Geo 873 – 001: Seminar in Human-Environment Geography

12:40 am – 3:30 pm; GEO120

Food and Energy in a changing climate; Nature Based Solutions (NBS)
-- A brief history of natural resource management --

Guest Lecture by Dr. Suraj Upadhaya, Iowa State University; Uncovering landowners' behaviors of conservation practices adoption in agricultural landscape-a social-ecological perspectives

Reading

Robertson, G. P., Hamilton, S. K., Paustian, K., & Smith, P. (2022). Land-based climate solutions for the United States. Global Change Biology, 28(16), 4912-4919.

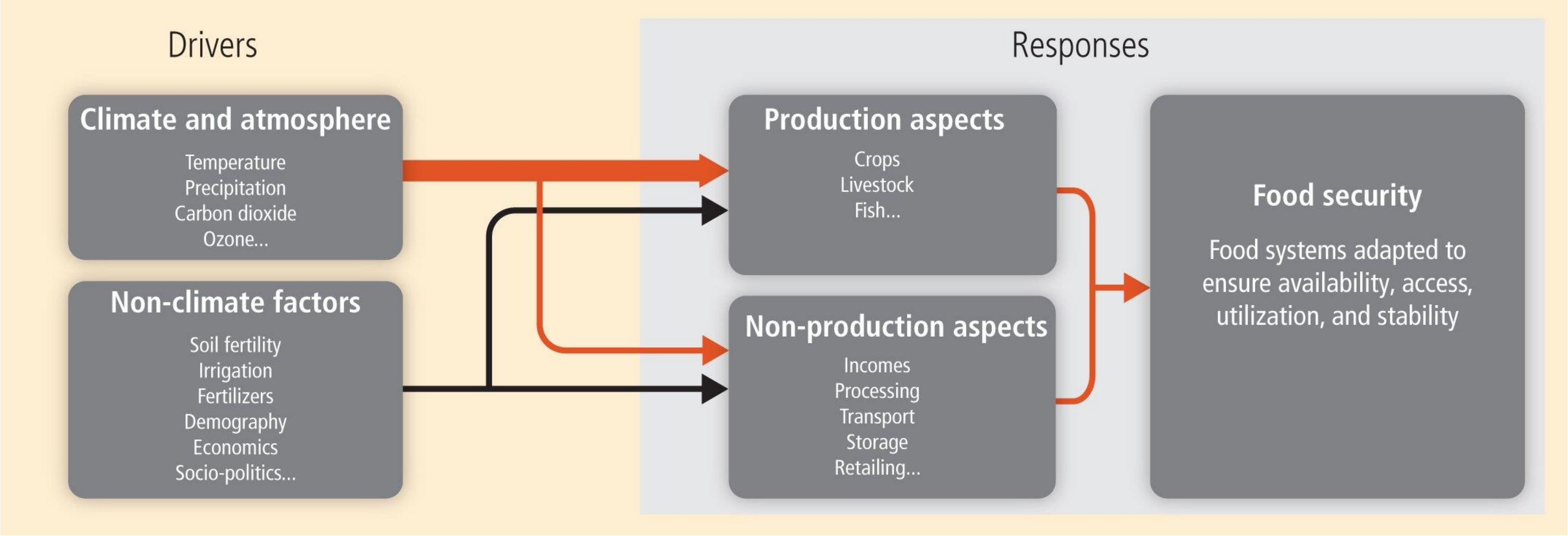
Lafortezza, R., Chen, J., Van Den Bosch, C. K., & Randrup, T. B. (2018). Nature-based solutions for resilient landscapes and cities. Environmental research, 165, 431-441.

Homework 4: Due date: 12:00 am, April 19, 2023.

April 12, 2023
GEO873-001, MSU

Food Production and Food Security:

- High yield
- Sustainable
- other benefits (environment, water, erosion, biodiversity, culture, etc.)

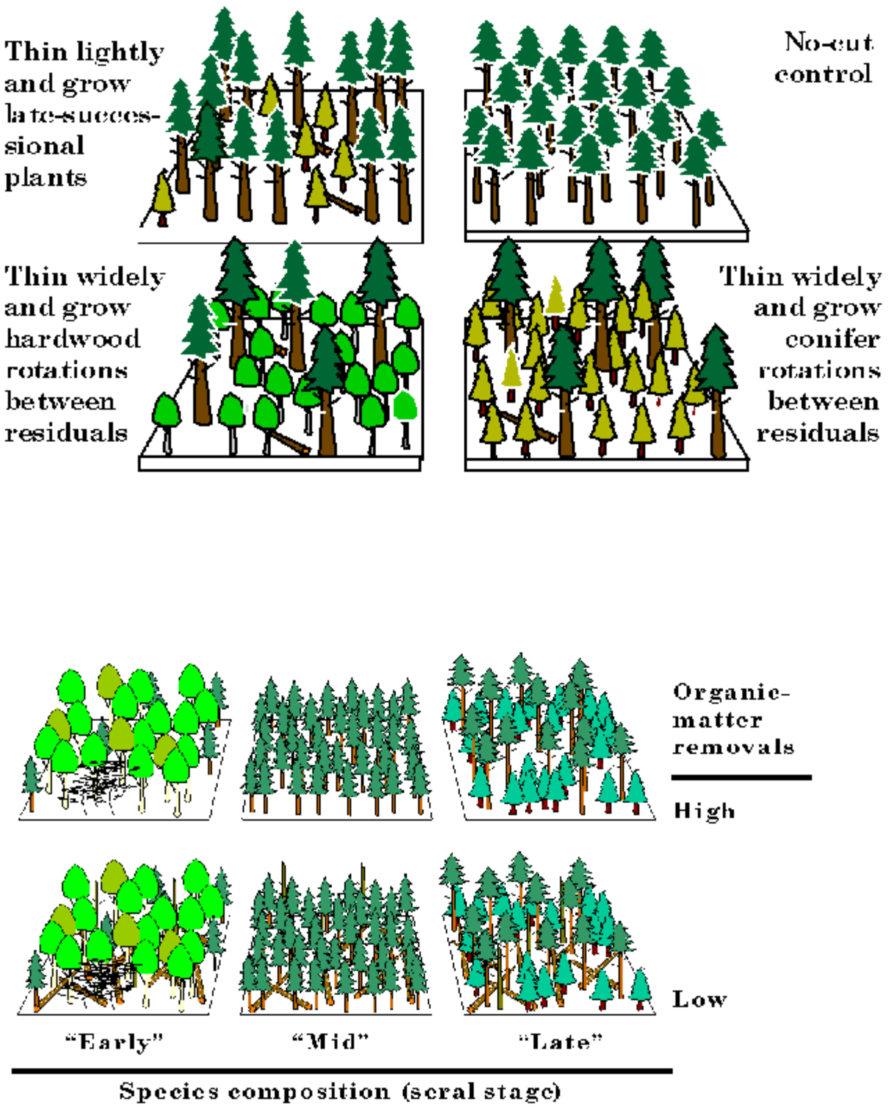


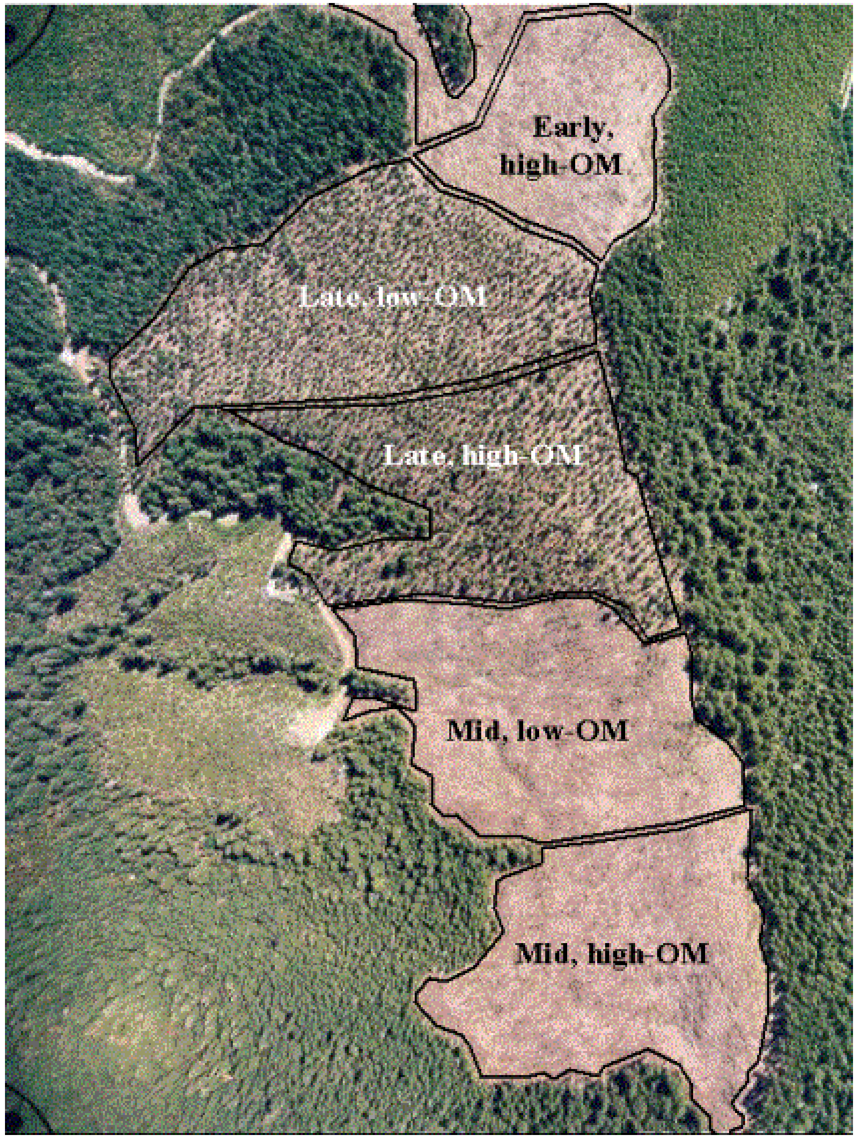
https://www.ipcc.ch/report/ar5/wg2/food-security-and-food-production-systems/

Natural Resources and Management

- Agriculture
- Aquaculture
- Fisheries (ocean and freshwater)
- Forestry
- Rangelands (livestock)

Long-Term Ecosystem Productivity (LTEP)





https://www.fsl.orst.edu/ltep/

A brief history of natural resource management: Challenges and Shifts

Human interferences for production

Genotype x Environment x Management (GEM) Reciprocity

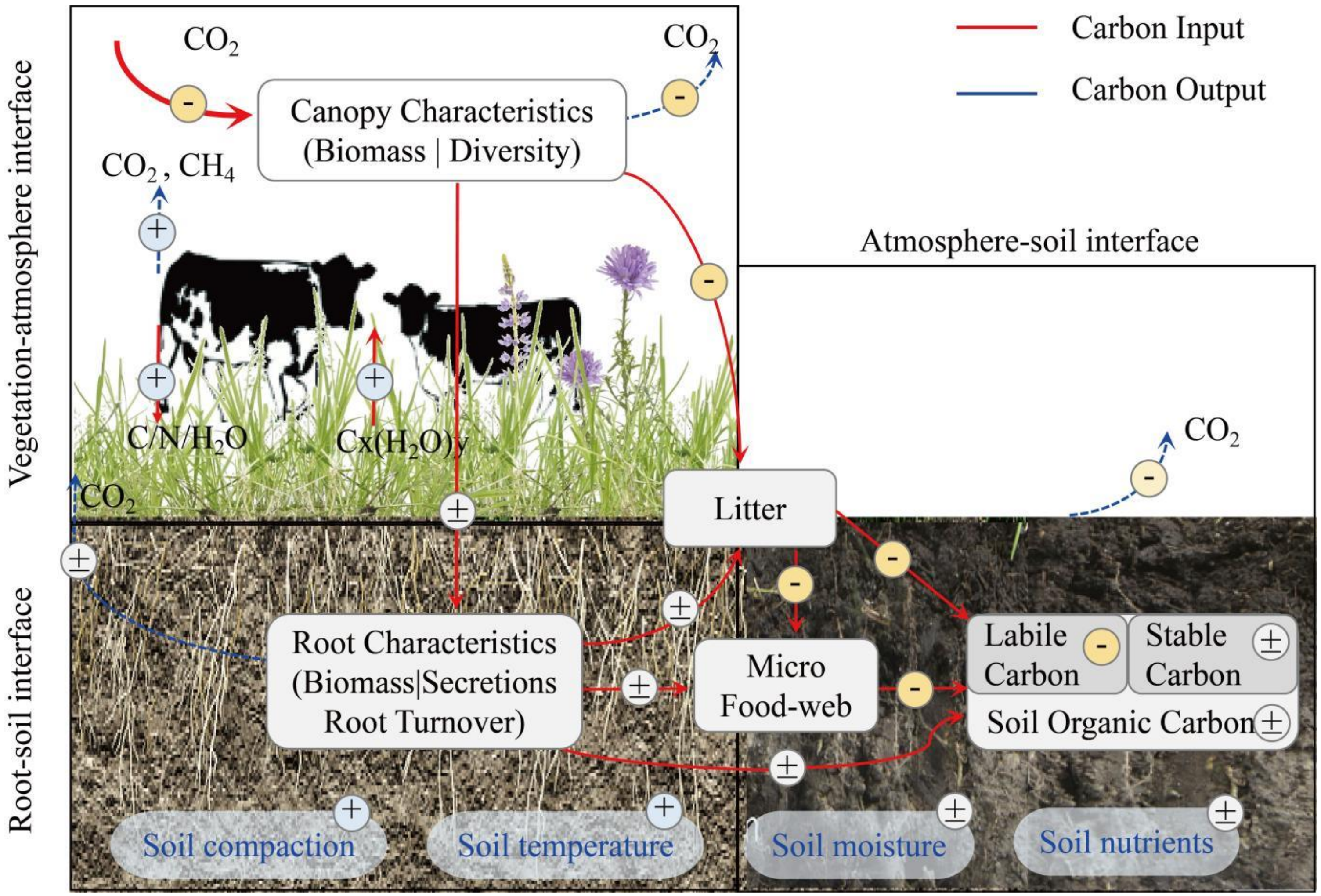
Best Management Practices
(https://www.frontiersin.org/articles/10.3389/fagro.2022.800365/full)

