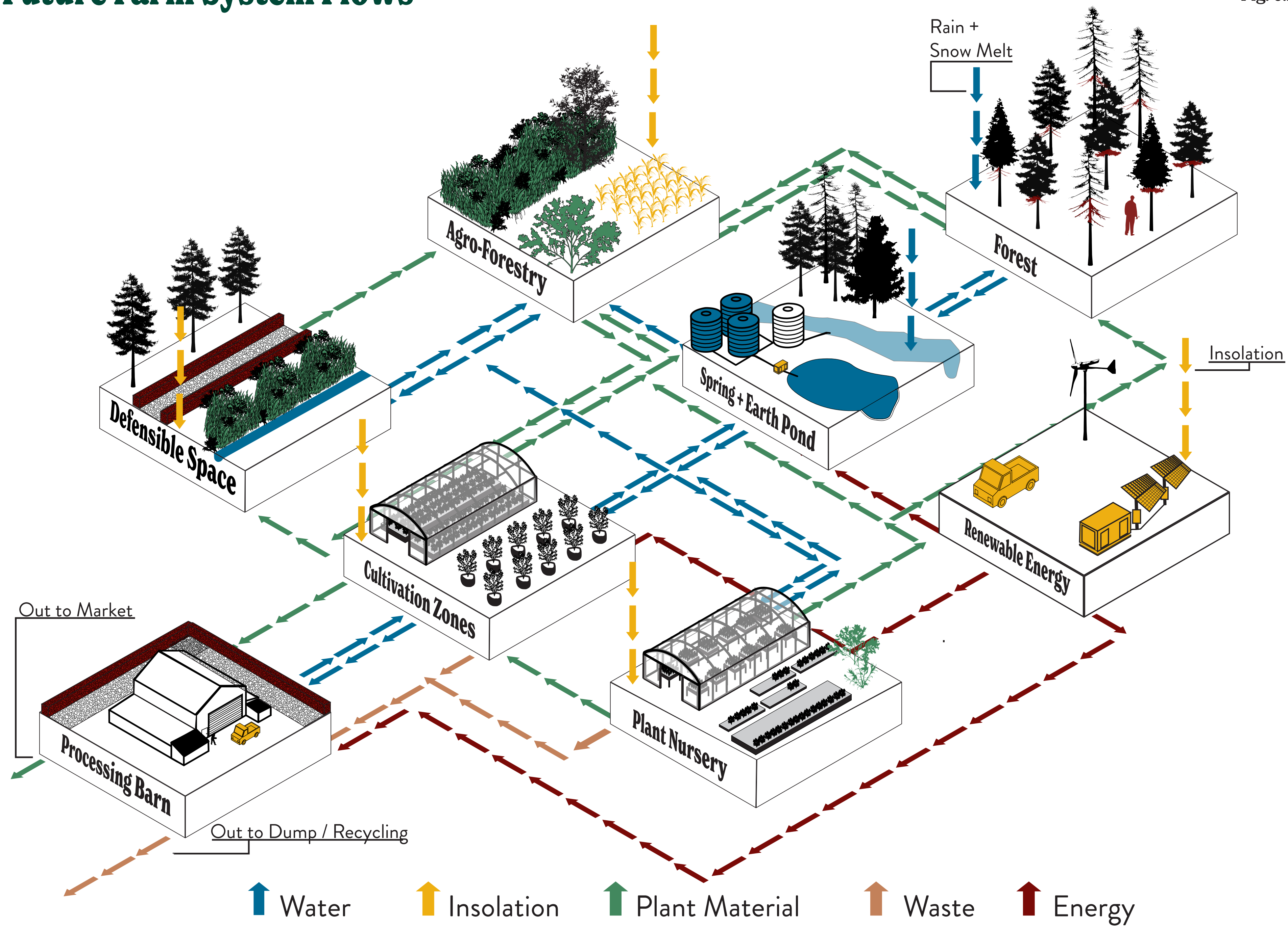
Current Farm System Flows

Fig. 6.1

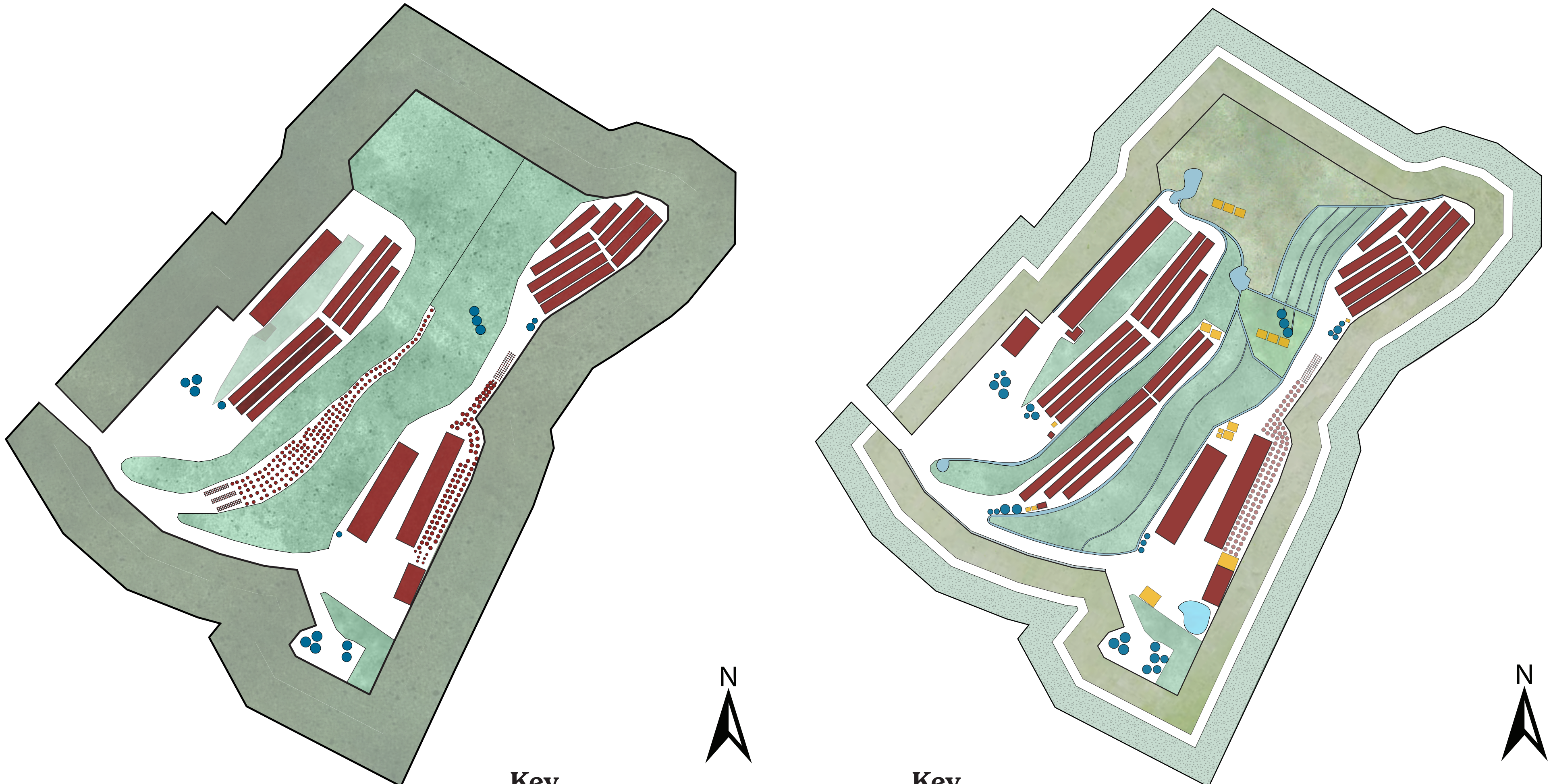


Future Farm System Flows

Fig. 6.2



Existing vs Proposed Conditions



Key

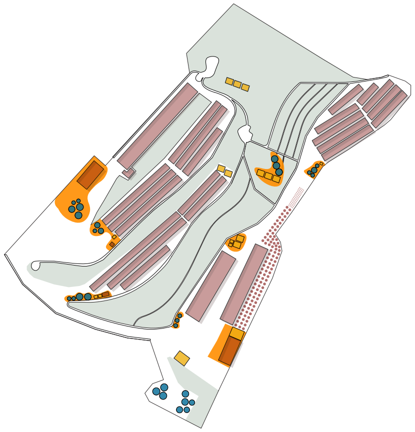
- Forest
- Disturbed Native Vegetation
- Cultivation Zones
- Irrigation Hubs

