The Unread Lectures:
Epistemological Foundations of War Pollution Research

From Individual Events to the Morphology of Military Contamination: An Epistemological Study of Form, Process, and Morphogenesis

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CONTENT

1. Abstract

Research on military contamination usually begins with the description of individual cases: specific wars, specific territories, specific contaminants, and specific environmental and health consequences. This approach is both inevitable and necessary. However, the accumulation of numerous facts does not by itself create a theoretical understanding of the process.

The central problem is the transition from a collection of individual events to an understanding of the morphology of military contamination as a distinct natural-anthropogenic process. Military contamination is initiated by human activity, but once it emerges, it becomes incorporated into natural systems and develops through interaction with soil, hydrological, geochemical, biological, climatic, and social processes.

This lecture examines the epistemological problem of such a transition. It draws upon ideas from the philosophy of science, process ontology, morphogenesis, complexity theory, self-organization, and assemblage theory. Particular attention is given to the fact that research on military contamination cannot be reduced to questions of funding, data collection, or technical expertise alone. It is necessary to develop a correct understanding of the object of study itself.

Military contamination is considered not only as a collection of consequences of war, but also as a source of new processes capable of altering the environmental history of territories over long periods of time. For this reason, a special epistemology of military contamination is required—one capable of connecting individual cases, models, observations, and theoretical concepts into a unified research program.

2. Keywords

Military contamination; morphology of natural processes; morphology of military contamination; morphogenesis; epistemology; philosophy of science; process ontology; complex systems; self-organization; emergence; environmental consequences of war; natural-anthropogenic processes; assemblages; DeLanda; scientific models; theory-ladenness of observation.

3. Key Ideas of the Lecture

• Military contamination is not merely a collection of individual cases but a distinct class of natural-anthropogenic processes

Most studies of military contamination begin with specific cases. These may include the Vietnam War, the war in Ukraine, the destruction of industrial facilities, contamination of soils by heavy metals, the use of toxic substances, the destruction of water infrastructure, or the emergence of new forms of military waste. Each case is unique. However, if science limits itself to uniqueness, it cannot reach the level of process understanding. Military contamination must be viewed as a specific form of interaction between military activity and the natural environment. It originates from human actions, but its consequences develop within natural systems and acquire their own dynamics.

• The main problem of military contamination research is not only funding

Funding is necessary. Without it, fieldwork, laboratory studies, monitoring programs, medical examinations, and restoration activities cannot be carried out. However, money alone does not create scientific understanding. Moreover, funding is often used for purposes unrelated to the stated goals. It is possible to finance numerous projects, collect vast amounts of data, establish extensive soil and water sample databases, and conduct thousands of measurements, yet still fail to understand what process has been initiated by war. Some forms of scientific knowledge cannot be purchased. They emerge only when the problem is correctly formulated and an adequate theoretical framework is established.

• The transition from individual cases to process understanding is a fundamental epistemological task

Science always begins with the observation of individual events. Mature scientific knowledge, however, seeks to move beyond isolated cases. It searches for stable forms, recurring structures, mechanisms, and regularities. In the case of military contamination, this task is especially difficult because every conflict occurs under different natural, social, technological, and historical conditions. For this reason, it is necessary to understand how knowledge of the morphology of military contamination as a process can emerge from a multitude of unique cases.

• The morphology of military contamination is not a ready-made object that can simply be discovered

The morphology of a process does not lie on the surface. It is not an object in the same sense as a soil sample, a river section, or a contaminated site. Morphology is revealed through comparison, modelling, interpretation, and theoretical generalization. Different scientific schools may therefore propose different descriptions of the morphology of the same process. A geochemist, toxicologist, ecologist, hydrologist, geomorphologist, physician, public health specialist, and philosopher of science will all perceive different aspects of the same reality. This is not a weakness of science. It is an indication of the complexity of the object itself.

• Military contamination is initiated by humans but subsequently develops through interaction with natural systems

Military actions are initiated by people. People create weapons, use munitions, destroy infrastructure, and contaminate soils, waters, and the atmosphere. However, once the process has been initiated, its subsequent trajectory is no longer determined solely by human actions. Contaminants begin to migrate. Soils enter new chemical and biological regimes. Water systems transport contamination. Ecosystems respond, reorganize, degrade, or develop new states. At this stage, military contamination becomes a complex natural-anthropogenic process.

• The consequences of war do not end when hostilities cease

The end of a war does not mean the end of military contamination. In many cases, the conclusion of military operations marks the beginning of a prolonged phase of natural and social processing of war-related consequences. The migration of contaminants, changes in soil processes, destruction or recovery of vegetation, alterations in hydrological regimes, and the emergence of new health risks may continue for years or decades. Military contamination therefore cannot be studied only within the chronological boundaries of war. It has its own post-war time.

• The morphogenesis of military contamination is one of the key scientific problems

War does not merely destroy existing natural and social structures. It may also initiate processes that generate new ecological states. New trajectories of contaminant migration emerge. New forms of soil degradation appear. New technogenic landscapes develop. New combinations of chemical, biological, and social risks arise. These processes are neither entirely random nor entirely predetermined. They develop within a space defined by human intervention, natural regularities, historical contingency, and the internal dynamics of complex systems.

• Contemporary philosophy of science provides tools, not ready-made answers

Hume, Popper, Kuhn, Whitehead, Prigogine, Haken, DeLanda, and other authors are important not because they have already explained military contamination. They are important because they help formulate the problem more precisely. They help explain why the simple accumulation of facts is insufficient, why observation is always linked to theory, why processes cannot be reduced to things, and why complex systems are capable of generating new forms. Philosophical ideas alone, however, will not solve the problem of military contamination. They must be transformed into practical research approaches designed specifically for this object of study.

• The contemporary scientific community is not only an investigator but also part of the reality being investigated

Military contamination is not produced by abstract forces. It is associated with the activities of states, armies, industrial systems, engineering structures, and scientific-technological complexes. Modern science is not always external to these processes. It may participate in the creation of technologies that later become sources of new forms of military contamination. Depending on the regime of scientific recognition, the results of scientific investigations may differ radically. For this reason, the study of military contamination requires a critical examination not only of the object itself, but also of the scientific community, its institutions, interests, limitations, and modes of knowledge production.

• A special epistemology of military contamination is required

Military contamination cannot be fully understood within the boundaries of individual disciplines. Chemistry, toxicology, medicine, ecology, soil science, hydrology, geography, military studies, and the philosophy of science are all necessary, but each sees only part of the problem. A special epistemology of military contamination is therefore required. Its task is to connect individual cases, empirical data, models, theoretical approaches, and practical restoration tasks into a unified system of understanding.

4. Introduction

Research on military contamination faces many challenges. Some of these challenges are obvious. They are associated with the dangers of working in areas where military operations have taken place or are still ongoing. These include minefields, unexploded ordnance, destroyed infrastructure, lack of access to certain areas, the need to obtain official permissions, and risks to the life and health of researchers.

There are also technical challenges. High-quality data require samples of soils, water, sediments, vegetation, and biological tissues. Laboratories, equipment, methodologies, standards, long-term monitoring programs, and interdisciplinary teams of specialists are needed.

There are financial challenges as well. Research of this kind is expensive. It requires time, transportation, security measures, analytical facilities, international cooperation, and stable institutional support.

However, this lecture focuses on a different set of issues. There exists a special group of problems that is related neither to funding, nor to access to territories, nor to laboratory capabilities. These problems are connected with scientific knowledge itself and with the scientific community.

Military contamination is an exceptionally complex object of study. It does not exist as a single simple object that can be measured, described, and then considered understood. We are dealing with a multitude of events. Each event occurs under specific natural conditions. Each event is associated with a particular type of military activity. Each event has its own history, geography, chemistry, and consequences.

Yet an expert cannot stop at the description of individual events. If one stops there, the result is a collection of cases rather than an understanding of the process.

The central question of this lecture is therefore the following:

How can we move from a collection of unique cases of military contamination to an understanding of the morphology of military contamination as a process?

This lecture is part of a broader series. It does not claim to provide a complete theory of military contamination. That would be premature. The task of this first lecture is more modest. It is necessary to formulate the problem correctly. It is necessary to demonstrate why military contamination cannot be understood merely as a set of individual environmental consequences of war. It is necessary to explain why a transition toward the analysis of morphology and morphogenesis is required.

The focus of this lecture is not philosophy for its own sake. The focus is military contamination as a complex scientific problem.

The philosophy of science is used here neither as decoration nor as a demonstration of erudition. It is used as an instrument that allows us to formulate more precisely the following question:

How can science move from individual events to an understanding of the morphology of a process?

I have always believed that conferences require preparation. Preparation does not consist solely of writing one's own presentation. It may also involve the systematic examination of fundamental questions without which meaningful discussion of specific scientific problems is impossible.

This lecture is largely addressed to colleagues participating in the conference (1–7). It is written not as a finished article but as a text intended for reading, reflection, and subsequent revision.

I have been engaged in scientific geographical research since 1978. I am now sixty-nine years old. Consequently, this lecture draws not only upon the literature but also upon personal experience accumulated through many years of work on problems related to natural processes and the scientific community. It also reflects extensive experience communicating with members of scientific communities in different countries.

I entered university in 1974. This took place in the USSR. It was a period when Soviet geographical science was at its peak. It achieved a number of significant results. At the same time, it was characterized by rigid Marxist-Leninist dogmatism. Soviet geography had reached its highest level and categorically rejected virtually everything taking place in Western science.

Meanwhile, a scientific revolution was occurring. Geography, particularly in Western countries, was changing rapidly. I aligned myself with Western science. This led to conflicts with the Soviet scientific community. My response to that pressure was the development of metageography as a reflection on what was happening within science itself (8–10). As a result, careful attention to the ways scientific communities function has been part of my work for a very long time.

This is important for understanding how the scientific community functions specifically in relation to the study of military contamination. There are many aspects of this field that are rarely discussed openly. In order to understand cognitive failures, it is important to recognize the implicit characteristics of scientific activity. Analyzing them is associated with obvious professional risks.

Nothing damages relations with scientific colleagues more effectively than the analysis of their activities.

I do not consider myself a member of any scientific community. From that perspective, I have no reason to conceal the implicit aspects of scientific activity. They will be examined consistently throughout this work.

My interest lies in military contamination, not in the reaction of institutional scientific network to my texts.

5. The Problem of Transition from an Individual Event to Theoretical Understanding

One of the fundamental problems of science is the transition from individual empirical events to theoretical understanding.

At first glance, this problem may appear excessively abstract. However, for the study of military contamination it has direct relevance. The researcher initially encounters not a theory but facts of reality. More precisely, the researcher encounters fragmented data that indicate military-induced changes relative to previous conditions. Facts themselves are already part of a theoretical perception of the world.

The researcher encounters destroyed landscapes. The researcher encounters contaminated soils. The researcher encounters altered water systems. The researcher encounters toxic remnants of military activity. The researcher encounters new medical, ecological, and social consequences of war.

