Pošumljavanje krša hrvatskoga Sredozemlja

Matić, Slavko; Oršanić, Milan; Anić, Igor; Drvodelić, Damir; Topić, Vlado; Mikac, Stjepan; Đurđević, Zoran

Source / Izvornik: **Šume hrvatskoga Sredozemlja, 2011, 393 - 426**

Book chapter / Poglavlje u knjizi

Publication status / Verzija rada: **Published version / Objavljena verzija rada (izdavačev PDF)**

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:108:784827

Rights / Prava: In copyright / Zaštićeno autorskim pravom.

Download date / Datum preuzimanja: **2025-01-08**

Repository / Repozitorij:

University of Zagreb Faculty of Forestry and Wood Technology

POŠUMLJAVANJE KRŠA HRVATSKOGA SREDOZEMLJA

AFFORESTATION IN THE CROATIAN MEDITERRANEAN REGION

Slavko Matić, Milan Oršanić, Igor Anić, Damir Drvodelić, Vlado Topić, Stjepan Mikac, Zoran Đurđević

UVOD

INTRODUCTION

Rana naseljenost, velika koncentracija stanovništva, razvoj kulture i ostalih civilizacijskih pokazatelja na području Hrvatske imale su znatan utjecaj na propadanje šuma s jedne strane i razvoj stručne šumarske misli i znanosti kao protuteža propadanju šuma s druge strane.

Zbog vjekovne povezanosti čovjeka sa šumom, koja traje neprekinuto od postanka čovjeka do današnjih dana, pojedine faze razvoja ljudskoga društva mogu se promatrati u kontekstu odnosa prema šumi (Matić 1990). Svi usponi i padovi u gospodarskom i civilizacijskom razvoju društva definirani su i prepoznatljivi u njegovu odnosu prema šumi.

U prvoj etapi odnosa čovjek – šuma, koja seže u daleku prošlost, šuma se sjekla i uništavala stihijski, u prvom redu zbog dobivanja plodnoga šumskoga tla koje je bilo potrebno za preživljavanje. Drvo kao proizvod bilo je u drugom, sporednom planu.

Drugu etapu obilježava dalja intenzivna sječa šuma radi dobivanja tla, ali uz naglašenu potrebu i uporabu drva kao značajnoga građevnoga, energetskoga i ostaloga materijala. Dolaskom Rimljana na naša područja i izgradnjom utvrđenja, gradova, cesta, rudnika i topionica smanjuju se velike površine šuma. Nakon Rimljana dolaskom drugih osvajača (Gota, Huna i dr.) nastavlja se uništavanje šuma, koje ne prestaje ni dolaskom Hrvata u VII. stoljeću.

I uz to što je šuma obnovljivo prirodno bogatstvo i što se ona na pojedinim područjima ponovno obnavlja, vrlo se rano javljaju erozija, bujica, poplava i druge negativne pojave kao posljedica stihijske sječe šuma. U tom se razdoblju još ništa ne radi na organiziranom podizanju šuma pošumljavanjem i pomlađivanjem.

Većina dalmatinskih, primorskih i istarskih gradova rano je uočila posljedice nestanka šuma te su u svoje statute unijeli odredbe o čuvanju šuma, ali bez većega uspjeha.

Strah od stihijskih sječa i nestanka šuma doživio je svoj vrhunac početkom XVIII. stoljeća, otkad se smatra da je u ovom dijelu Europe nastala šumarska znanost i organizirano šumarstvo i gdje se nastojao urediti odnos čovjek – šuma na pravnoj osnovi. To smatramo trećom etapom u povijesnom razvoju odnosa čovjek – šuma koja traje do danas. Nju je obilježila u Hrvatskoj pojava čuvenoga Šumskoga reda koji je izdala Marija Terezija 1769. godine na hrvatskom i njemačkom jeziku. Osim što pravno uređuje odnose i postupke prema šumi, Šumski red sadrži i čitav niz uputa o pomlađivanju, njezi i uređivanju šuma pa ga s pravom možemo smatrati prvim udžbenikom o šumama i šumarstvu u nas. Nakon toga vrlo je značajan Zakon o šumama iz 1852. godine u kojem se difinira potrajnost ili održivi razvoj koji je imao i danas ima značajnu ulogu u gospodarenju i očuvanju šuma.

Ova treća etapa u odnosu čovjek – šuma nosi obilježje razvijene znanstvene misli o vrijednostima šuma u posrednim i neposrednim koristima te jasnim spoznajama kakve negativne posljedice donosi propadanje i nestanak šuma. I uz to šume propadaju zbog vrlo intenzivnih zahvata u prostor i zbog promjena koje se događaju u klimi i izvan prostora šuma, a posredno utječu na njihovu stabilnost i opstanak.

Danas možemo tvrditi da se već nalazimo u četvrtoj etapi odnosa čovjek – šuma u kojoj je potrebno ponajprije obaviti i pravno urediti odnos cijeloga društva prema šumi. Šumu treba štititi od svih koji uživaju njezine blagodati, tj. od cijeloga društva, a najmanje od šumara i šumarskih organizacija. Katastrofalna trovanja zraka, vode i tla, promjena klime, šumski požari, poplave, erozije, bujice, pad razine podzemnih voda, hidromelioracijski radovi koji iz temelja mijenjaju ekološke uvjete koji tisućama godina vladaju u šumi, izgradnja cesta, dalekovoda, plinovoda, kanala, pruga i dr. utječu na brzo propadanje šuma, a da na to šumari koji gospodare šumama nemaju nikakva utjecaja.

Nigdje nije tako značajno vidljiv negativan utjecaj čovjeka i njegovih loših navika na pojavu propadanja šuma kao u Sredozemlju. To je glavni razlog što je ovo područje, a i odatle zemlje koje oplakuje Sredozemno more, uglavnom ostalo bez šume, a kao posljedice toga i bez vode i tla, s lošom poljoprivrednom proizvodnjom, ekstremnim klimatskim uvjetima, intenzivnim bujičnim i erozijskim procesima, poplavama i sl.

Zbog svega navedenoga, a posebno zbog nepovoljnih klimatskih, edafskih, geomorfoloških, biotskih i dr. čimbenika uočljiv je nestanak autohtonih regularnih sastojina visokoga uzgojnoga oblika u hrvatskom dijelu Sredozemlja te njihov prelazak u neki niži, manje kvalitetni uzgojni oblik (srednji, niski) ili u neki degradacijski stadij (šikara, makija, šibljak, garig, goli krš).

Goli je krš krajnji degradacijski stadij posebno klimatogenih šuma toga područja koje tvore hrastove šume: hrasta crnike (*Quercus ilex* L.), medunca (*Quercus pubescens* Wild.), oštrike (*Quercus coccifera* L.) i cera (*Quercus cerris* L.). Isto tako degradaciji su izložene i šume pionirskih i prijelaznih vrsta drveća u kojima prevladava od zimzelenih vrsta bor: alepski (*Pinus halepensis* Mill.), brucijski (*Pinus brutia* Ten.), crni (*Pinus nigra* J. F. Arnold), primorski (*Pinus pinaster* Aiton), pinija (*Pinus pinea* L.) te obični čempres (*Cupressus sempervirens* L.). Od listopadnih vrsta u tu se skupinu ubrajaju crni jasen (*Fraxinus ornus* L.), bijeli grab (*Carpinus orientalis* Mill.), crni grab (*Ostrya carpinifolia* Scop.), koprivić (*Celtis australis* L.), rašeljka (*Prunus mahaleb* L.), rogač (*Ceratonia siliqua* L.) i dr.

Goli krš najčešće su šumske površine s kojih je nestala šuma i na kojima je degradirano tlo i koje prevladavaju u sredozemnom prostoru Hrvatske. One su sposobne za rekultivaciju ili pošumljavanjem pionirskim i prijelaznim vrstama drveća ili pak spontanom sukcesijom prirodne vegetacije.

Promatramo li šume na hrvatskom dijelu Sredozemlja sa šumskouzgojnoga stajališta, možemo zaključiti da hrast medunac i njegove sastojine, zajedno s ostalim vrstama drveća, poludrveća, grmlja i prizemnoga rašća, koje se javljaju u tim zajednicama, daju temeljno obilježje submediteranu. Crni je bor pionirska vrsta koja raste na tim staništima i značajna je vrsta koja je nezamjenjiva u rekultivaciji degradiranoga staništa bilo da se radi o prirodnoj sukcesiji ili o pošumljavanju.

Eumediteran je obilježen hrastom crnikom i njegovim zajednicama. Alepski bor prevladava prilikom procesa rekultivacije tih staništa. Ostale vrste bora, kao što su brucijski, primorski, pinija, uz čempres imaju svoje značajno mjesto u tim procesima.

Borove su vrste pionirsko drveće. Široke su ekološke valencije (eurivalentne vrste) glede uvjeta u tlu, posebice vlage tla. Pod borovim sastojinama tlo postupno poprima svojstva koja su dostatna da se na njem pojavi autohtona vegetacija u nekom od degradacijskih stadija ili uzgojnih oblika. Obično se kao podstojna etaža borovih sastojina stvara makija ili šikara sastavljena od elemenata autohtone klimatogene vegetacije.

S vremenom bor postupno nestaje iz makije ili šikare, a one prelaze u neki od uzgojnih oblika (niski, srednji, visoki). Navedeni se procesi najčešće odvijaju u razdoblju od jedne (od 60. do 80. godine) do dvije ophodnje borovih sastojina, što opet ovisi o stanišnim uvjetima, a posebno o stupnju degradacije tla. Ako borova sastojina nije bila u stanju stvoriti prilike u tlu za povratak autohtone vegetacije, bor se može nesmetano prirodno pomladiti oplodnim sječama. Kad se javi autohtona vegetacija, nužno je u određenoj dobi borovih sastojina ići u obnovu, koristeći se prirodnom sukcesijom uz unošenje sjemena ili biljaka autohtonih vrsta, najčešće hrasta, poštujući načela prirodne obnove.

Zbog intenzivnoga negativnoga djelovanja biotskih i abiotskih čimbenika (čovjeka, stoke, požara) sukcesija i pošumljavanje stalno su prisutni u crnikovim i medunčevim šumama. Neprestano se stvara goli krš, a njega ponovno prirodnom sukcesijom ili pošumljavanjem osvajaju najčešće borovi kao pionirske vrste. Oni u većini slučajeva na svom razvojnom putu stradavaju od požara, a da prethodno nisu stvorili uvjete za povratak autohtone vegetacije. To je dinamični proces progresije i regresije šumske vegetacije na našem Sredozemlju koji traje neprekidno (Matić i dr. 1997). U različitim stadijima nalazimo ga na području cijele eumediteranske i submediteranske zone.

Tamo gdje borovi ne dolaze prirodno ili pak dolaze nespontano (sjeverozapadni dio eumediterana i veći dio submediterana), nužno je da čovjek pošumljavanjem borovima, ali i drugim pionirskim i prijelaznim vrstama crnogorice i bjelogorice, zaustavi degradaciju staništa i omogući progresivnu sukcesiju šuma hrasta crnike i medunca. Površine šumskih kultura borova koje su podignute na našem Sredozemlju nedvosmisleno na to upućuju.

Pošumljavanje je sadnja biljaka ili sjetva sjemena na goloj površini na kojoj je prethodno nestala šumska vegetacija. Obavljamo ga s pionirskim i prijelaznim vrstama drveća čiji je zadatak da s vremenom tlu vrate ona biološka, pedofizikalna i pedokemijska svojstva koja imaju šumska tla stvorena i očuvana pod šumom. Takvo je tlo spremno prihvatiti klimatogene vrste drveća koje rastu na tom području i omogućiti im uspješan razvoj do maksimalnih vrijednosti koje navedene vrste mogu postići na određenom staništu u skladu s njihovim biološkim svojstvima.

U skladu s definicijom pošumljavanja koje je dao FAO, minimalna pošumljena površina treba biti 0,5 ha, krošnje drveća trebaju pokrivati najmanje 10 % površine, a visina odraslih stabala treba biti veća od 5 m (Oršanić 2003).

Umjetnu obnovu i popunjavanje obavljamo sadnjom biljaka ili sjetvom sjemena najčešće u sastojinama koje se obnavljaju ili su nedovoljno obnovljene te se popunjavaju.

Pošumljavanje je dakle osnovni šumskouzgojni postupak kojemu je neposredan zadatak da sadnjom biljaka ili sjetvom sjemena osnuje sastojine koje će, među ostalim, početi zaustavljati daljnju degradaciju tla te će stvarati gospodarska i općekorisna dobra.

Nakon pošumljavanja slijedi gotovo stoljetni proces njegovanja novopodignutih šuma radi formiranja kvalitetne sastojine u kojoj se moraju uvažavati i potpomagati klimatogene vrste drveća (hrast crnika i medunac). One se počinju spontano javljati sa stvaranjem boljih stanišnih uvjeta (tlo, mikroklima) u šumskoj kulturi.

Kao zadnji postupak u tom dugom procesu slijedi obnavljanje šuma, prirodnim ili umjetnim načinom, bilo da se ponovno obnavlja neka od pionirskih ili, ako su za to stvoreni uvjeti, neka od klimatogenih vrsta drveća. To je siguran znak da smo pošumljavanjem, njegom i obnovom zaokružili jedan stoljetni proces te šumi koju smo podigli i uzgojili osigurali stabilnost, produktivnost i vječnost.

STANJE ŠUMA U PROŠLOSTI PRIJE INTENZIVNE DEVASTACIJE

FOREST CONDITIONS IN THE PAST PRIOR TO INTENSIVE DEVASTATION

Rana naseljenost Sredozemlja i tisućugodišnji negativni utjecaji čovjeka i ostalih čimbenika glavni su razlozi nestanka šuma ili njihova prelaska u neki od degradacijskih stadija koji je najčešće goli krš. Dosta je pisanih podataka da je naš krš u prošlosti bio pokriven kvalitetnim šumama.

Uništavanje šuma na našem je Sredozemlju počelo vrlo rano, puno ranije nego što se nestajanje javilo u unutrašnjost Europe u kojoj su se između 300. i 1300. godine šumske površine smanjile na gotovo 25 % (Androić 1977).

Već u 3. stoljeću pr. Kr. grčki pisac Apollonius s Rodosa opisuje otok Hvar koji naziva *Pitisia*, tj. borik. Grčki pisac Polybe 219. godine p. Kr. opisuje dolazak rimske flote na Hvar, koja se trebala boriti protiv vojske ilirskoga vojskovođe Demetrisa s Hvara, a koja se skrivala u gustim šumama (Androić 1977).

Grubić (1928) navodi da se 32. godine p. Kr. Oktavijan August ustoličio u Promoni (kraj Drniša) i noću napao Dalmate koristeći kao zaštitu guste šume koje su ga skrivale. Progoneći Dalmate Rimljani su spalili Synodium (kraj Muća) i posjekli mnoge šume. U pobuni koja je izbila u rimskoj Dalmaciji 7. godine poslije Krista, poslije dugih borbi Baton, vođa pobunjenika, morao je napustiti posljednje utočište Andertium (danas Muć). Njegovi se vojnici nisu predali te poslije ogorčene bitke pobjegoše u brda. Rimljani su ih progonili, većinu pronašli u šumama i pobili.

Iz vremena hrvatske dinastije vladara u XI. i XII. stoljeću nema mnogo podataka, ali ono malo što ih ima potvrđuje da je Dalmacija bila pokrivena šumama. Iz navoda križara Rajmunda iz Agilesa i Ademara iz Piya te njihova suvremenika Guillauma Tryja, koji su najvjerojatnije išli starim rimskim putem Aquileia – Seni (Senj) – Arupium – Obrovac – Šuplja Crkva (kod Knina) u smjeru Konstatinopola, vidi se da je ondašnja Dalmacija bila zemlja bogata šumama, rijekama i pašnjacima, a siromašna obradivom zemljom.

Prema podacima u *Monumentica historica slavorum Meridionalium,* I, 1307. godine nastao je spor krčkih knezova i krčke općine zbog sječe šume te je dogovoreno da knezovi neće sjeći općinske šume.

U *Statutu krčkom* iz 1443. piše da su znatni posjedi općine Vrbnik bili obrasli šumom. Kad su 1480. Mlečani zaposjeli Krk, posebno su se brinuli za hrast ponajprije zbog opskrbe svoje mornarice drvenom građom. Krčki providur August Valerije u izvješću mletačkomu duždu ističe bogatstvo Vrbnika šumama.

Nešto poslije u putopisu Ivana Giustiniona (*Monumenta historica*, VIII) godine 1553. spominje se da na Krku ima šuma s vrlo velikim i vrlo korisnim stablima koja se u velikim količinama izvoze u Veneciju. Tih je stabala sve manje i ako se ništa ne poduzme, za kratko će vrijeme stanovnici otoka oskudijevati drvom. U tom se dijelu govori i o nekim mjerama koje trebaju urediti sječu, pašu koza, krčenje panjeva i sl.

Prema Zoričiću (2009) Mlečani su se 1480. godine riješili krčkih knezova Frankopana odstranivši kneza Ivana. Krk su uzeli u izravnu upravu na čelu s providurom. Providur je radio u interesu Venecije posebno koristeći se zemljištem, šumom, vinogradima i dr. Po nalogu Venecije svake su se godine sjekli hrastovi, koji su služili za izradu brodova, bačava za vino i ogrjevno drvo. Venecija je gradila brodove za prijevoz vina s Krka i drugih posjeda našega Sredozemlja, gdje se građa dobivala iz šuma na otoku Krku. Brodovi su bili posebno oblikovani tako da u jedan brod stane 500 bačava, svaka od 751 litru.

Područje Splita zbog rane naseljenosti već je u XIV. i XV. stoljeću ostalo bez šuma i drva pa se građevno drvo dovozilo iz Senja odnosno s Velebita. I taj podatak govori o često isticanoj i pretjeranoj ulozi Venecije kad je riječ o uništavanju šuma hrvatskoga Sredozemlja.

Venecija je ušla dublje u kopno našega Sredozemlja tek 1699. nakon mira u Karlovcima, a tada je naš krš bio dobrim dijelom obešumljen. Bez obzira na to Venecija je nastavila uništavati šume, među ostalim, i zbog izgradnje flote iz strategijskih razloga posebno zbog obrane od Turaka. Poznato je da je Venecija nastojala zakonima spriječiti uništavanje šuma požarima koje su lokalni stanovnici izazivali zbog dobivanja pašnjačkih površina. U njezino se vrijeme zabranjuje ispaša koza na kultiviranim površinama, a poznate su i naredbe o sadnji nekih vrsta drveća i voćaka na površinama koje je stanovništvo dobivalo od države. Po tome je poznat i čuveni Grimanijev zakon iz 1756. godine.

Nakon dolaska Austrije u Dalmaciju 1797. godine mirovnim ugovorom u Campformiju ona je izdala 1805. godine zakon o zaštiti dalmatinskih šuma. Te iste godine Dalmacija dolazi pod jurisdikciju Francuza. Francuzi, iako su kratko vladali tim područjem, poduzimaju značajne korake da bi se očuvale i podigle nove šume. Na tom su zauzetom području postojale državne, privatne i općinske šume.

Napoleonov providur Vicko Dandolo u svom izvješću piše o lošem stanju šuma u Dalmaciji, a posebno općinskih. Providur poduzima mnoge mjere da bi se očuvale i podizale nove šume pošumljavanjem. Svojim dekretom naređuje obvezno odabiranje i označivanje pojedinih šumskih površina za koje bi pojedini gradovi snosili punu odgovornost. Te su šume nazivane "svete šume" zbog toga što ih nitko nije smio dirati. Njihova je površina uznosila oko 10 000 ha.

Vrlo brzo dolazi do rata s Austrijom pa Austrija drugi put, 1813. godine, ulazi u Dalmaciju. Austrija je općenito prihvatila sve ono što su Francuzi za šume propisali. Poznata je usmena predaja koja govori o tome da je austrijski kralj Franjo Josip za vrijeme obilaska Dalmacije odmah nakon odlaska Francuza izjavio da je šteta što Francuzi nisu ostali malo duže kako bi dovršili sve ono što su započeli, posebno u pogledu šuma i pošumljavanja.

Austrija donosi više novih zakona i mjera za čuvanje i podizanje šuma, npr. Zakon o obveznom pošumljavanju općina 1867. godine, osnivaju se šumarske komisije, čuvarske službe, donose se propisi o održavanja šuma i dr. U isto vrijeme zbog pošumljavanja počinje kampanja protiv držanja koza kojih je 1873. godine u Dalmaciji bilo oko 400 000.

U to je vrijeme uspješno podignuto oko 1500 ha šumskih kultura, ali svijest o čuvanju šuma kod lokalnoga stanovništva nije porasla. Šume su i dalje uništavane, a zabrana o držanju

koza nije poštovana. Zabrana je obuhvaćala površinu od oko 450 000 ha.

Uza sve to osnivaju se šumarske službe i šumski rasadnici, a opskrba se drvom poboljšava, iako se broj stanovnika u Dalmaciji do konca 19. stoljeća u odnosu na početak stoljeća udvostručio.

Prema Popariću (1936) uskoci su se iz utvrde Klis preselili u Senj 1537. kad su Klisom zavladali Turci. Prvi susjedi tada slobodnomu Senju bili su Turci, u to doba gospodari Krbave i Like. Oni su se teško odlučivali svojom konjicom i pješaštvom probijati prema moru zbog gustih šuma koje su tada okruživale i štitile Senj.

Anonimni autor u *Starinama* 1877. iznosi podatke o šumama u okolici Senja te piše: "Imade velikih šuma jelovih svake vrste, hrastovih, bukovih i drugoga drveća za brodogradnju i za gorivo, da se moglo sagraditi najveće ratno brodovlje."

Prema svemu navedenom šume su bile najveća obrana Senja od Turaka. Bez obzira na to mnogi su u vrijeme uskoka zagovarali u Grazu i Pragu sječu šuma koja bi carskoj blagajni donijela veliki novac.

Šume koje su okruživale Senj u nekim se ispravama iz 16. stoljeća nazivaju "mortološke gore" najvjerojatnije zbog toga što su Senjani više puta u njima pobili turske mortološke čete (*mortolog* 'drumski razbojnik').

Biskup senjski Markantun de Dominis, poslije splitski nadbiskup, i povjerenik austrijske vlasti Josip Rabbata slagali su se u tome da senjske šume treba posjeći i prodati. Mislili su da bi s tim zauvijek riješili uskočko pitanje. Posao oko dozvole za sječu bio je gotovo zaključen u Grazu, ali je ipak prevladala sumnja da bi se sječom šuma oslabila granica prema Turcima. De Dominis je nakon toga odobrenje za sječu senjskih šuma tražio u Pragu od cara, ali ju nije dobio.

Ovaj kratki prikaz povijesnih podataka o stanju šuma hrvatskoga Sredozemlja u prošlosti nedvosmisleno nam pokazuje da su se na kvalitetnim šumskim tlima razvijale visokokvalitetne šume koje danas nalazimo samo u tragovima.

Vrste drveća takvih šuma na kvalitetnim staništima postizale su najveće vrijednosti glede visina, promjera i drvne pričuve, gdje su do izražaja došla biološka svojstva i ekološki zahtjevi svake vrste drveća.

Nepovoljnim stoljetnim degradacijskim procesima ta su tla izgubila svojstva šumskih tala, a samo pošumljavanja određenim vrstama i načinima mogu taj proces zaustaviti i usmjeriti ga u progresivnom smjeru.

ZNANSTVENE, STRUČNE I DRUGE AKTIVNOSTI NA ZAŠTITI I PODIZANJU ŠUMA NA GOLOM KRŠU

SCIENTIFIC, SPECIALIST AND OTHER ACTIVITIES AIMED AT PROTECTING AND ESTABLISHING FORESTS ON BARE KARST

Prema procjenama FAO-a (1981, 1991) godišnje se u svijetu podigne preko 4,5 milijuna hektara novih šumskih kultura od čega tri milijuna hektara uspješno (Oršanić 2003). U današnje vrijeme tijekom jednoga desetljeća nestane preko 125 milijuna hektara šuma, a podigne se samo 32 milijuna. Iako su mnoge zemlje uvele stroge mjere radi sprečavanja daljnjega obešumljavanja, šume i dalje nestaju.

U mnogim dijelovima svijeta šumske kulture osnovane pošumljavanjem glavni su izvor drva za domaće potrebe, a u nekim zemljama i za izvoz. Procjenjuje se da površina podignutih šumskih kultura iznosi 187 mil. ha, a to je samo 5 % ukupnoga šumskoga pokrova na zemlji. Od vrsta drveća prevladava rod *Pinus* sp. s oko 20 % te *Eucalyptus* sp. s 10 %.