Key

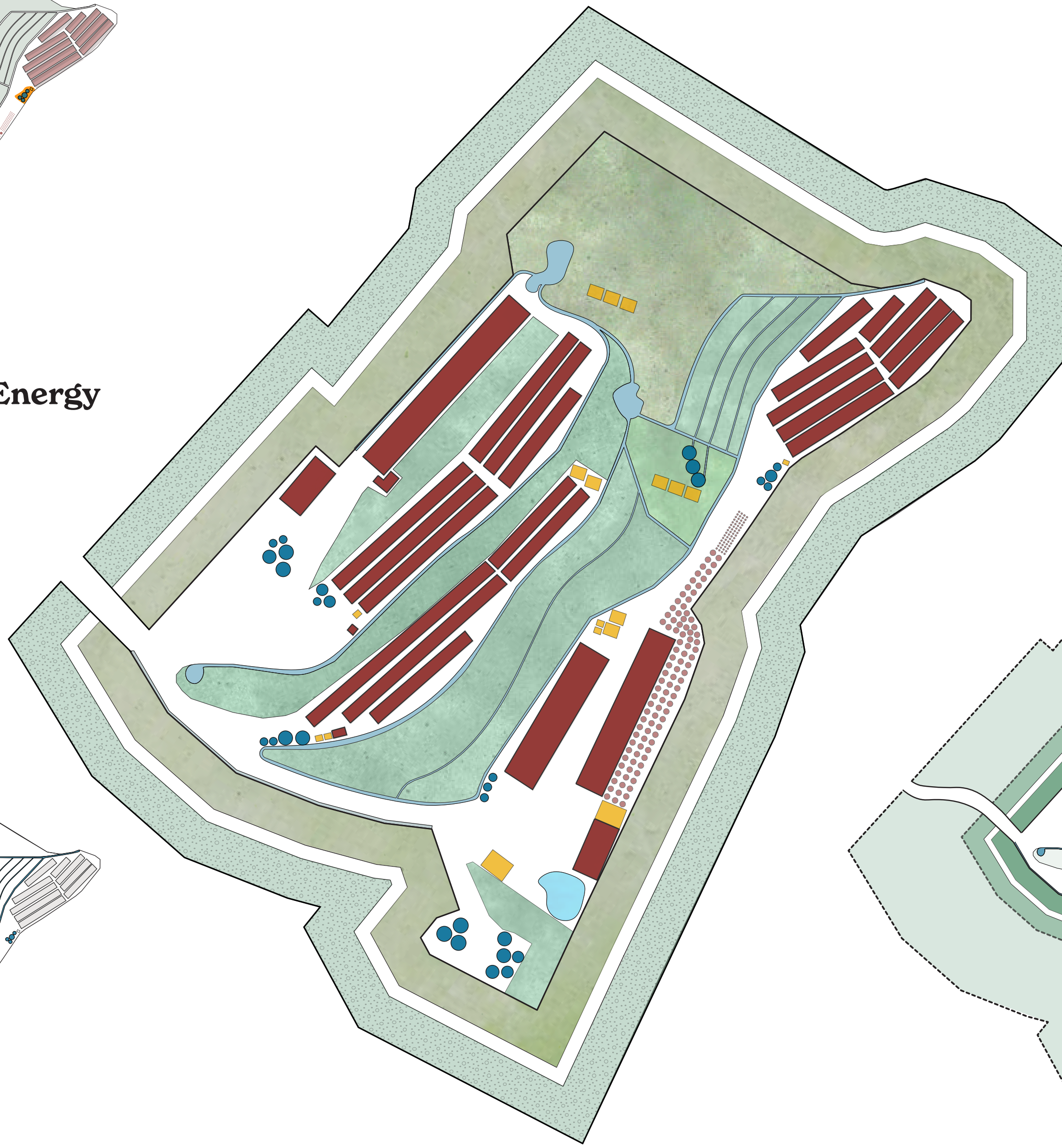
- Intensive Inner Fuel Break
- Fire Break
- Intensive Outer Fuel Break
- Expanded Cultivation Zones
- Enhanced Native Vegetation / Non-Cannabis Vegetation
- Renewable Energy Hubs
- Earth Ponds & Swale System
- Expanded Irrigation Hubs

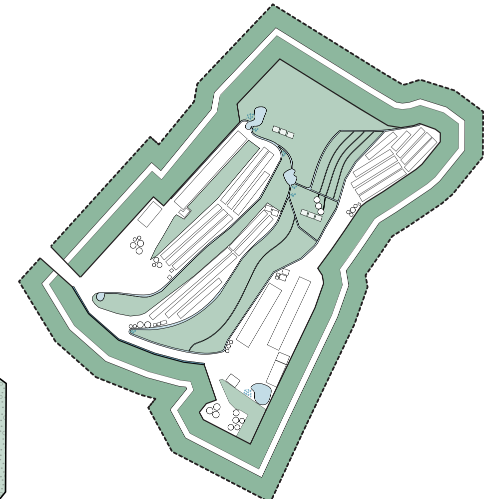
Fig. 6.3 Existing vs Proposed Conditions
Looking at the existing plan (left) one can see the 3 main farm spaces on a conventional cannabis farm such as this site at Kneeland. When you look at the proposed plan (right), employing a *radical cannabis ecologies* model, the site becomes more complex as previously singularly functional areas begin to take on multiple roles in the health of the farm.

