Research Paper

Habitat Quality Improvement as a Driver for Human-Tiger Conflict Mitigation in Northeast China Tiger and Leopard National Park: A Strategic Study

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Abstract

Human-Wildlife conflict is an important conflict for the protection of global biodiversity and regional sustainable development. This paper looks into how we can settle the increasing problem of humans versus tigers in The Northeast China's Tiger and Leopard national park. In order to explore the spatiotemporal of the conflict and the coupling mechanism of the conflict and habitat quality, in order to provide suggestions to convert the management from passivity to proactivity. The research uses landscape ecology and conflict geography to integrate into a spatio-temporal conflict diagnostic model (STCDM) for the integration all aspects of human activities, wildlife, habitat and conflict. Our analysis concludes as follows for the three points: first, conflict hotspots have their own season peaks, livestock depredation is most severe in winter, accounting for 73%. Second, 85% happened within a500m buffer of the edge between forest and village, a zone with much reduced habitat. Core conflict areas, only taking up 12 percent of the parks area, account for 68% of the total incidents. According to these diagnoses, it makes up three targeted solutions: 1. Precise territorial planning – Graded Habitat Zoning; 2. Benefit sharing mechanism – Dynamic compensation + community benefits; 3. Seasonal ecological interventions. It offers an original, location-based plan on how to stop human-tiger conflict, positioning it as a transferable template that gives helpful hints about how to handle biodiversity routes with comparable issues everyplace.

Keywords

Human-Wildlife Conflict, Habitat Quality Improvement, National Park, Nature Reserve

1. Introduction

Human-wildlife conflict (HWC) is a very important issue worldwide that has a big effect on protecting all kinds of creatures and developing places in a good way (Green et al., 2024). conflicts usually lead into loss of money, sicknesses or fatal accident for humans and animals causing retaliation towards animal and making problems even worse (Ayalew & Melese, 2024). There are many influencing factors for HWC such as socio-economic factors, behavioral factors, and environmental factors which differs from place to place where local flora and fauna and also human activities differ (Khan et al., 2025). conflicts destroy livelihoods especially rural and agriculture communities which results in land abandonment negatively impacting the

wildlife and livestock (Nieman et al., 2020). In the habitats where the predators are in the top position – tiger and leopard, these kinds of clashes can be especially sharp, posing immediate hazards for humans, taking away chances for making a living, and possibly hurting long-term protection goals (Yengoh, 2024). As the global emphasis on Nature-based Solutions surges, how to best optimize spatial planning and management for creating harmonious living with animals has become an emerging interdisciplinary field, incorporating landscape ecology, conservation biology and sustainable urban and regional development (Cousins, 2021).

Heilongjiang Province includes the most extensive areas of Amur tiger habitats in China, which account for more than 70% of the country's total (Gao et al., 2023). A number of publications regarding human-wildlife conflict have provided substantial evidence on many cases, but this is mainly post-event documentation of these conflicts and single-factor analyses, there has been no systematic and prospective diagnosis of the complex relationships between human behavior, habitat quality, and conflict risk (Mateo‐Tomás et al., 2012). Based on the latest monitoring data, there were over 400 records of wild Amur tigers in Heilongjiang province from 2020-2025(Zhu and Gou, 2025). Based on the research carried out by Li et al., there were 191 cases of human-tiger conflicts happening in the Hunchun area of Jilin Province between 2011 and 2020. Out of which 88% occurred on slopes less than 30 degrees and 84% occurred on the slope between 50-317 meters with more occurrence on east or south slope (Li et al. 2022) Cheng et al., 2024, used spatial-temporal niche modeling and camera-trap data to predict tiger occurrence and map human-tiger encounter risk. Their models said that tiger presence depended on where prey was and how far it was from people. Research into the spatio-temporal activity routines of tigers and their prey indicates that tigers lessen their encounters with people through both spatial and temporal avoidance and by becoming more nocturnal as they live closer to settlements (Yang et al., 2018).

Thus, calling for analytical techniques where spatiotemporal information can be utilized for integration and predictions made about regions under pressure from the ecology and community restoration programs. Taking Northeast China's Tiger and Leopard National Park (NCTLNP) as an example, this paper views habitat quality improvement as the main driver. And so that this study could completely understand on the spatial distribution of human - tiger conflict throughout 2000 - 2025, find out important elements and high - risk zones, try to figure out how to lessen it and then create adaptable management plans to improve the ecosystem and communities' safety.