Each such case has a specific location, a specific time, specific causes, and specific consequences. Yet science cannot stop at the level of case description. If it remains at that level, it becomes an archive of events. Such an archive may be extremely important. It may contain thousands of fragmented facts. It may be useful for courts, governance, territorial restoration, compensation programs, and political decision-making. But by itself it is not yet a theory.

Theoretical understanding emerges only when the researcher begins to recognize stable forms of process organization behind individual events. This is particularly important for the Earth sciences. Geomorphology studies not only individual landslides but also the morphology of slope systems. Hydrology studies not only individual floods but also the regimes of river basins. Climatology studies not only individual weather anomalies but also the structure of climatic dynamics. Ecology studies not only individual disturbances but also the mechanisms of ecosystem stability, degradation, and recovery.

Research on military contamination must follow a similar path. At the initial stage, it is inevitably studied through individual events. However, if the field is to become mature, it must move toward understanding the morphology of the process itself.

This leads to the central question:

How can knowledge of the general morphology of military contamination emerge from a multitude of unique cases?

This question extends far beyond the ordinary problem of data collection. It concerns the nature of scientific explanation. It concerns how facts become knowledge. It concerns how an event becomes an element of a process. It concerns how a process becomes an object of theory.

6. The Classical Problem: From Events to Generalization

The modern formulation of this problem largely begins with David Hume (11).

Hume demonstrated that no logically necessary connection exists between a finite number of observations and a universal statement. If we have repeatedly observed the recurrence of a particular event, this does not prove that it will always recur.

At first glance, this appears to be the classical philosophical problem of induction. However, for the study of military contamination it has entirely practical significance.

Suppose we have studied one case of soil contamination in a war zone. Then a second. Then a tenth. Then a hundredth. Can we conclude from this that we understand military contamination as a process?

No. The number of observations is not equivalent to understanding. One may possess an enormous amount of empirical data and still fail to understand the morphology of the process. This is especially important in the contemporary situation, where scientific communities increasingly produce large volumes of data, reports, maps, tables, samples, and measurements.

Data themselves are necessary. But data do not think. Data do not create concepts. Data do not generate theory. Theory emerges only when a conceptual framework exists that allows connections among events to be recognized.

For military contamination this means the following. It is impossible simply to collect many cases and automatically arrive at an understanding of the process. One must determine which characteristics are accidental, which recur, which form stable relationships, which mechanisms operate under different natural conditions, and which forms of contamination possess their own developmental dynamics.

For this reason, simple induction is insufficient. The problem is not merely to accumulate facts. The problem is to determine which facts possess theoretical significance.

Popper and the Limitations of Fact Accumulation

Karl Popper radicalized the critique of induction (12). He argued that scientific theories cannot be definitively established through the accumulation of confirming observations. Theories must remain open to criticism, testing, and possible refutation.

This insight is equally important for research on military contamination.

It is often assumed that if enough facts are collected, theory will emerge by itself. This is an illusion. Facts do not automatically assemble themselves into theory. Theory must be formulated in a way that allows it to be tested, refined, criticized, and modified.

For example, one might propose the statement that military contamination always leads only to the degradation of natural systems. At first glance, this appears obvious.

Scientifically, however, such a formulation is too crude. It identifies only a negative outcome and does not explain the process itself.

In reality, war may lead to the degradation of some systems, the transformation of others, the temporary release of territories from certain forms of economic pressure, the creation of new technogenic landscapes, the alteration of substance migration pathways, and the restructuring of ecological relationships.

This does not mean that war is beneficial for nature. Such a conclusion would be unacceptable and false. The point is different. Military contamination as a process is more complex than the simple formula of "impact–damage." It requires more precise concepts.

Popper's idea of the critical nature of knowledge reminds us that a theory of military contamination must not become a collection of slogans. It must be a research construct that can be developed, refined, and tested through concrete cases.

If a theory does not allow us to distinguish among different types of processes, different temporal horizons, different natural conditions, and different mechanisms of consequence formation, then it remains too weak.

Events Do Not Create Theory by Themselves

Hume and Popper demonstrated, in different ways, one important point: events by themselves do not generate theoretical knowledge.

Observation is necessary but insufficient.

Facts are necessary but insufficient.

Measurements are necessary but insufficient.

To understand military contamination, it is not enough merely to document the consequences of war. It is necessary to create a language within which those consequences can be understood as elements of a process.

Here it is particularly important not to confuse two levels. The first level is the level of the individual case. For example:

- contamination of a specific field;
- destruction of a specific dam;
- release of a specific toxic substance into a water system;
- burning of a specific forest area;
- emergence of a specific type of military waste.
- The second level is the level of the process. For example:
- alteration of the geochemical regime of a territory;
- restructuring of water exchange;
- long-term soil degradation;
- formation of new technogenic landscapes;
- alteration of the ecological memory of a territory;
- emergence of new trajectories of health risk.
- There is no automatic transition between these two levels.

It must be constructed. This is precisely the epistemological task.

Why This Problem Is Especially Difficult for Military Contamination

In the case of many natural processes, the researcher deals with phenomena that existed long before humans appeared. Rivers formed valleys before the emergence of modern states. Volcanoes erupted before the rise of industrial societies. Climatic fluctuations occurred before the development of modern science.

Military contamination has a different nature. It is initiated by humans. It is associated with states, armies, industry, technology, scientific developments, and political decisions. In this sense, military contamination is not an ordinary natural process.

It may be viewed as a special form of anthropogenic "anti-nature." This does not mean that it exists outside nature. On the contrary. Once it emerges, it immediately becomes incorporated into natural processes.

Contaminants enter soils, water, air, vegetation, and living organisms. They begin to move, accumulate, decompose, and participate in chemical and biological interactions. What was created by humans begins to live within the natural environment. This is precisely where the complexity lies.

Military contamination is not a purely natural process. Yet it does not remain a purely social event. It occupies an intermediate position. It originates as a result of human actions but develops through natural mechanisms.

For this reason, it cannot be studied solely as a military, political, chemical, medical, or ecological problem. It is a complex natural-anthropogenic process.

From a Collection of Cases to the Morphology of Military Contamination

Research on military contamination already includes many separate directions of inquiry:

- studies of heavy metals;
- studies of explosive residues;
- studies of petroleum contamination;
- studies of the destruction of industrial facilities;
- studies of the consequences of herbicide use;
- studies of changes in soil cover;
- studies of risks to public health;
- studies of the consequences of damage to water infrastructure.

However, these directions often exist in a fragmented manner. They do not always combine into a coherent picture.

This is precisely why a transition toward the morphology of military contamination is necessary.

In this context, morphology does not mean the external form of an object. It means the form of organization of a process. It seeks answers to questions such as:

- What types of military contamination exist?
- What mechanisms generate them?
- How do they develop through time?
- How do they interact with natural systems?
- Which processes are short-term?
- Which processes become long-term?
- Which consequences can be eliminated through technical measures?
- Which consequences initiate new natural trajectories?
- Which forms of contamination become part of the environmental history of a territory?

Only at this level can one speak of mature scientific understanding. Prior to this, we are dealing primarily with descriptions of isolated cases. The description of cases is necessary. But it should not remain the final goal.

First Interim Conclusion

For the study of military contamination, the classical problem of moving from events to theory has direct rather than abstract significance.

Military contamination is initially presented to the researcher as a multitude of unique cases. However, the scientific task is not limited to recording them. It is necessary to understand how these cases can be connected into a broader picture of the process.

The problem is not to replace facts with philosophy. That would be a mistake. The problem is to create a theoretical framework within which facts cease to be fragmented and become elements of understanding.

For this reason, the next step of the lecture is connected with the concept of morphology as a special object of scientific knowledge.

7. Morphology as an Object of Scientific Knowledge

If we accept that scientific research cannot be limited to the registration of individual events, then the next question inevitably arises: What exactly should scientific explanation strive to understand?

At first glance, the answer seems obvious. Science should seek to discover laws.

Many generations of scientific schools taught us this. However, when studying complex natural processes, such an answer proves insufficient. Between individual events and universal laws there exists another level of reality. This level can be defined as the morphology of a process.

Scientific knowledge gradually develops precisely in this direction. At first, individual events are recorded. Then the researcher begins to notice recurring forms.

After that, models emerge. Only then does it become possible to speak of broader regularities.

In mature sciences, the object of investigation is no longer the events themselves but the morphology of processes.

A geomorphologist is not primarily interested in an individual landslide. The interest lies in the organization of the slope system.

A hydrologist is not primarily interested in an individual flood. The interest lies in the morphology of the river basin.

A climatologist is not primarily interested in a single extreme season. The interest lies in the structure of climatic dynamics.

An ecologist is not interested only in an individual disturbance. The interest lies in the organization of the ecological system as a whole.

In all of these cases, scientific attention gradually shifts from the event to the form of the process. This transition is one of the most important indicators of the maturity of scientific knowledge.

What Is the Morphology of a Process?

The concept of morphology is often understood too narrowly.

It is commonly associated with the description of the external form of objects. In a contemporary scientific context, however, morphology has a much broader meaning.

Morphology is the relatively stable organization of change. It does not exist separately from the process. It manifests itself through the process.

The same idea can be expressed differently. Events show us movement. Morphology shows us the organization of that movement.

An individual flood is not the morphology of a river system. Yet through many floods, the form of basin functioning becomes visible.

An individual fire is not the morphology of an ecosystem. Yet through many events, the organization of the entire system becomes apparent.

The same applies to military contamination. An individual case of soil contamination is not the morphology of the process. An individual destroyed factory is not the morphology of the process.

An individual combat zone is not the morphology of the process. However, through a multitude of such cases, stable forms of organization of military contamination may become visible.

These forms become the object of scientific investigation.

Morphology Occupies an Intermediate Position

At this point, an important epistemological issue arises. Morphology occupies an intermediate position between facts and theories.

It is not a simple observation. Yet it is not a universal law. It represents a distinct level of scientific knowledge.

We cannot observe morphology directly in the same way that we can observe a destroyed bridge or a contaminated river. At the same time, we cannot derive it through logic alone without reference to reality.

Morphology emerges through comparison, abstraction, and interpretation. It is the result of sustained intellectual work.

For this reason, morphology is not only a property of the object being studied. It is also a product of the development of scientific knowledge itself.

This conclusion is particularly important for research on military contamination. Today we possess enormous amounts of information.

However, a serious question remains: Have studies of military contamination reached the level of understanding the morphology of the process?

The answer is far from obvious. Scientific communities do not always reach the level of morphological understanding.

At this point, an important clarification is necessary. It is often assumed that scientific development automatically leads to deeper understanding of processes.

In practice, the situation may be considerably more complex.

- There is no guarantee that the accumulation of data will necessarily lead to understanding the morphology of a process.
- There is no guarantee that a large number of publications will automatically produce theoretical progress.
- There is no guarantee that an increase in the number of researchers will necessarily generate new concepts.

The history of science provides numerous examples in which scientific communities successfully produced enormous amounts of information while simultaneously experiencing serious difficulties in developing new theoretical perspectives.

The situation of recent decades is especially interesting. Modern science has become increasingly institutionalized. Large research organizations have emerged. Major funding systems have developed. International expert networks have been established. The number of publications has become enormous. At the same time, new limitations have appeared.