Proposed Conditions & Priority Systems

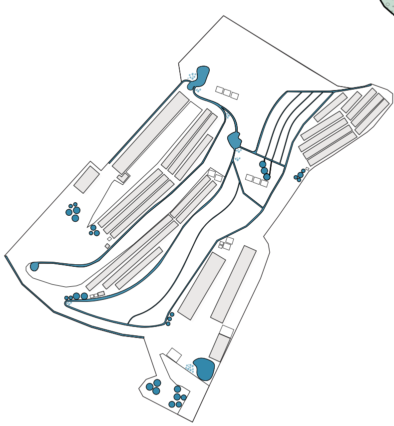


Productivity & Energy

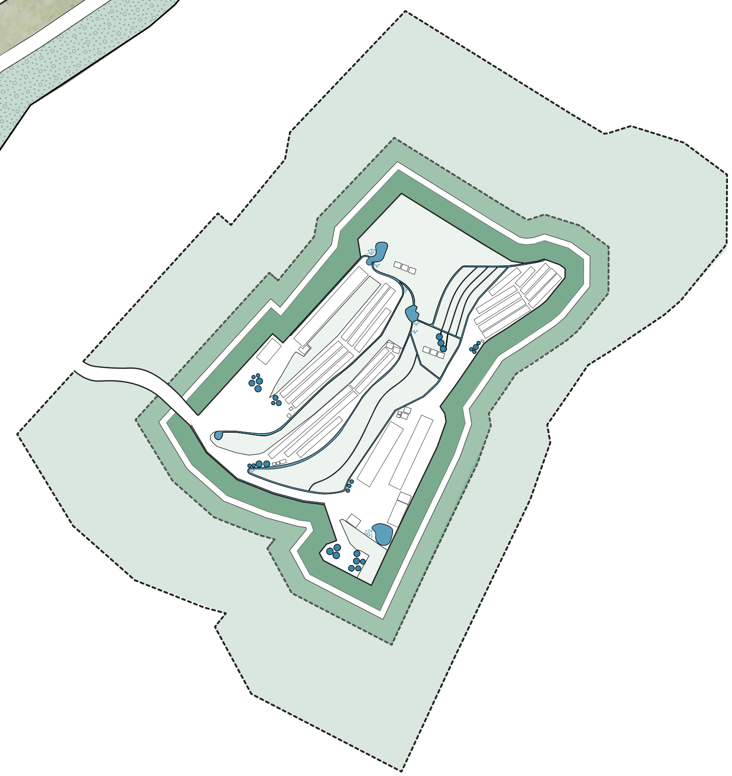




Agroforestry & Biodiversity



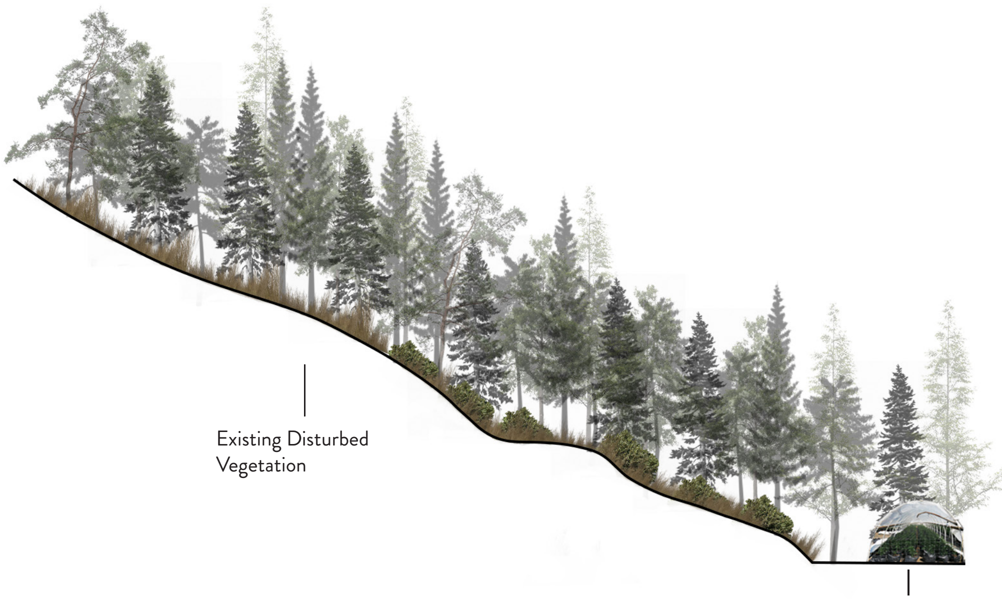
Water & Earthworks



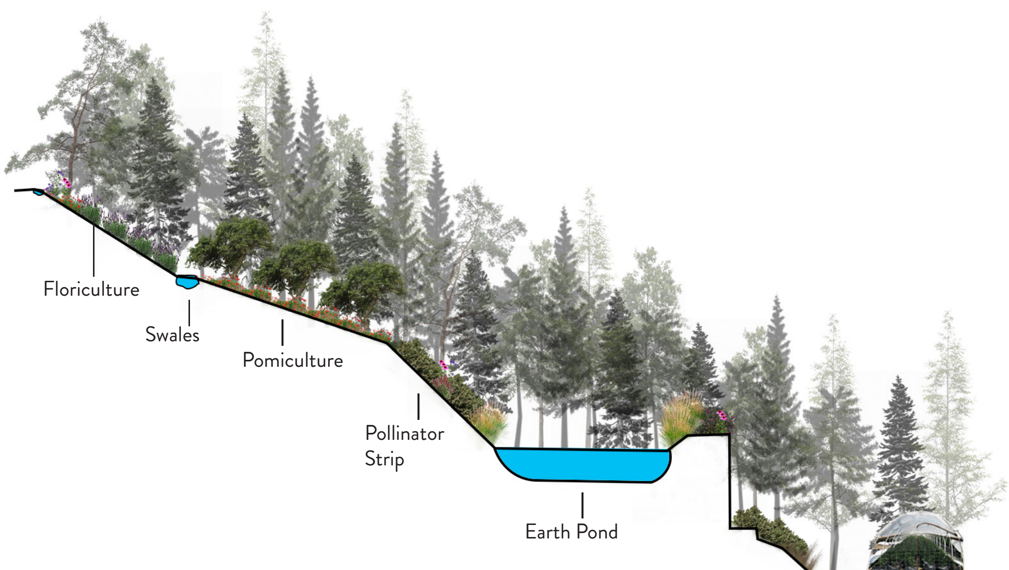
Forest Health & Fire

Fig. 6.4 Priority Systems of a Radical Cannabis Landscape
When we peel back each priority area one can begin to see the multiple functions that each area provides one another to build redundancy and resilience.

Radical Cannabis Ecologies: Water Conservation & Earthworks

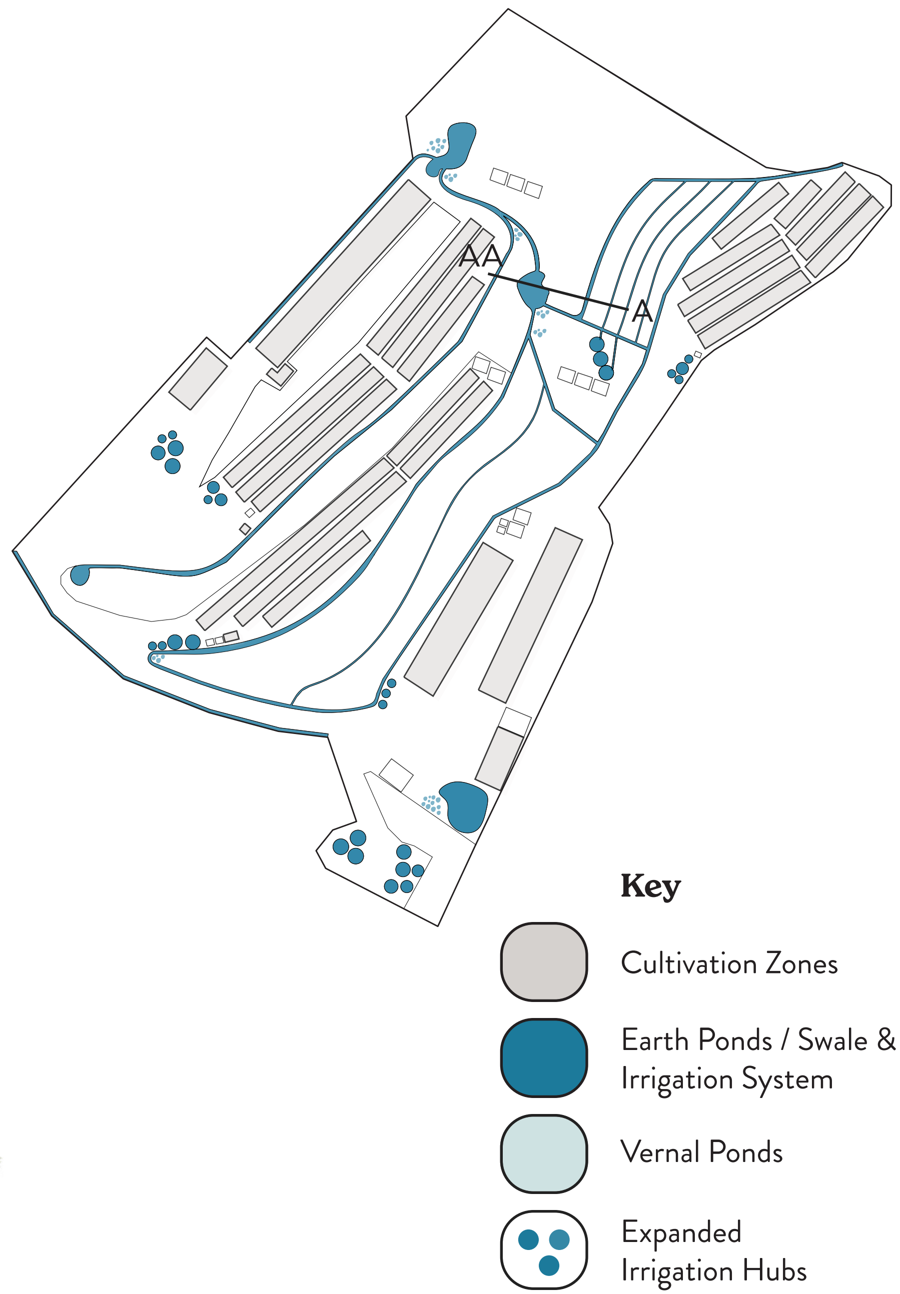


Existing Conditions Fig. 6.5



Proposed Conditions Fig. 6.6

Fig. 6.11 Plan Strategies



Through the creation of an integrated network of earth and vernal ponds, interconnected through swales and channels we can provide year-round water collection that can supply the farm during the growing season. To enhance the effectiveness and adaptability of the system, an expanded network of water channels interconnects the ponds, along with the incorporation of cisterns that aid in regulating and distributing water capacity to cultivation areas as needed.

Swales connected to vernal ponds effectively slow down and retain water throughout the site, thereby mitigating the risk of erosion and flood issues, particularly in areas with steep slopes. These channels and collection points effectively capture any excess water from cultivation zones, which then undergoes treatment and filtration in small filtering swales to remove any remaining nutrients or chemicals.

By employing this conveyance and collection network, the farm achieves multiple benefits, such as improving water oxygenation, reducing pollutant load, regulating downstream flow, and enhancing subsurface water quality. Additionally, the vernal ponds can serve as seasonal habitats for local aquatic animals, insects, and amphibians.

