Review Article

Beyond the Conservation Simplicism: Reconciling High Conservation Value and High Cultivation Value through a Diachronic Landscape Perspective

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Abstract

The prevailing intellectual habit in contemporary environmental governance is to equate high biodiversity with "High Conservation Value" (HCV) immediately, triggering a "fire alarm" simplicism that mandates strict protection. While well-intentioned, this synchronic view treats landscapes as static snapshots, ignoring the diachronic processes of soil pedogenesis and ecosystem evolution. This paper challenges the assumption that high biodiversity always indicates a fragile ecosystem in need of preservation. By synthesizing recent literature on soil age, nutrient dynamics, and land-use optimization, we distinguish between the biodiversity of "abundance" in geologically young, resilient soils and that of "survival" in old, nutrient-depleted soils. We argue that neglecting this distinction leads to strategic paralysis in land-use planning, particularly in the palm oil sector. The study introduces the concept of "High Cultivation Value"—identifying areas where ecosystem resilience supports intensive production—and proposes a transition from the binary HCV framework to a "High Understanding Value" (HUV) approach. This framework integrates the "critical radius" of observation and the landscape's geological age to resolve the dilemma between conservation and cultivation. We conclude that sustainable land management requires not just the protection of crowded ecosystems, but the discernment to understand whether that crowding represents the energy of youth or the fragility of old age.

JEL Classification: Q15 (Land Use and Lease), Q24 (Land), Q57 (Ecological Economics: Ecosystem Services; Biodiversity Conservation), Q56 (Environment and Development; Sustainability).

Introduction

The "Conservation Simplicism" in Environmental Governance

In the discourse of global sustainability, a specific intellectual habit has crystallized over the last two decades: the "conservation simplicism." This simplicism dictates that, upon detecting high biodiversity or dense vegetation cover, the immediate policy response must be protection. Like a fire alarm that rings regardless of whether the smoke comes from a catastrophic blaze or a cooking pot, the detection of biodiversity triggers a "No-Go" status. This approach is codified in global frameworks such as the High Conservation Value (HCV) and High Carbon Stock (HCS) approaches, which have become the gold standards for commodities like palm oil [1-4].

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While this simplicism is rooted in the precautionary principle, it risks becoming a dogma that replaces analytical thinking. By treating all biodiversity hotspots as identical conservation priorities, we often fail to ask a subversive but necessary question: Does high biodiversity always imply High Conservation Value? Or, under specific geomorphological conditions, could it actually signal "High Cultivation Value"—an area so robust and fertile that it is ethically and ecologically more responsible to cultivate it intensively rather than expanding into more fragile, marginal lands?

The Static Trap: Landscapes as Snapshots vs. Movies

The fundamental flaw in current land-use planning methodologies is their reliance on a synchronic perspective. Assessors enter a landscape, conduct a biodiversity inventory, measure carbon stocks, and produce a map. This process treats the landscape as a static photograph. However, landscapes are not static; they are dynamic entities undergoing continuous evolution—a "long film" in which the current scene is merely a fleeting moment in geological time [5,6].

Landscapes age. Rocks weather into soil; nutrients are released, cycled, and eventually leached. A young volcanic landscape behaves fundamentally differently from an ancient craton shield, even if both currently support dense vegetation. Current policy frameworks, however, often lack the temporal resolution to distinguish between these two states. They see the "crowd" of species but fail to understand the motivation behind the gathering. This "time-blindness" in conservation policy leads to the misallocation of resources, protecting resilient areas that could support food security while potentially neglecting the nuanced needs of truly fragile systems [5,6].

The Dilemma of Land Scarcity and Research Objectives

The tension between conservation and cultivation is exacerbated by global land scarcity. With the global population projected to reach 9.7 billion by 2050, the demand for vegetable oils and agricultural commodities continues to rise [7,8]. The dilemma is acute in the tropics, particularly in Indonesia and Malaysia, where the expansion of oil palm cultivation is directly at odds with biodiversity conservation. The current deadlock, where "conservation" and "cultivation" are viewed as zero-sum antagonists, is unsustainable.

This paper aims to break this deadlock by introducing a Qualitative Literature Review that synthesizes insights from soil science, landscape ecology, and agricultural policy. The objectives are threefold:

a) To critically analyze the limitations of the current HCV framework when applied without a diachronic (time-based) perspective.
b) To conceptualize "High Cultivation Value" as a legitimate ecological classification for young, resilient ecosystems.
c) To propose a "High Understanding Value" (HUV) framework that integrates soil age and spatial scale (critical radius) to guide strategic land-use decisions.

Literature Review: Conceptual and Theoretical Foundations

The Hegemony of HCV and HCS: A Critical Overview

The High Conservation Value (HCV) approach, initially developed by the Forest Stewardship Council (FSC) and adapted by the Roundtable on Sustainable Palm Oil (RSPO), identifies six categories of values, ranging from species diversity (HCV 1) to cultural sites (HCV 6) [1]. Similarly, the High Carbon Stock (HCS) approach distinguishes between viable forest areas and degraded lands suitable for development.

Recent literature acknowledges the success of these frameworks in halting rampant deforestation but highlights their limitations in landscape optimization. It has been argued that binary "protect/develop" classifications often fragment landscapes, leading to "leakage," in which development is pushed into less-monitored but potentially more fragile ecosystems [9]. Furthermore, the focus on "presence/absence" of species often overlooks the ecosystem's functional redundancy and resilience. It has been noted that not all high-biodiversity areas share the same level of irreplaceability or vulnerability, yet policy instruments rarely provide the granularity needed to distinguish among them [10,11].

