Programme Thesis

Accelerated adaptation

v0.4

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CONTEXT

This document presents **A DRAFT** of the core thesis underpinning a programme that is currently in development at ARIA. We share an early formulation and invite you to provide feedback to help us refine our thinking.

This is not a funding opportunity, but in most cases will lead to one — sign up **here** to learn about any funding opportunities derived or adapted from this programme formulation.

An ARIA programme seeks to unlock a scientific or technical capability that

+ changes the perception of what's possible or valuable
+ has the potential to catalyse massive social and economic returns
+ is unlikely to be achieved without ARIA's intervention.

Pending approval, we aim to launch a funding call for projects within this programme in February 2026 (tentative budget £50m). A call for Opportunity Seeds outside this programme will close 2nd February.

PROGRAMME THESIS, SIMPLY STATED

An overview of the programme thesis, accessible & simply stated

Over 25% of assessed animals and plants risk extinction within a century [1]. This potentially cataclysmic loss is shaped by the rapid acceleration of human-driven changes in land use, movement of species and their pathogens, pollution, and climate change. Indeed, our activities create **environmental pressures that now exceed the abilities of many species and ecosystems to adapt** sufficiently to persist [2], and we have surpassed seven of nine proposed biophysical limits linked to stable life on Earth [3]. These environmental changes put under existential threat the irreplaceable benefits every nation needs from nature [4], including pest control, carbon sequestration, clean water, and the production of food and materials [5].

Nature conservation typically focuses on protecting habitats. Such efforts, and those to reverse environmental pressures, are unlikely to be able to scale at the pace needed to prevent breakdown of our ecosystems and the services they provide. Furthermore, traditional nature protection has often been unable to consider the mechanistic bases of an ecosystem's resilience – in particular the interacting genetic, epigenetic, and environmental effects on behaviour, physiology, and symbiosis that are key to species' survival in new conditions. Genomics, assisted selection, and biotechnology have transformed agriculture and human health, but have rarely been applied to wild species [6,7]. We thus lack the tools needed to accelerate adaptation and help vulnerable populations acquire beneficial traits, to prepare them for known challenges, or to build resilience to less predictable environments.

Recent advances in high-throughput genomics, precision biology, robotics, and AI are converging, unlocking a new pathway that can complement and enhance traditional nature stewardship approaches. We can now identify molecular bases for vulnerabilities, rear species and measure phenotypes, and develop interventions that work alongside or accelerate natural processes of adaptation.

This ARIA programme aims to create the tools for accelerated adaptation in wild species and ecosystems and to deliver example case studies in confined settings. To achieve this, we will unite cross-disciplinary teams of experts in ecology, evolution, biological engineering, conservation, robotics, and AI. Applications could focus on strategically chosen vulnerable species, such as English oak [8], which support hundreds of other species [8], and/or critical functional groups such as pollinators or soil nutrient cycles that underpin ecosystem services [9].

Alongside technical research, we will incorporate ethical and governance dimensions from the outset. While this programme will not deploy novel interventions in the wild, the research conducted under this framework has the power to transform conservation and ecological engineering approaches, expanding traditional stewardship with proactive genetic, physiological and functional tools. Ultimately, this programme will help create a future where both humanity and biodiversity can persist and flourish.

This programme thesis is derived from ARIA's Engineering Ecosystem Resilience opportunity space.

PROGRAMME THESIS, EXPLAINED

A detailed description of the programme thesis, presented for constructive feedback

Why this programme

Nature's services and resources are essential to our existence. Our relationship with natural living systems has historically been extractive. Until now, the intrinsic resilience of species and ecosystems has enabled them to respond and continue to provide for our needs.

However, the environmental challenges we see today are substantially more acute and diverse than in the past, now outpacing nature's ability to buffer, adapt, or evolve. Indeed, seven of nine biophysical thresholds associated with stable life on Earth during the Holocene have now been crossed—four in just the past 15 years [3]. Over 25% of assessed animals and plants are at risk of extinction over the next 10–100 years [10], creating widespread dangers that span biomes and raising the risk of cascading collapses, where small-scale losses can lead to large-scale unravelling of ecosystems as we know them [11].

The accelerating pace and scale of biodiversity loss threaten our way of life. Over half of global GDP depends on ecosystem services and the natural systems that generate many of these services are under severe threat [5,12]. For example, pollinator decline alone puts ~£630 million of annual UK crop production at risk [13], predator insects annually contribute at least £145 million pounds to producers of three key UK crops annually by consuming pests [14]—global extensions of such **threats to agricultural ecosystem services undermine food sovereignty** worldwide [9]. Furthermore, most medicines originate from plant compounds [15], meaning that preserving biodiversity keeps future bioactive drugs discoverable [16]. Wild spaces and the plants, animals, and fungi they contain are also vital for mental health and wellbeing, cultural identity, and have intrinsic value [17,18]. Both moral imperatives and practical necessity compel us to preserve Earth's living heritage and maintain ecosystem function [18].

