Quiz SL104
Forest Dynamics
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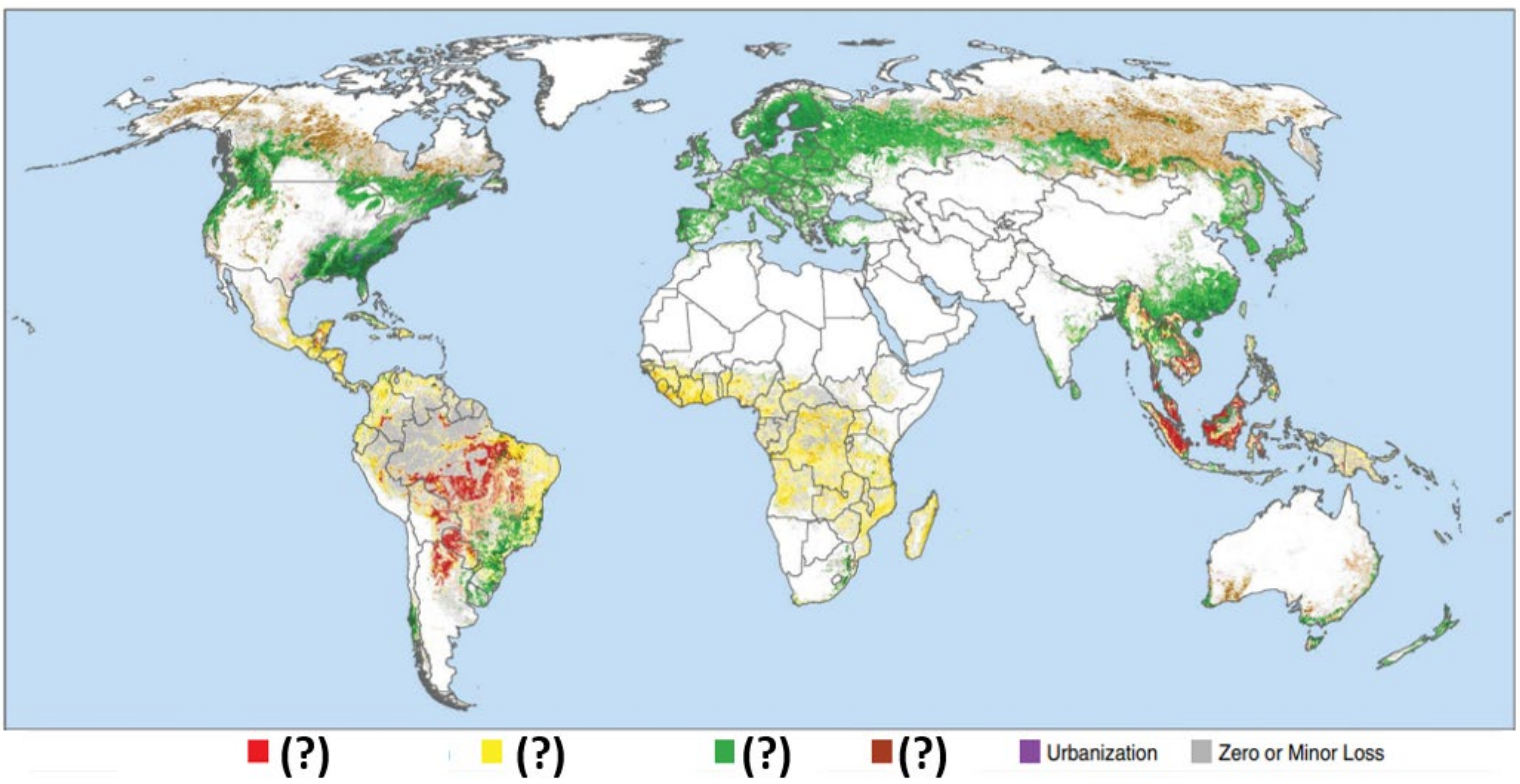
PROBLEMS

Problem 1

The following map shows the primary drivers of global forest loss for the 2001 – 2015 period. It is known that purple represents forest loss attributable to urbanization and gray indicates zero or minor loss. Darker shading is associated with greater loss. Which of the following alternatives correctly associates the four remaining colors with the corresponding sources of forest loss?



A) ■ Wildfire; ■ Shifting agriculture; ■ Forestry; ■ Commodity-driven deforestation;
B) ■ Community-driven deforestation; ■ Wildfire; ■ Shifting agriculture; ■ Forestry;
C) ■ Community-driven deforestation; ■ Shifting agriculture; ■ Forestry; ■ Wildfire;
D) ■ Forestry; ■ Community-driven deforestation; ■ Wildfire; ■ Shifting agriculture;

▶ Problem 2

Which of the following alternatives ranks tree species in terms of **decreasing** maximum growth potential?

A) Ruderal > Stress-tolerant > Competitor
B) Ruderal > Competitor > Stress-tolerant
C) Competitor > Ruderal > Stress-tolerant
D) Competitor > Stress-tolerant > Ruderal

▶ Problem 3

Which of the following alternatives correctly ranks forest types in order of **decreasing** decomposition constant k?