The Diachronic View: Soil Age and Ecosystem Dynamics

To understand the actual value of a landscape, one must look beneath the vegetation to the soil—the "skin" of the earth that ages over millennia. The theoretical foundation for this comes from the concept of the chronosequence in pedogenesis.

The Aging of Soil

Soil formation is a progression from physical weathering to chemical and biological maturation. In the early stages (young soils), the profile is often simple (AC horizons) and contains an abundance of primary minerals that release nutrients such as phosphorus, potassium, calcium, and magnesium [6]. As the soil matures into ABC horizons, it reaches a peak of fertility. However, as the "film" continues, leaching processes dominate. In ancient soils (such as the Oxisols of the Amazon or the highly leached soils of Kalimantan), primary minerals are exhausted. The soil becomes "senile," acidic, and nutrient-poor.

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Biodiversity: Abundance vs. Survival Strategy

The relationship between soil age and biodiversity is non-linear. In young, nutrient-rich soils, high biodiversity often reflects an energy surplus. The system is comfortable; resources are abundant, allowing a riot of life to flourish. Conversely, in old, nutrient-depleted soils, biodiversity serves a different function. As demonstrated by recent studies on nutrient-poor tropical forests (e.g., Kerangas forests), high biodiversity and complex root networks are survival strategies. The nutrients are no longer in the soil; they are locked in the biomass (living vegetation) to prevent leaching. Therefore, biodiversity in a young landscape signifies resilience (the ability to bounce back), while biodiversity in an ancient landscape signifies fragility (where removing biomass permanently removes nutrient capital) [5,12,13].

Land Use Optimization: Sparing, Sharing, and Scale

The debate between "land sparing" (high-yield agriculture on less land to spare nature) and "land sharing" (low-yield, wildlife-friendly agriculture) remains central. Recent modeling suggests that for tropical commodities such as palm oil, land sparing is often ecologically superior, provided that high-yield areas are selected appropriately [14-16].

This brings us to the concept of the "Critical Radius" or the species-area curve. Ecological theory states that species accumulation curves eventually saturate. Observing a small plot yields many species; expanding the radius yields more, but at a diminishing rate. There is a "critical radius" beyond which adding more conservation area yields diminishing marginal returns for biodiversity [17-19]. Current policies, however, often treat every hectare as having equal marginal value, ignoring the saturation point of regional biodiversity representation.

Methodology

Research Design: Qualitative Literature Review

This study employs a Qualitative Literature Review approach. Unlike a Systematic Literature Review (SLR), which focuses on statistical trends and keyword frequencies, a qualitative review is designed to synthesize concepts, interpret narratives, and construct new theoretical frameworks [20]. This method is chosen because the "High Cultivation Value" concept is not yet a standard term in the literature. Still, it is an emergent property of synthesizing soil science with conservation policy.

Data Collection Strategy

The review draws upon three primary streams of literature:
a) Ecological and Soil Sciences: Focusing on pedogenesis, nutrient cycling, and ecosystem resilience.
b) Agricultural and Development Policy: Focusing on RSPO/ISPO standards, land sparing/sharing, and food security.
c) Governance and Ethics: Focusing on the trade-offs in conservation decision-making.

Search Parameters:
a) Databases: Scopus, Web of Science, and Google Scholar.
b) Timeframe: Primary focus on 2020–2026 to capture the latest debates on post-2020 biodiversity frameworks, with inclusion of earlier seminal or important texts for theoretical grounding.
c) Keywords: "Soil age biodiversity relationship," "HCV critique," "Land sparing trade-offs," "Palm oil sustainability dilemma," "Nutrient cycling in tropical forests."

Analysis: Thematic Synthesis

The analysis follows a critical interpretive synthesis. We deconstruct the "texts" (articles and policy documents) to identify the underlying assumptions about time and stability. We then overlay the "soil age" logic provided in the foundational problem statement to categorize findings into three themes:
a) The Synchronic Fallacy
b) The Duality of Biodiversity
c) The Strategic Imperative

Results: Thematic Findings

Theme 1: The "Snapshot" Trap – How Policy Ignores Time

A dominant theme in the reviewed literature is the static nature of conservation assessments. Regulations focus on the state of the ecosystem (what is there now) rather than its trajectory (where it came from and where it is going).

a) Evidence: Studies on HCV assessments in Indonesia show that assessors rarely consult geological maps or soil chronosequences [21]. A secondary forest on fertile volcanic soil (resilient) is often given the same "disturbed" classification as a secondary forest on peat or quartz sand (fragile), despite their vastly different recovery potentials [22,23].
b) Implication: This "snapshot" approach creates a policy blind spot. It fails to recognize that landscapes are "aging" and that conservation value is dynamic. The landscape is not “a photo”; it is “a long film”.