Humanity's most urgent challenge is thus to halt and reverse human-controlled drivers of detrimental environmental change. Large scale interventions such as restoring natural landscapes, transitioning from agricultural monocultures, curtailing use of pesticides and fertilisers, eliminating plastic and chemical pollution, reducing the international movement of plants, animals, and their pathogens, and restoring atmospheric greenhouse gas concentrations to pre-industrial levels are all crucial to alleviate the pressures facing our ecosystems. The realisation by World Economic Forum leaders that over the next 10 years, four of the top five global risks are environmental [5] supports our perspective that we now need radical and proactive programmes to support nature.

Nature does know best. But the pace of environmental change today by far exceeds nature's abilities to adapt, and could even push biological systems into counterproductive and ultimately maladaptive changes. Thus a mantra of "let nature be" is impossible (we don't do that now), but more concretely is a risky and potentially unethical form of inaction.

We pragmatically recognise that the large-scale transformations required to reverse environmental pressures are unlikely to materialise fast enough to halt ongoing losses. Species losses and degradation of ecosystem functions will thus continue, increasing risks of cascading disruption, unless we undertake targeted interventions.

Recent technological breakthroughs offer a pathway that complements direct conservation and policy efforts—accelerated adaptation—which can significantly reduce the risk of ecosystem collapse even as environmental conditions continue to shift. In alignment with ARIA's mandate to advance science and technology "at the edge of the possible", this programme seeks to explore what is necessary to develop and harness this compelling parallel approach. Research on new interventions will occur exclusively in controlled laboratory settings and contained environments. By responsibly applying accelerated adaptation under robust governance, ethical oversight, and appropriate social licence, we can forge a more mutualistic relationship with nature while efforts continue to slow and ultimately reverse the underlying drivers of decline.

Accelerated adaptation is now within reach

Recent scientific and technological progress across multiple disciplines has converged to enable accelerated adaptation to become a reality:

+ **Commoditisation of robotics + hardware + electronic engineering**
  Custom incubators + growth chambers, and robots to automate handling can now be created at scale, enabling high-throughput experiments to screen, prime, or select for adaptations in individual species or communities.
+ **High-throughput genomics**
  Genome-wide study is now possible in almost any species, revealing vulnerabilities and potentially guiding breeding and assisted gene flow efforts. Fundamental genomics research has clarified the constraints and trade-offs that shape adaptation and evolutionary innovation [19,20].
+ **Precision molecular + cellular biology**
  Peptides, hormones, RNAs, vaccines, probiotics and transient viral vectors enable targeted yet reversible and non-heritable interventions. Molecular and cell-culture approaches enable enhanced micropropagation, grafting, and breeding to support populations at scale. Targeted heritable alterations (e.g., gene editing) offer new research pathways for candidate traits.
+ **Artificial intelligence + machine learning**
  New AI/ML techniques enable rapid analysis and synthesis of existing literature and novel datasets, which previously would have been infeasible or required substantial labour by human experts. The ability to detect previously hidden patterns can enable new decision-making approaches.
+ **Ecosystem sensing + modelling**
  New sensor technologies provide high-resolution near-real-time data on biodiversity and ecosystem dynamics. These data enable direct measurement or inference of traits and functions, facilitate new modelling paradigms, and ultimately create the ability to better predict ecosystem responses to potential interventions and identify high-leverage points for maximising resilience benefits.

Key assumptions and framing

+ Many critical ecosystem functions are delivered by assemblages, not individual species (pollination, carbon sequestration, soil health…).
+ Ecosystems are composite networks of interdependent species and abiotic conditions, with uneven levels of connectedness and redundancy. Disruption to highly connected species or to critical functions can trigger cascading losses.
+ Assemblages of species that have long co-existed provide more resilient foundations than those involving species that are new to an ecosystem.
+ Every species loss constitutes a reduction in overall resilience and a loss of deep evolutionary history.
+ For most species, we still lack basic knowledge of needs, interactions, and adaptive capacity within and across generations. This creates substantial challenges to predicting responses to environmental changes.
+ All models have blind spots: satellite-data models are species-blind, ecosystem-level models are blind to evolution and genetics, evolutionary models are blind to ecological complexity and often disconnected from empirical data estimation.
+ Not all species can move to more suitable environments fast enough (trees…); some may struggle even if moved (due to difficulty in local adaptation, competition for niches/nesting sites…), or have multiple requirements (e.g., breeding vs overwintering locations).

+ Techno-optimists argue that 50 to 200 years from now, limitless renewable energy will have resolved challenges related to greenhouse gases, that dense vertical farming will have freed most of our land for rewilding, and that the other major environmental pressures will similarly have been reversed. If one accepts these utopian views, the remaining challenge is to keep as many species alive and ecosystems functional as possible until then. If these utopian predictions fail to materialise, this programme is even more essential.

What we hope to accomplish: Accelerating adaptation for resilience

This ARIA programme seeks to unlock the capability of dramatically accelerating the adaptation of non-domesticated species to new environmental conditions. The resulting transformative paradigm for conservation and ecological engineering will complement traditional environmental protection and stewardship strategies. By accelerating adaptation of key ecosystem members or functions, we aim to help preserve ecological interactions and maintain or recover important functions and services despite environmental changes.