A) Tundra > Tropical moist forest > Temperate grassland > Boreal forest
B) Temperate grassland > Boreal forest > Tropical moist forest > Tundra
C) Tropical moist forest > Tundra > Temperate grassland > Boreal forest
D) Tropical moist forest > Boreal forest > Temperate grassland > Tundra
E) Boreal forest > Temperate grassland > Tropical moist forest > Tundra

▶ Problem 4

Regarding different aspects of forestry theory, true or false?

1.( ) More photosynthetic active radiation (PAR) reaches the understory of a rainforest on an overcast than on a sunny day.

2.( ) Specific leaf area (SLA), sometimes denoted as σ_F, is a plant's leaf area per unit foliage mass. It is also the constant of proportionality that links the leaf area A_F to the foliage mass ω_F, so that $A_F = \sigma_F \omega_F$. In general, the SLA averaged over a canopy decreases as a tree ages.

3.( ) Tan and Black (1976) assessed the canopy resistance of a Douglas-fir forest. The canopy resistance was found to increase steadily during daytime hours. What's more, this increase was accompanied by increasing stomatal resistance, hence we may conclude that the increase in canopy resistance is driven by closure of stomata.

Recommended research: Tan and Black (1976).

Using a thermal camera while in a helicopter, Leuzinger *et al.* (2010) scanned trees of 10 different species across different parts of Basel, Switzerland. They noted that scanned trees had a mean temperature of 27°C – a typical value – and, coupled with stomatal conductance data, found that the trees probably enjoyed an adequate water supply.

4.( ) Crucially, Leuzinger's group found significantly higher crown temperatures for trees located in park environments than for trees located in street. environments. ■ **(A black square indicates the end of a multi-paragraph statement.)**

Recommended research: Leuzinger *et al.* (2010).

5.( ) Aware of the need for better understanding of the interaction between forest biomass and climate, Stegen *et al.* (2011) assessed the relative importance of several environmental variables, such as temperature and precipitation, in determining the local biomass. They also attempted to relate biomass to a tree's water deficit, but this approach yielded a correlation with biomass no better than either mean annual temperature or annual precipitation.

Recommended research: Stegen *et al.* (2011).

6.( ) Stanton *et al.* (2014) showed that epiphytes have important effects on host plant-water interactions, be it by directly retaining throughfall and stemflow water or indirectly by buffering canopy microclimate. Simply put, the presence of dense epiphyte cover significantly alters the microclimate at the surface of host plants. As an important limitation, however, Stanton's group studied only plants that hosted lichens – namely, *Usnea* spp. and *Ramalina usnea* – therefore it remains to be shown that higher epiphytes, such as bromeliads, can produce similar effects.

Recommended research: Stanton *et al.* (2014).

7.( ) Enquist (1999) is a much-debated paper that exemplifies use of metabolic ecology theory to plant structural growth. One of the most contentious concepts posed in that paper is that a plant's biomass growth rate scales with its biomass M as $M^{3/8}$, and its diameter growth rate scales with the trunk diameter D as $D^{1/3}$. Enquist's and other scaling laws involving relationships between photosynthetic rates, growth rates, or mortality rates and size have received substantial support from recent papers, as in the case of Muller-Landau *et al.* (2006).

Recommended research: Enquist (1999); Muller-Landau *et al.* (2006); Coomes and Allen (2007).

In several reforestation initiatives around the world, the norm has been the use of monoculture plantations of exotic species, selected for their tolerance to degraded soils or high value as sources of timber and other natural products. However, adoption of monocultural plantations has been accompanied by community opposition, as this type of reforestation does not provide many of the traditional forest goods used and required by local stakeholders.

8.( ) Economic issues aside, Erskine *et al.* (2006) have noted that the productivity of monocultural plantations, at least those established in the humid tropics of Australia, was found to be generally greater than that of multi-species plantations. ■

Recommended research: Erskine *et al.* (2006).

Castillo-Campos *et al.* (2008) assessed the biodiversity of the Mexican tropical deciduous forests, known for their rich vascular flora – which, those authors note, rivals even those of some moist forests.

9.( ) Importantly, in the area studied by Castillo-Campos' group the secondary vegetation was found to have greater alpha diversity than the primary forest, both in terms of the cumulative number of species and in terms of mean species richness. ■

Recommended research: Castillo-Campos *et al.* (2008).

10.( ) Jacob *et al.* (2010) quantified biomass and above-ground production in nine forest stands with species diversity ranging from monocultures of beech to stands consisting of up to five deciduous tree species (*Fagus sylvatica*, *Fraxinus excelsior*, *Tilia* spp., *Carpinus betulus*, *Acer* spp.) typical of Central-European forest biomes. In contrast to several other pieces of research, Jacob's group reported that there was no increase in above-ground productivity with increasing tree species diversity.

Recommended research: Jacob *et al.* (2010).