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The Limitations of Remote Sensing in Ecological History

A critical finding in recent literature is the over-reliance on optical satellite imagery (e.g., Landsat or Sentinel data) as the primary proxy for conservation value. While remote sensing excels at detecting cover (forest vs. non-forest) in the present moment, it is structurally blind to chronology and pedogenesis. It has been argued that current "Zero Deforestation" algorithms often classify distinct ecological histories—such as a 20-year-old secondary regrowth on fertile volcanic ash versus a 20-year-old degraded scrub on distinct ancient sands—into the same "High Carbon Stock" or "HCV" category [24-28]. This "spectral blindness" results in a policy failure in which land-use decision-makers cannot distinguish between a robust, recovering ecosystem capable of sustaining cultivation and a fragile system that requires strict protection. The satellite sees green, but it does not see the "age" of the resilience beneath the canopy.

The "Shifting Baseline" in Certification Standards

The review identifies a pervasive issue of "shifting baselines" among certification bodies such as the RSPO and FSC. It has been noted that audit frameworks typically utilize a "baseline year" (e.g., November 2005 for RSPO) to assess land status [9,29]. This administrative timeline creates an artificial "Year Zero" that ignores the geological timeline. Consequently, a landscape that has been dynamically evolving for millennia is judged solely on its status at a specific calendar date. This leads to the "lock-in" of lands that may have high current biodiversity due to temporary successional stages but lack the long-term edaphic capacity to sustain it without human intervention. Conversely, it prevents the rehabilitation of lands that—while currently degraded—possess the "High Cultivation Value" soil characteristics necessary for highly productive agriculture.

Governance Dilemmas and the "One Map" Paralysis

The synthesis of governance literature reveals that the "Snapshot Trap" is institutionalized through static spatial planning tools, such as Indonesia's "One Map Policy." While intended to resolve tenure overlaps, it these maps have been argued to often freeze land classifications based on outdated biodiversity surveys [21,30-32]. The literature highlights a "bureaucratic rigidity" in which reclassifying land from "conservation" to "cultivation"—even when scientific evidence shows the soil is robust, and the biodiversity is common/resilient-is politically impossible. This results in what has been described as "zombie conservation": the legal protection of areas that do not function as critical biological refugia, simply because the map reflects a snapshot of high vegetation cover from a previous decade [33].

The Economic Cost of "Stranded Assets"

Finally, the "snapshot" approach creates significant economic inefficiencies identified as "stranded land assets." It has been demonstrated that applying generic HCV protocols prevents the optimization of land use [34-37]. When a "High Cultivation Value" area (young, fertile soil) is locked away due to a temporary high biodiversity score (the "snapshot"), agricultural expansion is hydraulically pushed into "Low Cultivation Value" areas. These marginal lands require significantly more fertilizer and other chemical inputs to achieve comparable yields, thereby increasing the risk of eutrophication and reducing overall sustainability. The literature suggests that by ignoring the land's potential (a function of time and soil) in favor of its state (a snapshot of cover), policy inadvertently maximizes the environmental footprint of production per unit of output.

Theme 2: The Two Faces of Biodiversity – Luxury vs. Necessity

The synthesis of soil science literature reveals a stark dichotomy in the functions of biodiversity, which we categorize as "Biodiversity of Luxury" versus "Biodiversity of Necessity."

a) Biodiversity of Luxury (Young/Mature Soils): In geologically young regions (e.g., the Ring of Fire), nutrient supply from weathering rocks is high. Biodiversity here is a result of "comfort." The system is robust. If disturbed, nutrient capital remains in the soil (Horizons A and B), allowing rapid regeneration. This aligns with the "Intermediate Disturbance Hypothesis," which holds that such systems can tolerate significant human interaction [38].

b) Biodiversity of Necessity (Senile Soils): In ancient, stable shields, the soil is merely a physical anchor. The nutrients are almost entirely biotic—cycled rapidly between decaying leaf litter and root mats. Here, high biodiversity is a desperate mechanism to catch every ion of nutrient before it leaches away [39,40].

c) The Misinterpretation: Current HCV metrics view both systems simply as "High Biodiversity." However, the conservation implication is radically different. Protecting the "Senile" system is a matter of life and death for the ecosystem. Protecting the "Luxury" system is a matter of preference, as it has a high capacity to recover or support high-yield cultivation.

Nutrient Stoichiometry as the Hidden Indicator

Deepening the analysis of soil age, recent pedological studies provide a chemical signature for the "Luxury vs. Necessity" distinction: nutrient stoichiometry (specifically Nitrogen-to-Phosphorus ratios). It has been established that geologically young soils are typically Nitrogen-limited but Phosphorus-rich

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(derived from weathering rock) [6,41]. In these "Luxury" environments, plants invest energy in rapid growth and competition, resulting in high biodiversity driven by abundance. Conversely, ancient, weathered soils are Phosphorus-limited. Here, the ecosystem shifts to a "closed cycle" economy. In these "Necessity" environments, biodiversity is functionally distinct; it comprises specialized species with complex root traits designed solely to scavenge and retain phosphorus [12,13]. Distinguishing between "P-rich" (resilient) and "P-depleted" (fragile) biodiversity is crucial, yet absent from current HCV toolkits.

The "Root Mat" Mechanism and Fragility

The literature highlights the physical structure of the root zone as a definitive difference between the two types of biodiversity. In "High Conservation Value" ancient systems (like the Kerangas heath forests or peat swamps), the majority of the biomass and nutrient capital is located above the mineral soil, often in a thick, woven root mat. It has been emphasized that this structure is profoundly fragile; mechanical disturbance breaks the cycle, leading to irreversible nutrient leaching [35,42-44]. In contrast, in "High Cultivation Value" young soils (e.g., Andisols or young Inceptisols), the nutrient capital is bound to clay minerals deep within the soil profile. It has been noted that a deep resource base supports biodiversity here. Consequently, "cultivation" (disturbance) on young soils does not decouple the nutrient cycle as catastrophically as it does on old soils, supporting the argument for differential protection statuses [45-48].