Application contexts for this capability include:

+ **Preservation of species that many other species rely on** for food, habitat, or both, such as trees or reef-building corals, which have long generation times and cannot disperse or otherwise handle dramatic changes in seasonal environmental extremes. For example, some tree species support over 1,000 other species [8], but are vulnerable to anticipated climatic changes [21]. Pre-adapting such species to known threats could help preserve local species assemblages and thus help maintain ecological resilience.
+ **Preservation of priority functional groups** such as pollinators, soil nutrient cyclers, or predators facing diverse challenges such as habitat fragmentation and exposure to pollutants. Accelerated adaptation of the species contributing to a functional group could ensure critical ecosystem functions persist under stress, providing cascading benefits across the communities of species they interact with.
+ **Post-disturbance recovery.** Acute disturbances including deforestation, pollution, storms, heatwaves, wildfires, and disease outbreaks can significantly destabilise local ecosystems. Accelerating the ability of key pioneer functional groups, such as bioremediating fungi or soil-binding plants, to rapidly establish and function under post-disturbance stress could significantly boost natural regeneration and the recovery of ecosystem functions and resilience.
+ **Supporting strategically selected at risk species** (e.g., those with cultural significance). Enhancing population viability by facilitating appropriate adaptation of characteristics such as fertility, genetic diversity, movements and their plasticity, or the ability to survive through specific environmental challenges to substantially reduce extinction risks.

Species and ecosystems can be supported through diverse interventions that vary in technological sophistication, risk, cost, ethical complexity, and controversy. Traditional conservation approaches are essential. They complement the aims of this programme, which focuses on "edge of the possible" research [22] where transformative impact is possible but tools are lacking.

Two major directions of technical innovation can enable accelerated adaptation. The relevance and feasibility of the two directions, and the whether both are needed, varies across study systems:

1) **Supercharged natural adaptation.** This can include assisted migration, breeding, fertilisation or hybridisation. It can include physiological priming through controlled exposure to environmental challenges (e.g., chemicals, future climatic conditions, inactivated pests/pathogens) which may lead to epigenetic or microbiome-level changes. It can include directed evolution under exposure to environmental challenges, and may use tricks such as shortened days, altered seasons, grafting, hormonal treatment, or *in vitro* gametogenesis to reduce generation times.
2) **Engineered molecular adaptation.** This can involve temporary changes to an organism, for example through injections or topical applications of RNA or peptides, the use of cell lines, or manipulating symbionts to achieve a particular goal (e.g., enhancing near-term survival, reproduction, or growth). Heritable genome modification can also be considered.

By responsibly applying accelerated adaptation under robust governance, ethical oversight, and appropriate social licence, we could reverse our extractive approach and forge a mutualistic relationship with nature, while simultaneously working to slow, and ultimately reverse, the underlying drivers of biodiversity decline.

What we expect to fund

To develop the capability of accelerating adaptation of wild species at scale, we will fund three types of teams:

+ **System-focused teams** that will aim to increase resilience of their study system or the ecosystems it contributes to,
+ **Platform-focused teams** that will support system-focused teams and build capabilities essential for scaling the newly developed approaches, and
+ **Theory & modelling-focused teams** that will help ensure judicious application of accelerated adaptation capabilities.

System-focused teams are the core of our programme. A study system might be a single, highly connected species where cascading functional benefits are likely. Alternatively, a study system may be a group of species that are related functionally (e.g., pollinators, soil nutrient cyclers, insect predators), taxonomically, or ecologically (e.g., grassland). It may also be that a study system has cultural value. We anticipate funding teams working on complementary systems that aim to protect or enhance function delivery under known or unknown environmental changes.

These teams should:

+ Use existing evidence to explain why their chosen system should be prioritised, with a focus on its functional importance and ecological/community context.
+ Embed social, ethical, and governance considerations from day one, including stakeholder engagement and social-license assessment.

These teams may:

+ Need to identify the genetic basis of vulnerability, and/or determine whether the target function needs directional support in the face of specific environmental challenges (e.g., specific climatic condition, pollutant, pathogen, or parasite), or more generic support to become more resilient to perturbations in general (e.g., through increased fertility, genetic diversity, recombination rates, broader immune defences, or plasticity).
+ Focus on accelerated natural processes or engineered molecular adaptation, or combine both.
+ Propose multi-species designs when functions depend on multiple species.

We will consider any well-justified study system and can fund worldwide. However, we will prioritise systems with strong relevance to the UK, systems with clear diagnosable vulnerabilities, and systems in which measurable progress on the pathway towards success or failure is feasible within two years. Traditional conservation approaches are utterly central to strengthening ecosystem resilience, but are out of scope. While there is much potential for new technologies to reduce the impact of invasive or pest species, direct work on invasive-species is out of scope. Similarly, while genetic rescue efforts are within the scope of this programme, efforts to revive long-extinct species are not [23].

Annex 1 provides a speculative list of example ideas we would consider to be within scope. These are not requests; the examples aim to stimulate creativity by illustrating a breadth of possible approaches.

We expect **System-focused teams** to achieve specific targets:

+ **Meeting metrics for increased resilience**
  Teams must aim to achieve demonstrable increases in resilience using one of the three metrics below, or a justifiable alternative. Measurement capabilities may in some cases need to be developed. By default, teams should target outcomes that exceed nature's best-case, i.e., ≥99th percentile of unaided natural processes under matched stress scenarios.