- conservation tillage
- contour farming on slopy lands
- erosion and sedimentation control
- cover cropping
- use of better adapted cultivars
- integrated pest management
- irrigation and nutrient management
- crop rotation
- rotational grazing
- effective marketing
- waste management
- wildlife habitat management

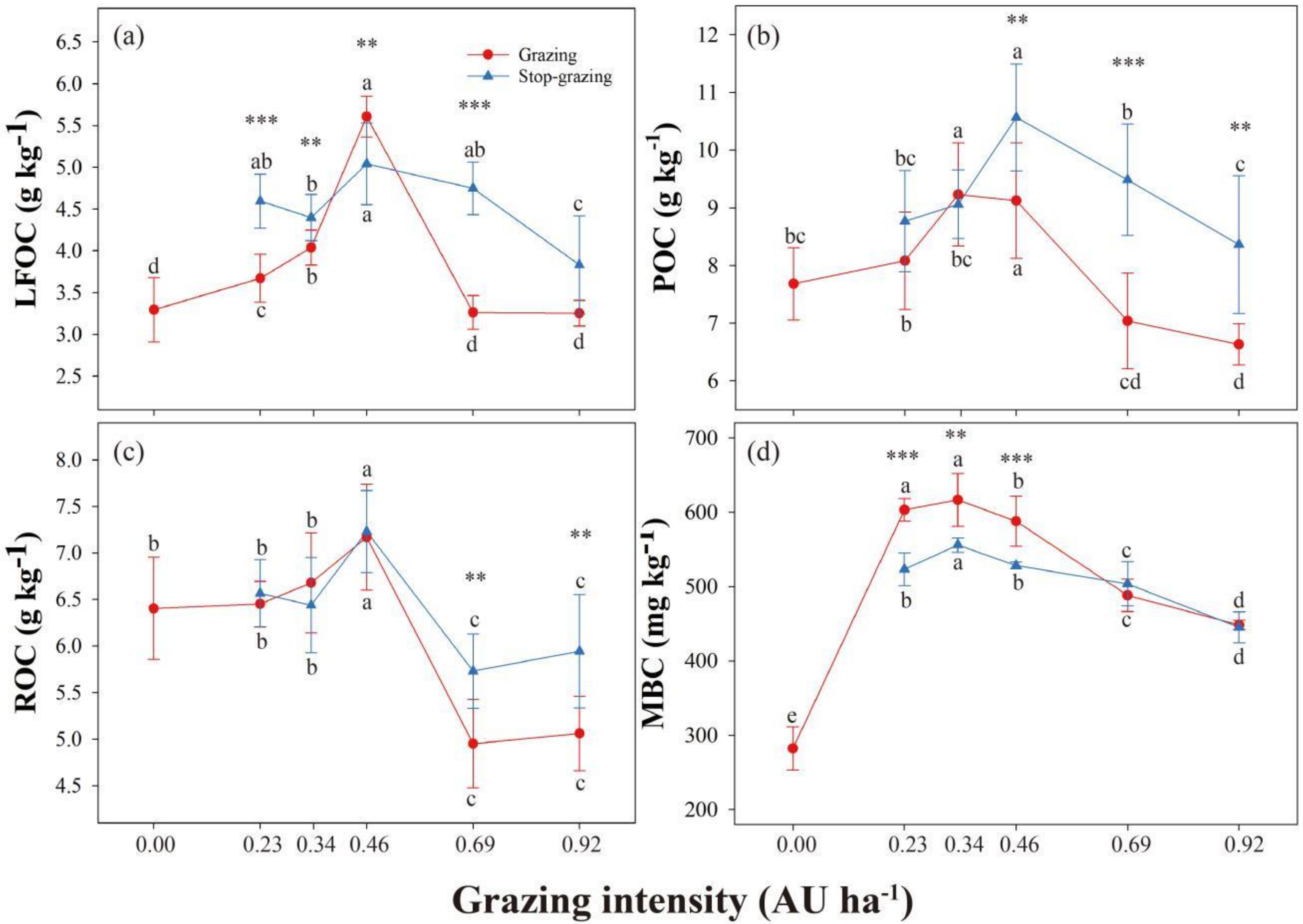
What is the appropriate grazing intensity for the maintenance of ecosystem functions (productivity, diversity, resilience, etc.)?

No Grazing → Light Grazing → Intensive Grazing

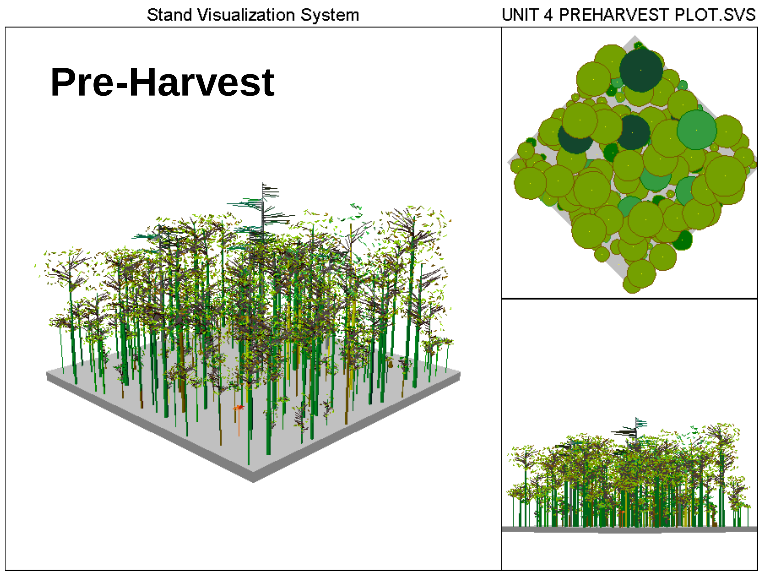
Hypothesized major pathways of carbon flux in grazed grasslands where grazing directly/indirectly alters carbon gains and losses of different components

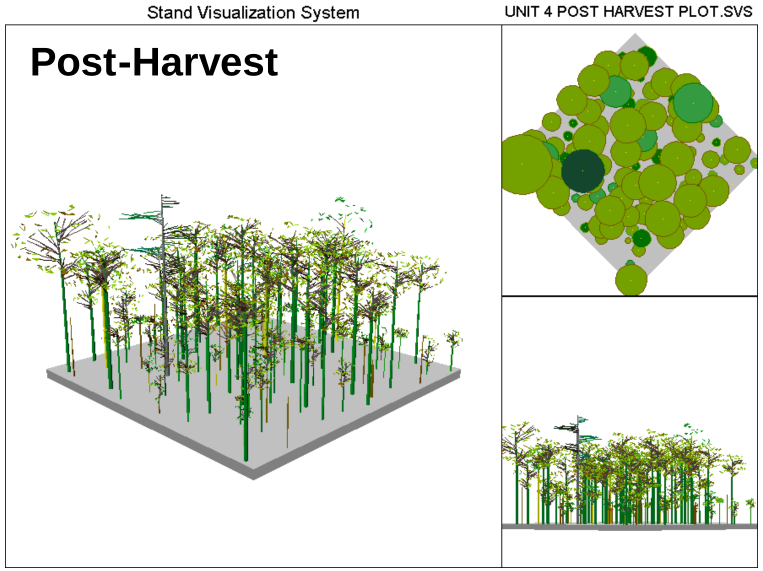


The LFOC (a), POC (b), ROC (c) and MBC (d) in 0-30 cm depth soil along the grazing intensity gradients in continued grazing and grazing excluded treatment

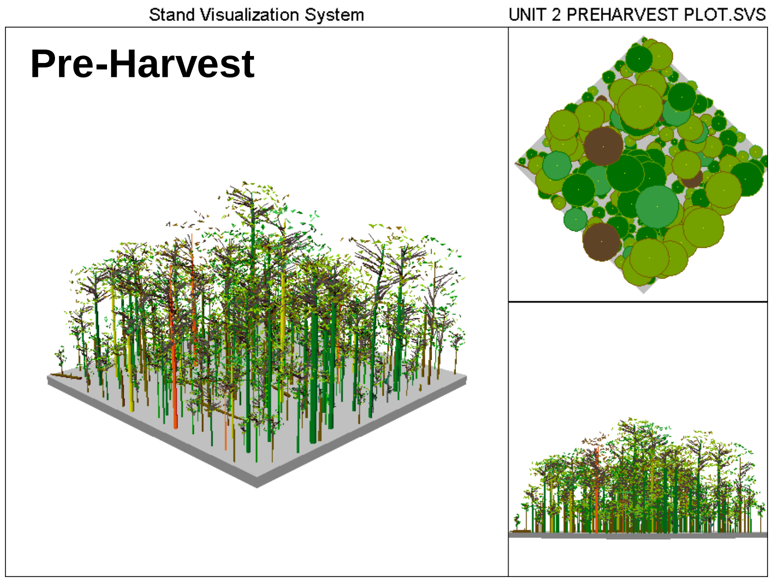


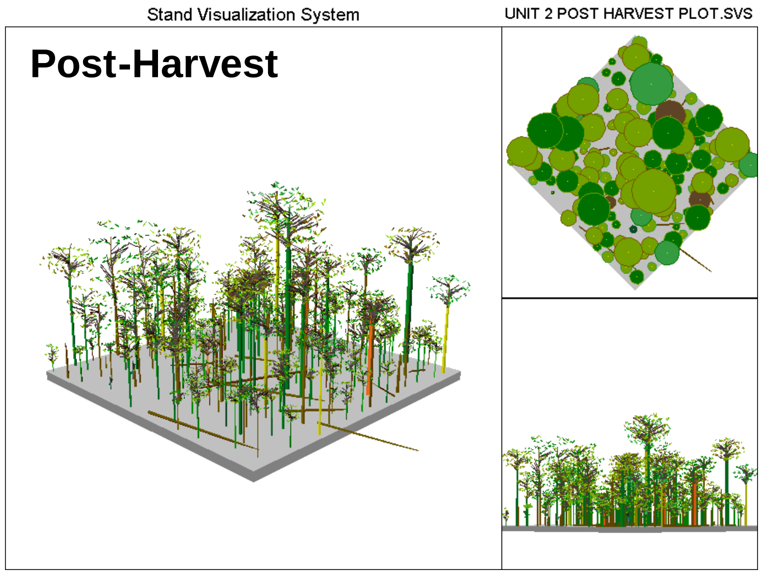
Single -Tree Selection Unit





Structural Complexity Enhancement Unit





Sierra Nevada, CA

Landscape Level (Four Landscapes)