The Sardinilla field site, a native tropical tree biodiversity plantation in central Panama, is a plantation conceived by Healy *et al.* (2008) to explore biodiversity and ecosystem function (BEF) at a scale relevant to forest management.

11.( ) After monitoring the Sardinilla forest for about 5 years, Healy's group performed a statistical analysis to assess the relative importance of environmental heterogeneity and biodiversity in the plantation's productivity. Crucially, their study does not corroborate the notion that ecosystem properties may be more influenced by abiotic conditions than by species richness. Indeed, Healy's group found that their 'environment matrix' outstripped their 'diversity matrix' in terms of explanatory power for both productivity and mortality. ■

Recommended research: Healy *et al.* (2008).

The Janzen-Connell hypothesis has been proposed as an explanation for the high tree species biodiversity observed in tropical rainforests. Simply put, the model postulates that seed or seedling density decreases with distance from the parent; assuming either density-responsive or distance-responsive predators, seed predation is thought to be greatest near the maternal parent, causing survival to increase with distance from the parent.

12.( ) Field experiments conducted by Burkey (1994) showed that predation patterns of *Brosinum alicastrum* seeds exhibited a spatial pattern aligned with the J-C hypothesis. ■

Recommended research: Burkey (1994).

Girão *et al.* (2007) tested the hypothesis that habitat fragmentation may change the frequency of tree species and individuals within categories of reproductive traits and consequently reduce the functional diversity of tree assemblages. Their habitat of choice was the Brazilian Atlantic forest, a biome that has been severely disrupted and fragmented since colonization began in the 16th century.

13. ( ) Girão's group found that the tree communities in more fragmented forest patches generally included species with a more limited assortment of reproductive strategies than observed in an untouched biota. Specifically, the plant assemblages in forest fragments were dominated by generalists in lieu of species with particular pollination systems; further, species with self-compatible reproductive strategies were favored to the detriment of self-incompatible species. ■

Recommended research: Girão *et al.* (2007).

14.( ) Onaindia *et al.* (2004) studied plant species composition in oak-mixed Atlantic woodlands in Spain's Basque Country. Indices of species diversity and evenness were used to evaluate the effects of disturbance regimes in those forests. Specifically, Onaindia's group employed two indices of species evenness, namely Pielou's evenness index *J'* and Simpson's evenness index *E*. The former was found to be superior to the latter in reflecting disturbance levels, as it more clearly distinguished between less (old-growth and regenerated woodlands) and more (regenerating and grazed woodlands) disturbed groups.

Recommended research: Onaindia *et al.* (2004).

Activities such as burning of fossil fuels and excessive use of nitrogenous fertilizers have increased the nitrogen (N) load in biomes all over the world. Research on the responses of plant community biodiversity to increasing N deposition suggests a negative trend, although some studies have indicated no significant change. In one of the first contributions of its kind, Lu *et al.* (2010) assessed the effect of N deposition on the plant diversity of an old-growth tropical forest in southern China; the observation period was from July 2003 to July 2008.

15.( ) Lu's group reported that increased N deposition had a deleterious effect on the biodiversity of tree seedlings and ferns – in contrast to findings from temperate and boreal forests, wherein N-induced loss of plant biodiversity has been generally associated with forbs and grasses. ■

Recommended research: Lu *et al.* (2010).

16.( ) Working in the context of the Brazilian Atlantic forest, Amazonas *et al.* (2018) explored the viability of intercropping native tree species with a fast-growing species of *Eucalyptus*, a tree species widely used by industry in the tropics. Amazonas's group found that, while it is feasible to establish a mixture of *Eucalyptus* and native tree species, these mixed forests were undermined by the fact that native species could not grow appreciably due to competition with *Eucalyptus*. The growth of *Eucalyptus* itself was shown to be much lower in the intercrop scheme than in a monocultural plantation, precluding any prospective economic viability of a mixed-forest approach in that region.

Recommended research: Amazonas *et al.* (2018).

17.( ) Malhi *et al.* (2006) and Saatchi *et al.* (2007) independently estimated the aboveground live biomass of the Amazonian rainforest. Both estimates, without accounting for confidence intervals, are within the range 50 – 200 Pg of carbon, where 1 Pg = 10^{12} kg.

Recommended research: Malhi *et al.* (2006); Saatchi *et al.* (2007).

Asner *et al.* (2004) used a GIS and *in situ* surveys to analyze deforestation in the rainforest that spans eastern Pará, one of the states in the Brazilian Legal Amazon. Archer's group inventoried sites prior to and following harvest operations, and mapped roads, skid trails, and log decks associated with logging activity. Those workers also made sure to distinguish between conventional logging (CL) and reduced-impact logging (RIL).

18.( ) Crucially, Asner's group found that, over the course of the 3½ years encompassed by their study, roads contributed much more to ground damage than did skid trails or log decks. ■

Recommended research: Asner *et al.* (2004).