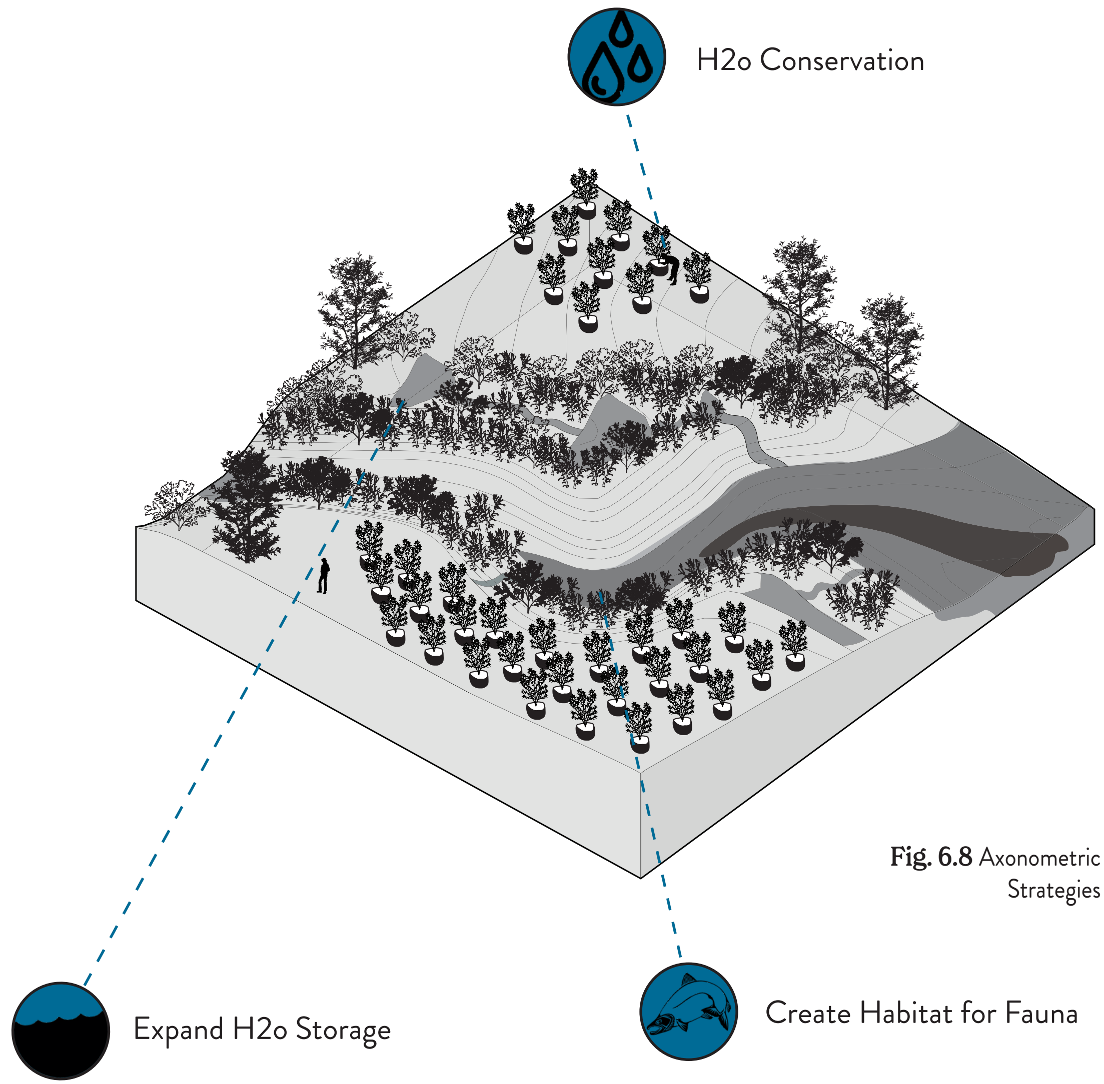
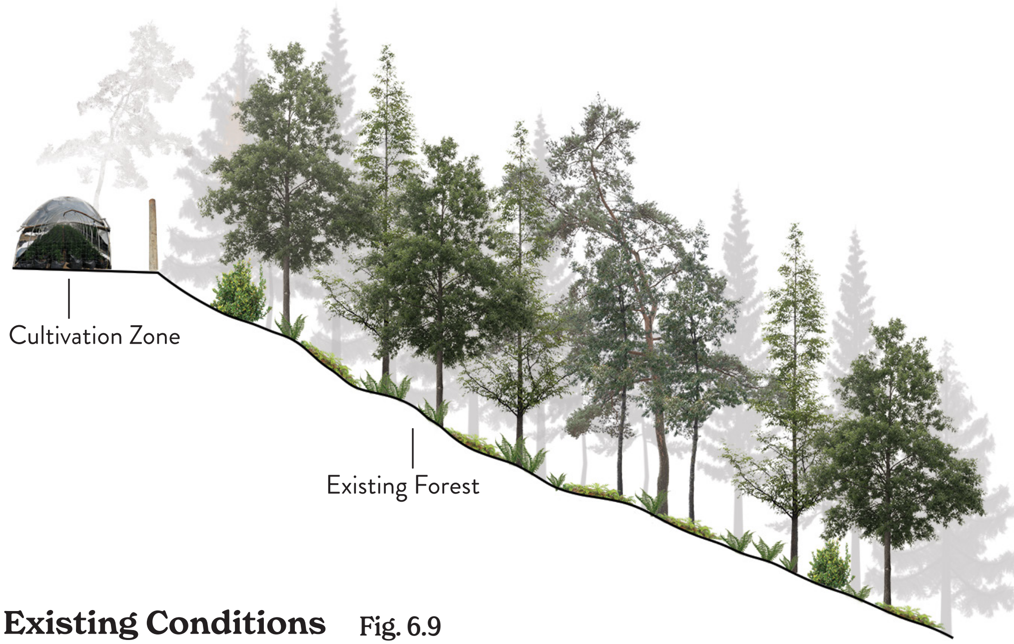
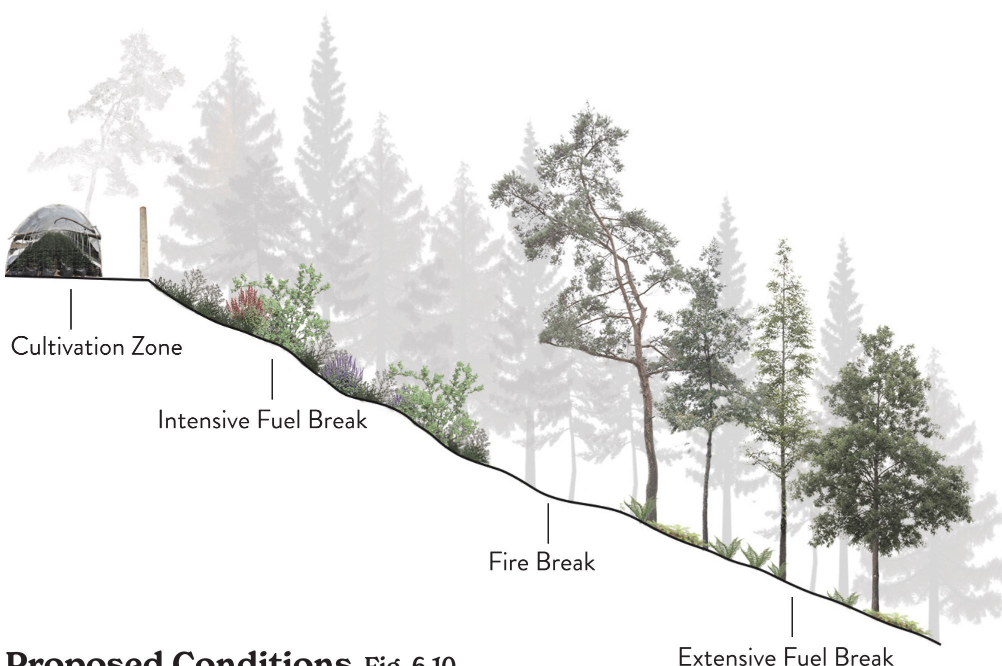