    - **Improved function**: Examples: increased survival, growth, or fecundity, or faster recovery under or after stress.
    - **Increase in indicators of adaptability**: Examples: increased effective population size or related genetic metrics.
    - **Improved robustness of ecological function**: Rescue or maintenance of ecosystem service provision under conditions of environmental stress. Examples: pollination, predation ability, carbon sequestration, pest control.
+ **Demonstrating sufficient persistence**: System-focused impacts should remain useful without excessive fitness costs over ecologically relevant timescales. While benefits should be long-term, the mechanisms to obtain them may be temporary.
+ **Exhibiting scalability:** Newly developed protocols should be applicable across sites, populations, species, and ideally systems.
+ **Identifying milestones + risks**: Teams will provide clear metrics and quarterly milestones for tracking project progress. Plans will list early warning signs of failure and identify potential risks, including those that should trigger project cessation.

Platform-focused teams. System-focused teams may include the collaborators and/or service suppliers that cover all project needs. However, we will also support purely platform-focused teams across several aims:

+ To support system-focused teams, by developing solutions and expertise that can be shared across systems during the programme.
+ To synthesise learnings from across different systems.
+ To reduce redundancy across teams and increase efficiency of systems-focused teams.
+ To enable scaling developed approaches during the programme, and for post-programme success and impact.
+ To independently verify claims of system-focussed projects through standardised approaches and metrics.

Platform-focused teams may be new or existing entities including core facilities, contract research organisations, design studios, research labs, frontier research contractors [24], or collaborations among diverse entities. Platform-focused teams will focus on scalable delivery of one or more of the following:

+ Genomic vulnerability mapping + molecular engineering (including cell culture, in-vitro phenotyping, design and synthesis of RNA, vectors, peptides or proteins, performing gene edits, creating transgenic lines).
+ Automatic rearing + phenotyping. This includes:
    + Robotics for automated rearing in climate-controlled conditions (e.g., incubators, ecotrons, climate-temperature chambers/vivaria/terraria).
    + Sensors and algorithms for automated phenotyping of plants and animals.
+ Ethics, governance, stakeholder engagement, and systemic risk assessment (participatory methods, multi-criteria mapping, social-license frameworks). Platform-focused teams in this area should answer the question: how will the new capability be harnessed and regulated?
+ Impact catalysis. This involves integration and synthesis across all teams during the last 18 months of the programme, to ensure that discoveries, tools, and insights translate into tangible outcomes (workshop convening, engaging and establishing partnerships with government, NGOs, investors).

Theory or modelling-focused teams. Given limited resources, we will need to improve our ability to identify priority functions, species, and communities where support can be the most impactful, to understand how to trade off different manners of supporting them, and to understand which levels of support are sufficient. For example, what level of genetic diversity + gene flow is needed and when? What are the impacts and risks of different interventions on resilience? We anticipate that a combination of empirical work with theoretical, simulation or modelling efforts can help improve that prioritisation. New models may focus on one level (e.g., genetic diversity), or span levels (genes-species-ecosystems). Empirical studies could involve large-sample-size studies with particularly tractable empirical systems, or piggy-back off natural or incidental experiments.

Cross-team collaboration

The long-term success and impact of this programme depends critically on dynamic collaboration among teams. We will strive to attain the outcomes of existing best practices for collaboration and data sharing (e.g., SORTEE [25], FAIR [26]). Where possible, we expect:

+ **Shared standards and metrics** to be developed collaboratively and adopted programme-wide.
+ **Code** to follow best practices in software engineering for reuse and reliability.
+ **Rapid sharing** with data approaches, protocols, and analytical frameworks to flow between teams. Successful and unsuccessful approaches in one system should inform and improve interventions in others.
+ **Integrated ethical oversight** with governance frameworks to be co-developed across teams.

These sharing and centralisation approaches will be coordinated by representatives of the platform teams.

Success criteria

By programme end, we expect to demonstrate:

+ **Generalisability indicated by** measurably increased resilience in at least two distinct study systems, with persistence across an ecologically relevant or representative timescale (e.g., ≥ 3-5 generations for short-lived organisms) under simulated stress.
+ **Scalable infrastructure indicated by** platform tools adopted and validated across multiple teams, and development of relevant ethical + governance toolkits. Stretch goal: clear financial and technical pathways towards real-world deployment.
+ **Regulatory pathway development indicated by meaningful progress toward new frameworks or revision of established frameworks.** Current regulations largely address domesticated species and omit many of the approaches and outcomes we discuss, including assisted migration, hybridisation, physiological/epigenetic priming, release of populations of wild species after directed evolution, or resilience-focused ecosystem modification. As part of ensuring that appropriate regulation and governance exist, we aim for constructive engagement with relevant UK pathways (e.g., Genetic Technology Act for plants; ACRE guidance on precision breeding), and international organisations (e.g., IUCN) and we aim to produce white papers outlining options for wild systems in both controlled and real-world settings. Stretch goal: draft guidance accepted.
+ **Ecosystem impact indicated by demonstrated functional benefits in confined space** that are due to increased resilience focal system(s). Stretch goal: demonstrate community-level functional benefits in a large contained mesocosm/greenhouse with local stakeholder support and interest in real-world deployment.

Ethics

Interventions in wild populations raise profound ethical questions that cannot be resolved through technical excellence alone. This programme recognises multiple, sometimes conflicting, value systems: the intrinsic worth of species, their cultural significance, ecosystem integrity, and human dependencies on nature's services. We will combine clear guardrails with built-in ethical considerations, and independent oversight.

