# Integrative Community Ecology

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### ABSTRACT

The goal of our unit is to determine the fundamental principles governing the assembly, dynamics, and functioning of communities and ecosystems.

We are a group of interdisciplinary scientists broadly interested in the origins and maintenance of biodiversity in natural ecosystems. We are especially interested in the causes and consequences of spatiotemporal variation in biotic interactions such as competition, predation, and mutualism. It is increasingly acknowledged that many ecological patterns – from local species co-occurrences to continental range limits – result from the joint effects of species' physiological responses to their environments, the biotic interactions in which they are participating, and their abilities to disperse across the landscape. Guided by theory, we conduct field and lab experiments to develop and quantify these interrelationships. We ask, for instance, whether dispersal of obligate mutualists such as pitcher plant arthropods or nitrogen-fixing bacteria is limited by habitat configuration, and, if so, how this impacts the performance and distribution of their host plants. Reciprocally, using molecular tools and gnotobiotic cultures, we also investigate how microbial partners' performance is influenced by variation in their host phenotype, genotype, or local environment.

We are also exploring feedbacks between communities and ecosystems. While we know that ecosystem processes such as nutrient cycling and productivity are set in part by the compositions of their local communities, the development of a predictive theory of community-ecosystem feedbacks has lagged. We use laboratory and field experiments to study links between community assembly and ecosystem function with the goal of predicting how critical ecosystem functions will be affected by species invasions and extinctions – both of which have dramatically increased in frequency during the Anthropocene.

Although the majority of our unit's research is empirical and fundamental in nature, it remains highly interfaced with both theoretical and applied conservation fields. At OIST, we aim to cultivate a multidisciplinary research group that values diverse backgrounds and expertise in order to advance the science of ecology – hence the "Integrative" in our unit's name!

*KEYWORDS: integrative, community, ecology, environment, interactions, research*

## INTRODUCTION:-

**Community integration**, while diversely defined, is a term encompassing the full participation of all people in community life. It has specifically referred to the integration of people with disabilities into US society[1][2] from the local to the national level, and for decades was a defining agenda in countries such as Great Britain.[3] Throughout recent decades, community integration programs have been increasingly effective in improving healthcare access for people with disabilities. They have been valued for providing a "voice for the voiceless"[4]

In the United States, the Consortium of Citizens for Disabilities[5] advocates for a national public policy that "ensures the self-determination, independence, empowerment, integration, and inclusion of children and adults with disabilities in all parts of society". Other countries (such as Canada) with different roots often spoke of inclusion: the unifying, global agenda in "disability and community life".[6][7]

### Theory

Theorists have differentiated types and levels of integration in special education as physical, functional, social, community, and organizational.[8] In disability circles, community integration meant opportunities for participation in schools, careers, homes, relationships, leisure, and a variety of interests and lifestyles.[9] Bengt Nirje and the late Wolf Wolfensberger of the US are internationally known for their concept of normalization and social role valorization,[10][11] with a particular emphasis on physical and social integration. Anders Gustavsson (c. 1990) of Sweden has indicated that physical integration best describes the common use of the term "integration", with social integration the struggle for "equality and quality in life."[12]

The intent of community integration was the participation of people with disabilities in regular environments, the antithesis of exclusionary practices (such as the minority-group model).[13][14] As the field moved toward community support, theories related to community living began to require applicability beyond a minority-group model[15] with a new emphasis on self-determination.[16] As described by Racino, these theories include ecological theory, community-support theories, systems theory, feminist theories, family theories, sociocultural theories, critical theories in education, psychosocial theories, the generic human-concept theory, and universal theories.[15]

### Systems change

Taylor, in his analysis of community systems in the US, proposed the principle of the non-restrictive environment as a counterpoint to the federal government's least-restrictive-environment principle.[17][18] In 2014, the governing principle in the US is that of the most integrated setting based upon the Supreme Court Olmstead Decision.[19]

Before the Olmstead decision, the Supreme Court addressed the community integration issues multiple times in the case, Halderman v. Pennhurst State School and Hospital, a class action filed in Pennsylvania by attorney David Ferleger.[20] Although the Olmstead decision explicitly did not reach the

constitutional issues decided in the Pennhurst and other cases, limitations in Olmstead have been critiqued and it has been argued that there is a constitutional right to community services.[21]

The analysis of large-scale systems change in community integration has involved challenges by local public agencies, key elements of these strategies (e.g., enabling leadership, putting people first, values and vision, learning for quality), and its implications for national policy.[22] Disability-agency, state-level disability-system, community, and societal change are essential (but insufficient) elements of the process and outcomes of community integration.[23]

Community integration also has strong community roots which place it in community practice fields from community psychology, to sociologists studying community, to inclusive education in local school systems, competitive businesses (with rehabilitation), rural independent living, urban sociology, local parks, and recreation programs, community development and housing, neighbourhoods, and communities, among others.[1,2,3]

### Education
Educational integration has a long history, described as "more comprehensive than academic mainstreaming".[24] Community integration in this context refers to opportunities "to learn practical social and community living skills in a wide variety of community settings".[25]:3 Based in part on the civil-rights movement[26] as represented by Brown v. Board of Education, school integration was based on the right to free and appropriate education.[27][28]

Educational integration (often equated with inclusion) remains controversial in the US (although it is supported by law) due, in part, to special-education systems.[29][30][31] School integration also involves children with more significant disabilities, such as those with technology-assistance needs.[32] Progress has been made in education at the post-secondary level (in almost all population groups) due, in part, to disability-services departments at colleges.[33][34] Instead of educational integration, the goal is for continued school reform through inclusion (education) and for education with legally-mandated accommodations.