Pine Barrens

Large-Block Pine Oak

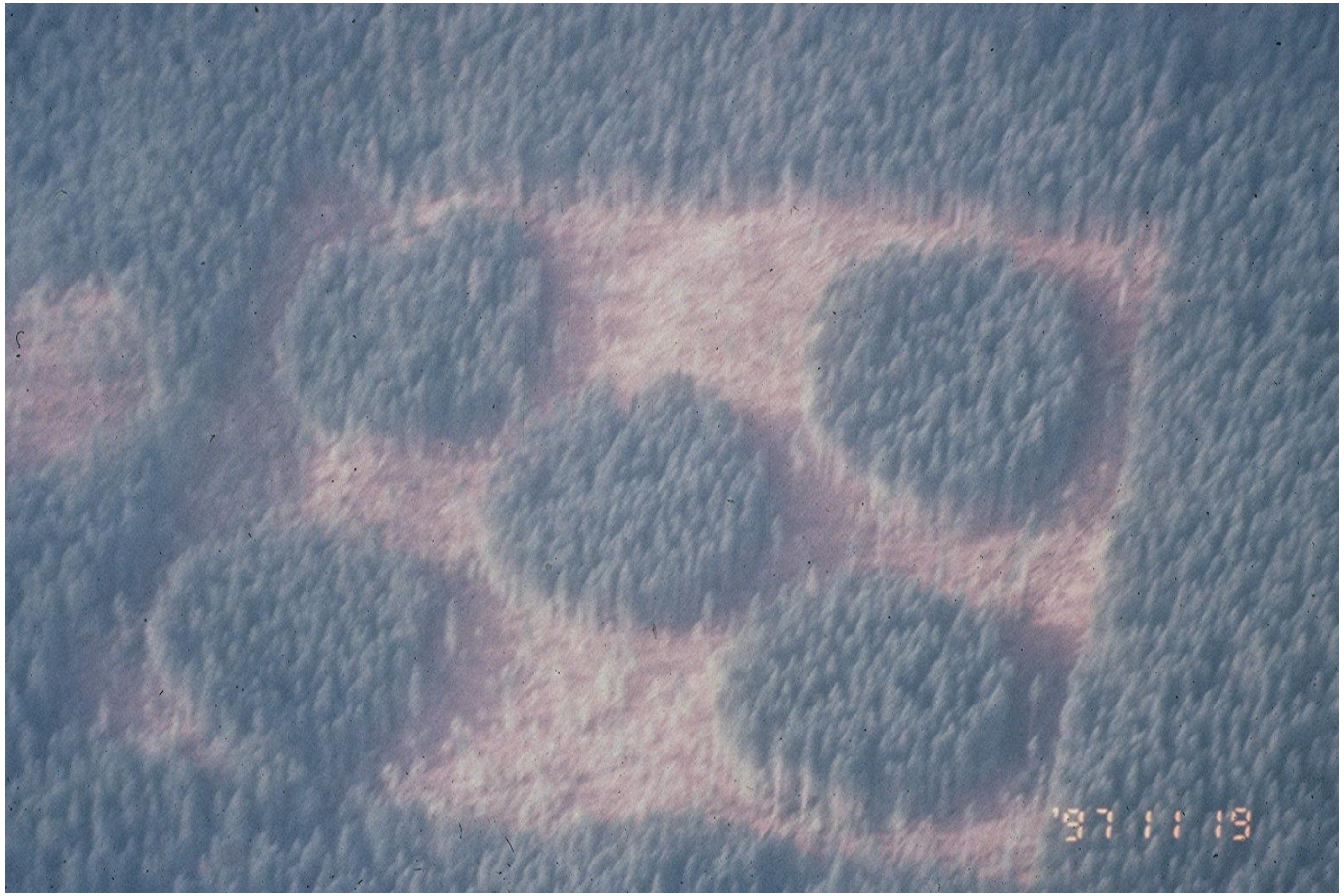
Do differences among landscape-level disturbance regimes influence patterns of understory plant diversity or composition?

Small-Block Pine

Pine-Oak-Aspen Forest

Missouri Ozarks

Douglas-fir forests, PNW



From C. Nelson

Evolving concept in Forestry as an example

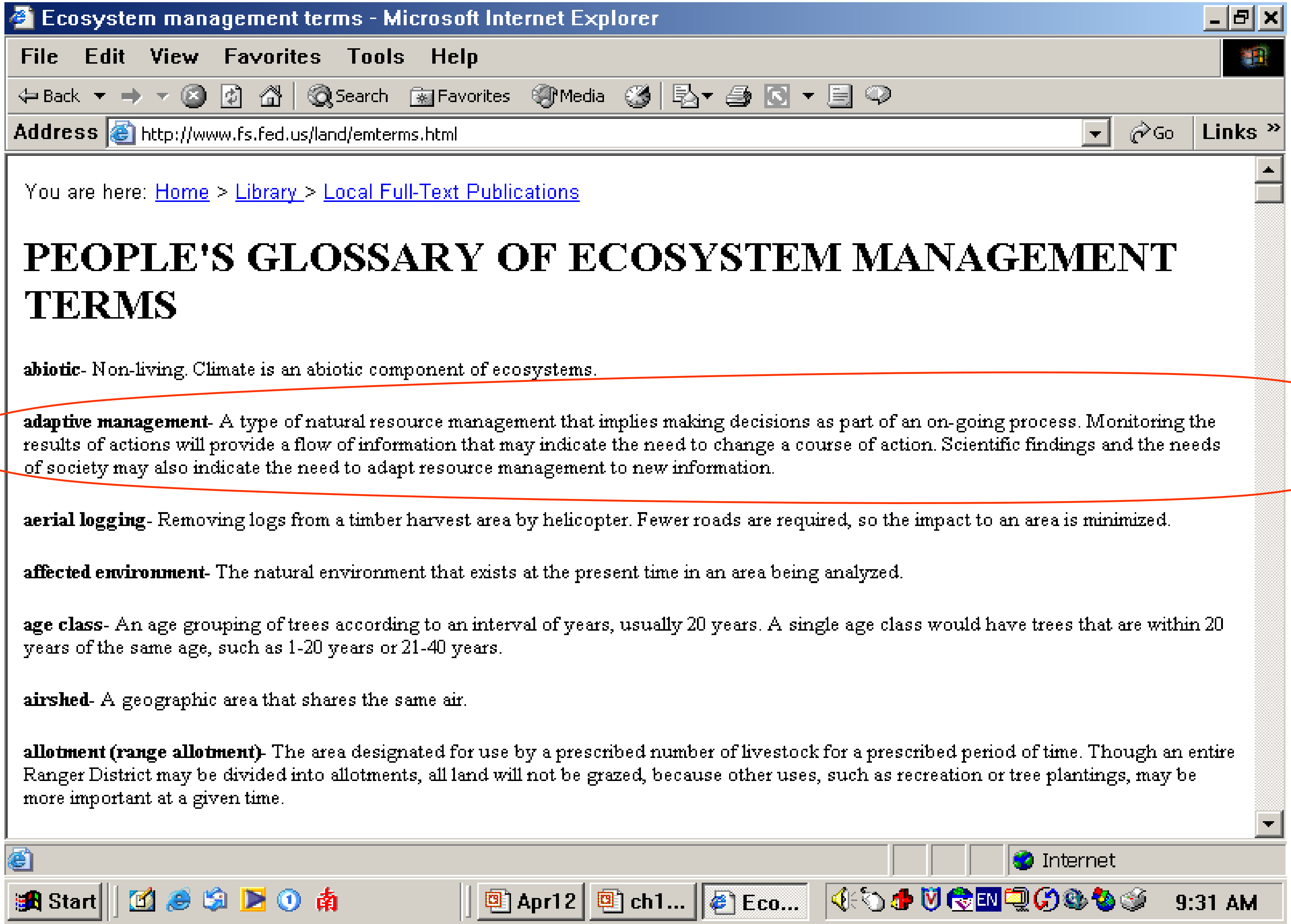
- Plantations -> thinning/fertilization -> Harvesting
- Rotation and spatial arrangement
- Sylviculture -> Multiple Purposes -> New Forestry -> Adaptive Management -> Ecosystem Management
- Nature-Based Solutions

President Bill Clinton's administration held the Portland Timber Summit in an effort to find new directions for the management of federally owned forestlands in the Pacific Northwest.

Ecosystem Management, or
Ecological Management

- In June, 1990, the U.S. Fish and Wildlife Service Fish and Wildlife Service, U.S. declared the northern spotted owl Northern spotted owls to be an endangered species.
- In May, 1991, U.S. District Judge William Dwyer ruled that President George H. W. Bush’s environmental policy was deliberately violating the Endangered Species Act (1973) by failing to develop an adequate plan to protect the owl from extinction.
- The judge placed an injunction against logging on approximately three million acres of federally owned old-growth forestland in Northern California, Oregon, and Washington until an acceptable plan was developed.
- This ruling effectively meant that the forests were being managed by the federal courts rather than by the U.S. Forest Service.
- Clinton Convenes the Forest Summit (Apr. 3, 1993)

1. What is ecosystem management?



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PEOPLE'S GLOSSARY OF ECOSYSTEM MANAGEMENT TERMS

abiotic- Non-living. Climate is an abiotic component of ecosystems.

adaptive management- A type of natural resource management that implies making decisions as part of an on-going process. Monitoring the results of actions will provide a flow of information that may indicate the need to change a course of action. Scientific findings and the needs of society may also indicate the need to adapt resource management to new information.

aerial logging- Removing logs from a timber harvest area by helicopter. Fewer roads are required, so the impact to an area is minimized.

affected environment- The natural environment that exists at the present time in an area being analyzed.

age class- An age grouping of trees according to an interval of years, usually 20 years. A single age class would have trees that are within 20 years of the same age, such as 1-20 years or 21-40 years.

airshed- A geographic area that shares the same air.

allotment (range allotment)- The area designated for use by a prescribed number of livestock for a prescribed period of time. Though an entire Ranger District may be divided into allotments, all land will not be grazed, because other uses, such as recreation or tree plantings, may be more important at a given time.

Google search of Ecosystem Management: About 26,800,000 results (0.30 seconds)

Wikipedia: http://en.wikipedia.org/wiki/Ecosystem_management

"Ecosystem management is a process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political and cultural and needs of current and future generations.[1][2] The principal objective of ecosystem management is the efficient maintenance, and ethical use of natural resources.[3] [4] It is a multifaceted and holistic approach which requires a significant change in how the natural and human environments are identified. Several approaches to effective ecosystem management engage conservation efforts at both a local or landscape level and involves: adaptive management, natural resource management, strategic management, and command and control management."

Robertson (1992)

- USDA Forest Service future management guideline.

Jack Ward Thomas (1992)

- EM is evolutionary, is not radical shift in the way we manage forestlands but instead a logical step in the progression of the practice of forestry.

Al Gore (1993)

- Principle of ecosystem
- Adaptive management
- Not only forests, but people and people's needs

Salwasser (1994)

- All ecosystems have biological and physical limits (input vs output)
- Complex and interconnected in space and time (cause-effect)
- Humans are the key (including their influences and needs), so economic and cultural changes need to be changed
- Sustainable is the goal
- Three principles: people are the most important, ecosystem principles, and human needs

Grumbine (1994)

1) Hierarchical context (multiple scales)
2) Boundaries or edges
3) Ecological integrity
4) Systematic research and data collection
5) Monitoring
6) Adaptive
7) Interagency cooperation
8) Organizational
9) Human as ecosystem components
10) Human needs

Jerry Franklin (1995)

- Ecosystem management is managing ecosystems so as to assure the sustainability“, a synonym for "Multiple Uses", "New Forestry", "New Perspectives", "Sustainable".

- Preventing the degradation of productive capacity

- Preventing accelerated loss of genetic diversity

What is ecosystem management ?