2. Methodology

We adopt the interdisciplinary Spatio-temporal Conflict Diagnostics Model (STCDM) as our study methodology. We'd like to use STCDM to have an accurate diagnosis and predictive map of conflict drivers for humans vs tigers by putting multiple datasets in one.

2.1. Case study area introduction

This research takes NCTLNP as the main case (Figure 1): The park is located at the border of Jilin and Heilongjiang, adjacent to Russia' s "Land of the Leopard" national park (Liu, 2022). It is thus a key ecological corridor for the inland dispersal and recovery of Tiger and Leopard (Wang et al., 2025) Because it is China's number one national park created to conserve these apex predators and their living environment, the park spans about 14,600 kilometers squared of some many administrative areas (Wang & Cheng, 2020): the area contains a temperate mixed coniferous - broad - leaf forest ecosystem, which has remarkably high

biodiversity (Wang et al., 2024): Park's creation was a great national effort towards apex predator protection and an entire ecosystem's recovery, which could also be a "laboratory of global significance".

But it also shows a classic conflict between preservation and development (Du et al., 2024). It's landscape is a complex patchwork of many villages, settlements, arable land. With a rise in the level of conservation in the last few years the Tiger population and Leopard population has seen a rebound and their range too has expanded. At the same time human economic activities like grazing, farming, and foraging continue inside and outside of the park. This kind of spatial dynamic with "human settlement expansion" and "carnivore population recovery" will lead to direct competition for space. Due to such a rise in the frequency and seriousness of conflict events, this region is suitable for conducting research into the reasons behind human wildlife conflicts and devising methods to alleviate them. Park has special transboundary ecologies， the park is closely integrated into local communities and there is a clear national conservation strategy， all of which create the difficult real world context of our work.