### Housing
In the US disability field, a major shift has occurred from the group and facility-based models to homes with support services,[35] emphasizing a change from "home-like" housing to community homes, neighbourhoods, and relationships.[36][37] The most-recent initiatives were in homeownership,[38] an important form of community integration that also involves a feeling of ownership.[39] Housing integration builds on a long history of support for good quality, affordable housing which often includes analyses of social exclusion which may concentrate on US-protected classes.[40]

Housing integration is of great importance, in part, because of the history of residential segregation (usually by race and class) in the US.[41][42] Residential segregation due to inequality and disparity continues to be studied in ethnic, social, and economic frameworks, including the process of desegregation, gentrification, and hyper segregation.[43][44][45] In addition, redlining, as a bridge issue across lower and middle classes, affects housing and neighbourhood integration from as early as the 1970s with gerrymandering districts for community development funds more common in

the 2000s.[46] A discussion of residential segregation in the US and Europe and a "critique of the ideal of integration" can be found in *Inclusion and Democracy*.[47]

In the US, mixed-income and scattered-site housing was reported in a case study of a housing association supporting people with disabilities in Madison, Wisconsin (the Madison Mutual Housing Association and Cooperative).[48] In Canada, the Prairie Housing Cooperative (as reported by David Wetherow) integrates persons with disabilities into the community via housing.[49] An early review on nonprofit housing in the US and Canada, with increasing governmental funds in the US today, indicates that mixed-income housing[50] was used primarily in "troubled neighbourhoods" with efforts to seek higher-income tenants to move into those neighbourhoods as opposed to raising the entire group's living standards.[51] In 2013, the emphasis is on inclusive and sustainable housing,[52] while other groups support equitable and sustainable housing in the US (Policy Link). The status of housing and disability in America was reported by the National Council on Disability in the US,[53] and compared to Harvard University's report on the nation's housing.[54][55]

### Recreation
Being in the community has meant being part of local activities and events in towns, cities, and suburbs.[56] Recreational integration is one facet of inclusion and community access.[57] School-and-recreation integration was promoted in the US, Canada, and Australia.[58][59] On the local level, concerns have included acceptance and friendships, support services, site accessibility, group size, and "truly integrated" (in contrast to side-by-side) activities; in Great Britain, for example, community opportunities were sought for people to belong, contribute and make friends.[60] Recreational funding has also often been tied to facilities, and community integration involves staffing changes in environments such as the YMCA.[61]

Recreational inclusion may be a camp,[62] a neighbourhood centre,[63] a girls' softball league,[64] school sports or technology clubs,[65] a community choir,[66] or a public-speaking course[67] as integrated social participation.[68][69] Auto-related examples include an amusement-park car track; car shows, bike nights and car cruise-ins, and model-car racing.[70]

### Employment
Employment integration was advocated during the 1970s for women, people with disabilities, and racial groups, who were seen as discriminated against in employment (Racino for the Urban League of Onondaga County, Inc., 1978); for example, occupations and professions were constructed based upon gender: women's professions (nurses, teachers, secretaries) and men's professions (scientists, managers, administrators, police, firemen, and construction).[71] Progress has been made at the leadership level with the first African American president (Barack Obama), disability leadership in the United States Department of Education (Judith Heumann), and the rise of prominent women in the State Department (Madeleine Albright and Hillary Clinton).

For those with severe disabilities, employment-integration initiatives were often framed as supported employment, which allowed jobs at regular businesses and employment sites.[72][73][74][75][76] Similar initiatives in the mental health field were often called transitional employment, and other forms of integration included competitive placements in

businesses and industry, targeted positions, and even affirmative businesses in the hearts of business districts. A major success was the passage of the Americans with Disabilities Act of 1990, amended in 2008 (following the Rehabilitation Act of 1973, amended in 1978), which protected men and women with disabilities in obtaining jobs, careers, and positions with necessary workplace accommodations.[77] A key service for employment integration is often considered to be personal assistance services,[78] or in other fields a job coach[79] before more "natural" models of supervision and support.[80]

In this context employment integration has been conceptualized, including social aspects of promotion, discriminatory hiring and termination practices, performance standards, job-sharing and modification, educational attainment, internships and volunteer experiences, workplace relationships, team-building, supervisory roles, workers' compensation, accommodations, and supports (Urban League of Onondaga County, 1978). Competitive employment integration in the US workplace is expected by law, and categorical services have tended to be developed segregated bases (e.g., sheltered facilities to supported employment). Employment integration is a worldwide issue, modified by approaches to multicultural groups (e.g. the growing Latino population in the US), the changing economy (e.g. from manufacturing to service), and increasing unemployment.[4,5,6]