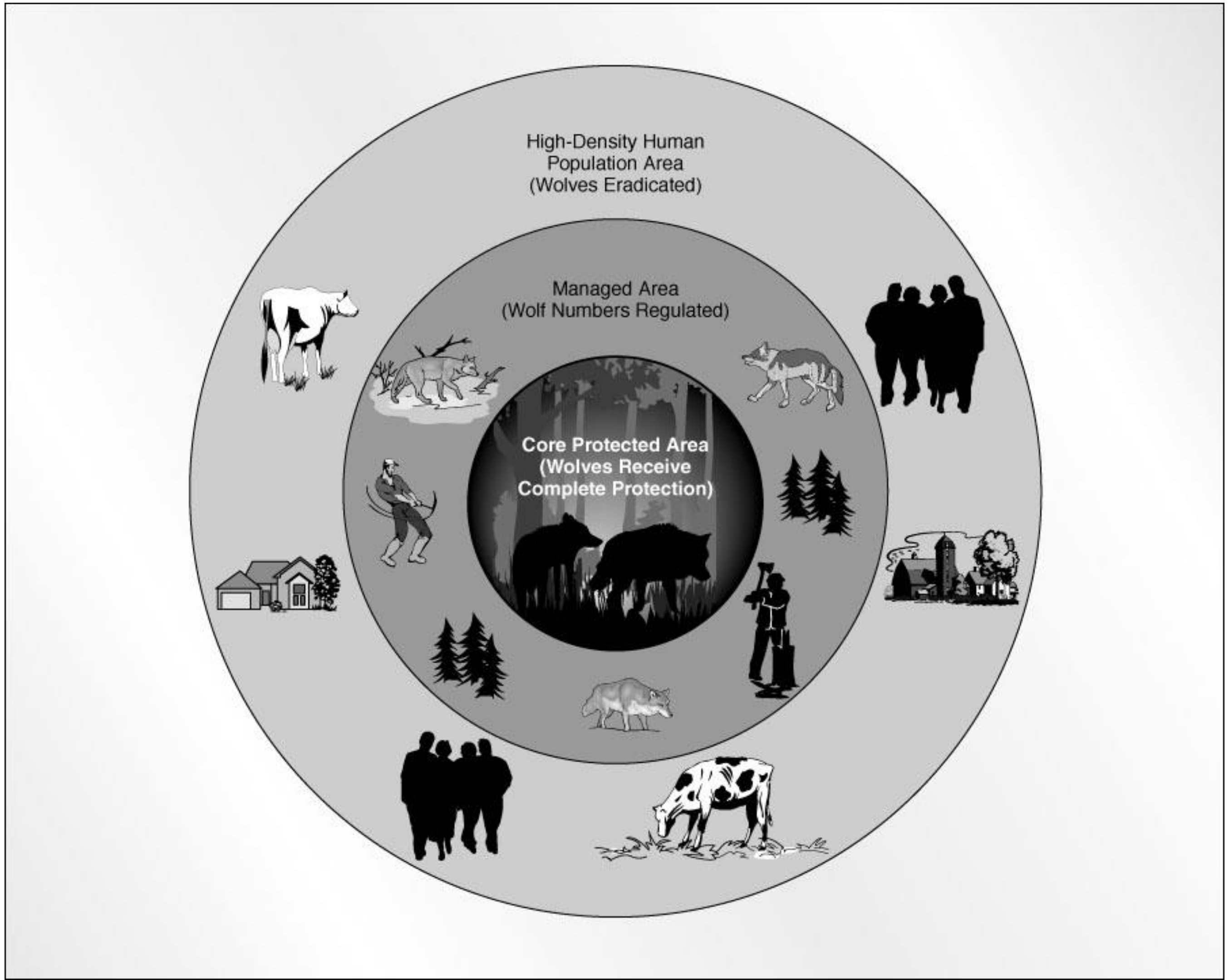
Ecosystem management has now become a well-established discipline that transcends many traditional areas of teaching and research. It involves aspects of both basic and applied ecology, biology and other natural sciences and, more importantly, the application of scientific principles to the management of natural resources.

What is ecosystem management ?

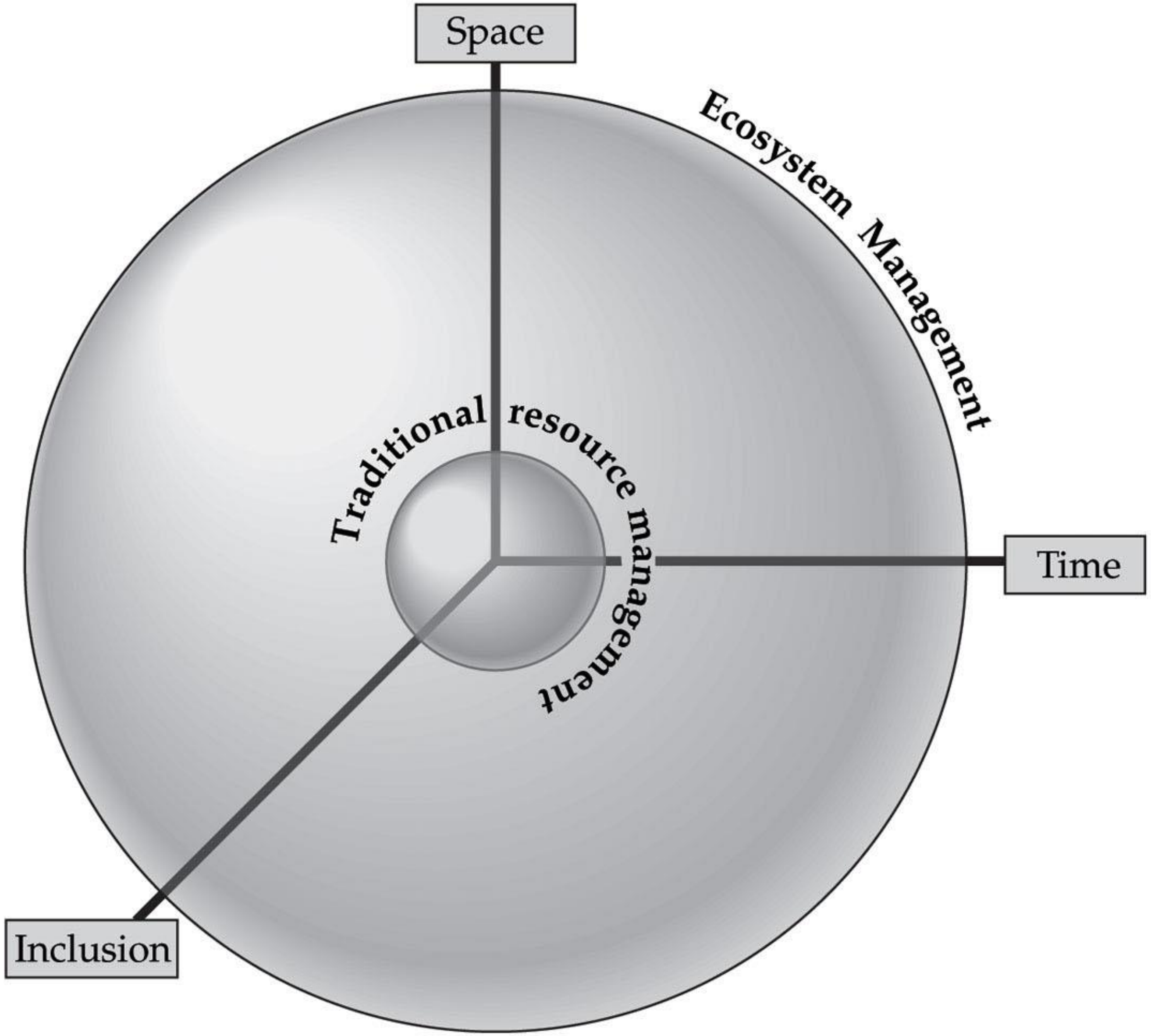
Natural resources management involves not only the understanding of ecosystem structure and function when used for a variety of purposes, but also the incorporation of social, economic and political considerations into decision-making. Consequently the discipline involves the collection, analysis, interpretation and integration of information from not only the more traditional areas of science but also from the areas of management. The discipline must also embody a level of professionalism that is essential in any management area.