Fig. 6.8 Axonometric Strategies

Radical Cannabis Ecologies: Fire & Defensible Space

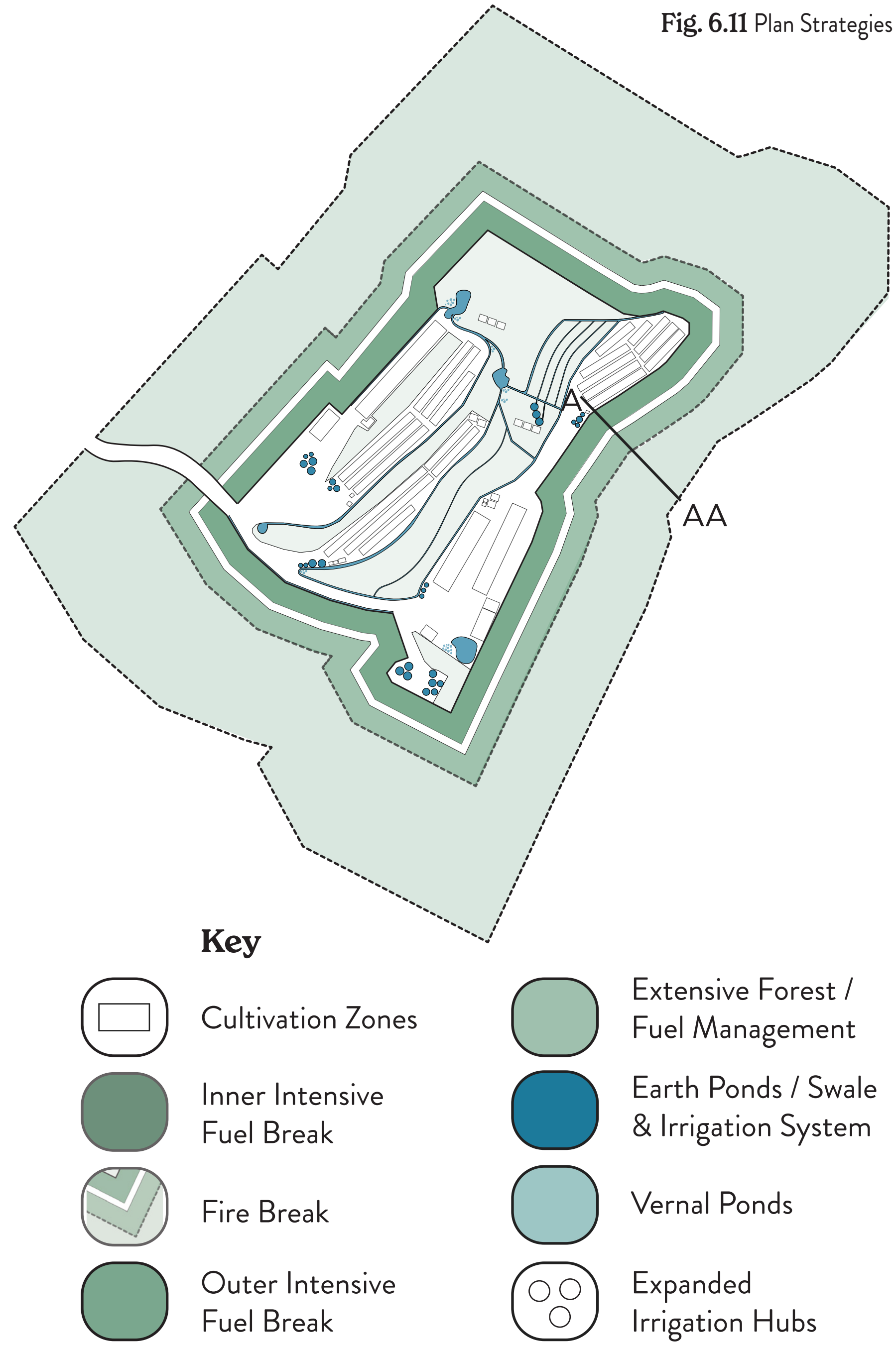


Existing Conditions Fig. 6.9



Proposed Conditions Fig. 6.10

Fig. 6.11 Plan Strategies



To promote forest health and ensure the safety of workers and farm assets, I have implemented a series of fuel and fire breaks within the site as defensive space. The first break is an intensive fuel break, 20ft wide, extending from the existing cultivation boundary into the forest. This break involves removing most of the tree canopy and replacing it with small, fire-resistant shrubs, perennial grasses, and drought-tolerant plants. These vegetation changes help stabilize the slope and adapt to the sunnier conditions.

Following the intensive fuel break is a 10 ft fire break devoid of vegetation. It consists of compacted gravel and soil, creating a distinct boundary zone between the forest and the farm. This fire break acts as a wide space that serves as a fire line during low to moderate-severity fires, effectively stopping the spread of surface and ground fuels.

Deeper into the forest, beyond the fire break, is an extensive fuel break that varies in width from 70 to 100 ft depending on the slope orientation of the site. Within this extensive fuel break, the fire is actively managed in two ways. Firstly, fuel treatment involves clearing fuel loads through prescribed burns or manual removal from the forest. Secondly, mechanical thinning, limbing, and tree removal are performed using chainsaws and branch loppers.

By managing the density and structure of the forest, the spread and speed of fires can be reduced. As a result, the forest structure more closely resembles a pre-fire suppression era density. If replanting is necessary, it is important to select and space future trees based on their tolerance to drought and fire to anticipate future climatic trends.