Scientific communities are capable not only of creating new knowledge. They are also capable of effectively reproducing existing approaches. They can reinforce established views. They can construct durable intellectual boundaries. They can effectively resist scientific innovation.

For this reason, the transition toward understanding the morphology of a process cannot be regarded as an automatic outcome of scientific development. It requires special effort. It requires a willingness to ask new questions. It requires a willingness to move beyond familiar explanatory frameworks.

Military Contamination as an Especially Complex Case

There are good reasons to consider research on military contamination one of the most difficult examples of this problem. Here we encounter constraints that cannot be explained solely through scientific logic.

- Military contamination is connected to states.
- It is connected to military institutions.
- It is connected to economic interests.
- It is connected to politics.
- It is connected to international conflicts.
- It is connected to questions of national security.

As a result, the researcher faces not only scientific difficulties. The researcher also faces a complex system of constraints that influences the production of scientific knowledge itself.

For this reason, the problem of the morphology of military contamination is considerably more complex than the problem of morphology in many classical natural processes.

The researcher attempts to understand a process that is simultaneously natural, technical, social, political, and historical.

This is precisely why it is so important to maintain attention to fundamental epistemological questions. Without such attention, there is a risk of endlessly accumulating facts without ever reaching understanding.

Interim Conclusion

Morphology represents a distinct level of scientific knowledge situated between individual events and general theories.

It allows researchers to identify stable forms of process organization that cannot be recognized through the study of isolated cases.

For research on military contamination, the transition toward morphology is a necessary condition for the development of mature scientific understanding.

However, such a transition does not occur automatically. It requires the development of new concepts, new models, and new ways of formulating research questions.

The next step is to examine the role of scientific models. In many cases, it is through models that the transition from observing individual cases to understanding the morphology of a process becomes possible.

8. The Scientific Community and the Limits of Knowledge

A Preliminary Remark on the Scientific Community

Up to this point, attention has been focused primarily on the complexity of the object of study itself. However, there is another aspect of the problem that cannot be completely ignored. This concerns the scientific community as a specific social institution.

In this lecture, the issue will be addressed only briefly. It deserves separate and much more detailed treatment. For the moment, it is sufficient to note the following.

The difficulties involved in studying military contamination are related not only to the characteristics of the process itself. They may also be related to the characteristics of the production of scientific knowledge. The scientific community is not an abstract mechanism for the automatic accumulation of truth. It possesses its own structure, traditions, methods of selecting problems, and limitations.

The history of science demonstrates that even productive scientific ideas and new ways of understanding processes are not always rapidly accepted by scientific communities. In some cases, decades pass between the appearance of a promising idea and its recognition. In other cases, new approaches remain on the periphery of science for long periods of time.

For studies of military contamination, this issue has particular importance. Here we encounter not only scientific difficulties but also the intersection of interests involving states, military institutions, industry, international politics, and competing research programs.

This gives rise to an additional question: How does the organization of scientific knowledge itself influence the understanding of military contamination?

In this lecture, the question is merely introduced. Its detailed examination requires separate analysis. Even at this stage, however, it is important to recognize that limitations of understanding may arise not only from the complexity of the object of study but also from the complexity of the process through which scientific knowledge itself is produced.

9. Scientific Models and the Construction of Morphological Knowledge

Once we recognize the necessity of moving from individual events to an understanding of the morphology of a process, the next question naturally arises.

How does this transition occur in practice?

How does a researcher move from a multitude of facts to an understanding of the form of a process?

Contemporary philosophy of science increasingly answers this question through the concept of the scientific model. The scientific model is one of the most important instruments of scientific knowledge. It occupies an intermediate position between observation and theory. Observation provides facts. Theory seeks to explain regularities. The model connects the two. In many cases, it is through models that understanding of complex processes becomes possible.

A Model Is Not a Copy of Reality

At this point, it is important to avoid a common misconception. Many people view a scientific model as a reduced copy of a real object. This understanding is overly simplistic.

A scientific model does not reproduce reality in its entirety. It is always selective. It isolates only those elements that are considered essential for solving a particular problem.

For this reason, the same reality can be described through different models.

A geochemist constructs one model of contamination.

A hydrologist constructs another.

An ecologist constructs a third.

A toxicologist constructs a fourth.

Each of these models may be scientifically valid. Each reveals a particular aspect of the process. Yet none of them is identical to the process itself. This point is fundamentally important for research on military contamination.

A model does not replace reality. But without models, reality remains poorly understood.

Why Models Are Especially Important for Military Contamination

Military contamination is an extremely heterogeneous object. Differences exist in:

- natural conditions;
- types of weapons;
- types of contaminants;
- duration of conflicts;
- scales of destruction;
- approaches to territorial restoration.

For this reason, it is impossible to construct a single model that immediately explains everything. At the initial stage, models of individual cases inevitably emerge. For example:

- a model of contamination following the use of Agent Orange in Vietnam;
- a model of petroleum contamination resulting from the destruction of industrial infrastructure;
- a model of heavy metal contamination in areas of intense military activity;
- a model of contamination associated with new military technologies.

Each such model possesses independent value. It helps organize observations. It makes relationships among different facts visible. It helps identify mechanisms of the process. Most importantly, however, the model represents the first step from event to morphology.

The Transition from Case to Model

When a researcher first encounters a new case of military contamination, the amount of available information is enormous. Some information proves important. Some proves secondary. Some is entirely accidental.

At the beginning, these distinctions are difficult to make. This creates the need for simplification. It is here that the model emerges.

A model reduces the complexity of the object to a level that can be analyzed. It inevitably discards part of the information. At the same time, it makes understanding possible. This is the paradox of scientific modelling. To understand an object more clearly, one must deliberately abandon part of the information about it.

At first glance, this seems strange. Yet without such simplification, a complex object often becomes impossible to understand.

Military Contamination as a Collection of Models

An important question arises here. Can we already speak of a general model of military contamination?

Most likely, not yet. At the present stage, we possess primarily models of individual cases. And this is entirely normal. Science rarely begins with universal models. Usually, it develops in the opposite direction. Models of individual cases appear first. These models are then compared. Common elements gradually emerge. Broader conceptions of the process begin to form.

Only after that does it become possible to speak of morphology. In the case of military contamination, we are still largely at the stage of accumulating and comparing models. This is not a weakness. It is a natural stage in the development of knowledge.

Morphology as the Result of Interaction Among Models

This leads to an interesting conclusion. If morphology is not directly given in observation, where does it appear?

To a significant extent, it emerges in the space between models. Researchers begin to notice that different wars generate different consequences. At the same time, certain recurring structures become visible. Particular types of contamination recur. Particular mechanisms of contaminant migration recur. Particular forms of ecological consequences recur. Particular temporal sequences recur.

Gradually, it becomes apparent that behind the diversity of cases lie certain forms of process organization. This is where morphology begins to take shape. In this sense, morphology is not simply discovered. It is gradually constructed by the scientific community through the comparison of models.

This does not make it subjective. It demonstrates that morphology is the result of prolonged intellectual work.

The First Limitation of Modelling

At this point, caution is necessary. Models can facilitate understanding. They can also restrict it. Every model inevitably emphasizes certain aspects of a process while ignoring others. Over time, a researcher may become so accustomed to a particular model that it begins to be perceived as reality itself.

This is one of the most serious dangers of scientific knowledge. Especially in the case of military contamination. The process continues to evolve. New forms of contamination emerge. New technologies of warfare appear. Natural conditions change. The scale of impacts changes.

For this reason, models must remain open to revision. Otherwise, they cease to be instruments of understanding and become obstacles to further development of knowledge.

Model Versioning, Temporal Validity, and Methodological Provenance

Scientific models are often discussed as though each model existed in a single, stable, and definitive form. This assumption is inadequate for the study of military contamination. The reality represented by such models is not static. Types of weapons, materials, contaminants, pathways of dispersal, environmental conditions, remediation practices, and available empirical evidence all change over time. Consequently, a model that was empirically effective under one set of conditions may become partially obsolete or structurally inadequate when those conditions change.

Models of military contamination should therefore be treated not as timeless scientific objects, but as **versioned scientific constructs**. The analogy with computer software is methodologically useful. A software system is not identified solely by its general name; a particular version is specified because different releases may contain different functions, assumptions, corrections, and limitations. A similar principle should be applied to scientific models of military contamination. There should be no single, undifferentiated model presented as though it were final. Instead, there should be a sequence of explicitly identified versions, each with a defined empirical scope, temporal reference, and methodological basis.

Every model should include at least three forms of specification.

First, the model must identify the case for which it was constructed. This specification should include the conflict or military episode under consideration, the territory, the spatial scale, the relevant forms of military activity, the principal contaminants, and the environmental systems included in the analysis. A model developed for petroleum contamination following the destruction of industrial infrastructure cannot automatically be transferred to heavy-metal contamination caused by prolonged artillery activity. Similarly, a model constructed for one climatic, hydrological, or soil environment may not remain valid in another. Without an explicit specification of the case and its boundary conditions, there is a serious risk of unjustified generalization.

Second, the model must identify its temporal position. This should include the date on which the model was constructed, the date at which data collection was closed, the historical period represented by the model, and, where possible, the expected period of its operational validity. The date of model construction is not merely administrative metadata. It is part of the epistemic content of the model. A model created during active hostilities may represent a fundamentally different object from a model created five or ten years later, when contaminant migration, ecological succession, remediation, land-use change, and post-war reconstruction have altered the system.

Third, the model must identify the methodology by which it was constructed. This methodological specification should include the sources of data, sampling design, measurement procedures, criteria for the inclusion or exclusion of variables, analytical techniques, modelling assumptions, calibration procedures, validation methods, spatial and temporal resolution, and treatment of uncertainty. Two models constructed for the same territory at approximately the same time may nevertheless produce radically different representations if they are based on different methodologies. The methodological provenance of a model must therefore be treated as an integral part of its identity rather than as secondary technical information.

A version number should change whenever the empirical or conceptual content of a model changes substantially. A minor revision may involve the addition of new observations, recalibration of parameters, correction of errors, or improvement of spatial resolution without altering the basic structure of the model. A major revision should be introduced when there is a change in the model's conceptual architecture, causal assumptions, system boundaries, classification of contaminants, set of variables, or intended domain of application. In this sense, the transition from one major version to another may represent not merely an improvement in precision, but a different scientific interpretation of the process.

Such versioning is particularly important because military contamination is an exceptionally dynamic object. Its dynamics are produced not only by natural transformations, but also by continuing changes in warfare itself. New weapons, new materials, new delivery systems, new forms of military waste, and new patterns of infrastructure destruction can generate forms of contamination that were absent when an earlier model was constructed. At the same time, the receiving environment continues to change through contaminant migration, chemical transformation, erosion, sedimentation, biological uptake, climatic variability, remediation, reconstruction, and changes in land use. The model and the object therefore do not remain synchronized automatically.