## Policies
Community integration has been most criticized for its inattention to gender, ethnic, cultural, racial, class, and economic factors[81][82] ("double discrimination", pp. 60–61). At the university level multiculturalism, including disability, was proposed as the solution to these complex issues.[83] Community integration, in practice, involves diverse approaches and models (age, team, agency, area, and gender integration or segregation) and has been integral to de-institutionalization and community development for over two decades.[84][85] Community integration is a policy, concept, and practice to address systemic stigma and discrimination related to disability.[13][86][87] It competes with other policy models (such as multiculturalism) and changes its practices over time.[88]

## Cross-disability
In the sub-field of brain injury, community integration included areas ranging from supported employment to daily living skills, family interventions (versus support) and memory training, school reintegration, and transition to post-secondary education.[89][90][91][92] Community integration was being diversely defined by researchers, including those in fields such as brain injury,[93][94] sensory impairments (e.g., hearing, visual),[95] developmental,[96] and physical disabilities.[97] News and professional-journal articles will often read, "integration into the community" (from institutions and facilities), integrated care (health services integration), or "community reintegration" (after hospital care)[98] worldwide.

In the field of mental health Paul Carling promoted community integration in the 1980s and 1990s in opposition to the predominant medical model,[99][100] while psychiatric rehabilitation is also linked to the medical, often allied health, professions. Carling's approach to community integration in mental health was congruent with intellectual disabilities, particularly in areas of community living (e.g.,

supportive living in intellectual disabilities, supported housing in mental health, and housing and support).[101] In 2008, *Disability and Society*, a popular disability policy journal discussed community reintegration for people with psychiatric disabilities and their relationship to centres for independent living.[102]

Comprehensive medical systems were proposed to support the family in community integration, including new roles for specialized personnel from neuropsychologists to physiatrists.[103] In the field of traumatic brain injury, community integration was framed by both the social and medical models of disability to transition people from hospitals and rehabilitation centres.[104][105] Today, the Brain Injury Association of America recommends the educational needs of children with traumatic brain injuries and the health care required.[106]

## US federal initiative
In 1985, the US government-funded a national community-integration project identifying best community practices for people with the "most severe disabilities".[107][108] Technical assistance was funded through the Rehabilitation Research and Training Center on Community Integration (of the National Institute on Disability Rehabilitation Research and Training Center, US Department of Education) to all states.[109][110] The Rehabilitation Research and Training Center on Community Integration (Syracuse University, headed by Steve Taylor) also subcontracted with the University of Illinois (David Braddock), the University of Minnesota Institute on Community Integration (K. Charlie Lakin)[111] The federal departments subsequently offered contracts to evaluate the status of these new community services in the US[112] and others.

The principles of community integration through the national flagship centres (the Rehabilitation Research and Training Centre on Family and Community Living,[113] facilitated by Lakin and J.A. Racino of Syracuse University) were:

➢ All people with disabilities will be able to live successfully in (and as part of) natural communities that provide them with the support they need.

➢ All people with disabilities will be recognized for the positive contributions they make to their families and communities.

➢ All people with disabilities will benefit from enduring relationships with other people (including family members and community members without disabilities).

➢ All people with disabilities (and their family members) will be entitled to participate in decisions affecting the nature and quality of services they receive.

➢ All people with disabilities will have access to services and supports that provide choice and support for full citizenship.

➢ Services and supports for people with disabilities will be individualized and responsive to cultural and ethnic differences, economic resources, and life circumstances.

➢ Public policy will provide the opportunity to enjoy productive, integrated lives.[5,6,7]

The 1988 Leadership Institute on Community Integration (From Being in the Community to Being Part of the Community, Steve J. Taylor, director; Julie Ann Racino,

deputy director and B. Shoultz, information coordinator), held in Washington, D.C., was sponsored by the Research and Training Center on Community Integration in cooperation with the National Institute on Disability and Rehabilitation Research, the Office of Special Education and Rehabilitative Services, US Department of Education, Beach Center on Families and Disability (University of Kansas), California Research Institute (University of Connecticut), Rehabilitation Research and Training Center (Virginia Commonwealth University), Research and Training Center Consortium on Aging and Developmental Disabilities (an eight-university consortium coordinated by the University of Cincinnati), Research and Training Center on Community Living (University of Minnesota) and the University-Affiliated Program in Developmental Disabilities (University of Illinois at Chicago).[114] Workgroups were facilitated in community living, families, school, and employment with papers prepared, respectively, by K. Charlie Lakin, Ann P. Turnbull and H. Rud Turnbull, Douglas Biklen, and Paul Wehman.

By the late 2000s, the Centers were renamed to Community Participation, one aspect of community integration, or Employment, or other priority areas, such as Health, with many of the above centres still federally funded through the NIDRR program (National Institute on Rehabilitation Research and Rehabilitation), US Department of Education and new academic centres at universities such as Temple University in Pennsylvania.[8,9,10]

### Principles and practices
In particular, community integration in intellectual, disabilities, and developmental disabilities means families for all children.[115][116] For adults, it means 'ordinary' or 'regular' homes with support services.[117][118][119] In addition, community integration means recreation, employment, transportation, and education with the personal assistance and support(s) necessary to participate fully in the community.[120][121][122]

However, community support (e.g., consumer-directed services) as part of community-agency change and deinstitutionalization,[123][124] self-determination,[125][126] community participation,[127] individual planning,[128][129] social relationships[130] and personal-assistance services[131][132] became the leading direction in US community integration. Community integration has also been described as comparative to normalization, a widely known value-based system of human services (See, Wolfensberger, Nirje & Bank-Mikkelsen).