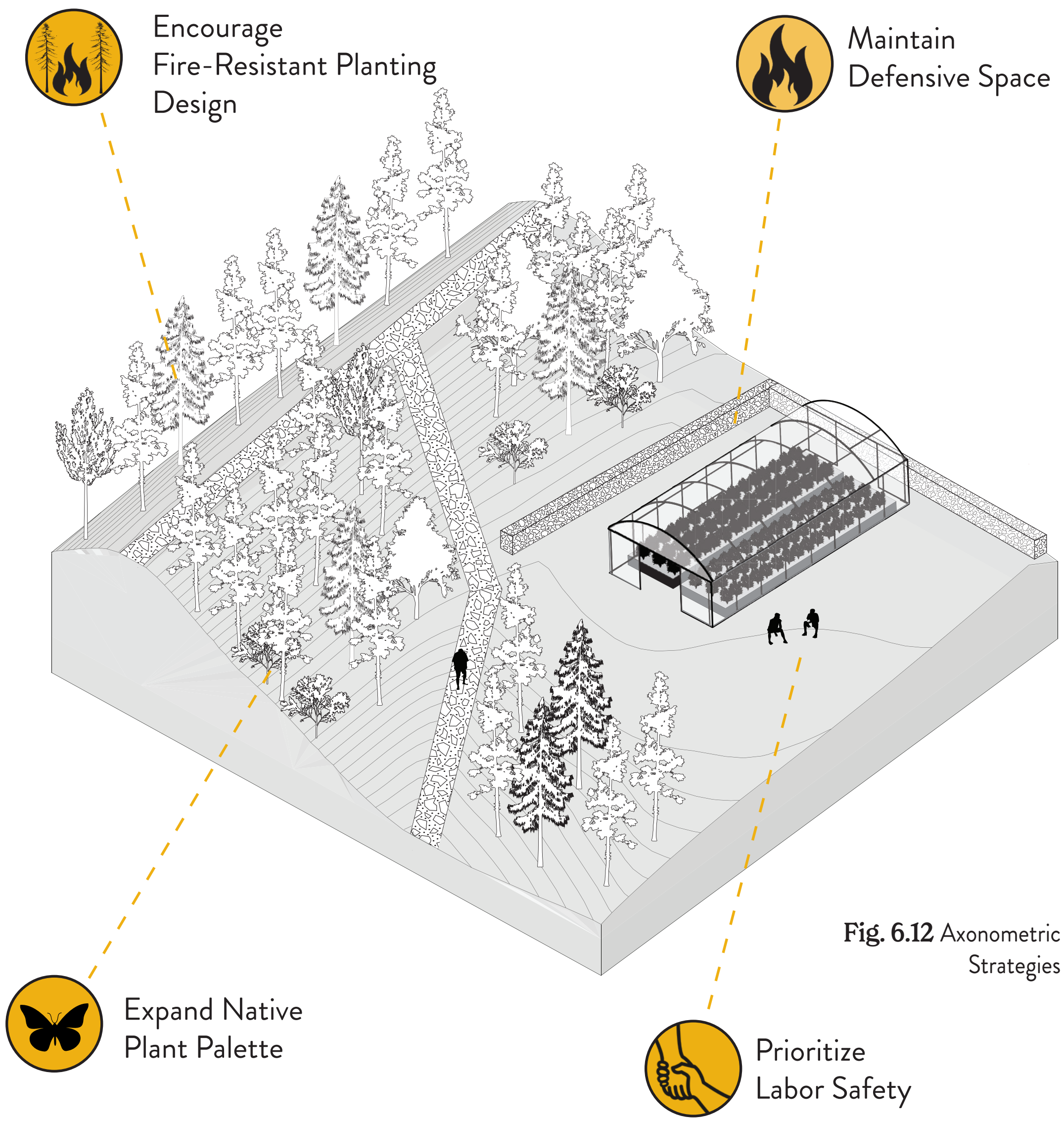
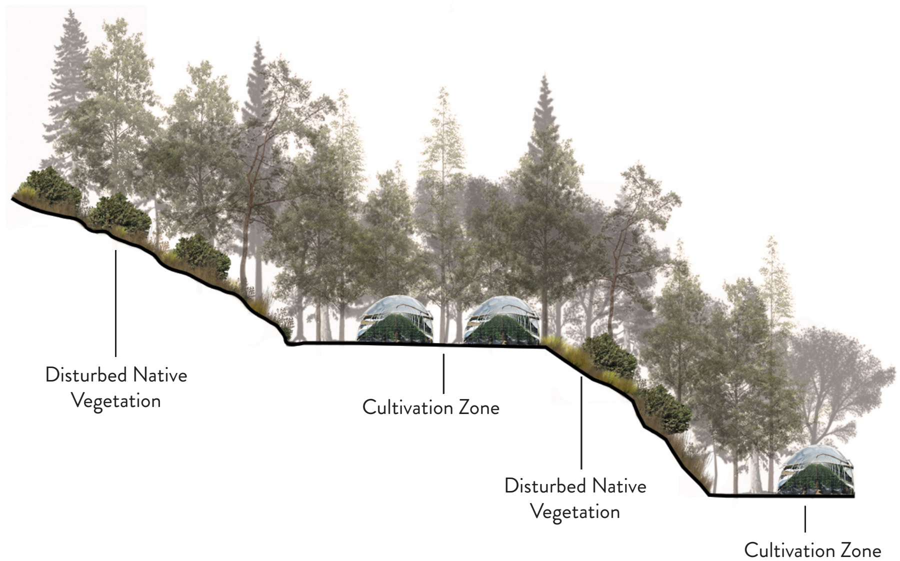
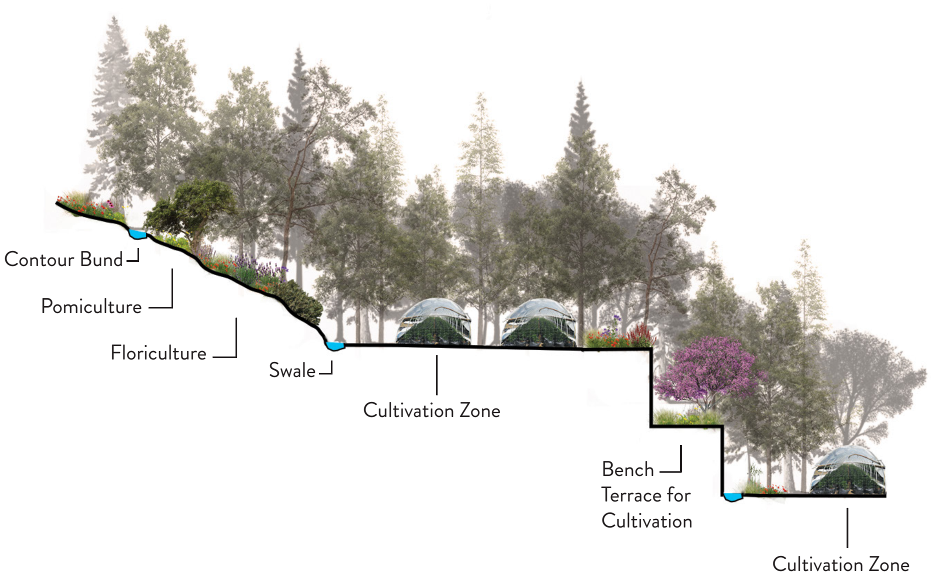


Fig. 6.12 Axonometric Strategies

Radical Cannabis Ecologies: Agroforestry & Biodiversity

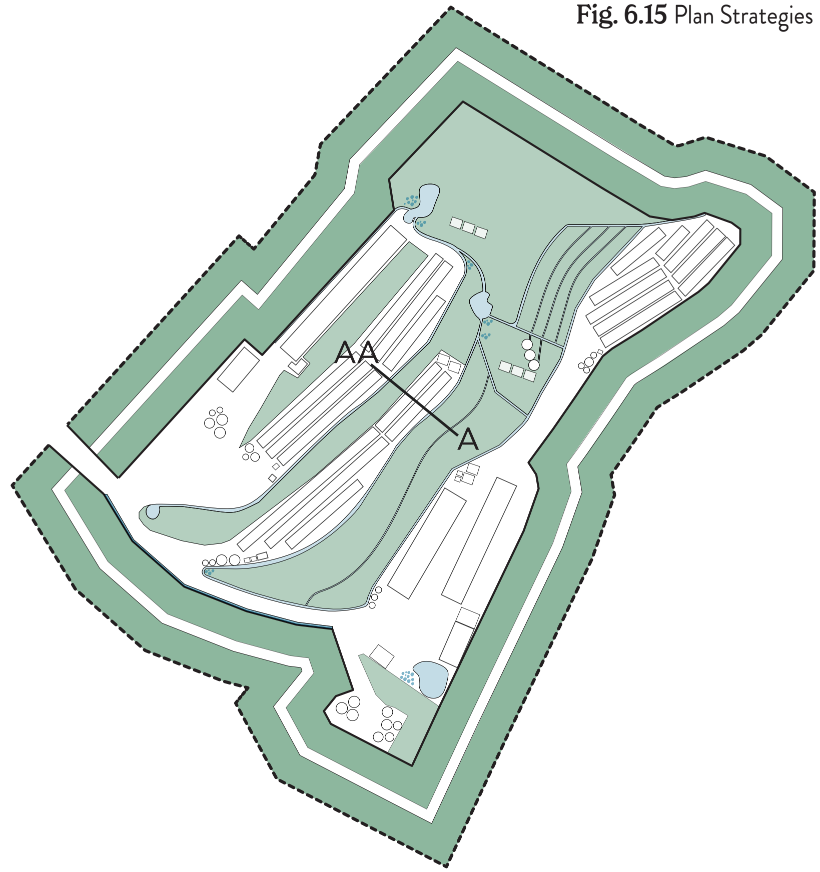


Existing Conditions Fig. 6.13



Proposed Conditions Fig. 6.14

Fig. 6.15 Plan Strategies



Key

- Cultivation Zones
- Extensive Fuel Break
- Fire Break
- Enhanced Native + Non-Cannabis Productive Zones
- Earth Ponds / Swale & Irrigation System
- Vernal Ponds
- Expanded Irrigation Hubs

Agroforestry strategies are implemented in two primary areas of the farm. The first area is along an extensive fuel break boundary, where the establishment of intensive fuel breaks has significantly reduced live fuel load. This reduction creates an opportunity to introduce a linear arrangement of native plants, forming a deep hedge that attracts animals and insects from both the forest and non-cannabis cultivation spaces.

The second area is within the spaces between cannabis cultivation areas, previously disturbed vegetation zones can now serve important ecological functions and expand cultivation opportunities. These areas are designed as pollinator strips or field borders, supporting pollination and providing nesting and foraging habitats. The favorable climate and sunny farm sites of the North Coast allow for the cultivation of cool-season pomological crops like apricots and pears. Additionally, floriculture production can contribute to supplemental cut flower harvests from plants such as Proteas (Leucadendrons, Leucospermum, or Grevillea). The cultivation of cool Mediterranean plants like Rosemary and Lavender offers the opportunity to produce valuable essential and aromatic oils, further diversifying revenue streams.

Another agroforestry area between the cultivation zones is alongside the network of earth and vernal ponds on the site. Riparian plantings around these water sources and courses capitalize on the new aquatic or seasonally wet environmental conditions. This, in turn, improves water uptake and retention, creating cooler micro-refuges throughout the farm. These spaces encourage water availability and moisture is distributed across the landscape, creating favorable conditions for increased cultivation. As cultivation practices and plant species diversify and expand across all available areas within the farm boundary, root systems, and mycorrhizal relationships intermingle, contributing to slope stabilization, improved soil health, and enhanced nutrient availability for all species.