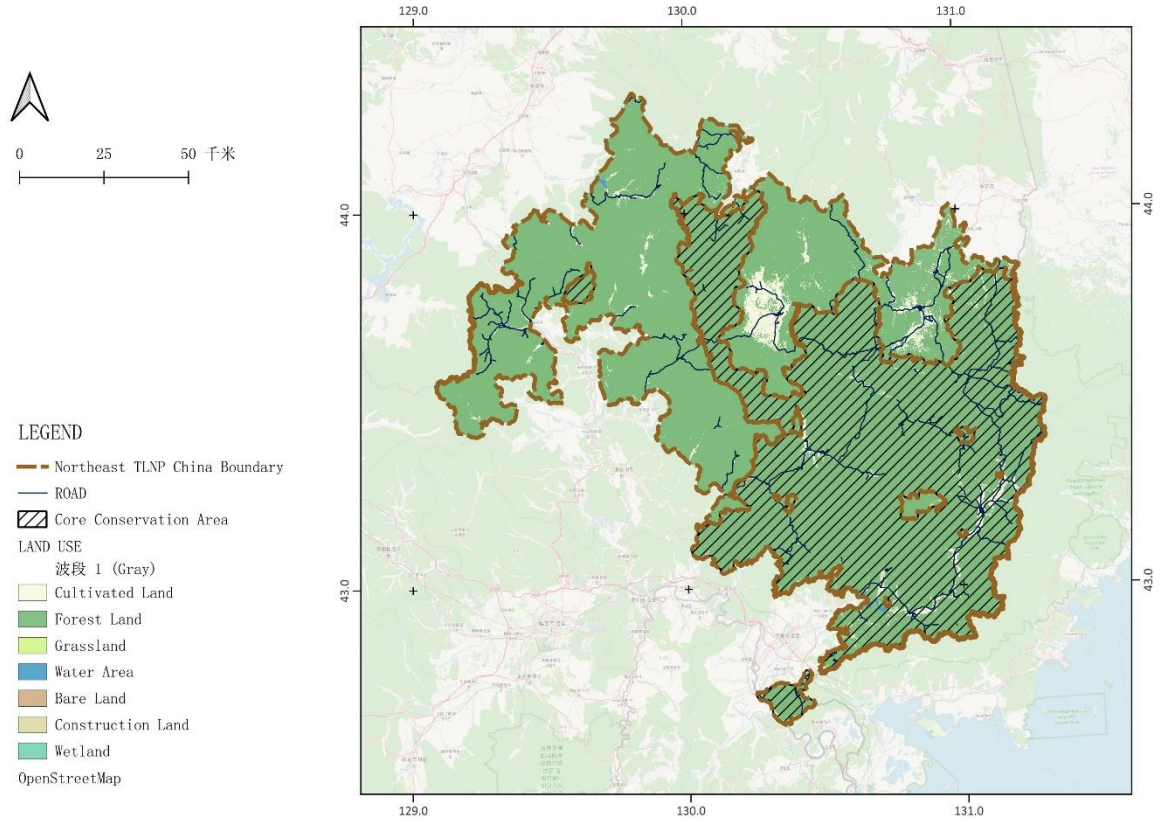


Figure 1. NCTLNP's geographical location and boundary, , Source: Created by the author.

2.2. Theoretical Foundation & Model Foundation

The Spatio-Temporal Conflict Diagnostic model(STCDM ） are derived from Landscape Ecology and Geography of Conflict. This multi-disciplinary background enables an analytic framework to break it (this complex socio-ecological human-tiger) into simple.

landscape ecologist contributes its central "pattern-process-scale" paradigm (Turner, 2005). From this perspective, the spatial configuration of different land use types is considered the most influential factor of the ecological flow, e.g., tiger dispersion, or the spread of the disturbance, e.g., conflict incident. pay s

special attention to the habiitat fragmentation, habitat fragmentation is one of the most important procedure which reduces the quality of habitatand increases the chance of human - wildlife conflict.

We look at the geography of conflict with a spatial perspective, and view conflicts as an interaction between different human spaces and animal spaces (Dickman, 2010). it talks about main ideas like "spatial squeeze," "edge effects," and territoriality. Edge effect refers to the ecological phenomenon where population or community structures differ at the boundary between two distinct habitat areas (Ries et al., 2004). Edge effect can bring about microclimate change, affect species migration and also increase human approach to previously isolated communities (Andrén, 1995). In the context of our research, the expansion of human settlements and the recovery of the tiger population, in essence, is a kind of competition for land use rights. The individual conflict events are an explicit expression of this background level of competition at specific moments in time, in particular places, so for example winter at the fringes of the forest.

Based on these theoretic linkage, STCDM treats human- tiger conflict in the course of 3 stages. Step one is to overlay the human and wildlife datasets to get "potential conflict interfaces" then incorporate landscape metrics and variables to see which structural aspects make the area more dangerous. Such as using edge effect to account for habitat quality in ecoronins serving as threshold of conflict occurrence The final stage incorporates the spatiotemporal characteristics to simulate the dynamic effect of the risk distribution from the spatial competition stage. It reveals the patterns from the simulation.

Thus, it is not to say that STCDM can be a mere technique, but a theory-oriented diagnostic. It ties landscape patterns, ecological processes, and geospatial competition to explain the mechanisms for conflict rather than just describe where and when conflicts occur. such theoretical depth provides a good foundation for proposing specific spatial interventions

2.3. Data Collection and Processing

In order to form and construct the Spatio - Temporal Conflict Diagnostic Model, the research carried out this work by integrating multi-source and dimensional data. So as to achieve comprehensive and objective analysis. The collected data has been put into five main categories, with various purposes in the study.

Human activity data such as settlement location and size, road network with traffic density, and land use/covarage changed were used to depict spatial intensity and extent of Human Pressure (Figure 2 & Figure 3). This information is also the cornerstone for finding the "human domain" and understanding how much of it overlaps with places where animals live.

Such as wildlife habitat data such as habitat suitability index, prey species distribution, dispersal corridor and so forth can support the evaluation of ecosystem Carrying Capacity and Quality (Figure 4). is important for understanding both spatial usage and what these species require in order to be present.

Core Conflict Incidents with in depth depredation accounts, human victims, direct encounter reports etc., are essential empirical evidence. The spatiotemporal occurenses of them is important for identify conflict heatpsots and check models.

The environmental and background data such as DEM, NDVI and seasonal climatic data gives the basic parameters that affect animal behavior,prey distribution and human activities. Variables that are highly important for explaining discrepancies in risk of a conflict over space, and across time.