For this reason, the obsolescence of scientific knowledge may be especially rapid in the field of military contamination. A model may remain internally coherent while becoming progressively less adequate to the reality it is intended to represent. Its assumptions may continue to be logically consistent, and its earlier predictions may have been successful, yet its scope conditions may no longer apply. Previous effectiveness must not be treated as sufficient evidence of continuing validity.

An updated model may differ radically from an earlier version. The changes may concern not only numerical parameters but also the variables considered relevant, the causal relationships proposed, the classification of processes, the spatial organization of the system, and the predicted trajectories of future development. Such a revision does not necessarily mean that the earlier model was scientifically defective. It may mean that the object itself has changed, that new evidence has become available, or that a different methodology has revealed relationships that the earlier model could not detect.

Accordingly, scientific publications, databases, monitoring programs, and restoration projects should refer to a specific version of a model rather than to a model only by its general name. Each version should indicate which earlier version it supersedes, what changes have been introduced, which assumptions remain unchanged, and under what conditions the new version should be applied. This would make it possible to reconstruct the development of the model, compare results obtained at different stages, and distinguish changes in scientific interpretation from changes in the object itself.

Formal versioning is not yet a universally established convention across the sciences. In many fields, models continue to be cited as though they were stable conceptual entities. For military contamination, however, this practice is insufficient. The unusually high variability of the object requires a more explicit system of model identification, revision, and archival documentation. Temporal and methodological information must be regarded as part of the scientific content of the model.

An unversioned model of military contamination should therefore be regarded as an incompletely specified model. Without an indication of the case, the time of construction, and the methodology employed, it is impossible to determine precisely what reality the model represents, under what conditions it was effective, and whether it remains scientifically valid.

Interim Conclusion

Scientific models are a necessary intermediary between individual cases and an understanding of the morphology of a process.

It is through models that researchers begin to move from a chaotic collection of observations toward the identification of stable forms of process organization.

For the study of military contamination, modelling has particular significance because the object is characterized by high complexity, heterogeneity, and historical variability.

Models, however, do not constitute final knowledge. They represent only one stage on the path toward understanding the morphology of a process.

The next question is even more difficult. If models are created by researchers, then to what extent do researchers themselves influence what they are able to see in reality? It is precisely this question that is raised by the work of Thomas Kuhn and Norwood Russell Hanson (13,14).

10. Theory-Ladenness in the Absence of an Object-Specific Theory

Observation as an Active Process

In the traditional view, observation was often understood as the passive registration of facts.

Contemporary philosophy of science offers a more complex picture Observation is an active process. The researcher does not merely record reality. The researcher continually asks questions. The researcher selects methods. The researcher selects information. The researcher interprets results. Observation is therefore a form of interaction between the researcher and the object of study.

This is especially evident in the study of military contamination. It is impossible to study everything at once. The number of potentially significant factors is too large. Selection therefore begins at the stage of observation itself. Such selection is unavoidable. It also means that every description of the process is partial. Each study illuminates only a particular aspect of reality.

Is There a Single Morphology of Military Contamination?

This brings us to an important question. If different research approaches distinguish different aspects of the process, does a single morphology of military contamination exist at all?

At the present stage of knowledge, it is difficult to provide an unambiguous answer. It may be more appropriate to speak not of one morphology but of several interconnected descriptions of the process.

- Geochemical morphology.
- Ecological morphology.
- Hydrological morphology.
- Medical morphology.
- Social morphology.

Each of these may reflect real aspects of what is occurring. None of them, however, exhausts the entire process. This conclusion may appear inconvenient. Many would prefer a single universal scheme. Complex processes, however, rarely conform to such expectations.

Military Contamination as an Evolving Object

The situation is complicated by another circumstance. Most classical scientific objects are relatively stable. Military contamination is not such an object. It continues to develop. New technologies of warfare emerge. New materials appear. New types of contamination arise. The scale of impacts changes. The natural systems within which the consequences of war unfold also change.

The researcher therefore faces not merely a complex object. The researcher faces an object that changes while it is being studied. This is a crucial point. We are not studying a completed reality. We are studying a process that is still taking shape. For this reason, every description of its morphology must remain open to further revision.

Disciplinary substitution under theoretical vacancy

The classical arguments of Norwood Russell Hanson and Thomas Kuhn remain fundamentally important. They demonstrated that scientific observation is never completely neutral. A researcher does not simply record what is present in reality.

Observation is organized by concepts, theoretical expectations, methodological habits, and the research tradition within which the scientist has been trained.

This account is highly accurate when a scientific community works within an established theoretical framework. A committed representative of a particular school sees the object through the concepts accepted by that school. Certain facts become visible, while others remain marginal or are excluded as irrelevant. In this sense, theory shapes observation.

Research on military contamination, however, reveals a different and more complex epistemological situation.

The problem is not always that researchers are committed to a dominant theory of military contamination. In many cases, no such theory exists. There is no consolidated paradigm that defines the object, establishes its boundaries, identifies its principal processes, and determines which forms of evidence are theoretically significant.

The field may therefore be described as **theoretically underdeveloped but institutionally occupied**. It lacks an object-specific theory, yet it is not approached without prior assumptions. The theoretical vacancy is filled by concepts, methods, and routine practices imported from already established disciplines.

This condition may be termed **disciplinary substitution under theoretical vacancy**.

The absence of theory does not produce neutral observation

The absence of a general theory of military contamination does not mean that researchers approach the object with an open and theoretically neutral mind. On the contrary, they usually approach it through the established intellectual resources of their own discipline.

A soil scientist applies soil science.

A geochemist applies geochemistry.

A toxicologist applies toxicology.

An agronomist applies agronomy.

A hydrologist applies hydrology.

A specialist in public health applies an epidemiological or sanitary framework.

Each of these approaches may be scientifically productive within its own domain. The difficulty arises when an inherited disciplinary framework is transferred to military contamination without a critical examination of whether the object has changed in ways that invalidate the original assumptions of that framework.

The resulting observation is still theory-laden. However, it is laden not by a theory of military contamination, but by a theory developed for another class of objects. This is the central difference.

The researcher does not necessarily impose an explicit dogmatic theory upon the new field. Instead, the researcher imports a disciplinary normality. Concepts, classifications, sampling procedures, standards of evidence, and established research questions are transferred from a familiar domain to an unfamiliar one.

Because these assumptions are routine, they may not be recognized as theoretical assumptions at all. They may be perceived simply as the correct scientific procedure.

The case of Ukrainian soil science

The study of war-affected soils in Ukraine provides an instructive example.

Ukrainian soil specialists do not enter the field of military contamination without scientific knowledge. They possess extensive professional training, laboratory methods, classification systems, field practices, and established concepts of soil functioning. However, this knowledge does not represent soil science in some universal and historically neutral form.

It represents a particular national and historical configuration of soil science. It has been shaped by Soviet scientific traditions, post-Soviet institutional development, agricultural priorities, national systems of land evaluation, and the practical requirements of soil management.

This scientific tradition is strongly connected with agriculture. It is therefore naturally oriented toward such questions as soil fertility, agricultural suitability, chemical composition, productivity, degradation, permissible concentrations, and the restoration of land to economic use.

These questions are legitimate and important. The problem begins when this historically specific version of soil science is treated not as one possible epistemic framework but as soil science itself.

Practitioners working within such a framework may not perceive its limitations. Its assumptions have been incorporated into professional education, institutional routines, laboratory procedures, publication standards, and administrative expectations. What is historically and methodologically specific becomes epistemically naturalized.

As a result, the researcher may sincerely believe that the object is being studied directly, while in fact the object is being reconstructed through the categories of a particular post-Soviet and agriculturally oriented scientific tradition.

This is not necessarily conscious dogmatism. It may be more resistant to criticism precisely because it is not experienced as dogmatism. The framework is perceived as normality.

The assumption of ontological continuity

One of the most important consequences of disciplinary substitution is the implicit assumption that the object remains fundamentally the same before and after military impact.

Within this assumption, a soil affected by war is treated as the same soil that existed before the war, but with additional contaminants, physical damage, or reduced agricultural quality.

The analytical formula becomes approximately the following:

pre-war soil + military contaminants = war-contaminated soil

This formula may be adequate for certain limited measurements. It may allow researchers to determine concentrations of metals, explosive residues, petroleum products, or other substances. It may support comparison with regulatory thresholds. It may also be useful for immediate risk assessment.

However, it does not necessarily provide an adequate scientific definition of the new object.

Military activity may alter not only the chemical composition of a soil but also its structure, microrelief, hydrological relations, thermal conditions, biological communities, erosion regime, land-use context, and future developmental trajectory. Explosions, fires, mechanical disturbance, fragments of military equipment, construction debris, damaged infrastructure, unexploded ordnance, and combinations of contaminants may produce a system that cannot be understood simply as an earlier soil with an added pollutant.

The war-affected soil may therefore represent not merely a modified state of a pre-existing object, but a new natural-anthropogenic configuration undergoing its own morphogenesis.

The epistemological error consists in assuming ontological continuity where a qualitative transformation may have occurred.

A familiar disciplinary framework may accurately measure individual variables while failing to recognize that the object itself has changed.

Methodological competence and object misidentification

This situation creates a particularly difficult form of scientific limitation. The research may be technically competent.

Samples may be collected correctly.

Laboratory procedures may be reliable.

Concentrations may be measured accurately.

Statistical analysis may be professionally conducted.

Maps may be produced at high resolution.

The resulting publications may satisfy the formal standards of the discipline.

Nevertheless, the object may still be incorrectly identified.

Methodological precision does not automatically guarantee conceptual adequacy. A researcher may measure with great accuracy what the inherited discipline permits the researcher to see, while failing to recognize what the object has become.

This is one of the central dangers in an emerging field. The absence of an object-specific theory may be concealed by an abundance of established methods. Because the methods are familiar and institutionally legitimate, their application creates the appearance that the scientific problem has already been correctly formulated.

In reality, an extensive body of data may be produced within a conceptual framework that excludes the most important characteristics of the process.

This is not merely a problem of specialization

The problem should not be reduced to the ordinary fact that different specialists study different aspects of reality.

Scientific specialization is unavoidable. A soil scientist cannot simultaneously become a hydrologist, toxicologist, physician, geographer, microbiologist, and military technologist. Different disciplines must necessarily divide the object into analytically manageable components.

The problem described here is different. It arises when the framework of one discipline is transferred to an emerging object and begins to define the object as a whole. The disciplinary perspective ceases to be recognized as partial. It becomes an implicit substitute for the absent theory of military contamination.

The soil scientist does not merely study the soil component of military contamination. Soil science begins to determine what military contamination of soil is.

The toxicologist does not merely study toxic effects. Toxicological categories begin to define which consequences count as scientifically real.

The agronomist does not merely investigate the possibility of returning land to agricultural use. Agricultural recovery begins to function as the principal criterion by which the condition of the territory is interpreted.

The issue is therefore not the coexistence of several disciplines. It is the unreflexive extension of one disciplinary ontology beyond the domain for which it was originally developed.

Imported normal science

Kuhn described normal science as research conducted within an established paradigm. Scientists solve problems that are already recognized as legitimate, use accepted methods, and work within a relatively stable conceptual structure.