19.( ) According to Brazil's National Institute for Space Research (INPE), deforestation in the Brazilian Legal Amazon has declined in the period spanning 2000 to 2013. However, in an independent monitoring effort, Tyukavina *et al.* (2017) argued that the methodology adopted by INPE was flawed because it only mapped vegetation loss in primary forests. Indeed, when accounting for nonprimary forest, the supposed reduction in deforestation observed in the 2000 – 2013 period is nullified.

Recommended research: Tyukavina *et al.* (2017)

20.( ) Forest transition theory was proposed by A.S. Mather in the early 1990s. Since then, researchers around the globe have pressed on to demonstrate how particular countries' land use histories have complied with (or constituted evidence against) FTT. In a case study based on Chile's experience, Heilmayr *et al.* (2016) showed that the country underwent a transition from anthropogenic, systematic deforestation throughout most of the 20th century to a phase of sustained vegetation recover afterwards. Importantly, Chile's recent bout of silvicultural recovery was mainly driven by restoration of native forests and not by implementation of monocultures.

Recommended research: Heilmayr *et al.* (2016).

21.( ) Although tropical plant species' reactions to environmental factors, namely light and nutrients, have been experimentally assessed in numerous studies, few have gone on to link these data to species distribution patterns. Studies were mostly restricted to a small number of species, precluding analysis of the importance of environmental factors across the community. One study that overcame these limitations is Engelbrecht *et al.* (2007), who, working in Panamanian forests, correlated the distribution of flora with species' sensitivity to drought. Engelbrecht's group found that the density of species in the drier regions relative to wetter regions was significantly and negatively correlated with drought sensitivity; this conclusion applied for seedlings and trees alike.

Recommended research: Engelbrecht *et al.* (2007).

22.( ) Arthropod diversity is positively associated with increased landscape heterogeneity, which can be achieved by planting forests with a mix of tree species that more closely approximate natural forests than simple monocultures. Oxbrough *et al.* (2012) put this hypothesis to the test by comparing the arthropod fauna of monocultures and mixed forests of conifers and deciduous species. In accordance with previous work, Oxbrough's group found that in comparison with monocultures mixed forests exhibited a more diverse assortment of spider and moth species, regardless of the relative proportion of conifer and deciduous vegetation.

Recommended research: Oxbrough *et al.* (2012).

23.( ) Intensification of land use is considered the main driver of global biodiversity change in terrestrial ecosystems. Because a large proportion of global biodiversity is located in fragmented landscapes, biodiversity protection hinges on stakeholders' ability to maintain biodiversity in these spatially heterogeneous landscapes. Arroyo-Rodríguez *et al.* (2012) evaluated the tree communities in 45 fragmented rainforest patches across Mexico; at the risk of giving in to ecological doomsaying, Arroyo-Rodríguez's group found that the phylogenetic composition of the forest patches carries little of the diversity and

structure of the original, pre-disturbance biomes, so that restoration efforts can do little to recover or at least maintain the vigor of those ecosystems.

Recommended research: Arroyo-Rodríguez *et al.* (2012)

24.( ) Kuuluvainen and Aakala (2011) reviewed several dozen studies on the dynamics of forests in boreal Fennoscandia. To date, their paper constitutes one of the most comprehensive reviews of forest dynamics in that biome, covering the northern, middle, and – especially – the southern Boreal Zones at equal length.

Recommended research: Kuuluvainen and Aakala (2011).

Deadwood is the most important factor influencing forest biodiversity in boreal, temperate and tropical forests. Around 7500 forest species in the Nordic countries are known to be dependent on dead trees over the course of their life cycles. The threshold associated with occurrence of saproxylic species is said to be in the range of 20 to 50 m^3 of deadwood per hectare. Accordingly, Scandinavian countries have implemented forestry policies with maintenance of deadwood as an overarching goal. One example is Sweden, where since the 1990s policymakers have sought to increase the volume of deadwood in their national territory by 40%.

25.( ) Jonsson *et al.* (2016) assessed the impact of Sweden's forest policy on deadwood prevalence and related factors. Crucially, they found that after nearly two decades of updated forestry policies, the increase in deadwood volume was concentrated in the southern parts of the country and mostly did not correspond to the proportion of deadwood expected of natural forests. ■

Recommended research: Jonsson *et al.* (2016).

26.( ) Forrester (2019) published an interesting conceptual framework for silvicultural management, emphasizing the relationship between forest growth and stand structure. His approach indicates that many effects of stand structure on growth may be described using a simple formulation that considers stand density, size distributions, and size-growth relationships. Size inequality, as represented by, e.g., the Gini coefficient or the Shannon index, was found to be not nearly as important.

Recommended research: Forrester (2019).

In species-rich continental rainforests, disturbance regimes are characterized by tree mortality and canopy gap dynamics, where localized physical damage reduces canopy height and initiates tree replacement by stimulating secondary succession.

27.( ) Kellner and Asner (2009) assessed the size frequency distribution of canopy gaps in those environments. Their power-law statistical distribution of choice was a discrete Pareto distribution. Importantly, although the studied sites had different species compositions and were subject to different disturbance mechanisms, power-law gap-size distributions were found to hold well for all sites. ■

Recommended research: Kellner and Asner (2009).