2. How and why the concept of ecosystem management developed?

Legal challenges

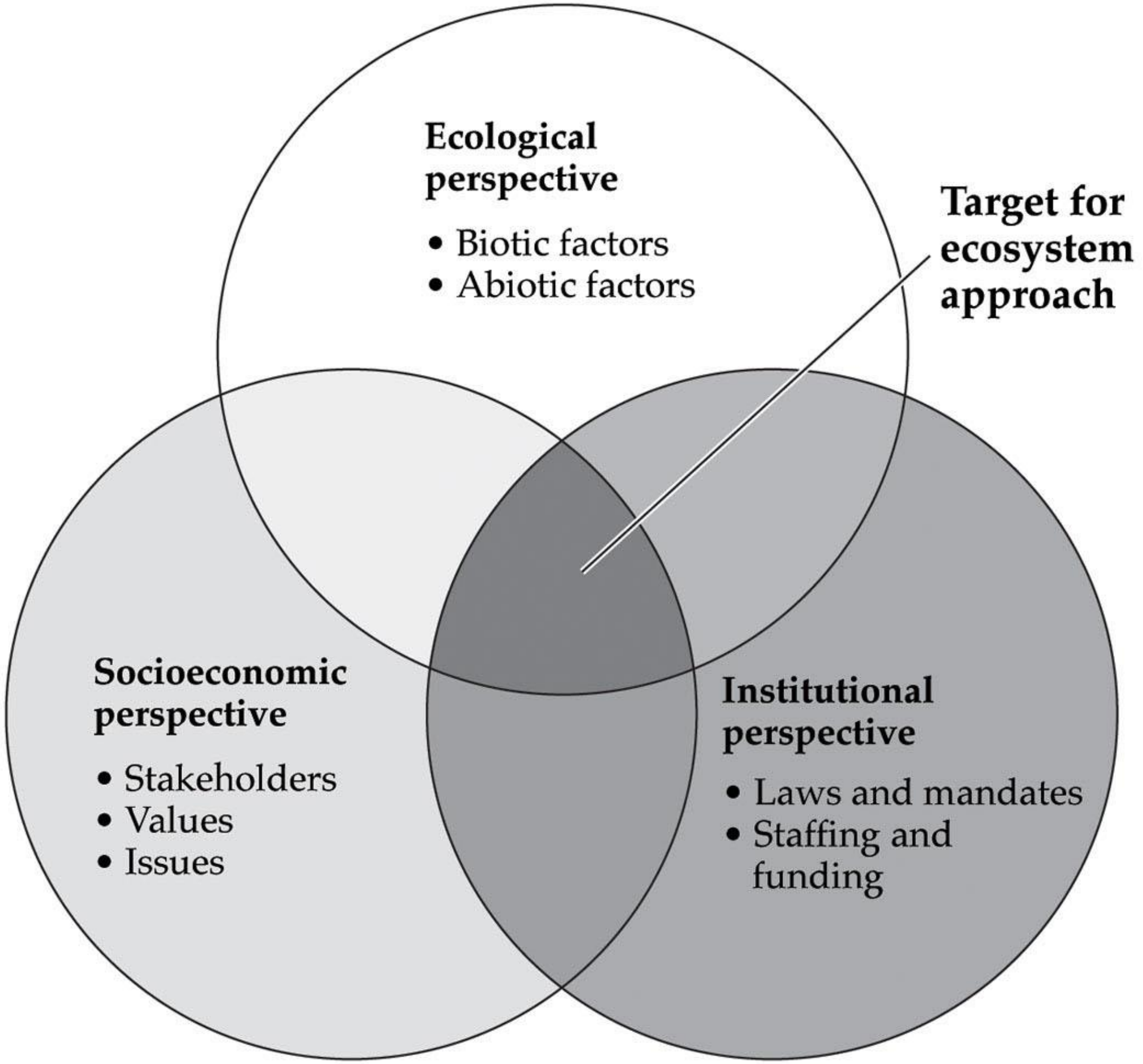


Keys in Ecosystem Management



PRINCIPLES OF CONSERVATION BIOLOGY, Third Edition, Figure 13.2

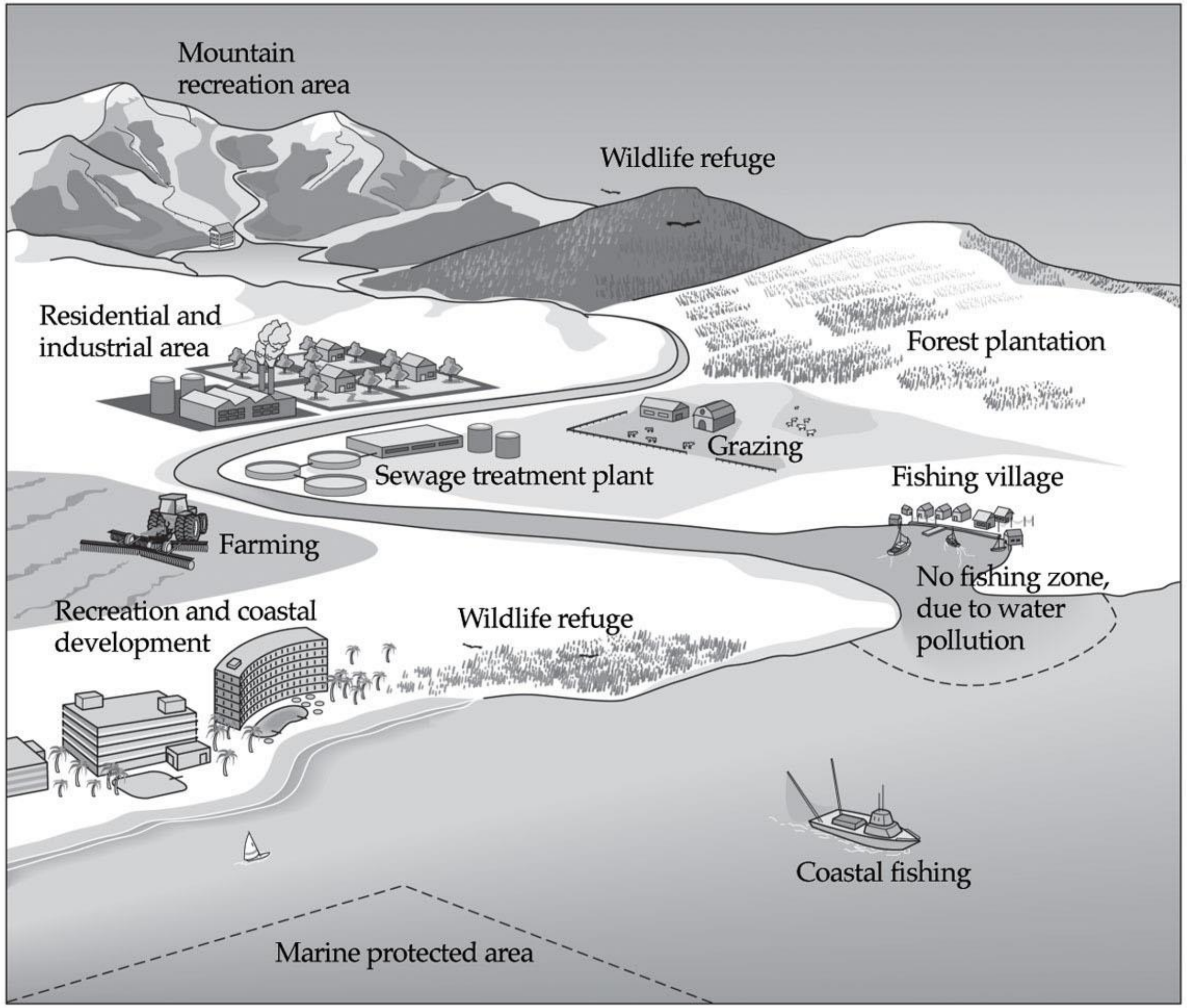
Chapter 13: Ecosystem Approaches to Conservation



PRINCIPLES OF CONSERVATION BIOLOGY, Third Edition, **Figure 13.1**

Ecosystem Management

13.4 Ecosystem management attempts to involve all stakeholders



PRINCIPLES OF CONSERVATION BIOLOGY, Third Edition, Figure 13.4

13.5 The Greater Yellowstone ecosystem

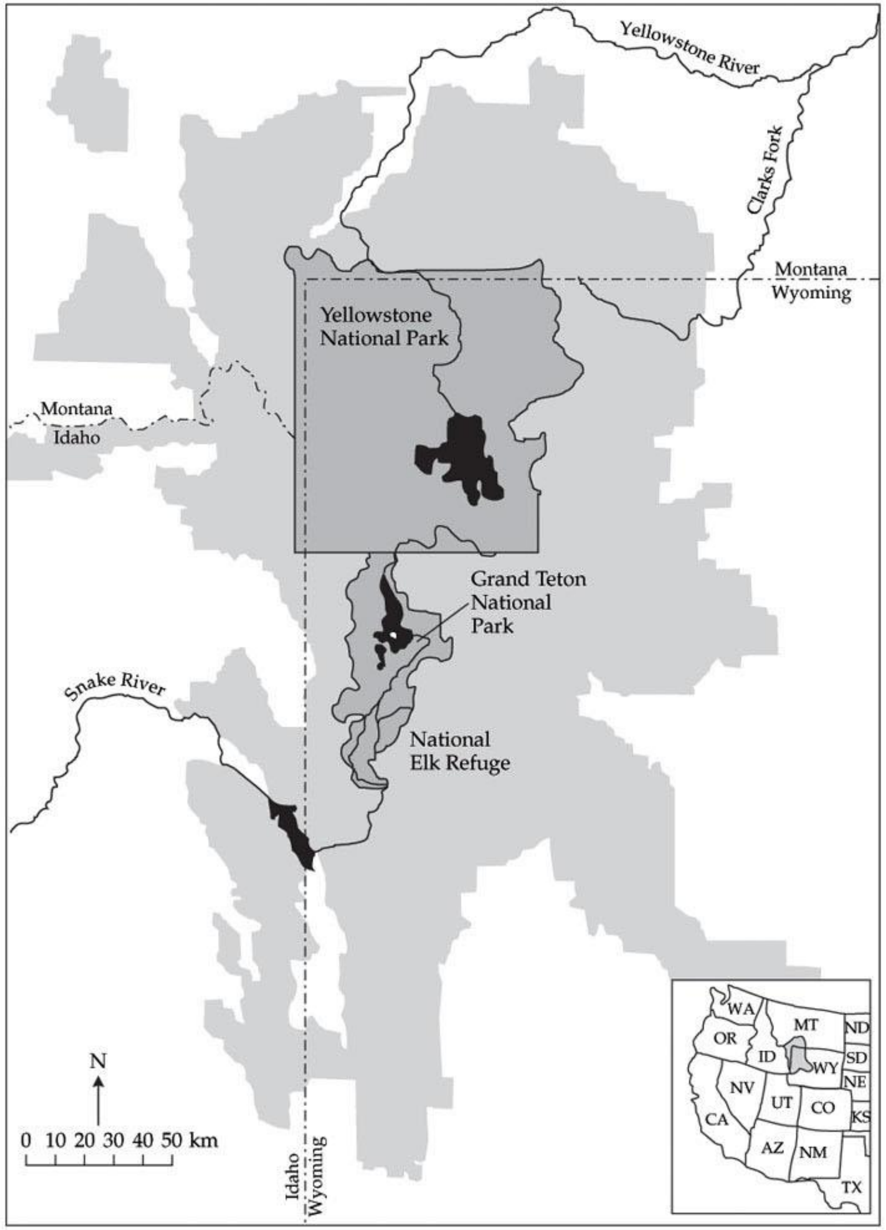


TABLE 13.1 *What Is a Stakeholder?*

Stakeholders are people who want to or should be involved in a decision or action because they have some interest or stake in it. Their level of interest can vary from mild to intense. People can be stakeholders for a variety of reasons; they:

1. have a real or perceived interest in the resource, its use, its protection, or its users;
2. are dependent on a resource (e.g., subsistence users, sole means of livelihood);
3. have a belief that management decisions will directly or indirectly affect them;
4. are located in or near areas about which decisions are being made;
5. pay for the decision;
6. are in a position of authority to review the decisions.

Inclusion of stakeholders in decision-making helps to ensure that their concerns are met early on and that they “buy into” the decision through partial ownership, thus being more likely to support it later.

Source: Modifed from materials provided by Dennis A. Schenborn.

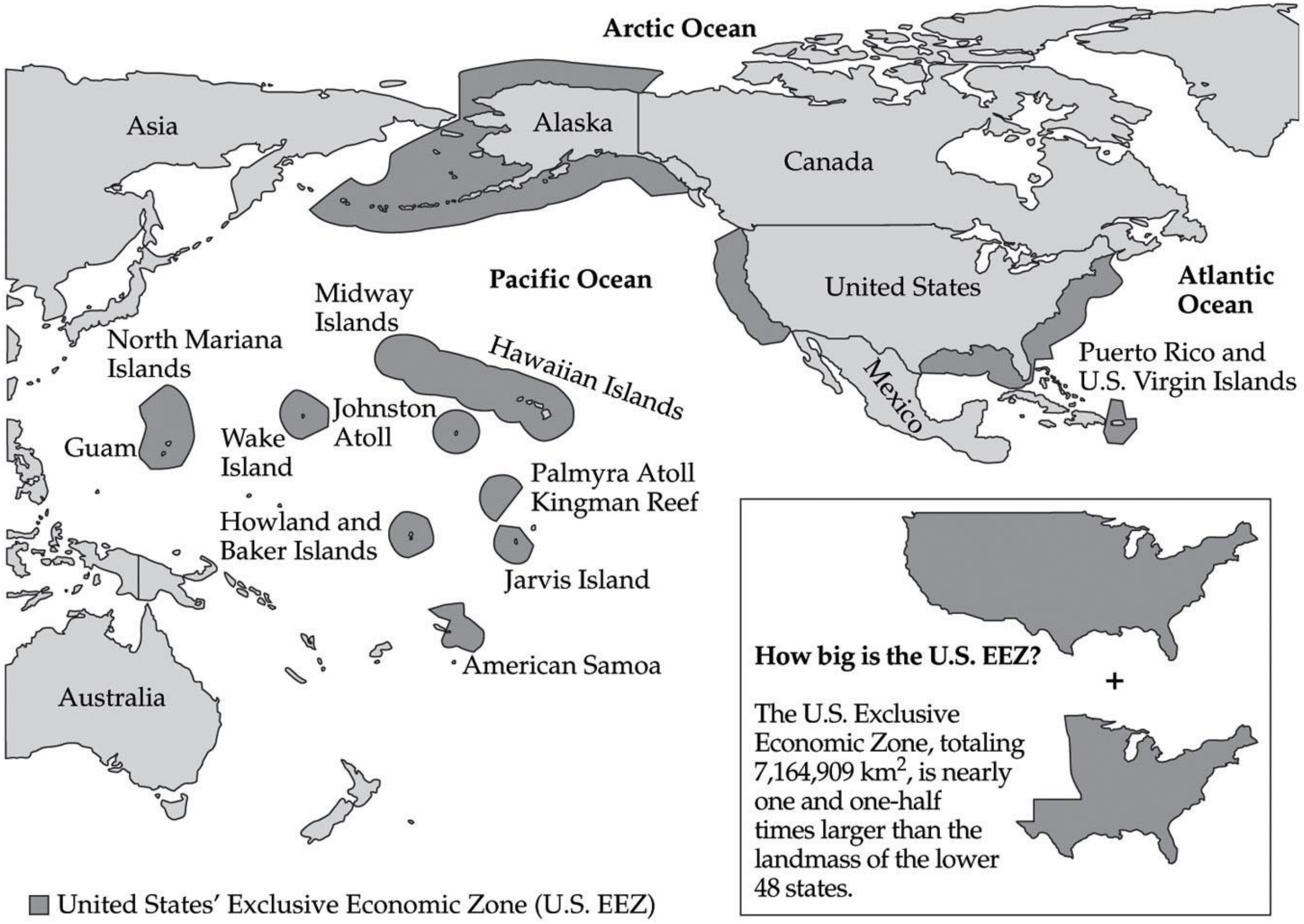
Large Ecosystem Management

Case 13.3 (A): The Chesapeake Bay Watershed spans five states in the eastern U.S.