Prema procjeni najviše je šumskih kultura zasađeno u Aziji – 62 %, Europi 17 %, Sjevernoj i srednjoj Americi 9 %, Južnoj Americi 6 %, Africi 4 %, Oceaniji 4 % (Oršanić 2003).

Šumske kulture trenutačno podmiruju 35 % potreba za oblim drvom, a procjena je da bi do 2020. godine podmirivale oko 44 %. Podizanjem novih šuma pošumljavanjem u odgovarajućim ekološkim zonama i primjenom potrajnoga gospodarenja smanjio bi se pritisak na prirodne šumske komplekse.

Šumske kulture podignute u Novom Zelandu podmiruju 99 % potreba za industrijskim drvom, u Čileu oko 84 %, a u Brazilu 62 %. One pružaju i općekorisna dobra koja se u mnogim zemljama nažalost malo vrednuju. Njihova je uloga nezamjenjiva u borbi protiv širenja pustinja, u apsorpciji ugljičnoga dioksida, zaštiti tla i voda, rekultivaciji ogoljelih tala i dr.

Osim općekorisnih funkcija koje pružaju, one mogu imati i negativan utjecaj na nekom području ako su podignute bez dobroga planiranja i gospodarenja, na neodgovarajućim tlima, vrstama i provenijencijama.

Vrlo je značajno što su šumske kulture obnovljivo dobro, gospodarski, socijalno, kulturno i okolišno potrajne odnosno održive. Njihova će uloga u pozitivnom smislu doći do punoga izražaja samo onda ako stručno planiramo njihovo podizanje te ih kvalitetno i pravodobno njegujemo i obnavljamo.

Zakonske, stručne, znanstvene i druge aktivnosti u vezi s hrvatskim sredozemnim šumama

Legal, specialist, scientific and other activities related to forests in the Croatian Mediterranean

Želja da se šume hrvatskoga Sredozemlja sačuvaju i da se zaustavi njihovo nestajanje datira od vremena dolaska Hrvata na te prostore i traje do današnjih dana.

Navodeći Kaudersovu raspravu, Horvat (1957) spominje gotovo sve statute primorskih gradova u kojima se zabranjuje sječa. Tako navodi statute Korčule iz 1214. godine s kasnijim dopunama, Dubrovnika iz 1272, Trogira iz 1322, Splita, Skradina, Hvara, Vrbnika, Grobnika i dr.

Jedlowski (1977) piše da je na savjetovanju "Ekološka valorizacija primorskoga krša" Vrdoljak u svom referatu istaknuo da su nastojanja da se šume primorskoga krša očuvaju vrlo stara. Navodi da statuti dalmatinskih i primorskih gra-

dova iz XIII. i XIV. stoljeća propisuju mjere za očuvanje šuma, kao što su zabrana ispaše koza, zabrana paljenja kreča u šumi, reguliranje sječa i dr., za što su propisivane stroge kazne. Te se mjere pokušavaju provesti u život i za mletačke vladavine od XV. do XVII. kad su te šume još uvijek bile značajna sirovinska osnova za gradnju brodova i sanaciju Venecije. Sve su te mjere uglavnom bile neuspješne u prvom redu zbog nefunkcioniranja mnogih čimbenika pravne države.

Iz pisane povijesti otoka Raba, nakon Mljeta najzelenijega otoka na Jadranu, doznaje se da su Rimljani u II. stoljeću pr. Kr. podigli na mjestu današnjega grada utvrdu koja se nešto kasnije uvrštava u red rimskih municipija u kojoj je život unutar utvrda organiziran po uzoru na Rim (Badurina 1936–1956).

Rapski je municipij imao svoj ustav i gradski magistrat. Blagajnik je upravljao gradskim prihodima, a najvažnije prihode za plaće kneza i činovnika općina je imala od iznajmljivanja općinskih šuma i pašnjaka (Rauš i Matić 1984). Od toga je vremena vidljivo da su općinske šume bile pod značajnim nadzorom, bilo ih je najviše s tim da su s vremenom formirane i manje površine privatnih i crkvenih šuma.

Rab je bio pod upravom Venecije od 1409. do 1797. godine. Narod je imao servitutna prava u općinskim šumama koja su se sve više ograničavala. Godine 1409. Rabljani su dobrovoljno predali Veneciji sve šume i pašnjake u vlasništvo države pod uvjetom da država plaća općinske činovnike. Država je preuzela šume, ali nije plaćala činovnike tako da su Rabljani bili prisiljeni otkupiti svoje šume od Venecije za 3000 lira godišnje. Tada je dužd propisao da se privatne šume mogu sjeći svakih 10, a općinske svakih 7 godina, a sjekle su se sve vrste osim crnike, duba, divlje masline i kruške.

Godine 1442. na Rabu je uočena velika opasnost za šume od koza, a 1487. godine dužd radi zaštite šuma zabranjuje upotrebu svih vapnenica u kojima se loži drvo. Zabrane sječe glavnih vrsta drveća obnavljale su se 1516, 1522. i 1540. (Badurina 1936–1956). Općina se toga propisa morala pridržavati i prema njemu je gospodarila svojim šumama. Slijedom provođenja propisa i brigom za šumu lugari kao čuvari šuma uvedeni su u šume na Rabu već 1892. godine (Rauš i Matić 1987).

Bez obzira na ranu naseljenost Raba, veliku koncentraciju stanovništva, intenzivan kulturni i društveni život stanovništva te intenzivan nepovoljan biotski i abiotski utjecaj na te šume, one nisu na cijelom otoku degradirane, kao što je to slučaj sa šumama u ostalom Sredozemlju.

Osim obešumljenih i degradiranih, nekad šumskih područja, kao što su Kamenjak, Fruga, Sorinj i dr., i danas smo svjedoci postojanja vječne autohtone, prirodne, klimatogene šume hrasta crnike na šumskim predjelima Kalifront i Dundo ukupne površine od 1141 ha. Tim se šumama upravljalo i organizirano gospodarilo od nastanka grada Raba do danas. Evidentno je da iz tih šuma nikad nije nestala crnika kao glavna vrsta drveća. One se, posebno gospodarska šuma Kalifront, danas nalaze u progresiji jer iz nekad degradacijskoga stadija makije hrasta crnike, zbog dobroga gospodarenja, prelaze u viši uzgojni oblik (niski, srednji, visoki).

Cilj kvalitetnoga i na znanstvenim osnovama temeljenoga gospodarenja šumama jest, među ostalim, i u tome da se dobrom gospodarskom njegom i obnovom učine vječnima. Upravljanje je i gospodarenje šumama Dundo i Kalifront dokaz da je svako organizirano gospodarenje, posebno u dalekoj prošlosti, bilo ono i na niskom stručnom stupnju, bolje od nikakva. Takvo gospodarenje u višestoljetnom nizu ove je šume sačuvalo i one su postale jedinstven primjer dobroga gospodarenja ne samo u Hrvatskoj i cijeloj Europi nego i puno šire (Matić 1983).

Prvi pokušaji unošenja borova na otoku Rabu zabilježeni su 1862. godine, kad šumarski savjetnik Eugen Deimel šalje sjeme bora *Pinus maritima* na Rab. Sjeme je skupljeno na Korčuli, a posijano je na šumskim predjelima Dundo i Kalifront (Rauš i Matić 1987). U tom se slučaju najvjerojatnije radilo o sjemenu alepskoga bora.

Prema Horvatu (1957) za vrijeme mletačke vladavine u Dalmaciji *providetore generale* Francesko Grimani 1756. godine izdaje zakon u kojem se predviđa sadnja drveća u ograđenim prostorima, ali se zbog loše organizirane uprave zakon nije provodio.

Prema Vrdoljaku (1977) počeci organiziranoga pošumljavanja u Dalmaciju datiraju od dolaska Francuza, posebno za vrijeme providura Vicka Dandola. On 1806. godine naručuje 100 000 sadnica iz Italije te osniva u Ninu manji rasadnik.

Prema Ivančeviću (2008) početak znanstvenoga pristupa zaustavljanja degradacije krša Hrvatskoga primorja vezan je uz odluku Zemaljske vlade u Zagrebu o financiranju elaborata koji je prirodoslovac J. Lorenz nakon terenskih istraživanja predstavio vladi u Zagrebu 1860. godine.

Opća skupština Austrijskoga šumarskoga društva 1865. preporučuje državi da se vlasnici pošumljenih površina oslobode poreza te da se na ta područja pošalju stručnjaci koji će organizirati i rukovoditi pošumljavanjem.

Prva pošumljavanja na primorskom kršu riječke županije u grobničkoj, hreljinskoj i vinodolskoj općini uz podizanje rasadnika i podršku šumarskoga stručnjaka I. Salzera počinju 1873. godine.

Nakon Francuza ponovnim dolaskom Austrije na te prostore još se više uništavaju šume. Zbog toga u osamdesetim godinama devetnaestoga stoljeća Austro-Ugarska uspostavlja u Dalmaciji šumarsku službu za državne i općinske šume. Otada u Dalmaciji postoji organizirana šumarska služba koja je do današnjih dana u organizacijskom smislu imala svoje uspone i padove.

Godine 1878. osnovano je Kraljevsko nadzorništvo za pošumljavanje krša krajiškoga područja – Inspektorat za pošumljavanje krševa, goleti i uređenje bujica u Senju koje je postiglo najbolje rezultate u pošumljavanju krša. Za vrijeme njegova djelovanja u trajanju od 64 godine (1878–1942) osnovano je 95 predjela kultura branjevina na površini od 10 097 ha. U njima je pošumljeno 1738 ha, popunjeno je 1441 ha i prirodno pomlađeno 7435 ha. Osnivaju se i rasadnici u Sv. Mihovilu s trušnicom za sjeme kod Senja te rasadnik u Crikvenici (Ivančević 2003).

Prvi svjetski rat prekinuo pošumljavanje. Radovi se nastavljaju 1920. tako da je od 1920. do 1927. pošumljeno 2014 ha. Pretpostavlja se da je za vrijeme stare Jugoslavije pošumljeno oko 25 000 ha, a od toga je uspjelo tek 3000 do 4000 ha. Prema Krpanovim (1957) podacima temeljenim na izvješćima šumarskih inspektorata 1955. godine za to je vrijeme podig-

nuto u Dalmaciji 5153 ha, Hrvatskom primorju 6115 ha i u Istri 3540 ha ili ukupno 14 808 ha šumskih kultura.

Krajem 1921. osniva se Zavod za šumske pokuse na Gospodarsko-šumarskom fakultetu u Zagrebu (Seletković 1998). Prva sjednica Zavoda održana je 2. travnja 1922. godine kada je konstituirano stručno vijeće. Prvi rezultati istraživanja objavljeni su u ljeto 1925. godine. Otada izlazi časopis *Glasnik za šumske pokuse* koji i danas izdaje Šumarski fakultet Sveučilišta u Zagrebu. To je prva znanstvenoistraživačka institucija koja se počela baviti i šumarskim problemima krša.

Odmah nakon Drugoga svjetskoga rata osniva se Institut za šumarska i lovna istraživanja u Zagrebu. Osnovan je posebni odjel unutar Instituta koji se bavio melioracijom krških terena sa stanicom u Rijeci i punktom na Rabu (Jedlovski 1957).

Nakon osnivanja Instituta u Zagrebu Jugoslavenska akademija znanosti i umjetnosti (JAZU, danas Hrvatska akademija znanosti i umjetnosti) osniva Institut za eksperimentalno šumarstvo sa stanicama u Trstenu kraj Dubrovnika, Splitu i u Matuljama kod Rijeke. Institut se bavio istraživanjima regresije i progresije šumske vegetacije, gustoćom sadnje na degradiranom kršu i tehnikom pošumljavanja dalmatinskih kamenjara te tehnikom uzgajanja lovora, plutnjaka, eukaliptusa, oštrike i drugih vrsta.

Institut za pošumljavanje i melioraciju krša u Splitu počinje raditi 1948. godine i organizacijski se sastojao od pet sekcija.

Nakon Drugoga svjetskoga rata počinju ozbiljnije akcije na kršu, kao što su pošumljavanje i melioracija degradiranih šuma (šikare, makije), a nakon 1956. uvođenjem sustava samofinanciranja ti se radovi svode na minimum (Androić 1977). Od 1945. pa do 1975. pošumljeno je oko 25 000 ha, a od toga je uspjelo 10 358 ha ili 40 %. Prema Krpanu (1957) u jesen 1956. godine obavljena je inventarizacija površina koje su pošumljene od 1946. do 1956. godine. Ustanovljene su ove površine i uspjesi pošumljvanja: Dalmacija 6658 ha s uspjehom od 58 %, Hrvatsko primorje 2125 ha s uspjehom od 61 % i Istra 2367 ha s uspjehom od 67 %. Ukupno je pošumljeno 11 150 ha s prosječnim uspjehom od 62 %.

Prema podacima Šumskogospodarske osnove šumskogospodarskoga područja Republike Hrvatske (2006–2015) u Hrvatskoj se nalazi 3 % ili 72 000 ha šumskih kultura. Od te površine šumske kulture crnoga, alepskoga i primorskoga bora, koje prevladavaju u hrvatskom dijelu Sredozemlja, pokrivaju 22 000 ha (Milković 2006).

U današnje se vrijeme u Hrvatskoj godišnje pošumi oko 1000 ha šumskoga zemljišta, što je više nego simbolična površina, imajući na umu da raspolažemo s 300 000 ha neobrasloga kvalitetnoga šumskoga tla koje treba pošumiti. Znajući da godišnje u našem Sredozemlju izgori u prosjeku oko 10 000 ha šumskih kultura i različitih degradacijskih stadija autohtone šumske vegetacije, podaci o godišnjem pošumljavanju u odnosu na potrebe još su porazniji.

Degradacija krša, koja se sve više širi, relativno je rano uočena kao problem u europskom šumarskom svijetu. Na Međunarodnom šumarskom kongresu u Madridu 1911. godine francuski šumar Hickel pokrenuo je pitanje pošumljavanja krša (Androić 1977).

Godine 1922. osnovana je u Marseilleu Šumarska liga zemalja Sredozemnoga mora pod imenom *Silva Mediteranea* u kojoj je surađivao akademik Aleksandar Ugrenović, profesor zagrebačkoga Šumarskoga fakulteta. Nakon Drugoga svjetskoga rata zadatak Lige preuzima komisija FAO-a te je problem krša prešao u međunarodne okvire u kojima su aktivno surađivali profesori Šumarskoga fakulteta akademik Dušan Klepac, prof. dr. sc. Šime Meštrović i dr.

Šumarska je struka u Hrvatskoj od Drugoga svjetskoga rata do danas organizirala više znanstvenih skupova o šumama i šumarstvu hrvatskoga Sredozemlja. Na ovom ćemo mjestu navesti neke od njih.

Godine 1957. održano je Savjetovanje o kršu koje je organizirao Savjet šumarskih inženjera, Savez poljoprivrednih inženjera i Savez ekonomista Jugoslavije. Radovi su objavljeni u pet tomova.

Odjel za prirodne znanosti JAZU u Zagrebu 1971. organizirao je savjetovanje o zaštiti prirode na kršu i izlaganja objavio u posebnoj ediciji.

Savez inženjera i tehničara šumarstva i drvne industrije Hrvatske organizirao je 1976. godine znanstveno savjetovanje u Zadru pod naslovom "Uloga šume i šumske vegetacije u zaštiti čovjekove okoline u odnosu na jadransko područje". Savjetovanje je strukturirano tako da se sastojalo od uvodnih izlaganja i izlaganja u šest sekcija.

Uvodna su izlaganja iznesena ovim redoslijedom:

- Stanko Tomaševski: Pobude i tematika savjetovanja "Uloga šume i šumske vegetacije u zaštiti čovjekove okoline u odnosu na jadransko područje"
- Milan Androić: Krš u prošlosti, sadašnjosti i budućnosti
- Dušan Klepac: Prijedlog petogodišnjega plana (1976–1980) znanstvenih šumarskih istraživanja na kršu
- Žarko Vrdoljak: Stanje i problemi šumarstva na kršu
- Zlatko Pavletić: Važnost zaštite šuma u jadranskom području i njihovo uklapanje u program "Čovjek i biosfera" u području Mediterana.

Rad se odvijao po ovim sekcijama:

1. Političko organizacijsko područje, voditelj A. Šobat
2. Područje ekologije, voditelj B. Prpić
3. Uzgajanje šuma, voditelj S. Matić
4. Općekorisne funkcije šuma, voditelj Đ. Rauš
5. Zaštita šuma, voditelj M. Androić
6. Ekonomika i kadrovi, voditelj Z. Tomac.

JAZU i Skupština općine Rab 1987. godine organizirali su znanstveni skup o otoku Rabu na kojem je vrlo detaljno analizirano gospodarenje i namjena rapskih šuma u prošlosti, sadašnjosti i budućnosti te je tiskan zbornik radova (Rauš i Matić 1987).

Sveučilište u Zagrebu i Hrvatsko ekološko društvo 1987. održali su znanstveni simpozij o otoku Lokrumu na kojem je problem šuma i šumarstva na tom otoku imao istaknuto mjesto. Zbornik je radova tiskalo Hrvatsko ekološko društvo 1979. godine.

Hrvatsko ekološko društvo i Nacionalni park Mljet 1995. godine organizirali su znanstveno savjetovanje "Prirodne značajke i društvena valorizacija otoka Mljeta" na kojem su šume kao najznačajniji prirodni fenomen otoka Mljeta bile u središtu zanimanja.

Znanstveno vijeće za poljoprivredu i šumarstvo HAZU 2000. godine održalo je u Splitu znanstveno savjetovanje "Unapređenje poljoprivrede i šumarstva na kršu", a izlaganja su objavljena u zborniku radova.

Hrvatsko šumarsko društvo i Hrvatske šume d.o.o. Zagreb 2003. godine organizirali su znanstveno savjetovanje povodom 125. obljetnice Kraljevskoga nadzorništva za pošumljavanje krasa krajiškoga područja – Inspektorata za pošumljavanje krševa, goleti i uređenje bujica u Senju. Radovi su objavljeni u posebnom broju *Šumarskoga lista*. Također su 2008. godine organizirali znanstveno-stručni skup i stručni izlet povodom obilježavanja 100-godišnjice (1908–2008) crikveničkoga rasadnika "Podbadanj".

Znanstveni i stručni radovi o pošumljavanju krša objavljeni u šumarskim glasilima

Karst afforestation in scientific and specialised articles published in forestry journals

Osim navedenih značajnih društvenih aktivnosti kojima se nastojalo dati prilog obnovi i zaštiti šuma na hrvatskom dijelu Sredozemlja, vrlo su značajni objavljeni stručni i znanstveni radovi u šumarskim i drugim znanstvenim časopisima i knjigama (*Šumarski list, Glasnik za šumske pokuse, Anali za šumarstvo* HAZU, *Radovi* i dr.).

Krš u Hrvatskoj, velik šumarski, društveni i socijalni problem, prevladava sa svojim temama tijekom svih 133 godina izlaženja *Šumarskoga lista*. Iako je pitanje krša nalazilo mjesta na stranicama svih do sada tiskanih brojeva *Šumarskoga lista*, ipak se primjećuje jedan kampanjski pristup tomu problemu. U početku izlaženja *Šumarskoga lista* krš je središnja tema s većim brojem radova. S vremenom krivulja zanimanja za to pitanje pada, a nakon 1918. godine ponovno poprima kampanjsko obilježje, s priličnim brojem radova u prvoj polovici toga razdoblja. Što se bližimo više početku Drugoga svjetskoga rata, zanimanje za rješavanje pitanja krša opet pada, a nakon 1945. godine ono opet raste. Broj radova iz nekoga područja šumarske znanosti uvijek je imao čvrstu vezu s konkretnim radovima u praksi na terenu te je bio uvijek odraz te aktivnosti. U današnje su vrijeme radovi na pošumljavanju krša, njezi i obnovi šuma na tom području svedeni na minimum, pa se to odražava i na broj objavljenih radova na stranicama naših šumarskih glasila, a posebno *Šumarskoga lista* (Matić 1977).

U Rijeku 1860. godine stiže prirodoslovac Lorenz koji istražuje krš i piše rad o uvjetima kultiviranja i pošumljavanja krša (Bura 1957). Prvi je prirodoslovac koji je izradio studiju biljnogeografskih, geoloških, pedoloških i klimatskih uvjeta Hrvatskoga primorja. Podijelio je krško područje od Rijeke do Novoga Vinodolskoga u tri vegetacijske zone i za svaku odredio vrste drveća kojima bi se trebalo pošumljavati.

Bogoslav Šulek (1866) piše knjigu *O koristi i gajenju šumah* u kojoj je jedno veće poglavlje posvetio pošumljavanju krša.

U prvom broju *Šumarskoga lista* 1877. nalazi se članak nepoznatoga autora koji piše o plutastom hrastu i njegovim svojstvima za "zaplođivanje krasa".

Jedan od prvih, najvećih i u ono vrijeme najvredniji rad koji obrađuje složenu problematiku krša i u kojem se nalaze prijedlozi za rješavanje mnogih problema svakako je Weselyjev rad "Kras Hrvatske krajine i kako da se spasi, za tiem krasko pitanje uploške" koji je u nastavcima izlazio u *Šumarskom listu* 1877, 1878. i 1879. godine. Wesely je u svojim razmatranjima obuhvatio "primorski kras" u otočkoj, ličkoj i ogulinskoj pukovniji. Uzroke pustošenja krša autor ne vidi samo u tlu i podneblju, već i u negativnom djelovanju čovjeka. Nakon detaljnoga opisa uzroka pustošenja daje preporuke za rješavanje pitanja krša kako s biološkoga tako i sa socijalnoga gledišta. U poglavlju "Zagajači postupak na krasu" opisuje sve radove od šumskoga rasadnika do pošumljavanja na terenu. U 23 točke iznesene su preporuke toliko stručne da i danas mogu izdržati stručnu kritiku i ocjenu.

Grobničko je polje od davnine bilo problem koji su šumari praktičari nastojali rješavati na terenu, a o tim su svojim radovima preko *Šumarskoga lista* obavještavali šumarsku javnost. Tako Ćelija (1879) piše o pošumljavanju Grobničkoga polja, Majnarić (1891) iznosi povijesne podatke o devastaciji Grobnika, a Ettinger (1897) piše o uspjehu pošumljavanja na Grobničkom polju i daje preporuke za uspjeh.

Da bi kršu dali važnost koja mu opravdano pripada, članovi Austrijskoga šumarskoga društva, u savezu s Hrvatsko-slavonskim i Kranjsko-primorskim šumarskim društvom, održavaju svoju XII. skupštinu na području "austrijskoga primorja i Hrvatske" sa stanicama u Divači, Rijeci i Senju. *Šumarski list* 1879. godine donosi opširan izvještaj i tiskane stručne referate s te skupštine.

Nanicini (1881) u raspravi "K pošumljavanju krasa" predlaže da se naši ljudi šalju u Francusku kako bi stekli iskustva o pošumljavanju krša koja bi nam prenijeli. On ističe da je šumarska struka jedna od glavnih struka za "promicanje materijalnoga napretka" pa se kao takva mora od države podupirati.

Nepoznati autor 1881. godine opisuje proizvodnju sadnica u zemljanim loncima i ističe dobre rezultate pri pošumljavanju s takvim sadnicama. To možemo označiti kao prvi pokušaji rasadničarske kontejnerske proizvodnje sadnica obložena korijenja ili s busenom u nas.

Guttenberg (1881) u radu "Kako ćemo u buduće na krasu" posebno ističe pašu kao problem broj jedan te inzistira na zakonu po kojem bi se znalo tko je dužan pošumiti krš.

Crnković (1882) piše o šumarstvu Istre, ističući da smo mi opustošili šume toga područja, a ne Mlečani, kako se priča. Dijeli Istru i Dalmaciju u tri pojasa, te za svaki preporučuje vrste drveća za pošumljavanje, a piše o osnivanju mješovitih sastojina radi veće otpornosti protiv kukaca.

O šumarstvu se Dalmacije pisalo u više brojeva *Šumarskoga lista*, npr. 1882, 1883, 1884, 1885, 1886, 1888, 1904, 1907. i 1912. godine. Ti su radovi donosili izvještaje o pošumljavanju, stanju ljudstva u dalmatinskom šumarstvu, o uređivanju bujica, stanju branjevina, ocjenjivali su razvoj šumarstva za konkretnu godinu, bavili se problemom koza, propagiranjem pošumljavanja, problemom nacrta zakona o pošumljavanju i zaštiti šuma itd.