Microbial Resilience: Generalists vs. Specialists

The thematic review extends below ground to the soil microbiome. Evidence has been provided that soil age dictates microbial composition [5,49,50]. Young, fertile soils are dominated by fast-growing, "generalist" bacteria (copiotrophs) that recover rapidly after tillage or land clearing—a biological marker of "High Cultivation Value." In contrast, ancient soils rely on highly specialized, slow-growing fungi and oligotrophic bacteria to mineralize recalcitrant organic matter. These specialists have low functional redundancy; once lost, they do not return. The literature argues that HCV assessments that focus solely on macro-biodiversity (mammals/birds) overlook this fundamental "microbial resilience" variable, thereby overestimating the fragility of young soils and potentially underestimating that of old soils.

Microbial Resilience: Generalists vs. Specialists

Finally, empirical studies on forest regeneration provide the "proof of concept" for the luxury/necessity dichotomy. It has been analyzed secondary forest recovery across the neotropics and tropics, finding that recovery rates of biomass and biodiversity are tightly correlated with soil fertility (a proxy for soil age). On young, high-fertility soils, secondary forests can recover 80% of their old-growth species richness within 20 years (high resilience). On old, infertile soils, recovery can take centuries, if it happens at all (low resilience). This finding critically undermines the "one-size-fits-all" conservation approach. It suggests that a "temporary" conversion of young soil ecosystems is a reversible event, whereas the conversion of ancient soil ecosystems represents a permanent crossing of an ecological tipping point [51-54].

Theme 3: Defining "High Cultivation Value

The literature on sustainable intensification increasingly points to the existence of "High Cultivation Value" areas—lands where the edaphic (soil) and climatic conditions allow for maximum output with minimum input (relative to marginal lands).

a) **Characteristics:** These are typically areas with young to mature soils (high Cation Exchange Capacity), low slope, and stable hydrology.

b) **The Dilemma:** Often, these areas are also "High Biodiversity" areas because everything grows well there. The current regulatory framework freezes these lands as HCV. Consequently, agriculture is pushed to "degraded" lands, which are often paradoxically more fragile (e.g., sandy soils with low resilience) or require massive chemical inputs to be productive, leading to worse overall environmental outcomes [55-57].

The Yield Gap and the Moral Imperative of Optimization

The literature increasingly frames "High Cultivation Value" not just as an agronomic opportunity, but as an ethical imperative within the "Land Sparing" framework. It has been argued that the failure to maximize production on robust, fertile lands (closing the "yield gap") directly drives deforestation elsewhere [58-62]. When "High Cultivation Value" lands are locked under rigid conservation statuses despite their resilience, the market demand for commodities forces expansion into "marginal" lands. These marginal lands often require three times as much acreage to produce the same tonnage of oil or crops, resulting in a net loss of global biodiversity. Thus, identifying and utilizing High Cultivation Value areas is recognized as a primary means of reducing agriculture's total land footprint.

Biophysical Markers of the "Goldilocks Zone"

Recent agronomic studies have begun to parameterize exactly what constitutes "High Cultivation Value." It is not merely "arable land." It has been defined these zones through a convergence of specific biophysical markers:

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a) Young parent material (volcanic/alluvial) ensuring long-term K/Mg/Ca supply
b) High Cation Exchange Capacity (CEC > 20 cmol(+)/kg)
c) Deep rooting depth (>1.5m)
d) Climatic stability [63,64]

The literature notes that these specific parameters define a "Goldilocks Zone" where the ecosystem is robust enough to buffer the "shock" of intensive agriculture without degrading. Current HCV maps overlay these zones with biodiversity data but often fail to weigh edaphic robustness against biological presence, effectively rendering the "best" farmland off-limits.

The Carbon Sequestration Potential of Cultivation

A counterintuitive finding in the recent literature is the carbon dynamics of High Cultivation Value lands. While the conversion of any forest releases carbon, it has been suggested that high-yield oil palm or agroforestry systems on young, fertile soils can achieve carbon sequestration rates (in biomass and soil organic carbon) that rival degraded secondary forests within two crop cycles [65-71]. This is, however, only possible on soils with high clay activity (High Cultivation Value). On sandy or peat soils (Low Cultivation Value), cultivation leads to continuous oxidation and carbon loss. Therefore, the literature supports a "Carbon-Efficient Land Use" argument: concentrating agriculture on soils that can physically protect organic carbon (via organo-mineral complexes) is a climate-smart strategy, further validating the distinct categorization of these lands.

Socio-Economic Stability as an Ecological Enabler

Finally, the review highlights a socio-economic dimension to High Cultivation Value. It has been found that smallholders operating on "High Cultivation Value" lands (fertile, resilient) exhibit significantly higher economic stability and are less likely to encroach on neighboring protected forests [72-76]. Conversely, farmers pushed onto marginal, fragile lands (due to the protection of better lands) suffer from "poverty traps" driven by fertilizer dependence and crop failure, leading to desperate expansionism (slash-and-burn). Thus, the recognition and utilization of High-Cultivation-Value lands are identified in the literature as a prerequisite for effective forest governance. You cannot stabilize the "frontier" of conservation if the core agricultural zone is not optimized for high productivity.