28.( ) Using several years' worth of data from 11 so-called Long Term Ecological Research sites in North America, Knapp and Smith (2001) performed a thorough study on the variation of aboveground net primary production (ANPP) across several biomes, namely forest, desert, arctic/alpine, and grassland. Knapp and his colleague found that forested sites were more productive than other sites; what's more, among the biomes considered, forested sites exhibited the lowest interannual variation in ANPP.

Recommended research: Knapp and Smith (2001).

29.( ) The El Niño Southern Oscillation (ENSO) system is known to produce striking effects on the biota of ecosystems across the world. In particular, ENSO-induced effects on the wet tropics are known to bring drier, warmer, and sunnier conditions. Wet-tropical-forest flora respond with enhanced seedling recruitment, population growth of understorey plant populations, such as herbs and vines, and increased fruit production.

Recommended research: Holmgren *et al.* (2001).

It is still unclear whether higher biodiversity also leads to improved resistance of terrestrial ecosystems to the more frequent droughts expected to hit temperate regions in the future. Grossiord *et al.* (2014) report that, in principle, forests with greater biodiversity should be more resistant to deal with drought stress because the trees should be able to maintain better access to diminishing water resources as the drought progresses, whereas if the interacting species in a forest have similar traits, niche overlap may lead to more stressful conditions during drought due to lower water availability for each species.

30.( ) Grossiord's group surveyed five types of mature forest in different European regions, from hemi-boreal stands in the northern part of the continent to Mediterranean stands in the south. Their conclusion was that higher tree species diversity confers a greater ecosystem-level resistance to drought events in all five biomes. ■

Recommended research: Grossiord *et al.* (2014).

31.( ) Given forecasts of continued rising temperatures in a global scale, there is a high risk of massive disruption of today's biomes as the climate crisis worsens. On the basis of Darcy's law, a relationship from groundwater engineering that has long been adopted by botanists to explain plants' hydrodynamics, McDowell and Allen (2015) argued that tall angiosperms seem to be particularly susceptible to the extra hydric stress imposed by climate warming, and hence may be gradually substituted by tall conifers, shrubs, grasses, and forbs in biomes all over the world.

Recommended research: McDowell and Allen (2015).

32.( ) Shortle and Smith (1988) assessed the impact of increasing aluminum ion in soil, an indirect effect of deposition of sulfur and nitrogen afforded by acid rain. Shortle and his colleague noted that extra Al^{3+} may be itself poisonous to plants' symplasts, but might also prove harmful by reducing uptake of magnesium (Mg^{2+}) through competition for binding sites in the cortical apoplast of fine roots.

Recommended research: Shortle and Smith (1988).

33.( ) Seidl *et al.* (2017) reviewed the forest disturbance literature published from 1990 onwards and performed a comprehensive meta-analysis of the effects of six major agents, including four abiotic (fire, drought, wind, and snow/ice) and two biotic (insects and pathogens). Their outlook was alarming, as they indicated that all six disturbance agents are expected to increase and worsen in a warming world.

Recommended research: Seidl *et al.* (2017).

34.( ) Dupont *et al.* (2011) conducted simulations of wind flow over a maritime pine forest characterized by a foliated layer concentrated in the upper canopy, above a deep and sparse trunk space. Their LES model was able to simulate fairly well the turbulent wind flow in this hypothetical canopy. One of their most striking findings was the occurrence of a layer with positive momentum flux behind the edge just below the crown of the canopy. This layer was shown to occur in their numerical scheme and Dupont's group managed to ascertain its existence with *in situ* measurements.

Recommended research: Dupont *et al.* (2011).

MAESTRA is one of the most well-known models for light interception in canopy processes. It has been used to examine the sensitivity of forest growth to foliar density or crown shape, to evaluate the importance of changes in canopy structure following silvicultural treatments such as pruning or thinning, to determine the consequences of defoliation by disease or insects, and to test the accuracy of predicted canopy light interception and photosynthesis made with simpler models.

35.( ) What's more, MAESTRA includes routines for respiration, nutrient cycling and carbon allocation, which makes it a viable tool for modelling forest growth. ■

Recommended book: Landsberg and Sands (2010).

SOLUTIONS

P.1 ➡ *Solution*

Option C contains the correct associations.

P.2 ➡ *Solution*

The life history characteristics of each tree type are tabulated below. Option B contains the correct associations.

Characteristic	Ruderal	Competitor	Stress-tolerant
Life longetivity	Short	Intermediate	Long
Leaf longetivity	Short	Intermediate	Long
% NPP[a] allocated to reproduction	Large	Intermediate	Small
Maximum growth potential	Rapid	Intermediate	Slow
a NPP = Net photosynthetic productivity.			