Za to su razdoblje karakteristični članci kao onaj iz 1882. godine u kojem autor navodi što se sve u toj godini napravilo u Dal-

maciji i zaključuje "da je Dalmacija u 1882. godini lijepo napredovala što se tiče šumarstva". Isto tako Zickmundovsky (1880) piše da Zemaljska kulturna naklada daje novce za pošumljavanje u Dalmaciji i da šumarstvo u njoj značajno napreduje.

Prestini (1885) piše što stranci misle o našem kršu. Opće je mišljenje da zabrana devastacije jamči uspjeh pošumljavanja. Ističe da se za vrijeme pjesnika Glaudijana Dalmacija zvala "zemlja šumovita", a Raguza je prozvana Dubrovnikom zbog hrastovih šuma.

Već 1885. godine nepoznati autor, kada piše o šumarstvu Dalmacije, ističe na prvom mjestu problem koza, pa se pita nije li došlo vrijeme da se Dalmacija od stočne privrede okrene ratarstvu i industriji.

U prijedlogu što ga Hirc (1885) daje za pošumljavanje bakarske okolice može se čitati da je u 16. stoljeću bilo lijepih šuma i s istočne strane Velebita, a za cara Augusta su u Primorju bile tako guste šume da se odatle cijela Italija opskrbljivala svinjama.

Malbohan (1885) iz Senja objavljuje članak "Pošumljenje hrvatskoga kraša", koji je u dijelovima tiskan u *Šumarskom listu*. U njem piše o šumskouzgojnim radovima potrebnim za ozelenjavanje krša, o podizanju ograda, rezanju žbunja škarama na panj, o sadnji dvogodišnjih četinjača i jednogodišnjih listača te o visinskoj zonaciji u kojoj se mogu saditi određene vrste drveća.

Iz rada "Zagajimo", koji je napisao 1888. šumar iz Dalmacije F. Z., doznajemo da je u Sinju uzgojeno 10 000 sadnica alepskoga bora, crnoga bora i pinije u loncima, a da se na otoku Hvaru već vide rezultati pošumljavanja.

"Kod učitelja se mora djelovati tako da kroz nastavu kod djece razvijaju ljubav prema šumi", piše Ilijić (1889) te daje još čitav niz prijedloga za pošumljavanje goleti i uređenje pašnjaka Otočke imovne općine.

U to se vrijeme vrlo često javlja M. Bona, opisujući radnje oko pošumljavanja krša na području Crikvenice i ostaloga Hrvatskoga primorja. Tako u *Šumarskom listu* 1889. godine čitamo da je u toj godini na tom području posađeno 95 000 biljaka.

Kramer (1889) piše raspravu "Da li je moguće kras šumom zasaditi?" te ističe da se treba pošumljavati tamo gdje ima zemlje, a gdje je nema, šuma se ne može podići. Na taj rad iste godine odgovara M. R. te piše "Moguće je kras pošumiti", što svaki šumar zna na osnovi tisuće primjera s kojima geolog Kramer nije upoznat.

M. pl. B. piše 1889. godine o opasnosti "koja prijeti branjevini crnog bora od požara koji može izazvati vlak, a glavni krivac je ugljen koji je željeznica počela nedavno upotrebljavati". On traži od željeznice da poduzme zaštitne mjere.

Tek nakon osnivanja posebnoga Nadzorništva za pošumljavanje krša u Senju 1878. godine počelo se ozbiljnije raditi na pošumljavanju toga područja, piše Malbohan (1892). Isto tako opisuje radove na pošumljavanju krša te inzistira na tome da se napiše zakon za pošumljavanje krša, sličan onomu u Kranjskoj i Istri.

Bona (1892) piše "O pošumljavanju hrvatsko-primorskog krasa" koji dijeli na tri klimatska i vegetacijska pojasa: pojas uljike, pojas hrasta i jasena i pojas bukve, jele i smreke. Navodi za svaki pojas vrste drveća kojima se može pošumljavati. Posebno ističe da je stroga zabrana od paše najjednostavniji i najbolji način pošumljavanja krša.

Nakon osnivanja posebnog Nadzorništva za pošumljavanje krša u Senju 1878. godine u *Šumarskom listu* često se tiskaju godišnji izvještaji o radu i aktivnosti toga Nadzorništva, primjerice 1896. i 1897. godine.

Najviše se pošumljavaju ona mjesta koja su uredila morska kupališta (Crikvenica, Novi, Kraljevica), piše J. P. 1901. godine, opisujući izlet slušača Kraljevske šumarske akademije zagrebačke u Hrvatsko primorje. Šumari se nadaju da će procvat ovih kupališta posredno donijeti ubrzanu akciju pošumljavanja krških goleti.

F. Z. K. (1901) ističe da je donedavno pitanje pošumljavanja krša bilo rješavano u svim stručnim austrijskim časopisima. Međutim, danas je to pitanje riješeno, samo ostaje problem novca i vremena. No ipak nova pošumljavanja krša ostaju i dalje najvažniji i najzanimljiviji zadatak šumske tehnike. Isti autor navodi da se uspjelom kulturom smatra samo ona kod koje je nakon ponovljena popunjavanja ostalo na životu oko 80 % biljaka. Nakon popunjavanja s četinjačama na istoj se površini počinju javljati autohtone listopadne vrste drveća.

Nepoznati se autor 1902. godine pita: hoće li se naše šume gnojiti umjetnim gnojivima te navodi primjer Danske u kojoj se već duže vrijeme gnoje sječine na slabim tlima.

U povodu 50. obljetnice vladavine Franje Josipa izdano je djelo *Povijest austrijskog šumarstva od 1848–1898. godine*. Knjiga je izišla u dva dijela, a obrađuje industriju, uporabu šuma, uzgoj šuma i pošumljavanje krša.

O pošumljavanju krša pisao je Guttenberg (1881), pokušavajući definirati krš opisujući sve njegove fenomene. Dijeli ga na klimatske zone i navodi vrste drveća i grmlja koje u njima pridolaze. Tvrdi da je šuma nestala zbog posjedničkih prilika, da su državne i veleposjedničke šume ostale, a općinske nestale. Sječa, koze, ovce i požari samo su neki od razloga propadanja šuma. Državni šumski zakon iz 1852. godine pobrinuo se da sačuva postojeće šume, ali nije propisivao pošumljavanje golih površina. Prve je korake napravio Trst kad je počeo pošumljavati (u početku bjelogoricom neuspješno, a poslije crnogoricom, odnosno crnim borom i većim uspjehom). Godine 1880. pošumljavanje uzima maha, smanjuju se pašnjačke površine, ali pučanstvo pruža otpor. U vremenu od 1882. do 1887. godine izdani su posebni zakoni za pošumljavanje i osnovana povjereništva za pojedine predjele Austro-Ugarske. U Dalmaciji nisu provođene takve mjere zbog većih troškova, jer tamo postoji još ostatak hrastovih šuma iz kojih bi se mogle razviti lijepe šume. Godine 1873. izlazi zakon o zabrani prodaje korijenja i ugonu koza na zemljišta koja bi se dala pošumiti, a 1876. godine određena je zakonom dioba zemljišta koja su prikladna za kulturu te se izlučuje jedan dio zemljišta za pošumljavanje. Pošumljavanje se izvodi ograđivanjem suhozidom, zabranom paše, sadnjom i sjetvom. Zemljišta su za pošumljavanja unesena u katastar i bila su pod nadzorom oblasti. Na taj je način stavljeno pod zabranu 155 000 ha površine, koja bi se već mogla nazvati šumom, a paša je koza zabranjena na 455 000 ha.

O postanku krša u ličko-krbavskoj i modruško-riječkoj županiji, te o njegovu sadašnjem stanju vrlo opširno piše Koso-

vić (1909). Isti autor 1910. godine objavljuje rad "Kultiviranje hrvatskog krša" u kojem se upušta u detaljna razmatranja o postanku krša.

Petrović (1910) pak piše o potrebi donošenja zakona o pošumljavanju krša te navodi da je bor prijelazna vrsta, a samo na glavicama ima trajnu funkciju. Nakon borovih kultura potrebno je podizati autohtonu vegetaciju i tek je nakon toga završeno pošumljavanje krša. Navodi da je Trst dobio Zakon o pošumljavanju krša 1881. godine, Gorica 1886, Kranjska 1885, Istra 1881. Taj je zakon od Istre prešao i na Kvarner. Zakon bi u Hrvatskoj trebao riješiti pošumljavanje krša i uređenje pašnjaka. Na kraju svojih razmatranja Petrović predlaže da se na Šumarskoj akademiji predaje pošumljavanje i kultiviranje krša.

Kauders (1912) dokazuje ovisnost visinskoga prirasta u kulturama crnoga bora na kršu i količine oborina u srpnju i kolovozu prošle godine. Isti autor 1914. godine piše o pošumljavanju krša u crikveničkom šumskom kotaru i ističe da će pošumljavanje uspjeti samo onda ako ga država uzme u svoje ruke. U radu iz 1915. godine navodi da imamo pisane dokumente iz 1813. godine u kojima se navode šumski predjeli na kojima je bila zabranjena paša koza.

Marčić (1914) piše o maslini i njezinoj rasprostranjenosti u šumama istočnih obala jadranskog mora te sadnji u uzgoju maslina na tom području.

Petračić (1913) objavljuje članak u povodu jubilarne 25. obljetnice pošumljavanja krša u Kranjskoj, odnosno u kotaru Postojna. Ističe da je do kraja 1910. godine pošumljeno 2910 ha. Opisuje način pošumljavanja i navodi iskustva s crnim borom koji, kako on smatra, ima trajnu i prijelaznu zadaću.

U prvim brojevima nakon Prvoga svjetskoga rata *Šumarski list* bilježi da je profesor Petračić 1922. godine održao predavanje u Pučkom sveučilištu pod naslovom "Naš krš i njegovo pošumljenje".

Godinu dana nakon toga u *Šumarskom listu* čitamo da rasadnici u Crikvenici i Senju dijele besplatno 200 000 sadnica, a da prednost pri diobi imaju oni koji će saditi na kršu.

Balen (1925) u radu "Organizacija rada na pošumljavanju krša i goleti" ističe: "Pošumljavanje ili bolje reći kultiviranje krša moći će se u većem obimu i u bržem tempu izvoditi samo onda ako ideja o pošumljavanju krša poprimi formu jednog socijalnog pokreta. Preporučam 1. Poznavanje objekta (staništa) 2. Izrada osnove za kultiviranje krša 3. Na temelju toga – izvoditi radove na terenu". U istom radu navodi da je za vrijeme rada Nadzorništva za pošumljavanje krša od 1878. do 1892. godine pošumljeno 12 000 jutara kultura. U tom radu predlaže osnivanje inspektorata za pošumljavanje.

U dva rada 1927. godine J. Balen piše o diobi gologa krša za pošumljavanje te o resurekcijskoj sječi kao mjeri za podizanje šuma na kršu. Iste godine javlja se s još jednim radom u kojem govori o pošumljavanju krša sjetvom. Navodi podatak da je kod Trsta 1843. godine pošumljavano sjetvom sjemena.

Balen (1928) piše i o klimatskim čimbenicima na kršu te daje dobar pregled vrsta koje dolaze u obzir za pošumljavanje krša. Također daje prikaz vegetacijskih zona i stanišnih prilika na kršu. Iduće je godine (1929) objavio članak "Tehnika zašumljenja krša". U njem preporučuje da se tamo gdje ima tragova šume obavlja resurekcijska sječa. U zoni makije preporučuje "alepski bor i primorski bor, a tamo gdje je najtoplije treba saditi pinj".

Balen (1931) objavljuje kapitalno djelo *Naš goli krš* na 311 stranica u kojem raspravlja o ekološkim prilikama i pošumljavanju krša. Obrađuje ova poglavlja: klima, edafske prilike, obilježja vegetacije, u čem je problem krša, problem zemljišta, šuma kao izvor proizvodnje, tehnika zašumljavanja, mišljenje raznih autora, tereni za pošumljavanje, pretvaranje sastojina, zaštita sastojina, pitanja u vezi s pošumljavanjem (površine), važnije zakonske odredbe o kršu, zadaci znanstvenoga rada na kršu, povijesne napomene.

Balen (1931) piše da prvo pošumljavanje na području Trsta 1843. nije uspjelo (crni bor, obični bor, kesten, bagrem). Ponovni pokušaj J. Kollera 1859. godine uspijeva i polako se širi i u Hrvatsku.

Kauders se (1933) javlja u *Šumarskom listu* radom "Rasprostranjenje i uzgoj šuma u području primorskog krša Savske Banovine", ističući ekološke čimbenike krša i njihov utjecaj na pošumljavanje.

Veseli (1935) također objavljuje rad na temu pošumljavanja. S tim u svezi opisuje tlo, vegetaciju, pašnjake, floru, katastar, pašu, vrste drveća, sjetvu, sadnju, načine sadnje (holova motičica), preporučuje i listopadne vrste koje po njegovu mišljenju jednako uspijevaju kao zimzelene te spominje i popunjavanje. Autor se u pisanju, kako sam ističe, držao gradiva iz knjige F. Holla *Die Karstaufforstung* (Sarajevo, 1901).

Beltram (1935) opisuje stvaranje krša, mjere za spas šikara i goleti, umjetno pošumljavanje (primjer francuskih Landa i južne Srbije) i mjere za pošumljavanje primorskoga krša. Ističe da pošumljavanje krša treba zauzeti oblik spontanoga narodnoga pokreta, ali na osnovi prosvjete, a nikako naređenjima i prisilom.

Oraš se javlja 1939. i 1940. godine s dva rada u kojima obrađuje "Problem pošumljavanja krša u Dalmaciji". Ističe da je pučanstvo na kršu zainteresirano za pošumljavanje i za rješavanje posjedovnih odnosa. Traži da se donese zakon o diobi općinskih i seoskih pašnjaka u Dalmaciji. Na kraju piše o organizaciji posla oko pošumljavanja te opisuje tehniku sadnje i sjetve.

Odmah nakon završetka rata javlja se Beltram (1946) i tvrdi da problem krša nije samo u pošumljavanju, nego da je to složen problem koji obuhvaća kadrove, agrarnu reformu, kolonizaciju, držanje koza itd. Nakon razmatranja o izboru vrsta drveća za pošumljavanje, tehnici rada na kršu, resurekcijskoj sječi i melioracijama pašnjaka autor određuje smjer budućega šumareva rada na kršu.

Uredništvo *Šumarskoga lista* u prvim brojevima nakon rata posvećuje veliku pažnju pitanju krša, te nakon osnivanja Instituta za krš 1948. godine tiska "Anketu o problemu krša". Pitanja javne ankete, među ostalim, obuhvaćaju djelokrug novoosnovanoga Instituta za krš.

O makijama i njihovu prevođenju u viši uzgojni oblik općenito je u tom razdoblju malo pisano na stranicama naše stručne šumarske literature, pa tako i u *Šumarskom listu*. Toliko je zanimljiviji Marinkovićev (1950) rad koji govori o devastiranim makijama i koji daje prijedloge za njihovu melioraciju.

August Horvat vrlo se često javlja na stranicama *Šumarskoga lista* sa svojim člancima koji obrađuju problematiku hr-

vatskoga krša. O gustoći sadnje na kršu, s prijedlogom da se alepskoga bora sadi 6500 sadnica po hektaru, piše u *Šumarskom listu* 1951. godine. Iste godine raspravlja o nekim neposrednim zadacima istraživačkoga rada na degradiranom kršu te slikovito predstavlja neke probleme vezane uz tehniku pošumljavanja na kršu. Zagovara istraživanje načina sjetve i sadnje posebno, vrijeme sadnje, metode sadnje i sjetve, uzroke propadanja sadnice, vrijeme unošenja drugih vrsta u postojeće kulture i dr. O rezultatima pošumljavanja koje je predviđeno petogodišnjim planom piše 1954. godine. Tom se prilikom kritički osvrće na uspjeh pošumljavanja koji su postigli brigadiri radeći bez stručnoga nadzora. "Podizanjem drače 2–3 godine prije pošumljavanja dobivamo dobru zaštitu za sadnice", tvrdi Horvat (1958), a o pošumljavanju krša sa sjetvom piše 1964. godine. U *Šumarskom listu* iz 1961. godine Horvat donosi opis raznih metoda pošumljavanja sa zaključkom da se nakon rata tehnika pošumljavanja poboljšala uz neznatno povećanje dimenzija jama za sadnju.

Giperborejski (1952) opisuje vrste drveća koje dolaze u obzir za pošumljavanje krša te osim crnoga i alepskoga bora i čempresa navodi i one vrste koje bi mogle dobro uspijevati na različitim područjima Dalmacije, kao što su himalajski cedar, bagrem, lipa, brijest, koprivić, pitomi orah, badem, lijeska, pajasen i ruj. Za svaku vrstu ističe ona svojstva zbog kojih bi bilo važno da uspijeva na tom području.

Marinković (1956) smatra da je pošumljavanje sadnicama alepskoga bora i čempresa bolje izvoditi u grupimičnoj smjesi.

Piškorić se javlja u ovom razdoblju s dva rada, i to 1960. i 1963. godine. U prvom radu dokazuje rentabilnost uzgoja duglazije, cedra, grčke i andaluške jele na kršu, a u drugom opisuje dinamiku visinskoga prirasta izbojaka česmine, a sve radi pošumljavanja krša.

Simunović (1957) opisuje pošumljavanje na terase te ističe prednosti takva načina pošumljavanja kao što su kvalitetna obrada tla na terasama, daje prednost jesenskoj sadnji i kitastoj sadnji četinjača u zasjeku s 3–5 sadnica alepskoga bora i 2 sadnice čempresa. Navodi rezultate takva načina pošumljavanja, među ostalim, i na Srđu iznad Dubrovnika.

Meštrović (1964) piše o primjeni mehaničke obrade tla pri podizanju šuma u Sredozemlju.

Vidaković (1972) daje pregled novih pogleda na pošumljavanje degradiranoga krša te proizvodnje prikladnih hibrida za krš. Prijić (1973) opisuje rezultate rada i poteškoće na koje šumar nailazi pri pošumljavanju krša u novim uvjetima, a posebno navodi problem nedovoljnih izvora financiranja.

Radove iz kojih se mogu doznati povijesni podaci koji se odnose na pošumljavanje krša u Hrvatskoj napisali su Vajda (1955), Marčić (1956) i Kauders (1963).

Šafar (1957) piše o melioracijama degradiranih panjača. Taj posao smatra prioritetnijim nego pošumljavanje goleti.

Sarajlić (1961) opisuje pošumljavanje kontinentalnih krških terena koja su, uz ostalo, izložena ekstremnim ekološkim uvjetima, a Šafar (1964) u topolama na sredozemnom području vidi put k bržemu stvaranju turističkih šuma.

Horvat (1965) objavljuje rad o melioraciji šikara u submediteranskom području krša te smatra da se melioracijom šikara brzo stvaraju uvjeti za razvoj turizma. Kulture koje su se počele podizati na kršu posljednjih stotinjak godina imale su, prema Horvatu, prijelaznu ulogu, ali se sad na to pomalo zaboravlja. U današnjim uvjetima kulture na kršu imaju važnost radi kampiranja, smolarenja i dobivanja celuloznoga drva.

Matić (1976) obrađuje problematiku utjecaja borovih kultura na sukcesiju autohtone vegetacije u staništima hrasta crnike. Ističe da je pošumljavanje devastiranih terena hrasta crnike sa sjemenom i sadnicama borova te njega novoosnovanih kultura četinjača tek jedna faza u dugotrajnom i mukotrpnom poslu privođenja tih površina u prvobitno stanje, tj. u šumu hrasta crnike.

Tomašević (1977) izvještava o rezultatima poredbenih istraživanja uspijevanja kultura alepskoga bora na vapnenastoj i flišnoj podlozi unutar prirodnoga areala. Zaključuje da je flišna podloga povoljnija od vapnene.

Prema Tomaševiću (1979) Venecija Grimanijevim zakonom 1756. godine potiče sađenje šuma u ograđenom prostoru, a općina grada Trsta potiče pošumljavanje već 1843, ali bez vidljiva uspjeha. Uspjeh se postiže tek 1859. godine kad je pošumljavao Josip Koller. Otada se pošumljavanje širi i u nas.

Piškorić (1979) piše o savjetovanju koje je 1879. održano u Rijeci i Senju. Navodi da su neki preporučali pri pošumljavanju sadnju crnoga jasena i pajasena. Ističe da je 1886. godine donesen zakon o pošumljavanju krša u Istri. Temeljem toga zakona već je do 1906. godine u Istri i šire pošumljeno 6500 ha krša. Godine 1947. osniva se Institut za pošumljavanje i melioraciju krša u Splitu. Iste se godine osnivaju i dvije posebne ustanove u Rijeci i Splitu, i to uprave za pošumljavanje i uređenje bujica. Godine 1948. osnovana je Srednja šumarska škola za krš u Splitu. Isti autor (1979a) piše o suvremenoj tehnici pošumljavanja krša. Opisuje pripremu terena, sadnju biljaka, gustoću i prostorno razmještanje biljaka, zatim sjetvu sjemena i neuspjeh sjetve sjemena hrasta crnike i medunca. Preporučuje sjetvu sjemena alepskoga bora i crnoga bora na požarištima.

Matić (1981) istražuje mjesto i ulogu mehanizacije u radovima na proširenoj biološkoj reprodukciji šuma. Navodi da je mehanizacija uvelike našla primjenu i u uzgajanju šuma i da se očekuje da će u pošumljavanju odigrati vrlo značajnu i korisnu ulogu. Daje pregled tadašnje postojeće mehanizacije koja bi bila korisna na pripremi tla za pošumljavanje, u sadnji biljaka i njezi kultura i plantaža.

Matić (1982, 1982a, 1982b, 1982c, 1982d) piše seriju radova o pošumljavanju u časopisu *Priroda*. Opisuje pošumljavanje novih površina kao osnovni preduvjet boljih životnih uvjeta i gospodarskoga napretka te ulogu i značenje šumskih rasadnika pri pošumljavanju novih površina. Zatim nastavlja s opisom pripremnih radovi pri pošumljavanju novih površina, načina pošumljavanja te njege novih šuma podignutih pošumljavanjem.

Matić i Prpić (1983) objavljuju knjigu *Pošumljavanje* u kojoj ističu da je pošumljavanje novih površina osnovni preduvjet boljih životnih prilika i gospodarskoga napretka. Opisuju rasadničarsku proizvodnju sadnica i radove koje treba obaviti prilikom pošumljavanja kontinentalnoga i sredozemnoga dijela Hrvatske uz opis bioloških svojstava i ekoloških zahtjeva glavnih vrsta drveća kojima se na tom prostoru može pošumljavati. Posebna je pažnja posvećena svim radovima koje treba obaviti, od prikupljanja sjemena određene vrste do pošumljavanja nove površine odnosno osnivanja nove kulture.

Matić (1986) objavljuje članak o šumskim kulturama alepskoga bora i njihovoj ulozi u šumarstvu u Sredozemlju. Prema njemu alepski je bor vrsta drveća koja je vrlo pogodna za pošumljavanje degradiranih staništa šuma hrasta crnike. Osnovane kulture imaju pionirsku ulogu. Ističe važnost njege i pomlađivanja pomoću kojih se postiže veća stabilnost i otpornost na biotske i abiotske čimbenike, posebno na požare. Te su kulture neprocjenjive jer pružaju vrijedno i upotrebljivo drvo te općekorisne vrijednosti.

Tomašević (1986) piše o rekultivaciji krških goleti pošumljivanjem. Ističe da se osnivanjem Nadzorništva za pošumljavanje krša u Senju 1878. godine organizirano radi na pošumljavanju i drugim radovima na podizanju i njezi šuma na kršu.

Tomašević (1990) piše o podrivanju kao prvoj fazi pripreme tla za pošumljavanje. Opisuje sadnju pod kramp (zasjek), sadnju u izvrtane jame bušilicom i sadnju na podrivnom tlu riperom. U drugom radu isti autor (1993) piše o piniji kao vrsti za pošumljavanje krša. Zaključuje da se ta vrsta može u nas uspješno uzgajati.

Matić (1994) daje prilog poznavanju broja biljaka i količine sjemena za uspješno pomlađivanje i pošumljavanje. Među ostalim određuje broj biljaka i količinu sjemena po hektaru koje treba saditi ili sijati da bi se dobile kvalitetne sastojine i za vrste drveća hrvatskoga dijela Sredozemlja.