Research on military contamination may operate differently. There may be no established paradigm of military contamination itself. Nevertheless, normal science is reproduced through the importation of disciplinary practices from other fields.

This may be called **imported normal science**.

The researcher continues to solve familiar types of problems:

- Which substances are present?
- Do their concentrations exceed existing standards?
- How has soil fertility changed?

- Can the land be returned to agricultural use?
- Which remediation technique should be applied?
- How should the contaminated area be classified administratively?

These questions may be useful. Yet they were largely formulated for objects that existed before the emergence of military contamination as a distinct field of inquiry.

The new object is therefore assimilated to an older problem structure. The unfamiliar is made familiar by redefining it in the language of the existing discipline.

The result is epistemic continuity for the scientific community, but possible misrepresentation of the object.

Limited reflexivity

Researchers working within an imported disciplinary framework may have little reason to question it. Their education, professional status, institutional authority, and access to funding may all depend upon mastery of that framework.

Critical reflection therefore creates a difficult situation. To recognize the limitations of the framework is not merely to correct an isolated methodological error. It may require acknowledging that:

- the object was defined too narrowly;
- important variables were excluded before data collection began;
- the sampling design reflected inappropriate assumptions;
- established standards were applied outside their domain of validity;
- previous publications described only one part of the process;
- recommendations for restoration may have been based on an incomplete conception of the object.

Such recognition can threaten professional identity and institutional legitimacy. For this reason, resistance to criticism may become especially strong.

The strongest resistance may come not from consciously dogmatic theorists but from researchers who do not perceive themselves as following a particular theory at all. They believe that they are simply applying science correctly.

This form of epistemic closure is difficult to overcome because the framework has become invisible to those who use it.

State-reinforced normal science

The problem becomes more serious when scientific research is conducted under wartime conditions and is expected to provide scientific support for state objectives.

Research may be connected with national security, territorial restoration, legal documentation, agricultural recovery, international assistance, compensation claims, or public communication. Under such conditions, the scientific community may be expected not only to investigate reality but also to produce administratively usable conclusions.

The demand for rapid, clear, and politically applicable results may strengthen existing disciplinary routines. Familiar methods produce familiar indicators. Familiar indicators can be incorporated into reports, regulations, maps, restoration programs, and official statements.

Critical examination of the conceptual framework may then be interpreted as an obstacle to urgent practical work.

In this situation, normal science may become administratively intensified. The disciplinary framework is supported not only by professional tradition but also by state institutions, funding structures, expert hierarchies, and political expectations.

Scientific criticism may consequently be treated not as a normal component of knowledge production but as disloyalty, incompetence, obstruction, or an attack on national interests.

Mechanisms of pressure may include exclusion from research projects, restriction of access to data or field sites, unfavorable peer review, denial of funding, reputational labeling, administrative isolation, and attempts to remove alternative interpretations from legitimate scientific discussion.

This is a structural risk rather than a claim about every institution or every individual researcher. However, it must be recognized as part of the epistemology of military contamination. Knowledge in this field is produced within conditions of war, state interest, professional competition, and institutional dependency.

An intensified form of normal science

This condition may be understood as an intensified or state-reinforced form of normal science.

Its defining characteristics are:

1. there is no mature theory of military contamination as an autonomous object;
2. an established disciplinary framework is transferred into the theoretically vacant field;
3. the transferred framework is treated as methodologically self-evident;
4. its historical and national specificity is rarely examined;
5. the object is redefined so that it can be studied through familiar procedures;
6. institutional and state demands reinforce the inherited framework;
7. alternative formulations of the object may be actively marginalized.

This is more than ordinary conservatism. It is a mechanism through which a theoretically immature field can generate large quantities of formally valid research without developing an adequate understanding of its object.

The problem is not unique to soil science or to Ukraine

The Ukrainian case is important, but the general epistemological problem is not limited to Ukraine, post-Soviet science, or soil research.

The same process may occur in any country and within any discipline.

Military contamination may be reduced to:

- a toxicological problem by toxicologists;
- an engineering problem by engineers;
- a question of regulatory exceedance by environmental agencies;
- a public-health problem by epidemiologists;
- a matter of land productivity by agricultural specialists;
- a problem of infrastructure repair by reconstruction institutions;
- a legal problem by specialists documenting environmental damage.

Each reduction may produce useful knowledge. The difficulty arises when the partial framework is presented as an adequate representation of the entire object.

Military contamination is especially vulnerable to such disciplinary capture because it has not yet developed a stable theoretical identity of its own.

A new epistemological configuration

The standard interpretation of Kuhn and Hanson does not fully capture this configuration.

Their work directs attention to the way an existing theory or paradigm shapes observation. The case of military contamination introduces an additional possibility: **observation may be shaped by a theory that does not belong to the object being studied.**

The problem is therefore not simply theory-ladenness. It is **mislocated theory-ladenness**.

There is an asymmetry:

- an abundance of inherited disciplinary concepts;
- an absence of an object-specific theory;
- a high level of methodological activity;
- a low level of reflection on whether the methods correspond to the transformed object.

By the second quarter of the twenty-first century, this configuration has become increasingly important. New research fields often emerge rapidly in response to war, technological change, environmental crises, and urgent state demands. Institutions cannot wait for a mature theory to develop. They mobilize existing disciplines.

This mobilization produces knowledge quickly. But it also creates the risk that a new reality will be interpreted entirely through categories inherited from an earlier and different reality.

Methodological implications

Research on military contamination must therefore include explicit reflection on the origin and limits of the disciplinary framework being used.

Every study should clarify:

- which disciplinary tradition defines the object;
- for what original class of problems that tradition was developed;
- which assumptions are transferred from the original domain;
- whether the study assumes continuity between the pre-war and war-transformed object;
- which war-specific processes are excluded by the chosen methodology;
- which dimensions of the object cannot be observed through the selected methods;
- whether alternative disciplinary frameworks would produce a different definition of the same case.

Such reflection is not an optional philosophical addition. It is part of scientific quality control.

A methodology cannot be evaluated only by asking whether it was applied correctly. It is also necessary to ask whether it was appropriate for the object that actually emerged.

Interim Conclusion

Hanson and Kuhn correctly demonstrated that observation is theory-laden. Research on military contamination requires an extension of this argument.

The principal problem may not be the dominance of an established theory of military contamination. Such a theory may not yet exist.

Instead, researchers import the normal concepts and practices of established disciplines into a theoretically vacant field. These imported frameworks organize observation, define relevant facts, determine legitimate methods, and shape practical recommendations.

The resulting research may be empirically rich and methodologically precise. Yet it may remain conceptually inadequate if it treats a war-transformed system as though it were simply the pre-war object with additional damage or contamination.

The absence of an object-specific theory is therefore not an empty space. It is occupied by inherited disciplinary assumptions.

For the epistemology of military contamination, this leads to a fundamental principle: **A scientific method should not be considered adequate merely because it is valid within its original discipline. Its adequacy must be re-established in relation to the new object created by war.**

11. Process Ontology: From Things to Becoming

At the preceding stage, we concluded that observation is always connected with theory. The researcher does not simply see an object. The researcher sees it through concepts, models, and research traditions.

We must now take another step. It may appear more difficult, but it is essential for understanding military contamination. This step involves moving from thought in terms of things to thought in terms of processes.

The Classical Conception of the World

In everyday thought, we usually imagine the world as a collection of things.

- There is a river.
- There is a forest.
- There is a field.
- There is soil.
- There is a city.
- There is an industrial facility.
- There is a contaminated territory.

It seems that these objects exist first and that something subsequently happens to them.

- The river flows.
- The forest burns.
- The soil becomes contaminated.
- The city is destroyed.
- The territory recovers.
- This way of thinking is convenient.
- It corresponds to ordinary language.
- It helps us describe the world.

When complex natural processes are studied, however, it becomes insufficient. Many objects that appear stable are in fact temporary results of processes.

A river exists because water is continually moving, sediments are being transported, banks are being eroded, deposits are accumulating, and the channel is interacting with relief, climate, and vegetation.

A forest exists because processes of growth, mortality, regeneration, species competition, soil formation, and matter exchange continually occur.

Soil exists because organic matter is continually decomposed, substances migrate, minerals weather, organisms remain active, and cycles of wetting and drying continue.

What we call an object is often a relatively stable form of a process. This is the fundamental intuition of process ontology.

What Process Ontology Claims

Process ontology begins from the proposition that processes are more fundamental than things. Things do not disappear from analysis. They are no longer understood, however, as absolutely autonomous and immutable entities. They are understood as temporary stabilizations within a flow of change.

Alfred North Whitehead and other representatives of process philosophy showed that reality can be understood not as a collection of static objects but as a multiplicity of interconnected events and processes (15). Nicholas Rescher later developed this line of thought into a systematic process metaphysics (16).

This approach is especially important for the Earth sciences. Rivers, coastlines, glaciers, soils, landscapes, ecosystems, and climate systems are not things that merely change from time to time. They exist as processes. Their stability is relative. Their form is temporary. Their state is the result of continual becoming.

Why This Matters for Military Contamination

For the study of military contamination, this shift has fundamental importance. If we think only in terms of things, military contamination appears as damage to an object.

- There was soil; now there is contaminated soil.
- There was a river; now there is a contaminated river.
- There was a forest; now there is a damaged forest.
- There was a territory; now there is a territory bearing the consequences of war.

Such descriptions are necessary. They are also too static. They record a result but reveal little about the process. A process-based approach offers a different perspective. Military contamination does not merely damage pre-existing objects. It intervenes in the processes that create and sustain those objects.

- It changes soil formation.
- It changes water exchange.
- It changes the migration of substances.
- It changes interactions among organisms.
- It changes biogeochemical cycles.
- It changes the rates and directions of recovery.

War therefore damages not only things. It restructures processes. This represents a substantially deeper level of understanding.

Military Contamination as an Intervention in Becoming

If soil is understood as a process, soil contamination cannot be reduced to the presence of a harmful substance at a particular concentration. The question becomes broader.

- How does the substance alter the future development of the soil?
- How does it affect microorganisms?
- How does it alter the water regime?
- How does it enter food chains?
- How long does it remain active?
- How does it interact with other contaminants?
- How does it affect the capacity of the territory to recover?

The same applies to water systems.

- River contamination is not only the presence of a substance in the water.
- It is a change in the movement of substances through the entire system.
- It affects bottom sediments.
- It affects aquatic organisms.
- It may lead to the accumulation of contaminants in biota.
- It changes risks for people living downstream.

From this perspective, military contamination is an intervention in the becoming of natural systems. It does not merely leave a trace. It may alter the direction of their subsequent development.

Military Contamination and Temporal Scales

Process ontology also helps clarify another important issue. Military contamination operates across different temporal scales. Some consequences appear immediately. These include explosions, fires, toxic releases, the destruction of industrial facilities, and the death of living organisms. Other consequences emerge after months. Still others appear after years. Some may persist for decades.

Military contamination therefore cannot be assessed solely by examining the condition of a territory when hostilities end. That moment provides only one cross-section of the process. The process itself continues. It develops. It enters new stages. It may weaken, intensify, change direction, or generate new effects. In this sense, military contamination has its own post-war history. That history may be no less important than the period of military operations itself.