Community integration has been tied to quality assurance in the community and improved quality of life.[133][134][135] It has involved evaluations and studies over at least two decades in areas ranging from service costs to personnel studies, service typologies, best practices and innovations, and community and integration studies.[136][137][138][139][140][141][142] Internationally, quality of life has been explored in Finland, Australia, the US, Germany, Hungary, Denmark, and Canada.[143]

### Global perspectives
Researchers in the US (Julie Ann Racino, Syracuse University) and Great Britain (David Towell, King's Fund College) collaborated on community integration, including a 1990 series of international seminars on community integration in the US held at the University of Manchester (Hester Adrian Research Center), Manchester Polytechnic and Manchester Health Authority, the King's Fund College (with Lyn Rucker), Campaign for the Mentally Handicapped (London), the University of Wales at Bangor (Center for Social Policy Research), and the University of Wales (Mental Handicap Research Unit). Internationally, research began on the "first integrated generation" in countries such as Sweden[144] and integration were confirmed as a legal principle in the US.[145]

Community services support, integration and inclusion are changing in countries such as Czechoslovakia (now the Czech Republic and Slovakia),[146] Australia, New Zealand, Japan, Israel, Austria, Great Britain, Iceland, and Sweden.[147] Since the 1990s the European Union has formed, populations in the Middle East have been emancipated, community self-advocacy has developed in South America and Africa and financial ownership of US debt has been undertaken (in part) by China.[148] The United Nations[149] offers guidance and leadership through its Convention on the Rights of Persons with Disabilities (particularly Article 19, which addresses independent living and community inclusion). A book based on these principles is "Public Administration and Disability: Community Services Administration in the US" (Racino, 2014)[150] which links to the diverse nation-states and rationales for continuing educational, employment, and housing segregation Segregation in Northern Ireland.[11,12,13]

### DISCUSSION
Forecasting and managing the effects of habitat loss, invasive species, and climate change require an expanded understanding of populations' responses to such stressors. To this end, the Integrative Community Ecology Unit employs theory-informed experiments and mathematical models to mechanistically identify how species interactions — such as competition and mutualism — vary over time and space to influence population dynamics and nutrient cycling in ecosystems. Current foci include the biogeography of plant-microbe interactions, determinants of species' range limits, and spatial variation in coexistence-promoting mechanisms.

In ecology, a **community** is a group or association of populations of two or more different species occupying the same geographical area at the same time, also known as a biocoenosis, **biotic community**, **biological community**, **ecological community**, or **life assemblage**. The term community has a variety of uses. In its simplest form it refers to groups of organisms in a specific place or time, for example, "the fish community of Lake Ontario before industrialization".[14,15,16]

**Community ecology** or **synecology** is the study of the interactions between species in communities on many spatial and temporal scales, including the distribution, structure, abundance, demography, and interactions between coexisting populations.[1] The primary focus of community ecology is on the interactions between populations as determined by specific genotypic and phenotypic characteristics. It is important to understand the origin, maintenance, and consequences of species diversity when evaluating community ecology.[2]

Community ecology also takes into account abiotic factors that influence species distributions or interactions (e.g. annual temperature or soil pH).[3] For example, the plant communities inhabiting deserts are very different from those found in tropical rainforests due to differences in annual precipitation. Humans can also affect community structure

through habitat disturbance, such as the introduction of invasive species.

On a deeper level the meaning and value of the community concept in ecology is up for debate. Communities have traditionally been understood on a fine scale in terms of local processes constructing (or destructing) an assemblage of species, such as the way climate change is likely to affect the make-up of grass communities.[4] Recently this local community focus has been criticized. Robert Ricklefs, a professor of biology at the University of Missouri and author of *Disintegration of the Ecological Community*, has argued that it is more useful to think of communities on a regional scale, drawing on evolutionary taxonomy and biogeography,[1] where some species or clades evolve and others go extinct.[5] Today, community ecology focuses on experiments and mathematical models, however, it used to focus primarily on patterns of organisms. For example, taxonomic subdivisions of communities are called populations, while functional partitions are called guilds.

## Organization
### Niche
Within the community, each species occupies a niche. A species' niche determines how it interacts with the environment around it and its role within the community. By having different niches species are able to coexist.[6] This is known as niche partitioning. For example, the time of day a species hunts or the prey it hunts.

Niche partitioning reduces competition between species.[7] Such that species are able to coexist as they suppress their own growth more than they limit the growth of other species. The competition within a species is greater than the competition between species. Intraspecific competition is greater than interspecific.

The number of niches present in a community determines the number of species present. If two species have the same niche (e.g., the same food demands) then one species outcompetes the other. The more niches filled, the higher the biodiversity of the community.