Discussion and Analysis

The "Teenager's Party" vs. "Hospital Waiting Room": An Ecological Metaphor

To synthesize the technical findings, we employ the analogy of two crowded rooms to represent high biodiversity.

a) Room A (The Teenager's Party): This room is crowded, noisy, and chaotic. The energy level is high. If you ask everyone to leave for an hour and come back, the party restarts immediately. This represents Young, Fertile Ecosystems. The "crowdedness" (biodiversity) is an expression of excess energy and vitality.

b) Room B (The Hospital Waiting Room): This room is also crowded. But the people are there because they are sick or supporting the sick. The "crowdedness" is a necessity for survival and support. If you disperse this crowd or remove the infrastructure, the system collapses. This represents Old, Fragile Ecosystems (e.g., Peatlands, Kerangas).

Analysis

The error of modern conservation is treating Room A and Room B the same because the "headcount" (biodiversity index) is the same. We apply "Hospital Rules" (absolute silence, no movement) to the "Teenager's Party," stifling its potential. Conversely, we sometimes fail to recognize the severity of the "Hospital" situation until it is too late. True sustainability requires distinguishing the nature of the crowd. We can afford to "disturb" the Teenager's Party (Cultivation) because the underlying energy (Soil Fertility) is robust. We absolutely cannot disturb the Hospital (Strict Conservation).

The metaphor of the teenager's party versus the hospital waiting room can be sharpened by linking it explicitly to empirical work on resilience and recovery trajectories. In young, fertile systems—the ecological equivalent of a teenager's party—disturbance is not only tolerated but often incorporated into the system's dynamics. Studies on secondary forest recovery across the tropics show that on fertile substrates, aboveground biomass, species richness, and functional diversity rebound rapidly after disturbance, reflecting a high intrinsic rate of increase in both plant and microbial communities. In such contexts, disturbance from carefully managed cultivation does not push the system beyond ecological thresholds; instead, it triggers successional pathways that can be steered through landscape design and restoration. By contrast, in the "hospital waiting room" systems—ancient, nutrient-poor soils with specialized biota—disturbance has qualitatively different consequences. Disturbance can erode irreplaceable evolutionary legacies, reduce niche specialization, and dismantle the very feedback loops that maintain ecosystem structure [77-81].

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This metaphor also exposes a fundamental misunderstanding embedded in many conservation narratives: the conflation of intensity with irreversibility. High-intensity land use on resilient, fertile lands can, under strict agronomic and governance conditions, be reversible or at least compatible with long-term ecological functions. For instance, high-yield agroforestry systems and perennial crops on mineral soils have demonstrated potential to retain substantial carbon stocks and habitat complexity while supporting intensive production. In fragile ecosystems, however, even low-intensity land use may be irreversible due to extremely slow rates of soil formation, nutrient replenishment, and species reassembly. The teenager–hospital distinction underscores that the same “crowd size” (biodiversity index) says nothing about the system’s capacity to absorb shocks or to regenerate once disturbed [82].

The metaphor further underscores the importance of functional redundancy and response diversity in determining whether an ecosystem functions like a teenager’s party or a hospital waiting room. In young systems, multiple species can perform similar functional roles (e.g., nitrogen fixation, pollination, decomposition), so the loss of any single species is buffered by others. This functional redundancy underpins resilience and justifies a more flexible land-use regime. In ancient systems, functional redundancy is often low; hyper-specialized plant and microbial taxa occupy narrow niches and cannot easily substitute for one another. Here, the loss of a single keystone or specialist species can precipitate cascading failures. Thus, treating both systems under a single HCV rubric is akin to applying the same emergency protocol to a noisy party and an intensive care unit based solely on headcount [83].

Finally, the metaphor provides a powerful lens to critique the “precautionary principle” when implemented without nuance. Precaution, properly understood, is not an argument for universal inaction but a framework for differentiated decision-making based on the severity and reversibility of potential harm. In the hospital waiting room, precaution means minimizing disturbance; at a teenager’s party, it requires rules, supervision, and clear exit strategies—but not a total ban on activity. Recent scholarship on “risk-based conservation” emphasizes the need to distinguish between contexts in which uncertainty justifies strict protection and those in which adaptive management is more appropriate. Integrating this risk-based thinking into HCV practice would move conservation beyond reflexive prohibition toward more intelligent, context-sensitive governance [84-86].

From HCV to HUV: High Understanding Value

We propose moving beyond the binary HCV/HCS system to a High Understanding Value (HUV) framework. HUV does not reject conservation; it contextualizes it.

HUV Equation:

$$HUV = Biodiversity\ Index \times Soil\ Age\ Factor \times Resilience\ Coefficient$$

Application: Under HUV, a tract of land with high biodiversity but young, deep, volcanic soil might be designated for "Strategic Sustainable Cultivation" (High Cultivation Value) rather than "Strict Protection," provided that the cultivation practices maintain soil health and a "Critical Radius" of representative biodiversity is preserved nearby.

This represents a shift from "don't touch" to "touch with understanding." It acknowledges that "cultivation value" is not just an economic metric, but an ecological one—cultivating where the earth is strongest is good ecology.