Topić (1997) piše o upotrebljivosti autohtonih listača pri pošumljavanju krša i iznosi rezultate istraživanja uspjeha pošumljavanja s hrastom meduncem, bijelim grabom, crnim jasenom, crnim grabom, rašeljkom, maklenom i koprivićem. Crni grab, crni jasen i bijeli grab pokazuju nešto bolje rezultate u odnosu na ostale istraživane vrste. Te vrste preporučuje kao melioracijski značajne i njihovo miješanje s četinjačama kao pionirskim vrstama (crni bor, primorski bor, atlaski cedar). Pritom naglašava važnost mikrostaništa za uspjeh.

Matić, Anić i Oršanić (1997) objavljuju članak o podizanju, njezi i obnovi šuma kao temeljnom preduvjetu ekološkoga, društvenoga i gospodarskoga napretka Sredozemlja. Ističu da je za ostvarenje stabilnosti, proizvodnosti i pokretanje progresivnih sukcesijskih procesa u sredozemnim šumama potrebno istraživati i poznavati uzgojne postupke u svim uzgojnim oblicima i degradacijskim stadijima. Iznose načela provedbe uzgojnih postupaka, kriterije za planiranje pošumljavanja. Cilj je svake obnove povratak autohtonih klimatogenih vrsta drveća.

Topić (1999) piše o melioracijskim učincima šumskih kultura na kršu u odnosu na pedosferu te ističe da su oni obilježeni kemijskim i fizikalnim promjenama u tlu. Treba istaknuti i biološke promjene. Fosfora ima najviše kod crnoga jasena s većom količinom listinca, a nešto manje pod kulturama hrasta medunca, primorskoga bora, bijeloga graba i atlaskoga cedra, najmanje pod kulturama crnoga bora. Slično je i s kalijem, humusom i ukupnim dušikom. Odnos je između sadržaja humusa, dušika, fosfora i kalija u tlu (A horizont) i šumskoga listinca visoko signifikantan.

Meštrović, Žaja i Đurđević (2000) govore o zaštiti sadnica pri pošumljavanju. Smatraju da je prve radove na pošumljavanju dalmatinskoga krša 1756. godine propisao generalni providur Francesco Grimani. Metode su i načini sadnje pri osnivanju pokusa primijenili prema Matiću i Prpiću (1983). Da se dobije veća prozračnost tla i veća zaliha vode, obavlja se sadnja na obrađeno tlo podrivanjem (Meštrović (1964). Opisuju različite načine zaštite sadnica i tla prilikom pošumljavanja, i to plastičnim folijama, omotačima (lijevak i dr.), kombinacijom prekrivač i omotač.

Matić, Anić i Oršanić (2000) pišu o obnovi, podizanju i njezi šuma na kršu u današnjim ekološkim i gospodarskim prilikama. Ističu da se uloga šuma na kršu u temeljnim postavkama ne razlikuje od uloge šuma u kontinentalnom dijelu. Postoji proporcionalna veza između kvalitetne proizvodnje drva i općekorisnih vrijednosti šuma. Šumarstvo na kršu treba prepoznati stvarne mogućnosti svakoga staništa i sastojine te na temelju njih odrediti način i intenzitet uzgojnih postupaka.

Matić i Topić (2001) sažeto prikazuju rezultate znanstvenoga skupa "Unapređenje poljoprivrede i šumarstva na kršu" te sve referate koji su bili predstavljeni. Iznose zaključke znanstvenoga skupa u 10 točaka, zatim podatke o površini krša hrvatskoga sredozemnoga područja i o površini šuma. Od ukupne površine Hrvatske na sredozemno krško područje otpada 15 389 km^2 ili 27,22 %. Gotovo 60 % površine pokrivaju panjače, šikare, makije, garizi, šibljaci i kamenjare-goleti, dok visoke šume zauzimaju samo 3,7 %.

Matić (2003) piše o šumarstvu u društvenom ozračju danas i 1878. godine. Iznosi da je u prošlosti glede zakonodavstva na našim prostorima bilo dosta aktivnosti u kojma je šuma bila u središtu pozornosti. Spominje statute gotovo svih južnohrvatskih gradova tijekom 13. stoljeća koji sadrže odredbe o čuvanju i zaštiti šuma. U Dalmaciji se 1464. godine utemeljuje šumarska služba pod nazivom Magistrat providure za drvo i šume. U Istri se već 1532. godine osniva šumarska inspekcija, a 1584. godine katastar šuma, prvi poznati u svijetu. Posebno ističe aktualne probleme vezane uz svakodnevno smanjenje površina šuma zbog Zakona o cestama iz 1992. godine te probleme vezane uz aktivnosti Ministarstva zaštite okoliša i prostornoga uređenja na "pasivnoj" zaštiti šuma te inzistiranje na dobiti u šumarstvu uz diktirane cijene, raspodjelu i netržišnu prodaju trupaca.

Prgin (2005) ističe da je alepski bor prvorazredna vrsta za podizanje šuma na sredozemnom kršu. Tvrdi da se u sastojini alepskoga bora tijekom jedne ophodnje bonitet tla povisi za jedan bonitetni razred.

Topić i dr. (2009) iznose rezultate istraživanja utjecaja tipa kontejnera na rast i razvoj sadnica običnoga čempresa u rasadniku i šumskoj kulturi. Skupina se autora u istraživanjima poslužila kontejnerima "Bosnaplast" 12 i 18 te PVC tuljcima 7 x 24 cm. Istraživanjima je utvrđeno da su biljke u kontejnerima s većim obujmom imale bolji rast na terenu te veći postotak preživljavanja.

Iz dosada navedenoga vidljivo je da sredozemne šume nose obilježje glavnih vrsta drveća koje se nalaze u klimatogenim i prijelaznim zajednicama eumediterana i submediterana.

Hrast crnika s alepskim i brucijskim borom glavne su vrste drveća eumediterana, gdje hrast crnika tvori temeljne i stabilne zajednice, prema kojima idu sve prijelazne zajednice, najčešće kulture borova koje podižemo pošumljavanjem krša.

Hrast medunac i crni bor tvore zajednice u submediteranu u kojem šume hrasta medunca imaju ulogu temeljnih i najsta-

bilnijih zajednica prema kojima su usmjereni svi zahvati rekultivacije i uzgajanja prijelaznih sastojina na tom području (Matić 1990).

Hrvatsko sredozemno područje nosi značajno obilježje vrlo rane naseljenosti i intenzivnoga razvoja kulture stanovništva. Pritisci su na šume bili veći svagdje tamo gdje je koncentracija stanovništva bila veća i gdje su formirane veće urbane cjeline. Tijekom dugoga povijesnoga razdoblja, otkada Hrvati naseljavaju ove prostore, bile su vidljive želje i inicijative da se te šume sačuvaju ili da se obešumljeni prostori ponovno privedu šumi. Neki povijesni podaci na to nedvojbeno ukazuju kao što su statuti dalmatinskih i primorskih gradova, mnoge uredbe, zakoni, u novijoj povijesti stručni i znanstveni skupovi, brojni stručni i znanstveni radovi i sl.

Nažalost, do današnjih je dana sve ostalo u željama ili slabo i kratkotrajno organiziranim radovima, koji su najčešće bili prekidani ratovima ili drugim aktivnostima koje su imale cilj zauzimanje ovoga atraktivnoga prirodnoga hrvatskoga područja ili, bolje reći, porobljavanje hrvatskoga naroda na njegovim tisućugodišnjim prostorima.

Sve je navedeno uvjetovalo da od nekad kvalitetnih šuma visokoga uzgojnoga oblika hrasta crnike, medunca i borova danas visoke šume zauzimaju samo 3,7 %, a gotovo 60 % površine pokrivaju panjače, šikare, makije, garizi, šibljaci i kamenjare-goleti na krškom sredozemnom području koje zauzima površinu od 15 389 km^2 ili 27,22 % ukupne površine Hrvatske (Matić i Topić 2001).

PODIZANJE ŠUMA NA GOLOM KRŠU (POŠUMLJAVANJE)

ESTABLISHING FORESTS IN THE KARST REGION (AFFORESTATION)

Svaka šuma nastala prirodnim ili umjetnim putem (pomlađivanjem, regeneracijom ili obnovom) ili sadnjom biljaka na goloj površini (pošumljavanjem), ako se nalazi na odgovarajućem staništu i u zreloj dobi, može se prirodno pomladiti. To znači da prirodnim pomlađivanjem, uz provođenje odgovarajućih zahvata u sastojinskom ambijentu i iz sjemena koje padne s krošanja starih stabala, nastaje nova generacija šuma. Ako je nužno sjeme ili sadnice donositi sa strane, sijati ga ili saditi u sastojinskom ambijentu ili na tlima koja još nisu izgubila svojstva šumskoga tla, tada je riječ o umjetnom pomlađivanju.

Prirodno je pomlađivanje logičan i prirodan slijed normalnoga razvoja svake stabilne i produktivne šume, a rezultat je dugogodišnjega pravilnoga i na znanstvenim osnovama provedenoga gospodarenja šumom. Izostanak je prirodnoga pomlađivanja siguran znak pucanja karike u složenom lancu stabilnoga šumskoga ekosustava ili je posljedica neodgovarajućih i nestručnih gospodarskih zahvata.

Pod pošumljavanjem smatramo ručno ili mehanizirano (umjetno) podizanje šuma sadnjom sadnica ili sjetvom sjemena na golim površinama koje su prija toga duže vrijeme bile bez šume i gdje je tlo izgubilo svojstva šumskoga tla.

Svi radovi koji se odnose na jednostavnu biološku reprodukciju šuma, što znači da pomlađujemo postojeće šume, pripadaju pomlađivanju.

Radovi koji se odnose na proširenu biološku reprodukciju šuma, odnosno radovi na osvajanju šumom novih površina (goli krš, bujadare, vrištine, livade i sl.), nazivaju se pošumljavanje (Matić i Prpić 1983). Radovima na pošumljavanju osnivamo šume koje već prema načinu podizanja i gospodarenja nazivamo šumskim kulturama, intenzivnim kulturama i šumskim plantažama.

Šumske su kulture šume koje su podignute sadnjom biljaka ili sjetvom sjemena bez primjene gnojidbe.

Intenzivne su kulture takve umjetno podignute šume koje su osnovane sadnjom biljaka ili sjetvom/sadnjom sjemena, s tim da se prilikom sadnje i sjetve obavila početna gnojidba tvorničkim ili domaćim gnojivom.

Slika 1. Fotografija Borove drage kraj Sv. Jurja, koju je snimio A. Kauders 1926. god. i I. Nekić 2003. god., zorni su primjer stanja i uspješnih uzgojno-tehničkih radova na pošumljavanju i saniranju nestabilnoga krša

Figure 1 These photos of Borova Draga near Sv. Juraj, taken by A. Kauders in 1926 and I. Nekić in 2003, are excellent examples of the condition and successful silvicultural-technical regeneration and recovery of unstable karst

Šumske plantaže su šume podignute sadnjom biljaka uz primjenu intenzivne agrotehnike i gnojidbe tla u kojima se mogu pored šumskih vrsta drveća u prvih nekoliko godina uzgajati i neke poljoprivredne kulture.

Svaki rad na pošumljavanju vrlo je opsežan i složen te zahtijeva značajna financijska sredstva i puno ljudskoga truda. Šumske kulture, intenzivne kulture i šumske plantaže podignute pošumljavanjem vrijedni su objekti koji će cijelo vrijeme postojanja ispunjavati zadatke za koje su osposobljene (proizvodnja gospodarskih i općekorisnih dobara).

Svako pošumljavanje, po uloženom radu i materijalnim sredstvima, zauzima prvo mjesto u usporedbi s ostalim uzgojnim zahvatima, ali je sve uloženo istodobno nezaobilazno ako se želi gole površine privesti biološkoj proizvodnji. Da bi se ti radovi uspješno obavili, nužno ih je dobro planirati i sustavno izvoditi. U skupinu značajnih radova o kojima ovisi uspjeh pošumljavanja pripadaju sljedeće faze (Matić i Prpić 1983, Matić 1994, 1994a, Matić, Anić i Oršanić 1996):

- odabiranje najprikladnijih površina
- odabir odgovarajućih vrsta drveća
- određivanje načina pošumljavanja
- određivanje razdoblja pošumljavanja
- priprema tla za pošumljavanje
- određivanje prostornoga rasporeda i međusobnoga razmaka biljaka, odnosno broja biljaka i količine sjemena po jedinici površine.

Odabir najprikladnijih površina za pošumljavanje

Selecting the most suitable afforestation areas

Šumske kulture podignute pošumljavanjem na svim područjima, pa tako i u Sredozemlju, trebaju ispunjavati gospodarske i općekorisne funkcije. Proizvodnjom drva u najvećem dijelu ispunjavaju gospodarsku funkciju, a općekorisna su dobra ekološka ili zaštitna, socijalna ili društvena i kombinirana ili socijalno-ekofiziološka (Prpić 2003). Značajno je da između gospodarskih i općekorisnih funkcija postoji čvrsta veza. Šuma koja ima veći prirast odnosno koja više proizvodi drva istodobno više proizvodi općekorisnih dobara. Turistička funkcija šume, unutar općekorisnih funkcija, ima posebno značajno mjesto na Sredozemlju. U novije vrijeme, kad je drvo postalo jednim od značajnih obnovljivih izvora energije, naglo je porasla i gospodarska vrijednost svake šume, pa i šuma u Sredozemlju (Matić, Anić i Oršanić 1996, Matić 2007). To samo može biti dodatni razlog za što veće pošumljavanje i potpuno iskorištavanje proizvedena drva i svih općekorisnih dobara šume.

Pri odabiru površina za pošumljavanje treba se odlučiti na one najkvalitetnije, jer će šume podignute na njima u kraćem vremenu pružati više gospodarskih i općekorisnih dobara. To mora biti temeljni kriterij da bi pošumljavanje bilo uspješnije.

Požari koji pustoše sredozemne šume uglavnom se događaju u blizini značajnih turističkih središta, pa će i površine za pošumljavanje biti odabrane u prvom redu na tim mjestima. Opožarene površine brzo dođu u kritično stanje zbog izloženosti eroziji, nestanku ili smanjenju biološke aktivnosti u tlu te izloženosti ekstremnim ekološkim utjecajima. Brzi i kvalitetni radovi na rekultivaciji tala pošumljavanjem jedini su način ponovnoga i brzoga vraćanja šumskih ekosustava na prostore s kojih su naglo uklonjeni.

Budući da je površinâ uništenih požarom mnogo više od mogućnosti kojima se raspolaže za obavljanje kvalitetnoga pošumljavanja, nužno je odrediti kriterije i prioritete koji će osigurati postizanje najvećih ekoloških, bioloških i gospodarskih učinaka uz racionalno ulaganje sredstava.

Prostorno razdjeljivanje i omeđivanje odabranih površina, određivanje površina i oblika odjela/odsjeka, planiranje, projektiranje i izgradnja pristupnih cesta, prosjeka i protupožarnih prosjeka te utvrđivanje smjera napredovanja pošumljavanja pripadaju skupini radova pri odabiranju površina za pošumljavanje.

Slika 2. Uspješno pošumljena površina – šumska kultura crnoga bora, Šumarija Split, GJ Zelovo

Figure 2 Successfully regenerated area – forest culture of black pine, Forest office Split, MU Zelovo

Slika 3. Još mlada biljka, a već uništena požarom

Figure 3 Very young plant already destroyed by fire

Odabir odgovarajućih vrsta drveća za pošumljavanje

Selecting suitable tree species for afforestation

Odabir vrsta drveća kojima će se osnivati buduća šuma pripada u najodgovornije poslove šumarskoga stručnjaka. Sudbina buduće šume, njezino uspijevanje i koristi koje će dati u posrednom i neposrednom smislu ovise o dobro obavljenom izboru vrsta drveća.

Te vrste moraju imati široku ekološku valenciju, odnosno svojstva pionirskih vrsta drveća, što znači da imaju takva svojstva koja im omogućavaju prilagodbu na ekstremno loša tla i da će tijekom jedne ili eventualno dviju ophodnji stvoriti uvjete za povratak elemenata autohtone klimatogene vegetacije na novostvorena kvalitetna šumska tla (Matić 1986).

Pri definiranju ekoloških cjelina za izbor vrsta drveća u obzir se uzimaju glavne skupine ekoloških čimbenika: klima, geološka podloga i tlo, reljef te utjecaj čovjeka i živoga svijeta uopće na prostor buduće šume. Ti čimbenici djeluju posredno na šumsko drveće. Posebno razmatramo neposredne ekološke čimbenike koji djeluju na šumsko drveće (voda, toplina, svjetlo, kemijski sastav tla i atmosfere, mehanički čimbenici) od kojih je svaki ovisan o svim posrednim ekološkim čimbenicima.

Na temelju navedenih podataka o staništu i određenoga cilja osnivanja buduće šume pristupamo razmatranju ekoloških zahtjeva i bioloških svojstava šumskoga drveća koja su nam, s obzirom na postavljeni cilj, zanimljiva (Matić i Prpić 1983).

Pod ekološkim zahtjevima razumijeva se više nasljednih svojstava određene vrste obilježenih njezinim odnosom prema vodi, svjetlu, temperaturi i tlu.

Biološka svojstva obuhvaćaju drugu skupinu nasljednih svojstava: klijanje sjemena, klijanac, razvoj mlade biljke, razvoj stabalca i stabla tijekom godine i tijekom više godina (jedno i više vegetacijskih razdoblja), oblik korijenske mreže i razvoj korijenja, dnevni ritam razvoja (transpiracija, asimilacija ugljičnoga dioksida i drugi značajni fiziološki procesi), najveće dimenzije koje stablo te vrste može postići, učestalost uroda sjemena, trajanje života vrste i njezina konkurentna sposobnost.

Značajke pojedine vrste drveća vrlo su složen mozaik koji je u trenutku pošumljavanja dio nevidljive građe buduće šume, što dolazi poslije do izražaja u grandioznosti stabala, u njihovim visinama, promjerima i razvijenim krošnjama te općenito u jednoj zapaženoj fizičkoj prisutnosti u prostoru. Za takav razvoj potrebno je da stanište koje je izabrano za pošumljavanje pruža određenoj vrsti, i to upravo prema njezinim zahtjevima, količinu vode, topline i svjetla te takva tla koja omogućuju razvoj njezina korijenskoga sustava i koja pružaju mineralna hraniva koja su prijeko potrebna za njezin razvoj.

Krš obuhvaća širi priobalni jadranski pojas u kojem prevladava sredozemna i polusredozemna klima. Tako smo pojednostavili shvaćanje krškoga područja koje je stvarno puno veće i koje obuhvaća velik dio Hrvatske južno od Karlovca. Taj dio krša, koji se nalazi u području kontinentalne i prijelazne klime, nije ekološki problem pri pošumljavanju kao što je slučaj s priobalnim područjem krša.

Uže krško područje sa sredozemnom i polusredozemnom klimom odlikuje se bezoborinskim ljetom, što otežava ljetno pošumljavanje sadnicama obložena korijenja. U priobalnom krškom području ima oko 300 000 ha koji se vode kao šumska površina u kojoj ili nema šumske vegetacije ili je vrlo devastirana. Na toj je površini tlo degradirano i ima ga malo. U takvim su uvjetima vrlo male mogućnosti zadržavanja vode od zimske, proljetne i jesenske kiše. Zadržavanje vode moguće je u dobro razvijenom ekološkom profilu tla ispod razvijene sredozemne i polusredozemne vegetacije, što je vrlo značajno jer je tu ukupna količina oborina dosta velika. U uvjetima gologa krša bez vegetacije kiša se brzo procijedi kroz poroznu vapnenastu podlogu i nepovratno izgubi za biljni svijet.

Pošumljavanje treba planirati na cijelom krškom području i zbog općekorisnih i zbog gospodarskih razloga. Normalno je da u prvom redu za pošumljavanjem dolaze u obzir veće turističke cjeline i mjesta njihove buduće izgradnje.

U primorskom zaleđu Dalmacije, Hrvatskoga primorja i Istre, na staništima medunčeve šume treba pošumljavati u blizini prometnica, u okolišu akumulacijskih jezera i na mjestima na kojima se pojavljuju bujice i jaki vjetrovi. U turističkom zaleđu treba odabrati medunčeva degradirana staništa s više oborina i dubljim tlom radi osnivanja šumskih kultura koje će stvarati povoljne klimatske uvjete i pridonijeti povećanju količine pitke vode.

Osim posrednih koristi koje daju novopodignute šume vrlo su značajne i neposredne koristi koje pružaju proizvodeći biomasu za industriju i energiju. Sredozemna i polusredozemna klima daje obilje topline koja uvjetuje dosta bujan rast u oborinskom razdoblju.

Od crnogorice koja dolazi u obzir za pošumljavanje sredozemnoga prostora na prvom je mjestu alepski bor (*Pinus halepensis*), potom također pogodan brucijski bor (*Pinus brutia*), zatim crni bor (*Pinus nigra*), primorski bor (*Pinus pinaster*), pinija (*Pinus pinea*), atlaski, libanonski i himalajski cedar (*Cedrus* sp.), obični ili mediteranski čempres (*Cupressus sempervirens*) i arizonski čempres (*Cupressus arizonica*).

Od bjelogoričnoga drveća dolazi u obzir za pošumljavanje ponajprije crni jasen (*Fraxinus ornus*), zatim koprivić (*Celtis australis*), bijeli grab (*Carpinus orientalis*), crni grab (*Ostrya carpinifolia*), rašeljka (*Prunus mahaleb*), rogač (*Ceratonia si-*

Slika 4. Pošumljena površina čempresom (*horizontalis* + *piramidalis*), šumarija Dubrovnik, GJ Topolo

Figure 4 Area regenerated with cypresses, Forest office Dubrovnik, MU Topolo

liqua) i veći broj drveća i poludrveća koji rastu kao pratioci u šumama hrasta crnike i šumama hrasta medunca.

Prema Topićevu (1997) istraživanju hrast medunac, rašeljka, košćela i maklen vrlo slabo rastu i prirašćuju na jako degradiranim krškim terenima i nisu upotrebljivi za njihovo pošumljavanje. Bolji uspjeh na takvim staništima pokazuje crni grab, crni jasen, a u kombinaciji s pionirskim vrstama četinjača (crni bor, primorski bor, atlaski cedar) te se listopadne vrste mogu upotrijebiti pri pošumljavanju krša, ali njihov udio i prostorni raspored u kulturi ovisi o kakvoći i prikladnosti mikrostaništa.

Takvim pošumljavanjem na kršu dobile bi se mješovite šumske kulture četinjača i listača koje ne samo što su stabilnije, otpornije i produktivnije šume nego one stvaraju povoljnije uvjete za brži povratak medunčevih šuma na ta staništa.

Hrast crnika (*Qurcus ilex*), hrast medunac (*Quercus pubescens*), cer (*Quercus cerris*) i suplutnjak (*Quercus pseudosuber*) vrste su koje se ne mogu i ne trebaju saditi na nešumska tla kao što se sade pionirske vrste drveća. One dolaze u obzir za unošenje nakon kultura četinjača koje su nakon pošumljavanja stvorile uvjete u tlu i na tlu za povratak elemenata autohtonih klimatogenih zajednica, koje na ovom području tvore navedene vrste hrasta. Ovdje moramo istaknuti da su hrast crnika i hrast medunac temeljne vrste koje tvore šumske zajednice u eumediteranu i submediteranu, dok su ostale navedene vrste hrasta primiješane u te zajednice prirodno ili umjetno kao pratioci s relativno malim udjelom u omjeru smjese.