### Trophic level
A species' trophic level is their position in the food chain or web. At the bottom of the food web are autotrophs, also known as primary producer. Producers provide their own energy through photosynthesis or chemosynthesis, plants are primary producers. The next level is herbivores (primary consumers), these species feed on vegetation for their energy source. Herbivores are consumed by omnivores or carnivores. These species are secondary and tertiary consumers. Additional levels to the trophic scale come when smaller omnivores or carnivores are eaten by larger ones. At the top of the food web is the apex predator, this animal species is not consumed by any other in the community. Herbivores, omnivores and carnivores are all heterotrophs.[8]

A basic example of a food chain is; grass → rabbit → fox. Food chains become more complex when more species are present, often being food webs. Energy is passed up through trophic levels. Energy is lost at each level, due to ecological inefficiencies.[9]

The trophic level of an organism can change based on the other species present. For example, tuna can be an apex predator eating the smaller fish, such as mackerel. However, in a community where a shark species is present the shark becomes the apex predator, feeding on the tuna.[10]

Decomposers play a role in the trophic pyramid. They provide energy source and nutrients to the plant species in the community. Decomposers such as fungi and bacteria recycle energy back to the base of the food web by feeding on dead organisms from all trophic levels.[11]

## Guild
A guild is a group of species in the community that utilize the same resources in a similar way. Organisms in the same guild experience competition due to their shared resource.[12] Closely related species are often in the same guild, due to traits inherited through common descent from their common ancestor. However, guilds are not exclusively composed of closely related species.[13]

Carnivores, omnivores and herbivores are all basic examples of guilds. A more precise guild would be vertebrates that forage for ground dwelling arthropods, this would contain certain birds and mammals.[14] Flowering plants that have the same pollinator also form a guild.[15]

## Influential species
Certain species have a greater influence on the community through their direct and indirect interactions with other species. The population of influential species are affected by abiotic and biotic disturbances. These species are important in identifying communities of ecology. The loss of these species results in large changes to the community, often reducing the stability of the community. Climate change and the introduction of invasive species can affect the functioning of key species and thus have knock-on effects on the community processes. Industrialization and the introduction of chemical pollutants into environments have forever altered communities and even entire ecosystems.[16]

## Foundation species
Foundation species largely influence the population, dynamics and processes of a community, by creating physical changes to the environment itself.[17] These species can occupy any trophic level, but tend to be producers.[18] Red mangrove is a foundation species in marine communities. The mangrove's root provides nursery grounds for young fish, such as snappers.[19]

Whitebark pine (*Pinus albicaulis*) is a foundation species. Post fire disturbance the tree provides shade (due to its dense growth) enabling the regrowth of other plant species in the community, This growth prompts the return of invertebrates and microbes needed for decomposition. Whitebark pine seeds provide food for grizzly bears.[20]

## Keystone species
Keystone species have a disproportionate influence on the community than most species. Keystone species tend to be at the higher trophic levels, often being the apex predator. Removal of the keystone species causes top-down trophic cascades. Wolves are keystone species, being an apex predator.[17,18,19]

In Yellowstone National Park the loss of the wolf population through overhunting resulted in the loss of biodiversity in the community. The wolves had controlled the number of elks in the park, through predation. Without the wolves the elk population drastically increased, resulting in overgrazing. This negatively affected the other organisms in the park; the increased grazing from the elks removed food sources from other animals present. Wolves have since been reintroduced to return the park community to optimal functioning. See

Wolf reintroduction and History of wolves in Yellowstone for more details on this case study.

A marine example of a keystone species is *Pisaster ochraceus*. This starfish controls the abundance of *Mytilus californianus*, allowing enough resources for the other species in the community.[21]

### Ecological engineers
An ecosystem engineer is a species that maintains, modifies and creates aspects of a community. They cause physical changes to the habitat and alter the resources available to the other organisms present.[22]

Dam building beavers are ecological engineers. Through the cutting of trees to form dams they alter the flow of water in a community. These changes influence the vegetation on the riparian zone, studies show biodiversity is increased.[23] Burrowing by the beavers creates channels, increasing the connections between habitats. This aids the movement of other organisms in the community such as frogs.[24]

### Theories of community structure
Community structure is the composition of the community. It is often measured through biological networks, such as food webs.[25] Food webs are a map showing species networks and the energy that links the species together through trophic interactions.[26]

### Holistic theory
Holistic theory refers to the idea that a community is defined by the interactions between the organisms in it. All species are interdependent, each playing a vital role in the working of the community. Due to this communities are repeatable and easy to identify, with similar abiotic factors controlling throughout.

Frederic Clements developed the holistic (or organismic) concept of community, as if it were a superorganism or discrete unit, with sharp boundaries.[27] Clements proposed this theory after noticing that certain plant species were regularly found together in habitats, he concluded that the species were dependent on each other. Formation of communities is non-random and involves coevolution.[28]

The Holistic theory stems from the greater thinking of Holism—which refers to a system with many parts, all required for the system to function.[20,21,22]

### Individualistic theory
Henry Gleason developed the individualistic (also known as open or continuum) concept of community, with the abundance of a population of a species changing gradually along complex environmental gradients.[29] Each species changes independently in relation to other species present along the gradient.[30] Association of species is random and due to coincidence. Varying environmental conditions and each species' probability of arriving and becoming established along the gradient influence the community composition.[31]

Individualistic theory proposes that communities can exist as continuous entities, in addition to the discrete groups referred to in the holistic theory.