P.3 ➡ *Solution*

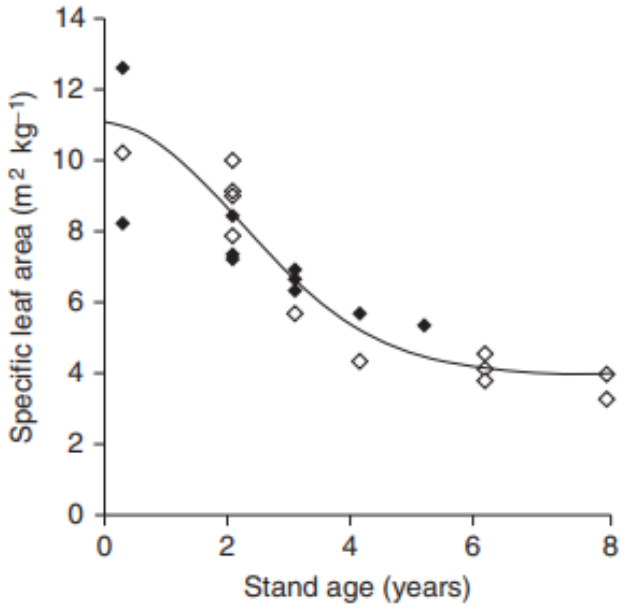
Refer to the table below; also shown is $3/k$, i.e., the time required for 95% of the standing crop to decompose. Option D contains the correct associations.

	Tundra	Boreal forest	Temperate deciduous forest	Temperate grassland	Savannah	Tropical moist forest
k (year^{-1})	0.03	0.21	0.77	1.5	3.2	6.0
$3/k$ (years)	100	14	4	2	1	0.5

P.4 ➡ *Solution*

1.True. Indeed, more PAR reaches the understory of a rain forest on an overcast than on a sunny day because the diffuse light of the cloudy day enters the canopy at many different angles, and thus has a greater probability of penetrating the canopy.

2.True. As an example, the following plot describes the temporal variation in specific leaf area (m^2 kg^{-1}) for *Eucalyptus globulus* (clear symbols) and *E. nitens* (dark symbols).



3.True. Indeed, Tan and Black attributed the increase in canopy resistance to the closure of stomata.

Reference: Tan and Black (1976).

4.False. The opposite is true, in that Leuzinger *et al.* (2010) found that park trees had crown temperatures 1 K lower on average than street trees. They argued that the incoming energy flux may have been higher for street trees because of the higher radiation load of the surrounding fabric, both in the short- and long-wave ranges.

Reference: Leuzinger *et al.* (2010).

5.False. Stegen *et al.* (2011) actually state that they failed to identify any climatic variable, including precipitation or temperature, that is consistently correlated with forest biomass. In view of this limitation, they chose to model forest biomass using an alternative approach, modelling the constituents of forest biomass instead of modelling forest biomass directly, and showed that forest biomass is determined by maximum individual biomass. In doing so, Stegen's group proposed that the maximum individual biomass should be constrained in part by the water deficit. They note that considering water deficit a better limiting factor for forest biomass than other climate variables is not surprising because it provides a much more detailed characterization of the abiotic environment than, say, mean annual temperature or annual precipitation.

Reference: Stegen *et al.* (2011).

6.False. Stanton *et al.* (2014) also included *Tillandsia* spp., a bromeliad, as one of the epiphyte species considered in their study. Importantly, Stanton's group note that contributions of vascular and non-vascular epiphytes to hosts are likely to differ slightly. Vascular epiphytes are far less efficient at fog-water absorption than bryophytes and lichens, and likely to be slower at releasing captured water to the canopy. The contribution of vascular epiphytes to canopy microclimate buffering might therefore be expected to be more limited.

Reference: Stanton *et al.* (2014).

7.False. The opposite applies here, in that simple metabolic-ecology scaling laws have been consistently undermined by a growing body of research. In one example, Coomes and Allen (2007) reject Enquist's (1999) scaling laws by noting that the statistical analyses in Enquist's original paper were based on inadequate replication of results to reach reliable conclusions; also, foresters have shown that power functions are not generally the best descriptors of tree growth; lastly, recent analyses have quite clearly showed, for example, that growth does not scale as $D^{1/3}$ (Muller-Landau, 2006).

Reference: Enquist (1999); Muller-Landau *et al.*; Coomes and Allen (2007).

8.False. Erskine *et al.* (2006) actually reported the opposite, in that greater productivity was achieved in multi-species woodlands.

Reference: Erskine *et al.* (2006).

9.True. The cumulative α-value is the sum of all the species found in all the sampling plots of a vegetation type over the course of a study; the mean α-diversity, in turn, reflects a general tendency in sample richness within a community. In Castillo-Campos' paper, both were found to be greater in the secondary vegetation than in the primary one, even though the sampling effort was greater in the primary forest (300 m^2 more primary vegetation were surveyed than secondary vegetation).

Reference: Castillo-Campos *et al.* (2008).

10.True. Jacob *et al.* (2010) recognize that their finding is in conflict with most literature published until then, noting, for instance, that mixed stands of *Fagus sylvatica* and *Picea abies* in Southern Germany were found to have productivity up to 59% greater than adjacent pure stands. Jacob's group argue that above-ground net primary production is much more under the control of climate and edaphic factors than mere species diversity.