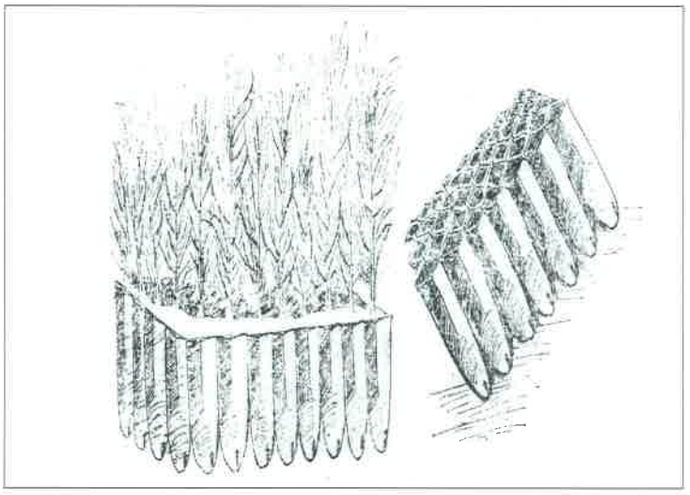
Određivanje načina pošumljavanja – *Selecting afforestation methods*

Šumske kulture osnivaju se na dva načina, sjetvom sjemena i sadnjom sadnica. Za koji ćemo se način pošumljavanja odlučiti, ovisi o biološkim svojstvima i ekološkim zahtjevima vrste drveća koju planiramo saditi, klimatskim prilikama u području pošumljavanja, fizikalnim i kemijskim svojstvima tla, mogućnostima nabave sjemena i sadnica, postavljenom cilju proizvodnje i namjeni osnovanih kultura. S obzirom na to da se površine za pošumljavanje nalaze isključivo u Sredozemlju, preporučuje se uz sadnju i sjetva sjemena uz odgovarajuću pripremu staništa, posebno zbog oborina koje su najčešće u jesen i zimi, a djelomično i u proljeće.

Sade se biljke gola i obložena korijenja. Biljke gola korijenja mogu se saditi isključivo za vrijeme mirovanja vegetacije, dok se biljke obložena korijenja mogu saditi i za vrijeme trajanja vegetacije.

Slika 5. Sadnica brekinje gola korijena
Figure 5 Seedling of wild service tree with well-developed root

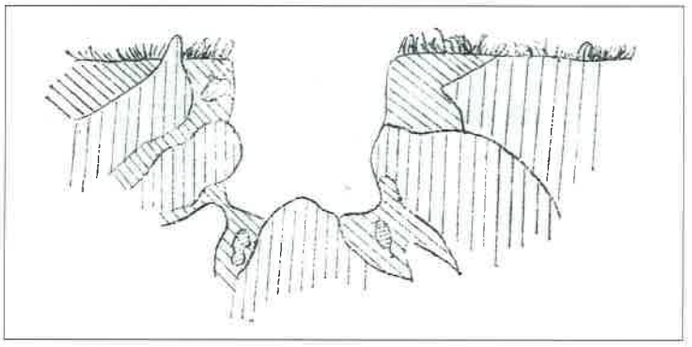
Najstariji i najviše upotrebljavani način sadnje na kršu jest sadnja u jame. Jame su veličine 40 x 40 x 40 cm. Prilikom kopanja jama odvaja se kamen od tla. Ako se pri kopanju naiđe na horizontalno uslojenu ploču, to se mjesto napušta i traži se ono s okomito uslojenim i raspucanim kamenom. Svaka iskopana jama treba biti takva da se u njoj korijen može dobro razvijati i probiti u dublje slojeve. Osim sadnje u iskopane jame moguća je sadnja na tlu podrivanom riperom.



Slika 6. Kontejner za proizvodnju sadnica obložena korijena
Figure 6 Container for the production of containerised seedlings

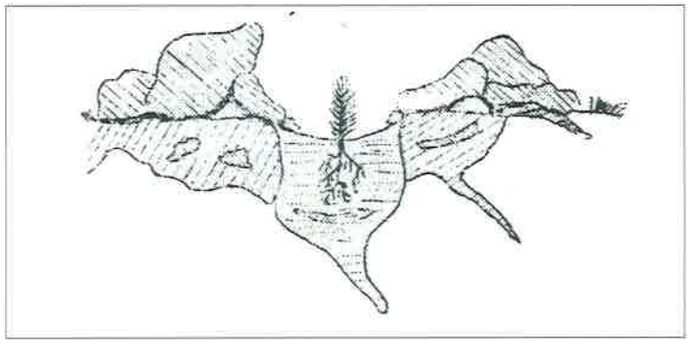
Sadi se uobičajenom tehnikom, s tim da se posebno vodi računa o sprečavanju isušivanja tla i akumulaciji vlage. Kad je biljka posađena, tlo oko biljke mora biti ljevkasto udubljeno da bi se što bolje skupljala kišnica u tlu oko biljke. Površinski sloj mora biti razrahljen i kapilare na površini tla prekinute i razrahljene. Zbijeno tlo ima dosta kapilara kroz koje se isušuje tlo. Zbog toga se tlo oko svake posađene biljke pokrije manjim kamenjem na udaljenosti od oko 15 cm ili slojem sitnijega šljunka.

Kod nekih vrsta drveća (crni bor, alepski bor) dobro je biljku gola korijenja posaditi nešto dublje u tlo nego što je bila



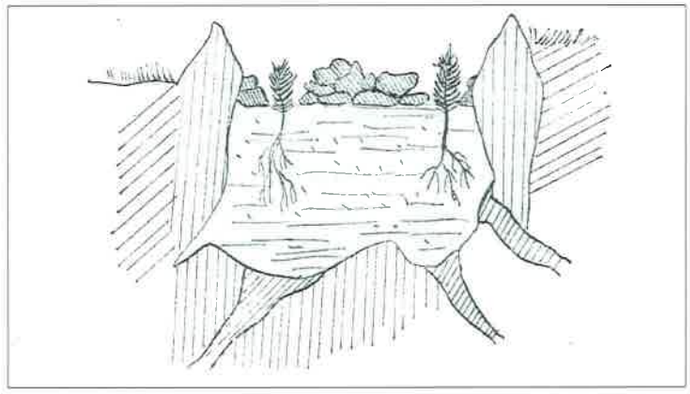
Slika 7. Pravilno iskopana jama za sadnju na kršu
Figure 7 Properly dug planting hole on karst

u rasadniku. Na taj se način smanjuje krošnja zatrpavanjem jednoga dijela iglica u tlu kako bi se uspostavila ravnoteža između krošnjice i smanjenoga korijenskoga sustava.



Slika 8. Zasađena biljka na kršu
Figure 8 Seedling planted on karst

Uzgajajući biljke obložena korijenja u različitim tipovima kontejnera, nužno je imati na umu da su veći kontejneri s većom količinom supstrata u koji sijemo sjeme i uzgajamo biljku povoljniji od manjih kontejnera. Istraživanja su pokazala da je pošumljavanje uspješnije uz upotrebu PVC tuljaca veličine 7 x 24 cm i obujma 923 cm^3 nego u kontejnerima "Bosnaplast" veličine 36 x 22,5 x 12 cm s 55 otvora u bloku i obujma svakoga otvora 120 cm^3 te u kontejnerima veličine 32 x 21,2 x 18 cm s 33 otvora u bloku i obujma svakoga otvora od 220 cm^3 (Topić 2009). Imajući na umu tu činjenicu, smatramo da je bolje u Sredozemlju pošumljavati klasičnim načinom biljkama gola korijenja nego biljkama uzgojenima u manjim kontejnerima.

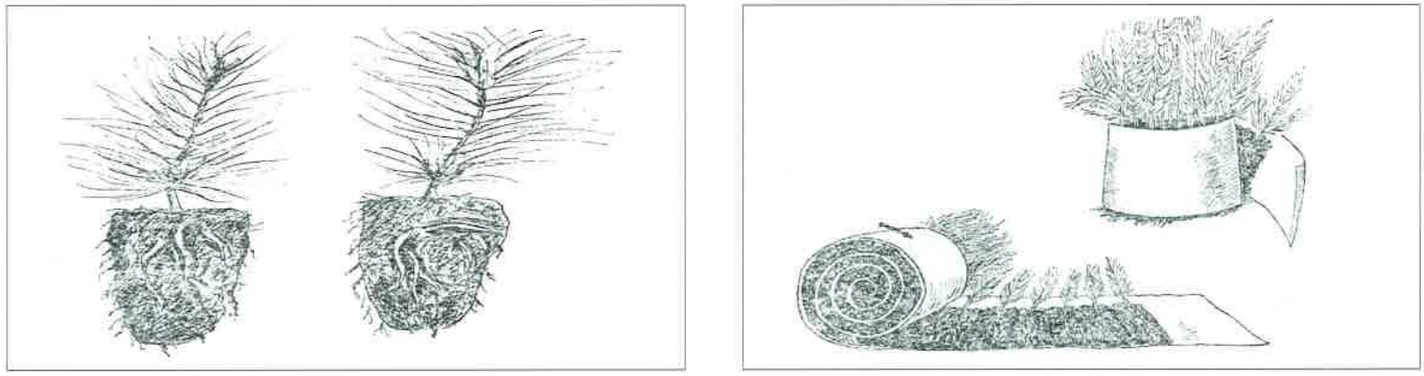


Slika 9. Biljke posađene u veću jamu na kršu i zaštita od prevelikoga isušivanja tla (malčiranje)
Figure 9 Seedlings planted on karst into a larger hole and protection against excessive soil desiccation (mulching)

Sadeći biljke u Sredozemlju moramo se držati svih onih temeljnih postavki o pošumljavanju u tom dijelu Hrvatske, a odnose se na način kopanja jama, podrivanje tla, malčiranje, zaštitu od vjetra, na posolicu, isparavanje i dr.

Dobre su rezultate pokazali radovi na pošumljavanju sjetvom domaćih vrsta bjelogorice (crni jasen, lovor, planika, koprivić, rašeljka i dr.) istodobno sa sadnjom crnogoričnih vrsta drveća. Tako se povećava stabilnost novopodignutih šuma i postupno se vraća autohtona vegetacija na svoje terene.

Pri odlučivanju o načinu pošumljavanja mora se imati na umu i činjenica da je sjetva sjemena jeftinija, a sadnja biljaka učinkovitija.



Slika 10. Sadnice s obloženim korijenom proizvedene u kontejneru (lijevo) i sustavu Nisula roll (desno)
Figure 10 Seedlings produced in the container (left) and in the Nisula system (right)

Slika 11. Sadnja biljaka na kršu u zaklonjene položaje (crteži – slike 6. do 11. – izvor: Matić, Prpić 1983)
Figure 11 Planting seedlings in sheltered positions on karst (Drawings – Figures 6. to 11. – Source: Matić, Prpić 1983)

Određivanje razdoblja pošumljavanja – *Determining the afforestation period*

Biljke gola korijenja sade se za mirovanja vegetacije, što je u Sredozemlju teže odrediti nego na kontinentu gdje temperaturne razlike lako određuju trajanje i prestanak vegetacijskoga razdoblja. Takve se biljke mogu saditi ujesen i proljeće. Opće je pravilo da se sadi u Sredozemlju u jesen i zimi kako bi se iskoristile pogodnosti obilnih oborina i povoljnih temperatura u tlu i iznad tla.

Biljke obložena korijenja (kontejnerske biljke) mogu se saditi tijekom cijele godine, a posebice se preporučuje jesenska, zimska i proljetna sadnja, dok se ljeti može saditi u iznimnim slučajevima, ako su povoljne stanišne prilike na terenu.

Sjetvom sjemena treba pošumljavati u jesen s obzirom na to da će se tijekom jeseni, zime i proljeća na taj način omogućiti klijanje i stabilizacija ponika glede dubljega zakorjenjivanja i veće otpornosti na ljetne suše.

Priprema tla za pošumljavanje – *Preparing the soil for afforestation*

Pripremom tla za pošumljavanje mladoj se biljci stvaraju povoljni uvjeti za rast i razvoj. Tako je biljci olakšana borba s postojećom korovnom vegetacijom i u području korijena i iznad tla. Pripremom tla u tlu se stvaraju povoljni vodno-zračni odnosi, koji omogućuju optimalne biokemijske procese nužne za život biljke. Kako će se i kojim intenzitetom prići pripremi tla, ovisi o stanju tla, metodi pošumljavanja, upotrebi postojeće mehanizacije itd.

U uvjetima opožarenih površina na Sredozemlju priprema će se u većini slučajeva odnositi na sječu i uklanjanje preostalih stabala i grmlja nakon požara i onih stabala i grmlja za koje nismo sigurni da će se uklopiti u novu sastojinu, uništavanje i čišćenje korova i drugoga materijala, potpunu ili djelomičnu obradu tla, posebno riperanje na određene razmake i dubine, nužno ravnanje tla i podizanje ograda radi zaštite podignute kulture od divljači i stoke.

Na nagnutim terenima i tlima na flišnoj podlozi primjenjuje se pošumljavanje na *gradone*. To su zasjeci širine od 70 do 120 cm koji se najčešće rade pomoću mehanizacije, a u smjeru izohipsa na terenu. Zasjek je nagnut prema brdu s nagibom od 30 %. Ako nagibi terena ne dopuštaju kopanje gušćih gradona, onda se svaka 3 m usporedno s gradonom kopaju zasjeci (*gradoncini*) isprekidani s neobrađenim terenom. Između gradona i gradoncina mogu se kopati terase veličine 1 do 2 m^2. Na gradonima, gradoncinima i terasama obrađuje se tlo, kopaju jame, sade biljke ili sije sjeme. Izvođenjem takvih radova omogućuje se bolji rast biljke, sprečava se naglo otjecanje vode, erozija i stvaranje bujica (Matić i Prpić 1983).

Dobra priprema tla često odlučujuće utječe na uspjeh pošumljavanja. Ti se radovi u većini slučajeva moraju obavljati primjenom odgovarajuće mehanizacije, kao što su rotacijski sjekači, grebači tla, čistači za uništavanje travne i korovne vegetacije, motorne pile različitih dimenzija, grederi, riperi, buldožeri, različiti plugovi za potpunu i djelomičnu obradu tla i dr.

Slika 12. Riperač u pripremi tla za pošumljavanje
Figure 12 Ripper preparing the soil for afforestation

Određivanje prostornoga rasporeda i međusobnoga razmaka biljaka, odnosno broja biljaka i količine sjemena po jedinici površine

Spatial distribution and plant distances: determining the number of plants and the quantity of seeds per surface unit

Prilikom pošumljavanja biljke se sade u pravilnom i nepravilnom prostornom rasporedu. Pravilan raspored ima više prednosti pred nepravilnim i primjenjuje se svugdje gdje to uvjeti na terenu dopuštaju (kamenje, panjevi i dr.). Oblici su raznoliki, na primjer pravokutni, četverokutni, trokutni, šesterokutni, s točno određenim razmacima između biljaka i redova. Takva sadnja ima svoje prednosti jer omogućuje jednostavnije njegovanje i gospodarenje u budućnosti. Tamo gdje se zbog uvjeta koji vladaju na tlu ne može primijeniti pravilan raspored, primjenjuje se nepravilan. Nepravilan je raspored biljaka čest na kršu jer se sadnja obavlja samo na mjestima koja imaju dovoljno tla i gdje je moguće iskopati jamu zadovoljavajuće veličine.

Broj biljaka po jedinici površine ili gustoća sadnje određuje međusobni razmak biljaka i redova, a i količina sjemena po jedinici površine. Taj broj i količina ovise o šumskouzgojnim svojstvima svake vrste drveća i o cilju gospodarenja.

Prema Matiću (1994) za alepski, brucijski, primorski i crni bor sjetvom omaške na cijeloj površini utrošit će se 3–5 kg, a sjetvom u brazde i krpe 2–3 kg sjemena po hektaru. Za sadnju

Slika 13. Pravilan raspored sadnje na terenu – strojni iskop sadnih mjesta, šumarija Split, GJ Primorski dolac

Figure 13 Regular distribution of planting in the field, Forest office Split, MU Primorski dolac

Slika 14. Za uspješnu sadnju na kršu potrebno je dovesti plodno tlo

Figure 14 Additional quantities of soil are necessary for successful karst planting

alepskoga, brucijskoga, primorskoga bora, pinije i čempresa trebat će 1000–2000 sadnica po hektaru, za cedrove 700–1200 sadnica po hektaru, a za sadnju crnoga bora 2000–2500 sadnica po hektaru.

Što se tiče broja sadnica i količine sjemena po hektaru, važno je napomenuti da veći broj biljaka po jedinici površine ubrzava stabilizaciju staništa glede stvaranja povoljnih mikroklimatskih uvjeta, kvalitetnijega tla, smanjenja konkurentskoga korova, što uvjetuje bolji i kvalitetniji rast i uspijevanje novopodignute kulture. Zbog toga preporučujemo gornje vrijednosti navedenih količina sjemena i broja biljaka.

Iz sindinamskih procesa u sredozemnim šumama izlaze tri skupine postupaka iz uzgajanja šuma koje treba stalno izvoditi, a to su podizanje šumskih kultura na golom kršu pošumljavanjem, njegovanje šuma te njihova pretvorba u viši uzgojni oblik i obnavljanje šuma prirodnim ili umjetnim načinom.

Pošumljavanje gologa krša prvi je, najvažniji i najteži korak, ali s njim se zaustavlja degradacija gologa krša te se stvaraju uvjeti za povratak stabilnih autohtonih, klimatogenih šuma. Njega i obnova šuma također su značajni koraci u njihovu očuvanju za budućnost.

Šuma je čovjeku uvijek bila čvrst oslonac u vjekovnoj borbi za bolje životne uvjete i opstanak. U vječitoj povezanosti čovjeka sa šumom ona je čovjeku davala sve svoje proizvode, zaštitu i utočište te je služeći mu, konačno, u većini slučajeva i sama nestala.

Danas, kad je šuma sve manje, golih, posebno krških površina sve više, a vode, čistoga zraka, energije i povoljnih uvjeta za kvalitetan život sve manje, zadnji je čas da smišljenom akcijom pošumljavanja počnemo vraćati šume na njihova napuštena staništa i da sebi stvaramo životne uvjete.

AFFORESTATION IN THE CROATIAN MEDITERRANEAN REGION

Slavko Matić, Milan Oršanić, Igor Anić, Damir Drvodelić, Vlado Topić, Stjepan Mikac, Zoran Đurđević

INTRODUCTION

Early settlement, high population density, and cultural and other achievements of human civilisation on the territory of Croatia have had a significant impact on forest decline on the one hand and, as a counterbalance, on the development of professional forestry thought and science on the other. The permanent interaction between man and forest, established from man's earliest times, allows us to observe certain stages of the development of human society in the context of man's attitude to the forest (Matić, 1990). All the ups and downs of economic and social development are defined and determined by man's relationship towards the forest.

In the first stage of the man-forest relationship, which goes far back in the past, the forest was cut down and destroyed chaotically, primarily for the purpose of obtaining fertile forest soil that was indispensable for survival. Wood as a product was less important.

The second stage is characterised by the intensive felling of forests, also for the purpose of obtaining land. However, the emphasis was on timber as an important material for construction, energy and other purposes. The arrival of the Romans in these regions and the construction of fortifications, towns, roads, mines and smelters resulted in the reduction of forested areas. The Romans were followed by other invaders (the Goths, Huns, etc.), who continued to destroy forests. The arrival of the Croats in the 7th century by no means put an end to the destruction.

Although forests are a renewable natural resource capable of natural regeneration, the severe consequences of chaotic felling occurring at that time were reflected in erosion, torrents, floods and other adverse events. This was the period in which there was no organised effort to establish forests through afforestation and regeneration.

The majority of towns in Dalmatia, Primorje and Istria saw the consequences of forest disappearance at a very early stage. In order to rectify the situation, they introduced regulations on forest protection in their statutes, but with little effect.

Fear of chaotic felling and forest disappearance culminated in the early 18th century. This period marks the beginning of the development of forestry science and organised forestry and witnesses the attempt to legally regulate the man-forest relationship. This period is considered the third stage in the historical development of this relationship, which is still continuing. In Croatia, this period was distinguished by the renowned "Forest Order", issued by Maria Theresa in 1769 and written in the Croatian and German languages. Besides legally regulating forest relations and procedures, the "Forest Order" also provided a set of instructions related to the regeneration, tending and management of forests. For this reason it deserves to be considered the first manual on forests and forestry in Croatia. The "Forest Order" was followed by the Law on Forests of 1852, which defines sustainability or sustainable development. This concept had and still has an important role in the management and preservation of forests.

This third stage in the man-forest relationship is characterised by developed scientific thought on the values of the forest and its direct and indirect benefits, and by keen awareness of the negative consequences of forest decline and disappearance. Despite all this, however, forests continued to decline owing to intensive interventions in forest space and to climate changes which, although taking place outside the forest area, indirectly affected their stability and survival.

We are currently entering the fourth stage of the man-forest relationship. Our primary task at this stage is to legally regulate society's attitude towards the forest. The forest should be guarded against those who enjoy its benefits, i.e., from society as a whole, but not from foresters and forest organisations. Catastrophic air, water and soil contamination, climate change, forest fires, floods, erosion, torrents, decreased groundwater levels, hydro-ameliorative treatments which fundamentally change the millennia-old ecological conditions in the forests, the construction of roads, transmission lines, gas pipes, canals, railroads and so on cause rapid forest decline. Yet, foresters who manage forests have no say in these events.

Nowhere is the negative impact of man and his bad habits on forest decline as clearly visible as in the Mediterranean region. This is the main reason for Croatia's part of the Mediterranean Sea, just as in other countries surrounding it, to be largely devoid of forests, and consequently of water and soil. Agricultural production is poor, while extreme climatic conditions, intensive torrential and erosive processes, floods, and similar events make the situation even worse.

A combination of the factors mentioned above and of adverse climatic, edaphic, geomorphological, biotic and other factors has led not only to the disappearance of autochthonous regular stands of a high silvicultural form in the Croatian Mediterranean area, but has also contributed to their conversion into lower, less valuable silvicultural forms (coppice with standards, coppice), or degraded stages (scrub, maquis, shybliak, garrigue, bare karst).

Bare karst is the extreme stage of degradation, particularly of climatogenic forests, which are made up of forests of the following oak species: holm oak (*Quercus ilex* L.), pubescent oak *(Quercus pubescens* Wild.*),* kermes oak (*Quercus coccufera* L.) and Turkey oak (*Quercus cerris* L.). Degradation

processes have also affected forests of pioneer and transitional tree species, in which the dominant role among evergreen species is played by the following pines: Aleppo pine (*Pinus halepensis* Mill.), Turkish pine (*Pinus brutia* Ten.), black pine (*Pinus nigra* J.F. Arnold), maritime pine (*Pinus pinaster* Aiton), stone pine (*Pinus pinea* L.) and by the Mediterranean cypress (*Cupressus sempervirens* L.). Deciduous species include manna ash (*Fraxinus ornus* L.), oriental hornbeam (*Carpinus orientalis* Mill.), hop hornbeam (*Ostrya carpinifolia* Scop.), nettle tree (*Celtis australis* L.), Mahaleb cherry (*Prunus mahaleb* L.), carob tree (*Ceratonia siliqua* L.) and others.

Bare karst generally represents forest areas from which forests have disappeared and in which the soil is degraded. Surface-wise, such areas are dominant in the Croatian Mediterranean basin. They can be re-cultivated either by reforestation with pioneer and transitional tree species or by spontaneous processes of natural vegetation succession.

Viewing the forests in the Croatian Mediterranean from a silvicultural standpoint, it can be concluded that the basic character of the sub-Mediterranean region is provided by pubescent oak and its stands, together with other species of trees, semi-trees, shrubs and ground vegetation occurring in these communities. Black pine, an exceptionally important pioneer tree species that grows on these sites, is irreplaceable in the processes of degraded site re-cultivation, whether by natural succession or afforestation.

The eu-Mediterranean area is characterised by holm oak and its communities. Aleppo pine has a dominant role in the process of re-cultivation of these sites. Other pines, such as Turkish, maritime and stone pine, together with Mediterranean cypress, also play an important role.

Pines are pioneer tree species. They have broad ecological valence (eurivalent species) in terms of the conditions in the soil, in particular of soil humidity. Under a pine stand, the soil gradually takes on characteristics that are conducive to the appearance of the elements of autochthonous vegetation in some of its degraded stages or silvicultural forms. In pine stands, maquis or scrub consisting of elements of autochthonous climatogenic vegetation is usually formed as an understory.

Over time, the pine gradually disappears from the maquis or scrub, while the latter are converted into some silvicultural forms (coppice, coppice with standards, high forest). These processes usually take place in the course of one (60–80 years) to two rotations of pine stands, which again depends on site conditions, and particularly on the degree of soil degradation. If a pine stand is not capable of creating the conditions in the soil for the return of the elements of autochthonous vegetation, the pine can easily be naturally regenerated with shelterwood cuts. Should the elements of autochthonous vegetation appear, it is necessary to undertake regeneration at a certain age of the pine stands. Regeneration is accomplished by natural succession and the introduction of seeds or plants of autochthonous species, most usually oaks, following the principles of natural regeneration.