PRINCIPLES OF CONSERVATION BIOLOGY, Third Edition, Case Study 13.3, Figure A

Marine Ecosystem-Based Management

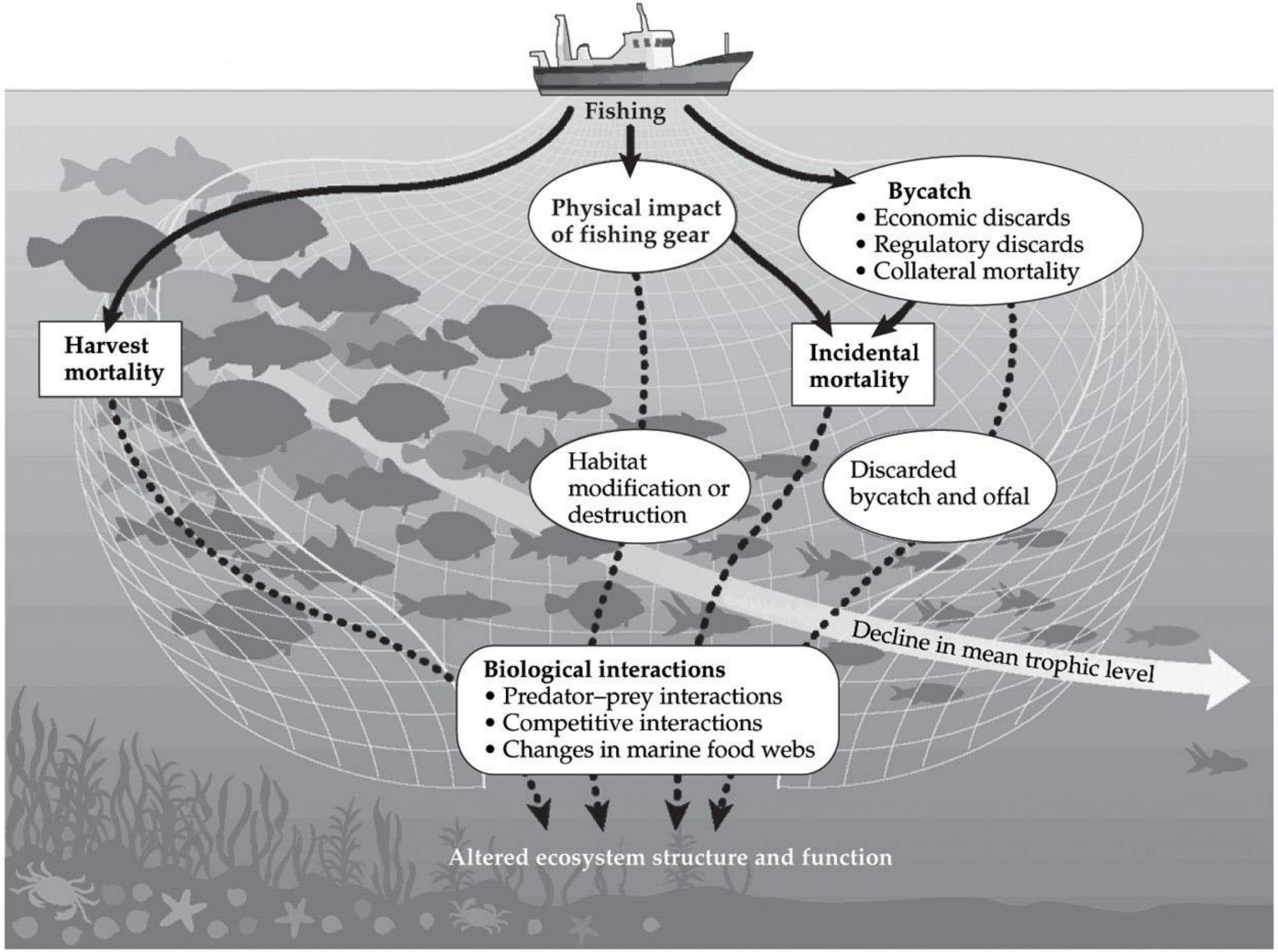
Essay 13.1 (A) The United States' Exclusive Economic Zone



PRINCIPLES OF CONSERVATION BIOLOGY, Third Edition, Essay 13.1, Figure A

Marine Ecosystem-Based Management

Essay 13.1 (B) The ecological effects of ecosystem over-fishing



Understanding ecosystem dynamics and resilience

- **Ecosystems Dynamics**: constantly change
- What does this mean for management?

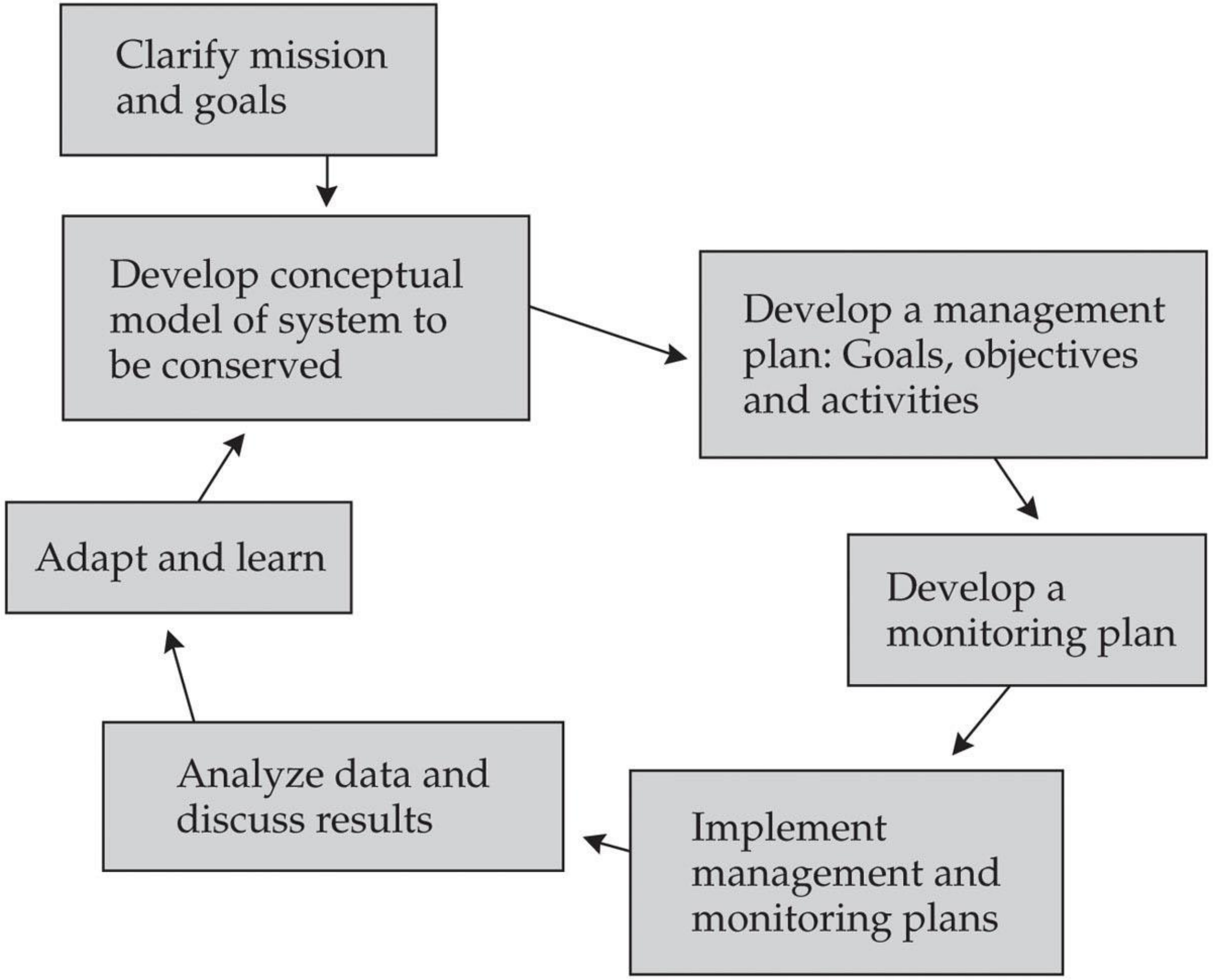
- **Ecosystems resilience**: the magnitude of disturbance that can be absorbed or accommodated by an ecosystem before its structure is fundamentally changed to a different state.

- This is about **resistance**, not resilience

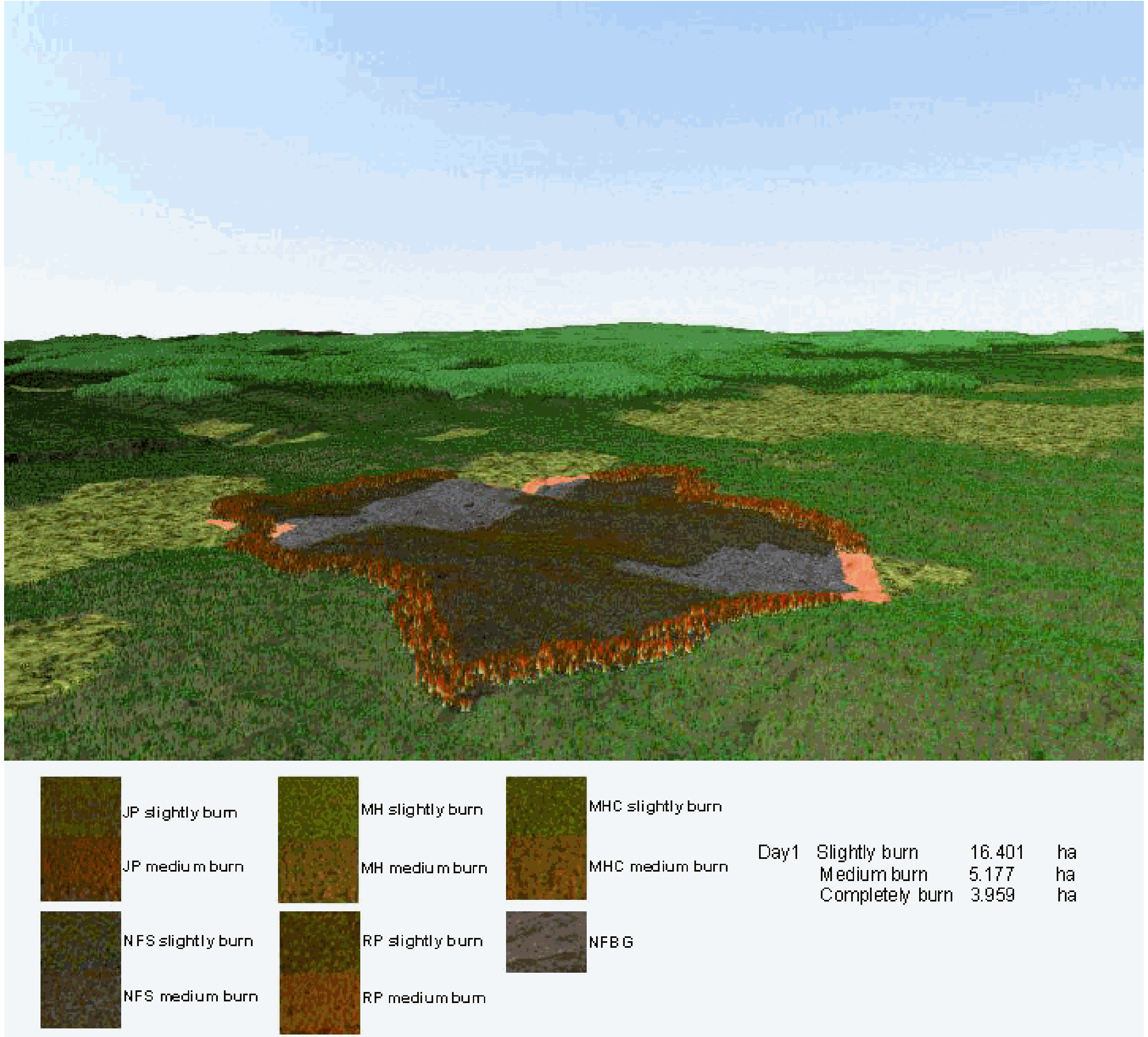
- **Resilience**: capability to recover

Adaptive Management

13.7 The adaptive management cycle allows for continual monitoring and refinement of objectives



Mimicking Natural Disturbances



Outcomes need to be variable-specific, compromises may not be made, pending on societal and political influences

1) Biodiversity vs. production

2) Water quality vs. fertilization

3) Jobs vs. preservation

4) Climate change vs. economic development

Not every landscape structural element can be manipulated (i.e., managed)

1) <u>Long-term</u> (100s yrs): streams, topography, climate, soils;

2) <u>Medium-term</u> (decades): roads, power lines, reserves, buildings, leased lands;

3) <u>Short-term</u> (yrs): plantations,

Management options and outcomes are scale dependent

1) <u>Temporal scale</u>: NEP of young and old-growth forest;
2) <u>Spatial scale</u>: species hot spots within low diversity region;
3) <u>Organization scale</u>: spotted owl and >480 interior species in the PNW.

Lacks of theoretical and empirical bases remain frustrations for landscape managers

Managers need “cook books”: available information is too abstractive, not specific. Products need to be simple, straightforward.

Can Optimal Outcomes Be Achieved?

Answer: NO

Why? They do not exist

Then What? Development of science-based options for managers and effectively present them to the policy makers.