Reference: Jacob *et al.* (2010).

11.False. Healy *et al.* (2008) actually found that the explanatory power of the environment matrix was higher than that of the diversity matrix for both

productivity and mortality. Environmental heterogeneity accounted for twice the variation in productivity as the diversity matrix; that said, components of diversity still explained an expressive fraction – about 30% – of the variation in mortality.

Reference: Healy *et al.* (2008).

12.False. Burkey's (1994) findings did not conform to the Janzen-Connell hypothesis. Indeed, that worker found that the only tendency for predation to be greater near the trunk was for seeds immediately near the *B. alicastrum* tree (1 m away from the trunk); furthermore, predation was substantial even as far as 25 m away from the tree, where one would be hard pressed to find a naturally occurring seed.

Reference: Burkey (1994).

13.True. Indeed, Girão *et al.* (2007) noted that small forest patches in severely fragmented landscapes were more likely to harbor many generalists while being strongly impoverished in terms of the number of species and individuals with particular pollination systems (e.g., pollination by bats, birds, non-flying mammals). Likewise, strategies that are more dependent on long-distance pollen movement and animal-mediated services, as in the case of self-incompatibility, were negatively affected by ecosystem fragmentation.

Reference: Girão *et al.* (2007).

14.False. Onaindia *et al.* (2004) actually found that, while two indices of evenness were used, only Simpson's *E* was capable of reflecting disturbance levels, as it better distinguished between the less (old-growth and regenerated woodlands) and more (regenerating and grazed woodlands) disturbed groups.

Reference: Onaindia *et al.* (2004).

15.True. Indeed, Lu *et al.* (2010) found that declines in biodiversity due to N deposition were mostly associated with the tree seedling and fern functional groups. The decline in biodiversity was attributed to nitrogen-related changes in soil properties, such as decreases in pH and extractable calcium, and increases in extractable aluminum.

Reference: Lu *et al.* (2010).

16.False. While Amazonas *et al.* (2018) found that although competition in mixed forests slowed the diameter growth of native species, their survivorship and height were not affected. At the stand level, Amazonas's group showed that, in mixtures, *Eucalyptus* produced nearly 75% of the basal area produced by *Eucalyptus* monocultures even though mixtures had only 50% of the density of *Eucalyptus* seedlings compared to monocultures. This was a result of the considerably greater diameters that individual *Eucalyptus* trees grew when intercropped with native species.

Reference: Amazonas *et al.* (2018).

17.True. Malhi *et al.* (2006) estimated the aboveground live biomass of the Amazon at 93 $\pm$ 23 Pg C, while Saatchi *et al.* (2007) placed it at 86 Pg C with $\pm$20% uncertainty.

References: Malhi *et al.* (2006) and Saatchi *et al.* (2007).

18.False. Asner *et al.* (2004) note that, across a wide range of harvest areas (14 – 158 ha) and intensities (2.6 – 6.4 felled trees/ha), the majority of ground damage resulting from selective logging occurs as skid trails (up to 12%); on an areal basis, log decks and roads constitute a small proportion of total ground damage. Those workers also stress that although timber harvest intensities are similar in conventional logging and reduced-impact logging, CL results in significantly more ground damage than does RIL.

Reference: Asner *et al.* (2004).

19.False. Tyukavina *et al.* (2017) never went on to state that accounting for deforestation in secondary vegetation falsifies the decreasing trend reported by INPE; they simply noted that it would be reasonable for national monitoring systems to expand beyond the ever-decreasing primary forest resources and better account for disturbance states instead.

Reference: Tyukavina *et al.* (2017).

20.False. Heilmayr *et al.* (2016) note that Chile's forest cover encompassed 34.6% of their study area in 1986, but rose to over 40% by 2011. However, rather than representing regeneration of native forests, this expansion of forest cover was the result of a rapid expansion of plantation forests.

Reference: Heilmayr *et al.* (2016).

21.True. The *p*-values for seedlings and trees were 0.035 and 0.0004, respectively, indicating that the relationship in question is significant in both cases. Nonetheless, Engelbrecht *et al.* (2007) note that drought sensitivity explained more than twice the variation in dry *versus* wet sites for adult trees than it did for seedlings (34% versus 14%).

Reference: Engelbrecht *et al.* (2007).

22.False. There is in fact evidence that the inclusion of species of native provenance in mixed plantations, such as oak, or those which create greater habitat heterogeneity, such as Scots pine, will benefit biodiversity. In the observations of Oxbrough *et al.* (2012), however, there was no clear evidence for an influence of oak or Scots pine on the arthropod fauna when they are a secondary component in the tree mix. Oxbrough's group notes, however, that previous research indicates that the expected biodiversity gain associated with more diverse tree communities may only become significant at relative proportions of conifer and deciduous species different from those they worked with.

Reference: Oxbrough *et al.* (2012).