Each funded team must include ethics expertise from the outset.

The cross-cutting platform team focused on ethics, governance and stakeholder engagement will ensure learnings are shared across all funded teams.

We will create an **independent external ethical oversight council**, including diverse stakeholder representatives (UK + overseas, academia, industry, charities, statutory corporations, government). This council will report to the programme director and ARIA management ahead of funding and at key go/no-go decision points. The council's function is to assure that all research and implementation of this work is ethically sound, has minimal risk, benefits society equitably, and achieves the desired aims of this programme.

Guardrails (during the programme)

+ All work within this programme's timeframe will be performed in **self-contained controlled facilities**—laboratories, climate chambers, ecotrons, glasshouses, or mesocosms. This confinement allows us to develop and test interventions while limiting risks to real-world environments.
+ No releases to the wild will occur during the funding period.
+ Nonetheless, teams must still design work with eventual real-world application in mind, ensuring their research trajectory aligns with principles and standards that would govern any future deployment.

Ethical principles

We acknowledge that ethics are not static—what is acceptable may shift as evidence accumulates and public discourse evolves. Nevertheless, all projects must adhere to the following principles, both for the research they do in contained facilities during the programme and in planning for potential future real-world deployment:

Precaution and reversibility: Teams must demonstrate that **inaction carries greater risk than intervention**, particularly where irreversibility is inherent to an approach. Risk assessments must consider both the immediate ecosystem and effects on longer temporal scales (e.g., 50+ years / 10+ generations). Teams must identify early warning indicators (unexpected population dynamics, range expansion beyond target areas, non-target species declines) that would trigger suspension or reversal of an intervention.

Ecosystem integrity: Interventions must assess and mitigate risks of harm to non-target species and ecosystem function, including:

+ Possibility of loss of genetic diversity or locally adapted alleles within target species, which could make the species more vulnerable to other environmental challenges.
+ Risk that enhanced resilience enables a target species to outcompete other native species, converting a vulnerable species into a pest.
+ Possibility that changes in the abundance or chemical composition of one species may affect others in the trophic cascade.
+ Risk that increased population size or range could increase the likelihood of disease transmission to other species.

Transparency, consent and social license: Research that may eventually affect specific ecosystems requires meaningful engagement with local communities, indigenous peoples where relevant, and other stakeholders—even for contained/conceptual work that may only eventually affect those ecosystems years later. Teams must explain how their work will influence society. Teams must secure social license beyond regulatory compliance, acknowledging that some interventions may be technically feasible yet ethically or socially unacceptable.

Equitable access: Every team will explain how their work will influence society, and how its benefits will be distributed equitably.

Responsible development: Techniques developed here could be misapplied to disrupt ecosystems or enhance pest species. Teams must consider misuse potential and propose safeguards.

Non-maleficence: No project may aim to increase extinction risk, reduce genetic diversity without compelling justification, or knowingly harm non-target species. Teams must explicitly consider worst-case scenarios.

Governance

Robust governance is essential to ensure responsible development and deployment of accelerated adaptation capabilities. Our governance framework operates at three levels:

Each project-level team must:

+ Establish a stakeholder advisory group including conservation practitioners, local community representatives, and domain experts.
+ Conduct risk assessments that explicitly model unintended consequences (ecological, evolutionary, social).
+ Implement staged decision-making with defined go/no-go criteria at each phase.
+ Maintain public registries of interventions, including negative results.

At the programme level, ARIA will:

+ Convene an independent external ethical oversight council including ethicists, indigenous knowledge holders, conservation biologists, regulatory experts, and social scientists.
+ Require cross-team review of high-risk interventions.
+ Commission independent assessments of programme-level risks and benefits.

Furthermore, we will proactively engage with:

+ UK regulators, government agencies, public bodies and stakeholder representatives (including JNCC, SEPA, DEFRA, Environment Agencies, ACRE and other devolved administrations and public bodies) to explore pathways for contained trials and eventual deployment.
+ International bodies (e.g., IUCN) to align with emerging guidance on interventions in conservation.

Our platform teams focusing on ethics and governance will lead development of white papers on these governance gaps and work with regulators to propose frameworks.

Governance structures will evolve as we learn. Annual reviews will assess whether our frameworks remain fit-for-purpose, and we will adjust in response to emerging evidence or stakeholder concerns.

Safety and compliance

All funded work must be aligned with applicable international and UK frameworks.

No real-world releases of supported organisms will occur during this programme. All work will be carried out under contained and controlled conditions with institutional oversight and, where applicable, the GMO (Contained Use) Regulations 2014—noting that GMO rules will only apply in some cases depending on the organism and activity. Day-to-day compliance will follow ASPA/3Rs, Nagoya ABS, CITES, the Wildlife and Countryside Act 1981 (including relevant licensing and conservation-translocation codes), and the appropriate UK regimes for chemicals/products (PPP, BPR, VMR, UK REACH), with environmental protection agency permits where relevant. Beyond this programme's funding term, if downstream translation involves environmental release or transboundary movement, teams would then enter the newly developed frameworks, and established regulatory pathways.