### Neutral theory
Stephen P. Hubbell introduced the neutral theory of ecology (not to be confused with the neutral theory of molecular evolution). Within the community (or metacommunity), species are functionally equivalent, and the abundance of a population of a species changes by stochastic demographic processes (i.e., random births and deaths).[32] Equivalence of the species in the community leads to ecological drift. Ecological drift leads to species' populations randomly fluctuating, whilst the overall number of individuals in the community remains constant. When an individual dies, there is an equal chance of each species colonising that plot. Stochastic changes can cause species within the community to go extinct, however, this can take a long time if there are many individuals of that species.

Species can coexist because they are similar, resources and conditions apply a filter to the type of species that are present in the community. Each population has the same adaptive value (competitive and dispersal abilities) and resources demand. Local and regional composition represent a balance between speciation or dispersal (which increase diversity), and random extinctions (which decrease diversity).[33]

### Interspecific interactions
Species interact in various ways: competition, predation, parasitism, mutualism, commensalism, etc. The organization of a biological community with respect to ecological interactions is referred to as community structure.

| Interactions | | Species 1 | | |
|---|---|---|---|---|
| | | **Negative** | **Neutral** | **Positive** |
| Species 2 | Negative | Competition | Amensalism | Predation/Parasitism |
| | Neutral | Amensalism | Neutralism | Commensalism |
| | Positive | Predation/Parasitism | Commensalism | Mutualism |

### Competition
Species can compete with each other for finite resources. It is considered an important limiting factor of population size, biomass and species richness. Many types of competition have been described, but proving the existence of these interactions is a matter of debate. Direct competition has been observed between individuals, populations and species, but there is little evidence that competition has been the driving force in the evolution of large groups.[34]

1.  **Interference competition**: occurs when an individual of one species directly interferes with an individual of another species. This can be for food or for territory. Examples include a lion chasing a hyena from a kill, or a plant releasing allelopathic chemicals to impede the growth of a competing species.

2.  **Apparent competition**: occurs when two species share a predator. For example, a cougar preys on woodland caribou and deer. The populations of both species can be depressed by predation without direct exploitative competition.[35]

1.  **Exploitative competition**: This occurs via the consumption of resources. When an individual of one species consumes a resource (e.g., food, shelter, sunlight, etc.), that resource is no longer available for consumption by a member of a second species. Exploitative competition is thought to be more common in nature, but care must be taken to distinguish it from the apparent competition. An example of exploitative competition could be between herbivores consuming vegetation; rabbit and deer both eating meadow grass. Exploitative competition varies:

- complete symmetric - all individuals receive the same amount of resources, irrespective of their size

- perfect size symmetric - all individuals exploit the same amount of resource per unit biomass

- absolute size-asymmetric - the largest individuals exploit all the available resource.[36]

The degree of size asymmetry has major effects on the structure and diversity of ecological communities[23,24,25]

## Predation
Predation is hunting another species for food. This is a positive-negative interaction, the predator species benefits while the prey species is harmed. Some predators kill their prey before eating them, also known as kill and consume. For example, a hawk catching and killing a mouse. Other predators are parasites that feed on prey while alive, for example, a vampire bat feeding on a cow. Parasitism can however lead to death of the host organism over time. Another example is the feeding on plants of herbivores, for example, a cow grazing. Herbivory is a type of predation in which a plant (the prey in this example) will attempt to dissuade the predator from eating the plant by pumping a toxin to the plant leaves. This may cause the predator to consume other areas of the plant or not consume the plant at all.[37] Predation may affect the population size of predators and prey and the number of species coexisting in a community.

Predation can be specialist, for example the least weasel predates solely on the field vole. Or generalist, e.g. polar bear primarily eats seals but can switch diet to birds when seal population is low.[38][39]

Species can be solitary or group predators. The advantage of hunting in a group means bigger prey can be taken, however, the food source must be shared. Wolves are group predators, whilst tigers are solitary.

Predation is **density dependant**, often leading to population cycles. When prey is abundant predator species increases, thus eating more prey species and causing the prey population to decline. Due to lack of food the predator population declines. Due to lack of predation the prey population increases. See Lotka–Volterra equations for more details on this. A well-known example of this is lynx-hare population cycles seen in the north.[40]

Predation can result in **coevolution** – evolutionary arms race, prey adapts to avoid predator, predator evolves. For example, a prey species develops a toxin that kills its predator and the predator evolves resistance to the toxin making it no longer lethal.

## Mutualism
Mutualism is an interaction between species in which both species benefit.

An example is *Rhizobium* bacteria growing in nodules on the roots of legumes. This relationship between plant and bacteria is endosymbiotic, the bacteria living on the roots of the legume. The plant provides compounds made during photosynthesis to the bacteria, that can be used as an energy source. Whilst Rhizobium is a nitrogen fixing bacteria, providing amino acids or ammonium to the plant.[41]

Insects pollinating the flowers of angiosperms, is another example. Many plants are dependent on pollination from a pollinator. A pollinator transfers pollen from the male flower to the female's stigma. This fertilises the flower and enables the plant to reproduce. Bees, such as honeybees, are the most commonly known pollinators. Bees get nectar from the plant that they use as an energy source. Un-transferred pollen provides protein for the bee. The plant benefits through fertilisation, whilst the bee is provided with food.[42]

## Commensalism
Commensalism is a type of relationship among organisms in which one organism benefits while the other organism is neither benefited nor harmed. The organism that benefited is called the *commensal* while the other organism that is neither benefited nor harmed is called the *host*.