Transitioning from HCV to High Understanding Value (HUV) involves more than adding additional indicators; it requires a paradigm shift from state-based to process-based conservation. HUV treats the current state of biodiversity as a single observation within a longer causal chain that includes soil formation, disturbance history, and socio-economic drivers. This aligns with the growing emphasis on “social–ecological systems” and “adaptive pathways” in sustainability science, where decision-making is grounded in an understanding of system dynamics rather than static snapshots. Under an HUV framework, classification is not limited to “protect” or “develop” but expands to a continuum that includes “protect strictly,” “cultivate with safeguards,” “restore actively,” and “monitor adaptively,” depending on the intersection of soil age, resilience, and societal needs [87].

Operationalizing HUV will require integrating multiple knowledge domains into assessment protocols. Recent advances in digital soil mapping, geospatial modeling, and trait-based ecology provide the tools for such integration. For example, high-resolution soil grids can be combined with functional trait databases to estimate resilience coefficients and the likelihood of recovery under different land-use scenarios. Likewise, dynamic vegetation models can simulate ecosystem responses over multi-decadal timescales, enabling ex-ante evaluation of proposed land-use changes. In an HUV paradigm, these tools would be mainstreamed into certification schemes and spatial planning processes, ensuring that conservation status reflects trajectory-informed risk rather than static occupancy of biodiversity [88].

HUV also implies a new ethic of transparency and learning in land governance. Instead of treating maps and classifications as irreversible verdicts, HUV recognizes them as hypotheses subject to revision as new data emerge. This is consistent with recent calls for “adaptive governance” and “learning-based policy” in conservation, which stress iterative monitoring, stakeholder participation, and feedback loops between science and policy. In practice, this might mean that an area initially labeled as “High Conservation Value” could be reclassified as “High Cultivation Value with safeguards” if subsequent evidence shows high soil resilience, widespread species distributions, and the existence of better candidate sites for strict protection. Conversely, areas once deemed suitable for development might be upgraded to strict protection if new data reveal unexpected fragility or endemism [34,89].

Critically, HUV is not an attempt to weaken conservation commitments but to make them more strategically defensible. By distinguishing where protection is non-negotiable (e.g., ancient peatlands, nutrient-poor heath forests, irreplaceable refugia) from where it is negotiable under strict conditions (e.g., young, fertile secondary forests), HUV can actually strengthen the case for hard protection where it matters most. This strategic differentiation is essential in contexts such as Indonesia, where political and economic pressures make universal, strict protection unrealistic. By grounding conservation claims in a deeper understanding of ecological and geomorphic processes, HUV can provide a more persuasive narrative to policymakers and investors, reducing the backlash associated with perceived “anti-development” positions [90,91].

The "Critical Radius" and the Limits of Conservation

The "Critical Radius" concept challenges the "more is always better" assumption. In a homogeneous landscape, once a certain area is conserved (the asymptote of the species accumulation curve), conserving additional area yields diminishing returns for biodiversity but imposes increasing opportunity costs for human welfare (food security).

A "High Understanding Value" approach would determine this critical radius. Once the "conservation quota" for a specific ecosystem type is met within a landscape unit, the remaining area—specifically if it is "High Cultivation Value" land—should be unlocked for production. This avoids the "Conservation Simplicism," in which every individual patch is fought over as if it were the last refuge on earth, ignoring the broader landscape context.

The “Critical Radius” concept reframes conservation from a parcel-level to a landscape-level optimization problem. Ecological theory and empirical studies show that species richness typically increases with area but at a diminishing rate, reaching an asymptote beyond which additional area adds little new diversity. This is particularly evident for widely distributed generalist species and for functional redundancy. In practical terms, this means that once a landscape has secured a sufficient “core” of representative habitats and population sizes for key species, expanding conservation areas further yields sharply diminishing returns while incurring rising opportunity costs from foregone cultivation and livelihoods. The absence of this logic in many current HCV designations results in “over-insurance” of some habitat types and under-representation of others.

The Critical Radius framework also clarifies the relationship between conservation configuration and function. Landscape ecology has long shown that connectivity, edge effects, and spatial arrangement significantly influence species persistence, ecosystem services, and climate resilience. A smaller but well-configured network of protected areas—and compatible land uses—may be more effective than a larger but fragmented and poorly placed network. Recent work on “climate-smart conservation” underscores the importance of protecting elevational and climatic gradients rather than simply maximizing total area. Applying this logic to the HCV/HUV debate suggests that conserving the right hectares—those that represent endmember soil ages, unique habitat types, and critical corridors—matters more than conserving the maximum number of hectares irrespective of their marginal contribution to landscape-level diversity.

From an implementation perspective, Critical Radius thinking supports more nuanced zoning decisions. For example, in a landscape where 30–40% of the area is already secured under strict protection and effectively covers the full gradient of soil ages and habitat types, HUV would justify allocating the remaining young, fertile lands to “High Cultivation Value” use, subject to strict sustainability criteria. This is consistent with recent modeling that demonstrates how intensifying production on suitable lands can reduce pressure on frontier forests and peatlands, achieving net gains for biodiversity and climate mitigation. Conversely, in landscapes with minimal protection or highly fragmented refugia, the Critical Radius analysis may justify temporary moratoria on new cultivation even on otherwise high-potential soils, until a robust core conservation network has been established [5].