Application process, stage gating + financial structure

This draft programme thesis is a science-focused component of the ARIA programme approval process. We very much welcome commentary and constructive critique & feedback that can help us to improve and revise this document.

If programme funding is approved—hopefully late January 2026—we will follow ARIA's standard solicitation process [https://www.aria.org.uk/funding-opportunities/applicant-guidance]. After review of concept-papers of full proposals, we may request changes to team composition or proposal scope.

To align risk and ambition levels with ARIA's mandate, only some of the teams that begin the programme will continue for the full four years. We will initially fund teams for 12-24 months (depending on team type), and subsequently provide follow-on funding to the teams with the most promising progress (Table 1).

Table 1) *Sample funding structure showing approximate team numbers, phasing, and stage-gates. Project costs are averages, and team counts per stage are illustrative rather than targets. Example here: eight systems-focused teams start across six systems; after two years, four receive additional funding. Teams can engage external contractors, consultants, or lab space to accelerate progress when internal capacity is limited or recruitment delays risk slowing delivery.*

Team type	Team number	Year 1	Year 2	Year 3	Year 4	Stage 1 Costs (m)	Stage 2 Costs (m)
Systems-focused	1	System A				£16	£18
	2	System A					
	3	System B					
	4	System C					
	5	System D					
	6	System D					
	7	System E					
	8	System F		System F ++			
Platform-focused	9	Genomics				£7	£8
	10	Genomics					
	11	Automation					
	12	Automation	Automated rearing + phenotyping				
	13	Ethics, governance + policy					
Modelling - focused	15	Approach i				£4	£5
	16	Approach ii					
	17	Approach iii					
	18	Approach iv					
Impact catalysis	19			Catalysis (6 months)		£0.2	£0.25
	20			Catalysis (6 months)	Catalysis		

Engage

Our next step is to launch a funding opportunity derived or adapted from this programme formulation. Click here to register your interest, or to provide feedback that can help improve this programme thesis.

Success in the programme requires multidisciplinary teams. For groups or individuals needing assistance in building these teams, you can register your capabilities and missing expertise to ARIA's teaming tool via the feedback form linked above, allowing us to support matching with other registered teams.

Intellectual Property and Access

ARIA's standard IP terms will apply to research we fund. To improve access to findings, protocols, code and data assets, we do ask recipients to share what they can in an open manner in accordance with their organisational structure.

What we are still trying to figure out

This is a draft programme thesis. During its development, we have engaged in hundreds of conversations and obtained feedback from diverse stakeholders. However, it remains a draft, and we eagerly invite constructive feedback.

+ Which intellectual-property framework would best support the goal of fostering resilient ecosystems?
+ What financing pathways can sustain the long-term impact of the capabilities developed?
+ What head-turning, high-impact demonstration of accelerated adaptation could we showcase during the programme?
+ Are there situations where release into the wild may be desirable, feasible, and ethically appropriate during the duration of the proposed programme?
+ What constitutes "enough data" to justify intervention?
+ As far as we understand, there is no clear regulatory pathway for release of adapted wild organisms, or with regards to targeted treatments of wild organisms. New regulations should likely be established for such interventions.
+ Similarly, if adaptation (e.g., via forced hybridisation and directional selection) happens in a different country, should the Cartagena Protocol for international movement of genetically modified organisms apply?
+ How should 'acceptable risk' for wild populations or ecosystems be defined?
+ Who should be responsible for, and will fund, the essential, difficult, and expensive long-term monitoring of interventions?
+ How do we define "sufficient" persistence in complex communities and/or long-lived organisms during a short programme?
+ Which factors make particular interventions more or less acceptable to different stakeholders?

Annex 1

The following examples illustrate potential interventions that span two broad modes of innovation. **"Supercharged Natural Adaptation"** approaches harness and intensify processes such as inducing phenotypes through environmental exposure, or selection across generations. In contrast, **"Engineered Molecular Adaptation"** approaches involve direct molecular or genetic modification of the target organism or its biological partners.

These examples are **not proposed projects**, but **thought experiments** designed to provoke discussion about the kinds of interventions that could yield transformative outcomes.

Target System	Approach Type	Intervention	Expected Outcome
English Oak (*Quercus robur*)	Supercharged Natural Adaptation	Place saplings in climate-controlled chambers to projected 2100 conditions (heat, drought, late frosts); select 2% survivors for planting.	Oak trees physiologically primed to future UK climate extremes, and with genetic variants that likely help their ability to cope. These saplings should directly have greater survival chances, and increase the prevalence of alleles useful for survival in the oak genepool.
Dragonflies/ damselflies (*Odonata*)	Supercharged Natural Adaptation	Multi-generation selection in gradient of pesticide concentrations using shortened photoperiods + seasons to accelerate generations.	Increased pesticide-resistance of species that are important predators of agricultural pests [14]
Dung beetles (*Geotrupidae*, *Scarabaeidae*)	Supercharged Natural Adaptation	Multi-generation selection for greater aeration of livestock faeces, fecundity, and persistence in excrement from medically treated livestock (e.g., ivermectin used to treat parasites is toxic to beetle larvae).	Maintain >£360m annual benefit to cattle industry through reduced pests & parasites, and increased soil nutrients [27]. Can decrease methane emissions 10-20% [28] from faeces.
Diverse target plants	Supercharged Natural Adaptation	Vaccinate plants ahead of an advancing wave of pest fungus or insect. Take key proteins from pest fungus or beetle, or specific plant hormone like salicylic acid, and use drones to automatically inoculate plant's phloem or xylem ahead of the pest arrival. This should prime the plants through triggering the systemic acquired resistance response and protect against pest damage.	Precision protection of key plant species, e.g., oak, ash, heather, bog mosses that have an oversized role in supporting other species. Reducing damage by pests, will retain services to native species that depend on them.
Successionary pioneer species	Supercharged Natural Adaptation	Selection experiments to accelerate the ability of early colonising species to stabilise environments after disturbance, e.g., waste contamination,	The equivalent of biological early response teams could be deployed to the site of disturbances to allow rapid recolonisation by stabilising species.