Solutions: Adaptation & Mitigation

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Nature-Based Solutions

Edited by Raffaele Lafortezza, Jiquan Chen, Cecil C Konijnendijk van den Bosch, Thomas B Randrup
Last update 4 November 2019

During the past couple of years, the environment unit within the Directorate-General (DG) Research and Innovation of the European Commission launched the concept of nature-based solutions (NBS) as a way of making ecosystems and nature an integral part of sustainable development. DG Research and Innovation commissioned an interdisciplinary Expert Group on 'Nature-Based Solutions and Re-Naturing Cities' to define and operationalize the concept and to identify research needs and priorities (EC, 2015). This Expert Group delivered its report during 2015 and defined nature-based solutions as living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits.

NBS are conceptualized as closely connected to related concepts such as sustainable science, ecosystem services, coupled human and environment, and blue and green infrastructure and result in multiple co-benefits for health, the economy, society and the environment. Thus they can represent more efficient and cost-effective solutions than traditional approaches to development. NBS can be linked to a sustainable use of nature and ecosystems protection; to sustainability and multi-functionality of ecosystems; and to the design and management of new ecosystems. Innovative uses of existing ecosystems should also be considered (such as the role of urban woodland in climate change adaptation and the role of green infrastructure in building social cohesion).

This Special Issue will involve original research, reviews, and synthesis studies. These manuscripts will contribute to the special issue by illustrating general theories and methods, generating and analyzing natural and social datasets, developing integrated modeling techniques, and presenting state-of-the-art research results.

Read less

1) Nature-based solutions for resilient landscapes and cities
2) Innovative urban forestry governance in Melbourne?: Investigating "green placemaking" as a nature-based solution
3) Ecosystem services: Urban parks under a magnifying glass
4) Green spaces are not all the same for the provision of air purification and climate regulation services: The case of urban parks
5) Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges
6) Cultivating nature-based solutions: The governance of communal urban gardens in the European Union
7) Nature-based solutions to promote human resilience and wellbeing in cities during increasingly hot summers
8) Nature-based agricultural solutions: Scaling perennial grains across Africa
9) Public health risk of mercury in China through consumption of vegetables, a modelling study
10) The health benefits of nature-based solutions to urbanization challenges for children and the elderly – A systematic review
11) Grassland productivity and carbon sequestration in Mongolian grasslands: The underlying mechanisms and nomadic implications
12) Aerosol pollution and its potential impacts on outdoor human thermal sensation: East Asian perspectives
13) Natural Assurance Scheme: A level playing field framework for Green-Grey infrastructure development
14) Nature based solution for improving mental health and well-being in urban areas
15) A spatial framework for targeting urban planning for pollinators and people with local stakeholders: A route to healthy, blossoming communities?
16) Regulating urban surface runoff through nature-based solutions – An assessment at the micro-scale
17) Nature based solutions to mitigate soil sealing in urban areas: Results from a 4-year study comparing permeable, porous, and impermeable pavements
18) Nature-based solutions for urban landscapes under post-industrialization and globalization: Barcelona versus Shanghai
19) The reduction of Chlorella vulgaris concentrations through UV-C radiation treatments: A nature-based solution (NBS)
20) Challenges for tree officers to enhance the provision of regulating ecosystem services from urban forests
21) Air contaminants and litter fall decomposition in urban forest areas: The case of São Paulo - SP, Brazil
22) Resilient landscapes in Mediterranean urban areas: Understanding factors influencing forest trends
23) Assessing allergenicity in urban parks: A nature-based solution to reduce the impact on public health
24) Hydro-dam – A nature-based solution or an ecological problem: The fate of the Tonlé Sap Lake
25) Comprehending the multiple 'values' of green infrastructure – Valuing nature-based solutions for urban water management from multiple perspectives
26) Re-defining the characteristics of environmental volunteering: Creating a typology of community-scale green infrastructure
27) Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews

Solutions: Adaptation & Mitigation

The Expert Group delivered its report in 2015 and defined NBS as

"living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits"

1) identifying obstacles (e.g., regulatory) and enabling factors (e.g., leverage of funding) to the delivery of NBS;
2) raising citizens' awareness, engagement and empowerment;
3) integrating research, policy and the economic sector to provide the evidence base for NBS; (iv) scaling up NBS across Europe through a more comprehensive evidence base;
4) developing new business and investment models as well as legal and institutional frameworks for NBS; and
5) developing and deploying NBS that maximize cost-effectiveness and co-benefits.

Solutions: Adaptation & Mitigation

Overall, this Special Issue includes 26 contributions spanning more than 20 countries around the globe (Table 2). NBS applications range from the micro-scale (e.g., UV radiation as NBS to treat algae-polluted water; Chen and Bridgeman, 2017) to the macro-scale (e.g., grasslands as NBS supporting climate change adaptation on the Mongolian Plateau; Shao et al., 2017). The impacts are varied and include mitigation measures (e.g., Cariñanos et al., 2017), health benefits, as well as the ecological and economic value of NBS. We also present lessons learned from these sources to provide a more comprehensive evidence base for NBS applications (e.g., 'NBS planning is used as a place-making tool to strengthen city image and attract global investment'; Fan et al., 2017).

Solutions: Adaptation & Mitigation

Remaining challenges:

- to understand the linkages between NBS and associated ecosystem services within the four main categories of provisioning, regulating, cultural and supporting across different scales (e.g., from the “core” urban area to the wider peri-urban landscape);
- to assess NBS using a multitude of sensors and data sources including remotely sensed images (i.e., high-resolution satellite sensors, field sensors, airborne LiDAR) and field data;
- to scale up NBS benefits to the global level and provide evidence metrics or indicators that managers and policy makers can easily access and use;
- to actually implement NBS in the future planning and management of green (blue) landscapes; and (v) to include institutional changes (e.g., policy, governance, and culture) for future refinements of the NBS concept and its applications in both rural and urban landscapes

Solutions: Adaptation & Mitigation – local applications

Received: 16 February 2022 | Accepted: 22 April 2022

DOI: 10.1111/gcb.16267

Global Change Biology WILEY

OPINION

Land-based climate solutions for the United States

G. Philip Robertson[1,2,3] | Stephen K. Hamilton[1,3,4,5] | Keith Paustian[6] | Pete Smith[7]

Solutions: Adaptation & Mitigation – local applications

we now face an urgent need for negative emissions technologies (NETs) capable of removing GHGs from the atmosphere.

1) improved ecosystem stewardship or nature-based solutions, whereby more carbon is stored in ecosystems via practices like reforestation and afforestation, conservation agriculture, and wetland restoration

2) biological carbon capture with geologic storage as in bioenergy with carbon capture and storage (BECCS) and ocean fertilization

3) non-biological technologies such as enhanced rock weathering and direct air capture

C-Negative farming: How to get to 1000 Gt CO_2 per year

Agricultural Climate Solutions

Includes both:
- -negative emissions (soil and plant carbon storage, geologic CCS)
- -avoided emissions (fertilizer efficiency, bioenergy production)

Simple-minded analysis:
- -for any given practice
  - -range of likely values weighted towards results from long-term studies
  - -potential areal extent, weighted to avoid double counting & opportunity costs
  - -Monte Carlo simulation to estimate uncertainty based on ranges
- -for example, for continuous no-till:

Practice	Local Rate $tCO_2eq\ ha^{-1}\ y^{-1}$	Extent Mha	Annual Total $MtCO_2eq\ y^{-1}$	Duration years	Y2100 Total $GtCO_2eq$
Continuous No-till	1.6 (0-3.4)	55 (42-84)	85.9 (20-168)	40 (30-50)	3.4 (0.8-6.9)

C-Negative farming: How to get to 1000 Gt CO_2 per year

Agricultural Climate Solutions

Top 5 Advanced Cropping practices (90% of Y2100 cropland gain)

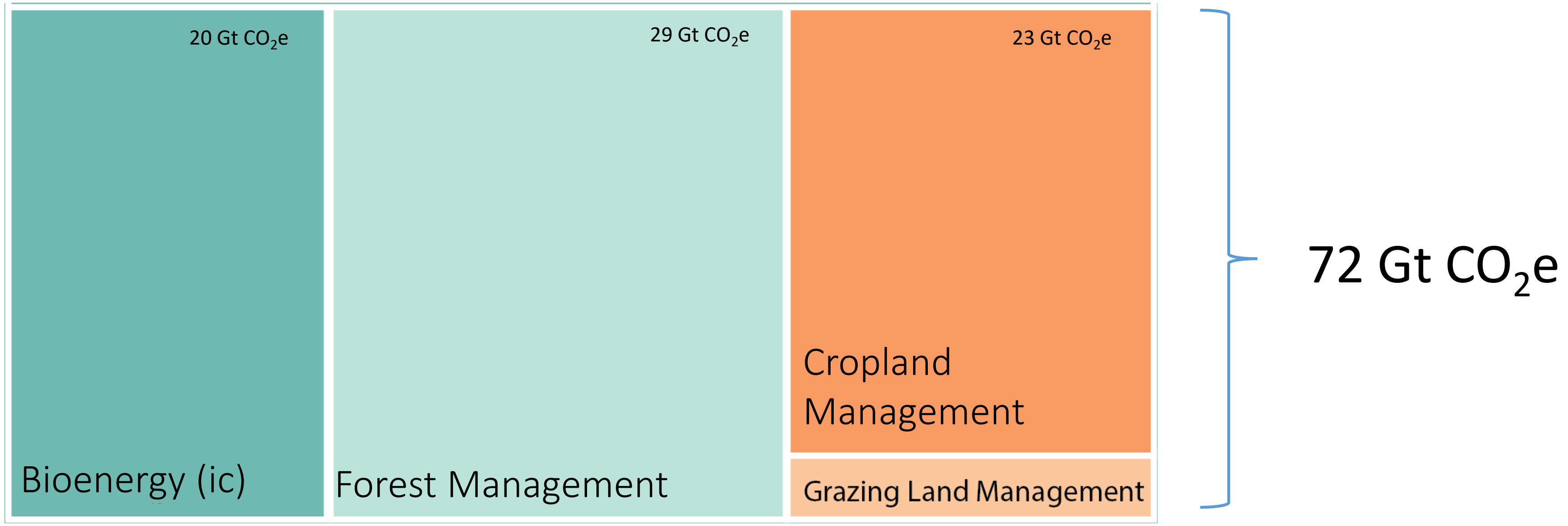
Practice	Local Rate $tCO_2eq\ ha^{-1}\ y^{-1}$	Extent Mha	Annual Total $MtCO_2eq\ y^{-1}$	Duration years	Y2100 Total $GtCO_2eq$
Winter cover crops	1.9 (.5-3.8)	69 (35-83)	131 (53-230)	50 (40-155)	8.8 (3.0-19.0)
Continuous no-till	1.6 (0-3.4)	55 (42-84)	86 (20-168)	40 (30-50)	3.4 (0.8-6.9)
Diversified rotations	0.9 (.1-4.0)	45 (30-59)	38 (5-109)	75 (40-75)	2.6 (0.3-7.5)
Manure management	2.6 (.2-5.1)	14 (6-17)	36 (11-65)	50 (40-70)	1.9 (0.6-3.5)
Advanced N management	0.7 (.5-.9)	21 (12-23)	15 (11-18)	75 (65-75)	1.0 (0.8-1.3)