The Metaphor of "Anti-Nature"

In the initial formulation of the problem, military contamination was described as a form of "anti-nature." This metaphor requires clarification. Military contamination is not a natural process in its origin. Nature does not create tank battles. Nature does not manufacture munitions. Nature does not destroy chemical plants during military operations. Nature does not develop toxic substances for military use. All of these are created by humans.

In this sense, military contamination can indeed be understood as a radically anthropogenic intervention, something opposed to the normal course of natural processes.

This "anti-nature," however, does not remain outside nature. It is immediately incorporated into the natural environment. Munitions, metals, petroleum products, explosive residues, toxic compounds, construction debris, burned materials, and new forms of military waste begin to interact with soil, water, air, organisms, and climate. What humans created against nature becomes part of natural processes.

The central difficulty arises precisely here. Military contamination is not natural in origin. Yet its subsequent development takes place through natural processes. More precisely, it becomes a natural-anthropogenic process.

Process as an Object of Study

A process-based approach changes the formulation of the research question itself. The issue is no longer only which territories are contaminated. It is no longer only which substances have been detected. It is no longer only which concentrations exceed permissible limits. The question becomes deeper.

- Which processes were altered by war?
- Which processes were newly initiated?
- Which processes were halted?
- Which processes accelerated?
- Which processes became irreversible?
- Which processes may shift into new stable states?

Questions of this kind lead toward an understanding of the morphology of military contamination.

Interim Conclusion

Process ontology makes it possible to move from a static understanding of military contamination to a dynamic one.

Military contamination should be understood not only as damage to objects but also as an intervention in the processes that form natural systems.

This is especially important because the consequences of war continue to develop after military operations have ended.

Military contamination has its own post-war dynamics. It changes not only the present condition of a territory but also the possible trajectories of its future development.

The next step concerns the concept of morphogenesis. If morphology describes the form of a process, morphogenesis allows us to ask how new forms arise.

12. Morphogenesis: The Emergence of New Forms

After considering process ontology, we can turn to the concept of morphogenesis.

If morphology answers the question of the form of a process, morphogenesis answers the question of how that form emerges. In other words:

- morphology is form;
- morphogenesis is the formation of form.

For research on military contamination, this distinction is fundamental. It is not enough to state that a territory is contaminated. It is not enough to identify the substances that have been detected. It is not enough to record which elements of a natural system have been damaged. It is necessary to understand which new formative processes were initiated by war.

What Is Morphogenesis?

The concept of morphogenesis has a broad meaning. It is used in biology, geomorphology, systems theory, the philosophy of science, and complexity research. In the most general sense, morphogenesis means the emergence of new structures, forms, and states.

René Thom was among the first to attempt the development of a general theory of morphogenesis. He was interested in how stable forms emerge within dynamic systems (17).

Brian Goodwin likewise showed that many biological forms cannot be explained solely by chance or by the historical sequence of events. Complex systems possess internal tendencies toward organization (18).

For the present discussion, the most important point is the following. Forms are not always fully predetermined. Nor are they entirely random. They emerge in the space between necessity and contingency.

Between Necessity and Contingency

This proposition has major importance for the study of military contamination. Military contamination is not an entirely natural process.

- It is initiated by humans.
- Humans create weapons.
- Humans use munitions.
- Humans destroy infrastructure.
- Humans employ toxic substances.
- Humans initiate the process.

After that point, however, the process is no longer fully controllable.

- Contaminants begin to interact with the natural environment.
- They move with water.
- They become fixed in soils.
- They enter plants.
- They affect microorganisms.
- They enter food chains.
- They interact with one another.

The consequences of military contamination therefore cannot be regarded as either fully predetermined or entirely random. They take shape within a complex field of interactions.

- Chemical regularities operate.
- Physical regularities operate.
- Biological regularities operate.
- Landscape conditions matter.
- Climate matters.
- The history of the territory matters.
- Post-war social decisions matter.
- Chance events matter.

Together, these factors shape the subsequent trajectory of the process.

War as a Trigger of Morphogenesis

War is often understood only as destruction. This is correct but insufficient. War destroys cities, infrastructure, soils, forests, water systems, and the conditions of human life. From the perspective of morphogenesis, however, war also serves as a trigger for new processes. It creates conditions that did not previously exist. New substances enter soils. Water systems receive new contaminant loads. Landscapes are mechanically transformed. Craters, trenches, destroyed structures, burned territories, metal residues, fragments of equipment, munition remnants, and new types of military waste appear.

These elements do not simply remain in the environment. They enter processes. They begin to interact with water, soil, air, vegetation, microorganisms, animals, and people. New forms of ecological reality emerge as a result. This is what may be described as the morphogenesis of military contamination.

New Ecological States

The morphogenesis of military contamination may lead to the formation of new ecological states.

- These states may be degraded.
- They may be toxic.
- They may be unstable.
- They may be hybrid natural-technogenic states.

The important point is not only that the previous state has been destroyed. Something new is taking shape in its place.

- This new state is not necessarily stable.
- It may be dangerous.
- It may be temporary.
- It may be poorly understood.

Yet it exists in reality. Post-war contaminated soil, for example, is not simply the former soil with a harmful substance added to it. It is a system in which microbiological processes, the water regime, chemical interactions, productivity, toxicity, recovery capacity, and suitability for agriculture may all change.

A damaged water system is not simply the former river plus contamination. It exhibits a new dynamics of substance transport, sediment movement, biological risk, and exposure of downstream populations.

A burned or damaged landscape is not simply the former landscape after a fire or explosion. It follows a new trajectory of recovery, erosion, revegetation, contamination, and possible reuse.

Morphogenesis and the Duration of Consequences

Time is especially important. We often do not know how long a process initiated by military contamination will continue. It may continue for years. It may continue for decades. In some cases, it may become part of the very long ecological memory of a territory.

Military contamination initiates processes that did not previously exist within the natural system concerned. Their duration cannot always be determined in advance. For this reason, it is dangerous to think only in terms of "damage and restoration." Such an approach assumes that a previous state exists to which the system can return. If war has altered the processes that form the territory itself, however, a simple return to the former state may be impossible.

Restoration must therefore address not only damaged objects but also the new processes that have been initiated.

Morphogenesis and Territorial Restoration

This conclusion is especially important for post-war restoration. Restoration is commonly understood as the elimination of damage.

- Clean the territory.
- Remove debris.
- Neutralize mines.
- Reduce contaminant concentrations.
- Restore infrastructure.
- Return land to economic use.

All of these tasks are necessary. They are not sufficient. If the morphogenesis of military contamination is not understood, restoration may remain superficial. Visible traces of war may be removed while processes continue to develop in soils, waters, ecosystems, and social systems.

Restoration must therefore be not only technical but also process-based. It is necessary to understand which forms have already emerged, which processes continue, and which trajectories of future development remain possible.

Interim Conclusion

Morphogenesis allows military contamination to be understood not only as destruction but also as the emergence of new forms of ecological reality.

These forms are not entirely random.

Nor are they fully predetermined.

They arise through the interaction of human actions, natural regularities, historical circumstances, and the dynamics of complex systems.

For research on military contamination, this means moving from the simple description of damage toward the analysis of processes that generate new natural-anthropogenic states.

The next step concerns complexity theory, self-organization, and emergence. These concepts help explain why the consequences of military contamination are often nonlinear and why individual impacts may produce unexpected systemic outcomes.

13. Complexity, Self-Organization, and Emergence

At the preceding stage, we concluded that military contamination should be understood not only as the destruction of existing structures but also as the initiation of new formative processes.

The next question arises immediately.

- Why are the consequences of war so diverse?
- Why can similar impacts in different places produce entirely different results?
- Why do some consequences appear immediately, while others become visible only after years or decades?
- Why do some territories recover relatively quickly, while others remain problematic for long periods?

These questions cannot be answered within simple linear frameworks. It is necessary to turn to the concepts of complexity, self-organization, and emergence.

The Emergence of Complexity Science

During the second half of the twentieth century, a broad field began to develop under such names as systems analysis, general systems theory, synergetics, the theory of self-organization, and complexity science.

For a time, these ideas became exceptionally popular. Interest later shifted partly toward other fields. Many of the concepts developed during that period, however, proved considerably deeper than initially assumed.

They have direct relevance to the study of military contamination. The central idea was that a complex system cannot be fully understood through the study of its separate elements alone. The interactions among those elements must also be considered. It is often those interactions that determine the behavior of the system as a whole. This conclusion became extremely important for understanding natural processes.

The World Is Nonlinear

One of the most important results was the recognition of nonlinearity.

In a linear system, a small impact produces a small change. A large impact produces a large change. Cause and effect are approximately proportional. This rule does not operate in many natural systems. A small impact may produce serious consequences. A major impact may produce relatively limited consequences. Much depends on the state of the system at the moment of impact.

This conclusion has major importance for military contamination. The same quantity of a contaminant may produce entirely different consequences under different natural conditions. Similar damage to infrastructure may produce different environmental outcomes. The same types of weapons may generate different consequences depending on soils, hydrology, climate, vegetation, and landscape characteristics.

Military contamination therefore cannot be understood solely by measuring the scale of the impact. The properties of the affected system must also be considered.

Self-Organization

The concept of self-organization was another major development.

The work of Ilya Prigogine showed that systems far from equilibrium are capable of forming new structures through their own dynamics (19,20). Order may arise not despite change but because of change.

This was a highly unusual conclusion. For a long time, order had been associated primarily with stability. It became clear that new forms may emerge precisely under conditions of disturbance and instability.

This idea is exceptionally important for the study of military contamination. War destroys existing structures. After destruction, however, a system does not remain in a state of chaos forever. It begins to establish new modes of functioning. Those modes may be unfavorable. They may be dangerous. They may involve environmental degradation. Nevertheless, they are forms of organization rather than mere disorder.

Emergence

Another important concept is emergence.

Emergence refers to the appearance of properties that cannot be fully explained by the properties of the separate elements of a system.

This is one of the most difficult and at the same time most important questions in contemporary science. Water molecules do not possess the properties of a river system. Individual organisms do not possess the properties of an ecosystem. Separate components of the atmosphere do not possess the properties of climate. New properties arise at the level of interaction. This conclusion is particularly important for military contamination.

- No single contaminant is military contamination.
- No single destroyed facility is military contamination.
- No single territory is military contamination.
- Military contamination emerges through the interaction of many processes.

It therefore possesses properties that cannot be reduced to its individual components.

Military Contamination as a Complex System

From this perspective, the object of study begins to appear differently.

- Military contamination is not a set of contaminants.
- It is not a set of destroyed objects.
- It is not a set of medical problems.
- It is not a set of environmental consequences.

It is a complex system of interacting processes. This system includes:

- chemical processes;
- physical processes;
- biological processes;
- hydrological processes;
- soil processes;
- social processes;
- economic processes;
- management decisions;
- restoration measures.

All of these elements interact with one another. The consequences of war are therefore shaped not by isolated factors but by their combinations. An important conclusion follows.