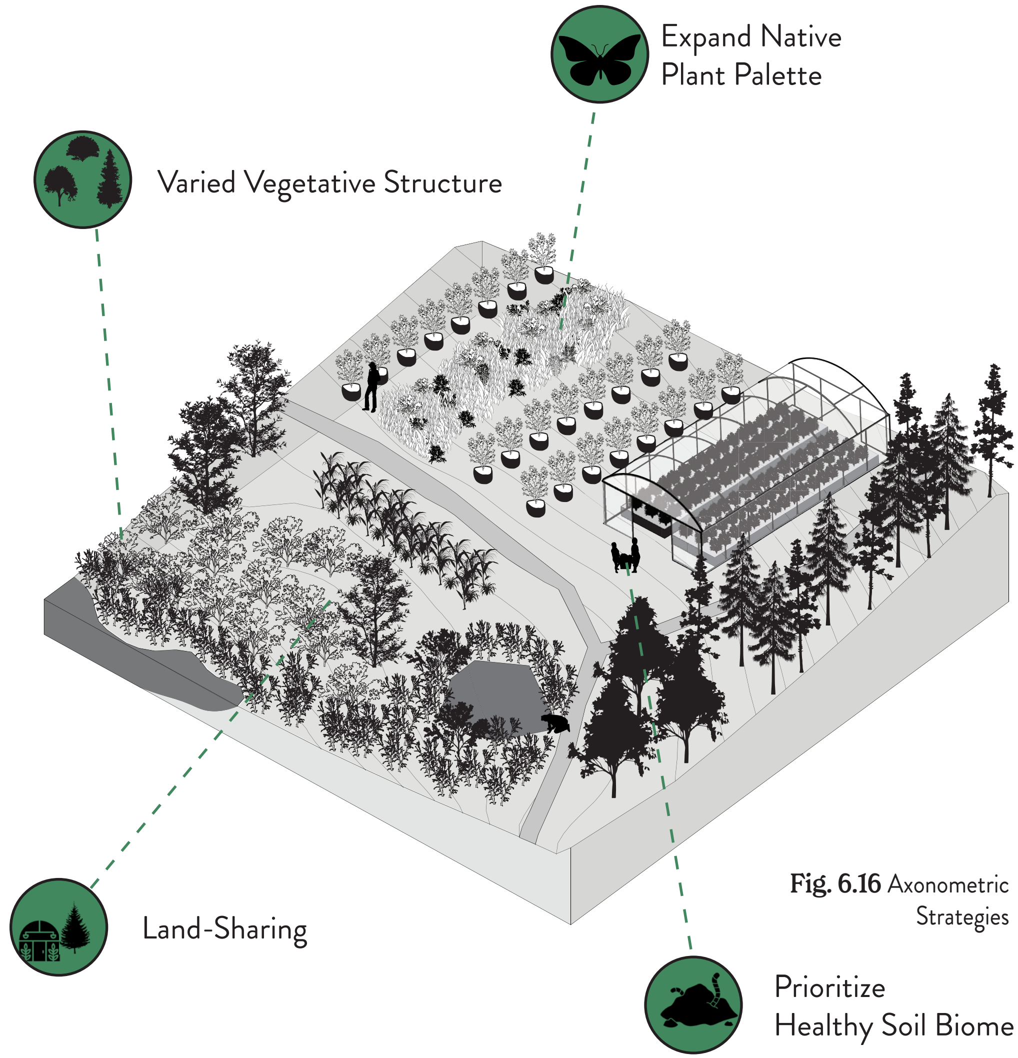


Fig. 6.16 Axonometric Strategies

Radical Cannabis Ecologies: Productivity & Energy

The three main focus areas mentioned prior (forest health, water conservation and earthworks, and agroforestry) all contribute to enhancing the productivity of the farm. To prepare for future agricultural intensification in response to market demands, I have expanded the size of many of the greenhouses on the site. Additionally, previously disturbed vegetation or soil areas have been transformed into terraced cultivation zones, capable of supporting various plant species beyond cannabis.

To ensure the well-being of plants, cultivation hubs have been strategically placed near each greenhouse or outdoor cultivation area. These hubs provide convenient access to fresh water, nutrients, compost, amendments, pots, tools, and other equipment needed for cannabis cultivation and maintenance. The infrastructure of the greenhouses has been upgraded to utilize renewable energy sources and smaller cultivation outbuildings have been connected to the electricity supply.