Socio-economic data, such as historical compensation data, community survey data, etc., intends to reflect the impact of conflicts on the livelihoods of local communities and the effectiveness of existing

management. The information required for developing options which are socially acceptable and economically feasible.

All the dataset got strictly geo-referencing, unify the format, and quality check before getting merge to the joint spatial database. This set up a good base for all the overlay analysis and model calculation to follow.

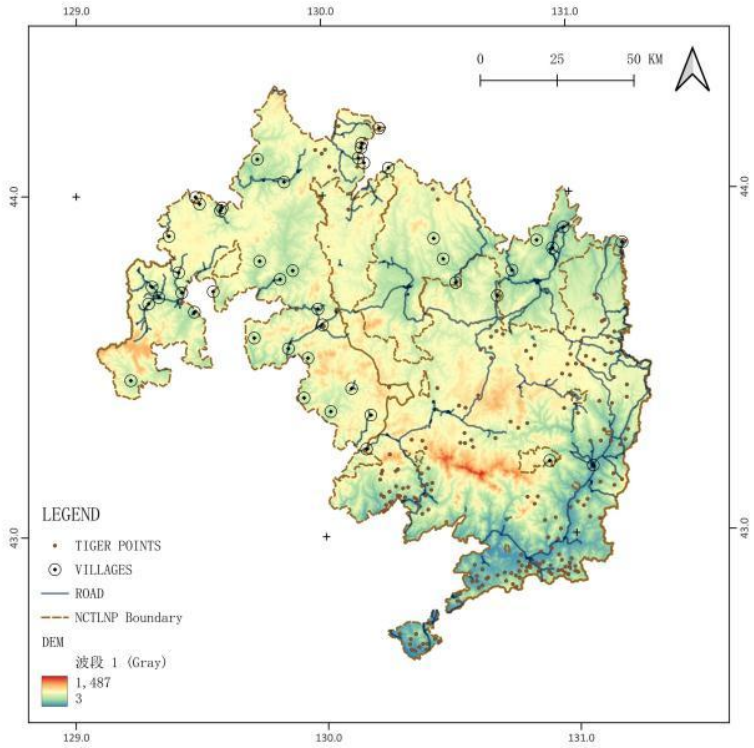


Figure 2. Village, Road and Record of Tiger sightings Distribution, Source: Created by the author.

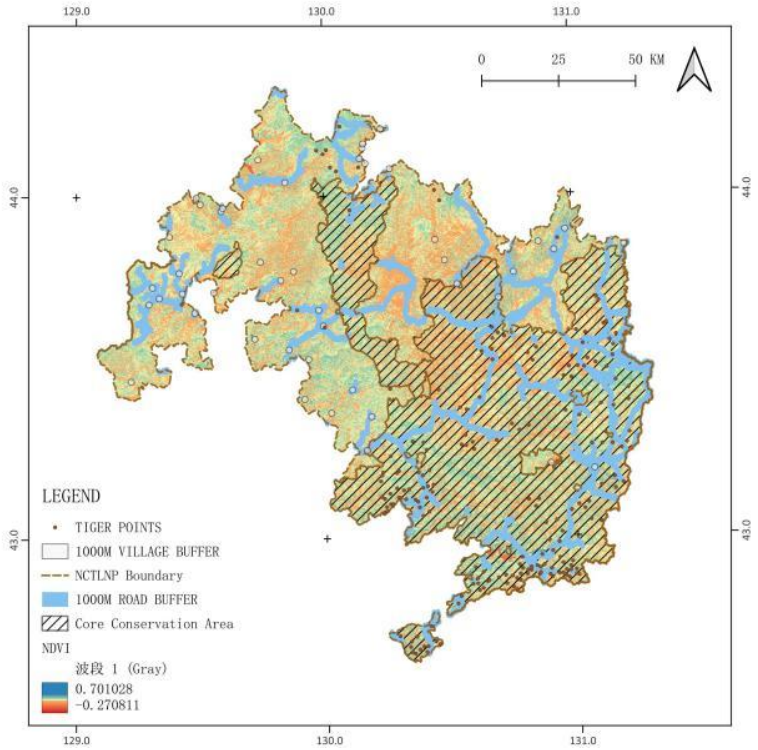


Figure 3. Draw 1000-m buffers based on the position of villages and roads, Source: Created by the author.