Source: Robertson, Paustian, Smith in review

C-Negative farming: How to get to 1000 Gt CO_2 per year

Agricultural Climate Solutions

Net Negative Emissions to 2100

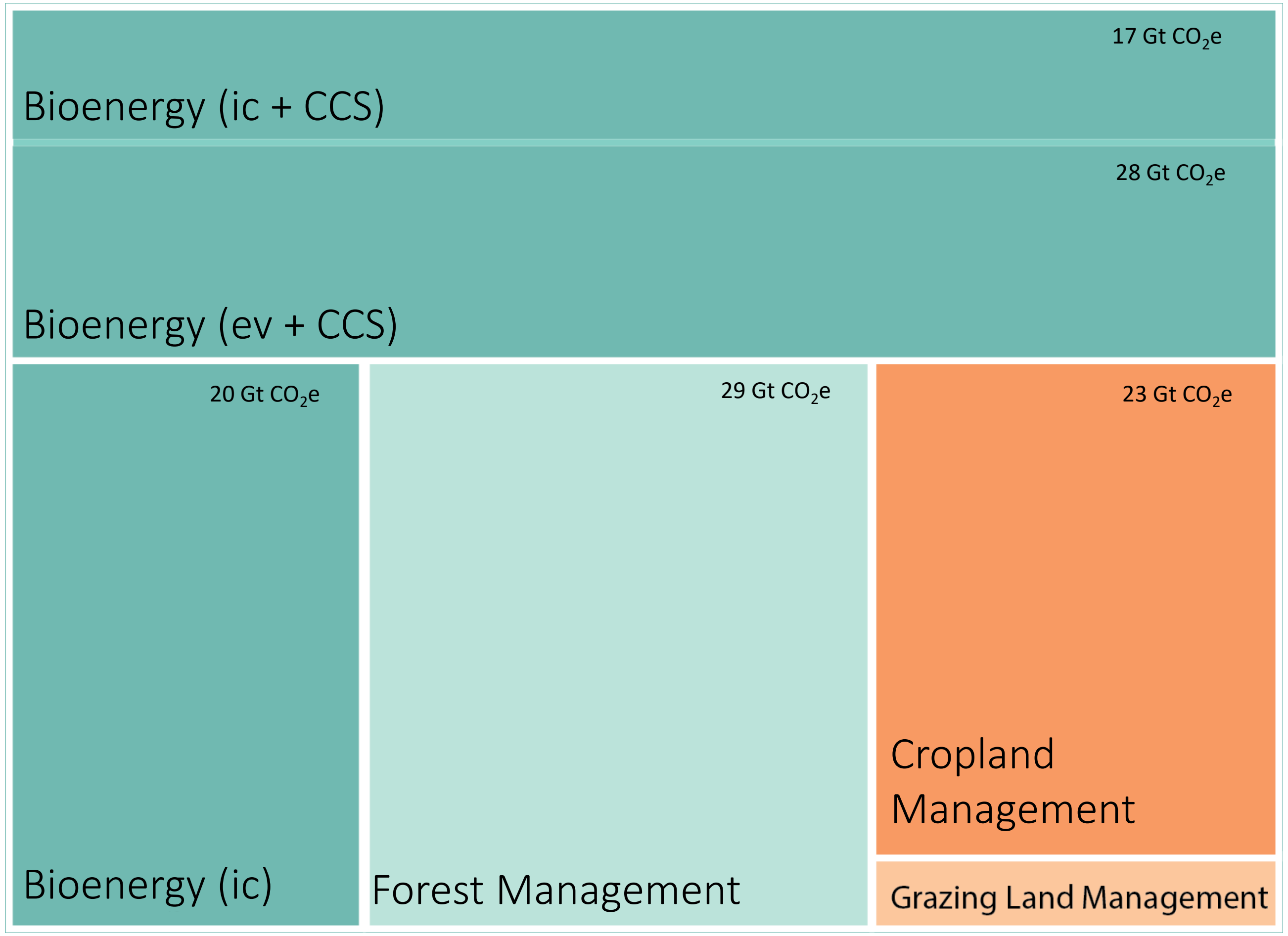


Robertson et al. 2023

C-Negative farming: How to get to 1000 Gt CO_2 per year

Agricultural Climate Solutions

Net Negative Emissions to 2100



17 Gt CO_2e

28 Gt CO_2e

from 2050

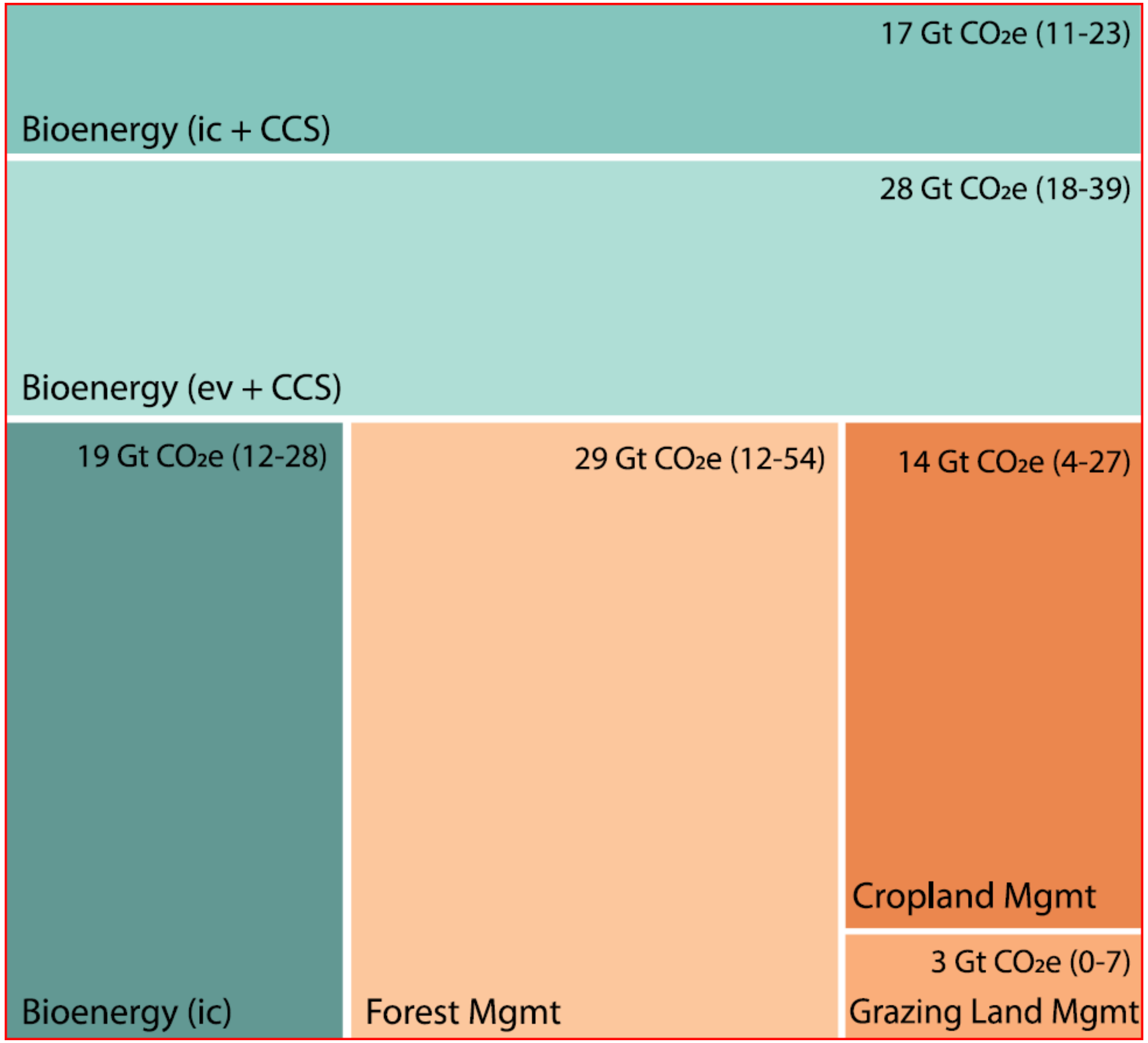
72 Gt CO_2e

117 (57-200) Gt CO_2e

Robertson et al. 2023

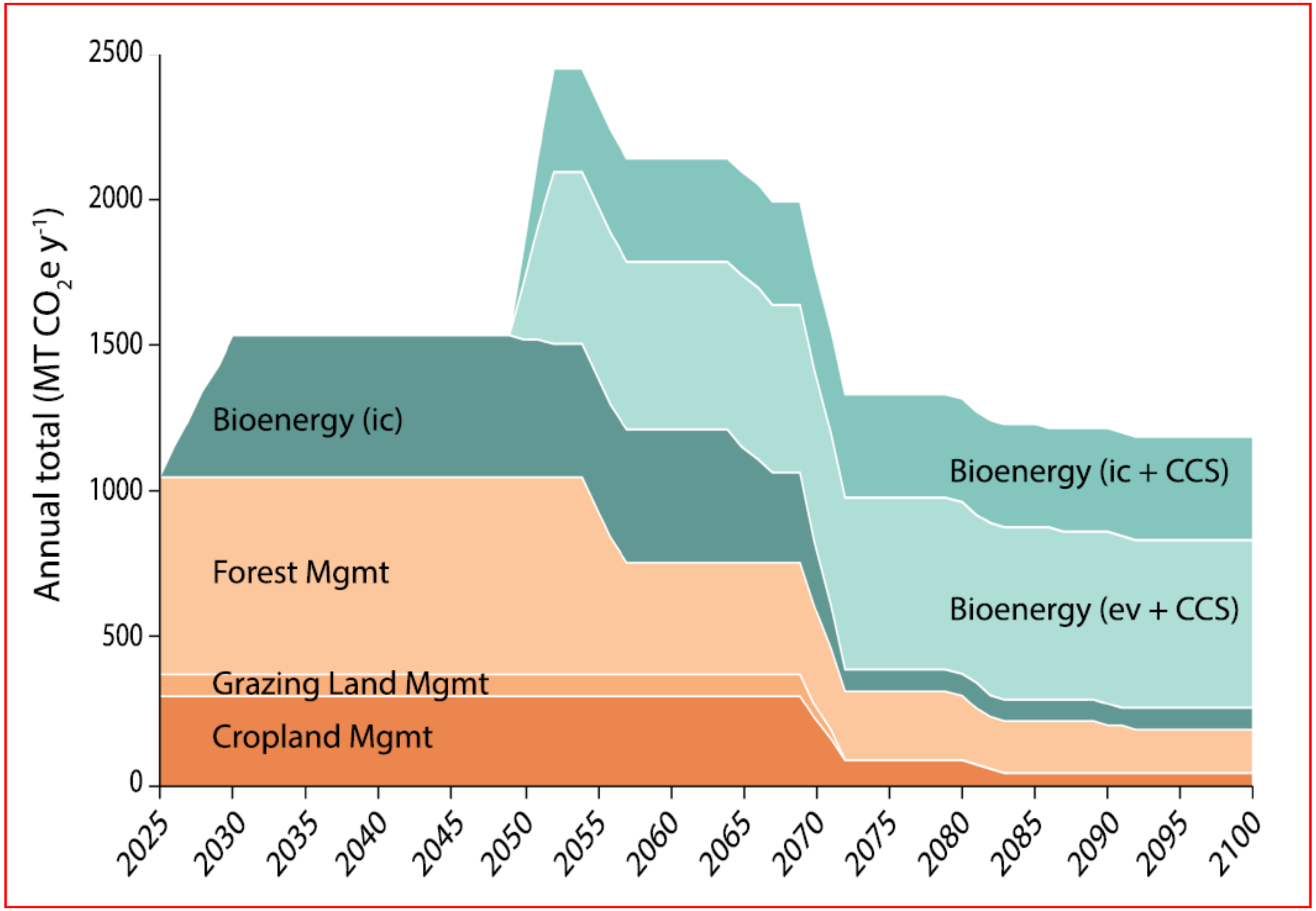
Solutions: Adaptation & Mitigation – local applications

F I G U R E 1 Mitigation potentials for U.S. land-based approaches totaling 110 Gt CO2e to 2100 (95% confidence interval: 57–178 Gt CO2e). Forest management includes afforestation and reforestation, and bioenergy is for light vehicle transportation. Bioenergy from 2050 includes carbon capture and storage with liquid fuel + internal combustion (ic) and then electricity production + electric vehicles (ev). Values in parentheses denote 95% confidence intervals. Values by emissions category and practice change appear in supplemental materials Table S1



Solutions: Adaptation & Mitigation – local applications

F I G U R E 2 Annual mitigation potentials through 2100 for different emissions categories considering the strengths and durations of various sinks, and the presumed availability of geologic carbon capture and storage beginning ca. 2050. The steep declines in nature-based sinks (soil organic carbon and tree biomass) reflect the assumption in the calculations of an abrupt termination of their effectiveness, when in reality they would approach carbon saturation in a more gradual and asymptotic manner. The 2025 start date (2030 for bioenergy) is arbitrary but useful for comparison with other efforts; the entire timeline could be shifted to a later date with no change to the 75 years potential.



Next Week: Water & Energy

Guest Lecture: Dr. jack Liu, MSU

Reading:

Liu, J., Dietz, T., Carpenter, S. R., Alberti, M., Folke, C., Moran, E., ... & Taylor, W. W. (2007). Complexity of coupled human and natural systems. *Science*, *317*(5844), 1513-1516.

Liu, J., Dietz, T., Carpenter, S. R., Taylor, W. W., Alberti, M., Deadman, P., ... & Lubchenco, J. (2021). Coupled human and natural systems: The evolution and applications of an integrated framework. *Ambio*, *50*(10), 1778-1783.