For example, an epiphytic orchid attached to the tree for support benefits the orchid but neither harms nor benefits the tree. This type of commensalism is called **inquilinism**, the orchid permanently lives on the tree.

**Phoresy** is another type of commensalism, the commensal uses the host solely for transport. Many mite species rely on another organism, such as birds or mammals, for dispersal.[43]

**Metabiosis** is the final form of commensalism. The commensal relies on the host to prepare an environment suitable for life. For example, Kelp has a root like system, called a holdfast, that attaches it to the seabed. Once rooted it provides molluscs, such as sea snails, with a home that protects them from predation.[44]

## Amensalism
The opposite of commensalism is amensalism, an interspecific relationship in which a product of one organism has a negative effect on another organism but the original organism is unaffected.[45]

An example is an interaction been tadpoles of the common frog and a freshwater snail. The tadpoles consume large amounts of micro-algae. Making algae less abundant for the snail, the algae available for the snail is also of lower quality. The tadpole, therefore, has a negative effect on the snail without a gaining noticeable advantage from the snail. The tadpoles would obtain the same amount of food with or without the presence of the snail.[46]

An older, taller tree can inhibit the growth of smaller trees. A new sapling growing in the shade of a mature tree struggles to get light for photosynthesis. The mature tree also has a well-developed root system, helping it outcompete the sapling for nutrients. Growth of the sapling is therefore impeded, often resulting in death. The relationship between the two trees is amensalism, the mature tree is unaffected by the presence of the smaller one.[47]

## Parasitism
Parasitism is an interaction in which one organism, the host, is harmed while the other, the parasite, benefits.

Parasitism is a symbiosis, a long-term bond in which the parasite feeds on the host or takes resources from the host. Parasites can live within the body such as a tapeworm. Or on the body's surface, for example head-lice.[26,27,28]

Malaria is a result of a parasitic relationship between a female Anopheles mosquito and *Plasmodium*. Mosquitos get the parasite by feeding on an infected vertebrate. Inside the mosquito the plasmodium develops in the midgut's wall. Once developed to a zygote the parasite moves to the salivary glands where it can be passed on to a vertebrate

species, for example humans.[48] The mosquito acts as a vector for Malaria. The parasite tends to reduce the mosquito's lifespan and inhibits the production of offspring.[49]

A second example of parasitism is brood parasitism. Cuckoos regularly do this type of parasitism. Cuckoos lay their eggs in the nest of another species of birds. The host, therefore, provides for the cuckoo chick as if it were as their own, unable to tell the difference.[50] The cuckoo chicks eject the host's young from the nest meaning they get a greater level of care and resources from the parents. Rearing for young is costly and can reduce the success of future offspring, thus the cuckoo attempts to avoid this cost through brood parasitism.[51]

In a similar way to predation, parasitism can lead to an evolutionary arms race. The host evolves to protect themselves from the parasite and the parasite evolves to overcome this restriction.[52]

### Neutralism
Neutralism is where species interact, but the interaction has no noticeable effects on either species involved. Due to the interconnectedness of communities, true neutralism is rare. Examples of neutralism in ecological systems are hard to prove, due to the indirect effects that species can have on each other.

### RESULTS
**Integrated conservation and development projects** (ICDPs), are biodiversity conservation projects with rural development components. It is an approach that aspires to combine social development with conservation goals.[1] These projects look to deal with biodiversity conservation objectives through the use of socio-economic investment tools. The World Wide Fund for Nature (WWF), first introduced ICDPs in the mid 1980s. They wanted to attend to some of the problems associated with the "fines and fences" (non-participatory) approach to conservation.[2]

### ICDPs under WWF
The Wildlands & Human Needs Program was initiated in 1985 by WWF, and incorporated 19 ICDPs in 12 countries in Africa and South America. They wanted to improve the quality of life of rural people through projects that integrated the management of natural resources with economic development. Today, there are around 300 ICDPs.[1]

### Various names of ICDPs
ICDPs have many different names, like "People-Centered Conservation and Development", "Eco-development", "grassroots conservation", community-based natural resource management (CBNRM), and community wildlife management (CWM), all of which were created by the conservation organizations, rather than the indigenous people.[3]

### Characteristics of ICDPs
Biodiversity conservation is the primary goal, but ICDPs also like to deal with the social and economic requirements of communities who might threaten biodiversity. They wish to improve the relationships between state-managed protected areas and their neighbors, but do not inevitably seek to delegate ownership of protected area resources to local communities. They usually receive funding from external sources and are externally motivated and initiated by conservation organizations and development agencies. ICDPs are normally linked to a protected area, usually a national park.[1] ICDPs, through benefit sharing, are believed to discourage poaching and promote economic development. ICDPs try to benefit indigenous populations in several ways: through the transfer of money from tourism, the creation of jobs, and the stimulation of productivity in agriculture.[4]

### ICDP assumptions
ICDPs make many assumptions during their project implementations, each of which may prove true or false. They are:[1]

1. Diversified local livelihood options will reduce human pressures on biodiversity, leading to improved conservation.

2. Local people and their livelihood practices comprise the most important threat to the biodiversity resources of the area in question.