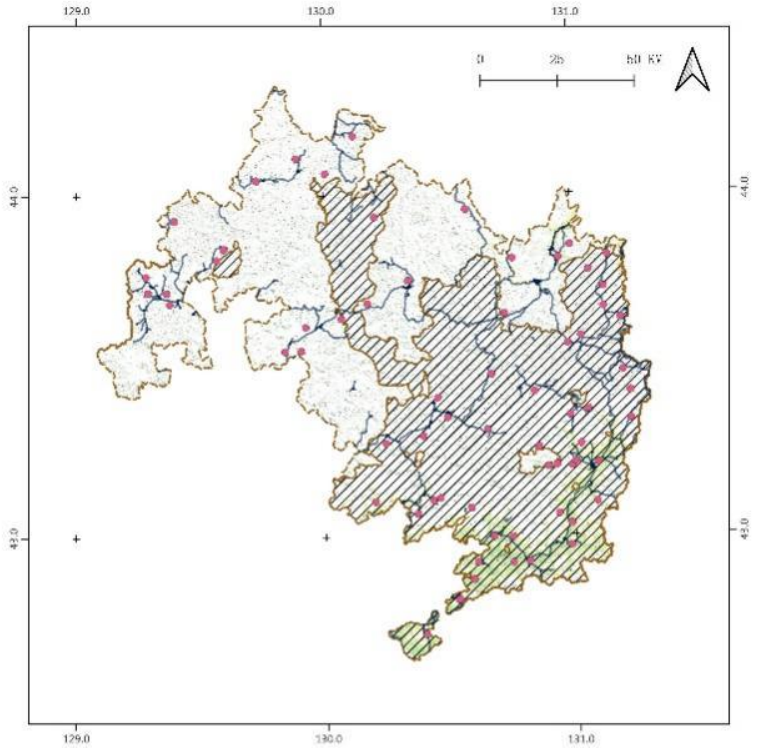


Figure 4. Human-tiger conflicts spatial distribution & suitable tiger/leopard habitat, Source: Created by the author.

2.4. Data Analysis

To gradually reveal the spatiotemporal distribution and causes behind human-tiger conflicts, we performed an analysis in this study. It started off with spatiotemporal hotspot analysis to spot where big clusters of conflict incidents were found, so as to locate important parts needing management attention.

Following this I did the analysis in terms of Habitat Quality Analysis and Edge effect analysis to understand the ecologic situation at critical areas like where the Forest villages intersect. Use spatial overlays to learn about what causes how bad habitats get damaged, and how many fights happen, so we can fix the places which need to be fixed:

Based on these conclusions, this study performed a graded habitat zoning in the park based on the dimensions involving the conflict risk, the quality of habitat, and human activities intensity. It was stratified into different protection zones: core protection zones, ecological remediation zones, high-risk conflict buffer zones. A major outcome was the exact determination of "core areas of contention" where most events happen, giving direct information to create different kinds of space arranging and special governance plans.

3. From diagnosis ideas to integration control

3.1. Define Primary conflict zones and a predictive planning paradigm

Quantitative analysis reveals a very important piece of information, the central conflict zones that make up just 12% of the total area of the park contain an incredibly high 68% of all of the conflict incidents. This extremely condensed spatial pattern both supplies an unambiguous "bullseye" for the aimed allocation of management resources and thoroughly overturns the conventional form. The traditionally uniform, static, and merely reactive governance method. In conventional mitigation, it usually depends on ex-post compensation and patch-up solutions, which is a reactive manner of "locking the stable door after the horse has bolted," being both ineffective and expensive.

The main contribution of the STCDM is its prediction ability. it integrates multi-source spatio-temporal data to alter the view of planning from a passive cycle "incident-response" to an active loop"risk recognition, spatial intervention, and impact assessment", the essence of this adjustment is transferring the management focus from treating the happened accidents to averting or decreasing the risks which cause these incidents. Specifically, according to the result of the high-risk regions of model to do the pre-emptive spatial intervention. Establishing physical barriers on the edges where risk is high, fine-tuning land use planning so as to reduce chances of meeting, deploying early warning system before high-risk seasons can also be considered.