Finally, the Critical Radius concept carries significant implications for equity and political economy. The costs and benefits of conservation and cultivation are not evenly distributed among communities, companies, and states. When conservation is

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expanded beyond ecological necessity without accounting for opportunity costs, local communities and smallholders often bear the brunt, with their access to land and livelihoods restricted. By contrast, a Critical Radius–informed strategy could explicitly quantify when conservation is "enough" to meet biodiversity and climate targets, creating political space to recognize and formalize High Cultivation Value zones where local actors can pursue intensive, sustainable production. Recent work on "just conservation" and "nature-positive development" argues that such explicit recognition of trade-offs is crucial for maintaining the long-term social legitimacy of conservation initiatives. In this sense, integrating Critical Radius analysis into HUV is not only an ecological innovation but also a governance and justice imperative.

Conclusion and Recommendations

Substantive Conclusion

The quest for sustainability in the palm oil and agricultural sectors has been hindered by a well-meaning but ultimately superficial reading of the landscape. By relying on synchronic biodiversity indicators, we have conflated the "crowdedness" of vibrant, resilient youth with the "crowdedness" of fragile, survivalist old age.

The central thesis of this paper is that biodiversity is not a uniform indicator of conservation value. In young, nutrient-rich landscapes, high biodiversity often masks a "High Cultivation Value"—an inherent capacity of the land to support intensive production without ecological collapse. Conversely, in ancient, nutrient-poor landscapes, biodiversity is the only thing holding the system together.

Therefore, the dilemma between HCV and cultivation is often a false one, manufactured by our inability to read the "age" of the land. We do not need more maps that paint areas red or green. We need "High Understanding Value"—a diachronic wisdom that respects the time, process, and context of the living earth.

Policy Recommendations

To operationalize these findings, we offer the following recommendations for policymakers, certification bodies (RSPO/ISPO), and industry leaders:

Integration of Geomorphology into HCV Assessments

The first critical step in operationalizing the HUV framework is to mandate the integration of geomorphological and pedological analysis into HCV assessment protocols. Current HCV toolkits—such as those used by RSPO, FSC, and ISPO—rely predominantly on biodiversity surveys and carbon stock assessments but systematically overlook soil formation age and nutrient status as determinants of conservation value. To remedy this gap, HCV assessment teams must be required to include a mandatory "Soil and Geology" module that identifies the geological age of the landscape, characterizes the soil profile (horizon structure, parent material, nutrient status), and estimates the long-term edaphic capacity of the system to support both biodiversity and cultivation. This geomorphological audit would distinguish, for example, between high biodiversity on young volcanic soils (where the nutrient legacy is robust) and high biodiversity on ancient, deeply weathered soils (where nutrients are locked in biomass and nutrient capital is fragile). By incorporating this temporal and chemical dimension, assessors would move beyond the static "species count" to a more nuanced characterization of why the biodiversity exists and how reversible or fragile it is to disturbance. The inclusion of soil scientists and geomorphologists in HCV assessment teams would require capacity building within certification bodies. Still, the dramatic improvement in decision quality justifies the investment it would enable.

Adoption of a "Resilience-Based" Zoning System

In place of the current binary "Go/No-Go" classification system, policymakers should adopt a "Resilience-Based" zoning framework that recognizes differentiated conservation needs across the landscape. Under this system, lands would be classified into distinct zones reflecting their ecological resilience and conservation urgency. Zone A (High Cultivation Value) would encompass young soils with high resilience, demonstrated by robust nutrient stocks, high Cation Exchange Capacity, deep solum profiles, and demonstrated capacity for rapid recovery after disturbance; these areas would be designated as permissible for sustainable intensification, subject to strict environmental performance criteria (e.g., no soil erosion, maintenance of groundwater quality, no conversion of adjacent high-conservation areas). Zone B (High Conservation Value) would comprise old, nutrient-poor, or specialized ecosystems (ancient peatlands, heath forests, wetlands) where biodiversity serves a non-redundant ecological function and where soil resilience is low; these areas would be subject to strict protection with minimal allowance for extraction or conversion. Zone C (Restoration Priority) would identify degraded lands that, despite current low biodiversity or carbon stocks, possess soil properties (edaphic resilience) that make them suitable candidates for active restoration, potentially offering higher long-term returns than protecting low-resilience secondary forests elsewhere. This tripartite zoning acknowledges that the same biodiversity index may reflect fundamentally different ecological meanings, and that conservation strategy must be calibrated to the underlying soil and

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evolutionary context. Implementation would require retraining auditors and regulators to think in terms of resilience trajectories rather than static snapshots. It would necessitate updating the technical guidance documents of certification bodies—a significant but achievable institutional shift.

Implementation of "Critical Radius" Landscape-Level Planning

Conservation targets must shift from the concession or project level to the landscape or ecosystem level, incorporating the "Critical Radius" principle to determine when a region has secured sufficient representative habitat to justify optimizing the remaining lands. Rather than treating every patch of high biodiversity as equally irreplaceable, landscape-level planning would first establish the biodiversity representation target for the region—typically 17–30% of the original ecosystem extent, depending on ecosystem type and conservation goals—and then strategically locate protected areas to achieve this target with the minimum land footprint while maximizing connectivity and climate resilience. Once this core conservation network is secured and functioning, the "Critical Radius" principle suggests that expanding conservation areas beyond this point yields diminishing marginal returns for biodiversity while imposing rising opportunity costs in terms of foregone food production, rural livelihoods, and economic development. Therefore, policy should explicitly acknowledge the point at which conservation is "sufficient" at the landscape level and, at that juncture, allow remaining land—particularly High Cultivation Value lands identified in Zone A—to be optimized for sustainable production under strict management criteria. This approach requires close collaboration between conservation organizations, landscape planning authorities, and industry stakeholders to agree on a scientifically rigorous, socially legitimate, and spatially explicit conservation target for each region. Implementation would involve integrating spatial planning tools (e.g., Marxan, InVEST) with soil and resilience data to identify the minimum-representative protected-area network, thereby creating a defensible boundary between "must protect" and "can cultivate with conditions." Such landscape-level planning is already being piloted in jurisdictions such as Sabah and North Sumatra; scaling these approaches globally is essential to moving beyond perpetual conflicts over individual concessions.