Military contamination cannot be fully explained through the analysis of separate components alone. The organization of the system as a whole must be studied.

Emergent Consequences of War

A particularly important question now arises. Some consequences of war may not yet exist when hostilities end. They emerge later.

This is precisely why they are difficult to predict. They result from the prolonged interaction of processes. Examples include:

- changes in the regimes of contaminant migration;
- changes in ecosystem structure;
- changes in soil quality;
- changes in water exchange;
- changes in risks to public health.

All of these consequences may develop gradually. They arise as emergent results of the development of the system. This is another reason why assessment cannot be limited to immediate damage. Military contamination continues to generate new consequences after war has ended.

From Complexity to Morphology

It now becomes clearer why the transition toward morphology is so important.

If military contamination is a complex system, individual events cannot explain its behavior. It is necessary to identify stable forms of process organization. This is precisely what a morphological approach seeks to do. It reveals not isolated episodes but the structure of interactions. It reveals not individual contaminants but forms of contamination organization. It reveals not isolated destruction but trajectories of system development.

Complexity theory therefore does not replace morphology. It helps explain why morphology emerges at all.

Interim Conclusion

Complexity theory, self-organization, and emergence show that the consequences of military contamination cannot be understood as the simple sum of separate impacts.

Military contamination is a complex system of interacting processes.

New properties, structures, and trajectories of development arise within such systems.

For this reason, research on military contamination must move from the analysis of separate events toward the analysis of process organization as a whole.

The next step concerns one of the most interesting contemporary concepts: assemblage theory and the work of Manuel DeLanda.

This approach offers a new way of examining the interaction of natural, technical, and social processes during war and in its aftermath.

14. A Brief Explanation for Those Who Are Still Awake

It is useful to pause for a moment.

We have already followed a rather long path. We began with individual cases of military contamination. We then considered why a multitude of cases does not automatically generate an understanding of the process. We introduced the concept of morphology. After that, we turned to models, the theory-ladenness of observation, process ontology, and morphogenesis.

A natural question may now arise: why is all of this necessary?

The answer is simple. We are trying to understand not only what war destroys. We are trying to understand what war initiates. This is where the greatest difficulty begins.

If war only destroys, then the scientific task is relatively clear: measure the damage, describe the consequences, assess the risks, and propose restoration. If war initiates new processes, however, the situation becomes much more complex. It then becomes necessary to understand:

- which processes were initiated;
- how they interact with one another;
- why they develop differently under different natural conditions;
- why some consequences appear immediately while others emerge years later;
- why territorial restoration does not always mean a return to the previous state.

This is why complexity theory is needed. It is not introduced merely to make the text more complicated. It is needed because the object itself is complex. Military contamination is not a straight line from cause to effect. It is a network of interactions.

Within this network, chemical, physical, biological, hydrological, soil, social, and political processes begin to influence one another. This is why the concepts of complexity, self-organization, and emergence are necessary. Without them, it is impossible to understand why military contamination often produces outcomes that cannot be predicted solely from the scale of the initial destruction.

15. Assemblages and Relational Morphology

After considering complexity, self-organization, and emergence, we can turn to another important approach. This is assemblage theory, associated with the work of Gilles Deleuze, Félix Guattari, and Manuel DeLanda (21,22).

At first glance, this may appear to be an excessively philosophical direction. For the study of military contamination, however, assemblage theory is highly useful. It allows us to describe objects that are neither purely natural, purely social, nor purely technical.

Military contamination is precisely such an object. It arises at the intersection of nature, war, technology, states, industry, infrastructure, landscapes, soils, water, organisms, and human decisions.

What Is an Assemblage?

An assemblage is a temporary configuration of heterogeneous elements that interact and together form a system.

These elements do not necessarily share the same nature. A single assemblage may include natural processes, technical objects, social institutions, chemical substances, infrastructure, organisms, people, and historical events. What matters is not that the elements resemble one another. What matters is that they enter into interaction and begin to produce a common result.

A river basin, for example, can be understood as an assemblage. It includes relief, water, soils, climate, vegetation, bottom sediments, economic activity, dams, contaminants, settlements, and management decisions.

A forest ecosystem can likewise be understood as an assemblage. It includes trees, soils, microorganisms, animals, climate, fires, pests, human use of the territory, and the historical memory of the landscape.

Military contamination can be understood in the same way. Its assemblage includes munitions, explosives, metals, destroyed infrastructure, soils, waters, vegetation, microorganisms, people, state decisions, restoration programs, and long-term natural dynamics.

An Assemblage Has No Fixed Essence

One of the central ideas of assemblage theory is the rejection of a fixed essence of an object.

An object is not defined once and for all. It exists through relations among its elements. If those relations change, the object itself changes.

This is especially important for military contamination. A contaminated territory is not simply a piece of land containing a particular quantity of harmful substances. It is a system of relations. Contaminants interact with soil. Soil interacts with water. Water transports substances. Plants incorporate substances into biological cycles. Animals and people come into contact with them.

Government decisions determine whether the territory will be cleaned, contained, returned to agriculture, or left without control. Military contamination therefore exists not only as a chemical fact. It exists as a network of relations.

Relational Morphology

This leads to the concept of relational morphology. Relational morphology means that the form of a process arises not from the internal essence of a single object but from relations among many elements.

This distinction is important. If military contamination is examined only through an individual contaminant, too little is seen. If it is examined only through a damaged territory, too little is again seen. If it is examined only through medical consequences, only one part of the process becomes visible.

The morphology of military contamination arises through relations. It arises through the relation between a substance and its environment. It arises through the relation between war and landscape. It arises through the relation between destruction and restoration. It arises through the relation among chemistry, biology, hydrology, and social decisions. Military contamination therefore has no single simple form. Its form is produced by a network of interactions.

Military Contamination as a New Component of a Natural Assemblage

From this perspective, military contamination is not merely an external impact on nature.

Once it emerges, it becomes a new component of a natural assemblage. This is a fundamental point. Military waste, toxic substances, destroyed structures, fragments of equipment, munition residues, and altered soils do not remain external to nature.

- They become incorporated into natural processes.
- They become part of new interactions.
- They may alter the hydrological regime.
- They may alter the chemical properties of soil.
- They may affect microorganisms.
- They may alter the trajectory of vegetation recovery.
- They may create new risks for people and animals.

The natural system therefore ceases to be what it was before the war. It becomes a new assemblage. It is not necessarily stable. It is not necessarily safe. It is not necessarily well understood. But it is new.

The Space of Possibilities

The idea of a space of possibilities plays an important role in DeLanda's work.

Every system may develop along more than one trajectory. It possesses multiple potential futures. The trajectory that is realized depends on history, chance events, internal constraints, and external impacts.

This idea is especially important for military contamination. After war, a territory does not have only one possible future.

- It may continue to degrade.
- It may recover partially.
- It may shift into a new stable state.
- It may become a source of long-term risks.
- It may be technically cleaned while retaining altered environmental dynamics.
- It may be returned to economic use too early, thereby creating new consequences for people.

War does not merely destroy the previous state of a territory. It changes the space of its future possibilities. Restoration therefore cannot be understood as a simple return to the past.

It is necessary to determine which trajectories became possible after the war and which of them are dangerous, acceptable, or desirable.

Nonlinearity and the Reconfiguration of an Assemblage

Assemblage theory connects well with the concepts of complexity.

If a system consists of many interconnected elements, a change in one element may reorganize the entire configuration. This is especially evident in natural systems.

- A small change in the water regime may alter the condition of soils.
- Changes in soils may affect vegetation.
- Changes in vegetation may alter erosion processes.
- Changes in erosion may affect the transport of contaminants.

A chain of consequences emerges. Military contamination often operates in precisely this way. It does not merely add a harmful substance to a system. It may reorganize relations among the elements. Changes in those relations may be more important than changes in the individual components themselves.

The Epistemological Significance of Assemblage Theory

For the purposes of this lecture, assemblage theory is important not only as a description of complex systems. It is also important epistemologically. It helps explain why military contamination is difficult to describe within the boundaries of a single discipline.

The object is interdisciplinary not merely in an external or administrative sense, but by its very nature.

- It consists of heterogeneous elements.
- It forms at the intersection of different processes.
- It changes through time.

- It has no single fixed essence.

It therefore cannot be fully understood only chemically, only ecologically, only medically, or only politically. An approach is needed that can hold the heterogeneity of the object together. Assemblage theory provides one possible language for such a description.

Interim Conclusion

Assemblage theory makes it possible to understand military contamination as a dynamic configuration of natural, technical, chemical, biological, and social elements. This approach shows that military contamination is not merely an external impact on nature. Once it emerges, it becomes incorporated into natural processes and becomes part of new assemblages.

The consequences of war therefore cannot be understood only as damage. They must also be understood as a reconfiguration of relations, processes, and possibilities for territorial development.

The next step is the transition toward a morphogenetic epistemology. If military contamination forms new assemblages and new trajectories of development, the central question becomes the following: what kind of scientific knowledge can understand not only completed objects but also the processes through which new forms arise?

16. Toward a Morphogenetic Epistemology

We can now turn to one of the principal concluding concepts of this lecture. This is the concept of morphogenetic epistemology.

The term may sound unfamiliar. It should therefore be explained carefully. Epistemology studies the conditions, forms, and limits of scientific knowledge. It asks:

- How does knowledge arise?
- How do observations become scientific facts?
- How are facts connected within models?
- How do models become theories?
- How does the scientific community distinguish justified knowledge from accidental opinion?

Classical epistemology often focuses on how we know objects that already exist. There is an object. There is a researcher. There is a method. There is an observation. There is a theory.

For complex natural and natural-anthropogenic processes, however, this scheme is incomplete. The object itself does not always exist as something ready-made, stable, and complete.

- It may be forming.
- It may be changing.
- It may be in a process of becoming.

This is where the need for morphogenetic epistemology arises.

What Is Morphogenetic Epistemology?

Morphogenetic epistemology is an approach to scientific knowledge that focuses not only on the description of completed objects but also on the processes through which new forms arise.

It asks not only: What exists?

It also asks:

- How did it arise?
- Which processes formed it?
- Which mechanisms sustain this form?
- Which conditions may alter its further development?

This is especially important for the study of military contamination. Military contamination is not a ready-made object. It emerges. It develops. It changes natural systems. It creates new ecological states. It reorganizes relations among natural, technical, and social elements. It therefore cannot be studied only as a set of consequences that already exist. The process through which those consequences arise must also be studied.

From Knowledge of Things to Knowledge of Becoming

Classical science often sought to describe stable objects.

- Soil.
- A river.
- A forest.
- A landscape.
- An ecosystem.
- A contaminated territory.

Contemporary science increasingly recognizes, however, that many such objects are temporary results of processes.

- Soil does not merely exist; it forms.
- A river does not merely exist; it forms its channel and is simultaneously formed by its basin.
- An ecosystem does not merely exist; it is sustained by a multiplicity of interactions.
- A territory contaminated by war is not simply a plot of land containing harmful substances; it is a system in the process of becoming.