This data guided, accurate zoning makes sure that few conservation resources are used first in the most important areas, this greatly improves management effectiveness, protects community safety, and makes the entire society and nature system more resistant. so it can not only serve as a technique model, but also promote the transition from a passive mode of preservation to an active way of governing space and provides new ways of methodology of protecting biodiversity and promote the regional sustainable development.

3.2. Edge effects, emerging community's functional roles and co-governance mechanisms

The "edge effect," as quantified here, i.e., 85% of human injury accidents happen within the first 500 meters from the edge where forest meets village, goes beyond just being a space pattern description. It shows a direct cause-and-effect relationship between ecological damage and community safety problems.

This transitional zone is always degraded in habitat quality and ecological functions because of human damage, it works as a high-risk passageway that helps animals go into human areas, so the pressure that nature gives changes to security problems for people living there.

conventional conflict management often casts communities as passive objects of conservation action or claimants of compensation Or it could mean compensation is just financial, and conservation can breed resentment. To solve these problems, we introduce two new mechanisms: "community-facilitated habitat restoration" and a "flexible compensation plan." The fundamental innovation is the shift in the community's role from "conflict sufferer," "policy objective," to a "steward of ecology," "participant in governance."

Financial incentives are directly coupled to pro-conservation action. For instance, communities engaging in habitat restoration or building protective infrastructure receive enhanced compensation or bonuses. This turns it into a proactive expense that gives long-term advantages for the ecology and people:

And the most profound significance lies in this community co-management model's institutional design, it connects community welfare with ecological health. Residents benefit directly from better safety and less conflict by participating themselves in habitat restoration, so their views on wildlife change dramatically, leading to an internal culture of coexistence, and thus the model isn't just a technical instrument for risk reduction anymore, but a very important governance invention for creating a strong, lasting community-and-biodiversity system which works towards both protecting nature and allowing local life to develop successfully.

4. Conclusion

Developed a spatiotemporal conflict diagnostic model (STCDM) to diagnose the roots of human-tiger conflicts and to develop human-tiger conflict governance solutions in Northeast Chinas Tiger & Leopard National park key conclusion is that the spatio-temporal patterns of the conflicts are really clustered and the hotspots are strongly associated with edges of degrading habitat and seasonality.

Based on the above diagnosis, three mitigation strategies have been proposed in this paper. firstly accurate spatial interventions are carried out with stringent land use limitations, and specific ecological restorations take place on key conflict core zones and degraded habitat boundaries so as to block key conflict passages physically. For example, in ecologically degraded edge areas, measures could include planting native shrubs to create ecological buffers that serve as both wildlife shelter and physical barriers; restoring key water sources and constructing wildlife drinking points to reduce animals' need to approach villages; and improving habitat at critical corridor nodes, such as by replenishing vegetation preferred by herbivores to increase prey density, thereby guiding wildlife activity towards core habitats away from human settlements. second, we should shift our compensation mechanism from ex-post pays for pre-paid. create a connection between a dynamic compensation model and habitat improvement results and then target higher risk villages to support communities building protective physical structure and restoring habitats instead of getting payment and turning them in investments in the ecosystem Finally, adaptive management should be promoted, implementing short-term interventions—such as prey supplementation and community patrols—during seasonal conflict peaks (e.g., winter when prey is scarce), accompanied by long-term monitoring to continuously refine management strategies.

The importance of the STCDM also does not lie in solving the local problems in the park alone. It provides a transferable, systematic way to solve the same kind of human-wildlife problems around the world. The

framework's biggest strength lies in its modular structure, it takes the complicated task of conflict resolution and divides it into four parts similar to having a conflict detective module, a spatial zoning regulation plan, a dynamic compensatory model, and a seasonal intervention pack. Modularity provides an extraordinary amount of adaptability and scalability so managers and researchers can alter just the specific part to fit the local species, ecosystem, or soci-economic situation without having to change all of the methodology.

Like for example areas in Africa dealing with human - elephant conflicts could use the diagnostic and spatial zoning logic but also adapt the intervention toolkit so it focuses on preventing elephants from damaging crops. just as with our jaguar conservation areas in south America, these areas can also take on and adapt the dynamic compensation mechanism. And this flexibility allows the STCDM framewrok to go beyond a single case study, and is a replicable model for different BiodiverCities and biodiversity corridors in the world.

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