Intensive negative impacts of biotic and abiotic factors (man, cattle, fires) result in the permanent presence of succession and afforestation processes in the areas of holm and pubescent oak forests. The constantly forming bare karst is usually invaded by pioneer pine species by means of natural succession or afforestation. On their developmental path, these pines generally perish in fires without previously creating the conditions for the return of the elements of autochthonous vegetation. This is a permanent, dynamic process of the progression and regression of forest vegetation in the Croatian Mediterranean region (Matić et al., 1997). Different stages of this process are found across the entire eu-Mediterranean and sub-Mediterranean zone.

In sites in which pines do not occur naturally, or in which they occur sub-spontaneously (the north-western part of the eu-Mediterranean and a larger part of the sub-Mediterranean regions), the process of site degradation must be prevented by means of afforestation with pines and other pioneer and transitional coniferous and deciduous species. This also encourages the process of the progressive succession of forests of holm and pubescent oak. A clear confirmation of this are the areas of forest pine cultures established in the Croatian part of the Mediterranean.

Afforestation is a silvicultural procedure of planting plants or sowing seeds in an area where a forest had previously disappeared. Pioneer and transitional tree species used for this purpose restore to the soil those biological, pedophysical and pedochemical properties which are characteristic of preserved soils formed under the forest. Such a soil will receive climatogenic tree species that grow in the area and allow them to develop until they reach maximal values which these species can achieve in a given site in accordance with their biological properties.

According to the FAO definition of afforestation, an afforested area should be no less than 0.5 ha, the tree crowns should cover a minimum of 10 % of the area, and the total height of adult trees should be over 5 m (Oršanić, 2003).

Stands in the regenerative stage, or stands which have been insufficiently regenerated, are artificially regenerated and restocked by planting plants and sowing or planting seeds.

Afforestation is a basic silvicultural treatment directly aimed at establishing a stand by planting trees or sowing seeds. Among other things, such stands are intended to stop further soil degradation processes and to yield commercial and non-commercial benefits.

Afforestation is followed by an almost hundred-year-long process of tending the newly-established forest. The goal is to form good quality stands in which the elements of climatogenic tree species (holm oak and pubescent oak) are favoured and assisted. These elements begin to occur spontaneously as the site conditions (soil, microclimate) in a forest culture improve.

The last treatment in this long process relates to activities of forest regeneration by natural or artificial means, regardless of whether a pioneer species, or, conditions permitting, a climatogenic tree species is being regenerated. This is a sure sign that a century-long process has been rounded off by afforestation, tending and regeneration and that the forest we have established and tended has been guaranteed productivity and eternity.

FOREST CONDITIONS IN THE PAST PRIOR TO INTENSIVE DEVASTATION

Early settlement in the Croatian Mediterranean and the millennia-long negative impacts of man and other factors are the main reasons for the disappearance of forests or for their conversion into degraded forms, which is usually bare karst. In the past, the Croatian karst was covered with high quality forests, as testified by numerous data.

The process of forest destruction in the Croatian Mediterranean began very early, much earlier than on the European continent, where forested areas were reduced to almost 25 % of their original area between 300 AD and 1300 AD (Androić, 1977).

As early as the 3rd century BC, the Greek writer Apollonius of Rhodes describes the island of Hvar, which he calls "*Pitisia*" (Pinus), i.e. pine grove. The Greek writer Polybius describes the arrival of the Roman fleet on Hvar in 219 BC for the purpose of fighting against the army of the Illyrian Commander Demetrius of Hvar, which was hiding in dense forests (Androić, 1977).

In the words of Grubić (1928), Octavian Augustus established himself in Promona (Promina near Drniš) in 32 BC and attacked the Dalmate tribe by night using the dense forests for protection and hiding. During the persecution of the Dalmate, the Romans burnt down the Synodium (near Muć) and cut down many forests. In a revolt that broke out in Roman Dalmatia 7 years later under the command of Bato Desital, Baton was forced to flee from his last refuge Andertium (today's Muć). His soldiers did not surrender but fled into the hills after a bitter fight. The Romans chased them, found them in the woods and killed most of them.

There is very little data from the period of the Croatian ruling dynasties in the 11th and 13th century, but what little there is confirms that Dalmatia was covered with forests. The crusaders Raymond d'Aguilers and Adhemar du Puy, as well as their contemporary Guillaume Try, who most probably followed the old Roman road Aguileia Seni (Senj) Arupium – Obrovac – Šuplja Crkva (near Knin) towards Constantinople, claimed that Dalmatia of that period was a country rich in forests, rivers and pastures, but poor in arable land.

According to data from *Monumenta historica Slavorum meridionalium I,* a conflict broke out in 1307 between the Dukes of Krk and the municipality of Krk over the felling of forests, which ended in an agreement stipulating that the dukes would not cut down municipal forests.

The Statute of Krk of 1443 states that considerable portions of land in the municipality of Vrbnik were covered with forests. When Venice invaded Krk in 1480, they paid special attention to oaks, primarily with the aim of obtaining timber for their navy. In his report to the Venetian Dodge, the Krk governor August Valerius emphasises the rich forests of Vrbnik.

Later, a travelogue of Ivan Giustinion (*Monumenta historica VIII*) from 1553 mentions that the forests on the island of Krk abounded in very tall and useful trees which were exported to Venice in enormous quantities. The trees were becoming scarce, and if nothing was done the inhabitants of the island would soon run out of timber. This part also mentions some measures intended to regulate cutting, goat pasture, the clearing of stumps and similar actions.

According to Zoričić (2009), in 1480 the Venetians finally got rid of the Frankopans, the Dukes of Krk, by removing Duke Ivan. They put Krk under their direct rule, headed by the *Provveditore* (governor). The governor exploited the estates, forests, vineyards and other areas in the interest of Venice. By order from Venice, oaks were cut down every year to supply timber for building ships, making wine barrels and for fuel. Venice built ships for transporting wine from Krk and other estates in the Mediterranean by extracting timber from the forests on the island of Krk. The ships were specially designed to hold 500 barrels with a capacity of 751 litres.

By the end of the 14th and 15th centuries, the area of Split had become devoid of forests and woods, so construction timber had to be imported from Senj and Velebit. This fact, too, serves to illustrate the frequently mentioned crucial role of Venice in the destruction of forests in the Croatian Mediterranean.

Venice penetrated deeper into the mainland Mediterranean only in 1699, after the Karlovac Peace Treaty was signed. By that time, however, the Croatian karst area had been largely denuded. Yet, regardless of this, Venice continued to destroy forests since it needed timber to build a fleet for strategic reasons, and particularly for defending itself against the Turks. Venice issued special laws in an attempt to stop the destruction of forests with fires, a method the local population employed in order to obtain pastureland. It was at that time that goat pasture was banned in cultivated areas. There were also regulations on planting certain species of trees and fruit trees in the areas given to the population by the state. The renowned Grimani Law of 1765 is an example of this.

After the Austrians arrived in Dalmatia in 1797 following the Campformio Peace Treaty, a law was passed in 1805 regulating the protection of Dalmatian forests. That same year Dalmatia came under French jurisdiction. The French, despite their brief presence in the area, undertook important steps to preserve the old and to establish new forests. In terms of ownership, there were national, private and municipal forests in the occupied territory.

In his report, Napoleon's *Provveditore* (governor) Vicko Dandolo mentions the poor condition of forests in Dalmatia, especially municipal forests. The *Provveditore* undertook a set of measures to preserve and establish new forests with afforestation. He issued a decree ordering the compulsory selection and marking of certain forested areas which would fall under the sole responsibility of towns. These forests were called "holy forests" because nobody was allowed to touch them. They covered an area of about 10,000 ha.

Soon afterwards, a war with Austria broke out, after which Austria entered Dalmatia for the second time in 1813. In general, Austria accepted everything relative to forests that the French had prescribed. During his tour of Dalmatia immediately after the French had left, the Austrian emperor Franz Joseph is said to have expressed regret that the French did not stay a little longer so they could finish what they had started, especially as regards forests and afforestation.

Austria passed several new laws and measures for the preservation and establishment of forests, such as the law relating to the compulsory afforestation of municipalities in 1867, the establishment of forestry commissions and of the forest guard service, forest maintenance, etc. In order to promote afforestation, a campaign was simultaneously launched against keeping goats, of which there were about 400,000 in Dalmatia alone.

About 1,500 ha of forest cultures were successfully established, but there was very little awareness of the need to guard forests among the local population. Forests continued to be destroyed, and the ban on keeping goats, encompassing an area of about 450,000 ha, was ignored.

Yet, there were also improvements in this area: a forest service was established, forest nurseries were founded, and the supply of wood rose, in spite of the fact that the population of Dalmatia had doubled by the end of the 19th century in comparison with the beginning of the century.

According to Poparić (1936), when the fortress of Klis was occupied by the Turks in 1573, the *Uskoci* (Uskoks) moved to Senj. The first neighbours of the free town of Senj were the Turks, at that time the rulers of Krbava and Lika. The dense forests that surrounded and protected Senj at that period prevented the Turks from penetrating towards the sea with their cavalry and infantry.

In 1877, an anonymous writer of "Starine" gives data on the forests around Senj and writes: "There are huge fir forests, as well as oaks, beeches and other trees for shipbuilding and fuel, in sufficient quantities for building the largest war fleet."

Forests provided Senj with the strongest defence against the Turks. In spite of this, however, there were many in Graz and Prague who advocated the cutting down of forests, as this would bring a lot of money into the royal treasury.

In some documents from the 16th century, the forests that surrounded Senj were called "*martological forests*", most probably because Turkish mercenaries were killed there on several occasions by the people of Senj (martologist – mercenary).

Marco Antonio de Dominis (Markantun de Dominis), Bishop of Senj, later Archbishop of Split, and Josip Rabbat, the Austrian commissioner, agreed that the forests of Senj had to be cut down and sold. They believed that this would put an end to the issue of the Uskoks for good. The cutting permit was on the point of being issued in Graz, but there was prevailing concern that the cutting down of forests would weaken the boundary against the Turks. De Dominis later turned to the emperor in Prague to ask for a permit to cut down the Senj forests, but was refused.

This brief overview of historical data on the condition of forests in the Croatian Mediterranean region shows that in the past it was home to excellent forests growing on good quality forest soils. Today, only traces of these forests have remained.

The forests and tree species growing on good quality sites achieved maximal values in terms of height, diameter and growing stock and reflected the biological properties and ecological requirement of each individual tree species.

Centuries-long adverse degradation processes have caused these soils to lose their properties of forest soils. Only by afforesting with certain species and methods can this negative process be reversed in a positive direction.

SCIENTIFIC, SPECIALIST AND OTHER ACTIVITIES AIMED AT PROTECTING AND ESTABLISHING FORESTS ON BARE KARST

According to FAO estimates (1981, 1991), over 4.5 million ha of new forest cultures are established in the world annually, of which 3 million ha are established successfully (Oršanić, 2003). In present times, more than 125 million ha of forests disappear, but only 32 million ha of forests are established in the course of one decade. Although many countries have introduced strict measures aimed at preventing further deforestation, a trend of forest disappearance is still very much present.

In many parts of the world forest cultures established with afforestation are the main source of timber for domestic use, and in some countries also for export. The area of established forest cultures is estimated at 187 million ha, which accounts for only 5 % of the total forest cover on earth. Of tree species, the genus *Pinus sp* with about 20% and the genus *Eucalyptus sp*. with 10 % are prevalent.

According to estimates, the majority of forest cultures have been established in Asia (62%), Europe (17 %), North and Central America (9 %), South America (6 %), Africa (4 %), and Oceania (4 %) (Oršanić, 2003).

Forest cultures currently satisfy 35 % of the need for roundwood. It is estimated that they will satisfy about 44 % of the need by the year 2020. The establishment of new forests with afforestation in suitable ecological zones and the application of the principle of sustainable management will alleviate the pressure on natural forest complexes.

Forest cultures established in New Zealand satisfy 99 % of the need for industrial wood, in Chile about 84 %, and in Brazil 62 %. They also supply non-commercial goods, which, regrettably, receive little appreciation in many countries. Their role in the fight against desert expansion, carbon dioxide absorption, soil and water protection, bare soil re-cultivation, etc., is irreplaceable.

In general, forest cultures provide generally beneficial functions; but they may also have a negative impact on an area if they are planted in unsuitable soils, with unsuitable species and provenances, and if good planning and management is lacking.

It should be stressed that forest cultures are a renewable resource and that they are economically, socially, culturally and environmentally sustainable. Their positive role will come to full expression only if their establishment is carefully planned and if they are tended and regenerated professionally and in a timely manner.

Legal, specialist, scientific and other activities related to forests in the Croatian Mediterranean

Efforts to preserve forests in the Croatian Mediterranean and prevent their disappearance date back to the time of the arrival of the Croats in these areas.

In his citation of the discussion of A. Kauders, Horvat (1957) lists almost all the statutes of maritime towns which contain a ban on timber felling. He mentions the statutes of Korčula from 1214 with later additions, Dubrovnik from 1272, Trogir from 1322, Split, Skradin, Hvar, Vrbnik, Grobnik and others.

Jedlowski (1977) writes that at the conference "Ecological valorisation of the littoral karst" Vrdoljak stressed in his paper that attempts to preserve the forests of maritime karst go far back in the past. He points out that the statutes of Dalmatian and northern Littoral towns from the 13th and 14th centuries prescribed measures of forest protection, such as banning grazing by goats, forbidding lime burning in forests, regulating cutting, etc. Severe punishments were imposed for violating the regulations. The measures were also applied during Venetian rule from the 15th to the 18th centuries, when these forests still represented an important source of raw material for building ships and for improving the city of Venice. All these measures were mainly ineffective, however, due primarily to the non-functioning of the legal state.

According to the written history of the island of Rab, the second greenest island in the Adriatic after Mljet, the Romans erected a fort at the site of the present town in the 2nd century BC, which was later included in the order of Roman *municipia,* in which life inside the fort was organised on the example of Rome (Badurina, 1936–1956).

The *municipium* of Rab had its own statute and its own town magistrates' office. The treasurer was responsible for managing the income of the town. Most of the income needed for the salaries of the Duke and the civil servants came from the rental of municipal forests and pastures (Rauš and Matić, 1984). Municipal forests of that period were carefully guarded. Smaller areas of private and church forests were also formed later on.

Rab was under Venetian rule from 1409 to 1797. The people had servitude rights in municipal forests, but these were increasingly limited as time passed. In 1409, the people of Rab voluntarily gave over to Venice all the forests and pastures into state ownership, under the condition that the state covered the salaries of municipal civil servants. The state took over the forests but did not pay the salaries, so that the people of Rab were forced to buy back their forests from Venice at a price of 3,000 lira per year. The Dodge then ruled that private forests could be cut down every 10 years and municipal forests every 7 years. All tree species could be cut down, except for holm oak, pedunculate oak, wild olive and pear.

In 1442, the forests on Rab were threatened by goats. In order to protect the forests, the Dodge banned the use of all lime kilns fuelled by wood in 1487. Bans on cutting principal tree species were renewed in 1516, 1522 and 1540 (Badurina, 1936-1956). The municipality had to observe the ban and manage its forests according to the prescribed regulations. The tradition of caring for forests resulted in the introduction of forest keepers on Rab from as early as 1892 (Rauš and Matić, 1987).

In spite of the very early settlement of Rab, its high population density, the intensive cultural and social life of the people, and the intensive adverse biotic and abiotic effects on these forests, in many parts of the island they were not degraded, unlike the forests in other parts of the Croatian and European Mediterranean.

To counterbalance the severely deforested and degraded areas, such as Kamenjak, Fruga, Sorinj, etc., there are also ancient, autochthonous, natural, climatogenic forests of holm oak in the forest regions of Kalifront and Dundo, covering a total area of 1,141 ha. These forests have been managed in an organised manner since the very formation of the town of Rab. It is evident that holm oak as the principal tree species has never disappeared from these forests. These forests and the forest of Kalifront, in particular, are currently in progression. Due to good management, the formerly degraded stage of holm oak maquis is being converted into a higher silvicultural form (coppice, coppice with standards, high forest).

The goal of professional and scientifically based forest management is, among other things, to prolong the life of these forests as much as possible by applying high quality tending and regeneration treatments. The planning and management of the forests of Dundo and Kalifront is proof that any kind of organised management, especially in the distant past, even if it was at a low level, is better than none. The preservation of these forests is certainly due to centuries-long management, making them a prime example of good management not only in Croatia and Europe, but also in the world (Matić, 1983).

The first attempts to introduce pines on the island of Rab were recorded in 1862, when the forest advisor Eugen Deimel sent the seeds of the pine *Pinus maritime* collected on the island of Korčula to Rab, where they were sown in the forest areas of Dundo and Kalifront (Rauš and Matić, 1987). The seeds in question were most probably Aleppo pine seeds.

According to Horvat (1957), during Venetian rule in Dalmatia, the *Provveditore generale* Francesco Grimani issued a law in 1756 on the planting of trees in enclosed spaces. However, due to the poorly organised administration, the law was not implemented.

In the words of Vrdoljak (1977), the beginnings of organised afforestation in Dalmatia date to the arrival of the French, especially during the time of the *provveditore* (governor) Vicko Dandolo. In 1806, he ordered 100,000 seedlings from Italy and established a smaller nursery in Nin.

According to Ivančević (2008), the beginnings of a scientific approach to curbing karst degradation in the Croatian Littoral can be dated to the decision of the state government in Zagreb to finance a study by the nature scientist J. Lorenz, which he presented to them in 1860 on the basis of extensive field research activities.

In 1865, the General Assembly of the Austrian Forestry Association recommended that the state should exempt the owners of forested areas from taxes and that it should send experts to these areas with the task of organising and conducting afforestation activities.

The first littoral karst afforestation activities in the municipalities of Grobnik, Hreljin and Vinodol in the County of Rijeka were undertaken in 1873 under the guidance of the forestry expert I. Salzer, who also established a nursery.

With the return of the Austrians to these areas after the French, the destruction of forests further increased. For this reason, the Austro-Hungarian Empire organised a forestry service in the 1890s for state and municipal forests in Dalmatia. This marks the beginning of an organised forestry service in Dalmatia, which has since had its ups and downs in the organisational sense.

In 1878, the "Royal Inspectorate for Karst Afforestation in the Military Border Region – the Inspectorate for Karst and Bare Land Afforestation and Torrent Management" was established in Senj. The Inspectorate achieved the best results in karst afforestation. During its activity of 64 years (1878–1942), ninety-five cultures – forest preserves were established over an area of 10,097 ha. Afforestation was accomplished over 1,738 ha, restocking took place over 1,441 ha and natural regeneration over 7,435 ha. Nurseries with seed extraction plants were established in Sv. Mihovil near Senj, and a nursery was organised in Crikvenica (Ivančević, 2003).

World War One put an end to afforestation activities. Work continued in 1920, resulting in 2,014 ha of afforested areas between 1920 and 1927. It is presumed that about 25,000 ha were afforested during Old Yugoslavia, of which only 3,000 to 4,000 ha were successful. Based on the reports of forestry inspectorates from 1955 (Krpan, 1957), 5,153 ha of forest cultures were established in Dalmatia, 6,115 ha in the Croatian Littoral and 3,540 ha in Istria, totalling 14,808 ha.

After the First World War, at the end of 1921, the Institute for Forest Experiments was founded at the Agronomy-Forestry Faculty in Zagreb (Seletković, 1998). The first session of the Institute was held on 2 April 1922, when the Expert Council was constituted. The first research results were published in the summer of 1925. The Institute's journal *Glasnik za šumske pokuse* (Herald of Forest Experiments), currently published by the Faculty of Forestry of the University of Zagreb, has been coming out ever since. This was the first scientific-research institution dealing with the forestry problems of karst.

The Institute for Forestry and Game Management Research was founded in Zagreb shortly after the Second World War. A special department within the Institute was established dealing with karst terrain amelioration, with a station in Rijeka and a point on Rab (Jedlovski, 1957).

Upon the establishment of the Institute in Zagreb, the Yugoslav Academy of Sciences and Arts (JAZU, today the Croatian Academy of Sciences and Arts) founded the Institute of Experimental Forestry with stations in Trsteno near Dubrovnik, Split and Matulji near Rijeka. The Institute dealt with different issues, ranging from the regression and progression of forest vegetation, planting density on degraded karst, afforestation techniques on Dalmatian bare stone, and methods of cultivating laurel, cork oak, eucalyptus, kermes oak and other species.

The Institute of Karst Afforestation and Amelioration in Split, consisting of five sections, began working in 1948.

More extensive operations were undertaken on karst after the Second World War. These included afforestation and amelioration of degraded forests (scrub, maquis).

With the introduction of a self-financing system after 1956, these operations were reduced to the minimum (Androić, 1977). Between 1945 and 1975, about 25,000 ha were afforested, of which 10,358 ha or 40% were successful. According to Krpan (1957), the area afforested between 1946 and 1956 was inventoried. The following areas and afforestation successes were achieved: Dalmatia – 6,658 ha with 58 % success, Croatian Littoral – 2,125 ha with 61 % success, and Istria – 2,367 ha with 67 % success, totalling 11,150 ha with an average success rate of 62 %.

According to the data from the Forest Management Plan of the Republic of Croatia (2006 – 2015), forest cultures account for 72,000 ha or 3 % of the territory of Croatia. Of this, forest cultures of black, Allepo and maritime pine, which dominate in the Croatian Mediterranean region, cover an area of 22,000 ha (Milković, 2006).

Currently, only about 1,000 ha of forest land is afforested annually in Croatia, which is only symbolic, knowing that there are 300,000 ha of bare forest soil of good quality that need afforesting. In view of the fact that on average about 10,000 ha of forest cultures and different degraded stages of autochthonous forest vegetation in our Mediterranean perishes in fires every year, the data on annual afforestation in relation to needs are even more shocking.

The ever expanding process of karst degradation was identified as a problem in the European forestry world relatively early. The issue of karst afforestation was discussed at the International Forestry Congress in Madrid in 1911. The debate was initiated by the French forester Hicke (Androić, 1977).

A Mediterranean Forestry League was established in Marseilles in 1922 under the name of *Silva Mediterranea*. Academy member Aleksandar Ugrenović, professor at the Faculty of Forestry in Zagreb, cooperated with the League. After World War Two, *Silva Mediterranea* evolved into a FAO statutory body, as a result of which the problem of karst gained international importance. Academician Dušan Klepac, Professor Šime Meštrović and other professors from the Faculty of Forestry in Zagreb were actively involved in the activities of this body.

Following the end of the Second World War, the Croatian forestry profession and other specialist, scientific and scientific-teaching forestry organisations held a number of scientific conferences that addressed the issue of the forests and forestry of the Croatian Mediterranean. We shall mention below only a few.

In 1957, the Council of Croatian Forestry Engineers, the Association of Agricultural Engineers and the Yugoslav Association of Economists organised a Symposium on Karst. The proceedings were published in five volumes.

The JAZU Department of Natural Sciences organised a symposium on nature protection on karst in Zagreb in 1971 and published the proceedings in a special edition.

The Croatian Association of Forestry and Wood Industry Engineers and Technicians organised in 1976 a scientific symposium in Zadar entitled "The Role of Forests and Forest Vegetation in the Protection of the Human Environment in the Adriatic Region". The symposium consisted of introductory papers and six different sections.

The introductory papers were presented in the following order:

- Stanko Tomaševski, B.Sc.: *Raison d'être* and theme of the symposium "The Role of Forests and Forest Vegetation in the Protection of the Human Environment in the Adriatic Region".
- Prof. Milan Androić, Ph.D.: Karst in the past, present and future.
- Prof. Dušan Klepac, Ph.D.: Proposal of a five-year plan (1976 – 1980) of scientific forestry research on karst.
- Žarko Vrdoljak, B.Sc.: The condition and problems of forestry on karst.
- Prof. Zlatko Pavletić, Ph.D: The importance of forest protection in the Adriatic region and its inclusion in the "Man and Biosphere" programme in the Mediterranean area.

Work was organised in the following sections:

1. Political-organisational area. Leader: A. Šobot
2. Ecology. Leader: B. Prpić
3. Silviculture: Leader: S. Matić
4. Beneficial forest functions. Leader: Đ. Rauš
5. Forest protection. Leader: M. Androić
6. Economics and Cadres. Leader: Z. Tomac

In 1987, JAZU (Yugoslav Academy of Sciences and Arts) and the Assembly of the Commune of Rab organised a scientific gathering dealing with the Island of Rab, where the management and purpose of Rab forests in the past, present and future were analysed in detail. The symposium was followed by the published Proceedings (Rauš and Matić, 1987).

In 1987, the University of Zagreb and the Croatian Ecological Society organised a scientific symposium dealing with the Island of Lokrum, where the problem of forests and forestry was highlighted. The Proceedings from the symposium were published by the Croatian Ecological Society in 1979.