Chemical reactions, the migration of substances, biological changes, social decisions, technical interventions, and new risks continue within that system. Knowledge of military contamination must therefore be knowledge of becoming.

This does not eliminate measurement. It does not eliminate laboratory analysis. It does not eliminate maps of contamination. All of these must be included within a broader question: what process is taking shape before us?

Between the Individual Event and the Universal Law

Morphogenetic epistemology is especially important because it operates at an intermediate level between an individual event and a universal law. An individual event explains nothing by itself. For example:

- a dam is destroyed;
- an explosion occurs;
- an industrial facility burns;
- soil is contaminated;
- a toxic substance is detected;
- a water regime is disrupted.

Each event is important. By itself, however, it does not yet provide an understanding of the process. Universal laws of physics, chemistry, or biology are also insufficient. They are necessary, but they do not explain the entire concrete historical situation. The same chemical substances may behave differently in different soils. Similar destruction may have different consequences in different water systems. The same type of military impact may produce different ecological trajectories in different landscapes. Explanation must therefore identify an intermediate level. This is the level of generative mechanisms.

Generative Mechanisms

A generative mechanism is not a single cause. It is a set of interactions capable of producing a particular type of form or process. In ordinary natural systems, examples include:

- soil formation;
- erosion;
- sediment accumulation;
- channel dynamics;
- revegetation of disturbed land;
- self-organization of biological communities.

In the case of military contamination, generative mechanisms are more complex. They arise at the intersection of human intervention and natural processes. Examples include:

- the migration of contaminants after military or industrial infrastructure is destroyed;
- changes in soil processes following explosions, fires, and mechanical disturbance of the surface;
- the formation of new technogenic micro-landscapes;
- the reorganization of water exchange after hydraulic structures are destroyed;
- changes in ecological relationships caused by the prolonged presence of toxic substances;
- the formation of new health risks through water, soil, food chains, and dust.

Scientific explanation must therefore ask not only what happened. It must ask which mechanism is capable of generating the observed form of consequences. This is the transition toward morphogenetic thinking.

Why This Matters in Practice

A question may arise: is this not excessively theoretical? No.

Its practical significance appears precisely here. If generative mechanisms are not understood, restoration may be organized incorrectly. The visible surface may be cleaned without understanding the migration of contaminants deeper into the soil profile. Infrastructure may be restored without understanding the altered water regime. The concentration of one substance may be reduced while interactions among several risk factors remain unrecognized. A territory may be declared safe without accounting for the long ecological memory of the process.

Morphogenetic epistemology therefore has direct practical relevance. It helps not only to describe the past but also to understand the future development of a territory.

Military Contamination as a Problem of Future Trajectories

One of the principal errors in research on military contamination is to treat it solely as a problem of the past. A war occurred. Damage was inflicted. The consequences must now be eliminated.

From the perspective of morphogenetic epistemology, however, military contamination is also a problem of the future. The question is not only what has already happened. The question is which processes will continue.

Which substances will migrate?

Which soil processes will change?

Which water systems will become channels for the transport of contamination?

Which ecosystems will be capable of recovery?

Which territories will shift into new stable states?

Which risks to people will appear not immediately but only after years?

Research on military contamination must therefore look not only backward but also forward. It must reconstruct past impacts while simultaneously analyzing possible trajectories of future development.

Epistemology as a Condition of Responsibility

Another important issue appears here. A correct understanding of military contamination is not only a scientific task. It is also a condition of responsibility. If the process is poorly understood, incorrect decisions may follow. The safety of territories may be assessed incorrectly. Restoration may be planned incorrectly. Long-term risks may be underestimated. An illusion of resolution may be created while the process continues to develop.

The question of knowledge is therefore not abstract. It has direct moral, social, and political significance. In the case of military contamination, an error of understanding may be extremely costly. It may affect human health, the fate of territories, agriculture, water resources, and the lives of future generations.

Interim Conclusion

Morphogenetic epistemology proposes that scientific knowledge be understood as knowledge of the emergence, development, and transformation of forms.

For research on military contamination, this means moving from the description of separate consequences toward the analysis of the processes that generate and sustain them.

This approach does not replace empirical research. It gives empirical research a deeper meaning. Soil samples, contamination maps, medical data, environmental observations, and restoration models should all be included within one general question: which new natural-anthropogenic processes were initiated by war, and how will they develop further?

This question may provide the foundation for a special epistemology of military contamination.

17. Conclusions of the First Lecture

We can now draw several preliminary conclusions. They do not close the subject. On the contrary, they open the way for further work. This lecture did not seek to provide a complete theory of military contamination. That would be both impossible and premature.

Its task was different. It was necessary to show that research on military contamination requires a deeper epistemological formulation of the problem. Military contamination cannot be understood only as a set of consequences of war. It cannot be reduced solely to contaminated soils, destroyed infrastructure, toxic substances, health risks, or the cost of restoration.

All of these aspects are important. Taken together, however, they still do not provide an understanding of the process. The central conclusion is that military contamination should be understood as a distinct natural-anthropogenic process. It is initiated by humans, but once it emerges, it develops through interaction with natural systems. This is what makes it an exceptionally complex object of study.

First Conclusion: Individual Cases Are Necessary but Insufficient

Research always begins with concrete cases. Science is impossible without them. Specific wars, territories, contaminants, consequences for human health, and changes in the natural environment must all be studied. The description of individual cases, however, should not become the final goal. If science limits itself to the case, it creates an archive. Such an archive may be important. It is not yet understanding. It is necessary to move from a multitude of cases toward analysis of the process. This is the first fundamental task of research on military contamination.

Second Conclusion: The Accumulation of Data Does Not Guarantee Understanding

Contemporary science can produce enormous volumes of data. Data, however, do not create theory by themselves. Thousands of soil samples may be collected. Numerous maps may be constructed. Dozens of reports may be written. International databases may be established. None of this guarantees an understanding of the morphology of military contamination. Understanding requires concepts, models, theoretical frameworks, and the ability to recognize connections among events. For this reason, the problem of military contamination is not only a problem of funding. Funding is necessary. Scientific knowledge at this level, however, cannot simply be purchased.

Third Conclusion: The Morphology of Military Contamination Must Become an Independent Object of Study

The morphology of military contamination is not the external shape of a single object. It is the form of organization of a process. It appears in the ways military activity interacts with soils, waters, landscapes, biota, climate, infrastructure, and social decisions. This morphology is not immediately given. It must be identified. It develops through the comparison of cases, the construction of models, the criticism of concepts, and the development of a theoretical language. Without a transition toward morphology, research on military contamination will remain fragmented.

Fourth Conclusion: Military Contamination Is a Process, Not Only a State

It is important not to think of military contamination only as the condition of a territory after war. Such an approach is too static. Military contamination has a dynamics of its own. It develops. It changes form. It enters new stages. It may continue after military operations have ended. In some cases, the longest phase of its natural and social processing begins only after the war. Research must therefore examine not only what has already happened but also what continues to happen.

Fifth Conclusion: War Not Only Destroys but Also Initiates New Processes

This proposition requires careful interpretation. It does not mean that war can be beneficial. It does not justify war. It does not diminish the destructive consequences of war. The point is different. From a scientific perspective, war is not only an act that destroys existing structures. It may also serve as a trigger for new processes. Those processes may be dangerous, toxic, unstable, and profoundly harmful to people and nature. Nevertheless, they are real. They must be studied. This is where the problem of the morphogenesis of military contamination arises.

Sixth Conclusion: Territorial Restoration Requires an Understanding of the Processes That Have Been Initiated

Post-war restoration is often understood as a return to the previous state. Such a return is not always possible. If war has altered the processes through which a natural system forms, the removal of visible traces of destruction does not solve the problem. Debris can be removed. The surface can be cleaned. Buildings can be restored. Land can formally be returned to economic use. If contaminants continue to migrate, the water regime has changed, the soil system has been damaged, or a new ecological trajectory has emerged, however, restoration remains incomplete. Restoration must therefore rely not only on technical solutions but also on an understanding of the post-war morphogenesis of the territory.

Seventh Conclusion: Military Contamination Is Interdisciplinary by Its Nature

Military contamination cannot be fully understood within a single discipline. Chemistry sees substances. Toxicology sees effects on organisms. Medicine sees consequences for health. Ecology sees changes in living systems. Hydrology sees water movement and contaminant transport. Soil science sees the transformation of soil processes. Geography sees spatial organization. The social sciences see decisions, institutions, and human behavior. The philosophy of science helps explain how knowledge can emerge from all of these perspectives. No single discipline, however, exhausts the entire object. Military contamination is a complex assemblage of natural, technical, social, and historical processes.

Eighth Conclusion: The Contemporary Scientific Community Itself Requires Critical Analysis

It cannot be assumed that the scientific community always moves easily and rapidly toward new forms of understanding. Scientific communities possess their own traditions, interests, methods, institutional limitations, and forms of resistance to the new. The situation is especially complex in the case of military contamination. Science does not merely study the consequences of war. Part of the scientific-technological complex participates in the creation of military technologies that later become sources of new forms of contamination. Research on military contamination therefore requires not only analysis of the object but also analysis of the conditions under which knowledge of that object is produced.

Ninth Conclusion: A Special Epistemology of Military Contamination Is Required

The principal result of the lecture can be formulated as follows. Research on military contamination requires its own epistemological foundation. This does not mean creating an artificial new discipline merely for the sake of a name. It means connecting fragmented investigations within a unified system of understanding. Such an epistemology should explain:

- how individual cases become elements of knowledge;
- how data become models;
- how models make it possible to identify the morphology of a process;
- how the emergence of new ecological states should be understood;
- how nonlinearity, complexity, and emergence should be taken into account;
- how natural, technical, and social aspects should be connected;

- how to avoid the illusion that funding by itself creates understanding.

Tenth Conclusion: The First Task Is to Understand the Problem Correctly

Research on military contamination often seeks to move immediately toward practical solutions. This is understandable. Territories have been destroyed. People have suffered. Soils and waters have been contaminated. Restoration is necessary. Premature action without understanding, however, may lead to errors. The first task is therefore to formulate the problem correctly. It is necessary to understand what kind of object is being studied. If it is merely a collection of contaminated sites, a technical approach may be sufficient. If it is an evolving natural-anthropogenic process, a much more complex research program is required. The second interpretation appears more adequate.

Conclusion

Military contamination is one of the most complex problems of the contemporary world. It lies at the intersection of war, science, nature, technology, politics, economics, and human health. It cannot be understood through individual cases alone.

It cannot be understood through chemical indicators alone. It cannot be understood through damage assessment alone. It must be understood as a process. That process has a morphology. It has a morphogenesis. It develops within complex systems. It creates new assemblages. It changes the space of future possibilities available to territories.

Research on military contamination therefore requires not only funding, laboratories, and projects. It requires a new level of understanding. This lecture is only a first step. It does not conclude the subject. It establishes a foundation for the subsequent lecture series.

Future unread lectures should examine specific types of military contamination, the forms of their morphology, methods of modelling, the characteristics of post-war restoration, and the new concepts required to study military contamination as an independent class of natural-anthropogenic processes.

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