3. ICDPs offer sustainable alternatives to traditional approaches of protected areas management.

### Critiques of ICDPs
Conservation organizations do not necessarily understand the social and economic arenas they are trying to work in. They are the ones to start the ICDPs, rather than the rural people, and have little experience working with communities. They are also unwilling to bear or support legal battles over land and are not willing to strengthen rural organizations because they find it to be "too political".[1] However, WWF claims that ICDPs strengthen local organizations and "broker new land-use agreements between governments and communities, and helping communities challenge encroachment upon their natural resources, ICDPs involve local communities to improve livelihoods and conservation".[5]

Agroforestry and organic gardening projects do not work as well, because it is difficult for indigenous peoples to market what is grown.[6] Minority ethnic groups and women are many times not accounted for in the redistribution of costs and benefits. There are many limitations on participation by women, so many feel there are not equal opportunities for all people within the community.

External effects like a growing market demand for forest and wildlife products, demographic pressures and vested interests like illegal logging, mineral extraction and ranching often go disregarded by ICDPs. In addition, community-based conservation projects are often found to be divergent to the goals of biodiversity conservation, and should be based more on biological sciences. As stated by Katrina Brandon with, "Not all things can be preserved through use".[3] Another problem is that some of the ICDPs that are funded internationally may not be financially or economically sustainable once their external funding has been exhausted.

### Integrated conservation and development practices in Madagascar
The ICDP in Madagascar has unintentionally led to environmental sustainability and degradation simultaneously. The organization relies on the cheap and local labor of select individuals to enforce their conservation practices among the communities near the forests. Problems occur due to the disparity in wages and lack of communication between the local conservation agents and the government. The conservation agents are placed in the difficult position of doing their duties as workers for the ICDP and their duties as members of the community. On one

hand, the conservation agents are required to monitor the forests, and prevent peasants and other locals from farming portions of the land, which can become violent and dangerous. These encounters between the hired locals and the rest of the community causes friction between them, and run the risk of being shunned.[7]

The local agents are also aware of the wage gap between them and the external officials who work for the ICDP. The high paying jobs are universally given to foreign workers who come into the community while the low paying, harder working jobs are given to the local conservation agents. This recognition has led many local conservation agents to turn a blind eye to illegal logging and unapproved agricultural practices by other peasants. These interactions lead to further destruction of the environment which contradicts the motives and goals of the ICDP.[29]

Additionally, the arrival of another conservation organization, ANGAP, has also discouraged locals from continuing their conservation work and are beginning to quit their jobs despite the economic ramifications. These labor tensions surrounding conservation help are rarely discussed as Western authorities continually emphasize the successes while diminishing any failures. This is to continue the ideology that all conservation endeavors are inherently beneficial to everyone involved. However, the Malagasy people are aware of these fallacies, and many feel that these conservation organizations are profiteering land for personal gain. Ideas like these continue to cause hesitation among local communities to participate with organizations such as the ICDP.[7]

The ICDP, however, has introduced many conservation activities encouraging participation among local communities. Tools such as lesson plans, trainings, and increasing communications between themselves and the local community have occurred in order to ease tensions and build a better relationship. The Malagasy people hope this will encourage the ICDP to allow them to take over some of the labor given to foreign workers. By replacing these kinds of positions, the locals will achieve better compensation for their work which will ultimately strengthen relationships.[7]

## CONCLUSION
**Community-based management** (**CBM**) is a bottom up approach of organization which can be facilitated by an upper government or NGO structure but it aims for local stakeholder participation in the planning, research, development, management and policy making for a community as a whole.[1][2] The decentralization of managing tactics enables local people to deal with the unique social, political and ecological problems their community might face and find solutions ideal to their situation.[3][4][5] Overwhelming national or local economic, political and social pressures can affect the efficiency of CBM as well as its long term application.[6] CBM varies across spatial and temporal scales to reflect the ever-changing distinctive physical and/or human environment it is acting within. While the specifics of each practice might differ, existing research maintains that community based management, when implemented properly, is incredibly beneficial not only for the health of the environment, but also for the well-being of the stakeholders.[7][8][9][10][11]

### Cultural change and sustainability
Social ideologies and cultural divides between regions and often within regions challenge the implications of CBM.[12]

The process of identifying stakeholders and maintaining policies needs to fluctuate culturally to imply the sustainability of CBM.[13] Scrutiny of inequality issues and the level of self-management a community will take on needs to be evaluated for each CBM implementation.[14] Therefore, cultural beliefs can be communicated politically whether the community agrees with CBM or not.[15]

### Natural resources
The community-based management concept is often integrated into the conservation and development projects of natural resources.[16] Referred to as community-based natural resources management (CBNRM), these projects aim to develop a partnership between wildlife and communities while generating a revenue to benefit the community as well as its resources management[30]

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