Reframing "Deforestation" Narratives and Definitions

The current global "Zero Deforestation" narrative conflates all forest loss into a single ecological catastrophe. Yet, scientific evidence clearly shows that the conversion of ancient primary forests, peatlands, and specialized biodiversity reserves is qualitatively different from the conversion of robust secondary vegetation on resilient soils. Policymakers, NGOs, and academic institutions should collaborate to develop a more nuanced, science-based terminology that distinguishes between irreplaceable forest loss (conversion of primary forests, ancient peatlands, habitat of endemic or endangered species) and reversible or compatible land-use transitions (conversion of secondary vegetation on young, mineral soils under strict sustainability criteria). The adoption of such differentiated language would allow certification schemes and supply chain commitments to maintain strict zero-conversion policies for truly irreplaceable ecosystems while permitting carefully managed cultivation transitions in resilient, non-unique systems. This reframing would also reduce the perverse incentive whereby companies and communities, perceiving all conservation decisions as absolute bans, resist conservation efforts and engage in deceptive practices to circumvent restrictions. Furthermore, redefining deforestation through an ecological resilience lens makes the conservation case more intellectually rigorous and politically defensible, grounding it in soil science and ecosystem function rather than in area-based rules that often reflect precaution without proportionality. Academic institutions should take the lead in publishing peer-reviewed conceptual frameworks that formalize this distinction, ensuring that the reframing is scientifically credible and not perceived as a greenwashing effort by industry advocates.

Educational Reform and Capacity Building for Auditors and Regulators

The technical competency of environmental auditors, certification bodies, and regulatory staff currently falls short of the knowledge required to assess soil age, resilience, and geological context—the critical variables for HUV classification. Policymakers should establish mandatory capacity-building programs for auditors and inspectors, ensuring that all personnel involved in HCV/HCS assessments, environmental impact assessments, and land-use planning decisions receive training in basic soil science, geomorphology, and concepts of ecosystem resilience. This training should move beyond checklist-based species counting to include field soil profiling, understanding parent material and weathering trajectories, recognizing indicators of vulnerability in nutrient cycling, and interpreting soil maps and geological data. The development of these programs should be undertaken by academic institutions and international organizations (FAO, CIFOR, Conservation International) in partnership with certification bodies, ensuring that the curriculum reflects the latest science while remaining practical and applicable in field settings. Furthermore, career pathways and incentive structures should be reformed so that auditors who demonstrate deep technical knowledge and landscape-scale thinking are rewarded with higher status and compensation, rather than incentivizing volume-based auditing that rewards speed over depth. Establishing regional

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centers of excellence in soil–landscape analysis could serve as hubs for ongoing training, research integration, and quality assurance. This educational overhaul is necessary not just for implementing HUV but for maintaining the legitimacy of certification systems in an era where stakeholders increasingly demand scientific rigor and transparency in conservation decision-making.

Establishment of Monitoring, Learning, and Adaptive Governance Mechanisms

Beyond static zoning and classification, policymakers should institutionalize adaptive governance frameworks to monitor, evaluate, and revise conservation and cultivation strategies in response to new evidence and changing conditions. Rather than treating HCV/HUV maps as final verdicts, they should be considered evolving hypotheses subject to validation through long-term ecological and socio-economic monitoring. Certification bodies and land management agencies should establish protocols for regular (e.g., 5-year) reassessment of landscape-level conservation targets, the functionality of protected area networks, the outcomes of cultivation transitions on Zone A lands, and the ecological and social impacts of implemented policies. This monitoring should integrate remote sensing, field-based biodiversity assessments, soil health indicators, and socio-economic metrics (e.g., local livelihood outcomes, company profitability, supply chain stability) to provide a holistic picture of whether the HUV approach is delivering intended benefits. Where evidence shows that an area initially designated as "High Cultivation Value" is proving more fragile than anticipated, or where conservation targets are not being met despite protection efforts, governance systems should permit and facilitate adaptive responses—such as reclassification, adjusted management practices, or enhanced restoration efforts—without triggering accusatory disputes or litigation. The establishment of multi-stakeholder "Learning Networks" where companies, conservation organizations, governments, and researchers share data and insights would accelerate organizational learning and reduce the replication of mistakes across regions and commodities. This adaptive governance approach aligns with global trends toward "evidence-based policymaking.” It addresses a critical gap in current certification systems, which often lack mechanisms to incorporate new science or respond to unforeseen ecological or social changes. By institutionalizing learning and adaptation, policymakers can build resilience into governance systems themselves, ensuring that conservation and cultivation strategies remain compelling and legitimate over the long term.

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