		physical disturbance, salt-water intrusion.	
At-risk amphibians, e.g., great crested newts (*Triturus cristatus*)	Engineered Molecular Adaptation	Develop species-specific adenovirus vector which exposes newts to harmless ranavirus proteins, thereby vaccinating the newts against actual ranavirus.	Survival in the face of a widespread and highly detrimental ranavirus.
Bumblebees (*Bombus* spp.)	Engineered Molecular Adaptation	Develop species-specific adenovirus vector delivering RNA interference against parasite (e.g., *Crithidia*, *Nosema*, or *Syntretus*).	Immunity to otherwise impactful parasites that suppress survival or reproduction. These parasites are cosmopolitan and can be spread among bumblebee species.
Bog mosses (*Sphagnum* spp.)	Engineered Molecular Adaptation	Application of receptor-matched peptides that induce physiological changes that lead to greater heatwave/drought resistance.	Greater heatwave survival, and thus bog persistence / peatland foundation.
Vulnerable solitary bees (e.g., *Adrena, Megachile* spp.)	Engineered Molecular Adaptation	Provide engineered probiotics - so the gut microbiome has neonicotinoid degradation capacity.	Pesticide tolerance without genetic modification of the host.
Red squirrel (*Sciurus vulgaris*)	Engineered Molecular Adaptation	CRISPR-mediated introduction of squirrelpox resistance genes from grey squirrels.	Eliminate a key threat faced by the susceptible red squirrels when they encounter the asymptomatic carrier grey squirrels.

Lexicon

This draft lexicon provides a set of working definitions for concepts used in our programme thesis. The goal is to establish a shared, operational vocabulary to ensure clarity in this interdisciplinary work.

The definitions presented here are starting points. Please challenge, critique, and propose improvements to these definitions.

Adaptive alleles: Variants that are beneficial under the conditions of interest due to the fitness advantage they confer, typically by altering protein structure, enzymatic efficiency, or *cis*-regulatory elements in response to a specific environmental pressure. An allele's adaptive value is typically contingent on specific environmental pressures; some alleles beneficial in certain environments may go to fixation, others may remain polymorphic (for diverse reasons).

Bioactive compounds: Substances including molecules, peptides or proteins that have a biological effect on other living organisms; these can form the basis for medicines.

Biodiversity: In public discourse, biodiversity is often equated with species richness. Scientifically, the term spans genetic, species, functional, and phylogenetic dimensions across scales.

Biodiversity measurements: This is a concept that spans multiple organisational levels and spatial scales. At the species level, alpha diversity quantifies richness within habitats, beta diversity measures compositional turnover between habitats, and gamma diversity captures landscape-scale richness. Additional metrics characterise evenness (abundance distributions), functional diversity (trait variation), phylogenetic diversity (evolutionary distinctiveness), and genetic diversity within populations. These measurements can target compositional, structural, or functional aspects of biological systems depending on conservation or management objectives.

Conservation biology: An applied, interdisciplinary science that aims to diagnose and mitigate anthropogenic threats to biodiversity and ecosystem integrity.

Ecological tipping point: A critical threshold in a system parameter at which a small perturbation can induce a nonlinear state shift to an alternative stable state due to positive feedback mechanisms. Reversions post tipping are likely hard, if not impossible. Post-tipping-point states are typically considered less desirable than prior states.

Ecosystem: A spatially and temporally bounded system comprising interacting organisms and their physical-chemical environment (substrate, hydrology, climate), characterised by flows of energy and materials, biogeochemical cycling, and emergent properties arising from biotic-abiotic feedbacks. Explicitly includes abiotic context as determinants of interactions and processes.

Ecosystem engineering for conservation: Encompasses deliberate interventions in ecological systems to achieve conservation, restoration, resilience, or climate adaptation objectives.

Ecosystem services: The suite of benefits derived from natural capital, categorised as provisioning, regulating, supporting, and cultural services.

Functional group: A set of species that collectively deliver a focal ecosystem process (e.g., pollination), often interchangeable to some extent, conferring functional redundancy and resilience.

Functional redundancy: The capacity for multiple, taxonomically distinct species within the same ecosystem to perform equivalent ecosystem processes. Greater redundancy increases resilience.

Genetic diversity: The total genetic variation within (and among) populations of a species, commonly quantified by molecular metrics (nucleotide diversity, allelic richness, heterozygosity). Adaptive potential for a specific trait is instead quantified by its additive genetic variance (variance in the heritable component of the phenotype that responds to selection).