In 1995, the Croatian Ecological Society and the National Park of Mljet organised a scientific symposium on the topic "Natural features and social valorisation of the Island of Mljet", where forests as the most important natural phenomenon of the island of Mljet were discussed in depth.

In 2000, the HAZU (Croatian Academy of Sciences and Arts) Scientific Council of Agriculture and Forestry organised a scientific symposium in Split entitled "Improvement of agriculture and forestry on karst". The material was published in the Proceedings of the symposium.

In 2003, the Croatian Forestry Association and the company Hrvatske Šume, d.o.o., Zagreb, organised a scientific symposium on the occasion of the 125th anniversary of the Royal Inspectorate for the Afforestation of Karst in the Military Border Region – the Inspectorate for the Afforestation of Karst, Bare Land, and Torrent Management in Senj. The materials were published in a special issue of Forestry Journal. In 2008, they also organised a scientific professional gathering and a scientific excursion to mark the 100th anniversary of the "Podbadanj" nursery in Crikvanica 1908–2008.

Karst afforestation in scientific and specialised articles published in forestry journals

Efforts concerned with the regeneration and protection of forests in the Croatian Mediterranean have been accompanied by important specialised and scientific articles published in forestry and other scientific magazines and books (the Forestry Journal, the Herald of Forest Experiments, the HAZU Annals of Forestry, and in other academic papers).

The dominant topic throughout the 133 years of the publication of the Forestry Journal has been Croatian karst, a serious forestry and social problem. Although karst has been treated on the pages of all Forestry Journal issues printed to date, it is nevertheless apparent that there has been a hot and cold approach to this problem. When the Forestry Journal first appeared, karst was the central issue of a large number of articles. In the course of time, interest in this problem matter waned, but after 1918 it again took on its hot and cold character, with a relatively large number of articles appearing in the first half of this period. With the approach of the Second World War, interest in solving the karst issue declined, only to rise again after 1945. The number of articles in the field of forestry sciences has always reflected the concrete activities on the terrain. In present times, however, karst afforestation activities, as well as the tending and regeneration of forests in this area, have been reduced to the minimum, as seen by the number of articles published on the pages of our forestry magazines, and particularly in the Forestry Journal (Matić, 1977).

In 1860, the German naturalist Lorenz, arriving in Rijeka for the purpose of investigating karst, wrote extensively on the conditions of karst cultivation and afforestation (Bura, 1957). He was the first naturalist to make a study of plant-geographic, geological, pedological and climatic conditions on the Croatian Littoral. He divided the karst area from Rijeka to Novi Vinodolski into three vegetation zones and determined which tree species should be used for afforestation in each of the zones.

Bogoslav Šulek (1866) wrote a book "On Silviculture and the Use of Forests", in which a major chapter is dedicated to karst afforestation.

The first issue of the Forestry Journal in 1877 features an article by an anonymous author treating cork oak and its properties for "karst afforestation".

One of the first, the greatest and the most valuable works of the time to address the issue of karst and provide solutions for this problem was the work by Wesely, "*Kras Hrvatske krajine i kako da se spasi, za tiem krasko pitanje uploške*" (Karst of the Croatian Military Border and How to Protect It), which came out in instalments in the Forestry Journal in 1877, 1878, and 1879. In his observations, Wesely encompassed the "littoral karst" in the area of the Otočac, Lika and Ogulin regiments. The author attributes the causes of karst devastation not only to the climate but also to negative human impacts. After a detailed description of the causes of devastation, he recommends a complex solution for the karst issue from a biological and social standpoint. In the chapter "Silvicultural treatments on karst" he lists all the different activities, ranging from the forest nursery to afforestation in the field. His 23 recommendations were so expert that they would deserve full recognition by today's critics.

Grobničko Polje has always been a problem which practising foresters have attempted to solve *in situ*. They used the Forestry Journal as a medium through which they informed the forestry public of their activities. Thus, Ćelija (1879) writes on afforestation activities in Grobničko Polje, Majnarić (1891) provides historical data on the devastation of Grobnik, and Ettinger (1897) writes on the achievements of afforestation in Grobničko Polje and gives recommendations for success.

In order to highlight the problem of karst and give it the importance it deserves, members of the Austrian Forestry Association, in cooperation with the Croatian-Slavonian and Kranjska-Primorje Forestry Association, held their 12th Conference in the area of "*the Austrian littoral and Croatia*", with stations in Divača, Rijeka and Senj. The Forestry Journal (1879) gave a detailed report and published specialist papers delivered at the Conference.

In his debate "On Karst Afforestation", Nanicini (1881) proposes sending Croatian experts to France so that they could gain experience on karst afforestation and implement it at home. He emphasises that the forestry profession is one of the main professions for the "*advancement of material progress*", and as such should be supported by the state.

An anonymous author (1881) describes the production of planting material in earthen pots and points out good afforestation results with these seedlings. This could be regarded as the first attempt at nursery production of containerised balled-root seedlings in our region.

In his work "The future of karst", Guttenberg (1881) particularly stresses grazing as the number one problem and insists on a law where responsibility would be given for karst afforestation.

Crnković (1882) writes about forestry in Istria and points out that it was the Croats who had devastated the forests of this area and not the Venetians, as popularly believed. He divides Istria and Dalmatia into three belts, and proposes tree species for the afforestation of each of them. He also writes about the establishment of mixed stands for better resistance against insects.

Several issues of the Forestry Journal, including those published in 1882, 1883, 1884, 1885, 1886, 1888, 1904, 1907 and 1912, were dedicated to the forestry of Dalmatia. The articles treated afforestation, forestry personnel in Dalmatia, torrent management, the condition of forest preserves, the assessment of the development of forestry for the current year, the goat issue, advocating forestry, drafts of afforestation and forest protection laws, etc.

This period is characterised by articles, such as the one from 1882, where the author cites all the activities undertaken in Dalmatia for that year and concludes that "there was good progress in Dalmatia in 1882 as far as forestry was concerned". Zickmanovsky (1880) also writes that the State Cultural Fund allocates money for afforestation in Dalmatia and that the forestry of Dalmatia is visibly progressing.

Prestini (1885) gives foreigners' opinions on Croatian karst. There is a general view that a ban on devastation guarantees the success of afforestation. He points out that during the times of the poet Glaudian, Dalmatia was called "the land of forests", and that Ragusa was named Dubrovnik after oak forests (*dub* = oak).

As early as 1885, an anonymous author in his writings on forestry in Dalmatia stresses the acute problem of goats and asks whether the time had come for Dalmatia to convert from cattle breeding to agriculture and industry.

In his proposal related to afforesting the Bakar surroundings, Hirc (1885) mentions that there were beautiful forests on the eastern side of Velebit in the 16th century. During the times of Emperor Augustus, the forests in Primorje were so dense that the whole of Italy was supplied with pigs raised in these areas.

Malbohan (1885) of Senj published "Afforestation of Croatian Karst", parts of which were printed in the Forestry Journal. He talks about the silvicultural treatments necessary to regenerate karst, erecting fences, cutting down shrubs with secateurs, planting two-year-old conifers and one-year-old deciduous species, as well as about altitudinal zones in which suitable tree species can be planted.

From the work "*Zagajimo*" (Let's Afforest), written in 1888 by a Dalmatian forester with the initials F.Z., we learn that 10,000 containerised seedlings of Aleppo pine, black pine and stone pine were raised in Sinj, and that the results of afforestation were already visible on the island of Hvar.

"*Kod učitelja se mora djelovati tako da kroz nastavu kod djece razvijaju ljubav prema šumi*" ("Teachers should instil in children the love of forests from the earliest age") writes Ilijić (1889) who gives a number of recommendations for karst afforestation and pasture management in the Otočac municipality.

At that time, M. Bona often describes activities related to karst afforestation in the area of Crikvenica and the rest of the Croatian Littoral. Thus, the Forestry Journal of 1889 reports that 95,000 plants were planted at that time in the area.

Kramer (1889) writes a discussion "Is it possible to cover karst with forests" and points out that afforestation should be concentrated on soil-rich areas. Where there is no soil, no forests can be raised. That same year, M. R. replies by saying: "It is possible to afforest karst," adding that every forester knows of thousands of such examples, of which the geologist Kramer is not aware.

In 1889, M. von B. warns of the "threat of fires to forest preserves of black pine caused by passing trains. The main culprit is the coal which the railways have started using recently." He demands that the railway authority undertake protection measures.

It was only after the establishment of the Inspectorate for Karst Afforestation in Senj in 1878 that more extensive afforestation activities were launched in this region, writes Malbohan (1892). He describes the work involved in karst afforestation and insists that a law be written on karst afforestation similar to that in the Kranj region and Istria.

Bona (1892) writes "On Afforesting the Croatian-Littoral Karst Region" and divides the area into three climatic and vegetation belts: the belt of olive trees, the belt of oak and ash, and the belt of beech, fir and spruce. He lists tree species to be used for afforestation in each of the belts. He specifically points out that a strict ban on grazing is the simplest and the best karst afforestation method.

After the establishment of the special Inspectorate for Karst Afforestation in Senj in 1878, the Forestry Journal often featured annual reports dealing with the work and activities of the Inspectorate, as for example in 1896 and 1897.

Well-known seaside resorts (Crikvenica, Novi Vinodolski, Kraljevica) were the most intensely afforested areas, writes J.P. in 1901, describing a study trip of the Royal Forestry Academy of Zagreb into the Croatian Littoral region. The foresters hope that the blossoming of these resorts will indirectly accelerate karst afforestation activities.

F.Z.K. (1901) points out that the issue of karst afforestation has been treated in all specialised journals of Austria. However, this issue has been solved now, and the only remaining problem is time and money. Still, new afforestation actions remain the most important and the most interesting task. According to the same author, a successful culture is only the culture where about 80 % of the plants have survived after repeated restocking. After restocking with conifers, autochthonous deciduous tree species begin to sprout in the same area.

An unknown author wonders in 1902: "Will our forests be fertilised with artificial fertilisers?" He gives the example of Denmark, where felling areas on poor soils have been fertilised for some time.

The book "The History of Austrian Forestry from 1848 to 1898" marked the 50th anniversary of Franz Joseph's rule. This book, issued in two parts, deals with industry, the use of forests, silviculture and karst afforestation.

Guttenberg (1881) writes about karst afforestation in his attempt to define karst and all of its phenomena. He divides karst into climatic zones and lists tree and shrub species occurring in each of them. He attributes the disappearance of forests to ownership conditions and claims that forests owned by the state and large owners have survived while municipal forests have disappeared. Felling, goats, sheep and fires are only some of the causes of forest decline. The existing forests were protected by the state forest law of 1852, but afforestation of bare areas was not mentioned. The first steps towards solving this problem were made by Trieste, when it launched afforestation campaigns (initial afforestation attempts with deciduous species were unsuccessful, but later afforestation with black pine proved successful). In 1880, afforestation gained momentum and pastureland was reduced, but this provoked resistance by the local population. Between 1882 and 1887, special afforestation laws were issued and commissions for different parts of the Austro-Hungarian Empire were established. Due to the high costs, these measures were not intended for Dalmatia, but the remains of oak forests there could later develop into beautiful forests anyway. In 1873, a law was passed banning the sale of roots and goat breeding on the land intended for afforestation. The law of 1876 determined the land suitable for cultures and excluded a part of the land for afforestation. Afforestation involved enclosing the land with drywalls, banning grazing, planting and sowing, etc. Lands to be afforested were entered into land registers and were supervised by the District. In this way, 155,000 ha of the land was set aside for afforestation, while goat grazing was banned over 455,000 ha.

Kosović (1909) writes extensively about the origin of karst in the Lika-Krbava and Modruš-Rijeka counties, and about its present condition. In 1910, the same author published a paper "The Cultivation of Croatian Karst", where he discusses the origin of karst in detail.

Petrović (1910) writes on the necessity of issuing a law on karst afforestation and mentions that pine is a transitional species and that it has a permanent function only on mountain peaks. Pine cultures should be followed by autochthonous vegetation and only then will karst afforestation be final. He mentions that Trieste passed a law on karst afforestation in 1881, Gorica in 1886, Kranjska in 1885 and Istria in 1881. Initially referring to Istria, the law later embraced the Kvarner region. The intention of the law in Croatia was to regulate karst afforestation and pasture management. At the end of his discussion, Petrović proposes the introduction of a course on karst afforestation and cultivation at the Forestry Academy.

Kauders (1912) discusses the dependence of height increment in black pine cultures on karst and precipitation quantities in July and August of the previous year. The same author writes in 1914 on karst afforestation in the forest region of Crikvenica and points out that afforestation will only be successful if managed by the state. In a paper published in 1915 he says that there are written documents from 1813 which list forest areas in which grazing by goats is banned.

Marčić (1914) writes about the olive and its distribution in the forests on the eastern Adriatic coast and also deals with olive planting and cultivation in the area.

Petračić (1913) wrote an article on the occasion of the 25th anniversary of karst afforestation in Kranjska, that is, in the Postojna district. He points out that 2,910 ha had been afforested by the end of 1910. He describes afforestation methods and cites experiences with black pine, which, according to Petračić, has a permanent and transitional task.

In the first issues after World War One, the Forestry Journal makes a note of Professor A. Petračić's lecture entitled "Our karst and its afforestation", held at the People's University in 1922.

One year later, readers of the Forestry Journal learn that the nurseries in Crikvenica and Senj were donating 200,000 seedlings, and that priority would be given to those planting the seedlings on karst.

In his article "Organisation of work on karst and bare land afforestation", Balen (1925) points out that "the afforestation, or, better said, the cultivation of karst, will be undertaken on a larger scale and at a faster pace only if the idea of karst afforestation turns into a social movement of a sort". He recommends the following: "1) Getting to know the site; 2) Making a plan of karst afforestation; 3) Based on the plan – conducting afforestation activities in the field". In the same article he mentions that 12,000 acres of cultures were afforested during the activity of the Inspectorate for Karst Afforestation from 1878–1892. He proposes the establishment of an Afforestation Inspectorate.

In two articles from 1927, J. Balen discusses the classification of bare karst for afforestation, and resurrection felling as a means of establishing forests on karst. In the same year he wrote another article, in which he talks about karst afforestation with sowing. He points out that afforestation by sowing seeds was undertaken near Trieste in 1843.

Balen (1928) writes on climatic factors on karst and gives a survey of the species to be used for karst afforestation. He also provides a map of vegetation zones and site conditions on karst. In 1929, in his paper "Karst Afforestation Techniques", he recommends resurrection cuts wherever there are traces of forests. In the maquis zone he recommends "Aleppo pine and maritime pine, and stone pine for the warmest sites".

Balen (1931) wrote a 311-page capital work "Our Bare Karst". He treats ecological conditions and karst afforestation. He discusses the following topics: climate, edaphic conditions, vegetation characteristics, the problem of karst, the problem of soil, the forest as a source of production, afforestation techniques, opinions of different authors, afforestation terrains, stand conversion, stand protection, problems related to afforestation (areas), important karst-related legal regulations, the task of scientific work on karst, and historical observations.

Balen (1931) mentions that the first afforestation campaign in the area of Trieste in 1843 was not successful (black pine, Scots pine, chestnut, false acacia). A renewed attempt undertaken by J. Koller in 1859 was successful and gradually expanded into the territory of Croatia.

Kauders (1933) published an article in the Forestry Journal entitled "Distribution of forests and silviculture in the area of the littoral karst of Savska Banovina", pointing out the ecological factors of karst and their impact on afforestation.

Wessely (1935) produced an article intended to inform the public about the broader issue of karst. He describes the soil, vegetation, pastures, the flora, the cadastre, grazing, tree species, sowing, planting and planting methods, and recommends deciduous species which, in his opinion, are as successful as evergreen ones. He also mentions restocking. While writing the article, the author, in his own words, drew on the material from the book by Holl, F., 1902: *Die Karstaufforstung*, Sarajevo.

Beltram (1935) writes about karst and its afforestation. He describes the formation of karst, protection measures for scrub and bare land, artificial afforestation (the example of the French Lands and Southern Serbia), and measures for the afforestation of maritime karst. He stresses that karst afforestation should take on the form of a spontaneous national movement based on education and in no way on orders or enforcement.

In 1939 and 1940 Oraš wrote two papers that treated "The problem of karst afforestation in Dalmatia". He discusses the problem of the local population on karst, their interest in afforestation and the issue of ownership relations. He demands that a law be passed on the allocation of municipal and rural pastureland in Dalmatia. He finishes by writing about the organisation of work related to afforestation, and describes planting and sowing techniques.

Shortly after the end of the war, Beltram (1946) claims that afforestation is not the only problem of karst; rather, it is a complex problem that involves personnel, the agrarian reform, colonisation, goats, etc. After treating the choice of tree species for afforestation, working techniques on karst, resurrection felling and pasture amelioration, the author gives guidelines for future forestry work on karst.

In the first post-war issue, the editorial board of the Forestry Journal pays particular attention to the problem of karst. After the establishment of the Karst Institute in 1948, it published a "Questionnaire on the problem of karst". The public questionnaire, among other things, deals with the activity of the newly-established Institute for Karst.

During that period, very few pages of specialised forestry literature, including the Forestry Journal, were devoted to maquis and its conversion into a higher silvicultural form. For this reason, a work by Marinković (1950) dealing with devastated maquis and giving recommendations for its amelioration was more than welcome.

August Horvat frequently contributed to the Forestry Journal with his articles treating the problem of Croatian karst. In 1951, he wrote about the density of planting on karst, suggesting that 6,500 Aleppo pine seedlings be planted per ha. That same year he dealt with some immediate tasks of research on degraded karst, and made a picturesque presentation of some problems related to karst afforestation techniques. He advocates research into separate sowing and planting methods, planting periods, planting and sowing techniques, the causes of seedling mortality, the suitable time for introducing other species into the existing cultures, etc. In 1954, he wrote about the results of a five-year afforestation plan. On this occasion, he makes critical remarks on the success of afforestation achieved by workers who were not supervised by experts. "By planting Christ's thorn 2–3 years prior to afforestation, we ensure good protection for the seedlings," claims Horvat (1958). In 1964, he wrote about karst afforestation by sowing. The Forestry Journal of 1961 published Horvat's description of different afforestation methods and his conclusion that after the war the afforestation technique had improved due to the slightly enlarged dimensions of planting holes.

Giperborejski (1952) describes tree species to be used for karst afforestation and, in addition to black pine, Aleppo pine and cypress, he lists the species that could succeed in different parts of Dalmatia, such as the Himalayan cedar, false acacia, linden, elm, nettle tree, walnut, almond, hazel, tree of heaven and sumac. For each of these species he highlights the characteristics that make it suitable for a given area.

Marinković (1956) believes that it is better to undertake afforestation with Aleppo pine and cypress seedlings in a group mixture.

During that period, Piškorić contributed two articles: in 1960 and 1963. In the first article he attempts to prove the profitability of cultivating Douglas fir, cedar, and Greek and Andalusian fir on karst, and in the second he describes the dynamics of the height increment of holm oak shoots, all for the purpose of karst afforestation.

Simunović (1957) describes afforestation on terraces and highlights the advantages of this afforestation method, such as good quality soil preparation on terraces. He favours autumn planting, as well as the group planting of conifers into notches with 3–5 seedlings of Aleppo pine and 2 seedlings of cypress. He mentions the results of this afforestation method on Srđ above Dubrovnik, among others.

Meštrović (1964) writes on the application of mechanical soil preparation for the purpose of afforestation in the Mediterranean region.

Vidaković (1972) writes about new attitudes towards afforesting degraded karst and producing suitable hybrids for karst. Prijić (1973) describes the results of work and the difficulties a forester encounters during karst afforestation in new conditions. He specifically mentions the problem of insufficient financial means.

Articles providing historical data concerning karst afforestation in Croatia were written by Vajda (1955), Marčić (1956) and Kauders (1963).

Šafar (1957) discusses the amelioration of degraded coppices. He gives this activity priority over bare karst afforestation.

Sarajlić (1961) writes about the afforestation of continental karst terrains which are, among other things, exposed to extreme ecological conditions. Šafar (1964) considers poplars to be the means for the more rapid formation of tourist forests in the Mediterranean area.

Horvat (1965) writes an article on scrub amelioration in the sub-Mediterranean karst area. He claims that scrub amelioration opens the way for the more rapid development of tourism. The cultures established on karst about 100 years ago had, according to Horvat, a transitional role; this fact is, however, being gradually neglected. In today's conditions, cultures on karst are very important for different purposes, such as camping, resin collection and pulpwood.

Matić (1976) writes about the impact of pine cultures on the succession of autochthonous vegetation on holm oak sites. He stresses that afforestation of devastated holm oak sites with pine seeds and seedlings, as well as tending the newly established conifer cultures, represents only one stage in the long-lasting and tortuous work of restoring these areas to their original state, that is, into forests of holm oak.

Tomašević (1977) writes about the results of comparative research into the success of Aleppo pine cultures on the parent material of limestone and flysch within the natural distribution range. He concludes that flysch substrate is more favourable than limestone.

According to Tomašević (1979), Venice advocated the planting of forests in enclosed spaces through the Grimaldi Law of 1756. The municipality of the town of Trieste launched afforestation campaigns as early as 1843, but without much success. Success was achieved by Josip Koller only in 1859, when afforestation expanded into Croatian regions as well.

Piškorić (1979) writes about a symposium held in Rijeka and Senj in 1879. He mentions that some experts recommended afforestation by planting manna ash and tree of heaven. He points out that in 1886 a law was passed on karst afforestation in Istria. Based on this law, 6,500 ha of karst were afforested in Istria and beyond by 1906. The Institute for Karst Afforestation and Amelioration was founded in Split in 1947. That same year two separate institutions were also established in Rijeka and Split: the Afforestation Administration, and the Torrent Management Administration. In 1948, a Secondary Forestry School for Karst was opened in Split. The above author writes in 1971a about modern karst afforestation techniques. He describes activities on site preparation, planting seedlings, plant density and spatial distribution. He writes about seed sowing and the failure of sowing seeds of holm and pubescent oak. He recommends the seed of Aleppo pine and black pine. He also recommends sowing on burnt areas.

Matić (1981) discuses the place and role of mechanisation in activities related to the expanded biological reproduction of forests. In his view, mechanisation has been well accepted in silviculture and will, consequently, play a crucial role in afforestation campaigns. He lists all the available mechanisation of that time which would be useful in preparing the soil for afforestation, planting plants and tending cultures and plantations.

Matić (1982, 1982a, 1982b, 1982c, 1982d) writes a series of articles on afforestation for the journal "Nature". He claims that the afforestation of new areas is the basic prerequisite for better life conditions and economic progress. He also highlights the role and importance of forest nurseries in afforesting new areas. He goes on to describe preparatory activities in afforesting new areas, afforestation methods and the tending of new forests established by afforestation.

Matić and Prpić (1983) wrote a book under the title "Afforestation", where they point out that the afforestation of new areas is the basic condition for ensuring better life conditions and economic progress. They describe the nursery production of plant material and the activities to be undertaken for the purpose of afforesting the continental and Mediterranean part of Croatia. They describe the biological properties and ecological requirements of principal tree species which can be used to afforest this area. Special attention is paid to all the stages of work, ranging from selecting the seeds of a particular species to afforesting a new area, i.e. establishing a new culture.

Matić (1986) writes about the forest cultures of Aleppo pine and their role in Mediterranean forestry. In his opinion, Aleppo pine is a tree species that is particularly suitable for afforesting degraded sites of holm oak forests. The established cultures have a pioneer role. He stresses the importance of tending and regeneration activities, whose purpose is to ensure higher stability and resistance to biotic and abiotic factors, fires in particular. The priceless importance of these cultures is reflected in their supply of both wood mass and non-commercial forest functions.

Tomašević (1986) addresses the issue of recultivating bare karst with afforestation. He points out that the establishment of the Inspectorate for Karst Afforestation in Senj in 1878 marked the beginnings of organised afforestation activities and other activities related to the establishment and tending of forests on karst.

Tomašević (1990) writes about ripping as the first stage of preparing the soil for afforestation. He describes slit planting, planting into drilled holes, and planting in soil ripped with a ripper. This author (1993) writes about stone pine as a species suitable for karst afforestation. He concludes that this species can be successfully raised in our regions.

Matić (1994) contributes to knowledge of the number of plants and quantities of seed needed for good quality regeneration and afforestation. Among other things, he lists the number of plants and the quantity of seeds per hectare to be planted or sown in order to obtain good quality stands with tree species suitable for the Croatian Mediterranean.