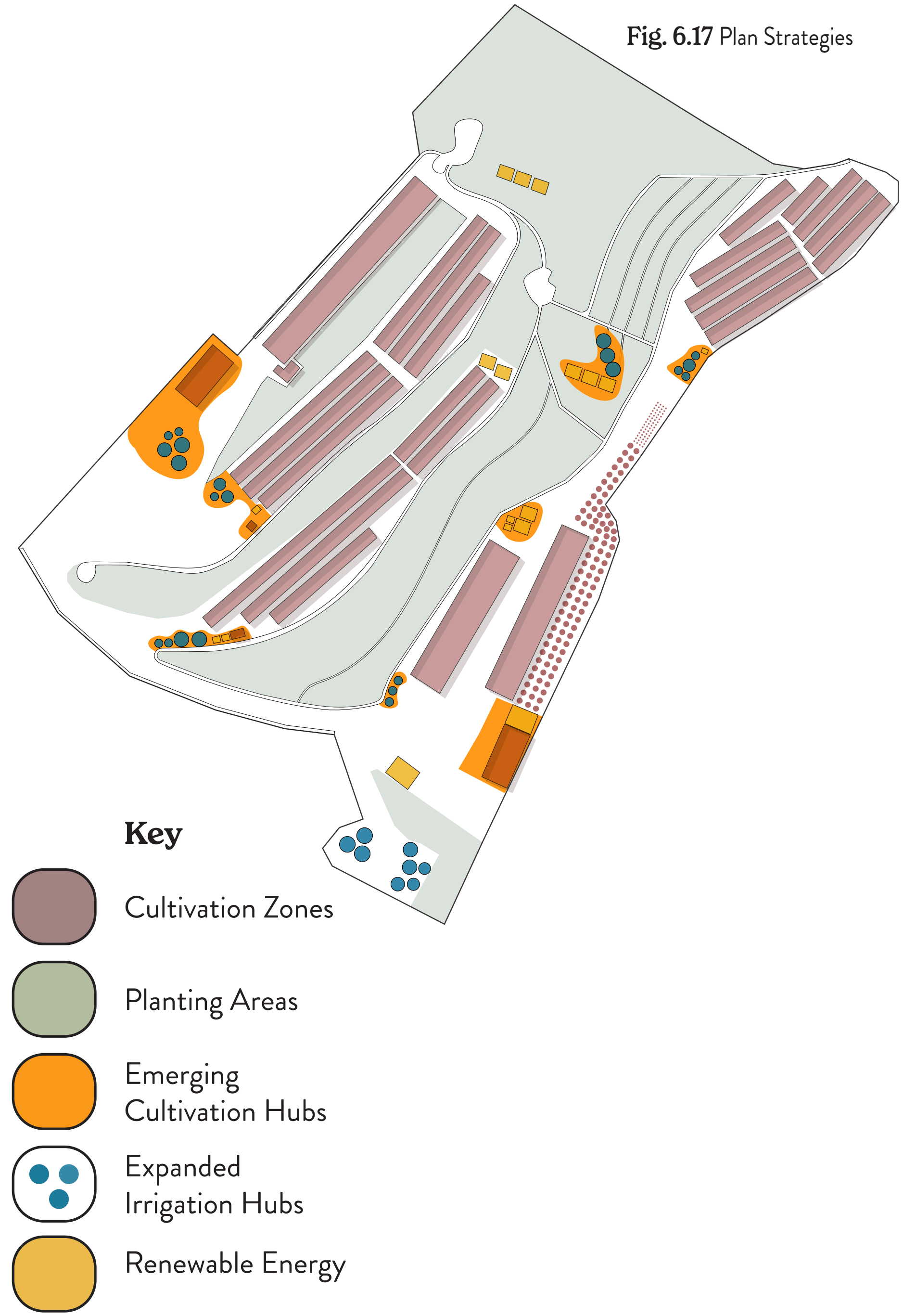


Fig. 6.17 Plan Strategies

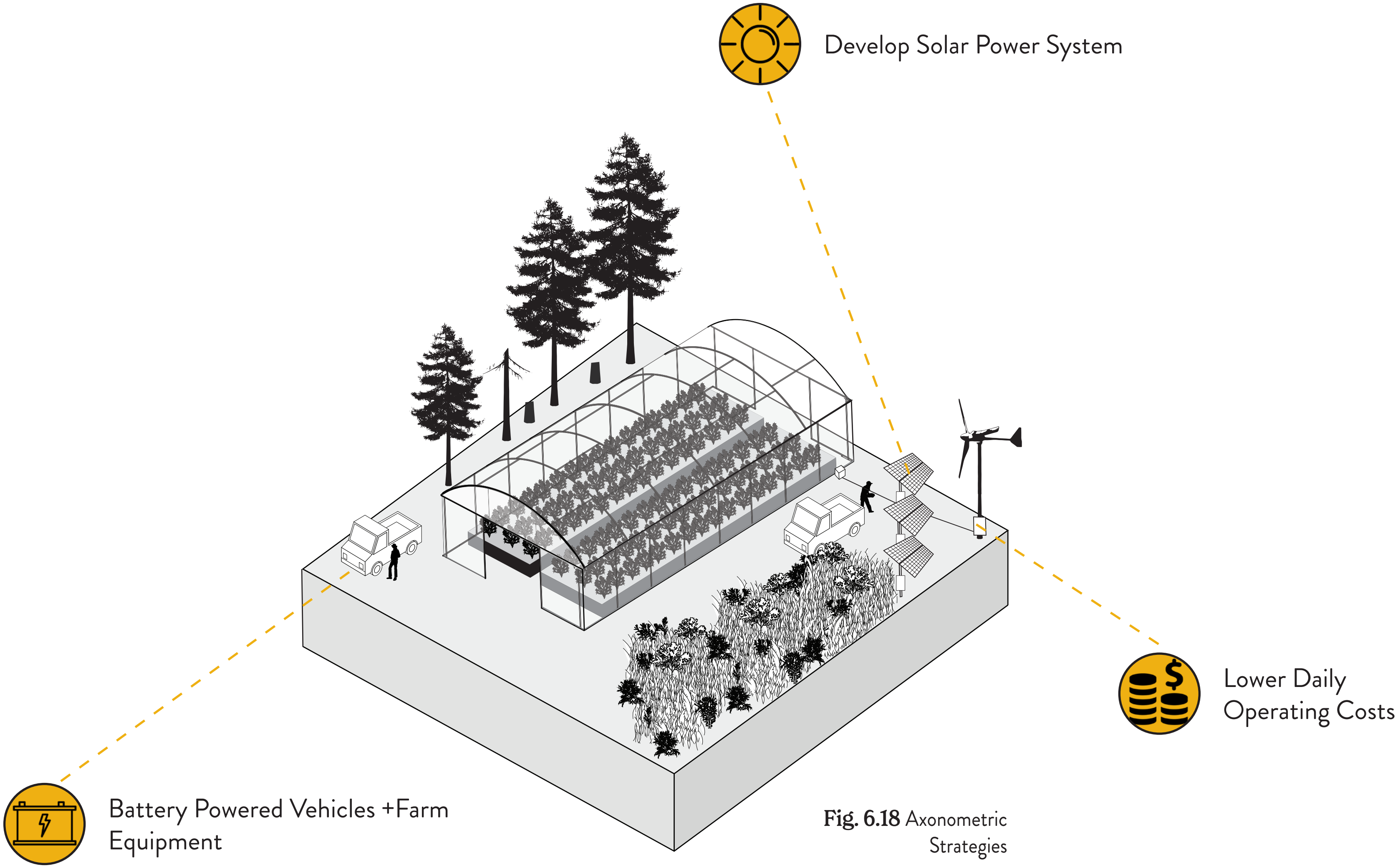


Fig. 6.18 Axonometric Strategies

Conclusion

In the coming decades, cannabis cultivation in the Emerald Triangle is expected to undergo a shift, with smaller growers ceasing operations while larger farms with access to capital may expand. As other cultivation hubs emerge throughout the state, the Emerald Triangle's status as a central hub will continue to decline. Its rise was shaped by a unique combination of factors, including the rise of the counterculture, the war on drugs, and changing perceptions of recreational cannabis use, all occurring alongside a gradual legalization process of a particular place and time in California.

Entering a cannabis retail store today in the United States reveals that capitalism is alive and well. Shelves are stocked with a dizzying array of strains, flavors of flowers, edibles, drinks, tinctures, and oils. Deals and promotions are plentiful, like those in a neighborhood grocery store, with "Happy Hour " offerings, $1 joints, 4/20 holiday sales, and frequent shopper programs. Well-established strains share shelf space with newer ones like OG Kush, Sour Diesel, Girl Scout Cookies, and Runtz, all competing for attention.

This expansive product selection owes its existence to the persistent growers of the Emerald Triangle. Their willingness to take risks, engage in experimentation, and pursue their passion has built a wealth of knowledge and expertise. Once hidden and secretive, this knowledge base is now openly shared, cultivated in full sunlight, and propagated across the country. It serves as the foundation for a thriving legal cannabis industry worth billions of dollars nationwide.

Soon the era of 'Big Pot' will be approaching, facing what similarly happened to the beer and wine industry. The market will expand, equalize, consolidate, and eventually specialize. This process will likely result in the dominance of a few large producers supplying the majority of the market in each state. While there will still be some presence of craft cannabis, it won't be like the heyday we see today.

The shift in cannabis production is moving towards the southern part of California, driven by the availability of cheap energy and water. However, even with a moderate warming scenario of 2.7°C by 2100, Southern California is expected to face increased water scarcity and hotter, drier temperatures, posing challenges for various agricultural crops, including cannabis.

In contrast, the Emerald Triangle may experience a shift in fortune due to climate change. The region's temperate climate, influenced by the ocean, is projected to be less impacted by severe climate changes compared to other parts of the state. Despite the risk of wildfires, the Emerald Triangle benefits from an abundant water supply, low population density, a relatively small-scale agricultural industry, and geographical isolation from water issues affecting other areas of California.

Regardless of what the future holds, cannabis growers in the Emerald Triangle continue to cultivate a significant amount of cannabis. By adopting a *radical cannabis ecologies framework* in rural and remote areas, these farms can maintain their viability even in the face of environmental challenges. I hope that this framework and its design strategies will bring about significant changes in the management of rural landscapes in this agricultural frontier. It has the potential to establish a regenerative form of cannabis agriculture, not only in

California but also in other dry landscapes across the West where outdoor cannabis cultivation takes place. The strength of the *radical cannabis ecologies* lies in its collective impact. If enough farms adopt this framework, it can lead to localized benefits and overall improvement in the ecological function of the region. This creates an opportunity for cannabis sites, whether new, existing, or abandoned, to serve as refuges, reservoirs, and interconnected wildlife corridors, linking the coast with protected state and federal wildlands along the North Coast Range.

In this envisioned future, it opens up exciting prospects for conservation. The diverse habitats of mixed evergreen forest, woodland, and prairie within these farm parcels offer great potential for restoration and conservation efforts. Given the dispersed nature of cultivation across various habitats in different stages of succession, with varying slopes and elevations, the conservation impact can be significant. Additionally, most farms in the region are located close to water sources such as streams or rivers. By ensuring the ecological health of the farms through this framework, these sites can be established with long-term conservation easements, promoting watershed health in the region. Furthermore, the ecosystems in this region hold important eco-cultural resources for the remaining descendants of the Northwestern Tribes of California. Conserving these lands provides an opportunity to protect vital habitats that hold cultural and environmental significance, helping prevent the loss of yet another type of potent reservoir and refuge.

Another alternate future for this landscape involves incorporating both ecological and cultural conservation into a unique form of cannabis agricultural hospitality. This concept blends ecotourism, recreation, and conservation within the context of a functioning cannabis farm. Similar to the experience offered in the wine industry, visitors could explore the landscape and witness the production of cannabis on-site. Farms could have tasting rooms, guided tours, and offer additional products for sale, creating alternative revenue streams beyond wholesale cannabis flower production.

As we enter a new era of cannabis legalization, growers in the Emerald Triangle hold an interesting position within this landscape. These remote and rural areas are experiencing depopulation, and a significant portion of the timberlands here is privately owned compared to other parts of the state. As logging and ranching tracts become available for sale, the question arises: who will purchase and care for these lands? Will the government step in and convert them into public forest land? After the logging industry's decline, it was cannabis growers who were among the first buyers, willing to invest in and give value back to these parcels. They became the caretakers of the land after loggers and land managers had harvested and moved on. In the end, will it be the growers who remain and steward the land, or will they also opt to sell? Regardless of the financial returns of cannabis, if the growers choose to stay and care for the land, utilizing a *radical cannabis ecologies* framework in their production practices, they can foster a more sustainable, responsive, and reciprocal long-term agricultural relationship, ensuring the nourishment and vitality of these lands for years to come.

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