The total genetic variation within a population or species that enables adaptive evolution, quantifiable either as molecular variation (nucleotide diversity, heterozygosity). Alternatively, variance in breeding value (ie. the heritable component of the phenotype that responds to selection).

Genetic erosion: The stochastic or directional loss of alleles from a gene pool, leading to a reduction in genetic diversity and a subsequent decrease in the population's adaptive potential to future environmental change.

Genetic resilience: A population's capacity to persist through environmental perturbations without a state shift. Fundamentally dependent on standing genetic variation and resulting phenotypic plasticity.

Holocene: The Holocene is the current geological epoch, beginning after the last major Ice Age, a marked period of relative climatic stability when human civilizations, agriculture, and most modern ecosystems developed.

Natural world: The Earth's biosphere and its integrated abiotic systems, considered exclusive of anthropogenic constructs and modifications.

Populations: A group of individuals forming a reproductive community that is characterised by a shared gene pool and a specific demographic trajectory.

Pre-adaptation: The process of adapting an organism or to an anticipated environmental challenge.

Species: Another common biological term with a fuzzy meaning. An evolutionary lineage or group of individuals, typically defined through the "biological species concept" of being reproductively isolated from others.

Symbiont engineering: Transplantation of existing or novel microbes to a host in order to modify the phenotype of the host.

Synthetic biology: An engineering-driven discipline focused on the *de novo* design and construction of synthetic genetic circuits, metabolic pathways, and orthogonal biological systems based on principles of modularity and standardisation.

System: The explicitly bounded operational unit of study, ranging in scale from a species to a global biome, defined to encompass the interacting components and processes relevant to a specific scientific question.

Vulnerable species: A formal IUCN Red List category for a species determined to have a high probability of extinction in the medium term, based on quantitative analysis of population size, geographic range, or rates of decline.

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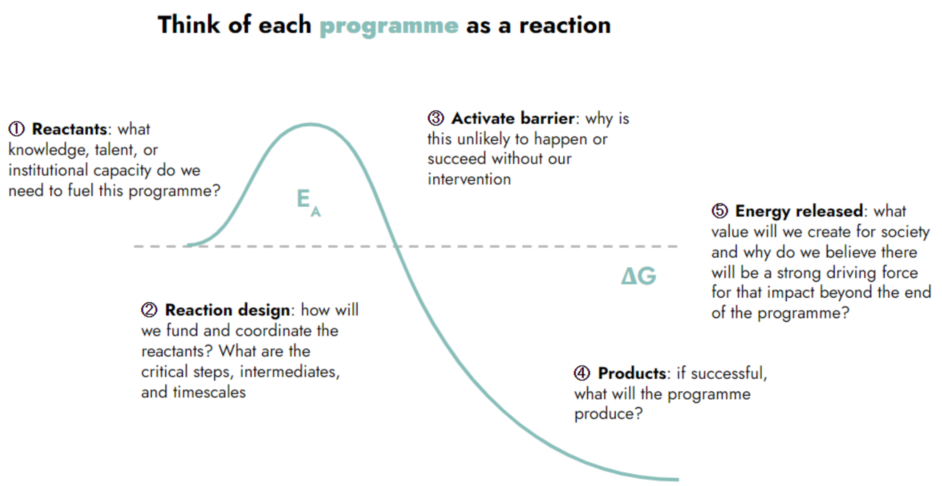
ENGAGE

Our next step is to launch a funding opportunity derived or adapted from this programme formulation. Click [here](#) to register your interest, or to provide feedback that can help improve this programme thesis.

PROGRAMME THESIS, REACTION DIAGRAM SUMMARY

We can metaphorically think of an ARIA programme as a chemical reaction. We present a simple reaction diagram to summarise the key elements of the imagined programme.



1. There are technological solutions and expertise distributed across robotics, ecology, evolution, biological engineering, conservation, and AI that are not yet being brought to bear on conservation problems. The UK has world-class capability in these areas, with leading research in these areas with advanced research

poised to transform conservation if united under a shared mission. The UK stands to lead globally in applying emerging technologies to strengthen biodiversity and resilience, having already laid the groundwork through Environment Act 2021 targets for 2042, measures such as the Biodiversity Net Gain market.

2. This programme will fund the development of platforms, systems, and models that innovate, translate, and scale tools for inducing rapid adaptation and resilience in natural systems. Our approach will overcome current limitations that prevent widescale adoption by integrating scientific, technical, and societal expertise. All discoveries and operations will be rooted in community consultation and ethical frameworks to ensure that solutions address both ecological integrity and community priorities.
3. Existing barriers are technical, economic, regulatory, and societal. Current research and funding mechanisms remain siloed by discipline and risk appetite, leaving cross-sector technologies underdeveloped for conservation use. ARIA's intervention is essential to de-risk high-potential approaches, overcome fragmentation, and integrate technical, ethical, and governance considerations that conventional programmes cannot.
4. This programme will catalyse a new innovation economy around ecological resilience, expanding the UK's leadership in bioengineering and AI to new sectors while directly protecting the natural capital that underpins economic and societal stability. Successful projects will deliver direct returns in existing markets, such as breeding programmes for conservation, and open adjacent markets in agriculture, fisheries, and human health.