Topić (1997) writes about the usability of autochthonous broadleaves for karst afforestation and gives the results of research into afforestation success with pubescent oak, oriental hornbeam, manna ash, hop hornbeam, Mahaleb cherry, field maple and nettle tree. Hop hornbeam, manna ash and oriental hornbeam show slightly better results in relation to the other studied tree species. He recommends these as very important ameliorative species. He stresses the importance of the micro site for success and recommends combining these species with conifers as pioneer species (black pine, maritime pine, Atlas cedar).

Matić, Anić and Oršanić (1997) write about the establishment, tending and regeneration of forests as the basic prerequisite for the ecological, social and economic development of the Mediterranean. In their view, to initiate and to achieve the stability and productivity of progressive successive processes in Mediterranean forests, it is necessary to investigate and learn about silvicultural treatments in all silvicultural forms and degraded stages. They provide the principles of silvicultural treatments and present the criteria for afforestation planning. Every regeneration attempt should have as its basic goal the return of autochthonous climatogenic tree species.

Topić (1999) writes about the ameliorative effects of forest cultures on karst in relation to the pedosphere and stresses that they are affected by the chemical and physical changes in the soil. Biological changes should also be pointed out. Quantities of phosphorus range from the highest in the forests of manna ash with a larger quantity of leaf litter, to lower quantities in cultures under pubescent oak, maritime pine, oriental hornbeam and Atlas cedar, to the lowest in cultures of black pine. Potassium, humus and total nitrogen follow a similar pattern. The correlation between the humus, nitrogen, phosphorus and potassium content in the soil (A horizon) and forest leaf litter is highly significant.

Meštrović, Žaja and Đurđević (2000) write about the protection of seedlings for afforestation. In their opinion, the first activities related to Dalmatian karst afforestation are those prescribed in 1756 by the general *provvedore* Francesco Grimmani. In their experiment, they applied planting methods according to Matić and Prpić (1983). In order to obtain better soil aeration and higher water supply, planting is done in soil prepared by ripping (Meštrović, 1964). They describe different methods of seedling and soil protection during afforestation, ranging from plastic folios, wrappers, the combination of a cover and a wrapper, etc.

Matić, Anić and Oršanić (2000) write about the regeneration, establishment and tending of forests on karst in today's ecological and economic conditions. They stress that the role of forests on karst does not differ essentially from the role of forests in the continental part. There is a proportionate relationship between the good quality production of wood mass and the forest values of general benefit. Forestry on karst should recognise the concrete possibilities of every site and stand, and should select the method and intensity of silvicultural treatments accordingly.

Matić and Topić (2001) present in brief the results of the scientific symposium "The improvement of agriculture and forestry on karst" and of all the presented papers. They bring together the conclusions of the scientific symposium in ten points. They particularly highlight the data on the surface area of karst in the Croatian Mediterranean and the data on the surface area under forests. Of the total area of Croatia, Mediterranean karst accounts for 15,389 km^2 or 27.22%. Almost 60 % of the area is covered by coppices, scrub, maquis, garrigues, shybliak and bare stone, while only 3.7% is covered with high forests.

Matić (2003) compares forestry in the social environment of today and in 1878. In terms of legal activities, there was keener focus on forests in the past. He mentions the statutes of almost all the south Croatian towns during the 13th century which contain regulations on guarding and protecting forests. A forestry service was established in Dalmatia in 1464 under the name "*Magistrat providure za drvo i šume*". As early as 1532, a forestry inspection was founded in Istria, and in 1584 a forest cadastre, the first known in the world, was established. He specially points out the current decrease in forest areas related to the Roads Act of 1992, problems related to the activities of the Ministry of Environmental Protection and Spatial Management on the "passive" protection of forests, as well as the insistence on profit in forestry at arranged prices, distribution and the private sale of logs.

Prgin (2005) stresses Aleppo pine as a first-class species for establishing forests on the Mediterranean karst. He claims that in the course of one rotation, site quality in a stand of Aleppo pine increases by one site quality class.

Topić et al. (2009) present the results of research into the effects of the container type on the growth and development of Mediterranean cypress seedlings in the nursery and in forest cultures. In their research, a group of authors used Bosnaplast 12 and 18 containers, and 7 x 24 cm PVC cylinders. The research confirmed that plants grown in larger-sized containers achieved better growth in the field and a higher rate of survival.

To summarise, it is clear that the forests of the Croatian Mediterranean are characterised by principal tree species growing in climatogenic and transitional communities of the eu-Mediterranean and sub-Mediterranean.

Holm oak, Aleppo pine and Turkish pine are the principal eu-Mediterranean tree species. Holm oak forms basic and stable communities, towards which all the transitional communities, most frequently pine cultures established by afforesting karst, are oriented.

Pubescent oaks and black pines form their communities in the sub-Mediterranean area. Forests of pubescent oak have the role of the basic and most stable communities towards which all the activities of re-cultivation and establishment of transitional stands in this area are oriented (Matić, 1990).

The Croatian Mediterranean area is characterised by very early settlement and the intensive development of culture. Pressures on forests were always stronger in places in which the concentration of the population was higher and where larger urban environments were formed. Ever since the Croats settled in these areas, there have been initiatives to preserve the forests or to restore deforested areas to their former status. This is clearly confirmed by historical documents, such as the statutes of Dalmatian and Littoral towns, many regulations, directives, laws, the specialist and scientific symposia of more recent times, a large number of specialist and scientific articles, etc.

Regrettably, however, the majority of these initiatives have remained wishful thinking or have ended as poorly organised short-term campaigns, which have usually been interrupted by wars or by other activities related to occupying this attractive natural Croatian territory, or better said, enslaving the Croatian people in their millennia-old territory.

Of the former quality forests of holm oak, pubescent oak and pines of a high silvicultural form, high forests currently cover only 3.7 % of the area, while coppices, scrub, maquis, garrigues, shybliak and stone cover almost 60 % of the Mediterranean karst area, which extends over 15,389 km^2 or 27.22 % of the total territory of Croatia (Matić and Topić, 2001).

ESTABLISHING FORESTS IN THE KARST REGION (AFFORESTATION)

Every forest established by natural or artificial means (rejuvenation, regeneration or restoration) or by planting seedlings over bare area (afforestation), if it is on a suitable site and at a mature age, can be naturally regenerated. This means that, with the assistance of adequate treatments, a new forest generation is born by natural regeneration from the seeds falling from the crowns of old trees. If the seeds or seedlings are introduced from outside, if they are sown or planted in the stand environment or in the soils which have not lost the properties of forest soils, then we talk of artificial regeneration.

Natural regeneration is the logical and natural sequence of the normal development of every stable and productive forest. It is the result of the appropriate and scientifically based management of a forest applied for a long time. The absence of natural regeneration is a sure sign that a link in the complex chain of a stable forest ecosystem has been broken, or that the applied management treatments have been inadequate and unprofessional.

Afforestation entails the manual or mechanised (artificial) establishment of a forest by planting seedlings or sowing seeds over bare areas which have previously been deforested for some time and in which the soil has lost the properties of forest soil.

All activities relating to simple biological reproduction, by which the existing forests are regenerated, belong to regeneration activities.

Activities that relate to extended biological forest reproduction, i.e. colonising new areas with forests (bare karst, heath, heather, meadows, etc.) are called afforestation activities (Matić and Prpić, 1983). The goal of afforestation activities is to establish a forest. Depending on the manner of establishment and management, these forests are divided into forest cultures, intensive cultures and forest plantations.

Forest cultures are forests raised by planting plants or sowing seeds without any fertilisation.

Intensive forest cultures are artificially established forests by means of planting plants or sowing or planting seeds. The soil is initially fertilised with artificial fertilisers or manure.

Forest plantations are forests established by means of planting seedlings and applying intensive agrotechnical measures and soil fertilisation. In these plantations, some agrocultures can also be cultivated along with forest tree species in the first few years.

Every afforestation campaign is a very extensive and complex undertaking which requires considerable financial means and hard human labour. Forest cultures, intensive cultures and forest plantations established by afforestation are highly valuable amenities which will provide planned benefits for a very long time (the production of market and non-market functions).

Compared to other silvicultural activities, afforestation takes first place in terms of the invested labour and material. However, if a bare area is to be restored to bio-production, such efforts are essential. In order for these activities to be properly executed, careful planning and systematic application is required. Important activities that determine the success of afforestation are divided into the following stages (Matić and Prpić 1983; Matić 1994, 1994a; Matić, Anić and Oršanić 1996):

- selecting the most suitable areas;
- selecting suitable tree species;
- selecting afforestation methods;
- determining the afforestation period;
- preparing the soil for afforestation;
- spatial distribution and plant distances: determining the number of plants and the quantity of seeds per surface unit.

Selecting the most suitable afforestation areas

Forest cultures established by afforestation should fulfil their market and non-market functions in all areas, including the Mediterranean area. The production of wood mass largely refers to the market function, while ecological or protective, social and combined socio-eco-physiological functions are non-market functions (Prpić 2003). There is a firm correlation between market and non-market functions. A forest which has a higher increment, or which produces more wood mass, also produces more generally beneficial goods. The tourist forest function, part of the non-market functions, has a special place in the Mediterranean. More recently, with wood becoming one of the more important renewable energy sources, the economic value of every forest, even those in the Mediterranean, has increased sharply (Matić, Anić and Oršanić 1996, Matić 2007). This is an additional reason for more intensive afforestation and for the total exploitation of produced wood mass and of all non-market forest goods.

In selecting areas for afforestation, we should decide on those of best quality, because forests established there will provide a larger amount of commercial and non-commercial goods in a shorter period. This should be the basic criterion for the selection of afforestation areas.

Fires that destroy Mediterranean forests generally occur in the vicinity of important tourist centres. Consequently, areas to be afforested will primarily be selected in these parts. Burnt areas rapidly enter a critical condition due to being subjected to erosion, the disappearance or decrease of biological activities in the soil, and exposure to extreme ecological impacts. Rapid and good quality recultivation of the soil by afforestation is the only method of restoring forest ecosystems to the areas from which they have been abruptly removed.

As there are many more fire-devastated areas than can be restored by the current possibilities of good quality afforestation, it is necessary to determine the criteria and priorities that will ensure the maximal ecological, biological and economic effects by means of rational investment.

Spatial separation and fencing off the selected areas, choosing the areas and forms of compartments – subcompartments, and planning, designing and constructing access roads and fire lines, as well as determining the direction of afforestation, belong to the group of activities of selecting afforestation areas.

Selecting suitable tree species for afforestation

The selection of tree species for the establishment of a future forest is one of the most highly responsible tasks of a forestry expert. The destiny of a future forest, its growth and the direct and indirect benefits it will provide depend on the selection of suitable tree species.

These species must have broad ecological valence, i.e., they must show the properties of pioneer tree species, which means that their properties will allow them to adapt to extremely poor soils and to create the conditions for the return of the elements of autochthonous climatogenic vegetation in the newly-formed forest soils of good quality in the course of one or possibly two rotations (Matić 1986).

In defining the ecological units for the selection of tree species, account must be taken of the main groups of ecological factors: climate, geological bedrock and soil, relief and the impact of man and the living world in general on the space of the future forest. These factors have an indirect impact on forest trees. We separately discuss the ecological factors that affect forest trees (water, warmth, light, chemical composition of the soil and the atmosphere, mechanical factors), of which each is dependent on all indirect ecological factors.

Based on the site data and the purpose of establishing the future forest, the ecological requirements and biological properties of interesting forest trees in relation to the set objective are then discussed (Matić and Prpić 1983).

Ecological requirements comprise several hereditary traits of a particular species characterised by its relationship towards water, light, temperature and soil.

Biological properties comprise the second group of hereditary traits: seed germination, cotyledon, the development of the young plant, the development of the young tree and tree during the year and over several years (one and more vegetation periods), the shape of the root network and root development, the daily developmental rhythm (transpiration, carbon dioxide assimilation and other important physiological processes), the largest dimensions a tree of a certain species can attain, the frequency of seed yield, the life expectancy of a species, and its competitive ability.

The properties of a tree species are a very complex mosaic which, at the moment of afforestation, represents a part of the invisible constitution of the future forest. This is later reflected in the grandiosity of the trees, their heights, diameters and developed crowns, and in their noticeable physical presence in space in general. Such development requires that the selected afforestation site conforms to the requirements of a particular species by providing adequate quantities of water, warmth and light, as well as offering soils which will support the good development of the plant root system and supply it with the mineral nutrients necessary for its growth.

The karst area comprises the wider coastal Adriatic belt dominated by the Mediterranean and semi-Mediterranean climate. This is a simplified concept which in reality embraces a much larger part of Croatia south of Karlovac. This part of karst, in the area of a continental and transitional climate, does not represent an ecological problem for afforestation as is the case with the littoral karst area.

A narrower karst area with a Mediterranean and semi-Mediterranean climate is characterised by precipitation-free summers, which makes summer afforestation with containerised seedlings much more difficult. The coastal karst areas of Croatia cover about 300,000 ha, which are defined as forest areas that are either devoid of forest vegetation or are severely degraded. The soil in this area is degraded and scarce. These conditions offer very few possibilities for the retention of water from winter, spring and autumn rains. Water retention is possible only in a well developed ecological soil profile below the Mediterranean and semi-Mediterranean vegetation, which is very important since the total precipitation quantity is relatively high. On vegetation-free bare karst, rain is rapidly leached through the porous limestone material and is irrevocably lost for the plant world.

Afforestation should be planned over the entire karst area both for generally beneficial and economic reasons. Naturally, larger tourist units and locations of future tourist resorts should be the first to be afforested.

In the hinterland of Dalmatia, Croatian Primorje and Istria, in the habitats of pubescent oak forests, afforestation should be concentrated in the vicinity of roads, retention lakes and localities exposed to torrents and strong winds. In the tourist hinterland, forest cultures should be established in degraded sites of pubescent oak which receive more precipitation and have deeper soils. These cultures will create favourable climatic conditions and will contribute to increased quantities of drinking water.

In addition to the indirect benefits provided by newly established forests, there are also very important direct benefits in the form of biomass for industry and as an energy source. The Mediterranean and semi-Mediterranean climate offer sufficient warmth that stimulates lush vegetation growth in the precipitation period.

Conifers used for the afforestation of the Mediterranean include in the first place Aleppo pine (*Pinus halepensis*), then Turkish pine (*Pinus brutia*), black pine (*Pinus nigra*), maritime pine (*Pinus pinaster*), Atlas, Lebanese and Himalayan cedar (*Cedrus* sp.), Mediterranean cypress (*Cupressus sempervirens*) and Arizona cypress (*Cupressus arizonica*).

Deciduous tree species to be used for afforestation primarily include manna ash (*Fraxinus ornus*), European nettle tree (*Celtis australis*), oriental hornbeam (*Carpinus orientalis*), hop hornbeam (*Ostrya carpinifolia*), Mahaleb cherry (*Prunus mahaleb*), carob tree (*Ceratonia siliqua*) and a number of trees and semi-trees occurring as accompanying species in forests of holm oak and forests of pubescent oak.

According to research by Topić (1997), pubescent oak, Mahaleb cherry, European nettle tree, and field maple manifest very poor growth and increment in severely degraded karst terrains and should therefore not be used for afforestation purposes. Hop hornbeam and manna ash achieve better success in such sites; in combination with pioneer conifer species (black pine, maritime pine, Atlas cedar) these deciduous species can be used for karst afforestation, but their participation and spatial distribution in the culture will depend on the quality and suitability of the micro-site.

The above afforestation practices on karst result in mixed forest cultures of conifers and broadleaves which will not only be more stable, more resistant and more productive, but will also create more favourable conditions for the faster return of pubescent oak forests in these sites.

Unlike pioneer tree species, holm oak (*Quercus ilex*), pubescent oak (*Quercus pubescens*), Turkish oak (*Quercus cerris*) and false cork oak (*Quercus pseudosuber*) are species that cannot and should not be planted in non-forest soils. These trees can only be introduced after the area has been afforested with conifer cultures which have created suitable conditions in and on the soil for the return of the elements of autochthonous climatogenic communities. In this area, climatogenic communities consist of the aforementioned oaks. It should be stressed that holm oak and pubescent oak are basic tree species that form forest communities in the eu-Mediterranean and sub-Mediterranean region, while the other oaks mentioned have been added to these communities either naturally or artificially as accompanying species with a relatively low participation in the composition mix.

Selecting afforestation methods

Forest cultures are established in two ways: by sowing seeds and planting seedlings. The choice of one or the other of these methods depends on several factors. These include the biological properties and ecological requirements of the tree species we plan to plant, the climatic conditions in the afforestation area, the physical and chemical properties of the soil, the possibilities of procuring seeds and seedlings, the set production objective and the purpose of the established cultures. Since afforestation areas are located exclusively in the Mediterranean region, in addition to planting it is recommended to sow the seeds in a previously prepared site. This depends particularly on the pattern of precipitation, which is the most frequent in autumn and winter, and partially in spring.

Planting is done with bare root seedlings and containerised seedlings. Bare root seedlings can only be planted during the dormant vegetation period, while containerised seedlings can also be planted during the vegetation season.

Planting in holes is the oldest and the most frequently applied planting method on karst. The holes have dimensions of 40 x 40 x 40 cm. While digging the hole, the stone is separated from the soil. If a horizontally layered slab is encountered during digging, the spot is abandoned and a new one with vertically layered and cracked stone is sought. Every dug hole should allow the root to develop well and penetrate into the deeper layers. Apart from planting into the dug holes, it is also possible to plant into ripped soil.

Planting is accomplished by using a regular technique, but special care should be taken not to allow soil desiccation and the accumulation of humidity. When a plant is planted, the soil around the plant must be cylinder-shaped so that the rainfall can accumulate in the soil around the plant. The surface layer must be crumbly and the capillaries on the soil surface must be broken up and friable. Compacted soil has many capillaries through which the soil is desiccated. This is why the soil around every planted seedling should be covered with smaller stones or a layer of small pebbles about 15 cm away from the plant.

With some tree species (black pine, Aleppo pine), it is good practice to plant a bare root seedling slightly deeper in the soil than in the nursery. By burying a part of the needles into the soil, the crown will be reduced and a balance maintained between the crown and the reduced root system.

To grow plants in different types of containers, we should bear in mind that larger containers with a higher quantity of planting medium are more suitable for sowing the seeds and raising the plants than smaller containers. Research has shown that 7 x 24 cm PVC cylinders with a volume of 923 cm^3 achieve better afforestation success than Bosnaplast 12 block containers with dimensions of 36 x 22.5 x 12 cm and 55 cavities in the block, each with a volume of 120 cm^3, and Bosnaplast 18 block containers sized 32 x 21.2 x 18 cm with 33 cavities, each with a volume of 220 cm^3 (Topić, 2009). With regard to the above, we consider that for the Mediterranean region it is better to apply a classical afforestation method with bare root seedlings than with seedlings raised in smaller containers.

Planting plants in the Mediterranean requires strict adherence to all the basic afforestation postulates in this part of Croatia. These refer to the ways of digging the holes, ripping the soil, mulching, protection against wind, salt spray, evaporation, etc.

Good results were achieved with afforestation that involved sowing domestic deciduous species (manna ash, laurel, strawberry tree, European nettle tree, Mahaleb cherry and others) simultaneously with planting conifer tree species. The stability of the newly established forests is thus increased and autochthonous vegetation is gradually restored to its terrains.

Decisions on afforestation methods should also be governed by the fact that sowing seeds is a cheaper method, but planting seedlings is a more effective one.

Determining the afforestation period

Bare root plants are planted during the dormant vegetation period, which is more difficult to determine in the Mediterranean than in the continental region, where temperature differences easily determine the duration and the cessation of the vegetation period. Such plants can be planted in the autumn and spring period. As a rule, planting in the Mediterranean is done in autumn and winter in order to take advantage of the abundant rainfall and favourable temperatures in and above the soil.

Containerised seedlings can be planted throughout the year, but autumn, winter and spring planting is recommended. Summer planting can also be undertaken in exceptional cases, or if site conditions in the field are favourable.

Afforestation by sowing seeds should be done in the autumn in order to allow seedlings to germinate and stabilise during autumn, winter and spring in terms of deeper rooting and higher resistance to summer droughts.

Preparing the soil for afforestation

To create favourable conditions for the growth and development of a young plant, the soil should be prepared for afforestation. Properly prepared soil will make it possible for the plant to fight against the existing weed vegetation, both in the root area and above the soil. Soil preparation is intended to create favourable water-air relationships in the soil, which will in turn enable the optimal biochemical processes necessary for the plant's life. The methods and intensities of soil preparation will depend on the condition of the soil, afforestation method, use of available mechanisation, etc.

In view of the fact that the Mediterranean area is frequently inflicted with fires, the main preparation activities include the following: cutting down and removing the trees and shrubs that remain after a fire, as well as the trees and shrubs that we are not sure will adapt well to the new stand, destroying and cleaning the weeds and other materials, preparing the soil completely or partially by ripping at certain distances and depths, flattening the soil and erecting protective fences against game and cattle.

Sloping terrains and soils on flysch parent material require bench terrace afforestation (*gradoni*). These are machine-made slits from 70 to 120 cm wide in the direction of the contour lines on the terrain. The slit is tilted towards the hill at a slope of about 30°. If terrain inclinations prevent making more densely spaced bench terraces (*gradoni*), then smaller terraces (gradoncini) intersected by uncultivated terrain are made parallel to the *gradon*i. Terraces of 1 to 2 m² can be made between the *gradoni* and *gradoncini*. The soil is cultivated, the holes dug, the plants planted or the seeds sown on *gradoni, gradoncini* and terraces. The purpose of these activities is to stimulate better plant growth and prevent abrupt runoff, erosion and torrents (Matić and Prpić, 1983).

Good soil preparation often has a decisive impact on afforestation success. Soil preparation activities should generally be executed with suitable mechanisation, such as different types of rotary cultivators, machines for destroying grass and weed vegetation, chain saws of different dimensions, graders, rippers, bulldozers, different ploughs for complete and partial soil cultivation, and others.

Spatial distribution and plant distances: determining the number of plants and the quantity of seeds per surface unit

Plants for afforestation are planted in a regular and irregular spatial pattern. A regular pattern has more advantages over an irregular one and is applied wherever the terrain conditions allow (stones, stumps, etc.). The forms are varied, e.g. rectangular, square, triangular or hexagonal, while distances between the plants and the rows are accurately defined. The advantages of such planting are multiple since it allows for simpler tending and management in the future. Where the terrain conditions prevent the use of a regular pattern, an irregular one is applied. An irregular planting distribution is frequent in the karst area, because planting is only done in those places which have sufficient quantities of soil and where it is possible to dig holes of satisfactory dimensions.

The number of plants per surface unit or the planting density is determined by the distance between the plants and the rows, as well as by the quantity of seeds per surface unit. The number and quantity depend on the silvicultural properties of a particular tree species and on management goals.

According to Matić (1994), broadcasting the seeds of Aleppo, Turkish, maritime and black pine over the entire area will require 3–5 kg of seeds, while sowing into rows and patches will require 2–3 kg of seeds per hectare. Planting Aleppo pine, Turkish pine, maritime pine, stone pine and cypress will require 1,000–2,000 seedlings per hectare, planting cedars will require 700–1,200 seedlings per hectare, while afforestation with seedlings of black pine will require 2,000–2,5000 seedlings per hectare.

As for the number of seedlings and quantities of seed per hectare, a larger number of plants per surface unit accelerate the process of site stabilisation in terms of creating favourable micro-climatic conditions and better quality soil, as well as reducing competition from weed vegetation, which results in the better growth and success of the newly established culture. We therefore recommend the above-mentioned quantities of seeds and numbers of plants.

The syndynamic processes in Mediterranean forests require the constant application of three sets of procedures in the field of silviculture. These include the establishment of forest cultures on bare karst by afforestation, the tending of forests and their conversion into a higher silvicultural form, and regenerating the forests by natural or artificial methods.

The afforestation of bare karst is the first, the most important and the hardest step; but once this step is taken, it stops the degradation processes of bare karst and creates conditions for the return of stable, autochthonous, climatogenic forests. Forest tending and regeneration are also important steps which ensure the eternity of forests.

The forest has always been man's strongest pillar in his millennia-long struggle for better life conditions and survival. In the eternal interaction between man and forest, the forest has always offered man all of its produce, protection and shelter; however, in doing so, it has largely disappeared.

Today, when forests are disappearing, when bare and karst areas are increasing, and water, clean air, energy and favourable conditions for a good quality life are becoming scarce, it is high time we started restoring the forests to their abandoned sites through afforestation, thus creating better living conditions for ourselves.