23.False. Surprisingly, Arroyo-Rodríguez *et al.* (2012) suggest that there is a low phylogenetic conservatism of traits associated with high vulnerability to forest fragmentation; this implies that although habitat fragmentation may impose important ecological barriers that negatively impact some tree functional groups, this ecological filtering does not result in dramatic differences in phylogenetic diversity or structure, at least within a certain range of species loss. It follows that preservation of patches both small and large should be considered a viable restorative strategy, because most of them have retained the original biome's evolutionary history.

Reference: Arroyo-Rodríguez *et al.* (2012) (Section "*Discussion*" verbatim)

24.False. Kuuluvainen and Aakala (2011) note that one important shortcoming of their study is the fact that the studies they reviewed were strongly biased towards the northern and middle regions of boreal Fennoscandia, whereas data from the southern Boreal Zone were scarce. This is attributable to the fact that most remaining natural boreal forest cover is concentrated in the upper and central portions of northern Europe, but nonetheless constitutes a problem because it is in the southern Boreal Zone that biodiversity issues are most urgent.

Reference: Kuuluvainen and Aakala (2011).

25.True. Jonsson *et al.* (2016) reported that after 15 years of sustained forestry policy, the nationwide prevalence of deadwood – about 60 dead trees per hectare – was still 5.7%, which is below the 10 – 40% proportion expected of natural Nordic woodlands. Also, gains were mostly concentrated in the southern part of the country.

Reference: Jonsson *et al.* (2016).

26. True. Section 5 of Forrester (2019) offers a detailed explanation for doing away with size inequality in his management scheme. For one, there is the likely hypothesis that size inequality can be correlated with all of the variables involved in Forrester's scheme. For example, with respect to size-growth relationships, size inequality often increases with age under size-asymmetric growth conditions, in the absence of self-thinning. Size inequality also increases with increasing stand density and changes with soil resource availability.

Reference: Forrester (2019).

27.True. Kellner and Asner (2009) indeed demonstrated that scaling relationships between gap size and canopy height were qualitatively similar for all sites, revealing a remarkable similarity despite clearly defined differences in species composition and mechanisms of prevailing disturbance. These findings

are indicative that power-law gap-size frequency distributions are inherent to all five tropical rainforest landscapes, even when disturbance histories are very different.

Reference: Kellner and Asner (2009).

28.True. Indeed, Knapp and Smith (2001) found that forested sites are generally more productive than desert, alpine, and arctic regions. In addition, grasslands exhibited the greatest interannual variation in ANPP, whereas forested sites had the least interannual variation in productivity.

Reference: Knapp and Smith (2001).

29.True. The effect on the understorey is caused mainly by El Niño seasons being associated with high levels of mortality among canopy trees, which causes changes in light and water availability to understorey plant populations.

Reference: Holmgren *et al.* (2001).

30.False. For three of the forest types considered by Grossiord *et al.* (2014) – namely, hemi-boreal, mountainous beech, and Mediterranean forests – statistical analysis revealed that no net partitioning or facilitation processes were in action. For these three forest types, tree species diversity did not play an important role in modulating ecosystem-level response to drought stress, despite strong functional differences among species in their response to drought.

Reference: Grossiord *et al.* (2014).

31.False. McDowell and Allen (2015) actually suggested that tall conifers are the most vulnerable higher plants, in view of their limited ability to drop leaf area rapidly, low hydraulic conductivity, and greater (globally averaged) height than angiosperms.

Reference: McDowell and Allen (2015).

32.False. Replace Mg^{2+} with Ca^{2+} and you'll obtain a correct statement. The problem with increased Al in solution is not one of direct poisoning (that is, an irreversible effect on the symplast) – although this can happen with prolonged exposure to high Al^{3+} concentrations – but rather a simple exchange phenomenon that can limit the rate of wood formation, decrease the amount of functional sapwood, and leave large trees more vulnerable to common diseases and insect pests.

Reference: Shortle and Smith (1988).

33.False. There was one exception, as Seidl *et al.* (2017) reported that disturbances from snow and ice are likely to *decrease* in the future, especially under warmer and drier conditions.

Reference: Seidl *et al.* (2017).

34.True. Indeed, Dupont *et al.* (2011) verified the existence of a positive momentum flux extending from the edge, around the base of the foliated layer, extending up to at least 9*h* downwind, where *h* is the canopy height. This layer is caused by the presence of the sub-canopy wind jet, which induces a negative vertical gradient of streamwise wind velocity below the foliage layer. This gradient generates an upward momentum flux that mirrors the downward shear stress in the canopy top region. Turbulent vertical transport of downward shear stress from above is not sufficient to compensate this upward shear stress. A secondary wind velocity maximum is also present within the trunk space in the stand case. However, it is probably not strong enough to generate a positive momentum flux or to compensate turbulent vertical transport of momentum.

Reference: Dupont *et al.* (2011). (Verbatim from Section 6)

35.False. MAESTRA does not include routines for respiration, has no nutrient cycling or nutrient feedbacks and contains no carbon allocation routines; these factors preclude using MAESTRA as a forest-growth tool.

Reference: Landsberg and Sands (2010).

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